TEXTBOOK OF

Neonatal Resuscitation®

8th Edition

American Heart Association

American Academy of Pediatrics

OEDICATED TO THE HEALTH OF ALL CHILOREN®

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Textbook of Neonatal Resuscitation, 8th Edition

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Contents

Preface

Being entrusted by parents to provide care for their newly born baby is both a privilege and an extraordinary responsibility. Since 1987, the Neonatal Resuscitation Program® (NRP®) has helped over 4.5 million health care providers fulfill this responsibility by acquiring the knowledge and skills necessary to save newborn lives. It has become the training standard for health care professionals throughout North America who manage newborns in the hospital setting. The *Textbook of Neonatal Resuscitation,* 8th edition, has been updated and includes new material; however, it emphasizes the same basic principles that have been the foundation of NRP since its inception.

The recommendations in this textbook are developed using a structured process. Through the International Liaison Committee on Resuscitation (ILCOR), the American Academy of Pediatrics (AAP) and American Heart Association (AHA) partner with resuscitation councils from around the world to evaluate resuscitation science. Members of the ILCOR Neonatal Task Force and a panel of content experts continuously identify knowledge gaps, perform systematic reviews that summarize the quality and certainty of evidence, and formulate consensus statements with treatment recommendations. A summary of recent consensus statements, called the 2020 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations (CoSTR), has been published and includes 22 neonatal resuscitation questions evaluated by 50 experts representing 17 countries. From this consensus, ILCOR member councils develop guidelines that address the specific needs in their own countries. The most recent guidelines for health care systems in North America (Part 5: Neonatal Resuscitation 2020 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care) are reproduced as an Appendix in this textbook. Finally, the NRP Steering Committee develops educational materials to help learners acquire the skills necessary to implement the guidelines. Although research since 2015 has provided additional evidence to support previous recommendations, the international science consensus has not resulted in any major practice changes. Minor practice changes have been incorporated in the NRP 8th edition Algorithm and several practices have been revised to improve patient safety and educational efficiency.

Similar to the 7th edition, the textbook emphasizes the importance of adequate preparation, effective ventilation, and teamwork. Practice changes incorporated in this edition include revising the pre-birth questions to include umbilical cord management, reordering the initial steps to better reflect common practice, recommending the use of an electronic cardiac monitor to continuously monitor heart rate when an alternative airway is placed, simplifying the suggested initial dose of epinephrine, increasing the flush volume for intravascular epinephrine, and extending the duration of resuscitative efforts for newborns with an absent heart rate. The 8th edition of the textbook includes updated versions of the previous 11 lessons and 3 new supplemental lessons. The supplemental lessons focus on using ergonomics and human factors to improve team performance (Lesson 12), resuscitation outside the delivery room (Lesson 13), and developing a resuscitation quality improvement program (Lesson 14). These lessons are intended to enhance resuscitation knowledge and performance for all readers but are not required as part of the NRP 8th edition course. Additional enhancements to the textbook include suggested quality improvement questions and metrics at the end of each lesson, new material describing considerations for the resuscitation of newborns with myelomeningocele and abdominal wall defects, and the incorporation of QR codes that can be scanned with mobile devices and enable readers to view short videos demonstrating important skills.

The production of a textbook as complex as the *Textbook of Neonatal Resuscitation* cannot be accomplished without the effort of a team of dedicated and talented individuals. John Kattwinkel (University of Virginia) is a giant in the world of neonatal resuscitation, a founding member of the NRP, former Steering Committee Chair, and editor of 4 previous editions of this textbook. His ongoing advice and counsel continue to guide the NRP. The partnership between the AAP, AHA, and ILCOR provides the infrastructure required to complete systematic reviews and develop evidence-based guidelines. The development of the international science consensus statements, the North American guidelines, and the NRP implementation were guided by a group of inspiring leaders, including Myra Wyckoff (University of Texas Southwestern), Jonathan Wyllie (James Cook University Hospital, UK), Khalid Aziz (University of Alberta, Canada), Marya Strand (St. Louis University), Henry Lee (Stanford University), and Vishal Kapadia (University of Texas Southwestern). The members of the NRP Steering Committee, its liaison representatives, and volunteers spent many hours reviewing the textbook to ensure current, accurate, and practical guidance even when the evidence was insufficient to make a definitive recommendation. Marya Strand, Henry Lee, and Beena Kamath-Rayne (AAP) reviewed every lesson for clarity and accuracy. The initial drafts of the supplemental lessons were written by Bobbi Byrne (Indiana University, Lesson 12), Michelle Rhein (California, Pacific Medical Center, Lesson 12), Taylor Sawyer (University of Washington, Lesson 13), and Henry

Lee (Stanford University, Lesson 14). Satyan Lakshminrusimha used his artistic talents to create new color illustrations that clearly demonstrate the technique and mechanism of chest compressions (Lesson 6). In addition to the images carried forward from the 7th edition, Shannon Vandervennet (University of Michigan) contributed new photographs for the 8th edition that highlight key procedures. Working with Shannon, Aunum Akhter (University of Michigan) patiently modeled positive-pressure ventilation for the new cover. Thanks again to assistance from Christopher Colby (Mayo Clinic-Rochester), live delivery room photographs of the staff and patients at Mayo Clinic have been included in this edition. Drew Smith (AAP) assisted with the creation of new graphic elements. Steven Ringer (Dartmouth-Hitchcock Medical Center) and Elizabeth Foglia (University of Pennsylvania) led the development of a new online assessment system. Continuing a long tradition, Lou Halamek (Stanford University) challenged the NRP to remain innovative, Jeffrey Perlman (Cornell University) asked key questions to confirm the scientific integrity and practicality of NRP recommendations, and Jerry Short (University of Virginia) helped to ensure that the instructional and assessment components of the program remain consistent with adult learning principles. During an international pandemic, Kaitlin Wolfe Butterfield (AAP) and Michelle Olech Smith (AAP) supervised the coordination of multiple projects to be certain that each component of the program was completed on time. This edition of the *Textbook of Neonatal Resuscitation* could not have been completed without the assistance of Jill Rubino. Her extraordinary patience and steadfast attention to detail during the copyediting process were critical to making certain that the text and images were clear, consistent, and accurate.

I am indebted to Jeanette Zaichkin for her partnership in every phase of producing the 8th edition of the textbook. For nearly 2 decades, Jeanette has been the heart and soul of the NRP. Advocating for providers who must implement NRP guidelines at the bedside, she has played a critical role in the production of every NRP activity, including the provider textbook, online assessments, adaptive learning materials, instructor course materials, *Instructor Updates*, charts, simulation scenarios, workshops, and seminars. She has been the voice of reason, the steady hand on the wheel, and the rainbow among the clouds.

On behalf of everyone involved in preparing the 8th edition NRP course materials, we hope that they are helpful as you fulfill your responsibility for the newborns entrusted to your care.

Gary M. Weiner, MD

Gary M. Weiner, MD, FAAP

Neonatal Resuscitation Program® Provider Course Overview

Neonatal Resuscitation Scientific Guidelines

The Neonatal Resuscitation Program® (NRP®) materials are based on the American Academy of Pediatrics (AAP) and American Heart Association (AHA) Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care (*Pediatrics*. 2021;147[Suppl 1]. doi:10.1542. e2020038505E). A reprint of the Guidelines appears in the Appendix. Please refer to the Guidelines if you have any questions about the rationale for the current program recommendations. The Guidelines, originally published in October 2020, are based on the International Liaison Committee on Resuscitation (ILCOR) Consensus on Cardiopulmonary Resuscitation Science with Treatment Recommendations.. The evidence-based reviews prepared by members of ILCOR, which serve as the basis for both documents, can be viewed in the Web-based integrated guidelines site (https://professional.heart.org/en/science-news/2020-international-consensus-on-cardiopulmonary-resuscitation-science-with-treatment-recommendations).

Level of Responsibility

The NRP 8th edition curriculum offers 2 NRP provider categories:

- **NRP Essentials:** Anyone involved in the care of a newborn should take NRP Essentials, which consists of materials in Lessons 1 through 4.
- **NRP Advanced:** This provider option may be appropriate for those who attend births and are responsible for anticipated resuscitation of the newborn with known risk factors and for those who participate in neonatal resuscitation beyond positive-pressure ventilation. The NRP Advanced participant is responsible for material in Lessons 1 through 11.

Any learner may study supplemental lessons 12 through 14 but will not be tested on that material.

Each facility determines its own policy for who should attain NRP Essentials or Advanced provider status. If most staff participate in births with risk factors and are called to assist with complex resuscitation, then only a small number of select staff with limited responsibilities may be suited to NRP Essentials.

Special Note: Neonatal resuscitation is most effective when performed by a designated and coordinated team. It is important for you to know the neonatal resuscitation responsibilities of team members who are working with you. Periodic practice among team members will facilitate coordinated and effective care of the newborn.

Course Completion

The NRP 8th edition offers 2 learning methodologies for attaining NRP provider status: Instructor-led courses and RQI® for NRP®.

Instructor-Led Courses

In hospitals that use the instructor-led course format, learners must complete the Online Learning Assessment and, within 90 days, attend the in-person skills/simulation portion of the course. During the in-person course, learners demonstrate mastery of resuscitation skills (Lessons 2 through 4 for Essentials, and Lessons 2 through 7 for Advanced) and participate in simulated resuscitation scenarios, as determined by the course instructor(s).

Upon successful completion of these requirements, participants are eligible to receive an NRP Course Completion eCard (Essentials or Advanced). Once the online course evaluation is completed, an electronic Course Completion Card will be available in the learner's profile of the NRP Learning Platform™. Learners who attain provider status through an instructor-led course must renew their provider status every 2 years.

RQI® for NRP®

Due to findings that episodic learning can improve neonatal resuscitation outcomes, the AAP has formed a collaboration with RQI Partners (a partnership between the American Heart Association and Laerdal Medical) to develop RQI for NRP, an optional learning methodology for NRP Essentials Provider training.

RQI for NRP is a quality improvement program that offers an alternative educational and administration method that verifies competence in positive-pressure ventilation (PPV) skills on a neonatal simulator. This program offers self-directed learning that uses low-dose, quarterly cognitive review and skills sessions to cover the content of NRP Essentials (Lessons 1 through 4).

Initial entry into the RQI for NRP format requires that learners complete the Online Learning Assessment and complete the skills required at the simulator. At that point, the learner attains an Essentials eCredential. An RQI for NRP learner is required to engage in quarterly cognitive and skills activities at their hospital simulation station (Figure 1) to maintain a current Essentials eCredential. With each quarterly activity, learner skills are reinforced, and the expiration of the learner's eCredential is extended by 3 months.

If an RQI learner changes their NRP training location to a hospital that uses instructor-led courses and 2-year provider renewal, the learner requests an eCard that is valid for 2 years from the last completed quarterly engagement activity.

The NRP Advanced provider in a hospital that uses RQI for NRP maintains their Essentials provider status by completing the quarterly cognitive and skills-based practice sessions at the simulation station and renews their Advanced provider status at an instructor-led course every 2 years.

Figure 1: An NRP learner practices PPV skills at the RQI simulation station.

Completion Does Not Imply Competence

The NRP is an educational program that introduces the concepts and basic skills of neonatal resuscitation. Attaining and maintaining NRP Provider status does not imply that an individual has the competence to perform neonatal resuscitation in the clinical setting. Each hospital is responsible for determining the level of competence and qualifications required for someone to assume clinical responsibility for neonatal resuscitation.

Standard Precautions

The United States Centers for Disease Control and Prevention has recommended that standard precautions be taken whenever risk of exposure to blood or bodily fluids is high and the potential infection status of the patient is unknown, as is certainly the case in neonatal resuscitation.

All fluid products from patients (blood, urine, stool, saliva, vomitus, etc) should be treated as potentially infectious. Gloves should be worn when resuscitating a newborn, and the rescuer should not use their mouth to apply suction via a suction device. Mouth-to-mouth resuscitation should be avoided by having a resuscitation bag and mask or T-piece resuscitator always available for use during resuscitation. Masks and protective eyewear or face shields should be worn during procedures that are likely to generate droplets of blood or other bodily fluids. Gowns or aprons should be worn during procedures that probably will generate splashes of blood or other bodily fluids. Delivery rooms must be equipped with resuscitation bags, masks, laryngoscopes, endotracheal tubes, mechanical suction devices, and the necessary protective shields.

Strategies for NRP Training During COVID-19

COVID-19 has brought significant challenges in implementing NRP trainings with physical distancing and restrictions on group gatherings. When leading instructor-led events despite these challenges, NRP instructors must ensure that courses include all required components, meet relevant learning objectives of participants, and comply with public health and institutional requirements for personal safety and resource utilization. The NRP Steering Committee has provided guidance on strategies for teaching NRP Provider courses during COVID-19, available at the NRP website at aap.org/nrp.

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Foundations of Neonatal Resuscitation

What you will learn

- Why neonatal resuscitation skills are important
- Physiologic changes that occur during and after birth
- The format of the Neonatal Resuscitation Program® Algorithm
- Communication and teamwork skills used by effective resuscitation teams
- How implementing quality improvement methods can improve outcomes

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Key Points

O Most newborns make the transition to extrauterine life without intervention.

f.) Before birth, pulmonary blood vessels in the fetal lungs are tightly constricted, and the alveoli are filled with fluid, not air.

Q Newborn resuscitation is usually needed because of respiratory failure.

9 The most important and effective step in neonatal resuscitation is to ventilate the baby's lungs.

0 Very few newborns will require chest compressions or medication.

O Teamwork, leadership, and communication are critica! to successful resuscitation of the newborn.

The Neonatal Resuscitation Program

The Neonatal Resuscitation Program (NRP®) will help you learn the cognitive, technical, and teamwork skills that you need to resuscitate and stabilize newborns. Most newborns make the transition to extrauterine life without intervention. Within 30 seconds after birth, approximately 85% of term newborns will begin breathing. An additional 10% will begin breathing in response to drying and stimulation. To successfully transition, approximately

- Five percent of term newborns will receive positive-pressure ventilation (PPV).
- Two percent of term newborns will be intubated.
- One to 3 babies per 1,000 births will receive chest compressions or emergency medications.

The likelihood of requiring these lifesaving interventions is higher for babies with certain identified risk factors and those born before full term. Even though the majority of newborns do not require intervention, the large number of births each year means that timely intervention can save many newborn lives. Because the need for assistance cannot always be predicted, health care providers need to be prepared to respond quickly and efficiently at every birth.

During your NRP course, you will learn how to evaluate a newborn, make decisions about what actions to take, and practice the steps involved in resuscitation. As you practice together in simulated cases, your team will gradually build proficiency and speed. The most gratifying aspect of providing skillful assistance to a compromised newborn is that your efforts are likely to be successful. The time that you devote to learning how to resuscitate 11ewbornsis time very well spent.

Why do newborns require a different approach to resuscitation than adults?

Most often, adult cardiac arrest is a complication of coronary artery disease. It is caused by a sudden arrhythmia that preve11tsthe heart from effectively circulating blood. As circulation to the brain decreases, the adult victim loses consciousness and stops breathing. At the time of arrest, the adult victim's blood oxygen and carbon dioxide (CO_2) content is usually normal and the lungs remain filled with air. During adult resuscitation, chest compressions maintain circulation until electrical defibrillation or medications restore the heart's function.

In contrast, most newbor11srequiring resuscitation have a healthy heart. When a newborn requires resuscitation, it is usually because respiratory failure interferes with oxygen and CO_2 exchange.

- Before birth, fetal respiratory function is performed by the placenta instead of the fetal lungs. When the placenta is functioning normally, it transfers oxygen from the mother to the fetus and carries CO_2 away from the fetus to the mother. A healthy fetus makes breathing movements, which are important for normal lung growth.
- When placenta! respiration fails, the fetus receives an insufficient supply of oxygen and CO_2 cannot be removed. Acid increases in the fetal blood as cells attempt to function without oxygen and CO_2 accumulates.
- Fetal monitoring may show a decrease in activity, loss of heart rate variability, and heart rate decelerations. If placenta! respiratory failure persists, the fetus will make a series of reflexive gasps followed by apnea and bradycardia.
- If the fetus is born in the early phase of respiratory failure, tactile stimulation may be sufficient to initiate spontaneous breathing and recovery. If the fetus is born in a later phase of respiratory failure, stimulation alone will not be sufficient and the newborn will require assisted ventilation to recover. The most severely affected newborns may require chest compressions and epinephrine. At the time of birth, you may not know if the baby is in an early or a late phase of respiratory failure.

- After birth, the baby's lungs must take over respiratory function. They must be filled with air to exchange oxygen and CO_2. Respiratory failure can occur if the baby does not initiate or cannot maintain effective breathing effort.
- If respiratory failure occurs either before or after birth, the primary problem is a lack of gas exchange. Therefore, ***the focus of neonatal resuscitation is effective ventilation of the baby's lungs.***

Many concepts and skills are taught in this program. Establishing effective ventilation of the baby's lungs during neonatal resuscitation is the single most important concept emphasized throughout the program.

Ventilation of the newborn's lungs is the single most important and effective step in neonatal resuscitation.

What happens during the transition from fetal to neonatal circulation?

Understanding the basic physiology of the cardiorespiratory transition from intrauterine to extrauterine life will help you understand the steps of neonatal resuscitation.

- Before birth, the fetal lungs are filled with fluid, not air, and they do not participate in gas exchange. All of the oxygen used by the fetus is supplied from the mother's blood by diffusion across the placenta. The oxygenated fetal blood leaves the placenta through the umbilical vein (Figure 1.1).
- Blood vessels in the fetal lungs (pulmonary vessels) are tightly constricted and very little blood flows into them. Instead, most of the oxygenated blood returning to the fetus from the placenta via the umbilical vein flows through the foramen ovale or ductus arteriosus and bypasses the lungs. Because blood flows directly from the right side of the heart to the left side without entering the lungs, it is called a *right-to-left shunt.* In utero, this right-to-left shunt allows the most highly oxygenated blood to flow directly to the fetal brain and heart.
- After birth, a series of events culminate in a successful transition from fetal to neonatal circulation.
  - *As* the baby takes deep breaths and cries, fluid is absorbed from the air sacs (alveoli) and the lungs fill with air (Figure 1.2).
  - Air in the lungs causes the previously constricted pulmonary vessels to relax so that blood can flow to the lungs and reach the alveoli where oxygen will be absorbed and CO_2 will be removed (Figure 1.3).

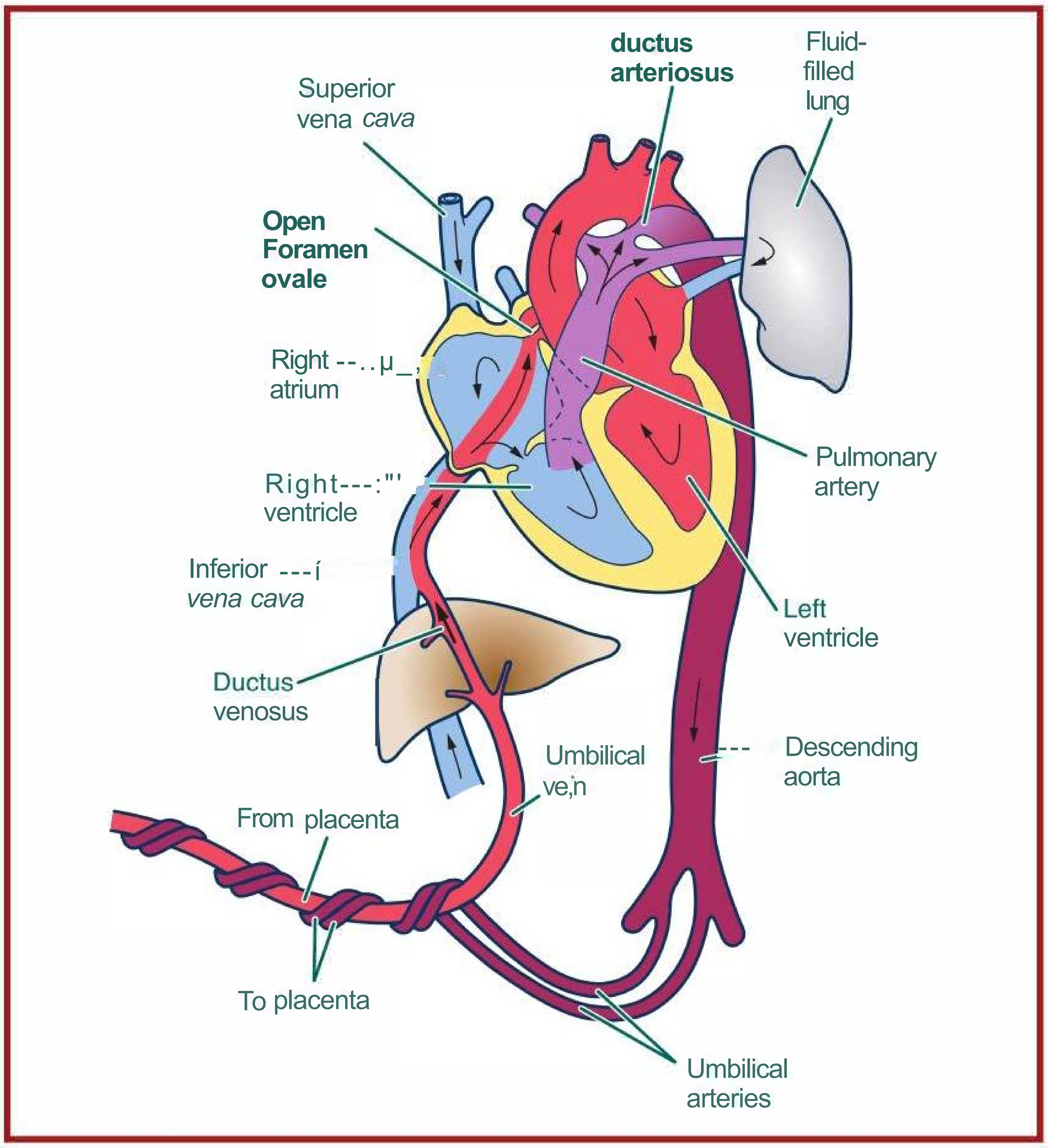


Figure 1.1. Fetal Circulation Path: Oxygenated blood (red) enters the right atrium from the umbilical vein and crosses to the left side through the foramen ovale and ductus arteriosus. Only a small amount of blood flows to the lungs. There is no gas exchange in the fluid-filled lungs.

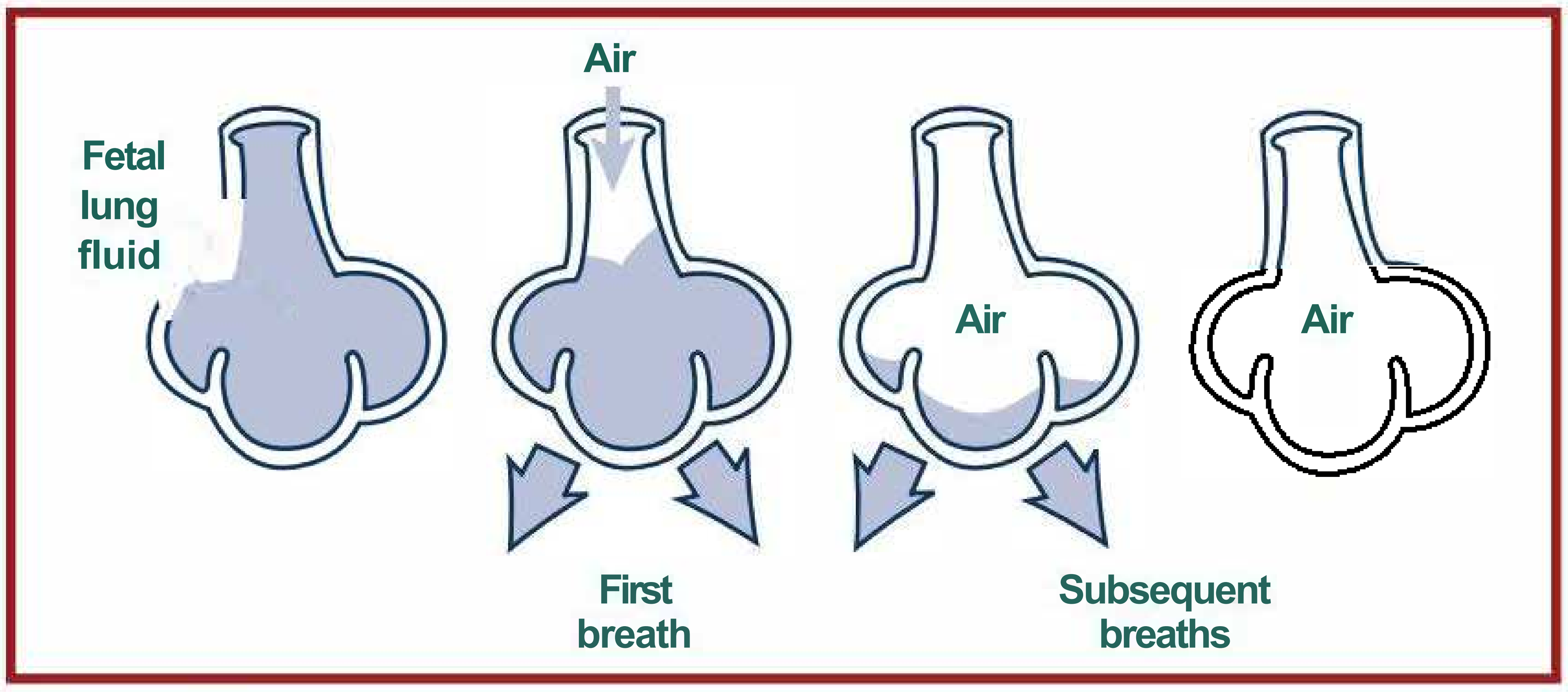


Figure 1.2. Air replaces fluid in the alveoli.

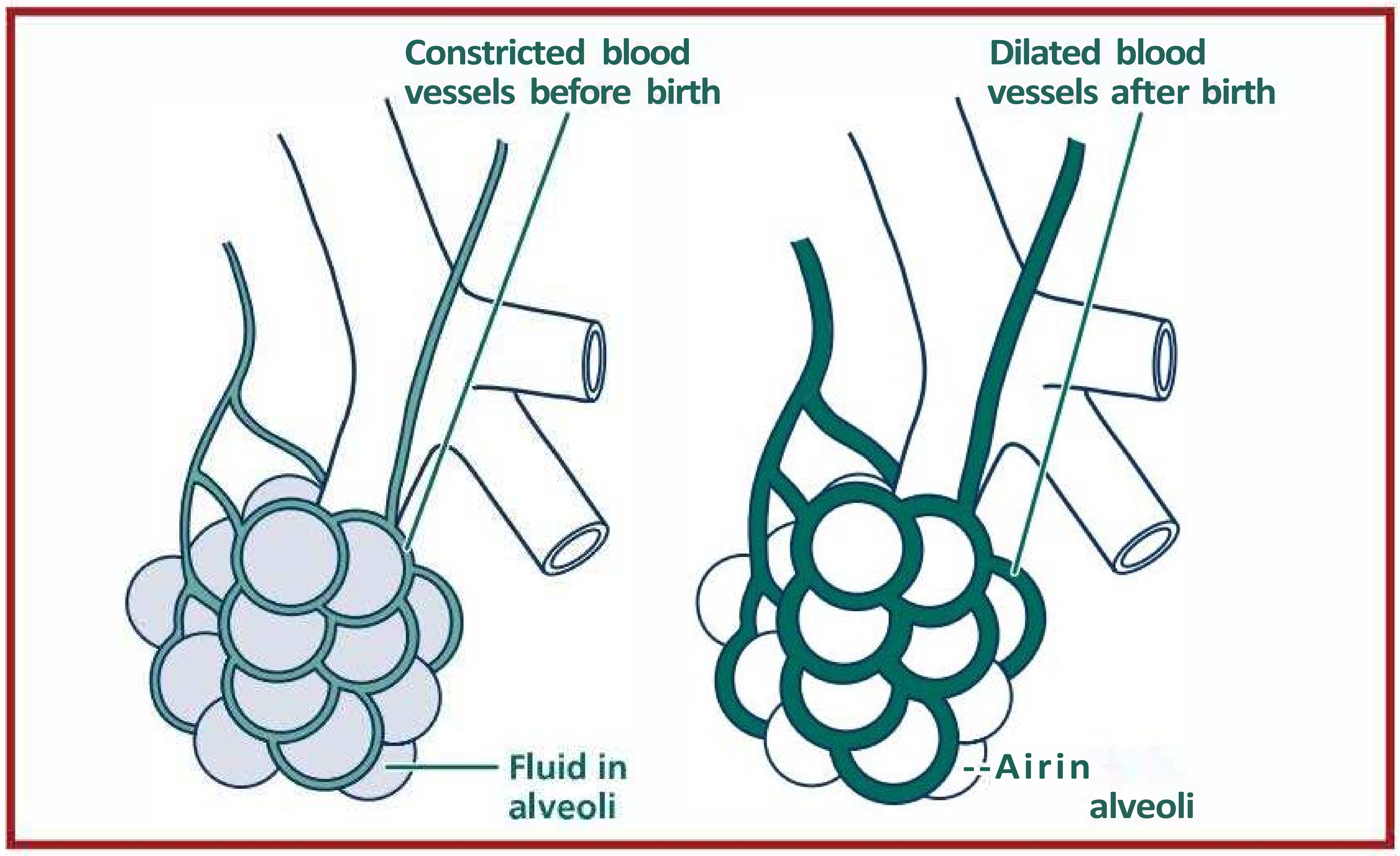


Figure 1.3. Blood vessels in the lungs open.

- Oxygenated blood returning from the baby's lungs helps to fill the baby's heart and ensure that the heart and brain will receive adequate blood flow once the umbilical cord is clamped (Figure 1.4).

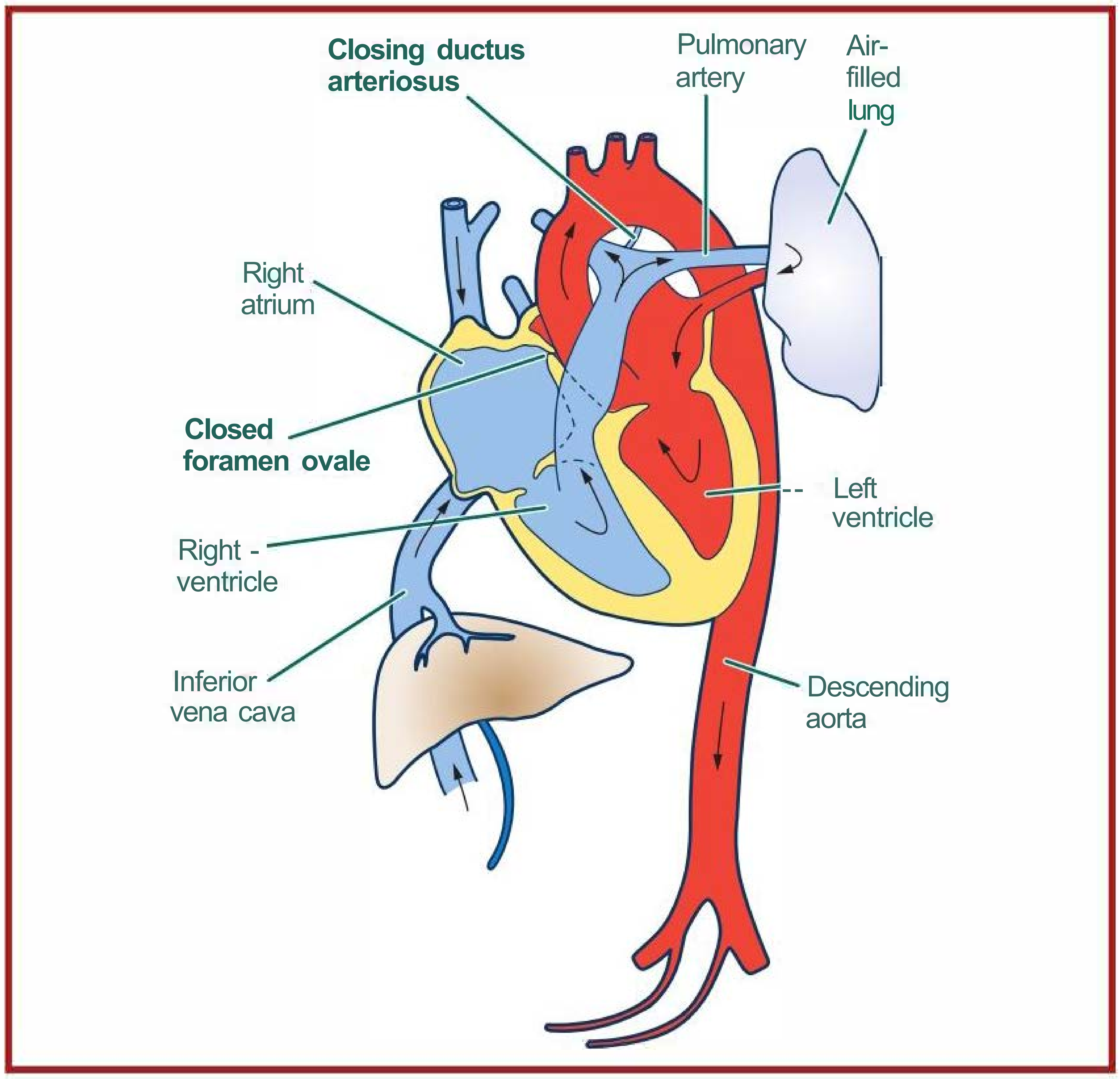


Figure 1.4. Transitional Circulation Path: The baby breathes, pulmonary vessels relax, and blood flows to the air-filled lungs. Blood returning to the left side of the heart from the lungs has the highest oxygen saturation.

- Clamping the umbilical cord increases the baby's systemic blood pressure, decreasing the tendency for blood to bypass the baby's lungs.

Although the initial steps of transition occur within a few minutes of birth, the entire process may not be completed for hours or days. For example, it may take up to 10 minutes for a healthy term newborn to achieve an oxygen saturation greater than 90%. It may take severa! hours for fluid in the lungs to be completely absorbed, and complete relaxation of the pulmonary blood vessels occurs gradually over severa! months.

How does a newborn respond to an interruption in normal transition?

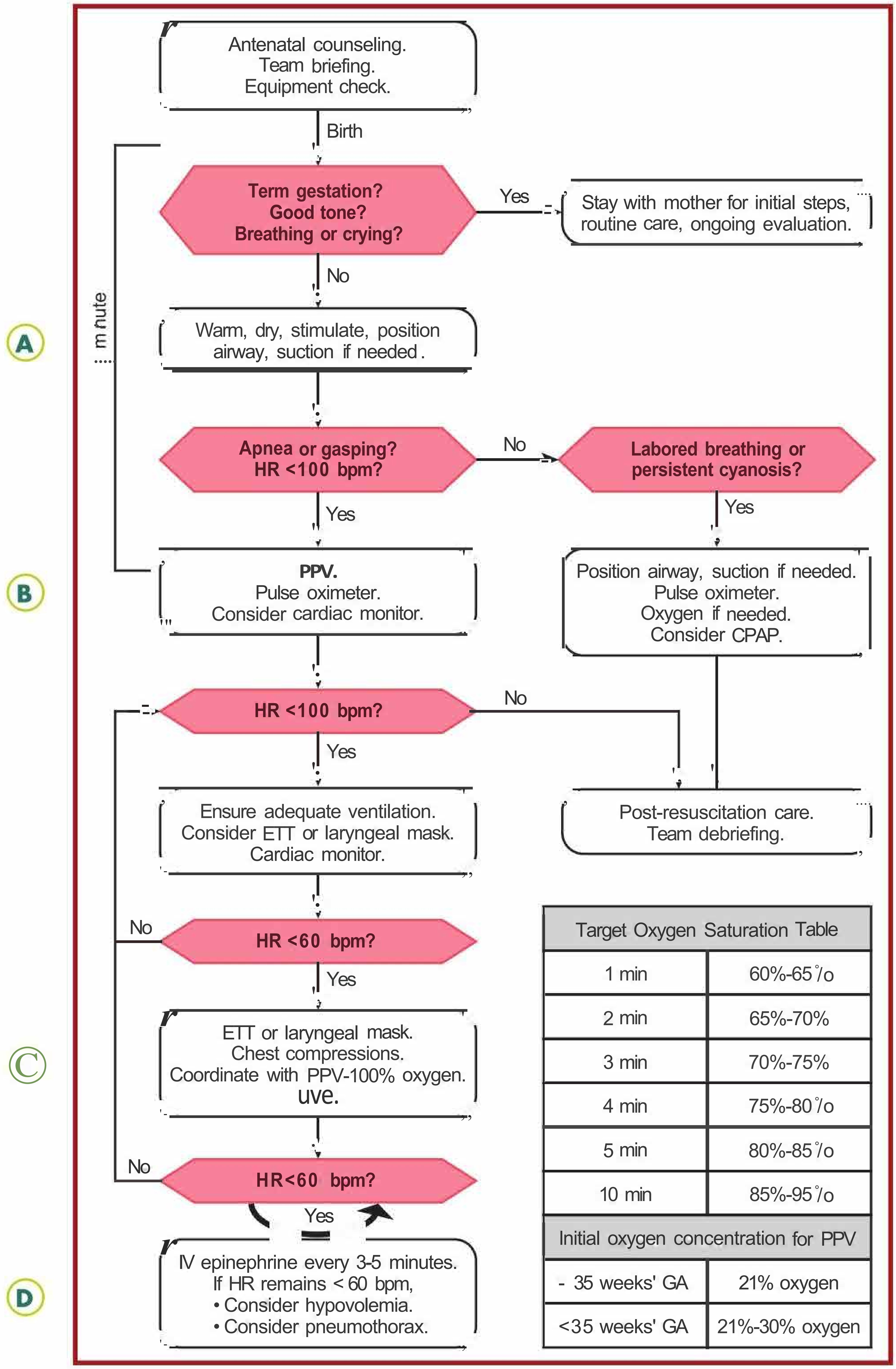
If normal transition <loes not occur, the baby's organs will not receive enough oxygen, acid will accumulate in tissues, and blood vessels in the baby's intestines, kidneys, muscles, and skin may constrict.

Temporarily, a survival reflex maintains blood flow to the baby's heart and brain to preserve function of these vital organs. If inadequate gas exchange continues, the heart begins to fail and blood flow to ali organs decreases. The lack of adequate blood flow and oxygen may lead to organ damage. Table 1-1 summarizes sorne of the clinical findings associated with an interruption in normal transition.

Table 1•l • Clinical Findings of Abnormal Transition
• Irregular breathing, absent breathing (apnea), or rapid breathing (tachypnea)
• Slow heart rote (bradycardia) or rapid heart rate (tachycardia)
• Decreased muscle tone
• Pale skin (pallor) or blue skin (cyanosis)
• Low oxygen saturation
• Low blood pressure

How is the Neonatal Resuscitation Program Algorithm structured?

The NRP Algorithm (Figure 1.5) describes the steps that you will follow to evaluate and resuscitate a newborn. It is divided into 5 blocks beginning with birth and the initial assessment. Throughout the Algorithm, hexagons indicate assessments and rectangles show actions that may be required. Although it is important to work quickly and efficiently, *you must ensure that you have adequately performed the steps of each block befare moving on to the next block.* Assessments are



Target Oxygen Saturation Table	
1 min	60%-65%
2 min	65%-70%
3 min	70%-75%
4 min	75%-80%
5 min	80%-85%
10 min	85%-95%
Initial oxygen concentration for PPV	
- 35 weeks' GA	21% oxygen
<35 weeks' GA	21%-30% oxygen

Figure 1.5. Neonatal Resuscitation Program Algorithm

repeated at the end of each block and will determine if you need to proceed. The details of each block are described in subsequent lessons.

- ***Rapid Evaluation:*** Determine if the newborn can remain with the mother or should be moved to a radiant warmer for further evaluation.
- ***(A) Airway:*** Perform the initial steps to establish an open Airway and support spontaneous respiration.
- ***(B) Breathing:*** Positive-pressure ventilation is provided to assist Breathing for babies with apnea or bradycardia. Other interventions (continuous positive airway pressure [CPAP] or supplemental oxygen) may be appropriate if the baby has labored breathing or low oxygen saturation.
- ***(C) Circulation:*** If severe bradycardia persists despite assisted ventilation, Circulation is supported by performing chest compressions coordinated with PPV.
- ***(D) Drug:*** If severe bradycardia persists despite assisted ventilation and coordinated chest compressions, the Drug epinephrine is administered as coordinated PPV and chest compressions continue.

Take a moment to familiarize yourself with the layout of the NRP Algorithm (Figure 1.5). Neonatal Resuscitation Program Essentials learners will focus on the Rapid Evaluation, Airway, and Breathing steps of the Algorithm. Neonatal Resuscitation Program Advanced learners will study the entire Algorithm.

Why are teamwork and communication emphasized throughout this program?

Effective teamwork and communication are essential skills during neonatal resuscitation. A Joint Commission investigation found that poor teamwork and communication were the most common root causes for potentially preventable infant deaths in the delivery room. During a complex resuscitation, providers need to perform multiple procedures without delay. Confusion and inefficiency may occur because severa! teams of caregivers are working in a confined space at the same time. Even though each individual may have the knowledge and skills to perform a successful resuscitation, each person's skills will not be used optimally without effective coordination.

Neonatal Resuscitation Program Key Behavioral Skills

The 10 NRP Key Behavioral Skills, described in Table 1-2, are adapted from previously described models of effective teamwork (Center for

Table 1-2. Neonatal Resuscitation Program Key Behavioral Skills

Behavior	Example
Know your environment.	• Know the location of resuscitation equipment and how to access it. • Know how to call for help and who is available.
Use available information.	• Know the prenatal and intrapartum history, including maternal complications, maternal medications, and other risk factors.
Anticípate and plan.	• Perform a pre-resuscitation team briefing to ensure ali team members know the clinical situation. • Assign roles and responsibilities. • Discuss an action plan in the event of complications.
Clearly identify a team leader.	• Identify the team leader before the birth. • Effective leaders - Clearly articulate goals. - Delegate tasks as appropriate while monitoring the distribution of workload. - Include other team members in assessment and planning. - Think out loud. - Maintain situation awareness. - Hand over leadership to another team member if they must become involved in a procedure.
Communicate effectively.	• Call team members by name. • Share information actively. • Inform your team if you identify a problem, error, or patient safety concern. • Order medications by name, dose, and route. • Use concise, clear language. • Use closed-loop communication. • Verify information. • Ensure that changes in information or assessments are shared with ali team members. • Include family members in communication as appropriate.
Delegate workload optimally.	• Do not duplicate work or use more resources than necessary. • Change task assignments depending on skill sets and what is required at the moment. • Do not allow one person to become overloaded with tasks. • Do not allow the team to become fixated on a single task.
Allocate attention wisely.	• Maintain situation awareness by scanning and reassessing the clinical situation frequently. • Monitor each other's skill performance to ensure patient safety.
Use available resources.	• Know what personnel are available. • Know what additional or special supplies are available and how to access them.
Call for additional help when needed.	• Anticípate the need for additional team members based on risk factors and the progress of the resuscitation. • Call for additional help in a timely manner. • Know how you will call for additional help and the process for getting the right kind of assistance.
Maintain professional behavior.	• Use respectful verbal and nonverbal communication. • Actively seek and offer assistance. • Support and promete teamwork. • Respect and value your team.

Advanced Pediatric & Perinatal Education [CAPE], Lucile Packard Children's Hospital at Stanford University). In each of the lessons that follow, we will highlight how effective teams use these behavioral skills.

Improving your teamwork and communication requires deliberate practice under conditions that are as realistic as possible. As you review each lesson and participate in simulation, think about how these behavioral skills can be used to improve your own team's performance. Remember that every member of the team has a responsibility to speak up to inform the leader and other team members of observations or information that will improve the resuscitation in progress.

How can quality improvement methods improve the outcome for newborns that require resuscitation?

The NRP course helps you acquire the knowledge and skills that you need to save babies' lives, but knowledge alone <loes not guarantee improved outcomes. Completing an NRP course is only the first step in improving the quality of care that you give.

- Making a difference in clinical outcomes requires a commitment to quality improvement (QI). Providers who are committed to quality improvement set goals, measure outcomes, identify areas for improvement, and make changes that improve care.
- Carefully look at the systems and processes used in your own delivery room setting to determine how best to put your knowledge and skills into practice.
- As you read the lessons in the textbook, think about opportunities to improve care in your own delivery room setting. In the lessons that follow, note the measurable processes and outcomes that may identify opportunities for improvement. Additional QI resources are included in Supplemental Lesson 14.

LESSON 1 REVIEW

1. Before birth, the alveoli in the fetal lungs are filled with (fluid)/(air).

2. Before birth, oxygen is supplied to the fetus by (the placenta)/(the fetal lungs).

3. Before birth, most fetal blood (enters the fetal lungs)/(bypasses the fetal lungs).

4. After birth, air in the alveoli causes vessels in the baby's lungs to (constrict)/(relax).

5. When resuscitating newborns, chest compressions and medication are (rarely)/(frequently) needed.

6. Members of an effective resuscitation team (share information)/(work quietly and independently).

Answers

1. Before birth, the alveoli in the fetal lungs are filled with fluid.

2. Before birth, oxygen is supplied to the fetus by the placenta.

3. Before birth, most fetal blood bypasses the fetal lungs.

4. After birth, air in the alveoli causes vessels in the baby's lungs to relax.

5. When resuscitating newborns, chest compressions and medication are rarely needed.

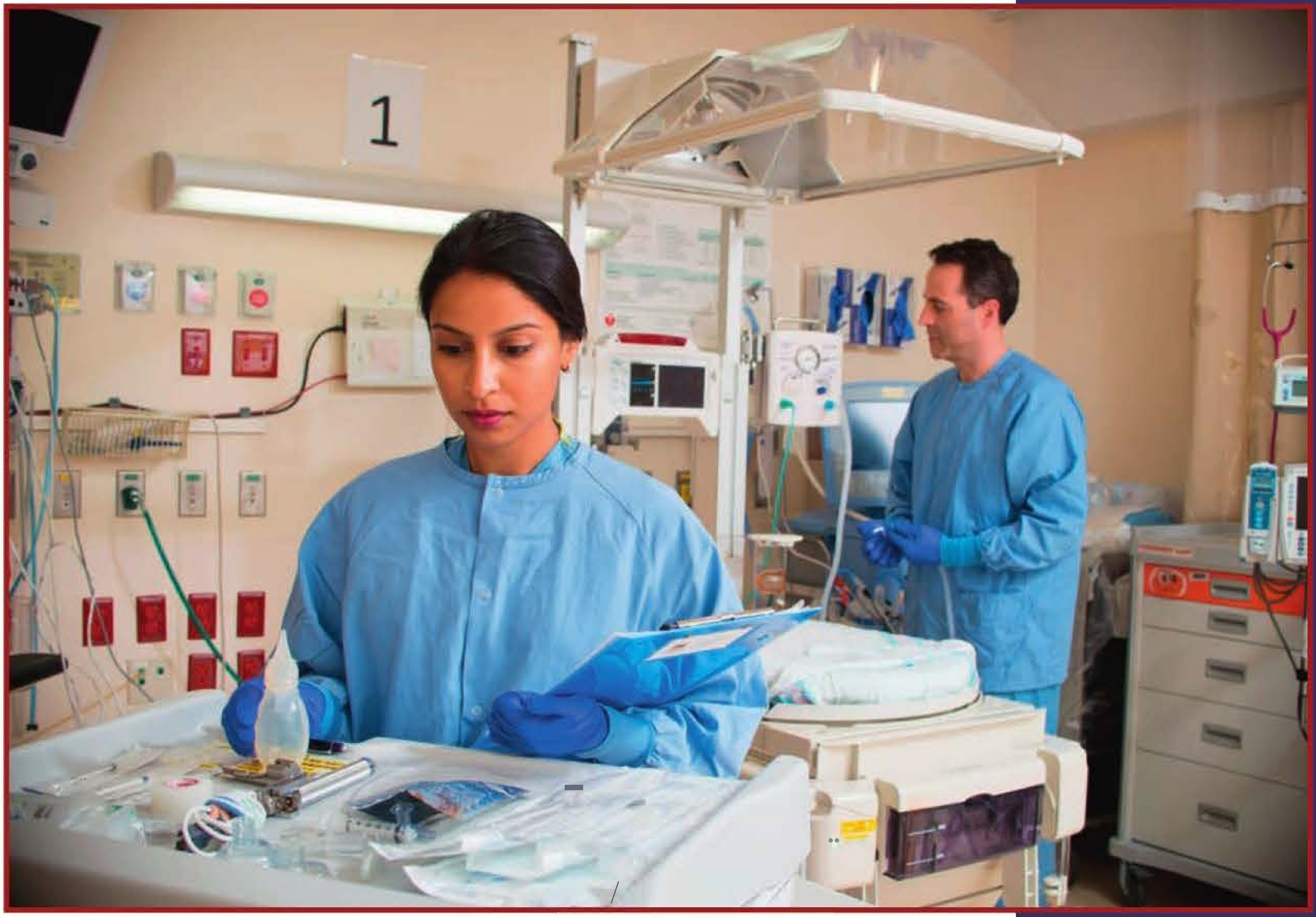
6. Members of an effective resuscitation team share information.

2

Anticipating and Preparing for Resuscitation

What you will learn

- Risk factors that can help predict which babies will require resuscitation
- Four key questions to ask the obstetric provider before birth
- How to determine who should attend a birth
- How to perform a pre-resuscitation team briefing
- How to assemble and check resuscitation supplies and equipment
- Why accurate documentation is important



Key Points

O Identify risk factors by asking the obstetric provider these 4 questions before birth: (1) What is the expected gestational age? (2) Is the amniotic fluid clear? (3) Are there any additional risk factors? (4) What is our umbilical cord management plan?

f) Some newborns without any apparent risk factors will require resuscitation.

8 Every birth should be attended by at least 1 qualified individual who can initiate resuscitation and whose only responsibility is management of the newly born baby.

C, If risk factors are present, at least 2 qualified individuals should be present solely to manage the baby. The number and qualifications of these individuals will be determined by the risk factors.

0 A qualified team with full resuscitation skills should be identified and immediately available for every resuscitation. The fully qualified resuscitation team should be present at the time of birth if the need for advanced resuscitation measures is anticipated. Ali supplies and equipment necessary for a complete resuscitation must be readily available and functional for every birth.

Case: Preparing for a birth with perinatal risk factors

A 30-year-old woman enters the hospital in labor at 36 weeks' gestation. She has insulin-requiring gestational diabetes and hypertension. She is found to have ruptured membranes with clear amniotic fluid. Fetal heart rate monitoring shows a Category II pattern (indeterminate pattern requiring evaluation, surveillance, and possibly other tests to ensure fetal well-being). Labor progresses rapidly and a vaginal birth is imminent. The obstetric provider calls your resuscitation team to attend the birth.

You ask the obstetric provider 4 brief questions and determine that there are several perinatal risk factors. You assemble a team composed of enough people with qualified skills to manage the interventions that may be needed. The team clearly identifies the team leader, performs a pre-resuscitation team briefing, discusses roles and responsibilities, and performs a complete equipment check. As your team enters the room, you introduce yourselves to the mother and the obstetric team and take your positions near the preheated radiant warmer.

Why is it important to anticipate the need for resuscitation before every birth?

At every birth, you should be prepared to resuscitate the newborn. Table 2-1 describes risk factors that increase the likelihood that the newborn will require support with transition or resuscitation. Thoughtful consideration of these risk factors will help you identify the correct personnel to attend the birth. Although attention to these risk factors is helpful and will identify most newborns that require resuscitation after birth, sorne newborns without any apparent risk factors will require resuscitation.

Table 2-1 • Perinatal Risk Factors Increasing the Likelihood of Neonatal Resuscitation

Antepartum Risk Factors	
Gestational age less than 36 0/7 weeks	Polyhydramnios
Gestational age greater than or equal to 41 0/7 weeks	Oligohydramnios
Preeclampsia or eclampsia	Fetal hydrops
Maternal hypertension	Fetal macrosomia
Multiple gestation	lntrauterine growth restriction
Fetal anemia	Significant fetal malformations or anomalies
	No prenatal care
Intrapartum Risk Factors	
Emergency cesarean delivery	lntrapartum bleeding
Forceps or vacuum-assisted delivery	Chorioamnionitis
Breech or other abnormal presentation	Opioids administered to mother within 4 hours of delivery
Category II or 111fetal heart rote pattern*	Shoulder dystocia
Maternal general anesthesia	Meconium-stained amniotic fluid
Maternal magnesium therapy	Prolapsed umbilical cord
Placenta! abruption	

*See Appendix 3 in this lesson for description of fetal heart rote categories.

What questions should you ask before every birth?

It is important for the obstetric and newborn health care providers to coordinate care by establishing effective communication. Before every birth, review the antepartum and intrapartum risk factors described in Table 2-1 and ask the following 4 pre-birth questions:

0 What is the expected gestational age?

f) Is the amniotic fluid clear?

Q Are there any additional risk factors?

8 What is our umbilical cord management plan?

Based on the responses to these questions, assemble the necessary personnel and equipment. You will learn more about the timing of umbilical cord clamping and establishing a plan for umbilical cord management in Lesson 3.

What personnel should be present at delivery?

The number and qualifications of personnel will depend on your risk assessment. Consider creating a written policy for how many people should attend a birth, what qualifications they should have based on assessment of perinatal risk, and how to call for additional help if needed.

- Every birth should be attended by *at least 1 qualified individual,* skilled in the initial steps of newborn care and positive-pressure ventilation (PPV), whose only responsibility is management of the newly born baby. When a birth is attended by only 1 qualified individual, the likelihood of resuscitation should be low. In the event of unanticipated resuscitation, this team member will initiate resuscitation and call for additional help.
- If risk factors are present (Table 2-1), *at least 2 qualified people should be present solely to manage the baby.* The number and qualifications of personnel will vary depending on the anticipated risk, the number of babies, and the hospital setting.
- A *qualified team with full resuscitation skills,* including endotracheal intubation, chest compressions, emergency vascular access, and medication administration, should be identified and immediately available for every resuscitation.
  - The fully qualified resuscitation team should be present at the time of birth if the need for advanced resuscitation measures is anticipated.
  - It is not sufficient to have the team with these advanced skills on call at home or in a remote area of the hospital. When resuscitation is needed, it must begin without delay.

For example, a nurse at an uncomplicated birth might evaluate gestational age, muscle tone, and respirations, and provide tactile stimulation. If the newborn <loes not respond appropriately, the nurse would position and clear the airway, start PPV, and initiate an emergency call for immediate assistance. Quickly, a second person comes to the warmer to assess the efficacy of PPV and places a pulse oximeter sensor. Another provider with full resuscitation skills, including intubation and umbilical venous catheter insertion, is in the immediate vicinity and arrives to assist the team.

In the case of an anticipated high-risk birth, such as an extremely preterm baby or prolapsed umbilical cord, a team with sufficient personnel to provide PPV, intubate the trachea, perform chest compressions, obtain emergency vascular access, prepare medications, and document events should be assembled before the birth. Depending on the setting, this will likely require 4 or more qualified providers.

Each hospital must develop and practice a system for assembling its resuscitation team. Identify how the team will be alerted if risk factors are present, who will be called, and how additional help will be called if necessary. Practice a variety of scenarios to ensure that you have sufficient personnel immediately available to perform ali of the necessary tasks.

How do you perform a pre-resuscitation team briefing?

Once your team is assembled, perform a pre-resuscitation team briefing to review the clinical situation and any management plans developed during antenatal counseling. Identify a team leader, delegate tasks, identify who will document events as they occur, determine what supplies and equipment will be needed, and identify .how to call for additional help (Figure 2.1). Use ali of the available perinatal information to anticipate potential complications and plan your response (Table 2-2). For example, if the obstetric provider tells you that the mother has just received narcotic analgesia, you will be prepared for a sedated baby that may require assisted ventilation. Discuss who will perform the initial assessment, who will stimulate the baby, who will start PPV if needed, and who will document the events.

The pre-resuscitation team briefing is important even for well-established teams. A common analogy is to compare the medical team's pre-resuscitation briefing to an airline pilot's preflight check. Even pilots that have flown the same flight many times perform their preflight check to ensure their passengers' safety.

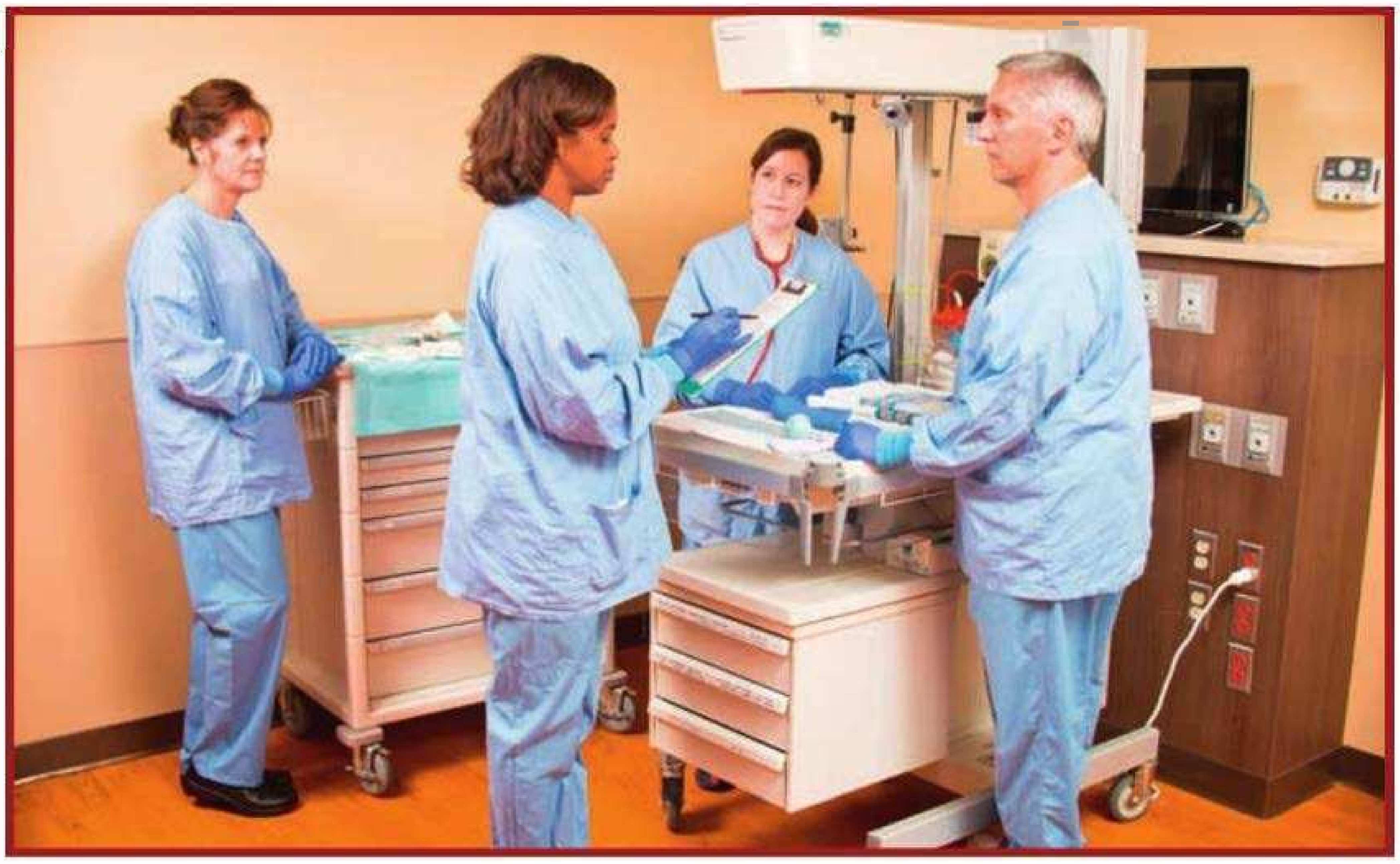


Figure 2.1. Neonatal resuscitation team briefing

Table 2-2. Pre-resuscitation Team Briefing

- Assess risk factors.
- ldentify team leader.
- Anticipate potential complications and plan a team response.
- Delegate tasks.
- ldentify who will document events as they occur.
- Determine what supplies and equipment will be needed.
- ldentify how to call for additional help.

What supplies and equipment should be available?

All supplies and equipment necessary for a complete resuscitation must be readily available and functional for every birth. When a high-risk newborn is expected, ali appropriate supplies and equipment should be ready for immediate use. It is not sufficient to simply look at what is on the radiant warmer. It is much more effective to establish an organized routine using a standardized checklist before every birth. In this way, you will confirm what is ready for immediate use and identify which pieces of equipment are missing.

The appendices of this lesson include 2 lists.

- The Neonatal Resuscitation Program® (NRP®) Quick Equipment Checklist is a tool that you can use during your briefing to check the most essential supplies and equipment. It follows the steps of the NRP Algorithm. Consider keeping this checklist near the radiant warmer so it is accessible before every birth.
- The Neonatal Resuscitation Supplies and Equipment List is a comprehensive inve11tory of the supplies and equipment that should be available within the resuscitation area.

What are the characteristics of an effective team leader?

Every resuscitation team needs to have a team leader. Any team member who has mastery of the NRP Algorithm and effective leadership skills can be the team leader. The leader <loes not have to be the most senior member of the team or the individual with the most advanced degree. That person may have technical skills that will be required during the resuscitation and may not be able to maintain their full attention on the baby's condition. If you are the person with sole responsibility for management of the baby at birth and the baby unexpectedly requires resuscitation, you become the team leader and direct your assistants to help you until the full resuscitation team arr1ves.

- Effective team leaders exemplify good communication skills by giving clear directions to specific individuals, sharing information, delegating responsibilities to ensure coordinated care, and maintaining a professional environment.
- A skilled leader effectively uses resources by allowing all team members to contribute their unique talents to the resuscitation process.
- It is important for the team leader to remain aware of the entire clinical situation, maintain a view of the "big picture;' and not become distracted by a single activity. This is called *situation awareness.*
- If the leader is involved in a procedure that diverts their attention, the leader may need to appoint another qualified person to assume the leadership role. If the person in the leadership role changes during the resuscitation, a clear verbal statement should be made so that all team members know who is leading the team.

What is closed-loop communication?

Although the team has a leader, each team member shares responsibility for ongoing assessment and ensuring that interventions are performed in the correct sequence with the correct technique. Successful coordination requires team members to share information and communicate with each other. Closed-loop communication is a technique that ensures instructions are heard and understood.

When you give an instruction,

- Direct the request to a specific individual.
- Call your team member by name.
- Make eye contact.
- Speak clearly.
- After giving an instruction, ask the receiver to report back as soon as the task is completed.
- After receiving an instruction, repeat the instruction back to the sender.

The following 2 examples demonstrate requests and questions directed to a specific individual, clear and concise language, and closed-loop communication.

Example 1	Example 2
Nicole: *"Lou, I need a three-point-five-millimeter endotracheal tube, with a stylet, and a laryngoscope with a size-one blade now. Tell me when they're ready."* Lou: *"You need a three-point-five-millímeter endotracheal tube, with a stylet, and a laryngoscope with a size-one blade."* Nicole: *"Correct."* Once the equipment is ready, Lou: *"Nicole, a three-point-fíve-millímeter endotracheal tube, with a stylet, and a size-one laryngoscope are ready for you now."*	Nicole: *"Lou, auscultote the heort rote ond tell me if it's increasing."* Lou: *"The heart rote is seventy beats per minute ond it is not increosing."* Nicole: *"Is the chest moving?"* Lou: *"No, the chest is not moving."* Nicole: *"Lou, opply o pulse oximeter now. Tell me when it's working."* Lou: *"You want o pulse oxímeter."* Nicole: *"Correct."* When the pulse oximeter is applied and working, Lou: *"The pulse oximeter is on the right hand ond reading sixty-five percent."*

Why is accurate documentation important?

During an emergency, highly effective teams accurately document the series of events as they occur. Complete and accurate documentation is important for clinical decision-making andas a source for quality improvement data.

The sense of urgency surrounding resuscitation can make accurate documentation challenging, but preparation can make this essential task easier. If your hospital uses paper documentation, consider keeping a hard copy of your hospital's neonatal code documentation sheet on a clipboard at every radiant warmer. If your hospital uses electronic documentation, consider keeping a device that can rapidly enter your electronic medical record system near every radiant warmer. Practicing documentation skills warrants the same preparation as any other resuscitation skill and should be practiced during mock codes and simulation.

- During your tean1 briefing, assign someone to be the scribe who will document events. Ideally, this should be an experienced team member who knows what is important to record, is comfortable communicating with team members, and can provide decision support to the team leader. For example, the scribe may remind the team leader how much time has passed since chest compressions were started or epinephrine was administered. Without experience, the scribe may have difficulty deciding what is important to record and providing decision support to the team leader.
- Use a single time reference to document when events occur. If team members use different watches or clocks during a resuscitation, it may cause confusion or documentation errors.

- Because multitasking can disrupt observation and communication, and increase medication errors, the scribe should not be responsible for performing other critical tasks.
- To assist the scribe, team members need to clearly announce their assessments and when interventions are performed.
- Consider using a paper form or electronic template designed specifically for neonatal resuscitation. Well-designed forms that follow the NRP Algorithm enable rapid data entry, allowing the scribe to assist the team leader by providing prompts for the next intervention and identifying delayed assessments. The NeoLog, available on the NRP website, is one example of a code documentation form designed specifically for neonatal resuscitation.
- After the event, consider supplementing the resuscitation record with a narrative summary that clarifies decision-making.

What are the benefits of a post-resuscitation team debriefing?

A post-resuscitation team debriefing is a constructive review of actions and thought processes that promotes reflective learning. Performing a debriefing after the resuscitation reinforces good teamwork habits and helps your team identify areas for improvement. A quick debriefing can be performed immediately after the event, while a more comprehensive debriefing may be scheduled a short time afterward. Your debriefings do not have to find major problems to be effective. You may identify a series of small changes that can result in significant improvement in your team's performance and clinical outcomes.

Focus on Teamwork

The preparation phase of neonatal resuscitation highlights severa! opportunities for effective teams to use the NRP Key Behavioral Skills.

Behavior	Example
Know your environment.	Know how the resuscitation team is called and how additional personnel and resources can be summoned. Know how to access additional supplies and equipment for a complex resuscitation.
Use available information.	Ask the obstetric provider the 4 pre-birth questions to identify risk factors.
Antici pote and plan.	Know which providers are qualified to attend the birth based on the identified risk factors. Perform a standardized equipment check before every birth. Assign roles and responsibilities.
Clearly identify a team leader.	If risk factors are present, identify a team leader before the birth and perform a pre-resuscitation team briefing to ensure that everyone is prepared and responsibilities are defined.
Use available resources.	Prepare additional supplies and equipment, as necessary, based on identified risk factors.

Quality Improvement Opportunities

Ask yourself the following questions and begin a discussion with your team if you find a difference between the NRP recommendations and what is currently done in your own hospital setting. Consider using the suggested process and outcome measures to guide your data collection, identify areas for improvement, and monitor if your improvement efforts are working.

Quality improvement questions

- Who is responsible for ensuring that supplies and equipment are ready before every birth?
- Is the table of risk factors accessible in your delivery setting?
- Is a supplies and equipment checklist available at every warmer?
- Do you have a designated paper form or electronic template designed specifically for neonatal resuscitation readily available for use at every birth?
- How is the resuscitation team mobilized when a newborn without risk factors needs resuscitation?

Process and outcome measures

- What percentage of providers involved in the care of newborns have completed the NRP course?
- What percentage of births have a qualified provider present who is only responsible for the newborn?
- What percentage of births have a standardized supplies and equipment checklist completed?
- What percentage of births attended by 1 NRP provider require additional team members for an unanticipated resuscitation?

Frequently Asked Questions

What is the ideal number of people to have on the resuscitation team?

There is no single correct answer to this question. You must have sufficient personnel immediately available to perform all of the necessary tasks without delay. The personnel required at any particular birth will depend on the identified risk factors, the qualifications of the individuals on the team, and the setting. Simulate different scenarios to ensure that you have sufficient personnel on your team to perform all necessary procedures quickly and efficiently. For a complex resuscitation, this will likely require 4 or more people.

What if I am concerned that we do not hove the correct team configuration (number of people or qualifications) to attend a birth?

This problem usually can be avoided by having a clearly written hospital protocol to determine the number and qualifications of people who should attend a birth based on a standardized assessment of risk factors and effective team communication. Remember that safety is the top priority in decision-making. Following the concepts outlined in the NRP Key Behavioral Skills, use the available information to identify the safety concern, use effective communication and professional behavior to express your concern, and use your knowledge of the available resources to suggest an alternative. Start by saying, "I believe this delivery has risk factors that require ... :' If your concern is not acknowledged, continue with "I am concerned because..." and suggest an alternative course of action.

LESSON 2 REVIEW

1. What are the 4 pre-birth questions to ask the obstetric provider before every birth?

2. Every delivery should be attended by at least 1 qualified person (whose only responsibility is the management of the newborn)/ (who shares responsibility for the mother and newborn's care).

3. If a high-risk birth is anticipated, (1 qualified person)/ (a qualified team) should be present at the birth.

4. During the pre-resuscitation team briefing, (prepare for a routine delivery because you do not know what will be needed)/(anticipate potential complications and discuss how responsibilities will be delegated).

5. A qualified nurse or respiratory therapist who has been trained in neonatal resuscitation and has strong leadership skills (can)/ (cannot) be the team leader.

6. The equipment check includes (checking that ali supplies and equipment for a complete resuscitation are readily available and functional only when anticipating a high-risk birth)/(checking that ali supplies and equipment for a complete resuscitation are readily available and functional for every birth).

Answers

1. The 4 pre-birth questions are: (1) What is the expected gestational age? (2) Is the amniotic fluid clear? (3) Are there any additional risk factors? (4) What is our umbilical cord management plan?

2. Every delivery should be attended by at least 1 qualified person whose only responsibility is the management of the newborn.

3. If a high-risk birth is anticipated, a qualified team should be present at the birth.

4. During the pre-resuscitation team briefing, anticípate potential complications and discuss how responsibilities will be delegated.

S. A qualified nurse or respiratory therapist who has been trained in neonatal resuscitation and has strong leadership skills can be the team leader.

6. The equipment check includes checking that all supplies and equipment for a complete resuscitation are readily available and functional for every birth.

Appendix 1. NRP Quick Equipment Checklist

This checklist includes only the most essential supplies and equipment needed at the radiant warmer for most neonatal resuscitations. Tailor this list to meet your unit-specific needs. Ensure that an equipment check has been done prior to every birth.

Warm	• Preheated warmer • Warm towels or blankets • Temperature sensor and sensor cover for prolonged resuscitation • Hat • Plastic bag or plastic wrap (< 32 weeks' gestation) • Thermal mattress (< 32 weeks' gestation)
Clear airway	• Bulb syringe • 10F or 12F suction catheter attached to wall suction, set at 80 to 100 mm Hg • Tracheal aspirator
Auscultate	• Stethoscope
Ventilate	• Flowmeter set to 10 L/min • Oxygen blender set to 21% (21%-30% if < 35 weeks' gestation) • Positive-pressure ventilation (PPV) device • Term- and preterm-sized masks • 8F orogastric tube and 20-ml syringe • Laryngeal mask (size 1) and 5-ml syringe (if needed for inflation) • 5F or 6F orogastric tube if insertion port is present on laryngeal mask • Cardiac monitor and leads
Oxygenate	• Equipment to give free-flow oxygen • Pulse oximeter with sensor and cover • Target Oxygen Saturation Table
Intubate	• Laryngoscope with size 0 and size 1 straight blades (size 00, optional) • Stylet (optional) • Endotracheal tubes (sizes 2.5, 3.0, 3.5) • Carbon dioxide (CO_2) detector • Measuring tape and/or endotracheal tube insertion depth table • Waterproof tape or tube-securing device • Scissors
Medicate	Access to • Epinephrine (0.1 mg/ml = 1 mg/10 ml) • Normal saline (100-ml or 250-ml bag, or prefilled syringes) • Supplies for placing emergency umbilical venous catheter and administering medications • Table of pre-calcuated emergency medication dosages for babies weighing 0.5 to 4 kg

Appendix 2. Neonatal Resuscitation Supplies and Equipment List

Suction equipment

Bulb syringe
Mechanical suction and tubing
Suction catheters, SF or 6F, lOF, 12F or 14F
8F orogastric tube and 20-mL syringe
Tracheal aspirator

Positive-pressure ventilation equipment

Device for delivering positive-pressure ventilation
Pace masks, term and preterm sizes
Oxygen source
Compressed air source
Oxygen blender to mix oxygen and compressed air with flowmeter (flow rate set to 10 L/min) and tubing
Pulse oximeter with sensor and cover
Target Oxygen Saturation Table
Stethoscope (with neonatal head)
Laryngeal mask (size 1) or similar supraglottic device, and 5-mL syringe (if needed for inflation)
5F or 6F orogastric tube if insertion port present on laryngeal mask
Cardiac monitor and leads

Intubation equipment

Laryngoscope with straight blades, No. 0 (preterm) and No. 1 (term)
Extra bulbs and batteries for laryngoscope, if required
Endotracheal tubes, 2.5-, 3.0-, 3.5-mm internal diameter (ID)
Stylet (optional)
Measuring tape
Endotracheal tube insertion depth table
Scissors
Waterproof tape or tube-securing device
Alcohol pads
Carbon dioxide detector or capnograph

Medications

Epinephrine (0.1 mg/mL= 1 mg/10 mL)
Normal saline for volume expansion-100-mL or 250-mL bag, or prefilled syringes
Dextrose 10%, 250 mL (optional)
Normal saline for flushes
Syringes (1 mL, 3 mL or 5 mL, 20-60 mL)
Three-way stopcocks or fluid-dispensing connectors
Table of pre-calculated emergency medication dosages for babies weighing 0.5 to 4 kg

Umbilical vessel catheterization supplies

Sterile gloves
Antiseptic prep solution
Umbilical tape
Small clamp (hemostat)
Forceps (optional)
Scalpel
Umbilical catheters (single lumen), 3.SF or SF
Three-way stopcock
Syringes (3-5 mL)
Needle or puncture device for needleless system
Normal saline for flushes
Clear adhesive dressing to temporarily secure umbilical venous catheter to abdomen (optional)

Miscellaneous

Timer/clock with second hand
Gloves and appropriate personal protection equipment
Radiant warmer or other heat source
Temperature sensor with sensor cover for radiant warmer (for use during prolonged resuscitation)
Warmed linens
Hat
Tape, 1/2 or 3/4 inch
Intraosseous needle (optional)

For very preterm babies

Food-grade plastic bag (1-gallon size) or plastic wrap
Thermal mattress
Size 00 laryngoscope blade (optional)
Transport incubator to maintain baby's temperature during move to the nursery

Appendix 3. Fetal Heart Rate Categories

Category I: This is a *normal* tracing and is predictive of normal fetal acid-base status at the time of the observation, and routine follow-up is indicated.

Category 11: This is considered an *indeterminate* tracing. There is currently inadequate evidence to classify these tracings as either normal or abnormal. Further evaluation, continued surveillance, and reevaluation are indicated.

Category 111: This is an *abnormal* tracing and is predictive of abnormal fetal acid-base status at the time of the observation. A Category III tracing requires prompt evaluation and intervention.

Reference

Macones GA, Hankins GD, Spong CY, Hauth J, Moore T. The 2008 National Institute of Child Health and Human Development workshop report on electronic fetal monitoring: update on definitions, interpretation, and research guidelines. *Obstet Gynecol.* 2008;112(3):661-666

LESSON 2: PRACTICE SCENARIO

Anticipating and Preparing for Resuscitation

Learning Objectives

O Determine the process for identifying antepartum and intrapartum risk factors for neonatal resuscitation and identifying how the decision is made for who will attend the birth.

f) Demonstrate a pre-resuscitation team briefing.

E) Demonstrate an organized method for performing an equipment check prior to the birth.

8 Identify the process used to call for additional help if needed for newborn resuscitation.

This Practice Scenario is for review/practice and evaluation.

This is the suggested Practice Scenario sequence.

O **Review the Knowledge Check Questions** with your Neonatal Resuscitation Program (NRP) instructor.

- a. What are the 4 key questions to ask the obstetric provider before the birth? What is the purpose of these questions?
- b. What is your unit's process for assessing risk factors that increase the likelihood of newborn resuscitation? How is it determined who will attend a birth?
- c. If a newborn unexpectedly requires resuscitation at birth, what is the system to call for help?
- d. What happens at a pre-resuscitation team briefing?
- e. Who is responsible for checking resuscitation supplies and equipment before every birth?

f) **Practice/review these skills** with your NRP instructor.

- a. Prepare the radiant warmer for use.
- b. Set up the positive-pressure ventilation (PPV) device(s) for use. If a T-piece resuscitator normally is used in the delivery room, the learner may demonstrate proficiency with setting up that device and check the readiness of a self-inflating bag and mask.
- c. Checl< the functio11 of wall suction device(s).
- d. Check the function of the laryngoscope.

8 **Practice this scenario** with your NRP instructor until you need little or no assistance or coaching.

8 **Pass the Lesson 2 Practice Scenario evaluation** by leading this practice scenario and performing the skills relevant to your role and responsibilities. If a technical skill included in this scenario is not within your scope of responsibility, delegate the skill to a qualified team member and perform the role of assistant, if appropriate. When you can lead the scenario(s) and perform the skills with little or no instructor coaching, proceed to the next lesson's practice scenario.

Practice Scenario

Two variations of the scenario are offered.

- A baby of 38 weeks' gestation with no known risk factors
- A baby of 29 weeks' gestation with additional risk factors

"You are notified that a woman has been admitted to the hospital in active labor. Prepare your team far the birth and check your supplies and equipment. As you work, say your thoughts and actions aloud so I will know what you are thinking and doing."

The instructor should check boxes as the learner responds correctly. The learner may refer to the NRP Quick Equipment Checklist or use a unit-specific checklist. Two gestational ages are offered for use.

Critical Performance Steps			
Assess perinatal risk.			
	Assesses perinatal risk (learner asks 4 pre-birth questions and instructor ["OB provider"] responds)		
	What is the expected gestational age?	**"38 weeks' gestation."**	**"29 weeks' gestation."**
	Is the amniotic fluid clear?	**"Clear fluid."**	**"Clear fluid."**
	Are there any additional risk factors?	**"No known risk factors."**	**"Preeclampsia."**
	What is our umbilical cord management plan?	**1will delay cord clamping. If the baby is not crying, 1'11take a moment to stimulate the baby. If there's no response, 1'11clamp and cut the cord."**	
Assemble team.			
	Assembles team based on perinatal risk factors. When the likelihood of resuscitation is low, I qualified individual should attend the birth. If risk factors are present, at least 2 qualified people should be present solely to manage the baby. The number of team members and qualifications vary depending on risk.		

Critical Performance Steps (cont)

If the birth will be attended by 1 person,

Knows the answers to the 4 pre-birth questions, determines supplies and equipment needed, knows how to call for help

If the birth will be attended by a team, perform a pre-resuscitation briefing.

Identifies team leader.

Assesses risk factors, discusses potential complications and the management plan, delegates tasks, identifies who will document events, determines supplies and equipment needed, knows how to call for additional help.

Perform equipment check.

Demonstrates an organized routine to locate the most essential supplies needed for newborn resuscitation:

Warm.

- Preheated radiant warmer
- Towels or blankets
- Temperature sensor and sensor cover for use during prolonged resuscitation
- Hat
- Plastic bag or wrap (< 32 weeks' gestation)
- Thermal mattress (<32 weeks' gestation)

Clear the airway.

- Bulb syringe
- 10F or 12F suction catheter attached to wall suction, set at 80 to 100 mm Hg
- Tracheal aspirator

Auscultate.

- Stethoscope

Ventilate.

- Sets flowmeter to 10 L/min
- Sets oxygen blender to 21% (21%-30% if < 35 weeks' gestation)
- Checks presence and function of PPV device(s), including pressure settings and pressure pop-off valves
- Sets T-piece resuscitator at peak inflation pressure (PIP) = 20 to 25 cm H_2O for term baby; PIP = 20 cm H_2O for preterm baby; positive end-expiratory pressure (PEEP) = 5 cm H_2O
- Term- and preterm-sized masks
- Laryngeal mask (size 1) and 5-ml syringe (if needed for inflation)
- 5F or 6F orogastric tube if insertion port present on laryngeal mask
- 8F orogastric tube and 20-ml syringe
- Cardiac monitor and leads

Oxygenate.

- Equipment to give free-flow oxygen
- Target Oxygen Saturation Table
- Pulse oximeter with sensor and sensor cover

Intubate.

- Laryngoscope with size 0 and size 1 straight blades and bright light (size 00, optional)
- Stylet (optional)
- Endotracheal tubes (sizes 2.5, 3.0, 3.5)
- Carbon dioxide (CO_2) detector
- Measuring tape and/or endotracheal tube insertion depth table
- Waterproof tape or tube-securing device
- Scissors

Critical Performance Steps (cont)

Perform equipment check (cont).

Medicate.
Ensure access to
- Epinephrine (1 mg/10 ml=0.1 mg/ml)
- Normal saline (100- or 250-ml bag, or prefilled syringes)
- Supplies for administering medications and placing emergency umbilical venous catheter and administering medications
- Pre-calculated medication dose chart

Other potential items to check.
- Temperature in resuscitation location (23°C to 25°C [74°F-77°F] if < 32 weeks' gestation)
- Oxygen and air tanks
- Access to intraosseous needle and insertion supplies
- Access to surfactant (preterm birth)
- Transport incubator for transfer to nursery or NICU

Sample Debriefing Questions

O What factors determined your decision for who would attend the birth(s) described in the scenario(s)?

f) If all equipment and supplies are present> how long <loes it take you to confirm readiness for a birth? Are there methods you could use to decrease the time needed to perform the equipment check?

E) Which of the NRP Behavioral Skills are demonstrated during preparation for resuscitation?

NRP Key Behavioral Skills

- Know your environment.
- Use available information.
- Anticipate and plan.
- Clearly identify a team leader.
- Communicate effectively.
- Delegate the workload optimally.
- Allocate attention wisely.
- Use available resources.
- Call for additional help when needed.
- Maintain professional behavior.

3

Initial Steps of Newborn Care

What you will learn

- How to perform a rapid evaluation
- The initial steps of newborn care
- How to determine if additional steps are required
- What to do if a baby has persistent cyanosis or labored breathing
- How to use a pulse oximeter and interpret the results
- How to give supplemental oxygen
- When to consider using continuous positive airway pressure
- What to do when meconium-stained amniotic fluid is present

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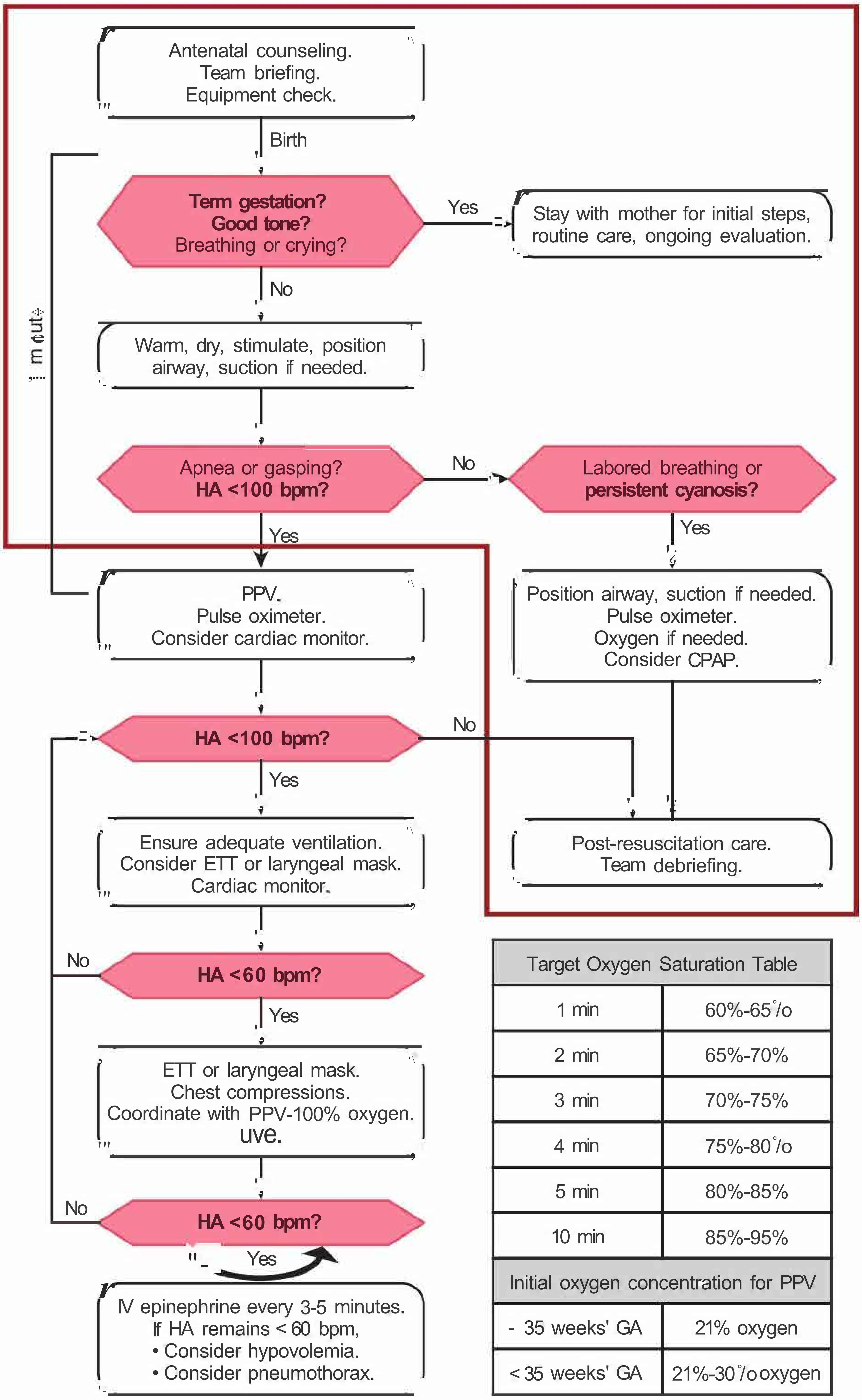


Target Oxygen Saturation Table	
1 min	60%-65%
2 min	65%-70%
3 min	70%-75%
4 min	75%-80%
5 min	80%-85%
10 min	85%-95%
Initial oxygen concentration for PPV	
≥35 weeks' GA	21% oxygen
< 35 weeks' GA	21%-30% oxygen

Key Points

O For most vigorous term and preterm newborns, clamping the umbilical cord should be delayed for at least 30 to 60 seconds.

f) Ali newborns require a rapid evaluation. Ask if the baby is term, has good muscle tone, and is breathing or crying. If the answer is "NO" to any of these, the newborn should be brought to the radiant warmer for the initial steps of newborn care.

E) The 5 initial steps include the following: provide warmth, dry, stimulate, position the head and neck to open the airway, clear secretions from the airway if needed.

8 Use pulse oximetry and the Target Oxygen Saturation Table to guide oxygen therapy (a) when resuscitation is anticipated, (b) to confirm your perception of persistent central cyanosis, (c) if you give supplemental oxygen, or (d) if positive-pressure ventilation is required. Visual assessment of cyanosis is not a reliable indicator of oxygen saturation.

0 If meconium-stained fluid is present and the baby is not vigorous, bring the baby to the radiant warmer to perform the initial steps. Routine laryngoscopy with or without intubation for tracheal suction is not suggested.

Case 1: An uncomplicated birth

A healthy woman arrives in active labor at 39 weeks' gestation. You are the nurse assigned to care for the newborn at birth, and you must know the answers to the 4 pre-birth questions to assess the perinatal risk and confirm that only 1 qualified person is needed to manage this newborn. You know that the baby is term. The mother's membranes ruptured shortly after arrival and the amniotic fluid is clear. You learn that her pregnancy has been uncomplicated. You complete a standardized equipment check to ensure that neonatal resuscitation supplies and equipment are ready for use if needed. You review the umbilical cord management plan with the obstetric provider and introduce yourself to the mother.

At the time of birth, the baby appears to be full term, has good muscle tone, and cries vigorously. The baby is placed skin-to-skin on the mother's chest and is covered with a warm blanket. You gently dry and stimulate the baby and position the baby's head to ensure the airway is open. One minute after birth, the cord is clamped and cut. The baby's color becomes increasingly pink during the transition to newborn circulation. You continue to evaluate breathing, tone, color, and temperature to determine if additional interventions are required. Shortly after birth, the mother positions the newborn to initiate breastfeeding.

Case 2: Delayed transition

A woman arrives in labor at 39 weeks' gestation. Labor progresses rapidly and the obstetric provider calls your resuscitation team to attend the vaginal birth. You ask the obstetric provider the 4 pre-birth questions to assess perinatal risk factors and determine who should attend the birth. This is a term baby. Membranes are ruptured and the fluid is clear. Additional risk factors include fetal tachycardia and maternal fever. The mother has received intrapartum antibiotics for suspected chorioamnionitis. Fetal heart rate monitoring shows a Category II (indeterminate) pattern. You discuss the umbilical cord management plan with the obstetric providers.

When you enter the room, you introduce the team to the laboring motl1er. Your team completes a pre-resuscitation briefing and equipment check.

Immediately after birth, the baby has poor tone and <loes not cry. The obstetric provider holds the baby in a warm blanket, and dries and stimulates the baby to breathe by gently rubbing the baby's back. The baby still has poor tone and irregular respiratory effort. The cord is clamped and cut and the baby is brought to the radiant warmer. You position the head and neck to open the airway and use a bulb syringe to clear secretions from the mouth and nose in anticipation of positive-pressure ventilation (PPV) while an assistant continues to provide gentle stimulation. A scribe documents the events as they occur.

The baby's tone and respiratory effort quickly improve. Listening with a stethoscope, your assistant reports that the baby's heart rate is 120 beats per minute (bpm). Five minutes after birth, central cyanosis persists and a pulse oximeter sensor is secured on the baby's right hand. The pre-ductal oxygen saturation (SPo_2) is below the target described in the Target Oxygen Saturation Table, so supplemental free-flow oxygen is administered. Documentation continues while the oxygen concentration ($F10_2$) is adjusted so that the SPo_2 remains within the target range. By 1Ominutes after birth, the baby is breathing regularly and supplemental oxygen has been gradually discontinued. The SpO_2 remains normal and the baby is placed skin-to-skin on the mother's chest to continue transition while vital signs and activity are closely monitored for possible deterioration. Shortly afterward, the team members conduct a short debriefing to evaluate their preparation, teamwork, and communication.

When should the umbilical cord be clamped?

At the time of birth, a large volume of the baby's blood remains in the placenta. If maternal blood is still flowing to the placenta and the umbilical cord has not been clamped, placental gas exchange will continue and additional oxygenated blood will be returned to the baby through the umbilical vein. This blood may play an important role in the newborn baby's transition from fetal to neonatal circulation.

Mark the *time of birth* by starting a timer when the last fetal part emerges from the mother's body. The ideal time for clamping the umbilical cord is the subject of ongoing research.

- In preterm newborns, potential benefits of delayed cord clamping compared with immediate cord clamping include decreasing the chance of needing medications to support blood pressure after birth, requiring fewer blood transfusions during hospitalization, and possibly improved survival.
- In term and late preterm newborns, delayed cord clamping may improve early hematologic measurements and, although uncertain, there may be benefits for neurodevelopmental outcomes. However, there may also be an increased chance of needing phototherapy for hyperbilirubinemia.

Before birth, establish with the obstetric provider what the plan will be for the timing of umbilical cord clamping. For most vigorous preterm newborns, the current evidence suggests that clamping should be delayed for at least 30 to 60 seconds. Among vigorous term newborns, the evidence suggests that a similar delay may be reasonable. During this time, the baby may be placed skin-to-skin on the mother's chest or abdomen, or held securely in a warm, dry towel or blanket. Very preterm newborns, less than 32 weeks' gestation, may be wrapped in a warm blanket or polyethylene plastic to help maintain their temperature. Remember, until the cord is clamped, the baby will also be receiving warm blood from the placenta. During the interval between birth and umbilical cord clamping, the obstetric provider and neonatal team should evaluate the baby's tone and breathing effort and continue the initial steps of newborn care described in the remainder of this lesson.

Early (immediate) cord clamping is indicated, or may be considered, in certain cases.

- If the placenta! circulation is not intact, such as after a placenta! abruption, bleeding placenta previa, bleeding vasa previa, or cord avulsion, the cord should be clamped immediately after birth.
- Most delayed cord clamping studies have excluded multiple gestations, so there is currently not enough evidence to evaluate the safety of delayed cord clamping in the setting of a multiple gestation birth.
- Other scenarios, where safety data on delayed cord clamping are limited, may benefit from a discussion between the neonatal and obstetric providers to plan whether cord clamping should be delayed. These scenarios may include fetal intrauterine growth restriction (IUGR), abnormal umbilical artery Doppler measurements, abnormal placentation, and other situations where utero-placental perfusion or umbilical cord blood flow are affected.
- There is not enough evidence to make a definitive recommendation whether umbilical cord clamping should be delayed in newborns who are not vigorous.
  - If the placental circulation is intact, it may be reasonable to briefly delay cord clamping while the obstetric provider gently stimulates the baby to breathe and suctions the mouth and nose with a bulb syringe. If the baby <loes not begin to breathe, additional treatment may be required. Clamp the umbilical cord and bring the baby to the radiant warmer.
  - Initiating resuscitation close to the mother with the cord intact is the subject of ongoing research that may provide additional evidence to inform future recommendations.

How do you evaluate the newborn immediately after birth?

After birth, ali newborns should have a rapid evaluation to determine if they can remain with their mother to continue transition or if they should be moved to a radiant warmer for further assessment. This initial evaluation may occur during the interval between birth and umbilical cord clamping. You will rapidly ask 3 questions: (1) Does the baby appear to be term, (2) Does the baby have good muscle tone, and (3) Is the baby breathing or crying?

Does the baby appear to be term?

Determine if the baby's appearance is consistent with the expected gestational age. In sorne situations, the baby's gestational age is unknown before birth. If the baby appears to be term, proceed to the next assessment question. If the baby appears to be preterm (less than 37 weeks' gestation), bring the baby to the radiant warmer for the initial steps.

Preterm babies are more likely to require interventions during the transition to extrauterine life. For example, they have more difficulty aerating their lungs, establishing good respiratory effort, and maintaining their body temperature.

- Because of these risks, once the cord has been clamped, preterm babies should have the remaining initial steps of newborn care performed under a radiant warmer.
- If the baby is born at a late-preterm gestation (34 to 36 weeks) and appears vigorous with good respiratory effort, the baby can be brought to the mother within severa! minutes to continue transition.

A Rapid Evaluation for Every Newborn

- Term?
- Tone?
- Breathing or crying?

Does the baby hove good musele tone?

Quickly observe the baby's muscle tone. Healthy term babies should be active with flexed extremities (Figure 3.1). Newborns requiring intervention may have flaccid extremities (Figure 3.2).

Is the baby breathing or crying?

A vigorous cry is a clear indicator of strong respiratory effort (Figure 3.1). If the baby is not crying, observe the baby's chest for breathing effort. Be careful not to be misled by a baby who is gasping. Gasping is a series of deep, single or stacked inspirations that occurs in the setting of severely impaired gas exchange. A gasping baby requires intervention and must be brought to the radiant warmer.

Figure 3.1. Low-risk newborn: full-term, good tone, crying. (Used with permission of Mayo Foundation for Medical Education and Research.)

Figure 3.2. High-risk newborn: preterm, poor tone, not cry1ng

Once you have completed your rapid evaluation, what are the initial steps of newborn care?

The initial steps include providing warmth, drying, providing gentle tactile stimulation, positioning the head and neck so that the airway is open, and clearing the airway of secretions if needed. These steps may be initiated during the interval between birth and umbilical cord clamping and should be completed within approximately 30 seconds of birth. In many cases, the initial steps are provided by more than 1 person and sorne steps may be performed simultaneously.

Initial Steps of Newborn Care

- Provide warmth.
- Dry.
- Stimulate.
- Position the head and neck.
- Clear secretions if needed.

How do you provide the initial steps for vigorous, term newborns?

If the answers to all 3 rapid evaluation questions are *"Yes,"* the baby can remain with the mother and have the initial steps performed on the mother's chest or abdomen.

- Warmth is maintained by direct skin-to-skin contact and covering the baby with a warm towel or blanket (Figure 3.3).
- Dry the baby with the towel or blanket and gently stimulate the baby.
- Position the baby on the n1other's chest or abdomen to ensure the a1rway 1sopen.

Figure 3.3. Vigorous, term newborn. Initial steps are performed skin-to-skin with mother. (Used with permission of Mayo Foundation for Medica! Education and Research.)

- If necessary, secretions in the upper airway can be cleared by wiping the baby's mouth and nose with a cloth. Gentle suction with a bulb syringe should be reserved for babies who are having difficulty clearing their secretions.
- After the initial steps are completed, continue monitoring the newborn's breathing, tone, activity, color, and temperature to determine if additional interventions are required.

How do you provide the initial steps for non-vigorous and preterm newborns?

If the answer to any of the initial evaluation questions is *"No,"* bring the baby to a radiant warmer because additional interventions may be required.

Provide warmth.

Place the baby under a radiant warmer so that the resuscitation team has easy access to the baby without causing excessive heat loss (Figure 3.4). Leave the baby uncovered to allow full visualization and to permit the radiant heat to reach the baby.

- If you anticipate that the baby will remain under the warmer for more than a few minutes, apply a servo-controlled temperature sensor to the baby's skin to monitor and control the baby's body temperature. Avoid both hypothermia* and overheating.
- During resuscitation and stabilization, the baby's body temperature should be maintained between 36.5°C and 37.5°C.

Figure 3.4. Radiant warmer used for the initial steps with high-risk newborns

Dry.

Wet skin increases evaporative heat loss (Figure 3.5). Place the baby on a warm towel or blanket and gently dry any fluid. If the first towel or blanket becomes wet, discard it and use fresh, warm towels or blankets for continued drying (Figure 3.6).

- Drying is not necessary for very preterm babies less than 32 weeks' gestation because they should be covered immediately in polyethylene plastic, which reduces evaporative heat loss.
- The interventions used to reduce heat loss in very preterm babies are described in Lesson 8.

*After resuscitation, therapeutic hypothermia is indicated for certain high-risk newborns and is further described in Lesson 8.

Figure 3.5. Wet skin prometes rapid body cooling.

Figure 3.6. Dry the baby and remove wet linen to prevent heat loss and stimulate breathing. Gentle tactile stimulation may also initiate breathing. (Used with permission of Mayo Foundation for Medical Education and Research.)

Stimulate.

Drying the baby will frequently provide enough stimulation to initiate breathing. If the newborn <loes not have adequate respirations, brief additional tactile stimulation may stimulate breathing.

- Gently rub the newborn's back, trunk, or extremities (Figure 3.6).
- Overly vigorous stimulation is not helpful and can cause injury.
- **Never shake a baby.**

Position the head and neck to open the airway.

Position the baby on the back (supine) with theh ead and neck neutral or slightly extended and the eyes directed straight upward toward the ceiling in the «sniffing the morning air" position (Figure 3.7). This position opens the airway and allows unrestricted air entry.

- Avoid hyp erextension or flexion of the neck because these positions may interfere with air entry.
- To help maintain the correct position, you may place a small, rolled towel under the baby's shoulders (Figure 3.8). A shoulder roll is particularly useful if the baby has a large occiput (back of head) from molding, edema, or prematurity.

If needed, clear secretions from the airway.

Routine suction for a crying, vigorous baby is not indicated. Clear secretions from the airway if the baby is not breathing, if the baby is gasping, if the baby has poor tone, if secretions are obstructing the airway, if the baby is having difficulty clearing their secretions, or if you anticípate starting PPV. Secretions may be removed from the upper airway by suctioning gently with a bulb syringe (Figure 3.9).

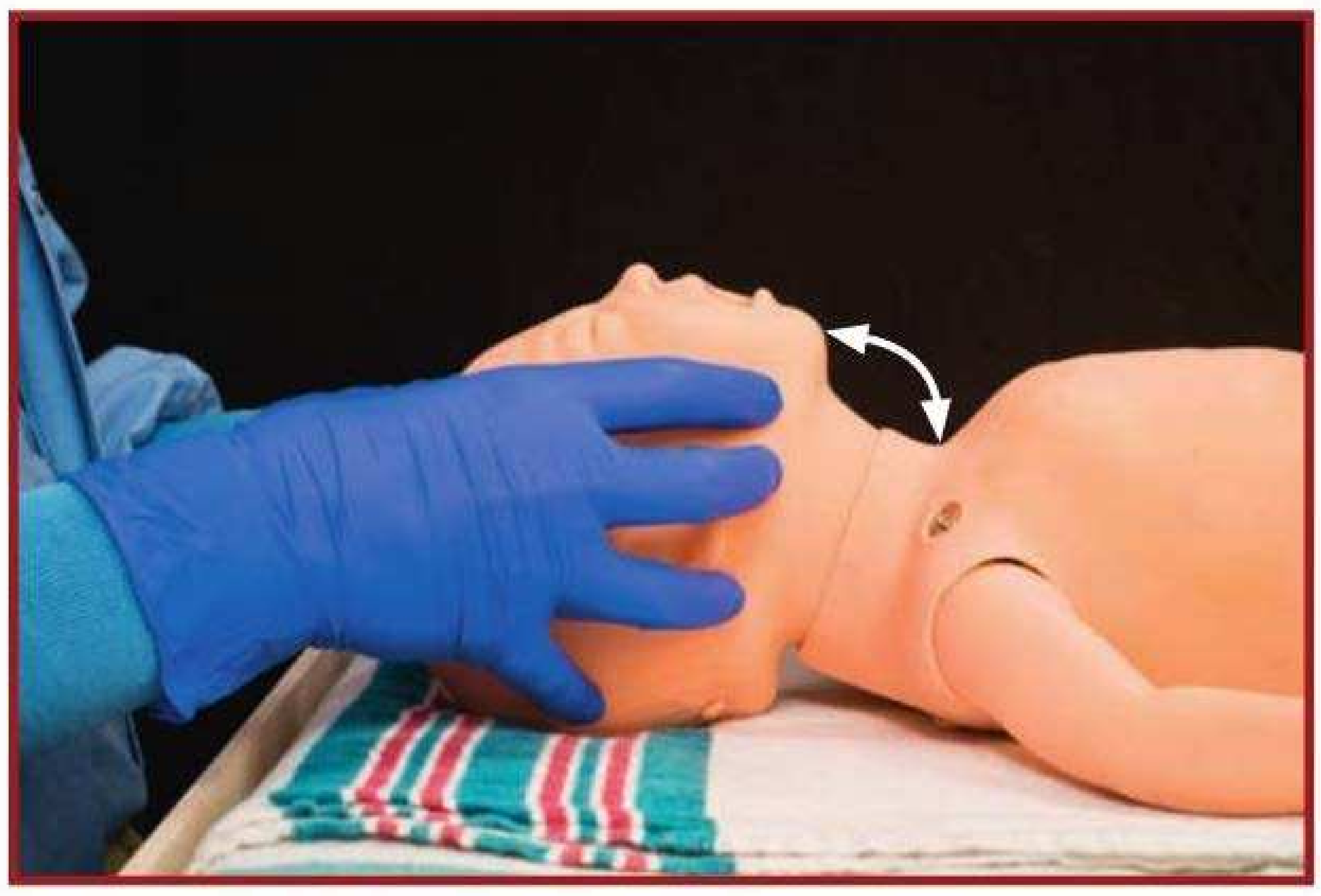


Figure 3.7. Correct sniffing position

Figure 3.8. Optional shoulder roll for maintaining the sniffing position

If the newborn has copious secretions coming from the mouth, turn the head to the side. This will allow secretions to collect in the cheek where they can be removed.

- Brief, gentle suction usually is adequate to remove secretions.
- Suction the mouth before the nose to ensure there is nothing for the baby to aspirate if the baby gasps when the nose is suctioned. You can remember «mouth before nose" by thinking «M" comes before «N" in the alphabet.
- *Be careful not to suction vigorously or deeply.* Vigorous suction may injure tissues. Stimulation of the posterior pharynx during the

Figure 3.9. Gently suction the mouth then nose with a bulb syringe. Use your thumb to depress the bulb syringe before placing it in the baby's mouth or nose.

first minutes after birth can produce a vagal response leading to bradycardia or apnea.

- If using a suction catheter, the suction control should be set so that the negative pressure reads approximately 80 to 100 mm Hg when the tubing is occluded.

How do you evaluate the newborn's response to the initial steps?

Assess the newborn's respirations to determine if the baby is responding to the initial steps. This should take no more than an additional 30 seconds.

Is the baby apneic or gasping?

After the initial steps, determine if the baby is crying or breathing. If the baby is apneic, or has gasping respirations after initial steps, proceed directly to PPV. Remember, gasping respirations are ineffective and are treated the same as apnea. The details of providing PPV with a face mask are described **in** Lesson 4.

If you are the only provider at the warmer, call for immediate additional help.

If the baby has not responded to the initial steps within the first minute of life, it is not appropriate to continue to provide only tactile stimulation. For babies who remain apneic or bradycardic, delaying the start of PPV beyond the first minute of life worsens outcomes.

Remember: Ventilation of the baby's lungs is the most important and effective step during neonatal resuscitation.

If the baby is breathing after the initial steps, assess the heart rote.

If the baby is breathing effectively, the heart rate should be at least 100 bpm. If the heart rate is less than 100 bpm, **start PPV even if the baby is breathing.**

Your initial assessment of the heart rate will be made using a stethoscope. Auscultation along the left side of the chest is the most accurate physical examination method of determining a newborn's heart rate (Figure 3.10). Although pulsations may be felt at the umbilical cord base, palpation is less accurate and may underestimate the true heart rate. While listening, you may tap out the heartbeat on the bed so that your team will also know the heart rate.

- Estimate the heart rate by counting the nu1nber of beats in 6 seconds and multiplying by 10. For example, if you listen for 6 seconds and hear 12 beats, the heart rate is 120 bpm.

- Clearly report the heart rate to your team members ("The heart rate is 120 beats per minute").

If you cannot determine the heart rate by physical examination and the baby is not vigorous, ask another team member to quickly connect a pulse oximeter or cardiac monitor. Other options include the use of a handheld Doppler ultrasound or digital stethoscope.

Cautions

- Pulse oximetry may not function if the baby's heart rate is low or if the baby has poor perfusion. In this case, determining the heart rate with a cardiac monitor is the preferred method.
- In unusual circun1stances, a cardiac monitor may show an electrical signal, but the heart is not actually pumping blood. This is called pulseless electrical activity (PEA). In the newborn, PEA should be treated the same as an absent heart rate (asystole).

Figure 3.10. Assess the heart rote by listening with a stethoscope. (Used with permission of Mayo Foundation for Medical Education and Research.)

What do you do if the baby is breathing and the heart rate is at least 100 bpm, but the baby appears persistently cyanotic?

The term cyanosis describes skin or mucous membranes with a blue hue caused by poorly oxygenated blood. Cyanosis limited to the hands and feet (acrocyanosis) is a common finding in the newborn and <loes not indicate poor oxygenation (Figure 3.11). Low oxygen saturation causing the baby,s lips, tongue, and torso to appear blue is called central cyanosis. Healthy babies may have central cyanosis for several minutes after birth. Studies have shown that visual assessment of cyanosis is not a reliable indicator of the baby,s oxygen saturation and should not be used to guide oxygen therapy. If persistent central cyanosis is suspected, a pulse oximeter placed on the right hand or wrist should be used to assess the baby's oxygenation.

Figure 3.11. This baby has cyanosis of the hands and feet (acrocyanosis), but the trunk and mucous membranes are pink. Acrocyanosis is normal. Supplemental oxygen is only needed if oxygen saturation is below the target range.

What is a pulse oximeter?

Oxygen is carried by the hemoglobin inside red blood cells. Hemoglobin that is carrying oxygen absorbs red light differently than hemoglobin that is not carrying oxygen. A pulse oximeter uses a light

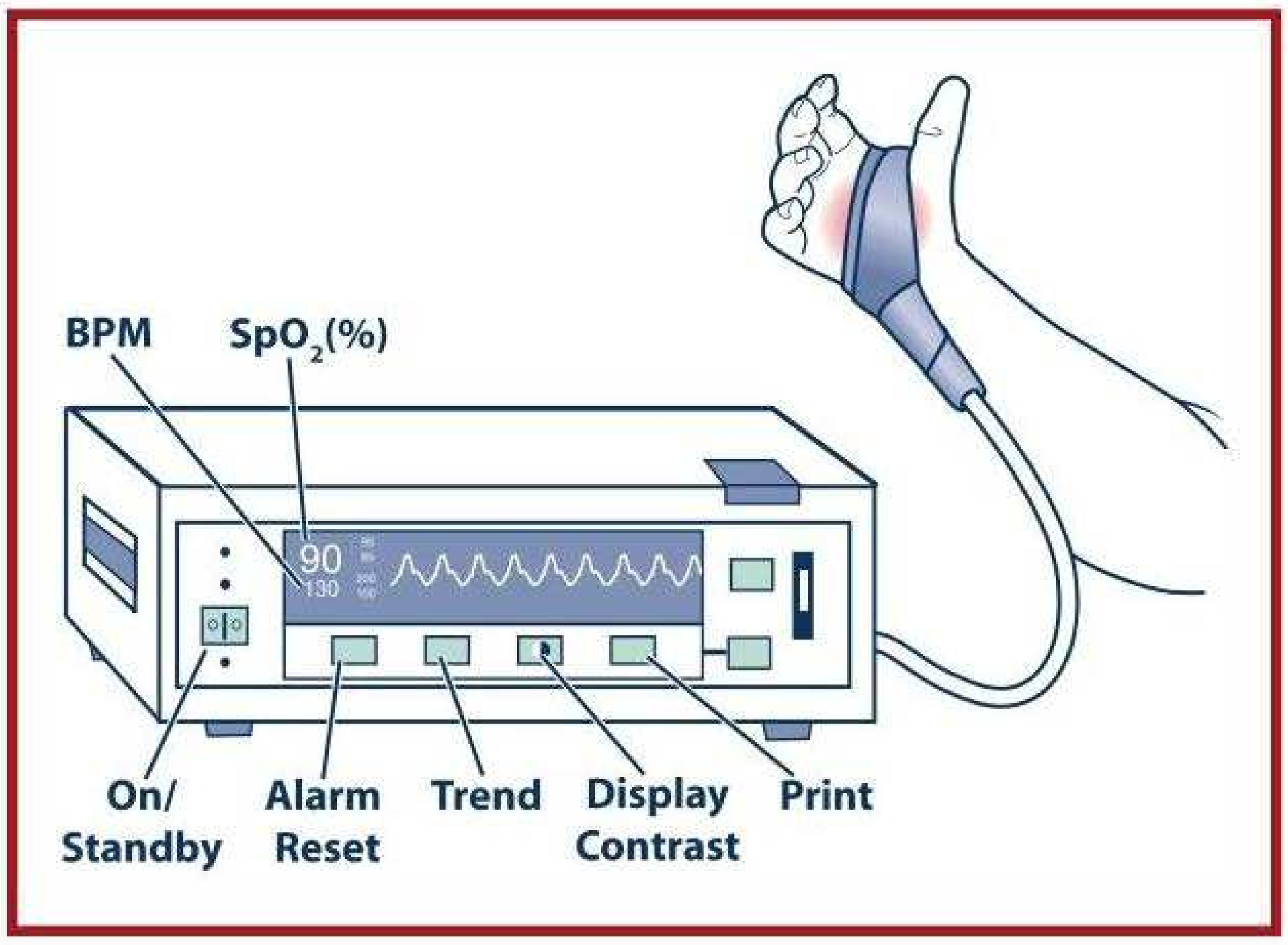


Figure 3.12. Pulse oximeter with sensor attached to a baby's right hand on the hypothenar eminence

source and sensor to measure the absorption of red light passing through capillaries in the skin and estimates the percentage of hemoglobin that is carrying oxygen (Figure 3.12). The 1nonitor displays the oxygen saturation, which ranges from 0% to 100%. This number is not the same as the partial pressure of oxygen (Po_2) measured by a blood gas machine. The pulse oximeter also displays the baby's heart rate by sensing pulsatile blood flow in the capillaries.

When is pulse oximetry used in the delivery room?

Use pulse oximetry to guide your treatment when resuscitation is anticipated, to confirm your perception of persistent central cyanosis, if you give supplemental oxygen, or if PPV is required.

Indications for Pulse Oximetry

- When resuscitation is anticipated
- To confirm your perception of persistent central cyanos1s
- When supplemental oxygen is administered
- When PPV is required

Where and how should the pulse oximeter sensor be placed?

In most babies, the artery supplying the baby's right arm branches from the aorta before the patent ductus arteriosus enters the aorta. Blood in the right arm is often called "pre-ductal" and has a similar oxygen saturation as the blood perfusing the heart and brain. The origin of blood flow to the left arm is less predictable. The arteries supplying both legs branch from the aorta after the patent ductus arteriosus and are called "post-ductal:'

- To measure the oxygen saturation of the pre-ductal blood that is perfusing the heart and brain, *place the pulse oximeter sensor on the baby's right hand or wrist.*
- The left arm and both legs may have lower oxygen saturation. They may receive blood from the aorta that has been mixed with poorly oxygenated venous blood that bypassed the lungs through the patent ductus arteriosus (post-ductal).

Proper placement of the sensor is important. Once the sensor is attached to the baby, watch the monitor to ensure that it is detecting a pulse with each heartbeat. Most instruments will not display a saturation reading until a consistent pulse is detected. If you are monitoring the heart rate with a cardiac monitor, the heart rate displayed on the pulse oximeter should be the same as the heart rate on the cardiac monitor.

- The sensor must be oriented correctly so that it can detect the transmitted red light. After placement, it may be helpful to cover the sensor to shield it from light in the room. If the pulse oximeter is not detecting a consistent pulse, you may need to adjust the sensor to be sure that it is positioned opposite the light source.
- With good technique, a pulse oximeter will accurately display the heart rate and oxygen saturation within approximately 1 to 2 minutes of birth.
- If the baby has a very low heart rate or poor perfusion, the pulse oximeter may not be able to detect the pulse or oxygen saturation.

What is the target oxygen saturation?

Healthy newborns undergoing normal transition usually take several minutes to increase their blood oxygen saturation from approximately 60%, which is the normal intrauterine state, to more than 90%, which is the eventual state of air-breathing healthy newborns. Figure 3.13 shows the time course of oxygen saturation changes after birth in healthy, full-term newborns breathing room air (21% oxygen). Oxygen saturation values following cesarean birth are slightly lower than those following vaginal birth.

When the pulse oximeter has a reliable signal, compare the baby's pre-ductal oxygen saturation with the range of target values in Table 3-1. These values are based on oxygen saturations obtained from healthy, term babies breathing room air during the first 10 minutes of life. The ideal oxygen saturation after birth has not been established and there is ongoing controversy about which targets should be used. These targets have been selected to represent a consensus of acceptable values that can be easily remembered.

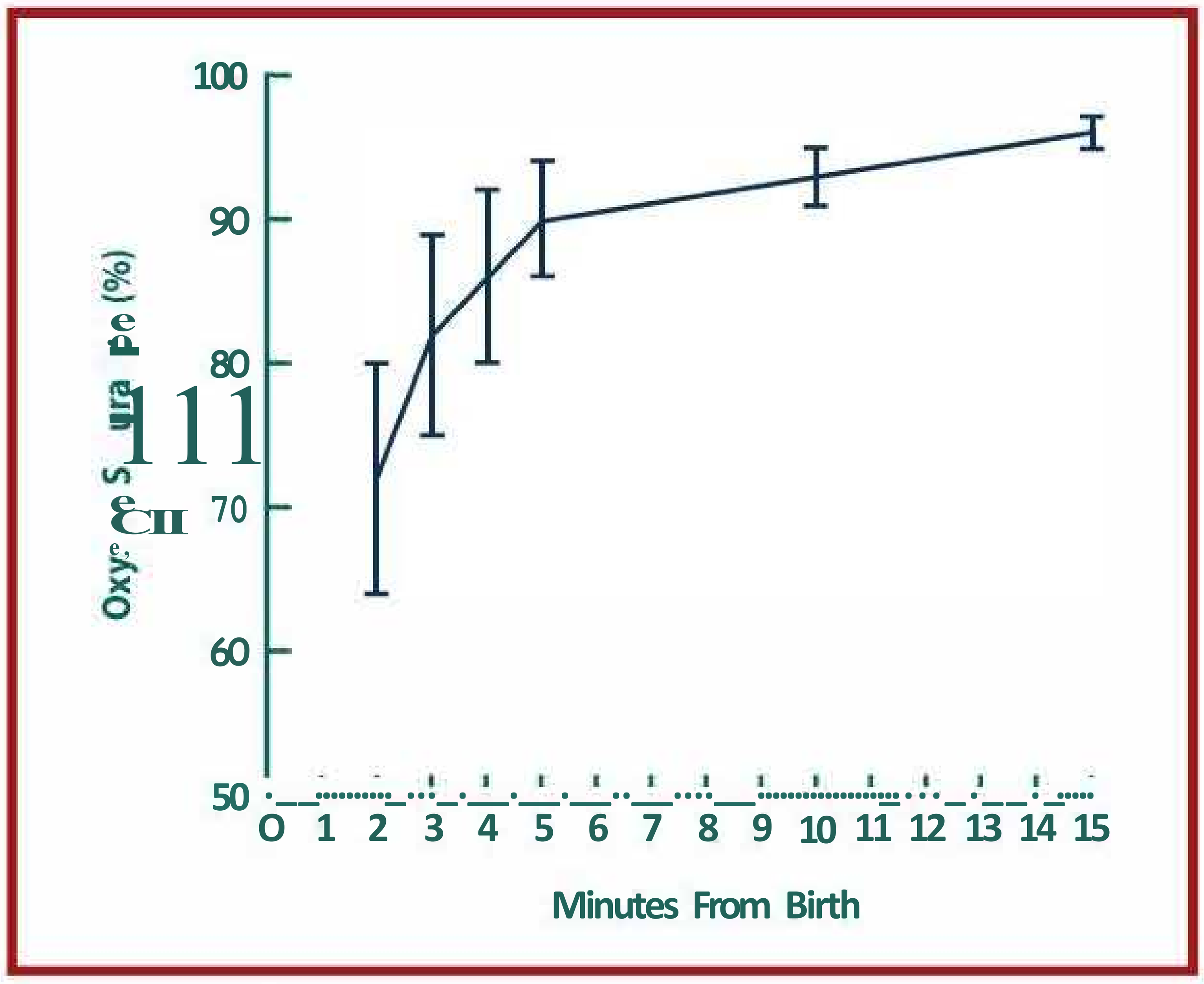


Figure 3.13. Pre-ductal oxygen saturation changes following birth (median and interquartile range). (From Mariani G, Dik PB, Ezquer A, et al. Pre-ductal and post-ductal O_2 saturation in healthy term neonates after birth. J *Pediatr.* 2007; 150[4]:418-421.)

Table 3-1 • Target Pre-Ductal Oxygen Saturation

Target Oxygen Saturation Table	
1 min	60%-65%
2 min	65%-70%
3 min	70%-75%
4 min	75%-80%
5 min	80%-85%
10 min	85%-95%

Figure 3.14. Free-flow oxygen given to a spontaneously breathing baby by holding oxygen tubing close to the baby's mouth and nose

When and how do you administer supplemental oxygen?

Use supplemental free-flow oxygen when the pulse oximeter reading remains below the target range for the baby's age. Free-flow oxygen can be given to a spontaneously breathing baby by holding oxygen tubing close to the baby's mouth and nose (Figure 3.14). Free-flow oxygen is not effective if the baby is not breathing.

You may also use one of the positive-pressure delivery devices described in Lesson 4 (Figure 3.15).

- If you are using a flow-inflating bag or T-piece resuscitator, hold the mask close to the face but not so tight that you make a seal and pressure builds up within the mask.

Figure 3.15. Free-flow oxygen given by (A) a flow-inflating bag, (B) a T-piece resuscitator, and (C) the tail of a self-inflating bag with an open reservoir.
Note: For free-flow oxygen, the mask of a flow-inflating bag and T-piece resuscitator is NOT held tightly against the face.

- If a flow-inflating bag is used, the bag *should not inflate* when used to provide free-flow oxygen.
  - An inflated bag indicates that the mask is tight against the face and unintended positive pressure is being delivered.
- If a T-piece resuscitator is being used, do not occlude the opening on the T-piece cap.
  - During free-flow oxygen administration, the T-piece pressure manometer should read "zero."
- **Do not** attempt to administer free-flow oxygen through the mask of a self-inflating bag (Figure 3.16) because gas does not reliably flow through the mask unless the bag is being squeezed.
  - Free-flow oxygen may be administered through the open reservoir (tail) on some self-inflating bags. If your hospital has self-inflating bags with closed reservoirs, you will need separate oxygen tubing to administer free-flow oxygen (Figure 3.14).

Figure 3.16. Do not attempt to give free-flow oxygen using the mask of a self-inflating bag.

How is the concentration of supplemental oxygen adjusted?

If supplemental oxygen is necessary, it is reasonable to start with 30%. Then, guided by pulse oximetry, adjust the FIO_2 to maintain the baby's oxygen saturation within the target range described in Table 3-1. The goal is to prevent low oxygen saturations without exposing the newborn to the potential risk of additional, unnecessary oxygen. Adjust the concentration and flow of supplemental oxygen using compressed air and oxygen, a blender, and a flowmeter (Figure 3.17).

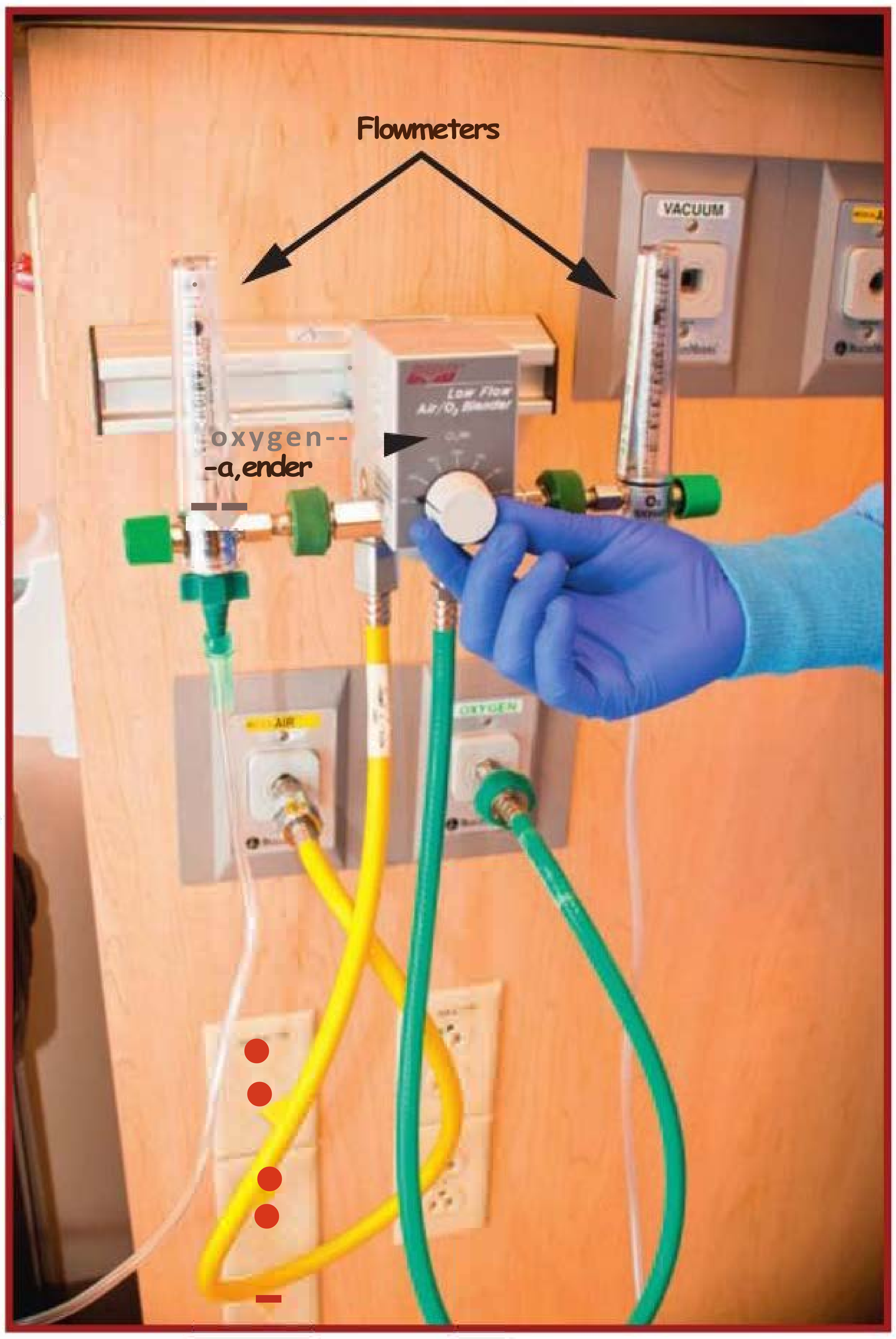


Figure 3.17. Adjust the concentration and flow of oxygen with compressed air (inflow from yellow hose), compressed oxygen (inflow from green hose), an oxygen blender, and a flowmeter. The image shows 2 flowmeters attached to the oxygen blender. Your system may only have 1 flowmeter.

Compressed air and oxygen

Compressed gases may be built into the wall or obtained from portable tanks. Medical air (21% oxygen) is supplied from high-pressure hoses that are color coded yellow, and 100% oxygen is supplied from high-pressure hoses that are color coded green.

Oxygen blender and flowmeter

The compressed gases are connected to a blender, which has a dial that adjusts the gas mixture (21%-100%). The blended gas travels to an adjustable flowmeter. The flowmeter commonly has a floating hall within a glass tube that indicates the rate of gas flow leaving the device. Depending on the size of the flowmeter, you can adjust the dial to achieve gas flows between OL/min and 20 L/min. The blended gas, adjusted to the desired concentration and flow rate, is directed through tubing to the oxygen delivery device.

- For free-flow supplemental oxygen, **adjust the flowmeter to 10 L/min.**
- Begin free-flow oxygen supplementation with the blender set to 30% oxygen. Using the blender, adjust the $F10_2$ as needed to achieve the oxygen saturation target.

If an oxygen blender is not available

If supplemental free-flow oxygen is necessary andan oxygen blender is not available, such as when resuscitation occurs outside the delivery room, free-flow oxygen may be delivered by using 100% oxygen from your wall or portable oxygen source. As described previously, direct the flow of oxygen toward the baby's mouth and nose using oxygen tubing, a mask, or appropriate PPV device. As oxygen flows out of the tubing or mask, it mixes with air. The concentration of oxygen that reaches the baby's nose is determined by the amount of 100% oxygen coming from the tubing or mask and the amount of air it must pass through to reach the baby. The closer the tubing or mask is to the face, the higher the concentration of oxygen breathed by the baby. Guided by pulse oximetry, adjust the $F10_2$ by moving the tubing or mask closer to or farther from the baby's face.

If the baby continues to require supplemental oxygen after the first few minutes, how should it be given?

Attempt to gradually decrease the $F10_2$ until the newborn can maintain saturation within the target range without supplemental oxygen. If respirations and heart rate are stable but the newborn continues to require supplemental oxygen, use pulse oximetry to guide the appropriate $F10_2$.

- Oxygen administered directly from a compressed source is cold and dry.
- To prevent heat loss, oxygen given to newborns for a prolonged period of time should be heated and humidified.

What do you do if the baby has labored breathing or persistently low oxygen saturation?

If the baby has labored breathing, or the oxygen saturation cannot be maintained within the target range despite 100% oxygen, you may considera trial of continuous positive airway pressure (CPAP) or PPV.

CPAP is a method of respiratory support that uses a continuous low gas pressure to keep a spontaneously breathing baby's lungs open. CPAP may be helpful if the airway is open, but the baby has signs of labored breathing or persistently low oxygen saturations. CPAP should only be considered in the delivery room if the baby is breathing and the baby's heart rate is at least 100 bpm.

- Administering CPAP may increase the chance of developing a pneumothorax (air leak).
- Providers should be aware of this potential complication and prepared to address it.

If desired, a trial of CPAP in the delivery room can be given by using a flow-inflating bag or a T-piece resuscitator attached to a mask that is held tightly to the baby's face (Figure 3.18). CPAP **cannot** be given using a self-inflating bag. The equipment and method for administering CPAP are described in more detail in Lesson 4.

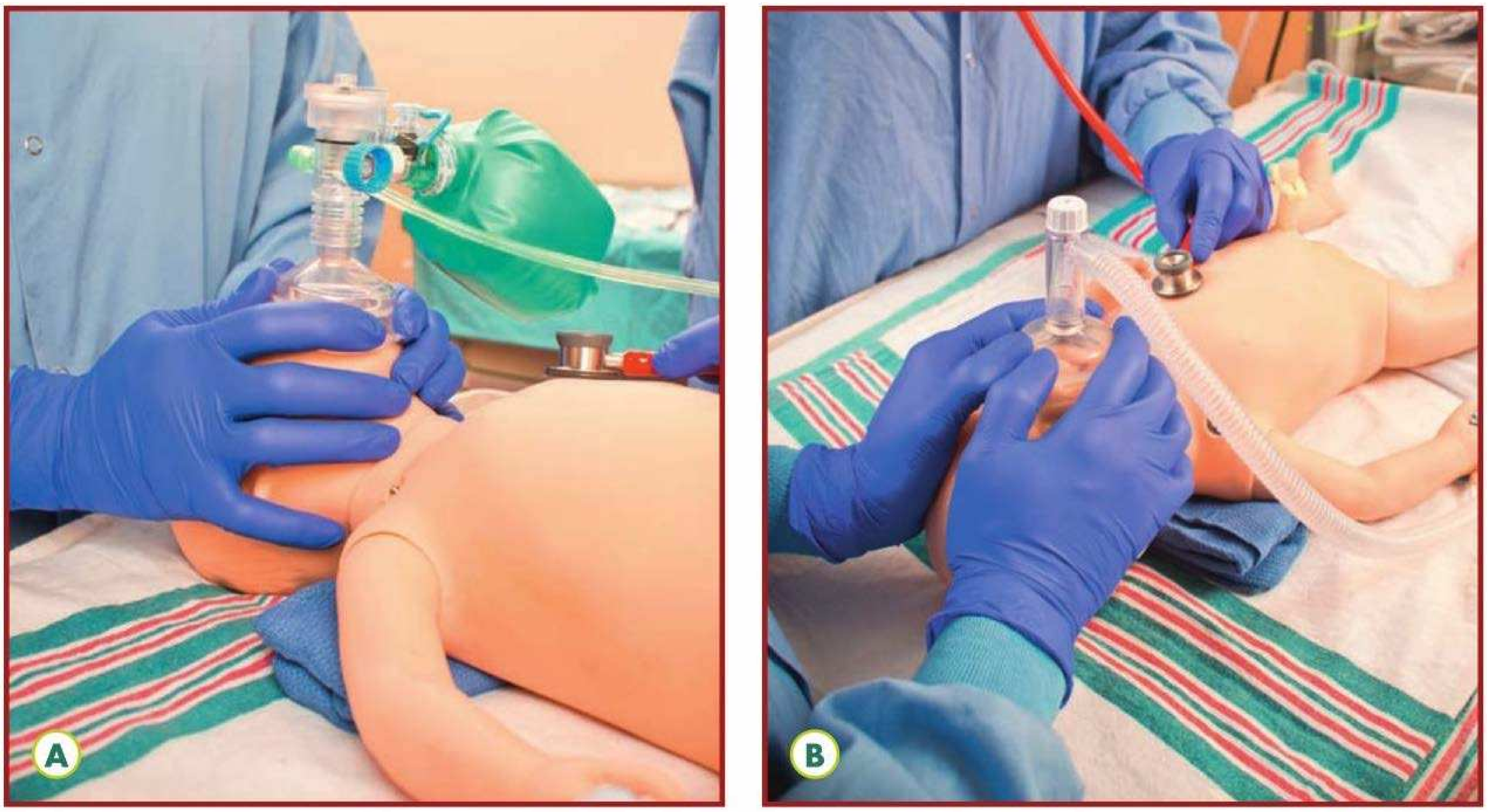


Figure 3.18. Administering CPAP using (A) a flow-inflating bag or (B) a T-piece resuscitator. The baby must hove spontaneous breathing and a heart rote greater than 100 bpm.
Note: For CPAP, the mask is held tightly against the face to create a seal.

Does the presence of meconium-stained amniotic fluid change who should attend the birth or how the initial steps are performed?

The presence of meconium-stained amniotic fluid may indicate fetal distress and increases the risk that the baby will require resuscitation after birth. At least 2 qualified people who can initiate resuscitation should be present at the time of birth solely to manage the baby. An individual with intubation sl(ills should be identified and immediately available.

If additional risk factors indicate that an extensive resuscitation is likely, a qualified team with full resuscitation skills should be present at the time of birth.

Meconium-stained fluid and a vigorous newborn

If the baby is vigorous with good respiratory effort and muscle tone, the baby may stay with the mother to receive the initial steps of newborn care.

Meconium-stained fluid and a non-vigorous newborn

If a baby is born through meconium-stained amniotic fluid and has depressed respirations or poor muscle tone, bring the baby to the radiant warmer and perform the initial steps of newborn care as described in this lesson. You will use a bulb syringe to clear secretions from the mouth and nose. If the baby is not breathing or if the baby is breathing and the heart rate is less than 100 bpm after the initial steps are completed, proceed with PPV.

Routine laryngoscopy with or without intubation for tracheal suction is not suggested. Historically, routine intubation and suction immediately after birth was recommended in an effort to reduce the chance of developing meconium aspiration syndrome; however, a recent systematic review found no evidence to support this practice. Intubation and tracheal suction may be necessary if PPV <loes not ínflate the lungs and airway obstruction is suspected.

Focus on Teamwork

The initial steps of resuscitation highlight several opportunities for effective teams to use the Neonatal Resuscitation Program® (NRP®) Key Behavioral Skills.

Behavior	Example
Anticipate and plan.	Ensure that you have enough personnel present at the time of delivery based on the identified risk factors.
Communicate effectively. Use available information.	Immediately after birth, the obstetric and neonatal care teams need to share their assessment of the newborn. Subsequent interventions will be based on this assessment. The care teams need to communicate their findings clearly and efficiently.
Know your environment.	Know how the pulse oximeter, compressed air and oxygen source, oxygen blender, and flowmeters work in your practice setting. Know what device is available to administer CPAP in your hospital. Know how to obtain a cardiac monitor if needed.
Use available resources.	If you cannot auscultate a heart rate and the baby is not vigorous, quickly place a pulse oximeter sensor or cardiac monitor leads and attach them to the appropriate monitor.
Call for additional help when needed.	After the initial steps, if you identify apnea, gasping, or a heart rate less than 100 bpm and you are alone, call for additional help. Positive-pressure ventilation is required and you will need additional personnel.

Quality Improvement Opportunities

Ask yourself the following questions and begin a discussion with your team if you find a difference between the NRP recommendations and what is currently done in your own hospital setting. Consider using the suggested process and outcome measures to guide your data collection, identify areas for improvement, and monitor if your improvement efforts are working.

Quality improvement questions

O Are vigorous newborns placed skin-to-skin with their mother?

8 How are the findings of the baby's initial assessment communicated between the obstetric and pediatric providers?

8 Do vigorous newborns routinely have their mouth and nose suctioned?

Process and outcome measures

O What percentage of vigorous newborns have umbilical cord clamping delayed at least 30 to 60 seconds?

f) What percentage of newborns are crying or breathing after drying and stimulation?

E) What percentage of newborns with meconium-stained fluid still undergo laryngoscopy and tracheal suction?

Frequently Asked Questions

After birth, do all babies need to have their mouth and nose suctioned with a bulb syringe?

No. Vigorous newborns that are breathing or crying and have good tone do not need to have their mouth and nose suctioned. If necessary, the upper airway can be cleared by wiping the baby's mouth and nose with a cloth. Gentle suction should be reserved for babies with difficulty clearing their secretions, babies with secretions obstructing their airway, and those who are not breathing or crying, have poor tone, or require PPV.

Does it matter if the pulse oximeter sensor is attached to the baby's hand or wrist?

For a small baby, sorne health care providers find it easier to secure the sensor to the baby's wrist; however, sorne manufacturers recommend placing the pulse oximeter sensor only on the baby's hand. There is evidence that an accurate reading can be obtained using a sensor placed on the baby's wrist. In the studies that established the normal progression of oxygen saturation in healthy newborns, the pulse oximeter sensor was placed on the baby's wrist. Placement on either the hand or wrist is acceptable as long as the transmitted light is detected by the sensor and a reliable signal is obtained.

Previously, the Neonatal Resuscitation Program recommended routine endotracheal intubation and suction for non-vigorous babies born through meconium-stained amniotic fluid. Why is this no longer recommended? Does this change who should attend the birth of the baby with meconium-stained amniotic fluid?

Prior to each edition of the *Textbook of Neonatal Resuscitation,* questions are identified by the International Liaison Committee on Resuscitation (ILCOR) Neonatal Task Force. The scientific evidence is reviewed using a systematic approach and treatment recommendations are developed using a method that evaluates the strength of the supporting evidence (GRADE). Before the *Textbook of Neonatal Resuscitation,* 7th edition (2016), the NRP recommendation for tracheal suction was based on small observational studies that did not use currently accepted research methods for comparing treatments. As a result, the conclusions from those studies are subject to bias and the strength of evidence is considered very weak.

Recently, several small randomized trials enrolling non-vigorous newborns have been published that do not show benefit to tracheal suction. Both the 2015 and 2019 ILCOR reviews determined that the existing evidence did not support routine tracheal suction. A large, properly randomized trial is still needed.

The NRP Steering Committee's values include avoiding invasive procedures without good evidence of benefit for important outcomes. As a result, the NRP Steering Committee does not currently suggest routine laryngoscopy with or without tracheal suction for non-vigorous babies delivered through meconium-stained fluid. If additional evidence becomes available, the ILCOR Neonatal Task Force and NRP Steering Committee will reevaluate this recommendation.

The presence of meconium-stained fluid is still considered a perinatal risk factor that increases the likelihood that the newborn will require resuscitation. At least 2 qualified people who can initiate resuscitation should be present at the time of birth solely to manage the baby. An individual with intubation skills should be identified and immediately available. If additional risk factors indicate that an extensive resuscitation is likely, a qualified team with full resuscitation skills should be present at the time of birth.

LESSON 3 REVIEW

1. List the 3 rapid evaluation questions that determine which newborns should be brought to the radiant warmer for the initial steps.

2. List the 5 initial steps of newborn care.

3. You count a newborn's heartbeat for 6 seconds and count 6 beats. You report the heart rate as (36 beats per minute)/(60 beats per minute).

4. Oxygen saturation should be 85% to 95% by (2 minutes of age)/(10 minutes of age).

5. Which image shows the correct way to position a baby's head to open the airway (A, B, or C)?

6. You have provided warmth, dried, stimulated, positioned the head and neck, and cleared the airway of secretions. It is now 60 seconds after birth, and the baby is still apneic and limp. What is your next action?

7. If a baby is breathing, the heart rate is greater than 100 beats per minute, the airway is clear and correctly positioned, but the respirations are labored, you may consider (deep pharyngeal suction)/continuous positive airway pressure [CPAP]).

Answers

1. Is the baby term? Does the baby have good tone? Is the baby breathing or crying?
2. Provide warmth, dry, stimulate, position the head and neck, clear secretions from the airway if necessary.
3. You report the heart rate as 60 beats per minute.
4. Oxygen saturation should be 85% to 95% by 10 minutes of age.
5. Image B shows the correct way to position a newborn's head to open the airway.
6. Your next action is to start positive-pressure ventilation. Call for help if you are alone.
7. You may consider continuous positive airway pressure (CPAP).

LESSON 3: PRACTICE SCENARIOS

Initial Steps of Newborn Care

Learning Objectives

0 Identify the newborn who requires initial steps of resuscitation at the radiant warmer.

f) Demonstrate correct technique for performing initial steps when the newborn stays with the mother and when the newborn is received at the radiant warmer.

E) Demonstrate accuracy when assessing a newborn heart rate with a stethoscope.

C, Demonstrate correct placement of the pulse oximeter sensor, interpretation of pulse oximetry, and administration of supplemental free-flow oxygen.

These Practice Scenarios are for review/practice and evaluation.

This is the suggested Practice Scenario sequence.

0 **Review the Knowledge Check Questions** with your Neonatal Resuscitation Program (NRP) instructor.

a. What are the 3 rapid evaluation questions? How do the answers to those questions determine whether a newborn may stay with the mother or come to the radiant warmer?

b. Which newborns receive the initial steps? What are the 5 initial steps of newborn care?

c. When do you start the Apgar timer?

d. How do you assess a newborn's heart rate? What will you do if the baby is not vigorous and you cannot hear the heart rate with the stethoscope?

e. Why do you use pulse oximetry and when is it indicated?

f. What concentration of oxygen is used to initiate free-flow oxygen?

g. What is CPAP and when is it a consideration in the delivery room?

8 **Practice/review these skills** with your NRP instructor.

a. Perform initial steps of care for a baby who stays with the mother.

b. Perform initial steps of care for a baby on the radiant warmer, including proper use of the bulb syringe.

c. Assess heart rate using a stethoscope.

d. Apply a pulse oximeter sensor and practice using the Target Oxygen Saturation Table to administer and wean free-flow oxygen.

E) **Practice the scenarios** applicable to your role with your NRP instructor until you need little or no assistance or coaching.

9 **Pass the Lesson 3 Practice Scenario evaluation** by leading practice scenario(s) and performing the skills relevant to your role and responsibilities. If a technical skill included in this scenario is not within your scope of responsibility, delegate the skill to a qualified team member and perform the role of assistant if appropriate. When you can lead the scenario(s) and perform the skills with little or no instructor coaching, proceed to the next lesson's practice scenario.

Practice Scenarios

Four scenario options are offered. Use the same scenario introduction for each scenario; the answers to the 4 pre-birth questions are different for each scenario. The number of people attending the birth and their qualifications are determined by the instructor and based on hospital policy.

0 Vigorous term newborn who may stay with the mother for initial steps

8 Vigorous term newborn with meconium-stained fluid and persistent cyanosis (this scenario is designed for a 2-person team)

E) Term newborn requires initial steps at radiant warmer, returned to mother for skin-to-skin care

9 Late preterm newborn with clear fluid, requires initial steps at radiant warmer, remains apneic

"You are called to attend a vaginal birth. The mother is in active labor with ruptured membranes. How would you prepare far the birth of this baby and perform the initial steps of newborn care? As you work, say your thoughts and actions aloud so I will know what you are thinking and doing."

Option 1: Vigorous term newborn may stay with the mother for initial steps

	Critical Performance Steps
Assess perinatal risk.	
	Assesses perinatal risk (learner asks the 4 pre-birth questions and instructor ["OB provider"] responds)
	Gestational age? **"39 weeks' gestation."**
	Clear fluid? **"Amniotic fluid is clear."**
	Additional risk factors? **"There are no additional risk factors."**
	Umbilical cord management plan? "I **will delay cord clamping. If the baby is not crying, 1'11take a moment to stimulate the baby. If there's no response, 1'11clamp and cut the cord."**
Assemble team.	
	Assembles team based on perinatal risk factors.
	When the likelihood of resuscitation is low, 1 qualified individual should attend the birth.
	If the birth will be attended by 1 person, Knows the answers to the 4 pre-birth questions, determines supplies and equipment needed, knows how to call for help
Perform equipment check.	
	"The baby has been born."
Rapid evaluation.	
	Asks 3 rapid evaluation questions:
	• Term? **"Yes."**
	• Muscle tone? **"Yes."**
	• Breathing or crying? **"Yes, the baby is crying."**
	Newborn stays with mother for initial steps.
Initial steps.	
	Places baby skin-to-skin with mother, dries baby and stimulates if needed, positions head and neck. Covers with warm blanket.
End scenario.	
	Continues ongoing evaluation of breathing, heart rote, tone, activity, color, and temperature

Option 2: Vigorous term newborn with meconium-stained fluid and persistent cyanosis

Critical Performance Steps	
Assess perinatal risk.	
Assesses perinatal risk (learner asks the 4 pre-birth questions and instructor ["OB provider"] responds)	
Gestational age?	**"41 weeks' gestation."**
Clear fluid?	**"The fluid is meconium-stained."**
Additional risk factors?	**"None besides meconium-stained amniotic fluid."**
Umbilical cord management plan? **"I will delay cord clamping. If the baby is not crying, I'll take a moment to stimulate the baby. If there's no response, I'll clamp and cut the cord."**	
Assemble team.	
Assembles team based on perinatal risk factors. • When meconium-stained fluid is the only risk factor, at least 2 qualified people who can initiate resuscitation should be present at the birth solely to manage the baby. An individual with intubation skills should be identified and immediately available. • A fully qualified resuscitation team should be present at the time of birth if additional risk factors suggest that advanced resuscitation measures may be required.	
Perform a pre-resuscitation team briefing.	
Identifies team leader. Assesses risk factors, delegates tasks, identifies who will document events as they occur (if necessary), determines supplies and equipment needed, knows how to call for additional help.	
Perform equipment check.	
"The baby has been born."	
Rapid evaluation.	
Asks 3 rapid evaluation questions:	
• Term?	**"Yes."**
• Muscle tone?	**"Yes."**
• Breathing or crying?	**"Yes."**
Newborn may stay with mother for initial steps.	
Initial steps.	
Places baby skin-to-skin with mother, dries baby, stimulates as needed, positions head and neck, clears secretions if needed. Monitors breathing, tone, activity, color, and temperature to determine if additional interventions are required.	
"The newborn is 4 minutes old and remarkably cyanotic."	
Checks breathing.	**"The baby is breathing, with no distress."**
Auscultates heart rate accurately.	**Heart rote per auscultation = 140 bpm**
Applies pulse oximeter sensor to right hand/wrist.	**SPO_2=68%**
Administer free-flow oxygen.	
Adjusts blender to 30% and administers free-flow oxygen using correct technique. Monitors oxygen saturation and adjusts blender appropriately per pulse oximetry to maintain oxygen saturation within target range. May attempt to wean supplemental oxygen. Monitors oxygen saturation with pulse oximetry until vital signs are stable and oxygen saturation is stable within target range. Monitors breathing, heart rate, tone, activity, color, and temperature. Communicates with neonatal team per hospital protocol to discuss next steps. Updates perinatal team. Updates parents and communicates next steps, including the plan for post-resuscitation care.	
End scenario.	

Option 3: Term newborn requires initial steps at radiant warmer, returned to mother for skin-to-skin care

	Critical Performance Steps
Preparation for resuscitation.	
	Assesses perinatal risk (learner asks the 4 pre-birth questions and instructor ["OB provider"] responds) • Gestational age? **"Term."** • Clear fluid? **"Amniotic fluid is clear."** • Additional risk factors? **"Repeated fetal heart rate decelerations have been noted in the last 15 minutes."** Umbilical cord management plan? **"I will delay cord clamping. If the baby is not crying, I'll take a moment to stimulate the baby. If there's no response, I'll clamp and cut the cord."**
Assemble team.	
	Assembles team based on perinatal risk factors. At least 2 qualified people should be present solely to manage the baby because risk factors are present. The number of team members and qualifications vary depending on risk.
Perform a pre-resuscitation briefing.	
	Identifies team leader. Assesses risk factors, delegates tasks, identifies who will document events, determines supplies and equipment needed, knows how to call for additional help.
Perform equipment check.	
	"The baby has been born."
Rapid evaluation.	
	Asks 3 rapid evaluation questions: • Term? **"Yes."** • Muscle tone? **"No."** • Breathing or crying? **"No."**
Initial steps.	
	Receives baby at radiant warmer. Dries with towel or blanket, removes wet linen. Stimulates by rubbing back and/or extremities. Positions airway. Suctions mouth and nose if still apneic.
Check breathing. If breathing, check heart rate.	
	Assesses breathing **"The baby is crying."** Auscultates heart rote accurately **Heart rate = 120 bpm**
End scenario.	
	Wraps baby in blanket, returns baby to the mother, and places baby skin-to-skin with the mother. Monitors breathing, tone, activity, color, and temperature to determine if additional interventions are required.

Option 4: Late preterm newborn with clear fluid, requires initial steps at warmer, remains apneic

	Critical Performance Steps
Assess perinatal risk.	
	Assesses perinatal risk (learner asks the 4 pre-birth questions and instructor ["OB provider"] responds) • Gestational age? **"36 weeks' gestation."** • Clear fluid? **"Amniotic fluid is clear."** • Additional risk factors? **"The mother has a fever."** Umbilical cord management plan? **"I will delay cord clamping. If the baby is not crying, 1'11 take a moment to stimulate the baby. If there's no response, 1'11 clamp and cut the cord."**
Assemble team.	
	Assembles team based on perinatal risk factors. At least 2 qualified people should be present solely to manage the baby because risk factors are present. The number of team members and qualifications vary depending on risk.
Perform a pre-resuscitation briefing.	
	Identifies team leader. Assesses risk factors, delegate tasks, identifies who will document events as they occur (if necessary), determines supplies and equipment needed, knows how to call for additional help.
Perform equipment check.	
	"The baby has been born."
Rapid evaluation.	
	Asks 3 rapid evaluation questions: • Term? **"No, appears 36 weeks' gestation as expected."** • Muscle tone? **"No."** • Breathing or crying? **"No."**
Initial steps.	
	Receives baby at radiant warmer. Dries with towel or blanket, removes wet linen. Stimulates by rubbing back and/or extremities. Positions airway. Suctions mouth and nose.
Check breathing. Also check heart rote if breathing.	
	• Breathing? **"No, baby is apneic."** **(Heart rote= 70 bpm, if assessed)** • Indicates need for PPV • Indicates the standardized method to call for additional help
End scenario.	

Sample Debriefing Questions

O What factors determined the decisions for who would attend the births described in these scenarios?

f) How <lid you know if the newborn required

   a. Initial steps at the radiant warmer?

   b. Pulse oximetry?

   c. Supplemental oxygen?

E) What would you do differently when preparing for resuscitation or performing initial steps in our next scenario?

O State an example of how you used at least one of the NRP Key Behavioral Skills.

NRP Key Behavioral Skills

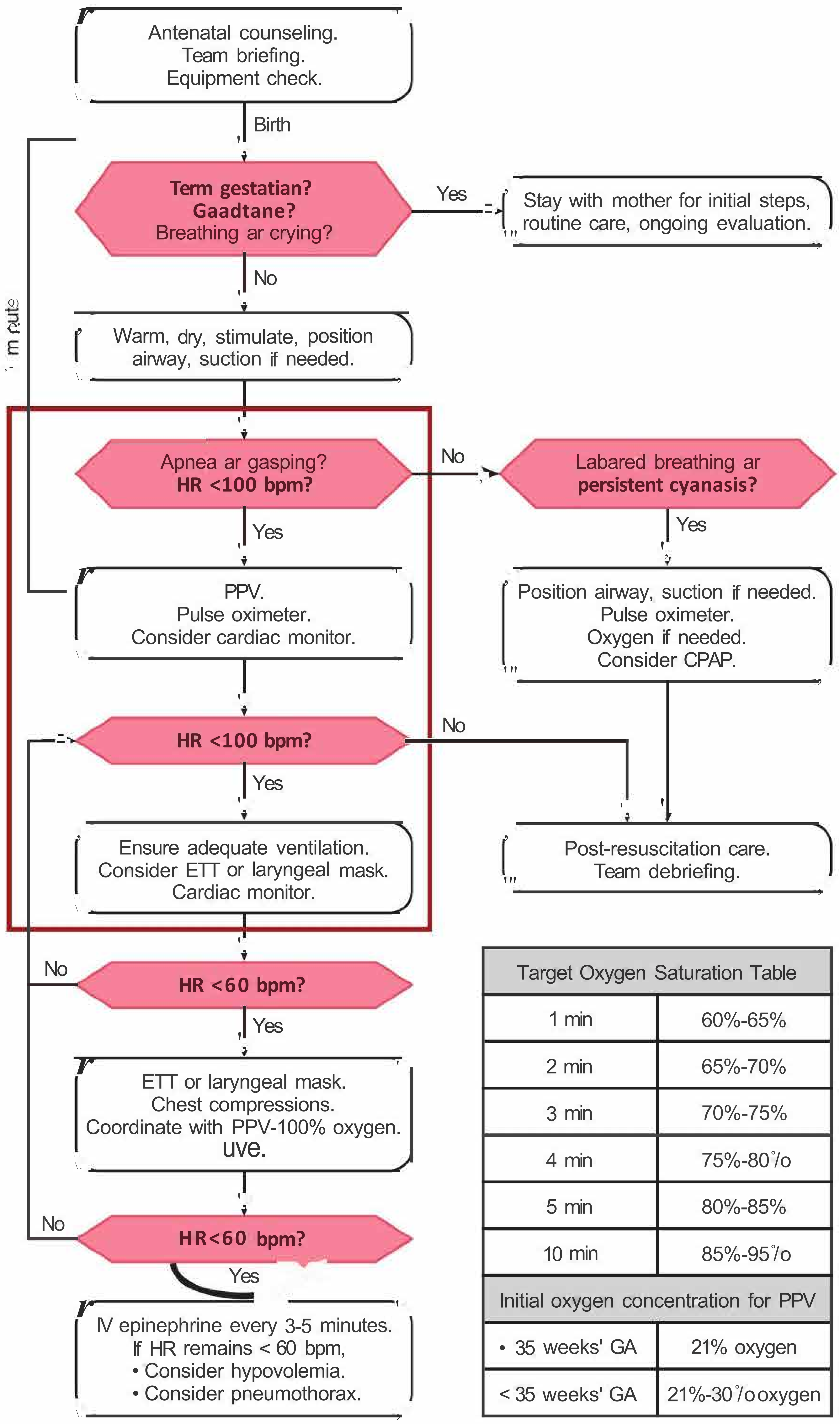
- Know your environment.
- Use available information.
- Anticipate and plan.
- Clearly identify a team leader.
- Communicate effectively.
- Delegate the workload optimally.
- Allocate attention wisely.
- Use available resources.
- Call for additional help when needed.
- Maintain professional behavior.

Positive-Pressure Ventilation

4

What you will learn

- The characteristics of self-inflating bags, flow-inflating bags, and T-piece resuscitators
- When to give positive-pressure ventilation
- How to position the newborn's head for positive-pressure ventilation
- How to place a resuscitation mask on the newborn's face
- How to administer positive-pressure ventilation and assess effectiveness
- How to use ventilation corrective steps
- How to insert a laryngeal mask for positive-pressure ventilation
- How to administer continuous positive airway pressure
- How to insert an orogastric tube



Target Oxygen Saturation Table	
1 min	60%-65%
2 min	65%-70%
3 min	70%-75%
4 min	75%-80%o
5 min	80%-85%
10 min	85%-95%o
Initial oxygen concentration for PPV	
• 35 weeks' GA	21% oxygen
< 35 weeks' GA	21%-30%o oxygen

Key Points

O Ventilation of the newborn's lungs is the single most important and most effective step in neonatal resuscitation.

f) After completing the initial steps, positive-pressure ventilation (PPV) is indicated if the baby is not breathing, <u>OR</u> if the baby is gasping, <u>OR</u> if the baby's heart rate is less than 100 beats per minute (bpm).

E) During PPV, the initial oxygen concentration (Fro$_2$) for newborns greater than or equal to 35 weeks' gestation is 21%. The initial Fro$_2$ for preterm newborns less than 35 weeks' gestation is 21% to 30%.

9 The ventilation rate is 40 to 60 breaths per minute and the initial ventilation pressure is 20 to 25 cm H$_2$0 .

0 The most important indicator of successful PPV is a rising heart rate.

O If the heart rate is not increasing within the first 15 seconds of PPV and you do not observe chest movement, start the ventilation corrective steps.

O The ventilation corrective steps *(MR. SOPA)* are:

a. Mask adjustment.

b. Reposition the head and neck.

c. Suction the mouth and nose.

d. Open the mouth.

e. Pressure increase.

f. Alternative airway.

0 If the baby cannot be successfully ventilated with a face mask and intubation is unfeasible or unsuccessful, a laryngeal mask may provide a successful rescue airway.

f) If the heart rate remains less than 60 bpm despite at least 30 seconds of face-mask PPV that inflates the lungs (chest movement), reassess your ventilation technique, consider performing the ventilation corrective steps, adjust the Fro$_2$ as indicated by pulse oximetry, insert an alternative airway (endotracheal tube or laryngeal mask), and provide 30 seconds of PPV through the alternative airway. After these steps, if the heart rate remains less than 60 bpm, increase the F10$_2$ to 100% and begin chest compressions.

4D) If you continue face-mask PPV or continuous positive airway pressure (CPAP) for more than several minutes, an orogastric tube should be inserted to act as a vent for gas in the stomach.

Case: Resuscitation with positive-pressure ventilation using a resuscitation bag and mask

Your team is called to attend the birth for a woman at 36 weeks' gestation whose pregnancy and labor are complicated by preeclampsia, intrauterine growth restriction, and a Category II fetal heart rate pattern. The amniotic fluid is clear. You complete a pre-resuscitation team briefing and prepare your supplies and equipment. After birth, the obstetrician dries and stimulates the baby, but the baby remains limp and apneic. The umbilical cord is clamped and cut, and the baby is moved to the radiant warmer.

You finish drying the baby, provide brief additional stimulation, and position and clear secretions from the airway, but the baby is still not breathing. Within 1 minute of birth, you start positive-pressure ventilation (PPV) with 21% oxygen (room air). An assistant reports that the baby's heart rate is 70 beats per minute (bpm), not increasing, and the chest is not moving. Another team member places a pulse oximeter sensor on the baby's right hand, places cardiac monitor leads on the baby's chest, and attaches the sensor and leads to the monitors. Another team member documents the events as they occur.

You initiate the ventilation corrective steps. First, you reapply the mask to the face and reposition the baby's head and neck. You restart PPV while your assistant watches the newborn's chest. After several breaths, the assistant reports that there is still no chest movement. You suction the mouth and nose and open the baby's mouth. Again, you start PPV, but there is still no chest movement. You gradually increase the inflation pressure and the assistant calls out, *"The chest is moving now:'* Within 30 seconds of achieving ventilation that inflates the baby's lungs, the baby's heart rate is greater than 100 bpm and oxygen saturation is 64%. The assistant adjusts the oxygen concentration (FIO_2) to maintain the baby's oxygen saturation within the target range.

You continue PPV while monitoring the baby's respiratory effort. The baby begins to breathe, and you gradually decrease the ventilation rate. When the baby is 4 minutes of age, there is good spontaneous breathing effort, the heart rate is 140 bpm, and oxygen saturation is 85%. You discontinue PPV and monitor the baby's oxygen saturation. While your team prepares to move the baby to the nursery for post-resuscitation care, you explain the next steps to the mother. Shortly afterward, you meet with your team and conduct a debriefing to evaluate your preparation, teamwork, and communication.

Why does the Neonatal Resuscitation Program® focus on positive-pressure ventilation?

Ventilation of the newborn's lungs is the single most important and effective step in neonatal resuscitation. Learning how to provide PPV is the foundation of neonatal resuscitation. This lesson focuses on assisted ventilation through a face mask and laryngeal mask. The next lesson describes how to provide ventilation through an endotracheal tube.

What is the common terminology used to describe positive-pressure ventilation?

Several terms and abbreviations are used to describe PPV (Figure 4.1).

- *Peak inflation pressure (PIP):* The highest pressure administered with each breath
- *Positive end-expiratory pressure (PEEP):* The gas pressure maintained in the lungs between breaths when the baby is receiving **assisted breaths**
- *Continuous positive airway pressure (CPAP):* The gas pressure maintained in the lungs between breaths when a baby is **breathing spontaneously**
- *Rate:* The number of assisted breaths administered per minute
- *Inflation time (IT):* The time duration (seconds) of the inflation phase of each positive-pressure breath
- *Manometer:* A gauge used to measure gas pressure

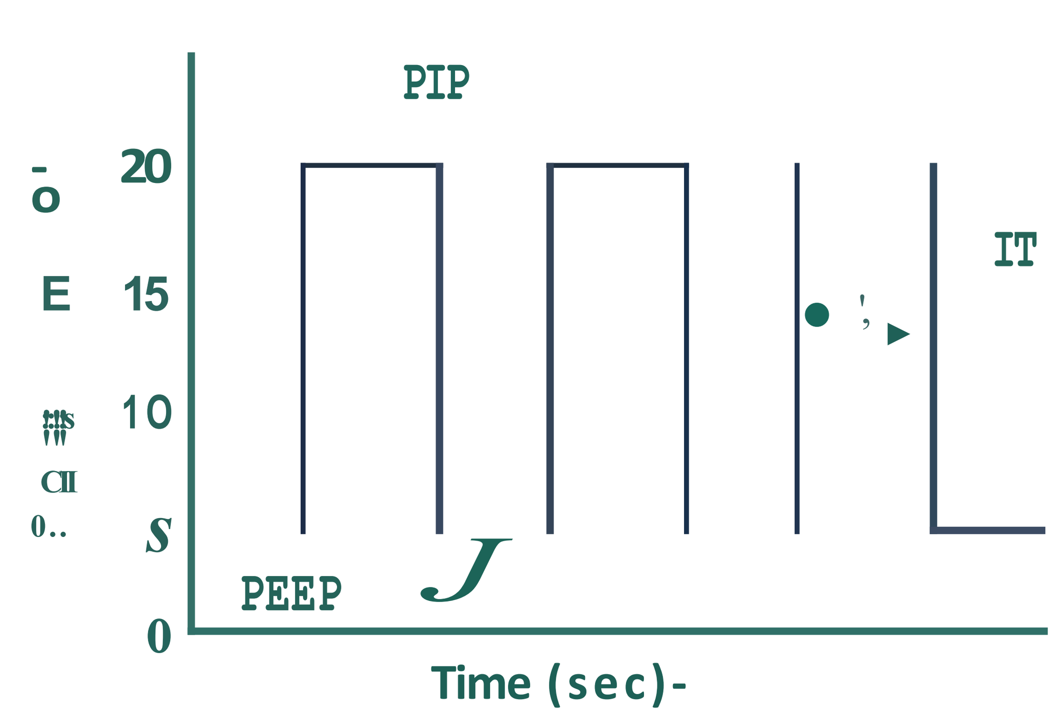


Figure 4.1. Pressure tracing during 3 positive-pressure breaths. PIP = peak inflation pressure, PEEP = positive end-expiratory pressure, IT = inflation time.

Figure 4.2. Self-inflating bag

Figure 4.3. Flow-inflating bag

Figure 4.4. T-piece resuscitator

What are the different types of resuscitation devices used to ventilate newborns?

Three types of devices are commonly used for ventilation.

- A ***self-inflating bag*** fills spontaneously with gas (air, oxygen, or a blend of both) after it has been squeezed and released (Figure 4.2).
- A ***flow-inflating bag*** (also called an anesthesia bag) only fills when gas from a compressed source flows into it and the outlet is sealed (Figure 4.3).
- A ***T-piece resuscitator*** continuously directs compressed gas toward the baby. Pressure increases when an opening on the top of the T-shaped device is occluded (Figure 4.4).

Find out what kind of resuscitation device is used in your hospital. If your hospital uses flow-inflating bags or T-piece resuscitators, you should still learn how to use a self-inflating bag. A self-inflating bag should be readily available as a backup wherever resuscitation may be needed in case compressed gas is not available. The 3 devices are briefly described in the following text. Additional details are found in the Appendix to this lesson. You should read those sections of the Appendix that apply to the devices used in your hospital.

Self-inflating bags

A self-inflating bag remains fully inflated unless it is being squeezed (Figure 4.5). Once you release the bag, it recoils and draws fresh gas into the bag. If the bag is attached to an oxygen source, it fills with gas at the supplied $F10_2$. If the bag is not attached to an oxygen source, it fills by drawing room air (21% oxygen) into the bag.

Because the bag self-inflates, it <loes not require compressed gas or a tight seal at the outlet to remain inflated.

- The ventilation rate is determined by how often you squeeze the bag and the inflation time is determined by how quickly you squeeze the bag.
- PIP is controlled by how hard the bag is squeezed.
- PEEP may be administered if an additional valve is attached to the bag.
- Because gas does not flow out of the mask unless the bag is being squeezed, a self-inflating bag and mask **cannot** be used to administer CPAP or free-flow oxygen.
- Free-flow oxygen may be administered through the open reservoir ("tail") on sorne self-inflating bags.

Most self-inflating bags have a pressure-release valve, also called a pop-off valve, which limits the peak pressure. These valves are usually set to release at 30 to 40 cm H_2O pressure, but they are not reliable and may not release until higher pressures are achieved. Sorne self-inflating bags have a device that allows the pressure-release valve to be temporarily occluded, allowing higher pressures to be administered. Occluding the pop-off valve should be an unusual occurrence and care must be taken not to use excessive pressure.

Figure 4.5. Self-inflating bags with a closed reservoir (A) and an open "tail" reservoir (B). Both bags reinflate automatically without compressed gas.

To ensure the appropriate pressure is used, a manometer should always be used. The manometer may be built into the bag or there may be an attachment site for an externa! manometer. If the attachment site is left open without a manometer attached, it will cause a large gas leak and prevent the baby from receiving the desired inflation pressure.

Testing a self-inflating bag during the equipment check and before use

Block the mask or gas outlet with the palm of your hand and squeeze the bag (Figure 4.6).

Figure 4.6. Testing a self-inflating bag

Testing a self-inflating bag

Block the mask or gas outlet and squeeze the bag.

- Do you feel pressure against your hand?
- Does the manometer register pressure?
- Does the pressure-release valve open when the manometer registers 30 to 40 cm H_2O pressure?
- Does the bag reinflate quickly when you release your grip?

If no,

- Is there a crack or leak in the bag?
- Is the manometer missing, resulting in an open attachment site?
- Is the pressure-release valve missing or blocked?

Flow-inflating bags

A flow-inflating bag inflates only when a compressed gas source is flowing into the bag and the outlet is sealed, such as when the mask is applied to a baby's face (Figure 4.7A). If compressed gas is not flowing into the bag or the outlet is not sealed, the bag collapses and looks like a deflated balloon (Figure 4.7B).

- The ventilation rate is determined by how often you squeeze the bag and the inflation time is determined by how quickly you squeeze and release the bag.
- PIP is controlled by how hard the bag is squeezed and the balance between the amount of gas flowing into the bag and the gas escaping through an adjustable flow-control valve.

- PEEP, CPAP, and free-flow oxygen can be administered with a flow-inflating bag and are adjusted by the balance between the gas flow into the bag and the gas escaping through the flow-control valve.

Similar to a self-inflating bag, a manometer should always be used to accurately measure the gas pressure. If the manometer attachment site is left open, it will cause a large leak and prevent the flow-inflating bag from filling.

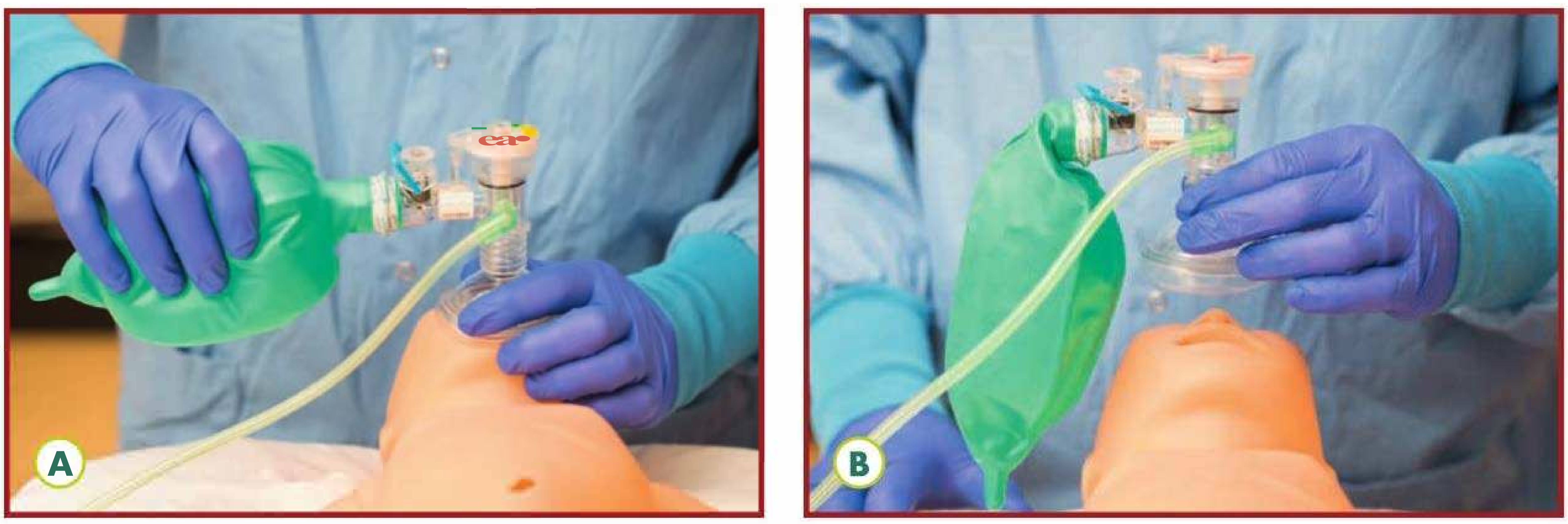


Figure 4.7. Flow-inflating bag inflated with compressed gas and a seal against the baby's face (A). If compressed gas is not flowing into the bag or the outlet is not sealed, the bag collapses (B).

Testing a flow-inflating bag during the equipment check and before use

Block the mask or gas outlet with the palm of your hand and squeeze the bag (Figure 4.8).

Figure 4.8. Testing a flow-inflating bag

Testing a flow-inflating bag

Block the mask or gas outlet.

- Does the bag fill properly?
- Adjust the flow-control valve to read 5 cm H_2O PEEP.

Squeeze the bag 40 to 60 times per minute.

- Does the bag reinflate quickly when you release your grip?
- Adjust the flow-control valve to read 30 to 40 cm H_2O when squeezed firmly.
- Check to be sure that the pressure still reads 5 cm H_2O when not being squeezed (PEEP).

If the bag does not fill correctly,

- Is there a crack or hole in the bag?
- Is the flow-control valve open too far?
- Is the manometer attached?
- Is the gas tubing connected securely?
- Is the gas outlet sufficiently blocked?

T-piece resuscitators

A T-piece resuscitator is a mechanical device that uses valves to regulate the flow of compressed gas directed toward the patient (Figure 4.9). Similar to the flow-inflating bag, the device requires a compressed gas source. A breath is delivered by using a finger to alternately occlude and release a gas escape opening on the top of the T-piece cap. When the opening is occluded, gas is directed through the device and toward the baby. When the opening is released, sorne gas escapes through the cap. The position and function of control dials on the T-piece resuscitator may vary by manufacturer. The operation of one example is described below.

- The ventilation rate is determined by how often you occlude the opening on the cap and the inflation time is controlled by how long the opening is occluded.
- There are 2 control dials that are used to limit the inflation pressure. The *peak inflation pressure* control limits the peak pressure during each assisted breath. The *maximum pressure relief control* is a safety feature, similar to the pop-off valve on a self-inflating bag, which prevents the user from increasing the peak pressure beyond a preset value. This control dial may be covered by a removable shield.
- An adjustable dial on the T-piece cap controls how much gas is allowed to escape between breaths and, therefore, adjusts the PEEP and CPAP.
- A built-in manometer measures the inflation and expiratory pressure.

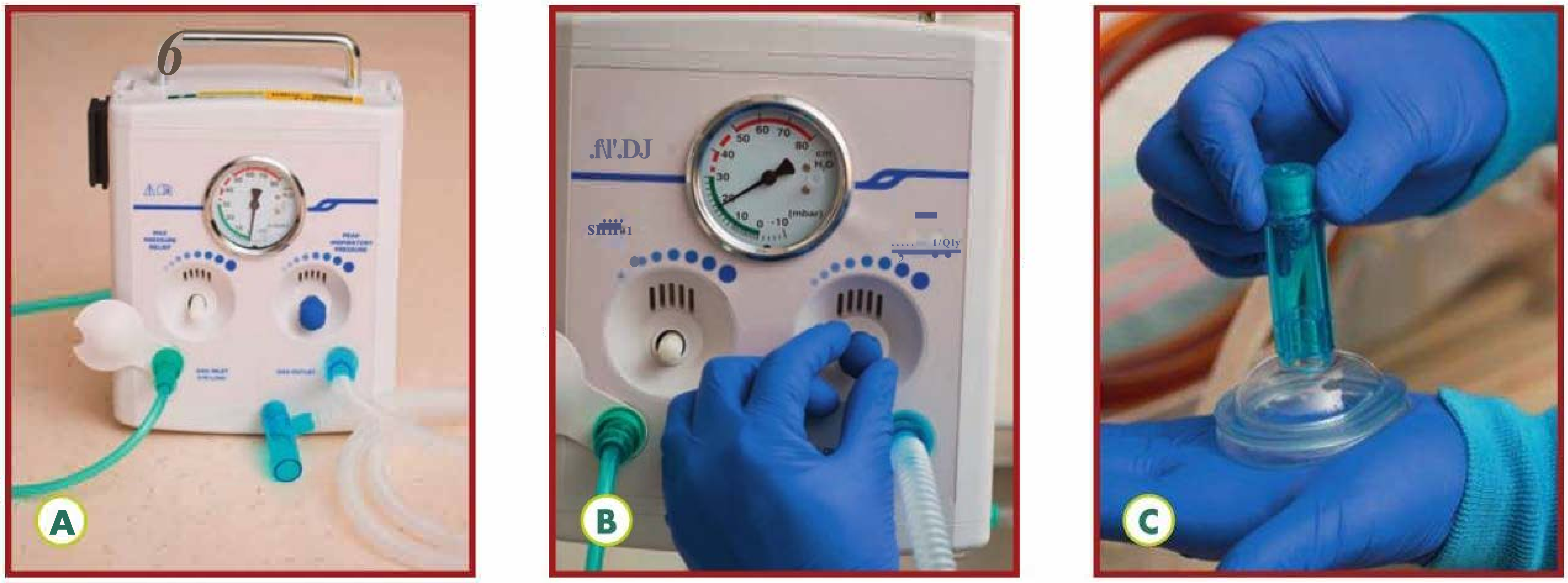


Figure 4.9. An example of a T-piece resuscitator (A). The T-piece resuscitator's pressure is controlled by adjustable valves. PIP is adjusted by a dial on the machine (B) and PEEP is controlled by a dial on the T-piece cap (C).

Testing a T-piece resuscitator during the equipment check and before use

Block the mask or gas outlet with the palm of your hand or occluding cap. First leave the opening on the T-piece cap open, then occlude the opening with your finger (Figure 4.10).

Testing a T-piece resuscitator

Block the mask or T-piece gas outlet without occluding the opening on the T-piece cap.

- Does the PEEP read 5 cm H_2O ?

Occlude the opening on the T-piece cap.

- Does the peak pressure read 20 to 25 cm H_2O ?

If the pressure is not correct,

- Is the T-piece gas outlet sealed?
- Is the gas tubing connected to the gas inlet?
- Is the gas flow set at 10 L/min?
- Is the gas outlet (proximal) disconnected?
- Is the maximum circuit pressure, PIP, or PEEP incorrectly set?

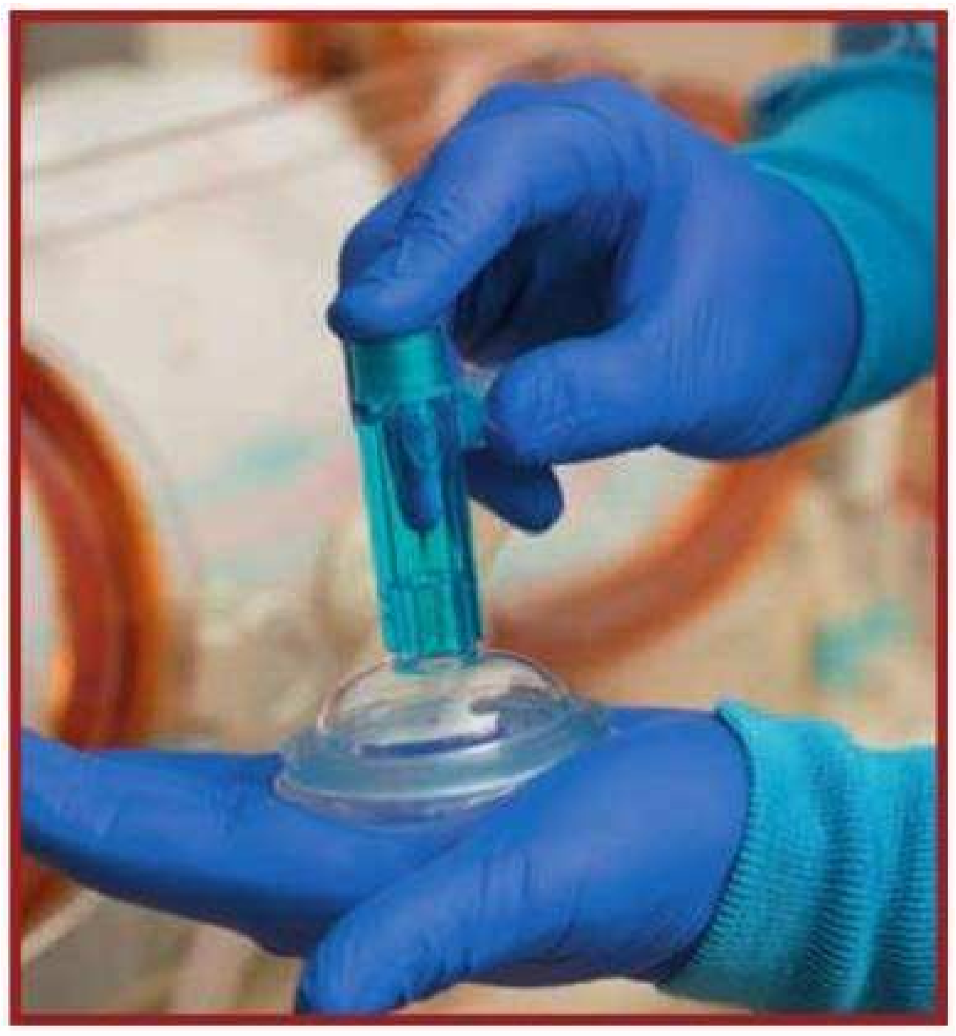


Figure 4.10. Testing a T-piece resuscitator

What are the indications for positive-pressure ventilation?

After completing the initial steps, PPV is indicated *if the baby is not breathing (apneic), OR if the baby is gasping, OR if the baby's heart rate is less than 100 bpm* (Figure 4.11). When indicated, PPV should be started within 1 minute of birth.

In addition, a trial of PPV may be considered if the baby is breathing and the heart rate is greater than or equal to 100 bpm, but the baby's oxygen saturation cannot be maintained within the target range despite free-flow oxygen or CPAP.

Immediately call for help if you are alone. Your assistant(s) will monitor the heart rate response to PPV, watch for chest movement, monitor the baby's oxygen saturation with pulse oximetry, and document events as they occur.

How do you prepare to begin positive-pressure ventilation?

Position yourself at the radiant warmer.

The person responsible for positioning the airway and holding the mask on the baby's face is positioned at the baby's head (Figure 4.12). It is difficult to maintain the head, neck, and mask in the correct position when standing at the side or foot of the bed. Team members at the side of the bed are better positioned to assess chest movement, listen to heart rate and breath sounds, and assist with pulse oximeter and cardiac monitor placement.

Complete the initial steps of newborn care.

If not done already, suction the mouth and nose to be certain that secretions will not obstruct PPV.

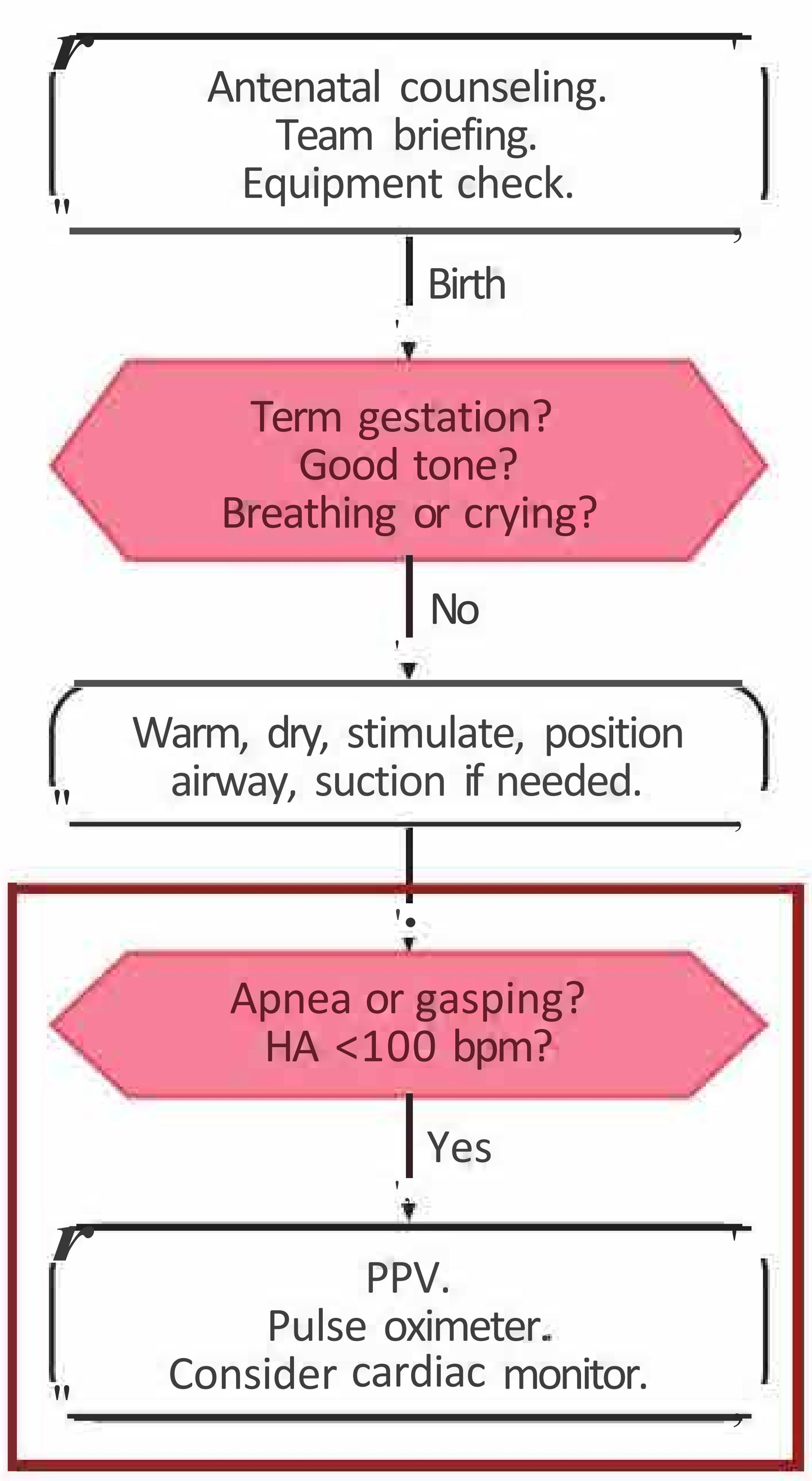


Figure 4.11. Indications for PPV

Figure 4.12. Position yourself at the baby's head to provide assisted ventilation.

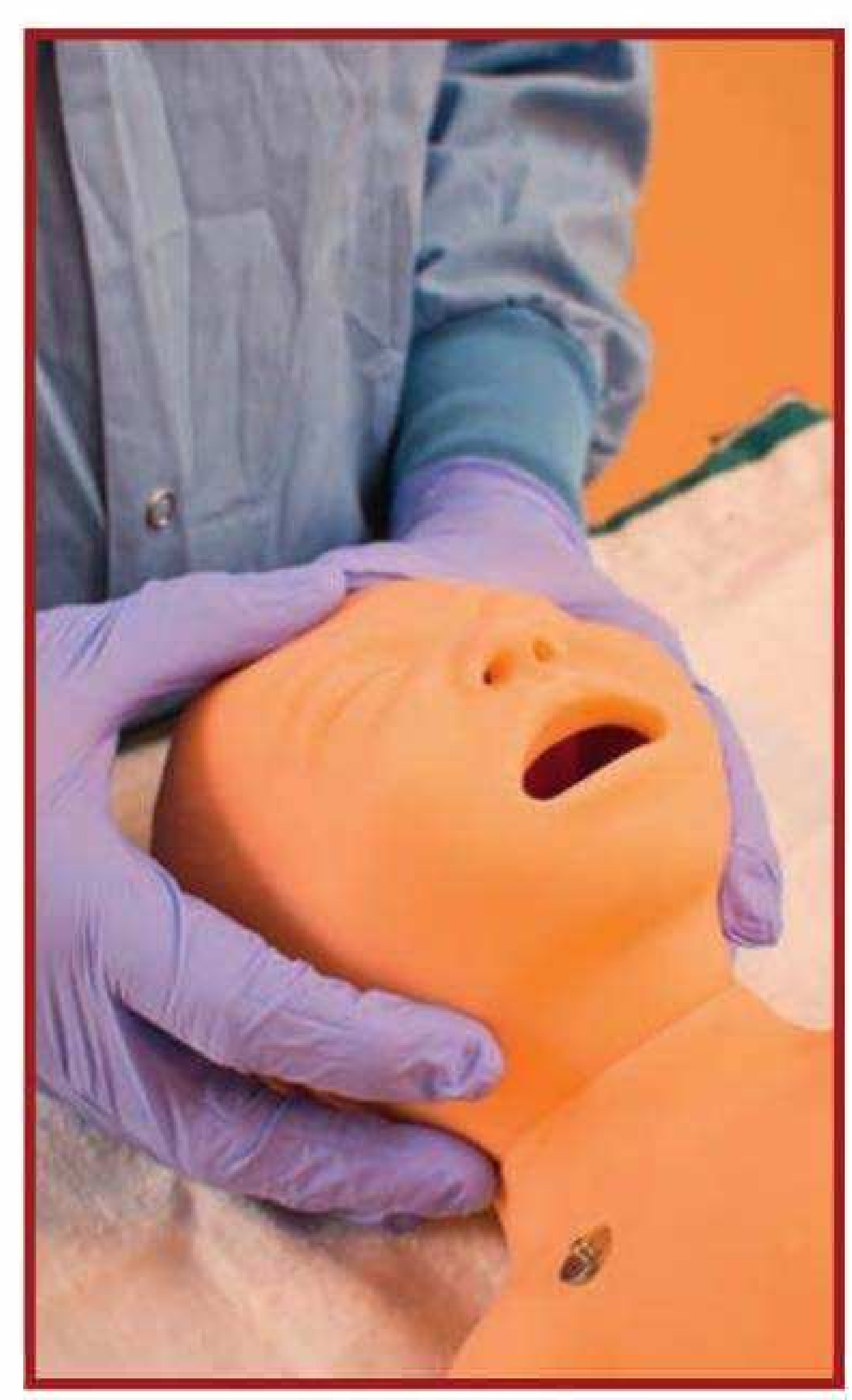


Figure 4.13. The sniffing position

Position the baby's head and neck for positive-pressure ventilation.

The baby's head and neck should be positioned midline and neutral, or slightly extended, in the sniffing position so that the baby's eyes are directed straight upward toward the ceiling (Figure 4.13). Improper positioning is one of the most common reasons for ineffective mask ventilation. The airway will be obstructed if the neck is excessively flexed or extended. Because the back of a newborn's head (occiput) is prominent, it may be helpful to lift the shoulders slightly by placing a rolled towel or small blanket under the baby's shoulders (Figure 4.14).

Figure 4. 14. Shoulder roll used to position the head and neck

How do you position the mask on the baby's face?

Select the correct mask.

A variety of mask sizes should be available at every birth. Neonatal masks have a cushioned or soft pliable rim and con1e in 2 shapes-anaton1ically shaped and round (Figure 4.15). Anatomically shaped masks are placed with the pointed part of the mask over the nose. The mask should rest on the chin and cover the mouth and nose, but not the eyes. The correct mask will create a tight seal on the face. If the rim of a cushioned mask is improperly inflated, it may be difficult to achieve a good seal.

Place the mask on the baby's face.

An airtight seal between the rim of the mask and the face is necessary to achieve the pressure that will inflate the lungs. Ventilation will not be successful if there is a large air leak from an improperly placed mask.

Figure 4.1 5. Correctly sized anatomic (A) and round (B) masks

One-Hand Hold

- Begin by cupping the chin in the bottom of an anatomic mask and then bring the mask over the mouth and nose (Figure 4.16).
- The bottom of the mask should rest on the chin, not below it. The tip of the mask should rest at or just below the nasal bridge to avoid putting pressure on the baby's eyes or causing a large leak around the eyes.
- Hold the mask on the face with the thumb and index finger encircling the rim.
- Place the other 3 fingers under the bony angle of the jaw and gently lift the jaw upward toward the mask.
- Once the mask is positioned, an airtight seal can be formed by using even, downward pressure on the rim of the mask while holding the head in the sniffing position (Figure 4.17).

Sorne round masl(s are designed to be placed directly over the nose and mouth and held in place by the stem rather than the rim (Figure 4.18). If you apply pressure to the rim of this type of mask, the mask shape will be deformed and will leak.

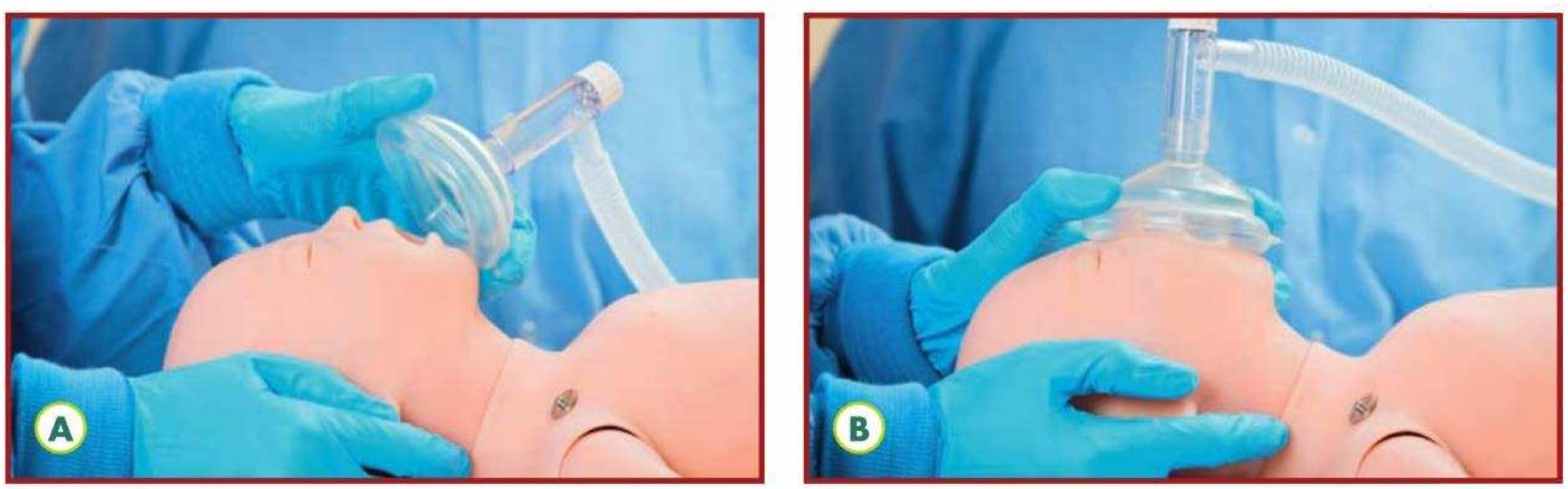


Figure 4.16. (A) Cup the chin in the anatomic mask. (B) Bring the mask over the mouth and nose.

Figure 4.1 7. Maintaining a seal with the 1-hand hold using an anatomic mask

Figure 4.1 8. Maintaining a seal with the 1-hand hold by holding only the stem of a round mask

Two-Hand Hold With Jaw Thrust

It can be difficult to maintain a good seal and the correct head position with 1 hand. If you cannot achieve a good seal, use both hands to hold the mask and lift the jaw.

- Use the thumb and first finger of both hands to hold the mask against the face.
- Place the other 3 fingers of each hand under the bony angle of the jaw and gently lift the jaw upward toward the mask (Figure 4.19).
- While you concentrate on making a good seal and maintaining the correct midline head position, another team member stands at the baby's side and squeezes the bag or occludes the T-piece cap.
- A third person monitors the baby's response.

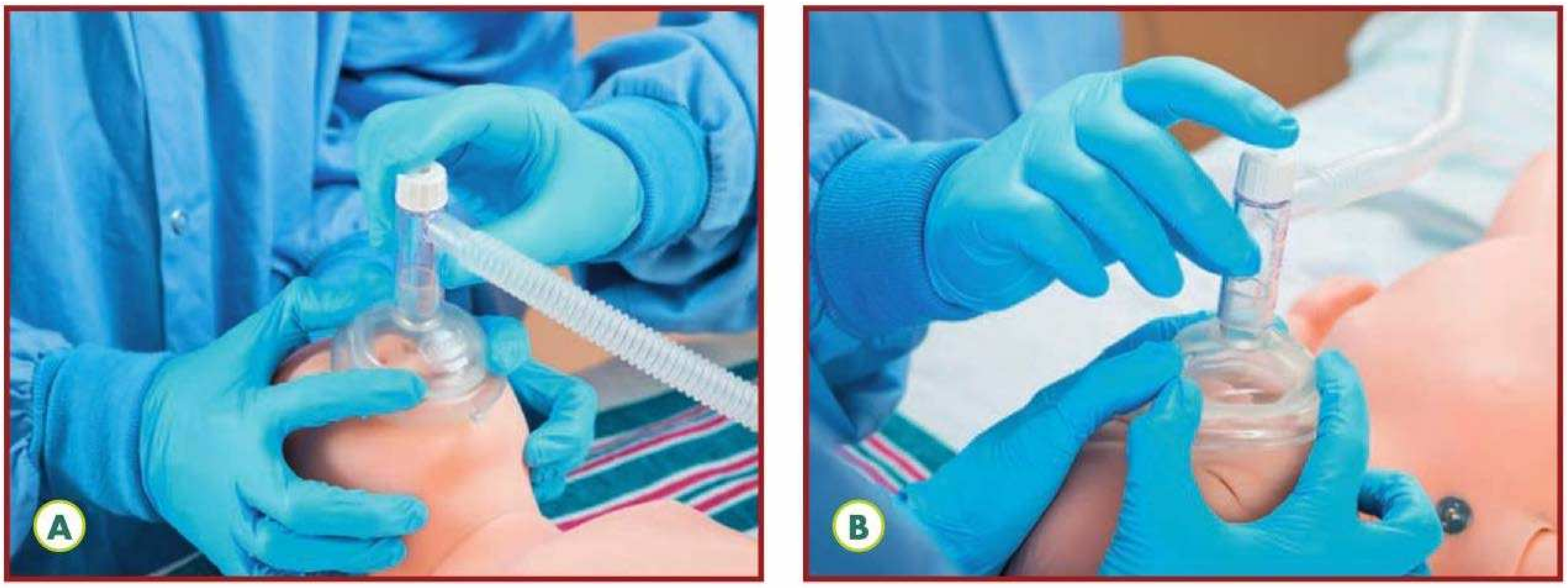


Figure 4.19. Two-hand hold with jaw thrust. An assistant delivers the breath.

Precautions

Care must be taken when holding the mask.

- Do not "jam" the mask down on the face or occlude the nasal passages. Too much pressure can obstruct the mask, cause air to leak around the side of the mask, inadvertently flex the baby's neck, or bruise the face.
- Be careful not to rest your hand on the baby's eyes.
- Be careful not to compress the soft tissue of the baby's neck.
- Recheck the position of the mask and the baby's head at intervals to make sure they are still correctly positioned.

Figure 4.20. Flowmeter (left) set to 10 L/min. Adjust blender to desired FIO_2.

Table 4-1. Target Pre-Ductal Oxygen Saturation

Target Oxygen Saturation Table	
1 min	60%-65%
2 min	65%-70%
3 min	70%-75%
4 min	75%-80%
5 min	80%-85%
10 min	85%-95%
Initial Oxygen Concentration for PPV	
≥35 weeks' GA	21% oxygen
< 35 weeks' GA	21%-30% oxygen

What concentration of oxygen should be used to start positive-pressure ventilation?

Studies have shown that resuscitation started with 21% oxygen in term and late preterm newborns, and 21% to 30% oxygen in preterm newborns, is just as effective as resuscitation started with 100% oxygen. To balance the hazards possibly associated with extremes of oxygenation, this program recommends attempting to maintain an oxygen saturation, measured with pulse oximetry, close to the saturation measured in healthy babies born at term. Before birth, the fetus has a blood oxygen saturation of approximately 60%. After birth, the oxygen saturation gradually increases above 90%. However, even healthy term newborns may take 10 minutes or longer to reach this saturation.

- For the initial resuscitation of newborns **greater than or equal to 35 weeks' gestation,** set the blender to **21% oxygen** (Figure 4.20).
- For the initial resuscitation of newborns **less than 35 weeks' gestation,** set the blender to **21% to 30% oxygen.**
- Set the flowmeter to **10 L/minute** (Figure 4.20).
- An assistant should place a pulse oximeter sensor on the right hand or wrist as soon as possible after PPV is started. Once the pulse oximeter is reading reliably, compare the baby's pre-ductal oxygen saturation with the range of target values summarized in Table 4-1 and adjust the FIO_2 as needed.

What ventilation rate should be used during positive-pressure ventilation?

Breaths should be given at a rate of ***40 to 60 breaths per minute.***

- Count out loud to help maintain the correct rate.
- Use the rhythm, "**Breathe,** *two, three;* **breathe,** *two, three;* **breathe,** *two, three."*
- Say "Breathe" as you squeeze the bag or occlude the T-piece cap and release while you say "two, three."

How much pressure should be used to start positive-pressure ventilation?

After birth, fetal lung fluid within the alveoli must be replaced with air for gas exchange to occur. If the baby has not taken a spontaneous breath, the first few assisted breaths may require higher than usual pressure to move fluid out of the air spaces and inflate the alveoli.

However, excessively high lung volumes and airway pressures can cause lung injury. The goal is to use just enough pressure to ínflate and aerate the lungs so that the heart rate and oxygen saturation increase (Table 4-2).

- Start with a **PIP of 20 to** 25 **cm** $\mathbf{H_20}$.
- Full-term babies may require a higher inflation pressure for the first few breaths to ínflate their lungs. After the initial inflating breaths, you may be able to decrease the inflation pressure.
- Administering PEEP with the initial inflating breaths helps to achieve stable lung inflation more quickly, remove fluid, and prevent the air spaces from collapsing during exhalation. **When PEEP is used, the suggested initial setting is 5 cm** H_20 .

Once you ínflate the lungs, you should see a gentle rise and fall of the chest with each breath. If the baby appears to be taking very deep breaths during PPV, you are probably using too much pressure and the lungs may become overinflated. This increases the risk of producing an air leak within the lung (pneumothorax). Remember that the volume of a normal breath is much smaller than the amount of gas in a typical resuscitation bag.

If the baby is preterm, visual assessment of chest movement may be less reliable and there may be a greater risk of injury from overinflation. It is possible to achieve successful ventilation without apparent chest movement. Additional details about providing assisted ventilation to preterm newborns are included in Lesson 8.

Table 4-2. Initial Settings for Positive-Pressure Ventilation

	Component	Initial Setting
Oxygen concentration	≥ 35 weeks' gestation < 35 weeks' gestation	21% 21%-30%
Gas flow		10 L/minute
Rote		40-60 breaths/minute
PIP		20-25 cm H_20
PEEP		5 cm H_20

How do you evaluate the baby's response to positive-pressure ventilation?

The most important indicator of successful PPV is a rising heart rate. When you start PPV, an assistant will monitor the baby's heart rate response. The initial heart rate assessment may be made with a stethoscope. Once PPV begins, an assistant should apply a pulse oximeter sensor to continuously assess the baby's oxygen saturation and heart rate. Continuous monitoring with a cardiac monitor may be considered. If PPV was started because the baby had a low heart rate, it should improve rapidly.

- Within 15 seconds of starting PPV, the baby's heart rate should be increasing.
- Within 30 seconds of starting PPV, the baby's heart rate should be greater than 100 bpm.

If the baby's **heart rate is increasing** after the first 15 seconds, continue PPV. You will check the response again after 30 seconds of PPV.

If the baby's **heart rate is not increasing** after the first 15 seconds, ask your assistant if the chest is moving.

- **If the chest is moving,** continue PPV while you monitor your ventilation technique. You will check the baby's response again after 30 seconds of PPV.
- **If the chest is NOT moving,** you may not be ventilating the baby's lungs. Perform the ventilation corrective steps described below until you achieve chest movement with PPV.

What are the MR. SOPA ventilation corrective steps?

The ventilation corrective steps are a series of adjustments that you will make if the baby's heart rate is not improving and the chest is not moving. The most likely reasons for ineffective mask ventilation are leak around the mask, airway obstruction, and insufficient ventilating

Table 4-3. The MR. SOPA Ventilation Corrective Steps

	Corrective Step	Actions
M	Mask adjustment.	Reapply the mask and lift the jaw forward. Consider the 2-hand hold.
R	Reposition the head and neck.	Place head neutral or slightly extended.
Give 5 breaths and assess chest movement. If no chest movement, do the next steps.		
S	Suction the mouth and nose.	Use a bulb syringe or suction catheter.
O	Open the mouth.	Use a finger to gently open the mouth.
Give 5 breaths and assess chest movement. If no chest movement, do the next step.		
P	Pressure increase.	Increase in 5-10 cm H_2O increments to maximum recommended pressure. • Max 40 cm H_2O term • Max 30 cm H_2O preterm
Give 5 breaths and assess chest movement. If no chest movement, do the next step.		
A	Alternative airway.	Insert a laryngeal mask or endotracheal tube.
Try PPV and assess chest movement and breath sounds.		

pressure. The ventilation corrective steps address these common problems and are summarized in Table 4-3.

You may use the MR. SOPA mnemonic to remember the 6 steps in order.

- Mask adjustment.
- Reposition the head and neck.
- Suction the 1nouth and nose.
- Open the mouth.
- Pressure increase.
- Alternative airway.

You will perform the corrective steps sequentially until you achieve chest movement with assisted breaths.

Figure 4.21 • Inadequate mask seal on the face may result in ineffective ven tilation. Ai r lea k between the cheek and bridge of the nose is common.

Mask adjustment.

Reapply the mask to the face to form a better seal. Indicators of a good seal while using a T-piece resuscitator and flow-inflating bag include achieving the desired PIP, maintaining the desired PEEP on the manometer, and rapid reinflation of a flow-inflating bag between breaths.

- If a leak is present, lift the jaw upward but do not press down hard on the baby's face. You may need to use a little more pressure on the rim of an anatomic mask.
- The most common place for a leak to occur is between the cheek and bridge of the nose (Figure 4.21).
- If you continue to have difficulty achieving a tight seal, use the **2-hand hold** described previously.

Reposition the head and neck.

The airway may be obstructed because the neck is flexed too far forward or is overextended. Reposition the baby's head and neck to ensure that it is midline and neutral or slightly extended (the sniffing position).

Once you have adjusted the mask and repositioned the head and neck, try PPV again and assess chest movement. If the chest is not moving, proceed to the next 2 corrective steps.

Suction the mouth and nose.

Suction the mouth and nose with a bulb syringe. The airway may be blocked by thick secretions. In unusual situations, thick secretions may be blocking the trachea, and tracheal intubation for suction may be required.

Open the mouth.

Opening the baby's mouth may decrease the resistance to airflow during PPV. Use your finger to open the baby's mouth and reapply the mask.

After suctioning the mouth and nose and opening the mouth, try PPV again and assess chest movement. If the chest is still not moving, proceed to the next step.

Pressure increase.

Although you have an adequate seal and an open airway, inflating the baby's lungs may require a higher inflation pressure.

- Use the manometer to guide adjustments of the inflation pressure. Increase the pressure by 5 to 10 cm H_20 increments until you achieve chest movement.
- The maximum recommended pressure with face-mask ventilation is 40 cm H_20 for a term newborn and 30 cm H_20 for a preterm newborn.

After each pressure increase, try PPV again and assess the chest movement. If the chest is not moving with the maximum recommended pressure, proceed to the next step.

Alternative airway.

Mask ventilation is not always sufficient to inflate the lungs. If you have completed the first 5 corrective steps and you still cannot achieve chest movement, you should insert an alternative airway such as a laryngeal mask or endotracheal tube. Once an alternative airway is inserted, begin PPV and evaluate the baby's chest movement and breath sounds. Instructions for inserting a laryngeal mask are included in this lesson. Endotracheal intubation is addressed in Lesson 5.

The baby's chest started moving after one of the ventilation corrective steps. Now what do you do?

Once you achieve chest movement with each assisted breath, announce, ***"The chest is moving NOW"*** This ensures that your team is aware of your assessment and knows that additional MR. SOPA steps are not necessary.

Continue PPV that moves the chest for 30 seconds while you monitor your ventilation rate, pressure, and the baby's heart rate response.

If you have difficulty maintaining chest movement during this time, repeat the ventilation corrective steps as needed. Insert an alternative airway if you have persistent difficulty maintaining effective ventilation with a face mask.

What do you do after 30 seconds of positive-pressure ventilation that ventilates the lungs?

After 30 seconds of PPV that ventilates the lungs, as indicated by an increasing heart rate or chest movement, you will check the baby's heart rate response again.

- **The heart rate is greater than or equal to 100 bpm.**

  Assisted ventilation has been successful.

  - Continue ventilating at a rate of 40 to 60 breaths per minute.
  - Monitor the baby's chest movement, heart rate, and respiratory effort.
  - Adjust the FIO_2 as needed based on pulse oximetry.
  - When the heart rate is consistently greater than 100 bpm, gradually reduce the rate of PPV, observe for effective spontaneous respirations, and gently stimulate the baby to breathe.
  - Positive-pressure ventilation may be discontinued when the baby has a heart rate continuously greater than 100 bpm and sustained spontaneous breathing.

- **The heart rate is at least 60 bpm but less than 100 bpm.**

  If the heart rate is improving, continue to administer PPV as long as the baby is showing steady improvement. Monitor the oxygen saturation and adjust the FIO_2 to meet the target saturation range indicated in the table.

  If the heart rate **is not** improving, consider each of the following:

  - Quickly reassess your ventilation technique. Is the chest moving? Are you ventilating at a rate of 40 to 60 breaths/minute? Do you hear breath sounds? If necessary, perform the ventilation corrective steps.
  - Adjust the FIO_2 to meet the target saturation.
  - If not already done, consider placing cardiac monitor leads for continuous monitoring.
  - If not already done, consider inserting a laryngeal mask or endotracheal tube.
  - If available, call for additional expertise to help problem solve this situation.

- **The heart rate is less than 60 bpm.**

  This uncommon situation occurs when the heart cannot respond to ventilation alone and requires additional support to bring oxygenated blood to the coronary arteries.

Consider each of the following:

- Quickly reassess your ventilation technique. Is the chest moving? Are you ventilating at a rate of 40 to 60 breaths/minute? Do you hear breath sounds? If necessary, perform ventilation corrective steps.
- If the pulse oximeter has a reliable signal, adjust the FiO_2 to meet the target saturation.
- If not already done, place cardiac monitor leads and begin continuous monitoring.
- If not already done, insert a laryngeal mask or endotracheal tube.
- If available, call for additional expertise to help problem solve this situation.
- If the baby's heart rate remains less than 60 bpm after at least 30 seconds of PPV that moves the chest, preferably through an alternative airway, increase the FiO_2 to 100% and begin chest compressions as described in Lesson 6.

While performing the ventilation corrective steps, can a carbon dioxide detector help assess the effectiveness of ventilation?

Using a carbon dioxide (CO_2) detector during the ventilation corrective steps can provide a visual cue that helps you and your team identify when you have achieved ventilation that inflates and aerates the lungs. Place a CO_2 detector between the PPV device and mask. If the lungs are being effectively ventilated and gas exchange is occurring, CO_2 should be exhaled through the mask.

Figure 4.22. Carbon dioxide detector used with face mask during ventilation corrective steps. Yellow color on the device as shown suggests ventilation of the lungs.

- If you are effectively ventilating the lungs, you should see the detector turn yellow during each exhalation (Figure 4.22).
- If the CO_2 detector is purple and turns yellow after a corrective step, the step was effective and the baby's heart rate will likely improve quickly.
  - If the CO_2 detector <loes not turn yellow, your face-mask ventilation attempts may not be ventilating the lungs.
  - If the detector remains purple after the first 5 corrective steps and the heart rate has not improved, it may be another indication that you have not achieved effective ventilation and an alternative airway is needed.
- **Caution:** If the baby's heart rate is very low or not pumping blood, the detector may not change color because CO_2 is not being carried to the lungs even though you are ventilating the lungs.

What is a laryngeal mask?

Figure 4.23. Examples of neonatal laryngeal masks

A laryngeal mask is a small mask attached to an airway tube (Figure 4.23). The mask is inserted into the baby's mouth and advanced into the throat until it makes a seal over the entrance to the baby's trachea (the glottis) (Figure 4.24). The laryngeal mask makes a better seal than a face mask and may improve the effectiveness of ventilation. Unlike endotracheal intubation, no instruments are required to insert a laryngeal mask and you do not need to visualize the baby's vocal cords during insertion. If the baby cannot be successfully ventilated with a face mask and intubation is unfeasible or unsuccessful, a laryngeal mask may provide a successful rescue airway.

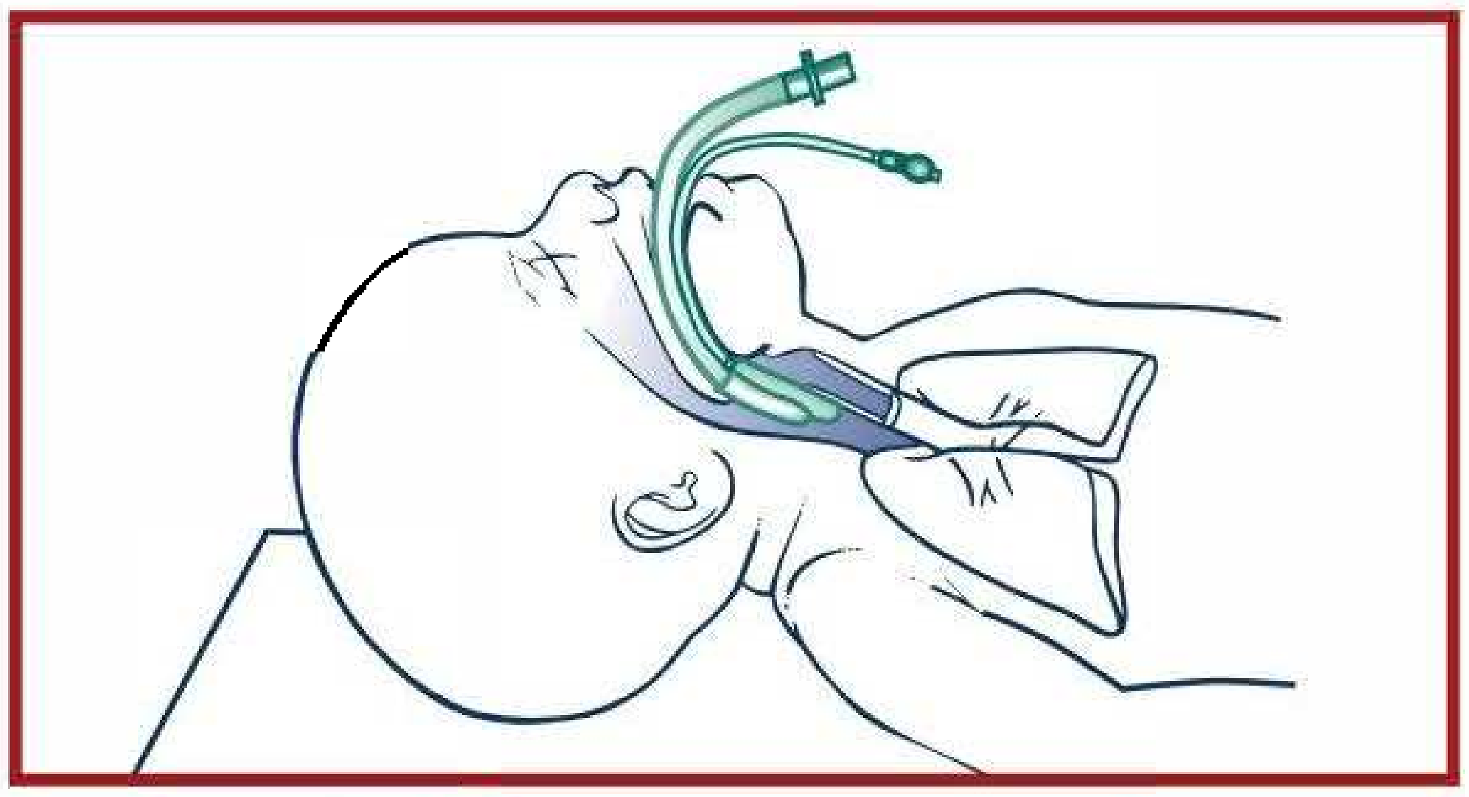


Figure 4.24. Laryngeal mask forming a seal over the glottis

Severa! variations are available, including devices with an inflatable mask, a soft-gel mask that <loes not require inflation, a pre-curved airway tube, and a port for a gastric drainage tube. The laryngeal mask is an effective alternative airway when attempts at face-mask ventilation or intubation are unsuccessful; however, its use in preterm newborns is limited because even the smallest laryngeal mask may be too large for very preterm newborns.

To learn more about limitations of the laryngeal mask, see the Frequently Asked Questions section in this lesson on page 96.

How do you insert a laryngeal mask?

The following instructions and images apply to one example of a disposable laryngeal mask with a pre-curved airway tube and a soft-gel mask that <loes not require inflation. It is intended for use in babies weighing 2 to 5 kg. Devices vary by manufacturer and you should refer to the manufacturer's instructions for the specific device used at your institution.

O If not already done, attach cardiac monitor leads for accurate assessment of the baby's heart rate.

f) Using clean technique, remove the device from the sterile package and protective container. You may place a thin layer of water-based lubricant onto the back and sides of the mask, but this may not be necessary because newborns often have sufficient oral secretions to lubricate the device (Figure 4.25).

Figure 4.25. Remove the device and lubricate the back and sides (optional).

E) Stand at the baby's head and position the baby in the sniffing position.

0 Hold the device along the airway tube with the closed bottom of the mask facing the baby's palate and the open bowl of the mask facing toward the baby's chin (Figure 4.26).

0 Open the baby's mouth by pressing gently downward on the baby's chin.

0 Insert the leading tip of the mask into the baby's mouth, on top of the tongue, with the bottom of the mask pressed against the baby's palate (Figure 4.27).

0 Glide the device downward and backward, following the contour of the palate, with a continuous but gentle push until you feel definitive resistance (Figure 4.28).

6) Holding the tube in place, attach a CO_2 detector and PPV device. Begin PPV and secure the device in place (Figure 4.29).

0 If the laryngeal mask is correctly inserted and you are providing ventilation that inflates the lungs, you should detect exhaled CO_2 within 8 to 10 positive-pressure breaths. You should see chest wall movement and hear equal breath sounds when you listen with a stethoscope. You should not hear a large leak of air coming from the baby's mouth or see a growing bulge in the baby's neck.

Figure 4.26. Preparing for insertion

Figure 4.27. Insert the mask into the baby's mouth.

Figure 4.28. Advance the device following the contour of the mouth and palote.

Figure 4.29. Start PPV and confirm placement.

When should you remove the laryngeal mask?

The airway can be removed when the baby establishes effective spontaneous respirations and the device is no longer needed or when an endotracheal tube can be inserted successfully. Babies can breathe spontaneously through the device, and crying and grunting sounds may be audible.

- When you decide to remove the laryngeal mask, suction secretions from the mouth and throat before you remove the device.
- If the device has an inflatable rim, deflate the rim before removal.

What do you do if the baby is breathing spontaneously and has a heart rate of at least 100 bpm, but has labored breathing or low oxygen saturation despite free-flow oxygen?

If the baby is breathing spontaneously and has a heart rate of at least 100 bpm, but has labored or grunting respirations or low oxygen saturation, CPAP may be considered. CPAP is **NOT** appropriate if the baby is apneic or gasping or if the baby's heart rate is less than 100 bpm.

CPAP is a technique for maintaining pressure within the lungs of a *spontaneously breathing* baby. CPAP keeps the lungs slightly inflated at ali times and may be helpful for preterm babies whose lungs are surfactant deficient, causing the alveoli to collapse at the end of each exhalation. When CPAP is provided, the baby <loes not have to work as hard to ínflate the lungs with each breath. Using early CPAP for preterm newborns may avoid the need for intubation and mechanical ventilation. Administering CPAP may increase the chance of developing a pneumothorax (air leak). Providers should be aware of this potential complication and be prepared to address it.

How do you administer CPAP during the initial stabilization period?

CPAP is administered by making a seal between the baby's face and a mask attached to either a T-piece resuscitator or a flow-inflating bag. CPAP **cannot** be administered with a self-inflating bag even if a PEEP valve has been placed. The desired CPAP is achieved by adjusting the PEEP dial on the cap of the T-piece resuscitator or the flow-control valve on the flow-inflating bag (Figure 4.30).

- Test the amount of CPAP before applying the mask to the baby's face by holding the mask tightly against your hand and reading the pressure on the manometer (pressure gauge).
- Adjust the PEEP cap or the flow-control valve so that the manometer reads 5 to 6 cm H_2O pressure.

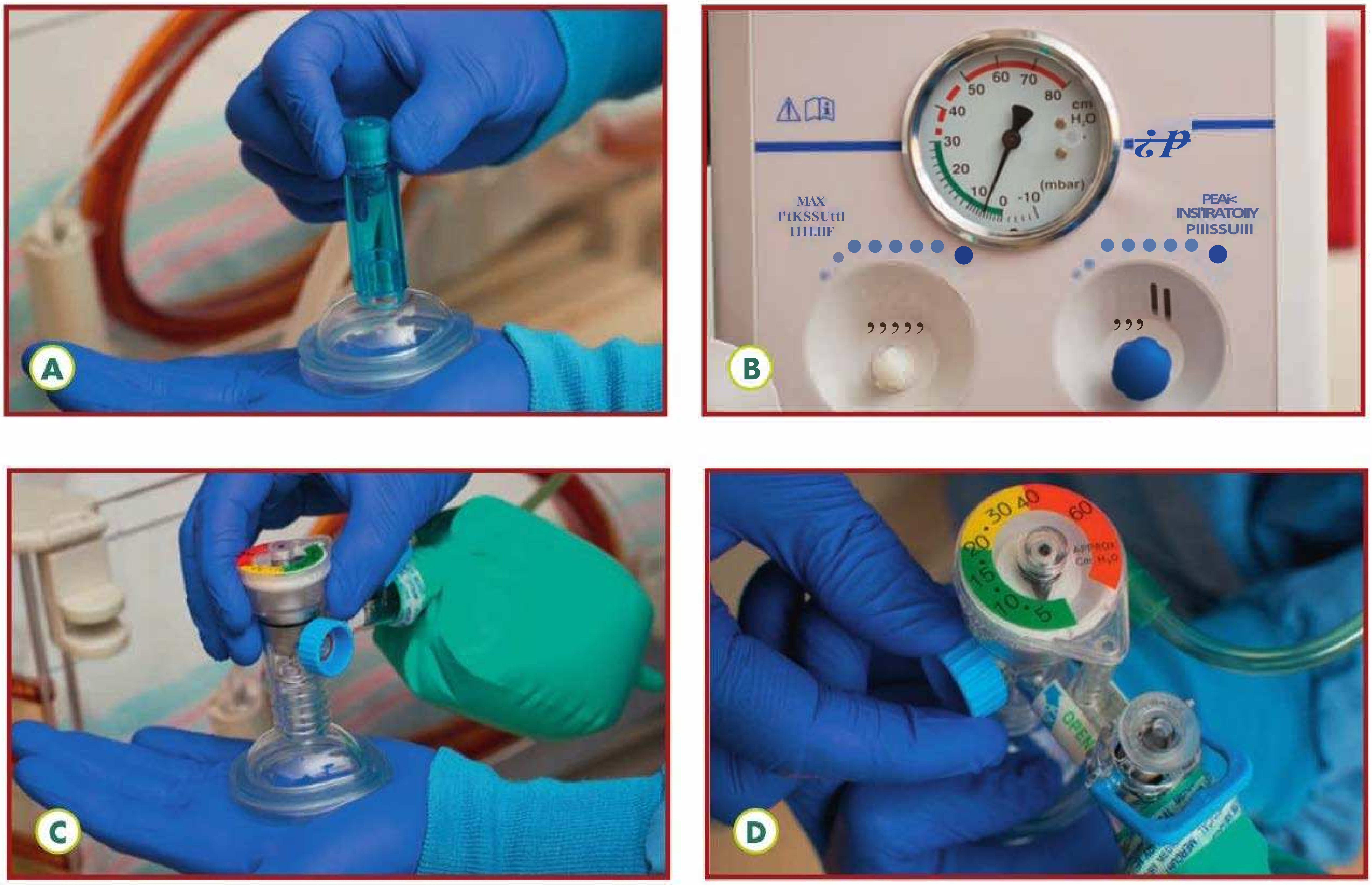


Figure 4.30. Adjust the CPAP pressure by turning the cap on a T-piece resuscitator (A). The resulting CPAP pressure is shown on the manometer (B). Adjust the CPAP pressure using the flow-control valve on a flow-inflating bag (C). The resulting CPAP pressure is shown on the manometer (D). For both, adjust the CPAP before placing the mask on the baby's face.

After you have adjusted the CPAP to the desired pressure, place it firmly against the baby's face (Figure 4.31) using the 2-hand hold with jaw thrust.

- Lift the baby's jaw into the mask instead of pushing the baby's head down into the mattress.
- Check that the pressure is still at the selected level. If it is lower, you may not have an airtight seal of the mask on the baby's face.
- You may adjust the CPAP depending on how hard the baby is working to breathe. Do not use more than 8 cm H_2O .

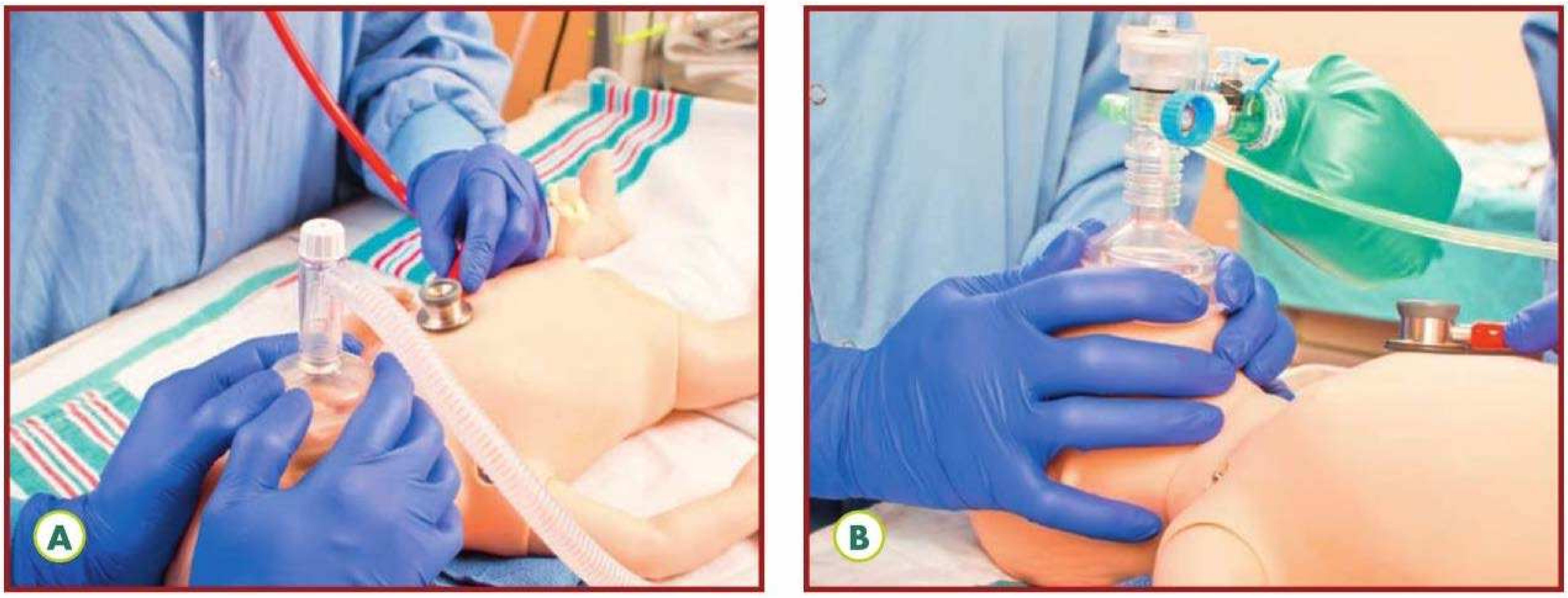


Figure 4.31. Administering face-mask CPAP with a T-piece (A) and flow-inflating bag (B). The manometer shows the amount of CPAP administered. An airtight seal must be maintained with the mask.

- During CPAP, you do NOT occlude the T-piece cap or squeeze the flow-inflating bag.
- If the baby cannot maintain a heart rate of at least 100 bpm with spontaneous respirations, you need to give PPV breaths instead of CPAP.

If CPAP will be administered for a prolonged period, you will use nasal prongs or a nasal mask (Figure 4.32). After the initial stabilization, CPAP can be administered with a bubbling water system, a dedicated CPAP device, or a mechanical ventilator.

Figure 4.32. CPAP administered to a preterm newborn with nasal prongs. (Used with permission of Mayo Foundation for Medica! Education and Research.)

When should you insert an orogastric tube?

During CPAP or PPV using a face mask or laryngeal mask, gas enters the esophagus and stomach. Gas in the stomach may interfere with ventilation. If a newborn requires CPAP or PPV for longer than several minutes, consider placing an orogastric tube and leaving it uncapped to act as a vent for the stomach.

Equipment needed

- 8F orogastric tube
- 20-mL syringe
- Tape

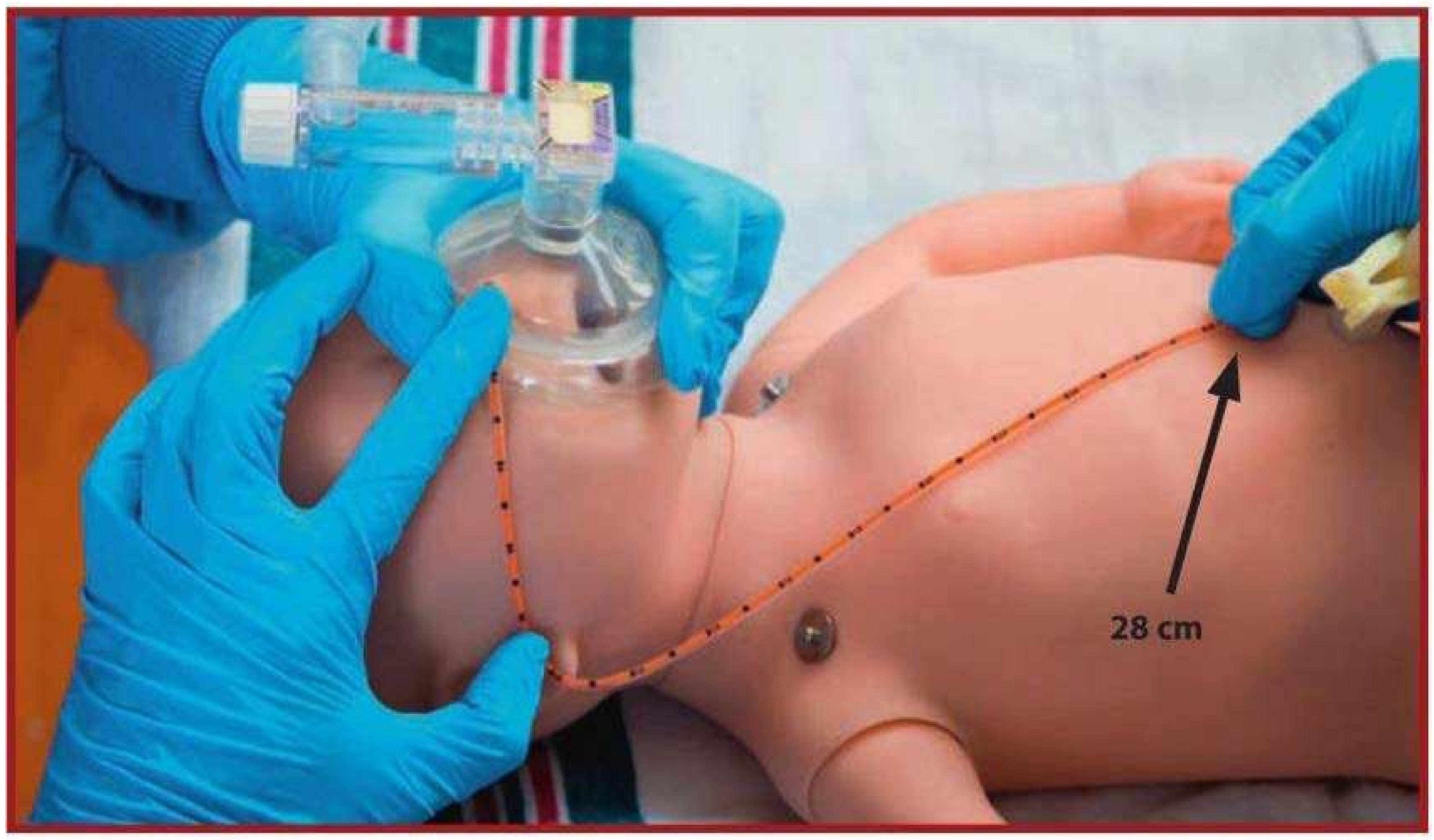


Figure 4.33. Measuring the correct insertion depth for an orogastric tube. In this example, the tube should be inserted 28 cm.

Insertion steps

0 Measure the distance from the bridge of the nose to the earlobe and from the earlobe to a point halfway between the xiphoid process (the lower tip of the sternum) and the umbilicus. Note the centimeter mark at this place on the tube (Figure 4.33). To minimize interruption of ventilation, measurement of the orogastric tube can be approximated with the mask in place.

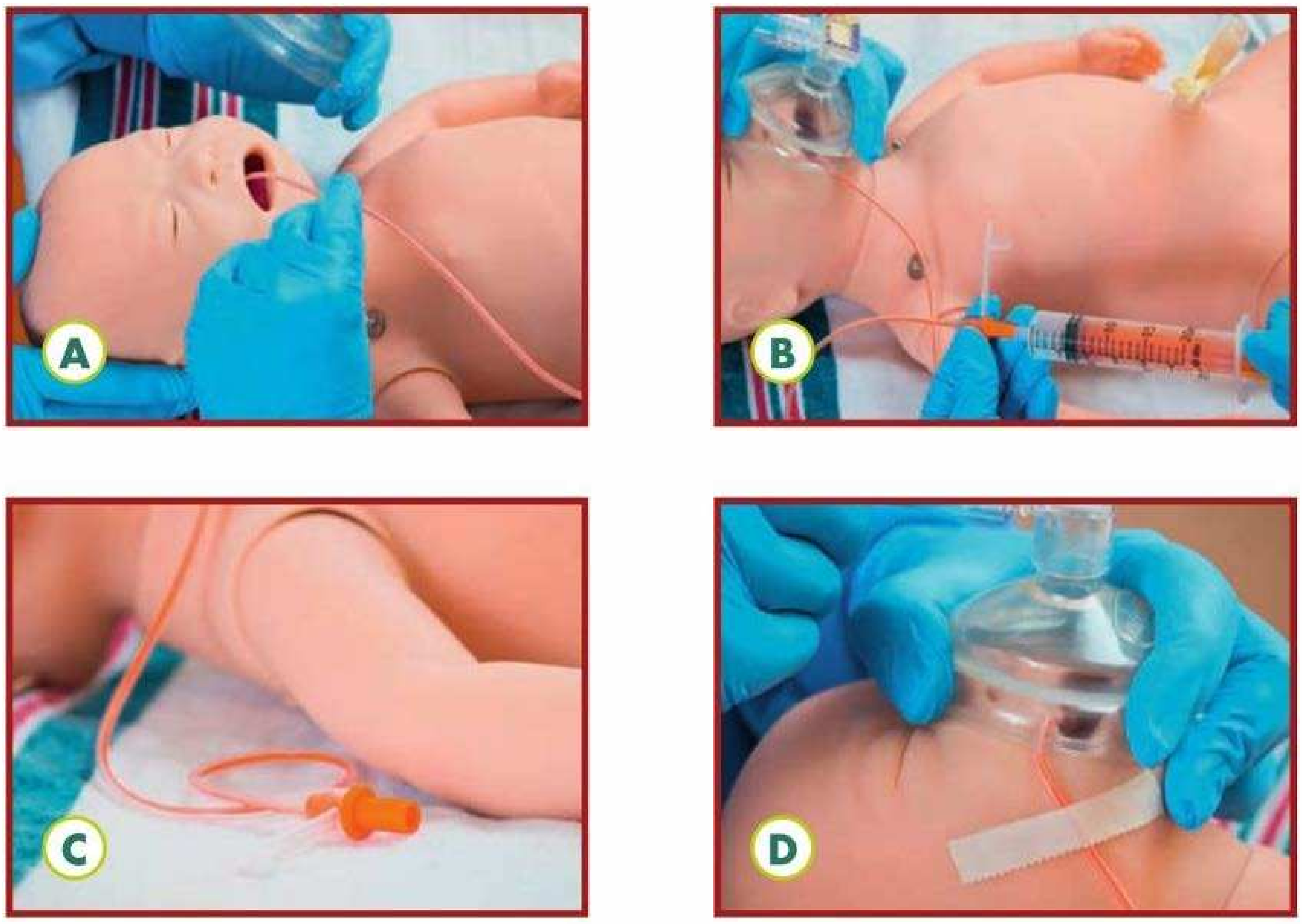


Figure 4.34. Insertion of an orogastric tube (A), aspirating the orogastric tube (B), opening the orogastric tube to vent (C), and securing the orogastric tube with tape (D)

f) Insert the tube through the mouth (Figure 4.34A). Ventilation can be resumed as soon as the tube has been inserted. Reassess the face-mask seal.

8 Once the tube is inserted the desired distance, attach a syringe and remove the gastric contents (Figure 4.34B).

8 Remove the syringe from the tube and leave the end of the tube open to provide a vent for air entering the stomach (Figure 4.34C).

0 Tape the tube to the baby,s cheek (Figure 4.34D).

Focus on Teamwork

Providing PPV highlights several opportunities for effective teams to use the Neonatal Resuscitation Program (NRP®) Key Behavioral Skills.

Behavior	Example
Anticípate and plan.	Ensure that you hove enough personnel present at the time of birth based on the risk factors you identified. During your pre-resuscitation team briefing, determine who performs PPV, auscultates the heart rote, assesses chest movement, places the pulse oximeter and cardiac monitor, and documents events as they occur.
Delegate workload optimally. Call for additional help when needed.	If PPV is required, at least 2 or 3 qualified providers are needed to perform all of the tasks quickly. If you hove difficulty maintaining a good seal, the 2-hand hold may be required, which requires a second person to administer the assisted breath and a third person to evaluate the response. You may need to call for additional help if intubation is required.
Communicate effectively.	The individuals providing PPV and assessing the effectiveness of ventilation must share information and communicate with each other. If the ventilation corrective steps are required, frequent information sharing after each step is crucial. It is important to announce when chest movement has been achieved ***("Chest is moving NOW")*** so that the team knows that the heart rote should be assessed in 30 seconds.
Know your environment. Use available resources.	Know how to operate and troubleshoot your PPV device. Know how to obtain a laryngeal mask and cardiac monitor.

Quality Improvement Opportunities

Ask yourself the following questions and begin a discussion with your team if you find a difference between the NRP recommendations and what is currently done in your own hospital setting. Consider using the suggested process and outcome measures to guide your data collection, identify areas for improvement, and monitor if your improvement efforts are working.

Quality improvement questions

O Who provides PPV in your delivery room setting?

f) Who monitors the baby's heart rate response during PPV?

E) Is a cardiac monitor for the newborn readily available in your delivery room setting?

8 How often do providers in your delivery room setting practice PPV?

0 Do providers know where to find a laryngeal mask and how to insert it?

Process and oukome measures

O How often is PPV given in your delivery room setting?

f) How often do newborns without any risk factors require PPV?

E) When PPV is required, how often is a second trained provider present at the time of birth?

8 How often are the MR. SOPA steps performed in your delivery room setting?

0 How often are chest compressions performed in your delivery room setting?

O How often is a complete resuscitation record completed for newborns that have received PPV?

Frequently Asked Questions

What are the advantages and disadvantages of each resuscitation device?

The *self-inflating bag* is often considered easier to use than the other devices and requires little time to set up. It <loes not require a compressed gas source and can be used in an emergency setting when compressed gas may not be readily available. Because it fully reinflates even without a seal, you will be less likely to know if you have a large leak between the mask and the baby's face. It is difficult to control the inflation time with a self-inflating bag. In addition, the mask cannot be used to administer free-flow oxygen or CPAP to a baby.

The *flow-inflating bag* is more complicated to set up than the other devices and takes more practice to use effectively. It requires a compressed gas source and adjustments to find the correct balance between gas inflow and outflow. The advantage is that you will know immediately if you lose gas pressure or have a leak between the bag and mask because the bag will deflate. Absent or partial inflation of the bag indicates that a tight seal has not been established or the bag has a leak. An effective face-mask seal is indicated by observing stable PEEP/CPAP on the manometer. The inflation time can be increased, if needed, by squeezing the bag for a longer period of time. The flow-inflating bag can deliver CPAP, PEEP, and free-flow oxygen.

The *T-piece resuscitator* also requires sorne preparation time for setup prior to use. Similar to the flow-inflating bag, it requires a compressed gas source and adjustment to the dials controlling the PIP and PEEP. The primary advantage of the T-piece resuscitator is that it provides more consistent pressure with each breath than either the self-inflating or flow-inflating bag. An effective face-mask seal is indicated by observing stable PEEP/CPAP on the T-piece manometer. In addition, the users may not become fatigued because they are not repeatedly squeezing a bag. The inflation time can be increased, if needed, by occluding the hole on the T-piece cap for a longer period of time. The T-piece can deliver CPAP, PEEP, and free-flow oxygen.

Why not routinely use 100% oxygen during all neonatal resuscitations?

Multiple studies in both animals and humans have raised concerns about the safety of routinely using 100% oxygen during neonatal resuscitation. A series of human randomized and quasi-randomized studies over the last 2 decades have demonstrated that resuscitation with 21% oxygen, is at least as effective as resuscitation with 100% oxygen. In meta-analyses of these studies, mortality was decreased among term and late-preterm babies resuscitated with 21% oxygen compared with 100% oxygen. Intermediate initial oxygen concentrations, between 21% and 100%, have not been studied. Because oxygen relaxes pulmonary blood vessels, sorne have expressed concern that babies resuscitated with lower oxygen concentrations will be more likely to develop pulmonary hypertension. Animal studies have shown that pulmonary vascular resistance decreases appropriately with 21% oxygen, and that resuscitation with 21% oxygen may actually prevent rebound pulmonary hypertension and preserve the response to inhaled nitric oxide if pulmonary hypertension develops.

In preterm newborns, there was no difference in outcomes between those resuscitated with low oxygen (21%-30%) and high oxygen (60%-100%). Although no difference was found, the recommendation to start with low oxygen and titrate upward as needed using pulse oximetry reflects a preference to avoid exposing preterm newborns to additional oxygen without evidence demonstrating a benefit for important outcomes. The ideal initial $F10_2$ for resuscitating preterm newborns is still unknown, but the majority of preterm newborns enrolled in studies required sorne oxygen supplementation during the first minutes of life.

Can a nurse or respiratory therapist insert a laryngeal mask?

Each health care provider's scope of practice is defined by their state licensing board, and each hospital determines the level of competence and qualifications required for licensed providers to perform clinical skills. Although laryngeal mask insertion is consistent with the general guidelines for nurse and respiratory therapist practice, you must check with your state licensing board and institution.

What are the limitations of a laryngeal mask?

Laryngeal masks have several limitations to consider during neonatal resuscitation.

- The device has not been studied for suctioning secretions from the a'1rway.
- If you need to use high ventilation pressures, air may leak through the seal between the pharynx and the mask, resulting in insufficient pressure to inflate the lungs.
- Few reports describe the use of a laryngeal mask during chest compressions. However, if tracheal intubation is unsuccessful, it is reasonable to attempt compressions with the device in place.
- There is insufficient evidence to recommend using a laryngeal mask to administer intratracheal medications. Intratracheal medications may leak from the mask into the esophagus and not enter the lungs.
- Laryngeal masks cannot be used in very small newborns. Currently, the smallest laryngeal mask is intended for use in babies who weigh more than approximately 2 kg. Many reports describe its use in babies who weigh 1.5 to 2.5 kg. Sorne reports have described using a laryngeal mask successfully in babies who weigh less than 1.5 kg.

LESSON 4 REVIEW

1. The single most i1nportant a11dmost effective step in neonatal resuscitation is (aggressive stimulation)/(ventilation of the lungs).

2. After the initial steps, positive-pressure ventilation is indicated ifthe baby is ___ , OR ifthe baby is ____ , OR ifthe baby's heart rate is less than _______ beats per minute. *(Fill in the blanks.)*

3. A baby is born limp and apneic. You place the baby under a radiant warmer, dry and stimulate, position the head and neck to open the airway, and suction the mouth and nose. It has been 1 minute since birth and the baby remains apneic. The next step is to (stimulate more)/(begin positive-pressure ventilation).

4. For positive-pressure ventilation, adjust the flowmeter to (5 L/min)/(10 L/min).

5. Administer positive-pressure ventilation ata rate of (20 to 25 breaths per minute)/(40 to 60 breaths per minute).

6. Begin positive-pressure ventilation with an inflation pressure of (20 to 25 cm H_20)/(40 to 60 cm H_20).

7. Ventilation of the term newborn begins with (21% oxygen)/(100% oxygen).

8. If you are using a device that administers positive end-expiratory pressure (PEEP), the recommended initial pressure is (5 cm H_20)/(10 cm H_20).

9. You have started positive-pressure ventilation for an apneic newborn. The heart rate is 40 beats per minute and is not improving. Your assistant <loes not see chest movement. You should (start the ventilation corrective steps)/(proceed to chest compressions).

10. Inflation and aeration of the lungs is suggested by a $C0_2$ detector that turns (yellow)/(purple).

11. You have started positive-pressure ventilation for an apneic newborn. The heart rate has remained 40 beats per minute despite performing all of the ventilation corrective steps and ventilating through an endotracheal tube for 30 seconds. Your assistant sees chest movement with positive-pressure ventilation. You should (increase the ventilation rate to 100 breaths/minute)/(proceed to chest compressions).

12. A laryngeal mask is inserted into the baby's mouth and advanced into the throat until it (passes between the baby's vocal cords)/(makes a seal over the entrance to the baby's trachea).

13. To insertan orogastric tube, measure the distance from the bridge of the nose to the earlobe and from the earlobe (to the nipples)/(to a point halfway between the xiphoid process and the umbilicus).

Answers

1. The single most important and most effective step in neonatal resuscitation is ventilation of the lungs.

2. After the initial steps, positive-pressure ventilation is indicated if the baby is apneic, OR if the baby is gasping, OR if the baby's heart rate is less than 100 beats per minute.

3. The next step is to begin positive-pressure ventilation.

4. For positive-pressure ventilation, adjust the flowmeter to 10 L/m1n.

5. Administer positive-pressure ventilation ata rate of 40 to 60 breaths per minute.

6. Begin positive-pressure ventilation with an inflation pressure of 20 to 25 cm H_20 .

7. Ventilation of the term newborn begins with 21 % oxygen.

8. If you are using a device that administers positive end-expiratory pressure (PEEP), the recommended initial pressure is 5 cm H_20 .

9. You should start the ventilation corrective steps.

10. Inflation and aeration of the lungs is suggested by a $C0_2$ detector that turns yellow.

11. You should proceed to chest compressions.

12. A laryngeal mask is inserted into the baby's mouth and advanced into the throat until it makes a seal over the entrance to the baby's trachea.

13. Measure the distance from the bridge of the nose to the earlobe and from the earlobe to a point halfway between the xiphoid process and the umbilicus.

Appendix

Read the section(s) that refers to the type of device used in your hospital.

A. Self-inflating resuscitation bag

What are the parts of a self-inflating bag?

There are 8 basic parts to a self-inflating bag (Figure 4A.l).

O Gas outlet

f) Positive end-expiratory pressure (PEEP) valve (optional)

E) Manometer

9 Pressure-release valve

0 Gas inlet

O Gas tubing

O (A) Oxygen reservoir (closed type), (B) Oxygen reservoir (open type)

0 Valve assembly

The self-inflating bag reexpands after being squeezed and fills with gas from 3 locations. As the bag reinflates, air from the room is drawn in from openings in the back of the bag. Gas from the blender and flowmeter travels through *gas tubing* and enters the bag at the *gas inlet.* Gas from the blender collects in the *oxygen reservoir* and provides a third source for gas to fill the bag. Oxygen tubing <loes not need to be attached for the bag to provide positive-pressure ventilation (PPV) with 21% oxygen. Oxygen tubing must be attached to a compressed gas source to deliver more than 21% oxygen. The *gas outlet* is where gas exits from the bag to the baby and where a face mask, laryngeal mask, or endotracheal tube is attached.

A *manometer* (pressure gauge) measures the inflating pressure used during PPV Sorne bags will have a built-in manometer and others will need one attached. The attachment site is usually close to the

Figure 4A.1. Self-inflating bags with a closed (7A) and open (7B) reservoir

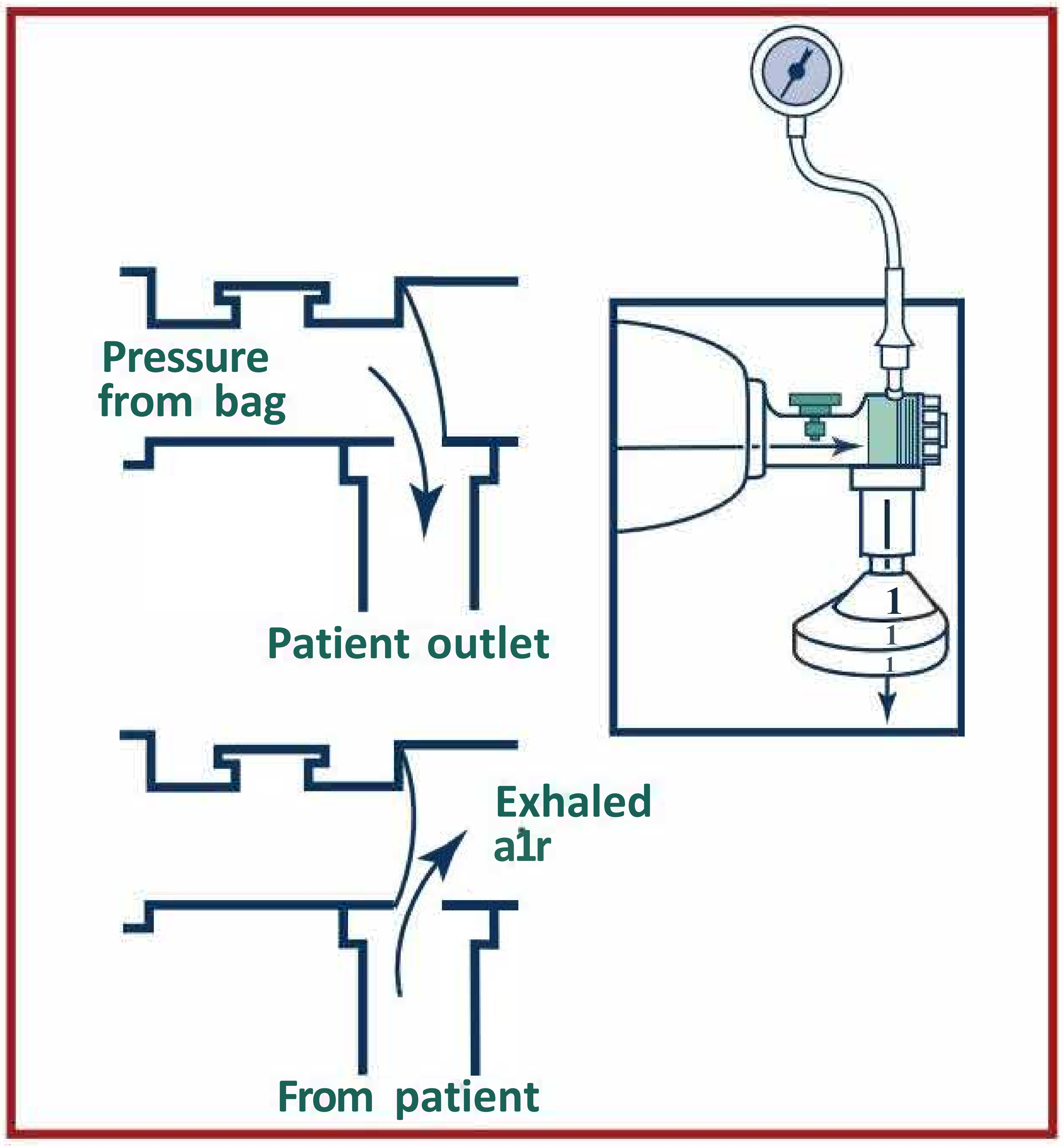


Figure 4A.2. Valve assembly within a self-inflating bag

patient outlet. If the .manometer attachment site is left open, without a manometer attached, air will leak out and prevent you from achieving inflation pressure. Do not attach the oxygen inflow tubing to the manometer attachment site. This could generate undesired high pressure. Most self-inflating bags also have a *pressure-release (pop-off) valve.* These valves are usually set to release at 30 cm to 40 cm H_2O pressure, but they are not reliable and may not release until higher pressures are achieved.

Self-inflating bags have a *valve assembly* positioned between the bag and the patient outlet (Figure 4A.2). When the bag is squeezed during ventilation, the valve opens and directs gas to the patient. When the bag reinflates, the valve is closed. This prevents the patient's exhaled air from entering the bag and being rebreathed. Sorne self-inflating bags also have an adjustable *PEEP valve.*

Why is an oxygen reservoir used on a self-inflating bag?

An oxygen reservoir is an appliance that can be placed over the bag's air inlet. Gas from the blender collects in the reservoir. At very low flow rates, the reservoir prevents blended gas from being diluted with room air. Several different types of oxygen reservoirs are available, but they all perform the same function. Sorne have open ends ("tails") and others look like a bag covering the air inlet.

B. Flow-inflating resuscitation bag

What are the parts of a flow-inflating bag?

There are 6 parts to a flow-inflating bag (Figure 4A.3).

O Gas outlet

f) Manometer

E) Gas inlet

8 Pressure-release valve (optional)

0 Gas tubing

O Flow-control valve

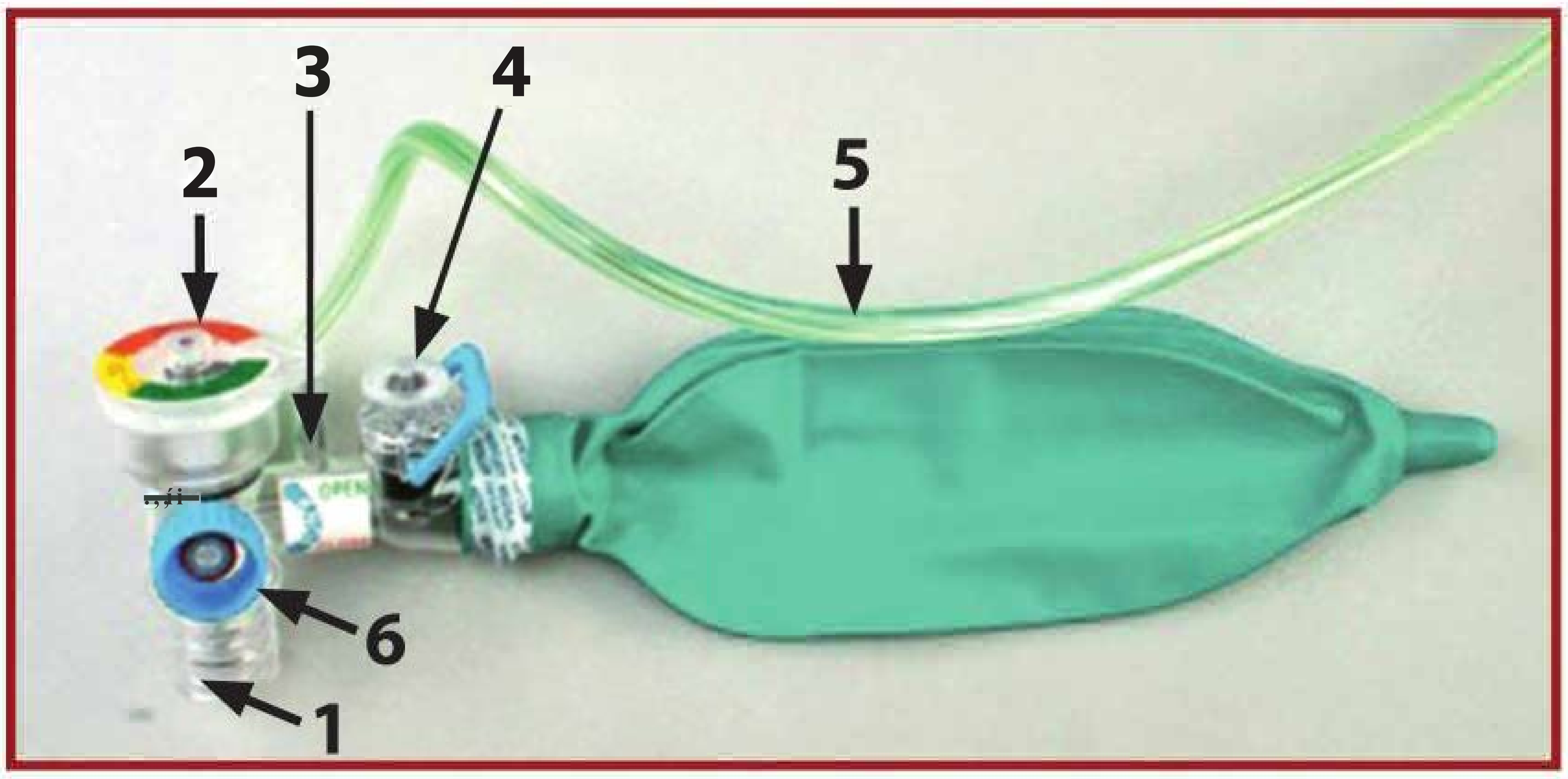


Figure 4A.3. Parts of a flow-inflating bag

Compressed gas from the blender and flowmeter enters the bag through oxygen tubing attached to the *gas inlet*. The *gas outlet* is where gas exits from the bag to the baby and where a face mask, laryngeal mask, or endotracheal tube is attached. Even if you plan to use 21% oxygen for PPV, you must have a compressed gas source to fill the flow-inflating bag.

The *flow-control valve* provides an adjustable leak that allows you to regulate the pressure in the bag. The adjustable leak allows excess gas to escape rather than overinflate the bag or be forced into the patient. The flow-control valve adjusts both the peak inflation pressure (PIP) and the PEEP.

Flow-inflating bags have a site for attaching a *manometer*. The attachment site usually is close to the patient outlet. A manometer must be attached or the site will be a source of leak and the bag will not inflate properly. A *pressure release (pop-off) valve* may also be present.

How does a flow-inflating bag work?

For a flow-inflating bag to work properly, there must be adequate gas flow from the source and a sealed system. The bag inflation is controlled by the balance between gas entering the bag, gas exiting the adjustable flow-control valve, and gas exiting the gas outlet. A flow-inflating bag will not ínflate adequately if the mask is not properly sealed; if flow from the gas source is insufficient, disconnected, or occluded; if there is a hole in the bag; if the flow-control valve is open too far; or if the manometer attachment site has been left open (Figure 4A.4).

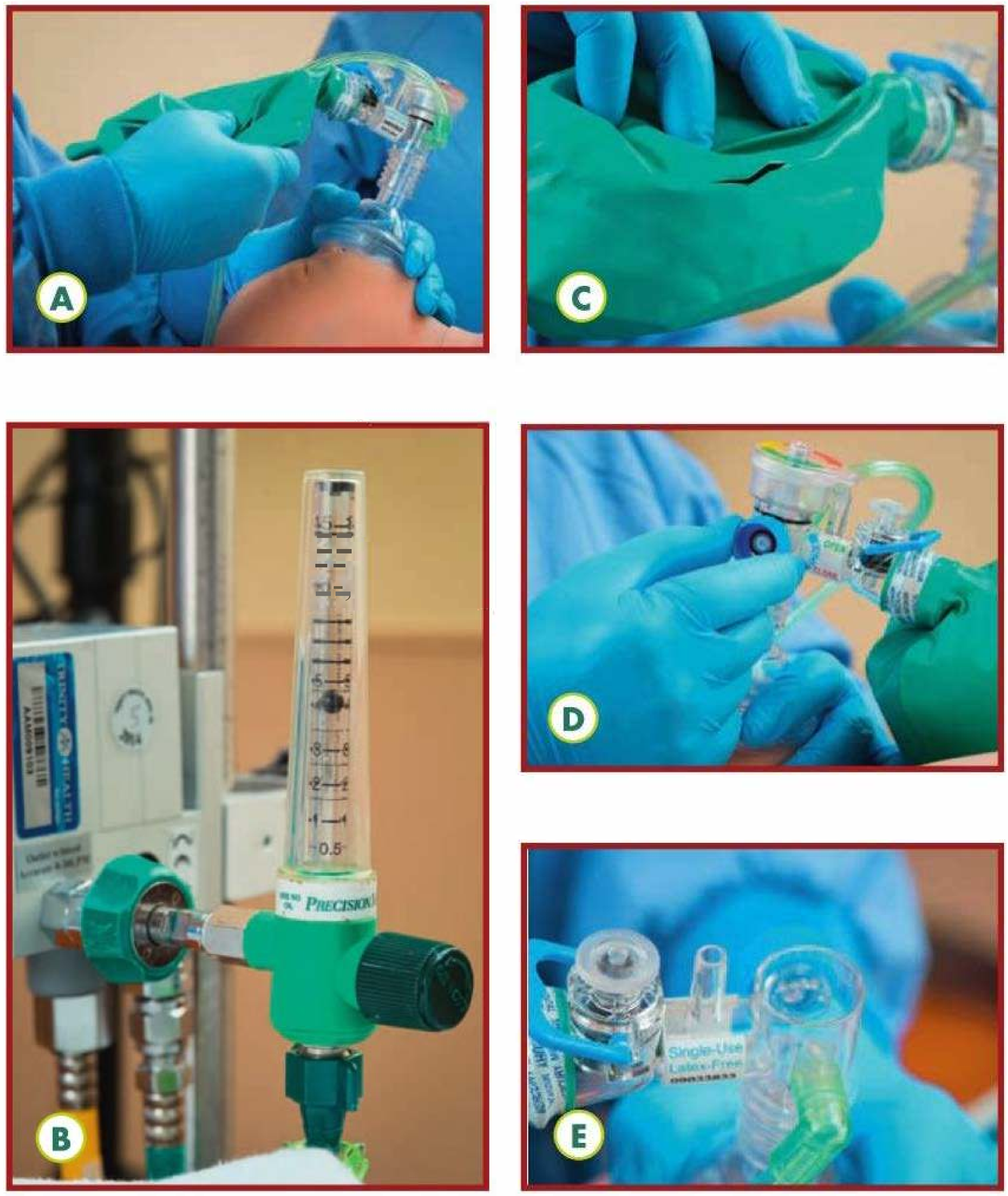


Figure 4A.4. Reasons for insufficient inflation of a flow-inflating bag: (A) inadequate mask seal with leak, (B) insufficient gas inflow, (C) hole in bag, (D) flow-control valve open too far, (E) manometer attachment site open

How do you adjust the inflation of a flow-inflating bag?

There are 2 ways that you can adjust the pressure in the bag a11dthus the amount of inflation of the bag.

- By adjusting the incoming gas from the flowmeter, you regulate how much gas enters the bag.
- By adjusting the flow-control valve on the bag, you regulate how much gas escapes from the bag.

The flowmeter and flow-control valve should be set so that the bag is inflated to the point where it is comfortable to handle and <loes not completely deflate with each assisted breath (Figure 4A.5A). An overinflated bag (Figure 4A.5B) is difficult to n1anage and may deliver high pressure to the baby; a pneumothorax or other air leak may

Figure 4A.5. Correct flow-inflating bag inflation (A), overinflation (B), and underinflation (C)

develop. An underinflated bag (Figure 4A.SC) makes it difficult to achieve the desired inflation pressure. With practice, you will be able to make the necessary adjustments to achieve a balance. If there is a good seal between the baby's face and the mask, you should be able to maintain the appropriate amount of inflation with the flowmeter set at 8 to 10 L/min.

C. T-piece Resuscitator

What are the parts of a T-piece resuscitator?

There are 9 parts to a T-piece resuscitator (Figure 4A.6). The position and function of control dials on the T-piece resuscitator may vary by manufacturer. The parts and operation of one example is described below.

O Gas tubing

8 Gas inlet

E) Maximum pressure-relief control

8 Manometer

0 Inflation pressure control

O Gas outlet (proximal)

O T-piece gas outlet (patient)

O T-piece PEEP adjustment dial

f) Opening on T-piece cap

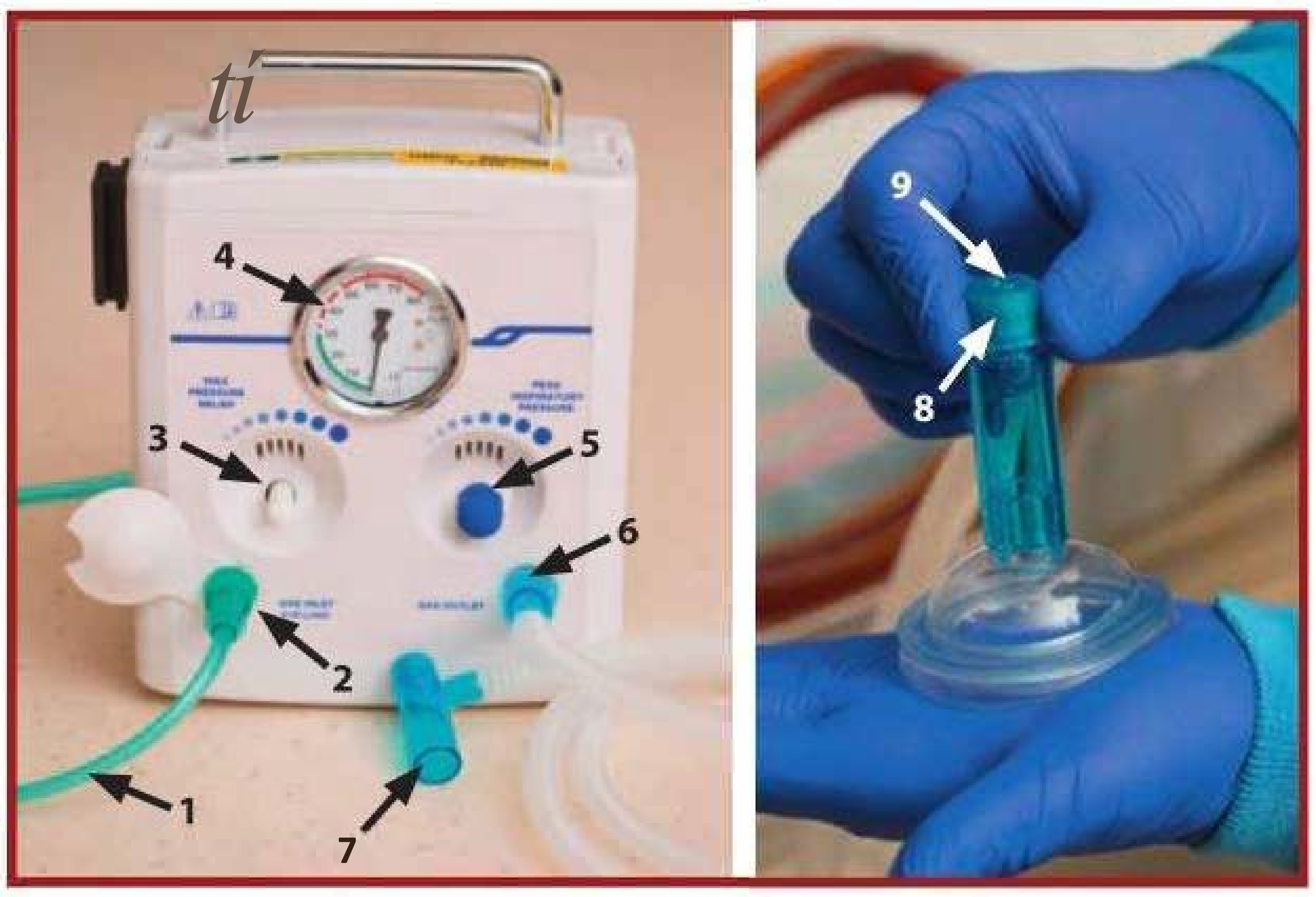


Figure 4A.6. Parts of a T-piece resuscitator

How does a T-piece resuscitator work?

Gas from a compressed source enters the T-piece resuscitator through *gas tubing* at the *gas inlet*. Gas exits the control box from the *gas outlet (proximal)* and travels through corrugated tubing to the *T-piece gas outlet (patient)*, where a face mask, laryngeal mask, or endotracheal tube attaches. When the *opening on the T-piece cap* is occluded by the operator, the preset inflation pressure is delivered to the patient for as long as the T-piece opening is occluded. On the device in Figure 4A.6, the maximum pressure that can be used is regulated by the *maximum pressure relief control* valve. *PEEP* is adjusted using a dial on the T-piece cap.

How do you prepare the T-piece resuscitator for use?

Assemble the parts of the T-piece resuscitator as instructed by the manufacturer. Occlude the patient outlet (using a test lung, outlet-occluding cap, or palm). Connect the device to the compressed gas source using gas tubing.

Adjust the pressure settings as follows:

- Adjust the blended gas flowmeter on the wall to regulate how much gas flows into the T-piece resuscitator. In most cases, **10 L/min is appropriate.**
- Set the *maximum pressure-relief control* by occluding the T-piece cap with your finger and adjusting the maximum pressure relief dial to a selected value (40 cm H_2O is the recommended maximum for term newborns, 30 cm H_2O is the recommended maximum for preterm newborns). Sorne manufacturers recommend that the maximum relief control be adjusted toan institution-defined limit when the device is put into original service and not be readjusted during regular use.
- Set the desired peak inflation pressure (PIP) by occluding the T-piece cap with your finger and adjusting the *inflation pressure control* to the selected pressure (Figure 4A.7).
- Set the PEEP by removi11gyour finger from the T-piece cap and adjusting the dial on the cap to the desired setting (5 cm H_2O is recommended) (Figure 4A.8).

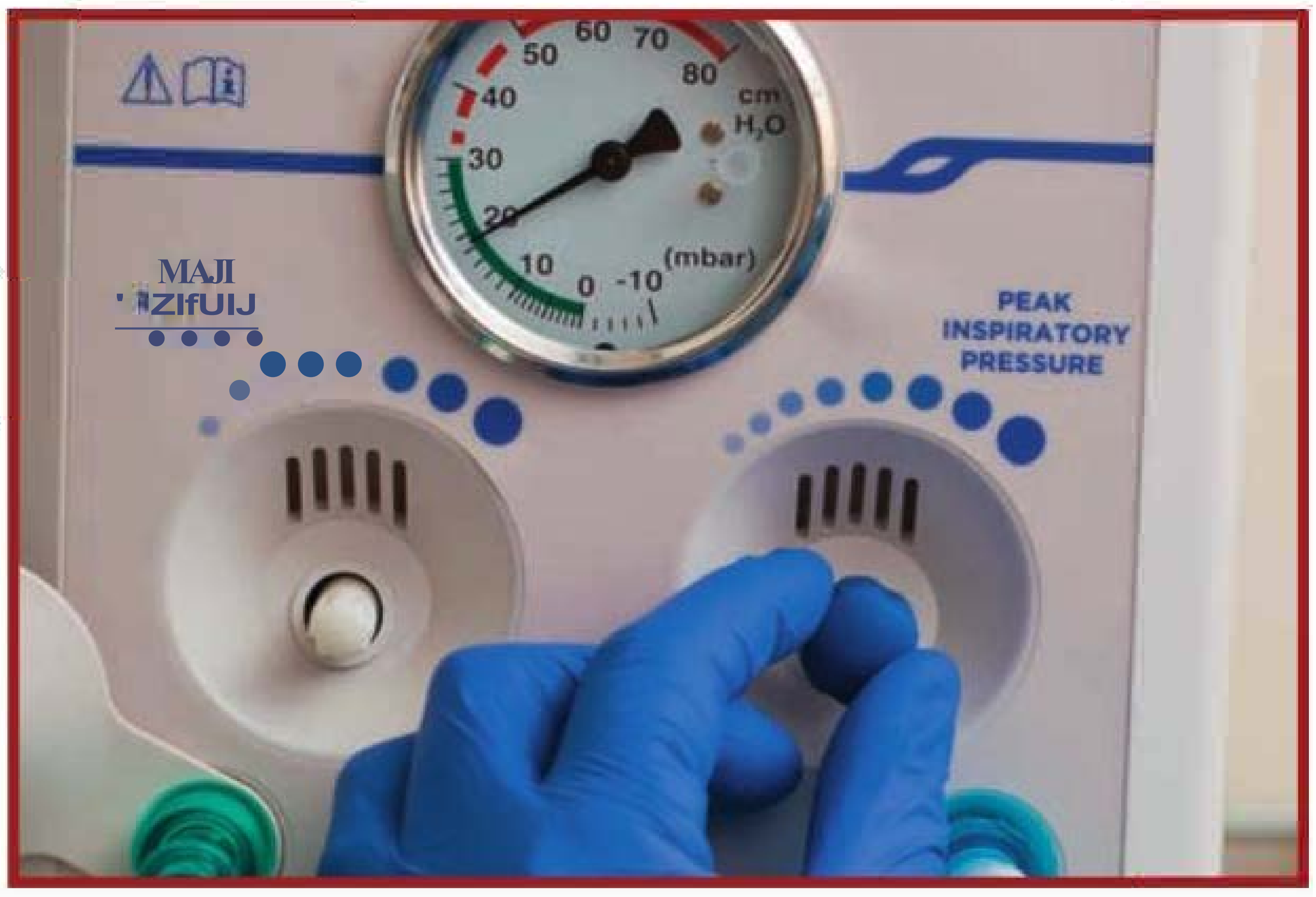


Figure 4A.7. Adjusting the peak inflation pressure (PIP)

Figure 4A.8. Adjusting the PEEP

When the device is used to ventilate the baby, either by applying the mask to the baby's face or by connecting the device to a laryngeal mask or endotracheal tube, you administer a breath by alternately covering and releasing the opening on the T-piece cap. The inflation time is controlled by how long your finger covers the opening. Be careful not to become distracted and inadvertently cover the opening on the T-piece cap with your finger for a prolonged time.

How do you adiust the concentration of oxygen in a T-piece resuscitator?

The concentration of oxygen delivered by the T-piece resuscitator is controlled by the oxygen blender.

LESSON 4: PRACTICE SCENARIOS

Positive-Pressure Ventilation, Laryngeal Mask, Orogastric Tube, and (optional} Continuous Positive Airway Pressure

Comprehensive Skills Test Scenarios for Neonatal Resuscitation Program (NRP) Essentials Providers

Learning Objectives

0 Identify the newborn that requires positive-pressure ventilation (PPV).

f) Demonstrate correct technique for delivering PPV.

E) Demonstrate the steps for assessing response to PPV.

9 Demonstrate ventilation corrective steps (MR SOPA).

0 Identify indications and method for discontinuing PPV.

0 Identify indications for continuous positive airway pressure (CPAP) in the delivery room and demonstrate correct technique for administering CPAP.

O Identify uses and limitations of the laryngeal mask.

C) Demonstrate the correct technique for inserting and removing a laryngeal mask.

0 List pertinent NRP Key Behavioral Skills related to successful PPV.

These Practice Scenarios are for review/practice and evaluation. The scenarios may also be used as the Comprehensive Skills Test ("test out") option during a Provider Course.

This is the suggested Practice Scenario sequence.

0 **Review the Knowledge Check Questions** with your NRP instructor.

a. What are the indications for PPV? When can you stop PPV?

b. What is PIP? PEEP? How is CPAP different than PPV?

c. What is the recommended oxygen concentration for beginning PPV for a newborn greater than or equal to 35 weeks' gestation? For a newborn less than 35 weeks' gestation?

d. What is the recommended initial ventilation pressure and rate for a term newborn?

e. What is the most important indicator of successful ventilation?

f. What are the MR. SOPA ventilation corrective steps?

g. What are the indications for CPAP? (optional)

h. What is the purpose of an orogastric tube?

i. What are the indications for a laryngeal mask? What are the limitations of a laryngeal mask?

j. At what point should you proceed to chest compressions?

8 **Practice/review these skills** with your NRP instructor.

a. Safety check a self-inflating bag prior to use. (Ensure that the pressure-release valve is not occluded.)

b. Safety check a T-piece resuscitator prior to use. (Ensure that pressures are correctly set prior to initiating PPV on the newborn.)

c. Position the newborn's head and neck in sniffing position.

d. Position the correct-sized mask on the newborn's face.

e. Perform the ventilation corrective steps (MR. SOPA).

f. Deliver PPV at the correct rate, pressure, and oxygen concentration per pulse oximetry.

g. Use the 2-hand hold with jaw thrust.

h. Discontinue PPV by decreasing rate and pressure as the baby begins to breathe.

i. Insert and remove a laryngeal mask (if this skill is within your scope of responsibility).

j. Measure and insertan orogastric tube to decompress the stomach.

k. Administer CPAP with a T-piece resuscitator and/or a flow-inflating bag using correct technique (if this skill is within your scope of responsibility).

8 **Practice the scenarios** applicable to your role with your NRP instructor until you need little or no assistance or coaching.

0 **Pass the Lesson 4 Practice Scenario evaluation** by leading practice scenario(s) and performing the skills relevant to your role and responsibilities. If a technical skill included in a scenario is not within your scope of responsibility, delegate the skill to a qualified team member and perform the role of assistant if appropriate.

0 When you can lead the scenario(s) and perform the skills with little or no instructor coaching, NRP Advanced learners may proceed to the next lesson's practice scenario. The NRP Essentials learners may proceed to the Simulation and Debriefing component of the Provider Course.

Note: If the institution's policy is that a T-piece resuscitator normally is used in the delivery room, the learner should demonstrate proficiency with that device. However, the learner also should demonstrate ability to use a self-inflating bag and mask.

Practice Scenarios

Three scenario options are offered. The number of people attending the birth scenarios and their qualifications are determined by the instructor and based on hospital policy.

O Term newborn with risk factors requires PPV. (CPAP and orogastric tube insertion are optional in this scenario.)

f.) Term newborn without known risk factors unexpectedly requires PPV.

Q Term newborn is difficult to ventilate with a face mask and requires a laryngeal mask.

"You are called to attend a vaginal birth. Labor is progressing rapidly. Demonstrate how you would prepare for the birth of this baby. As you work, say your thoughts and actions aloud so I will know what you are thinking and doing."

Option 1: Term newborn with risk factors requires PPV. (CPAP and orogastric tube insertion are optional.)

	Critical Performance Steps	
Assess perinatal risk.		
	Assesses perinatal risk (learner asks 4 pre-birth questions and instructor ["OB provider"] responds)	
	Gestational age?	**"38 weeks' gestation."**
	Clear fluid?	**"Amniotic fluid is clear."**
	Additional risk factors?	**"Mom has pregnancy-induced hypertension, and her labor has been induced at 38 weeks' gestation. Several late decelerations of fetal heart rote hove been noted."**
	Umbilical cord management plan? **"1 will delay cord clamping. If the baby is not crying, 1'11take a moment to stimulate the baby. If there's no response, 1'11clamp and cut the cord."**	
Assemble team.		
	Assembles team based on perinatal risk factors. If risk factors are present, at least 2 qualified people should be present solely to manage the baby. The number of team members and qualifications vary depending on risk.	

	Critical Performance Steps (cont)
Perform a pre-resuscitation briefing.	
	Identifies team leader. Assesses risk factors, delegates tasks, identifies who will document events as they occur, determines supplies and equipment needed, identifies how to call for additional help.
Perform equipment check.	
	"The baby has been born."
Rapid evaluation.	
	Asks 3 rapid evaluation questions: • Term? **'rves."** • Muscle tone? **"No."** • Breathing or crying? **"No, not breathing or crying."**
Initial steps at radiant warmer.	
	Receives baby at radiant warmer, dries and removes linen, stimulates briefly by rubbing the baby's back, positions airway, suctions mouth and nose
Assess breathing. If breathing, check heart rote.	
	Is the baby breathing? **"No."** **(Heart rote= 60 bpm, if assessed)**
	Indicates need for PPV
Begin PPV within 60 seconds of birth.	
	Applies mask correctly
	Starts PPV in 21 % oxygen (room air) at 20 to 25 cm H_2O (PEEP of 5 cm H_2O if using T-piece resuscitator, flow-inflating bag, or self-inflating bag with PEEP valve); rote 40 to 60 breaths/min
	Requests assistant to place pulse oximeter sensor on baby's right hand or wrist **"Pulse oximeter has no signal."**
	Requests cardiac monitor (optional)
	Within 15 seconds of beginning PPV, requests heart rote check to assess if heart rote is increasing **Heart rate=40 bpm, not increasing**
	Assesses chest movement **"No chest movement."**
Ventilation corrective steps (MR. SOPA). Instructor determines how many MR. SOPA steps are needed before PPV can result in chest movement.	
	• Mask adjustment • Repositions the head and neck Gives 5 breaths and asks assistant to assess chest movement **"No chest movement."**
	• Suctions the mouth and nose • Opens the mouth Gives 5 breaths and asks assistant to assess chest movement **"No chest movement."** **Heart rote= 40 bpm** **"Pulse oximeter has no signal."**
	• Increases Pressure by 5 to 10 cm H_2O increments to maximum 40 cm H_2O for term baby Gives 5 breaths and asks assistant to assess chest movement **"Chest moves with PPV." (Note:** If instructor states that the chest is <u>not</u> moving with PPV after this MR. SOPA step, the learners should inserta laryngeal mask. See Option 3.)
	The learner's assistant announces, "The chest is moving NOW. Continue PPV for 30 seconds."

	Critical Performance Steps (cont)
Deliver PPV that moves the chest.	
	Delivers PPV x 30 seconds. (Learner gradually discontinues PPV if baby has a heart rote greater than 100 bpm and críes before 30 seconds of PPV.)
	Assesses heart rote after 30 seconds of PPV that moves the chest **Heart rote= 120 bpm 5P0$_2$ = 64% "Occasional respiratory effort."**
	Continues PPV, adjusts oxygen concentration per pulse oximetry, monitors heart rote and respiratory effort **Heart rote= 140 bpm SP0$_2$ = 74%** **"The baby has increasing spontaneous respiratory effort and improving muscle tone."**
	Gradually discontinues PPV **Heart rote= 140 bpm SP0$_2$ = 72% "The baby has strong and continuous respiratory effort."**
Free-flow oxygen.	
	Discontinues PPV. Assesses need for free-flow oxygen to maintain oxygen saturation within target range. **Heart rote= 140 bpm 5P0$_2$ = 70% "The baby has good spontaneous respiratory effort."**
	Initiates free-flow oxygen correctly. Assesses heart rote, oxygen saturation, respiratory status. **Heart rote= 140 bpm 5P0$_2$ = 90% "The baby has good respiratory effort."**
End scenario.	
	Weans and discontinues free-flow oxygen and maintains oxygen saturation within target. Monitors heart rote, breathing, oxygen saturation, temperature. Plans post-resuscitation care. Communicates with perinatal team and parents. Debriefs the resuscitation.
Optional: CPAP and orogastric tube.	
	"After discontinuing PPV and free-flow oxygen, the newborn has labored breathing and grunting respirations." **Heart rote= 140 bpm SP0$_2$ = 80%**
Administer CPAP and insert orogastric tube.	
	Applies CPAP at 5 cm H_2O pressure. Adjusts oxygen concentration per pulse oximetry. **Heart rote= 140 bpm SP0$_2$ = 85%**
	Continues CPAP, adjusts oxygen concentration per pulse oximetry **Heart rote= 140 bpm SP0$_2$ = 90%** **"The baby is_ minutes old. Breathing effort has improved."**
	Measures insertion depth for orogastric tube while CPAP is in progress • Places the distal end of the orogastric tube at the bridge of the nose and measures to the earlobe and from the earlobe to a point halfway between the xiphoid process and the umbilicus. Notes the centimeter mark on the tube. Inserts the tube through the mouth. Resumes CPAP. • Attaches a syringe and removes the gastric contents. Removes the syringe from the tube and leaves the end open as an air vent. • Tapes the tube to the baby's cheek.
End scenario.	
	Monitors heart rote, breathing, oxygen saturation, temperature. Plans post-resuscitation care. Communicates with perinatal team and parents. Debriefs the resuscitation.

Option 2: Term newborn without known risk factors unexpectedly requires PPV. (This scenario is designed for attendance by 1 person assigned to manage newborn care at birth.)

	Critical Performance Steps
Assess perinatal risk.	
	Assesses perinatal risk (learner asks 4 pre-birth questions and instructor ["OB provider"] responds) Gestational age? **"39 weeks' gestation."** Clear fluid? **"Amniotic fluid is clear."** Additional risk factors? **"There are no additional risk factors."** **Plan for umbilical cord management? "I will delay cord clamping. If the baby is not crying, 1'11 take a moment to stimulate the baby. If there's no response, 1'11 clamp and cut the cord."**
This birth will be attended by 1 qualified individual. Knows the answers to the 4 pre-birth questions, determines supplies and equipment needed, knows how to call for help.	
Perform equipment check.	
	"The baby has been born."
Rapid evaluation.	
	Asks 3 rapid evaluation questions: • Term? **"Yes, as expected."** • Muscle tone? **"No."** • Breathing or crying? **"No, not breathing or crying."**
Initial steps at radiant warmer.	
	Receives baby at radiant warmer, dries and removes linen, stimulates briefly by rubbing the baby's back, positions airway, suctions mouth and nose
Assess breathing. If breathing, assess heart rate.	
	Is the baby breathing? **"No." (Heart rate = 70 bpm, if assessed)**
	Indicates need for PPV
	Uses standardized process to call for resuscitation team
Begin PPV by 60 seconds after birth.	
	Positions head in sniffing position
	Applies mask correctly
	Starts PPV in 21 % oxygen (room air) at 20 to 25 cm H_2O (PEEP of 5 cm H_2O if using T-piece resuscitator, flow-inflating bag, or self-inflating bag with PEEP valve); rote 40 to 60 breaths/min
	Requests additional help until resuscitation team arrives
	Requests pulse oximeter sensor placement on baby's right hand or wrist
	Requests cardiac monitor (optional)
	Within 15 seconds of beginning PPV, requests heart rote check to assess if heart rote is increasing **Heart rate = 70 bpm and not increasing SP02=66%**
	The learner asks assistant to assess chest movement **"No chest movement."**

	Critical Performance Steps (cont)
Ventilation corrective steps (MR. SOPA). Instructor determines how many MR. SOPA steps to use before PPV can result in chest movement	
	• Mask adjustment • Repositions the head and neck Gives 5 breaths and asks assistant to assess chest movement **"No chest movement."**
	• Suctions the mouth and nose • Opens the mouth Gives 5 breaths and asks assistant to assess chest movement **"No chest movement." Heart rote= 70 bpm $SP0_2$ = 66%**
	• Increases Pressure by 5 to 10 cm H_20 increments to maximum 40 cm H_20 for term newborn Gives 5 breaths and asks assistant to assess chest movement **"Chest moves with PPV." (Note:** If instructor states that the chest is not moving after this MR. SOPA step, the learners should insert a laryngeal mask. See Option 3.)
	The learner's assistant announces, "The chest is moving NOW. Continue PPV for 30 seconds."
Deliver PPV that moves the chest.	
	Delivers PPV x 30 seconds. (Learner may gradually discontinue PPV if baby has a heart rote greater than 100 bpm and críes before 30 seconds of PPV.)
	Assesses heart rote and assesses need for free-flow supplemental oxygen **Heart rote= 120 bpm $SP0_2$ = 72% "The baby has increasing respiratory effort."**
	Gradually discontinues PPV, monitors heart rote and respiratory effort **Heart rote= 140 bpm $5P0_2$ = *75%* and increasing "The baby is breathing regularly, muscle tone is improving."**
End scenario.	
	Discontinues PPV. Monitors heart rate, breathing, oxygen saturation, temperature. Communicates with resuscitation team members as they arrive. Updates parents and informs them of next steps. Debriefs the resuscitation.

Option 3: Term newborn is difficult to ventilate with a face mask and requires a laryngeal mask.

	Critical Performance Steps
Assess perinatal risk.	
	Assesses perinatal risk (learner asks 4 pre-birth questions and instructor ["OB provider"] responds) Gestational age? **"40 weeks' gestation."** Clear fluid? **"Amniotic fluid is clear."** Additional risk factors? **"A few fetal heart decelerations in the last 20 minutes."** Umbilical cord management plan? **"I will delay cord clamping. If the baby is not crying, I'll take a moment** to **stimulate the baby. If there's no response, I'll clamp and cut the cord."**
Assemble team.	
	Assembles team based on perinatal risk factors. When the likelihood of resuscitation is low, 1 qualified individual should attend the birth. If risk factors are present, at least 2 qualified people should be present solely to manage the baby. The number of team members and qualifications vary depending on risk.
	If the birth will be attended by 1 person, Knows the answers to the 4 pre-birth questions, determines supplies and equipment needed, knows how to call for help

	Critical Performance Steps (cont)
	If the birth will beattended by a team, perform a pre-resuscitation briefing. Identifies team leader. Assesses risk factors, delegates tasks, identifies who will document events, determines supplies and equipment needed, knows how to call for additional help.
Rapid evaluation.	
	Asks 3 rapid evaluation questions: • Term? **"Yes, appears termas expected."** • Muscle tone? **"No."** • Breathing or crying? **"No, not breathing or crying."**
Initial steps at radiant warmer.	
	Receives baby at radiant warmer, dries and removes linen, stimulates briefly by rubbing the baby's back, positions airway, suctions mouth and nose
Assess breathing. If breathing, ossess heort rate.	
	Is the baby breathing? **"No."** **(Heort rote = 70 bpm, if ossessed)**
	Indicates need for PPV. Requests immediate help from 1 person and uses standardized method to call for additional help.
Begin PPV within 60 seconds of birth.	
	Positions head in sniffing position
	Applies mask correctly
	Starts PPV in 21% oxygen (room air) at 20 to 25 cm H_2O (PEEP of 5 cm H_2O if using T-piece resuscitator, flow-inflating bag, or self-inflating bag with PEEP valve); rote 40 to 60 breaths/min
	Requests pulse oximeter sensor placement on baby's right hand or wrist
	Requests cardiac monitor (optional at this time)
	Within 15 seconds of beginning PPV, requests heart rote check to assess if heart rote is increasing **Heort rote = 70 bpm ond not increasing** **$SP0_2$ = 67%**
	Asks assistant to assess chest movement **"No chest movement."**
Perform ventilation corrective steps (MR. SOPA). Instructor determines how many MR. SOPA steps to use before PPV can result in chest movement.	
	• Mask adjustment • Reposition the head and neck Gives 5 breaths and asks assistant to assess chest movement **"No chest movement."** **Heart rate = 70 bpm and not increosing** **$SP0_2$ = 67%**
	• Suctions the mouth and nose • Opens the mouth Gives 5 breaths and asks assistant to assess chest movement **"No chest movement."** **Heart rate = 70 bpm and not increosing** **$SP0_2$ = 65%**
	• Increases Pressure by 5 to 10 cm H_2O increments to maximum 40 cm H_2O for term baby Gives 5 breaths and asks assistant to assess chest movement **"Chest moves with PPV." (Note:** If instructor states that the chest is not moving after this MR. SOPA step, learners will proceed with laryngeal mask insertion now.)
	Learner's assistant announces, "The chest is moving NOW. Continue PPV for 30 seconds."

	Critical Performance Steps (cont)
Deliver PPV that moves the chest.	
	Delivers PPV that moves the chest x 30 seconds
	Requests heart rote assessment **Heart rote=60 bpm and not increasing "Pulse oximeter has no signal."**
Laryngeal mask preparation.	
	Calls for additional help if needed. Places chest leads and attaches a cardiac monitor, if not already done.
	Obtains a size 1 laryngeal mask (and a 5-ml syringe if mask requires inflation), and a 5F or 6F orogastric tube if the laryngeal mask has an insertion port
	Resuscitation team continues MR. SOPA steps with face mask while operator is preparing laryngeal mask
	If the laryngeal mask requires inflation, Quickly inflates the rim with no more than 4 ml of air to test for leaks. Withdraws air.
	Lubricates back and sides of the mask with water-soluble lubricant, keeping lubricant away from the inside of the mask (optional step for manikin use)
Laryngeal mask insertion.	
	Stands at the baby's head. Places baby's head in sniffing position.
	Holds the device along the airway tube with the closed bottom of the mask facing the baby's palote and the open bowl of the mask facing toward the baby's chin
	Opens the newborn's mouth by gently pressing downward on the baby's chin. Inserts the leading tip of the mask into the baby's mouth, on top of the tongue, with the bottom of the mask pressed against the baby's palote.
	Glides the device downward and backward, following the contour of the palote, with a continuous but gentle push until definitive resistance is met
	If the laryngeal mask requires inflation, Supports the device in place, allowing it to rise and seat while inflating the rim by injecting 2 to 4 ml of air via the inflation valve. The pilot balloon mirrors inflation of the rim. Removes syringe.
	Holds the laryngeal mask in place and attaches a CO_2 detector and the PPV device
Positive-pressure ventilation with laryngeal mask	
	The person holding the laryngeal mask holds the PPV device and begins PPV.
	Learner and/or the assistant confirms insertion by assessing and announces the presence of • Symmetrical chest movement • Bilateral breath sounds • Color change on CO_2 detector within 8 to 10 positive-pressure breaths
	Operator continues PPV at appropriate rote and pressure for 30 seconds, monitoring heart rote and SPO_2
	Secures laryngeal mask with waterproof tape
	If the laryngeal mask has a gastric port and will be in place for more than severa! minutes, measures for orogastric tube insertion (described above), inserts orogastric tube down port, and decompresses stomach contents with syringe. Leaves orogastric tube open to air as a vent. Tapes tube to baby's cheek.

	Critical Performance Steps (cont)
Assess heart rote after 30 seconds of PPV that moves the chest.	
	Heart rote= 120 bpm $SP0_2$ = 74% "The baby has occasional spontaneous respirations."
	Gradually decreases PPV rote and pressure. Stimulates newborn. Requests heart rote assessment, SP02 to assess need for supplemental oxygen, and respiratory status
	Heart rote= 140 bpm $5Po_2$ = 78% and gradually increasing "The baby is crying."
Remove laryngeal mask.	
	Suctions secretions from the back of the mouth and throat. **If the mask has an inflatable rim,** deflates the rim before removing. Removes laryngeal mask.
	Monitors heart rote, breathing, oxygen saturation
	Heart rote= 140 bpm $5Po_2$ = 86% and gradually increasing "The baby has spontaneous, regular breathing."
End scenario.	
	Monitors heart rote, breathing, oxygen saturation, temperature. Communicates with perinatal team. Updates parents and informs them of next steps, including post-resuscitation care. Debriefs the resuscitation.

Sample Debriefing Questions

O What is the most important issue to discuss during this debriefing?

f) What went well during this resuscitation?

E) What will you do differently when faced with this situation in a future scenario?

8 Do you have additional comments or suggestions for your team members? For the team leader?

0 Give me an example of how you used at least one of the NRP Key Behavioral Skills.

If significant errors were made, consider asking the learners

O What happened? What should have happened? What could you have done to make the right things happen?

f) What NRP Key Behavioral Skills might have been helpful in this situation?

NRP Key Behavioral Skills

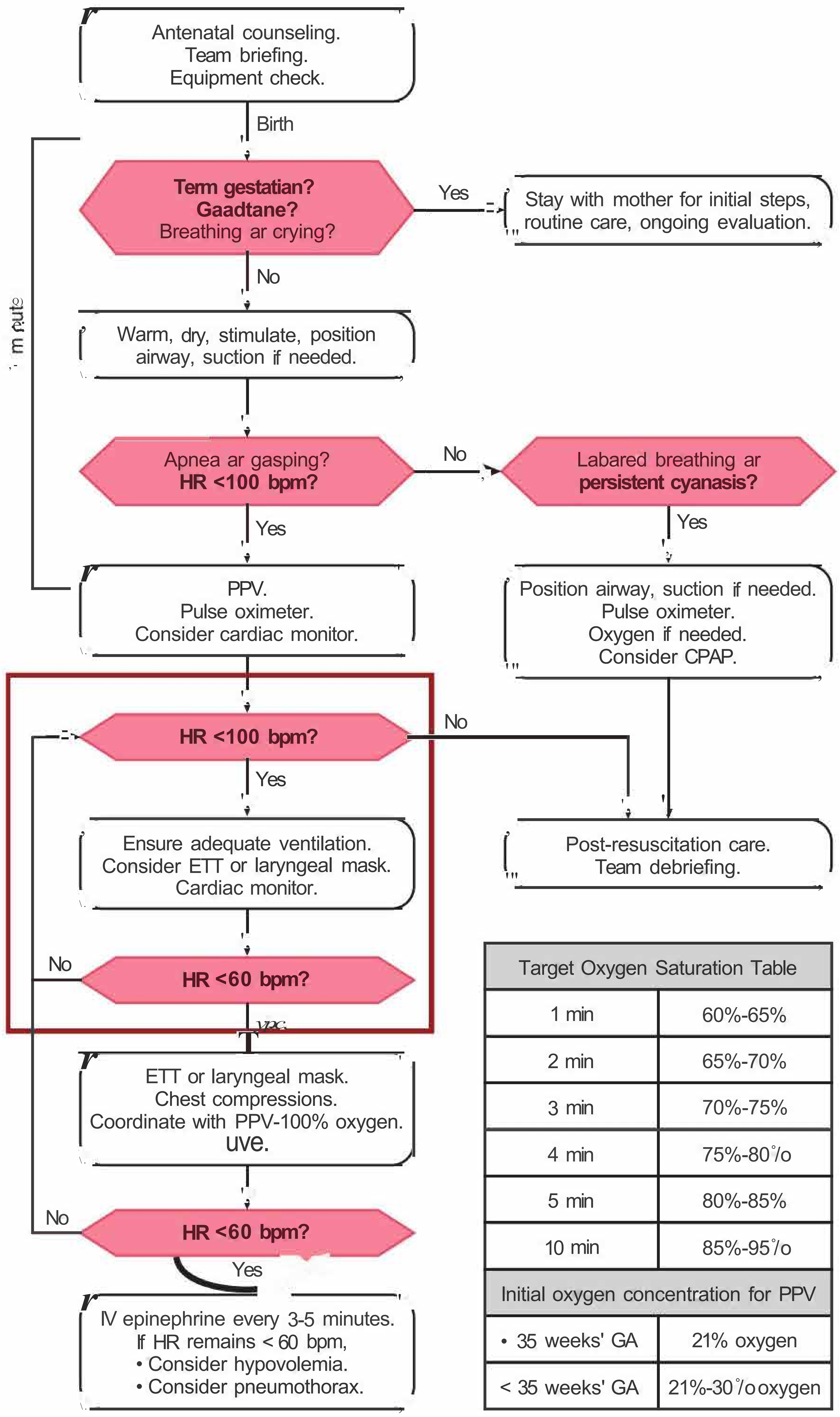
- Know your environment.
- Use available information.
- Anticipate and plan.
- Clearly identify a team leader.
- Communicate effectively.
- Delegate the workload optimally.
- Allocate attention wisely.
- Use available resources.
- Call for additional help when needed.
- Maintain professional behavior.

5

Endotracheal Intubation

What you will learn

- The indications for endotracheal intubation during resuscitation
- How to select and prepare the equipment for endotracheal intubation
- How to assist with endotracheal intubation
- How to use a laryngoscope to insert an endotracheal tube
- How to determine if the endotracheal tube is in the trachea
- How to use an endotracheal tube to suction thick secretions from the trachea



Target Oxygen Saturation Table	
1 min	60%-65%
2 min	65%-70%
3 min	70%-75%
4 min	75%-80°/o
5 min	80%-85%
10 min	85%-95°/o
Initial oxygen concentration for PPV	
• 35 weeks' GA	21% oxygen
< 35 weeks' GA	21%-30°/o oxygen

Key Points

- Insertion of an endotracheal tube (intubation) is strongly recommended if the baby's heart rate remains less than 100 bpm and is not increasing after positive-pressure ventilation (PPV) with a face mask or laryngeal mask.

- Insertion of an endotracheal tube is strongly recommended before starting chest compressio11s. If intubation is not successful or feasible, and the baby weighs more than approximately 2 kg, a laryngeal mask may be used.

- An endotracheal tube should be inserted for direct tracheal suction if the trachea is obstructed by thick secretions, for surfactant administration, and for stabilization of a newborn with a suspected diaphragmatic hernia.

- If PPV is prolonged, an endotracheal tube may be considered to improve the efficacy and ease of assisted ventilation.

- A person with intubation skills should be in the hospital and available to be called for immediate assistance if needed. If the need for intubation is anticipated, this person should be present in the delivery room at the time of birth. It is not sufficient to have someone on call at home or in a remote area of the hospital.

- The appropriate laryngoscope blade for a term newborn is size No. 1. The correct blade for a preterm newborn is size No. 0 (size No. 00 *optional* for extremely preterm newborn).

- The intubation procedure ideally should be completed within 30 seconds. Effective teamwork is required to perform this procedure quickly.

- Demonstrating exhaled carbon di oxide (C0$_2$) and observing a rapidly increasing heart rate are the primary methods of confirming endotracheal tube insertion within the trachea.

- Endotracheal tube insertion depth can be estimated using the nasal-tragus length (NTL) or the baby's gestational age; however, the depth estímate should be confirmed by auscultating equal breath sounds. If the tube is to remain in place, obtain a chest x-ray for final confirmation.

4D) If a correctly inserted endotracheal tube <loes not result in PPV with chest movement, suspect airway obstruction and suction the trachea with a suction catheter or tracheal aspirator.

G, If a baby's condition worsens after endotracheal intubation, the tube may have become **displaced or obstructed,** or there may be a **pneumothorax** or PPV **equipment** failure *(DOPE* mnemonic).

0 Avoid repeated unsuccessful attempts at endotracheal intubation. Por babies who weigh more than approximately 2 kg, a laryngeal mask may provide a rescue airway when PPV with a face mask fails to achieve effective ventilation and intubation is unsuccessful or not feasible.

Case: Resuscitation with positive-pressure ventilation using an endotracheal tube

Your team is called to attend the birth for a woman at 37 weeks' gestation whose labor is complicated by maternal fever and fetal tachycardia. The amniotic fluid is clear. You complete a pre-resuscitation briefing and prepare your supplies and equipment. After the vaginal birth, the obstetrician dries and stimulates the baby, but the baby remains limp and apneic. The umbilical cord is clamped and cut and the baby is moved to the radiant warmer. You position and suction the mouth and nose while providing brief additional stimulation, but the baby is still not breathing. You start positive-pressure ventilation (PPV) while another team member places a pulse oximeter sensor on the baby's right hand and another documents the events as they occur. The baby's heart rate is 50 beats per minute (bpm) and not increasing. You observe that the chest is not moving with PPV breaths and begin the ventilation corrective steps. After the first 5 corrective steps, the chest is still not moving and the heart rate has not improved. A carbon dioxide (CO_2) detector placed between the PPV device and mask remains purple with assisted breaths. You decide to insert an endotracheal tube to improve the effectiveness of PPV.

Leads are placed on the chest and attached to a cardiac monitor. An assistant holds a 3.5-mm endotracheal tube, provides cricoid pressure, and monitors the procedure time while a qualified provider uses a size 1 laryngoscope to insert the endotracheal tube. A CO_2 detector is placed on the tube, PPV is resumed, and the detector turns yellow, indicating that the tube is in the trachea and the lungs are being ventilated. The baby's chest is moving and the heart rate rapidly increases. Based on the nasal-tragus length (NTL) measurement, the endotracheal tube is held with the 8-cm marking adjacent to the lip. Breath sounds are equal in both axillae, the tube is secured, and PPV continues. You adjust the oxygen concentration based on pulse oximetry. The baby still has poor tone and irregular respiratory effort. You quickly update the parents and transfer the baby to the nursery for a chest x-ray and post-resuscitation care. Shortly afterward, your resuscitation team conducts a debriefing to discuss preparation, teamwork, and communication.

What is an endotracheal tube?

An endotracheal tube (Figure 5.1) is a thin tube that is inserted through the glottis, between the vocal cords, and advanced into the trachea. Although digital intubation using only the operator's finger has been described, endotracheal intubation typically requires the use of a lighted instrument (laryngoscope [Figure 5.2]) to visualize the larynx and guide the insertion of the tube between the vocal cords.

When should insertion of an endotracheal tube be considered?

- Insertion of an endotracheal tube (intubation) is strongly recommended if the baby's heart rate remains less than 100 bpm and is not increasing after PPV with a face mask or laryngeal mask.
- Insertion of an endotracheal tube is strongly recommended before starting chest compressions. If intubation is not successful or

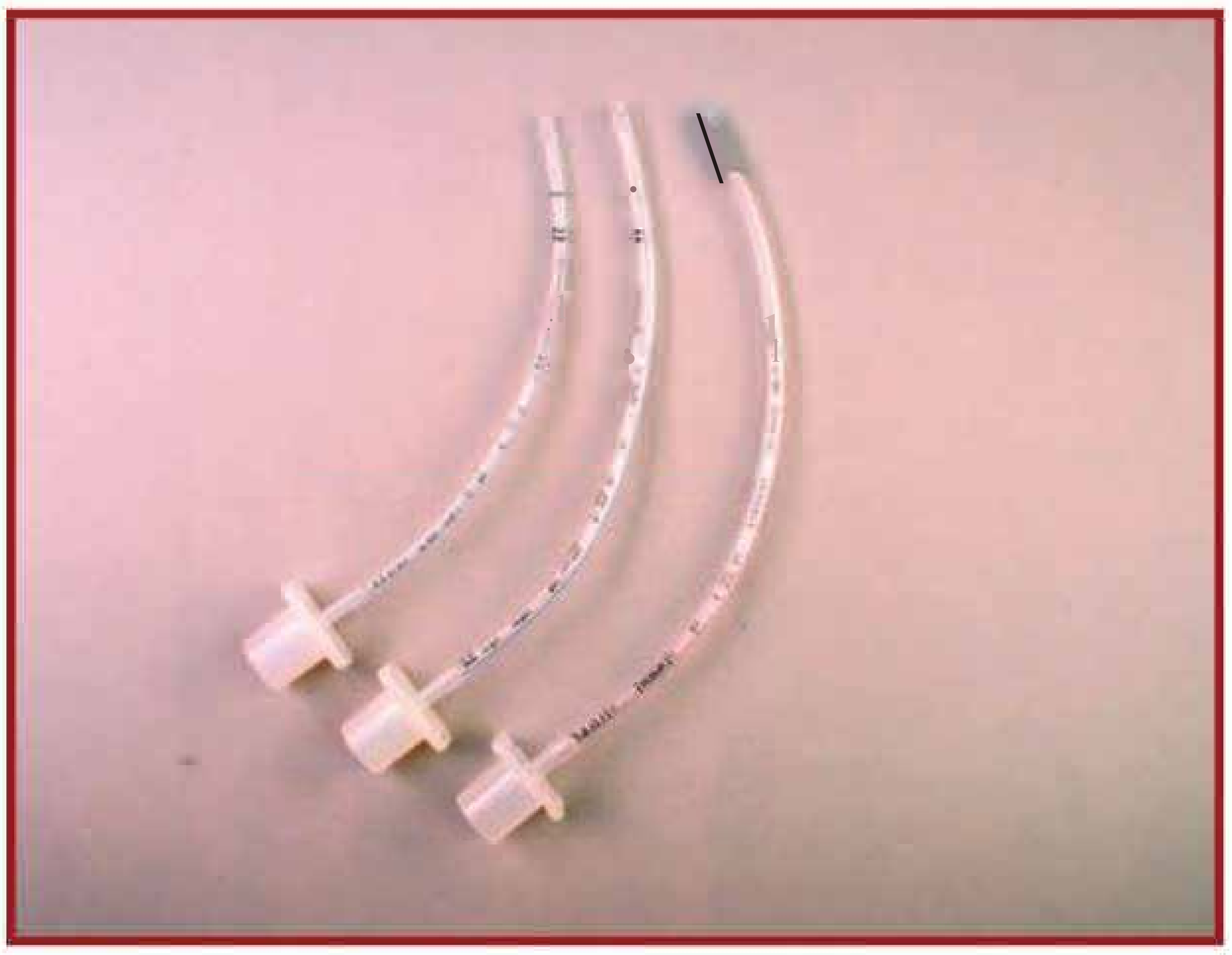


Figure 5.1. Endotracheal tubes (size 2.5, 3.0, 3.5)

Figure 5.2. Laryngoscope

feasible, and the baby weighs more than approximately 2 kg, a laryngeal mask may be used.

- Ventilation through an endotracheal tube for 30 seconds may improve ventilation efficacy and prevent the need to proceed to chest compressions.
- If chest compressions are needed, ventilation through an endotracheal tube may improve coordination with compressions.
- Intubation allows the compressor to give compressions from the head of the bed.

• An endotracheal tube should be inserted for direct tracheal suction if the trachea is obstructed by thick secretions, for surfactant administration, and for stabilization of a newborn with a suspected diaphragmatic hernia.

• If PPV is prolonged, an endotracheal tube may be considered to improve the efficacy and ease of assisted ventilation.

When endotracheal intubation is needed, it must be performed without significant delay. A person with intubation skills should be available to be called for immediate assistance if needed. If the need for intubation is anticipated, this person should be present in the delivery room at the time of birth.

What are the important anatomic landmarks in the neonatal airway?

The anatomic landmarks are labeled in Figures 5.3 and 5.4.

O **Esophagus:** The passageway extending from the throat to the stomach

8 **Epiglottis:** The lid-like structure overhanging the glottis

E) **Vallecula:** The pouch formed by the base of the tongue and the epiglottis

C) **Larynx:** Portion of the airway connecting the pharynx and trachea

0 **Glottis:** The opening of the larynx leading to the trachea, flanked by the vocal cords

O **Vocal cords:** Mucous membrane-covered ligaments on both sides of the glottis

O **Trachea:** Portion of the airway extending from the larynx to the car1na

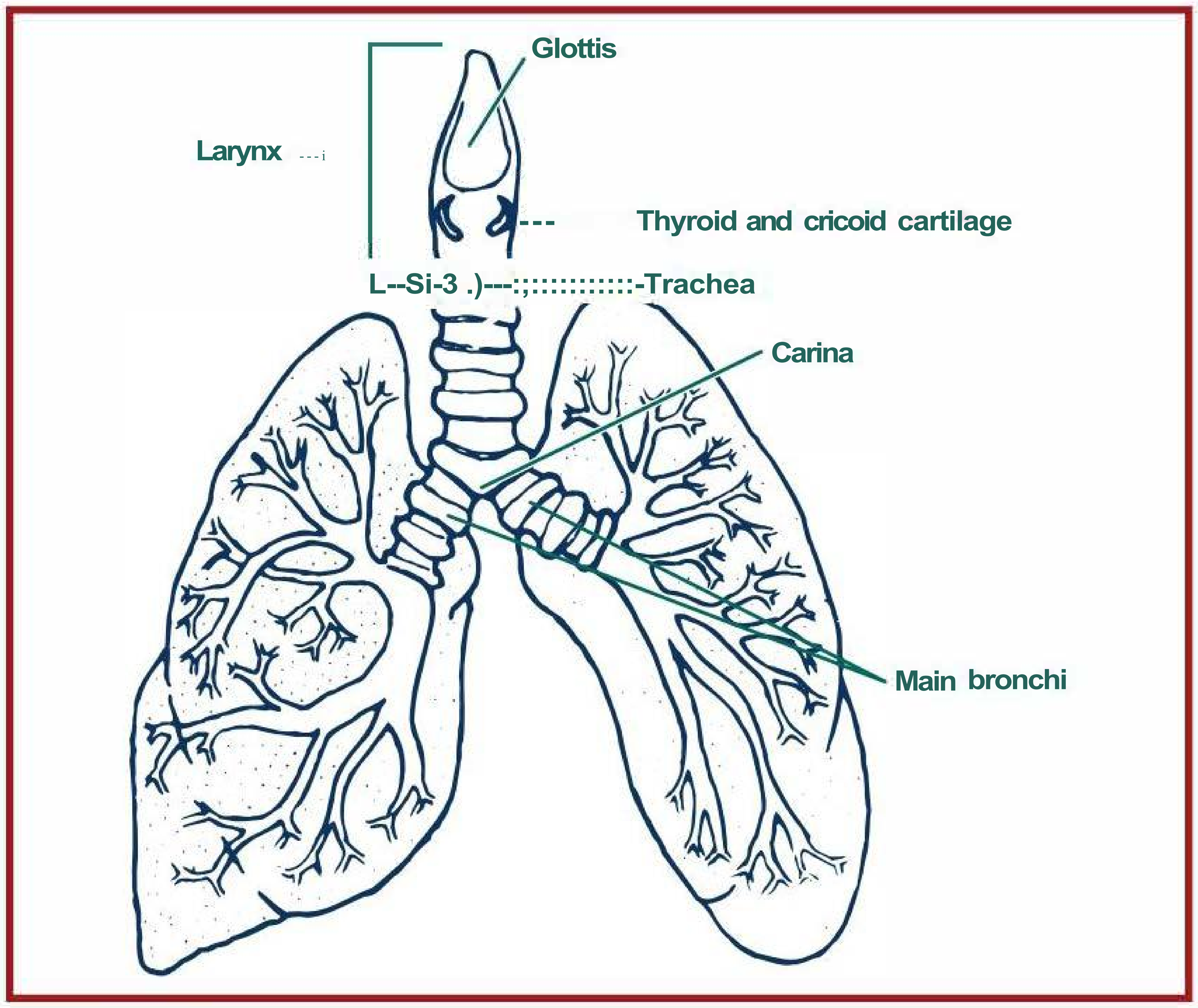


Figure 5.3. Airway anatomy

- **Thyroid and cricoid cartilage:** Lower portion of the cartilage protecting the larynx
- **Carina:** Where the trachea branches into the 2 main bronchi
- **Main bronchi:** The 2 air passageways leading from the trachea to the lungs

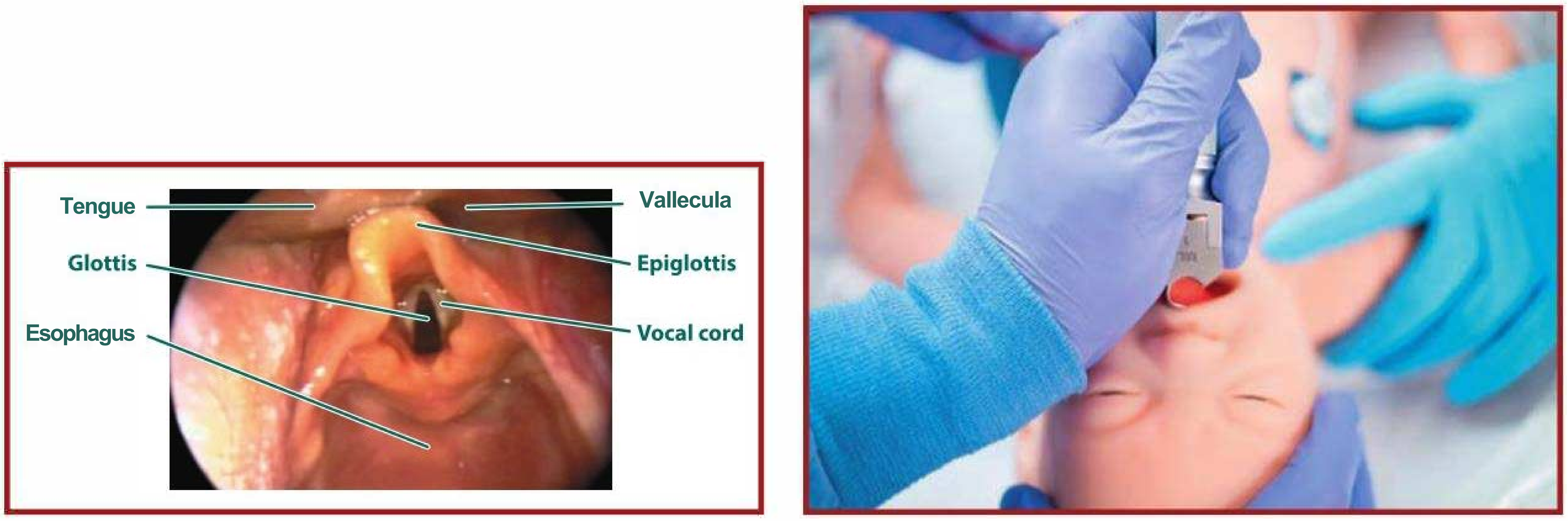


Figure 5.4. Laryngoscopic view of vocal cords and surrounding structures

What supplies and equipment should be available for intubation?

Intubation supplies and equipment should be kept together and readily accessible. It is important to anticipate the need for intubation and prepare the supplies and equipment before a high-risk delivery.

Each delivery room, nursery, and emergency department should have at least 1 complete set of the following items (Figure 5.5):

0 Laryngoscope handle•

- If the handle uses replaceable batteries and bulbs, an extra set should be available.

8 Laryngoscope blades (straight Miller)*

- No. 1 (term newborn)
- No. 0 (preterm newborn)
- No. 00 *(optional for extremely preterm newborn)*

E) Endotracheal tubes with inside diameters of 2.5, 3.0, and 3.5 mm

- Size 2.0 mm, size 4.0 mm, and tubes with inflatable cuffs are available and may be considered for specific indications but are not routinely used during neonatal resuscitation.

8 Stylet *(optional)* that fits into the endotracheal tube

0 CO_2 detector

0 Suction setup with suction catheters: size 10F or larger (for suctioning the pharynx), size 8F, and either size 5F or 6F (for suctioning endotracheal tubes of various sizes that become obstructed with secretions during resuscitation)

O Waterproof adhesive tape (1/2 or 3/4 inch), or other tube-securing device

0 Measuring tape and/or endotracheal tube insertion depth table (Table 5-4)

f) Scissors to cut tape

'A video laryngoscope with an integrated camera that displays a magnified view of the airway structures on a video screen is an option.

CD) Tracheal aspirator

fD Stethoscope (with neonatal head)

0 Positive-pressure ventilation device (bag or T-piece resuscitator) and tubing for blended air and oxygen

G, Pulse oximeter, sensor, and cover

4D Laryngeal mask (size 1) as a rescue airway

- 5-mL syringe if using a laryngeal mask with an inflatable rim

Intubation should be performed as a clean procedure. All supplies should be protected from contamination by being opened, assembled, and placed back in their packaging until just before use. The laryngoscope blades and handle should be cleaned, following your hospital's procedures, after each use.

When intubation becomes necessary, a cardiac monitor is recommended for the most accurate assessment of the baby's heart rate. During resuscitation, auscultation can be difficult and pulse oximetry may not reliably detect the baby's pulse. A cardiac monitor is a valuable tool at this point in resuscitation because an increasing heart rate is a critica} indicator for proper endotracheal tube insertion and because your decision to proceed with chest compressions after intubation depends on accurate assessment of the heart rate.

Figure 5.5. Neonatal airway supplies and equipment. (Supplies removed from packaging for demonstration purposes.)

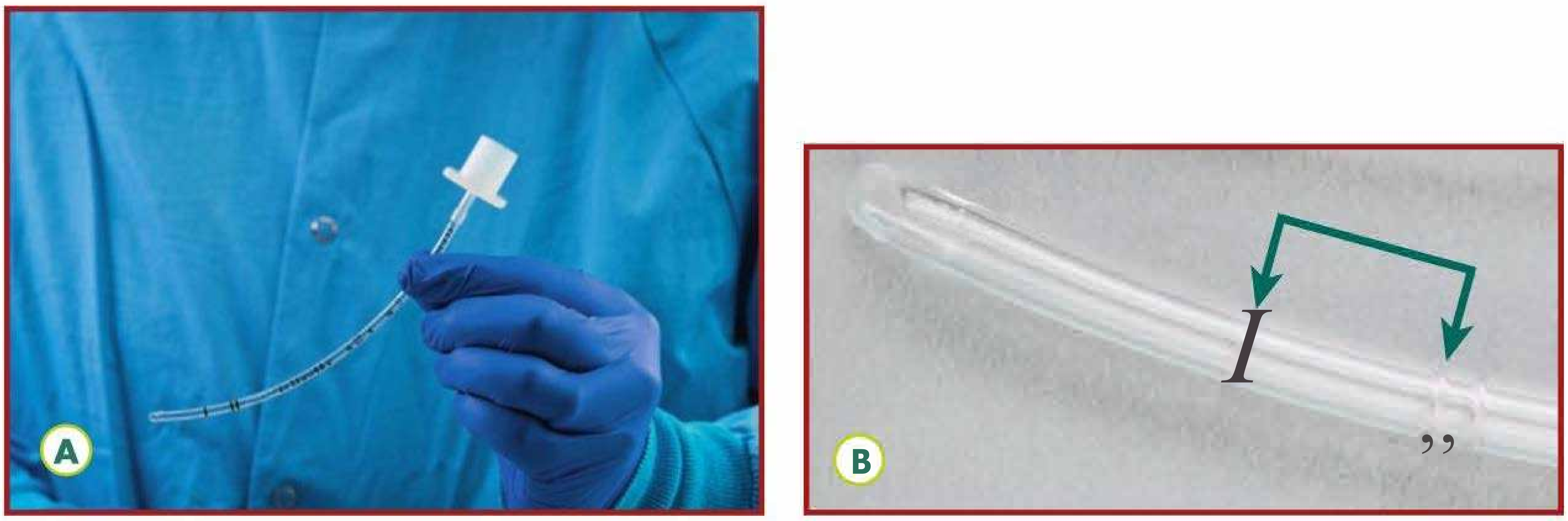


Figure 5.6. Neonatal endotracheal tube with a uniform diameter (A). This tube has a vocal cord guide that is used to approximate the insertion depth (B). The tube is inserted so that the vocal cords are positioned in the space between the double line and single line (indicated by the arrows). The vocal cord guide is only an approximation and may not reliably predict the correct insertion depth.

What type of endotracheal tube should be used?

The endotracheal tube should have a uniform diameter throughout the length of the tube (Figure 5.6A). Tapered tubes are not recommended for neonatal resuscitation. Endotracheal tubes have centimeter markings along the side measuring the distance to the tip of the tube. Many tubes will also have lines or markings (Figure 5.6B) near the tip that are intended to be a vocal cord guide. When the tube is inserted so that vocal cords are positioned between the 2 sets of lines, the tip of the tube is expected to be above the carina; however, the location and design of the lines varíes considerably between manufacturers. *The vocal cord guide is only an approximation and may not reliably indicate the correct insertion depth.*

How do you prepare the endotracheal tube?

Select the correct size.

Endotracheal tubes are described by the size of their interna! diameter (mm ID). The appropriate endotracheal tube diameter is estimated from the baby's weight or gestational age. Table 5-1 gives the recommended endotracheal tube size for various weight and gestational-age categories. Using a tube that is too small increases the resistance to air flow and the chance that it will become obstructed by secretions. Using a tube that is too large may traun1atize the airway. Size 2.0 mm, size 4.0 mm, and tubes with inflatable cuffs are available and may be considered for specific indications but are not routinely used during neonatal resuscitation.

Table 5-1. Endotracheal Tube Size for Babies of Various Weights and Gestational Ages

Weight	Gestational Age	Endotracheal Tube Size
Below l kg	Below 28 weeks	2.5 mm ID
1-2 kg	28-34 weeks	3.0 mm ID
Greater than 2 kg	Greater than 34 weeks	3.5 mm ID

Consider using a stylet.

Many operators find it helpful to use a stylet with the endotracheal tube to provide additional rigidity and curvature (Figure 5.7A). Use of a stylet is optional and depends on the operator's preference. When inserting a stylet, it is important to ensure that the tip is not protruding from either the end or side hole of the endotracheal tube (Figure 5.7B). If the tip protrudes, it may cause trauma to the tissues. The stylet should be secured with a plug, or bent at the top, so that it cannot advance farther into the tube during the insertion procedure. It is important to ensure that the stylet is easily removable from the endotracheal tube because aggressive attempts to remove the stylet after intubation can accidentally displace the tube.

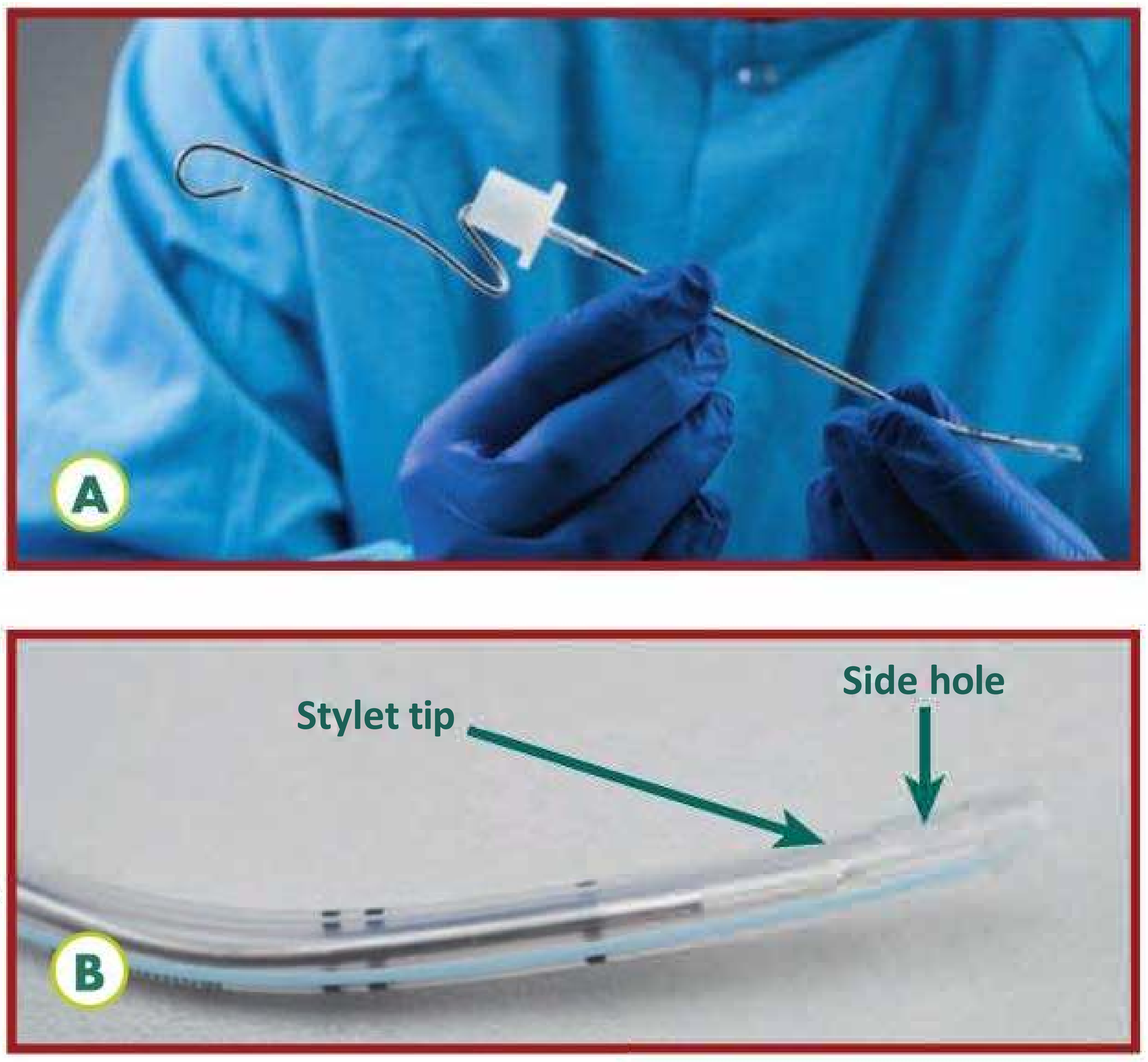


Figure 5.7. Optional stylet for increasing endotracheal tube stiffness and maintaining curvature during intubation

How do you prepare the laryngoscope and other equipment you will need?

The following steps describe how to prepare the equipment used for intubation:

0 If not already done, attach cardiac monitor leads for accurate assessment of the baby's heart rate.

f) Select the appropriate laryngoscope blade and attach it to the handle.

   a. Use a No. 1 blade for term newborns.

   b. Use a No. 0 blade for preterm newborns. Sorne operators may prefer to use a No. 00 blade for extremely preterm newborns.

E) Turn on the light by clicking the blade into the open position to verify that the batteries and light are working. If the light is dim or flickers, tighten or replace the bulb, insert a new battery, or replace the laryngoscope. If you are using a light-bulb laryngoscope, close the laryngoscope until ready for use to avoid overheating the light bulb and blade.

8 Prepare the suction equipment.

a. Occlude the end of the suction tubing to ensure that the suction is set to 80 to 100 mm Hg.

b. Connect a size lOF (or larger) suction catheter to remove secretions from the mouth and pharynx.

c. Smaller suction catheters (size 8F and size SF or 6F) should be available for removing secretions from an obstructed endotracheal tube, if necessary, after insertion. Appropriate catheter sizes are listed in Table 5-2.

d. A tracheal aspirator can be attached to the endotracheal tube to directly suction meconium or thick secretions that obstruct the trachea. Sorne endotracheal tubes have an integrated suction port that can be attached directly to suction tubing and do not require use of a tracheal aspirator.

0 Prepare a PPV device with a mask to ventilate the baby, if 11ecessary, between intubation attempts. Check the operation of the device as described in Lesson 4.

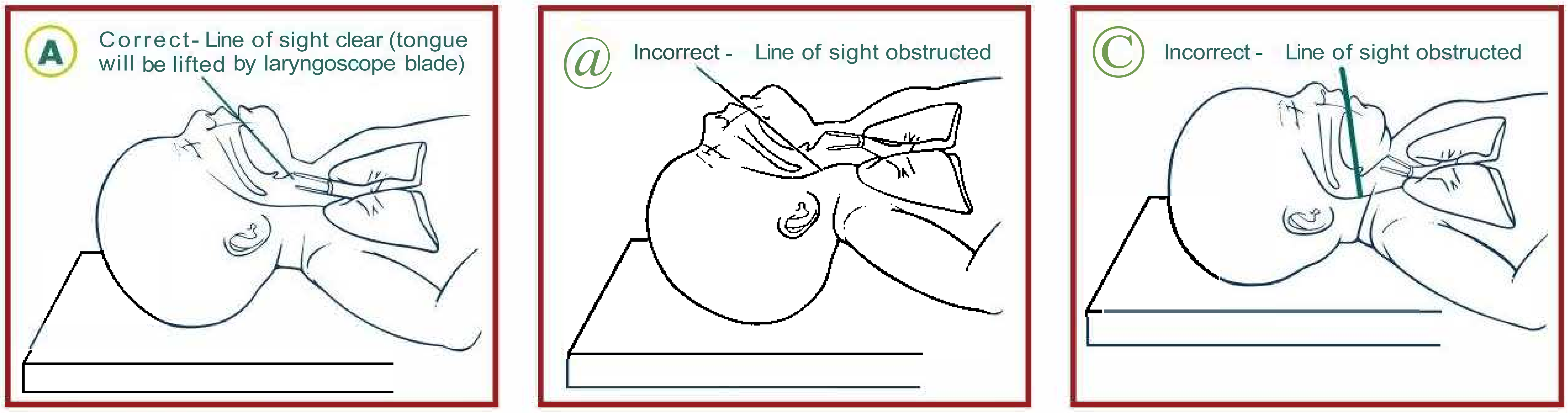
O Place a CO_2 detector, stethoscope, measuring tape or insertion depth table, waterproof adhesive tape (1/2 or 3/4 inch) and scissors, or other tube-securing device within reach.

Table 5-2. Suction Catheter Size for Endotracheal Tubes of Various Inner Diameters

Endotracheal Tube Size	Catheter Size
2.5 mm ID	5F or 6F
3.0 mm ID	6F or 8F
3.5 mm ID	8F

How should you position the newborn for intubation?

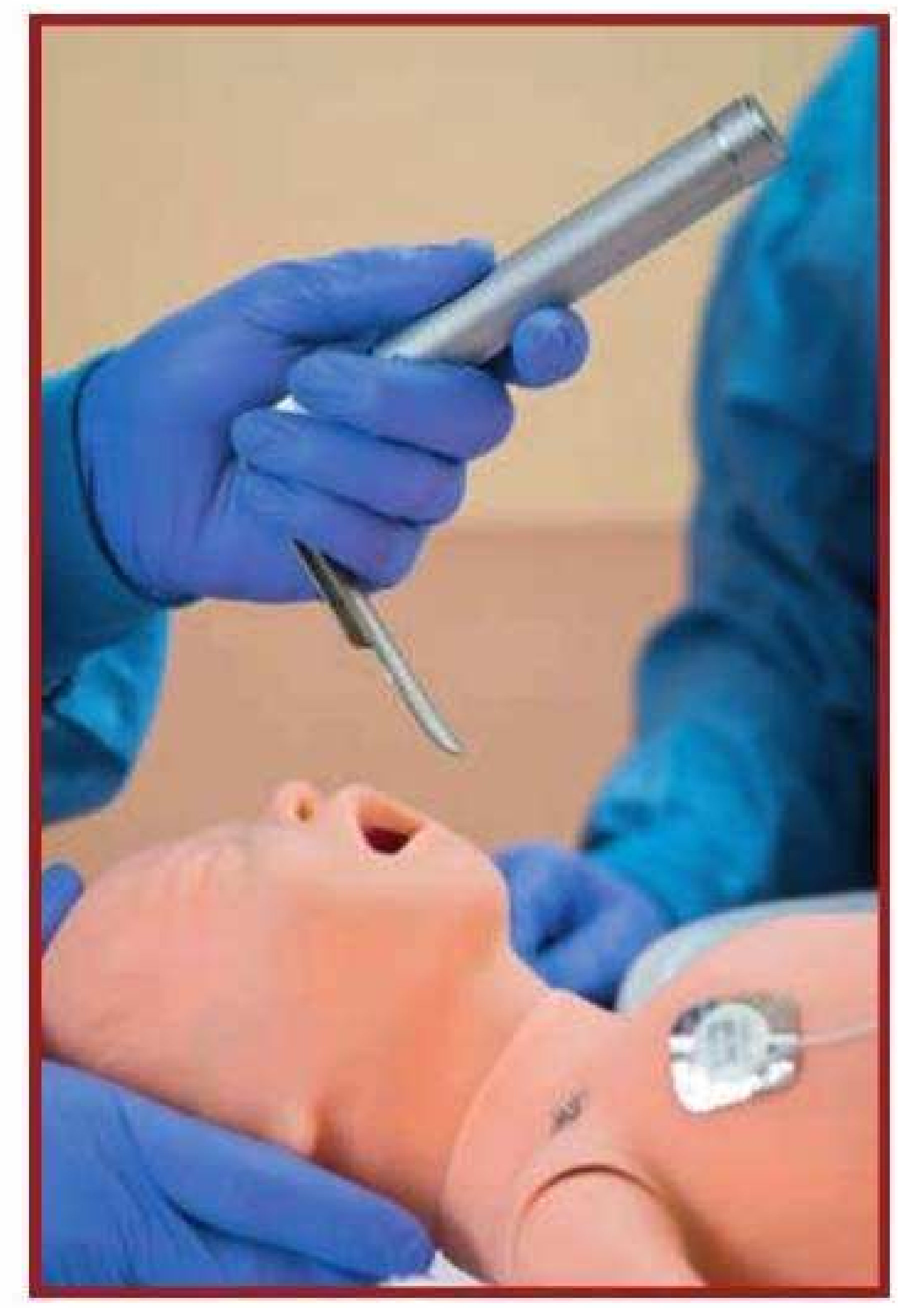
Place the baby's head in the midline, the neck slightly extended in the sniffing position, and the body straight. It may be helpful to place a small roll under the baby's shoulders to maintain slight neck extension. This position aligns the trachea for optima! viewing by allowing a straight line of sight into the glottis once the laryngoscope has been properly inserted. A team member should help to maintain good positioning throughout the procedure.



Fi g ure 5.8. Correct (A) and incorrect (B and C) positioning for intubation

Both overextension and flexion of the neck will obstruct your view of the airway. If the shoulder roll is too large or the neck is overextended, the glottis will be raised above your line of sight. If the neck is flexed toward the chest, you will be viewing the posterior pharynx and will not be able to visualize the glottis (Figure 5.8).

Adjust the height of the bed, if possible, so that the baby's head is level with the operator's upper abdomen or lower chest to bring the head closer to the operator's eye level and improve the view of the airway.



Fi g ure 5.9. Hold the laryngoscope in your left hand.

How do you hold the laryngoscope?

Always hold the laryngoscope in your **left** hand with your thumb resting on the upper surface of the laryngoscope handle and the blade pointing away from you (Figure 5.9). The laryngoscope is designed to be held in the left hand by both right- and left-handed users. If held in the right hand, your view through the open, curved portion of the blade will be obstructed.

How do you perform the intubation procedure?

The steps for endotracheal intubation are briefly described as follows; however, proficiency requires considerable supervision and practice. Even if you are not performing the procedure, it is helpful to understand the steps so you can effectively assist the operator.

Get ready to insert the laryngoscope.

O Correctly position the baby. If possible, adjust the height of the bed as needed. You may stabilize the baby's head with your right hand (Figure 5.10) while a team member ensures that the baby's whole body is lying straight and the head is in the sniffing position.

f) Use your right index finger or thumb to gently open the baby's mouth.

Figure 5.10. Positioning the baby for intubation

Insert the laryngoscope and identify key landmarks.

8 Insert the laryngoscope blade in the midline and gently slide it over the tongue through the oropharynx until the tip lies in the space between the base of the tongue and the epiglottis. This space is called the vallecula (Figure 5.11). In extremely preterm newborns,

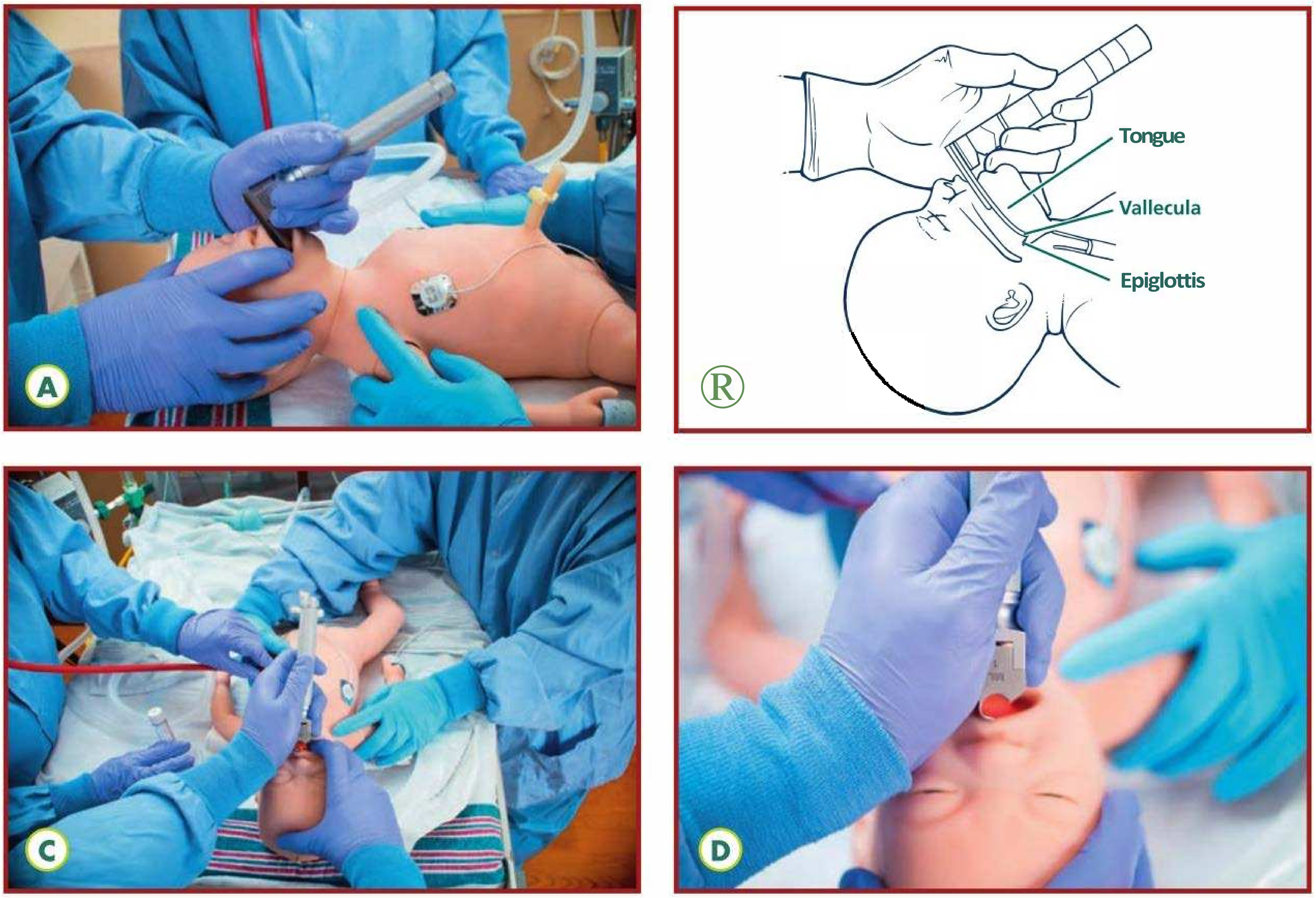


Figure 5.11. Insert the laryngoscope blade in the midline (A) and advance until the tip lies in the vallecula (B). Hold the laryngoscope in the midline (C) to identify landmarks through the open, curved portien of the laryngoscope blade (D).

the vallecula may be very small and you may need to gently place the laryngoscope tip directly under the epiglottis.

9 Lift the entire laryngoscope in the direction that the handle is pointing, opening the mouth and moving the tongue out of the way to expose the glottis. You may need to tilt the tip of the blade very slightly to lift the epiglottis and see the glottis and vocal cords.

When first learning the procedure, operators tend to bend their wrist, pulling the top of the handle toward themselves in a "rocking" motion against the baby's upper gum. This will not produce the desired view and may injure the baby's lips and gums (Figure 5.12).

Figure 5.12. Correct (left) and incorrect (right) method for lifting the laryngoscope to expose the larynx. Lift the laryngoscope in the direction that the handle is pointed; do not rotate or "rock" the handle against the baby's upper gum.

Note: This lesson describes placing the tip of the blade in the vallecula to lift the epiglottis. In sorne cases, where the vallecula is small or the epiglottis is large and floppy, it may be necessary to use the blade tip to *gently* lift the epiglottis directly.

0 The vocal cords and glottis appear at the very top of your view as you look down the laryngoscope. An assistant can help bring the glottis into view by using their thumb and first finger to provide gentle pressure on the baby's thyroid and cricoid cartilage (Figure 5.13). They should direct the pressure downward and toward the baby's right ear.

Figure 5.13. Thyroid and cricoid pressure provided by an assistant may improve visualization of the vocal cords and glottis. Press downward and toward the baby's right ear.

0 Identify the key landmarks (Figure 5.14). If the tip of the blade is correctly positioned in the vallecula, you should see the epiglottis hanging

clown from the top and the vocal cords directly below. The vocal cords appear as thin vertical stripes in the shape of an inverted letter «y»_

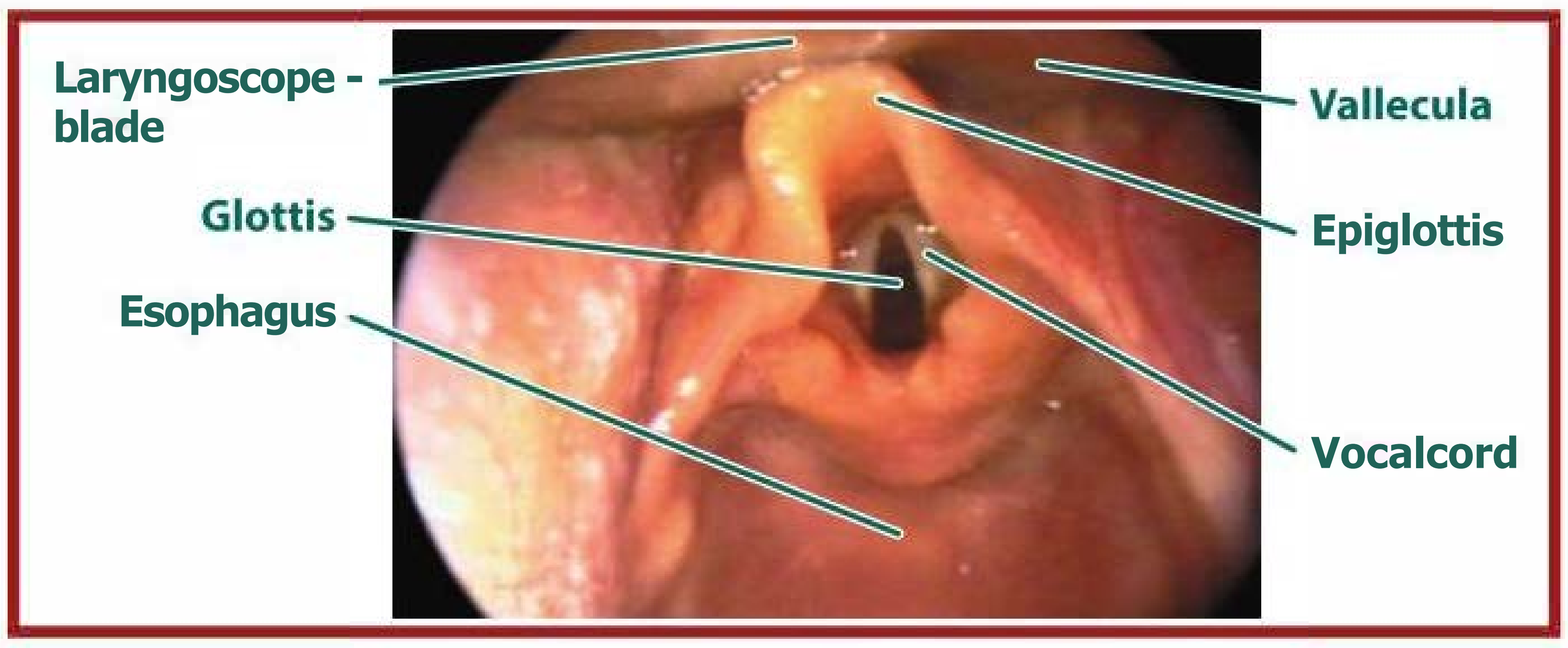
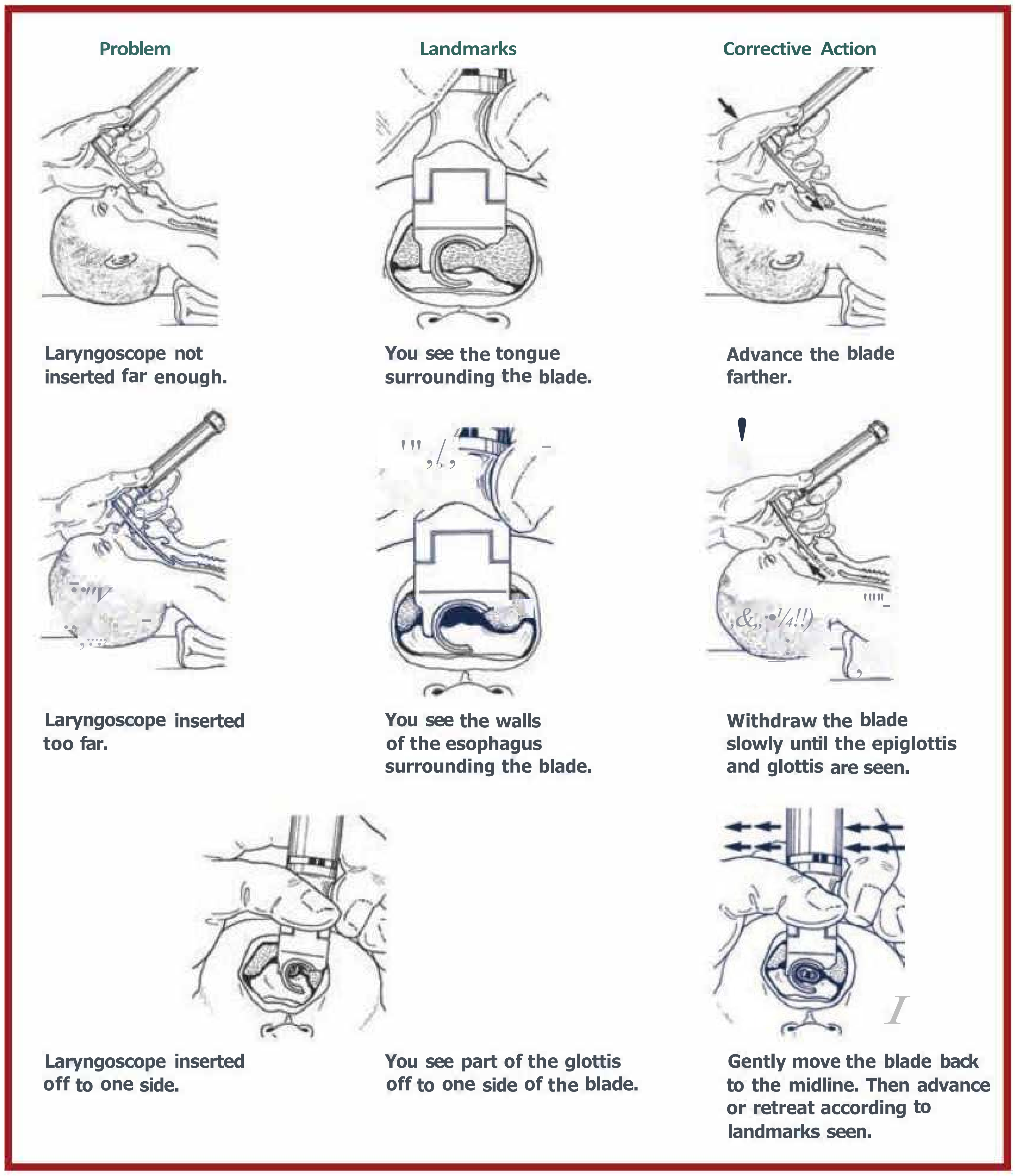


Figure 5.14. Key landmarks. The baby is lying supine. The laryngoscope blade is at the top of the photo, holding the tongue up and out of the way.

If these structures are not immediately visible, adjust the blade until the structures come into view. You may need to insert or withdraw the blade slowly to see the vocal cords (Figure **5.15**).

Figure 5.15. Corrective actions for poor visualization of landmarks during laryngoscopy



If the blade is not inserted far enough, you will see the base of the tongue and posterior pharynx (Figure 5.16). Advance the blade slightly until the epiglottis comes into view.

If the blade is inserted too far, you will see only the esophagus (Figure 5.17) and will need to withdraw the blade slightly until the epiglottis drops down from above.

Figure 5.16. Laryngoscope not inserted far enough. Tongue and posterior pharynx obscure view.

Figure 5.17. Laryngoscope inserted too far. Only the esophagus is visible.

Figure 5.18. Suctioning secretions during laryngoscopy

If the anatomic landmarks are obstructed by secretions, use a size 10F or 12F catheter to remove secretions from the mouth and pharynx (Figure 5.18).

Insert the endotracheal tube.

- Once you have identified the vocal cords, hold the laryngoscope steady and maintain your view of the vocal cords, while an assistant places the endotracheal tube in your right hand. Insert the tube into the right side of the baby's mouth, outside the blade, with the concave curve in the horizontal plane (Figure 5.19). Do not insert the tube through the laryngoscope's open channel. This will obstruct your view of the vocal cords.

Figure 5.19. Insertion of the endotracheal tube into the right side of the mouth

Pass the tube along the right side of the baby's mouth toward the vocal cords. As the tip approaches the vocal cords, rotate the tube's curvature into the vertical plane so the tip is directed upward. When the vocal cords open, insert the tube until the vocal cords are positioned between the marked guide lines on the tube. If your assistant is providing gentle thyroid and cricoid pressure, they may feel the tube pass beneath their fingers. Note the centimeter depth marking on the outside of the tube that aligns with the baby's upper lip.

If the vocal cords are closed, wait for them to open. Do not touch the closed cords with the tip of the tube and never try to force the tube between closed cords. If the cords do not open within 30 seconds, stop and resume ventilation with a mask until you are prepared to reattempt insertion.

Secure the endotracheal tube.

- Use your right index finger to hold the tube securely against the baby's hard palate. *Carefully remove the laryngoscope* without displacing the tube (Figure 5.20). If a stylet was used, an assistant should remove it from the endotracheal tube-being sure that you are holding the tube in place (Figure 5.21). Although it is important to hold the tube firmly, be careful not to squeeze the tube so tightly that the stylet cannot be removed.

Figure 5.20. Stabilize the tube against the baby's palote or cheek while carefully removing the laryngoscope.

Figure 5.21. An assistant removes the optional stylet while the operator holds the tube in place.

Figure 5.22. Attach a CO_2 detector and PPV device to the endotracheal tube and begin ventilation. Note the secure hand position used to hold the endotracheal tube in place.

Ventilate through the endotracheal tube.

- An assistant should attach a CO_2 detector and PPV device to the endotracheal tube (Figure 5.22). Having the same person hold the endotracheal tube and the PPV device may help to avoid accidental extubation. Once the PPV device is attached, begin ventilation through the tube.

How much time should be allowed for an intubation attempt?

The steps of intubation should be completed within approximately **30 seconds.** Effective teamwork is required to perform this procedure quickly. The baby is not being ventilated during the procedure, so rapid action is essential. If the baby's vital signs worsen during the procedure (severe bradycardia or decreased oxygen saturation), it is usually preferable to stop, resume PPV with a mask, and then try aga1n.

Repeated attempts at intubation are not advised because you will increase the likelihood of soft-tissue trauma and make subsequent airway management more difficult. If the initial attempts are unsuccessful, evaluate other options, including using a video laryngoscope if available, requesting assistance from another provider with intubation expertise (eg, anesthesiologist, emergency department physician, respiratory care practitioner, neonatal nurse practitioner, physician's assistant), inserting a laryngeal mask, or continuing face-mask ventilation.

Figure 5.23. The colorimetric CO_2 detector is purple or blue before detecting exhaled CO_2 (A). The detector turns yellow in the presence of exhaled CO_2 (B).

How do you confirm that the endotracheal tube is in the trachea?

The primary methods of confirming endotracheal tube insertion within the trachea are detecting exhaled CO_2 and a rapidly rising heart rate. As soon as you insert the endotracheal tube, connect a CO_2 detector (Figure 5.22) and confirm the presence of CO_2 during exhalation. If the tube is correctly inserted and you are providing effective ventilation through the tube, you should detect exhaled CO_2 within 8 to 10 positive-pressure breaths.

There are 2 types of CO_2 detectors available. Colorimetric devices change color in the presence of CO_2 (Figure 5.23). These are the most commonly used devices in the delivery room. Capnographs are electronic monitors that display the CO_2 concentration with each breath.

Can the tube be in the trachea even though CO_2 is NOT detected?

Yes, there are limitations to the use of CO_2 detectors. If the tube is inserted in the trachea, but the lungs are not adequately ventilated, there may not be enough exhaled CO_2 to be detected. This may occur if the endotracheal tube or trachea are obstructed by secretions, you are not using enough ventilating pressure, or there are large bilateral pneumothoraces and the lungs are collapsed. In addition, babies with a very low heart rate or decreased cardiac function (low cardiac output) may not carry enough CO_2 to their lungs to be detected.

Can the CO_2 detector change color when the tube is NOT in the trachea?

Although uncommon, it is possible for a colorimetric CO_2 device to change color even though the tube is not in the trachea (Table 5-3). If the detector has already changed color in the package and is yellow when you remove it, the device is defective and should not be used. If epinephrine, surfactant, or atropine are administered through the endotracheal tube and touch the paper inside the CO_2 detector, or if gastric secretions touch the paper, they may permanently change the screen yellow and make the detector unusable.

Table 5-3. Colorimetric CO_2 Detector Problems

False Negative (Tube IS IN trachea but NO color change)	False Positive (Tube IS NOT in trachea but color changes)
• Inadequate ventilating pressure • Collapsed lungs • Bilateral pneumothoraces • Very low heart rote • Low cardiac output • Obstructed endotracheal tube	• Defective device changed color in package before use • Epinephrine, surfactant, atropine, or gastric secretion contamination

What are other indicators that the tube is in the trachea?

Demonstrating *exhaled CO_2* and observing a *rapidly increasing heart rate* are the *primary methods* of confirming endotracheal tube insertion within the trachea.

If the tube is positioned correctly, you should also observe

- Audible and equal breath sounds near both axillae during PPV
- Symmetrical chest movement with each breath
- Little or no air leak from the mouth during PPV
- Decreased or absent air entry over the stomach

Be cautious when interpreting breath sounds in newborns because sounds are easily transmitted. When listening to breath sounds, use a small stethoscope and place it near the axilla. A large stethoscope, or one placed near the center of the chest, may transmit sounds from the esophagus or stomach.

What if you suspect that the tube is not in the trachea?

The tube is not likely to be in the trachea if the CO_2 detector <loes not show the presence of exhaled CO_2 within 8 to 10 breaths. An endotracheal tube inserted in the esophagus provides no ventilation to the baby's lungs, and continuing to use it only delays effective ventilation. In most cases, you should remove the tube, resume ventilation with a face mask, ensure that your equipment is properly prepared, ensure that the baby is optimally positioned, and repeat the procedure using a clean tube.

Remember that babies with a very low heart rate or decreased cardiac function may not carry enough CO_2 to their lungs to change the color on the CO_2 detector. If you believe that the tube is correctly inserted in the trachea despite the lack of exhaled CO_2, you may choose to stabilize the tube, reinsert the laryngoscope, and attempt to confirm that the tube is passing betwee11 the vocal cords. This "second look,, procedure can be difficult and may delay establishing effective ventilation if the tube is not correctly inserted. If the tube position is confirmed and the baby's heart rate <loes not improve with ventilation through the endotracheal tube, chest compressions are indicated. Once cardiac output is improved, CO_2 will be detected.

How deeply should the tube be inserted in the trachea?

The goal is to insert the endotracheal tube tip in the middle portion of the trachea. This generally requires inserting the tube so that the tip is only 1 to 2 centimeters below the vocal cords. It is important not to insert the tube too far so that the tip touches the carina or enters a main bronchus. Two methods may be used for estimating the insertion depth. Your team should determine which method is preferred in your practice setting.

The nasal-tragus length (NTL) is a method that has been validated in both full-term and preterm newborns. The NTL method uses a calculation based on the distance (cm) from the baby,s nasal septum to the ear tragus (Figure 5.24). Use a measuring tape to measure the NTL. The estimated insertion depth (cm) is NTL + 1 cm. Insert the endotracheal tube so that the marking on the tube corresponding to the estimated insertion depth is adjacent to the baby's lip.

Figure 5.24. Measuring the NTL. Measure from the middle of the nasal septum (arrow, A) to the ear tragus (arrow, B) and add 1 cm to the measurement.

Studies have shown that gestational age is also an accurate predictor of the correct insertion depth (Table 5-4) and has the advantage of being known before birth. This table could be placed near the radiant warmer or with your intubation supplies.

Table 5-4. **Initial Endotracheol Tube Insertion Depth ("Tip to Lip") for Orotracheal Intubation**

Gestation	Endotracheal Tube Insertion Depth al Lips	Baby's Weight
23-24 weeks	**5.5 cm**	0.5-0.6 kg
25-26 weeks	**6.0 cm**	0.7-0.8 kg
27-29 weeks	**6.5 cm**	0.9-1 kg
30-32 weeks	**7.0 cm**	1.1-1.4 kg
33-34 weeks	**7.5 cm**	1.5-1.8 kg
35-37 weeks	**8.0 cm**	1.9-2.4 kg
38-40 weeks	**8.5 cm**	2.5-3.1 kg
41-43 weeks	**9.0 cm**	3.2-4.2 kg

Adapted from Kempley ST, Moreiras JW, Petrone FL. Endotracheal tube length for neonatal intubation. *Resuscitation.* 2008;77(3):369-373.

Remember that both of these methods are estimates of the correct endotracheal tube depth. After inserting the tube, use a stethoscope to listen for breath sounds in both axillae and over the stomach (Figure 5.25).

- If the tube is correctly positioned, the breath sounds should be equal on both sides.
- If the tube is in too far, the breath sounds may be decreased on one side.
  - Most often, if the tube is inserted too far, it will enter the right mainstem bronchus causing breath sounds to be louder on the right side and quieter on the left side. Slowly withdraw the tube while listening to the breath sounds on the quieter side.
  - When the tube is correctly positioned, the breath sounds should improve and become equal.

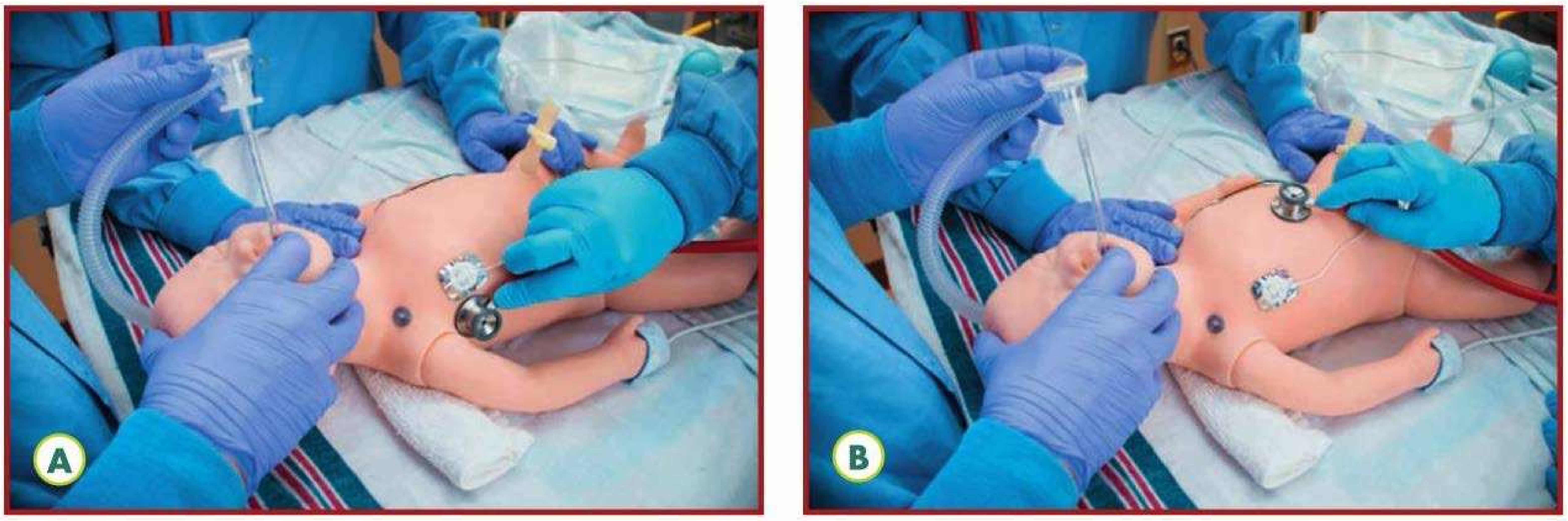


Figure 5.25. Listen for equal breath sounds in both axillae (A). Breath sounds should not be audible over the stomach (B).

If you plan to keep the tube in place, how do you secure it?

Severa} methods of securing the tube have been described. Either water-resistant tape or a device specifically designed to secure an endotracheal tube may be used.

One method is described as follows:

O After you have correctly positioned the tube, note the centimeter marking on the side of the tube adjacent to the baby's upper lip (Figure 5.26).

f) Cut a piece of 3/4- or 1/2-inch tape so that it is long enough to extend from one side of the baby's mouth, across the upper lip, and about 2 cm onto the opposite cheek (Figure 5.27).

8 Split the tape along half its length so that it appears like a pair of pants (Figure 5.27A).

8 Place the uncut section of tape on the baby's cheek so that the beginning of the split is close to the corner of the baby's mouth. Place the upper «leg„ of tape across the baby's upper lip (Figure 5.27B).

0 Carefully wrap the lower «leg„ around the tube (Figures 5.27C and 5.27D). Be sure that the desired centimeter marking remains next to the baby's upper lip. It is easy to inadvertently push the tube in farther than desired during the taping procedure.

Figure 5.26. Note the marking adjacent to the upper lip.

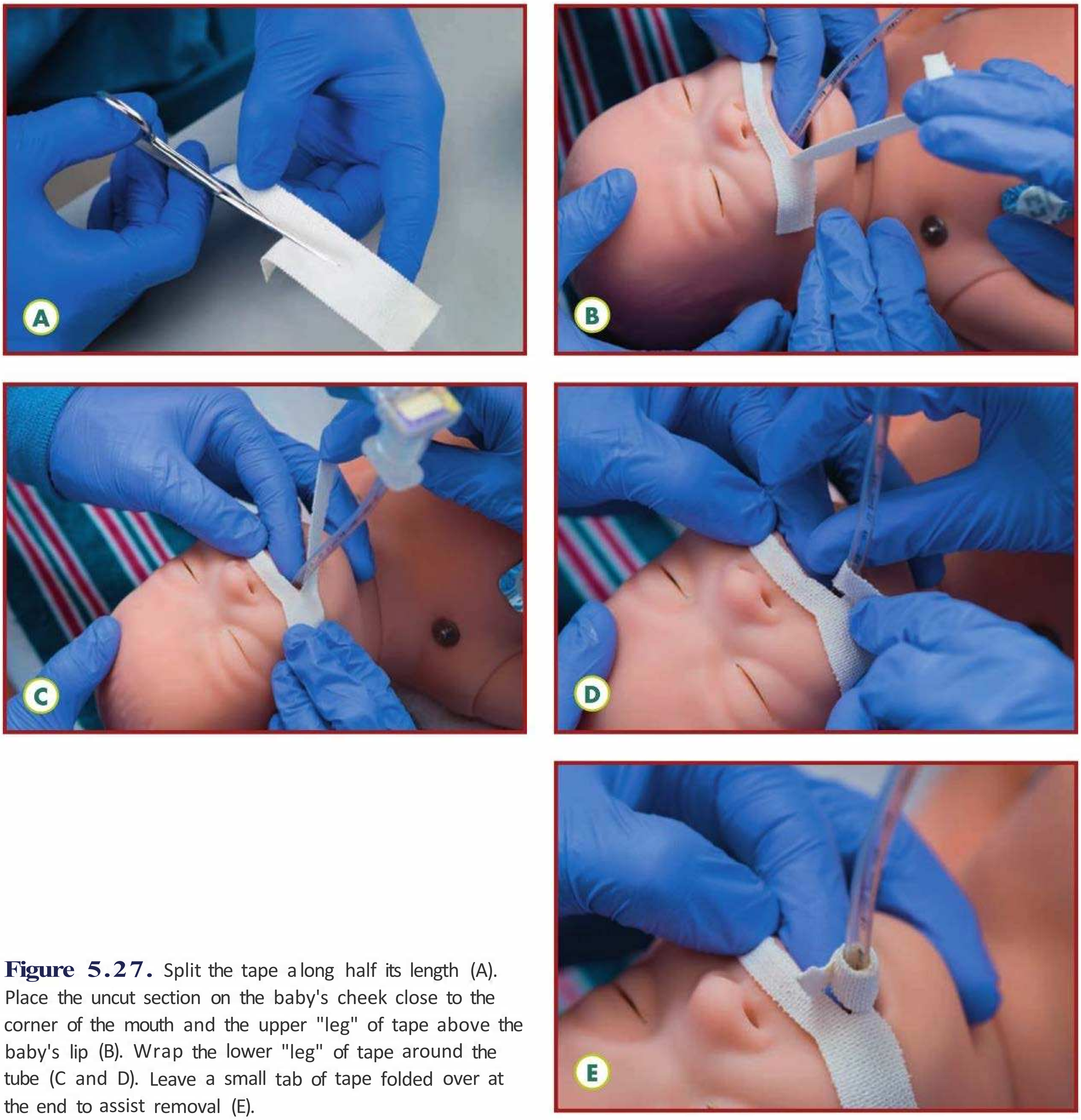


Figure 5.27. Split the tape along half its length (A). Place the uncut section on the baby's cheek close to the corner of the mouth and the upper "leg" of tape above the baby's lip (B). Wrap the lower "leg" of tape around the tube (C and D). Leave a small tab of tape folded over at the end to assist removal (E).

0 At the end, turn the tape onto itself to leave a small "tab" that you can hold to unwind the tape when you want to adjust the insertion depth or remove the tube (Figure 5.27E).

fj Listen with a stethoscope over both sides of the chest to be sure the tube has not been displaced. Assess color change on the $C0_2$ detector and rise and fall of the chest with each assisted breath.

0 If the tube will be left in place beyond the initial resuscitation, obtain a chest x-ray for fi11alplacement confirmation.

The tip of the tube should appear in the mid-trachea *adjacent to the first* ***or*** *second thoracic vertebra* (Figure 5.28). The tip should be above the carina, which is generally adjacent to the third or fourth thoracic vertebra. Avoid using the clavicles as a landmark because their location varíes depending upon the baby's position and the angle that the x-ray is taken. If the tube advanced too far, it may touch the carina or enter the right main bronchus and cause the right upper lobe or left lung to collapse (Figure 5.29).

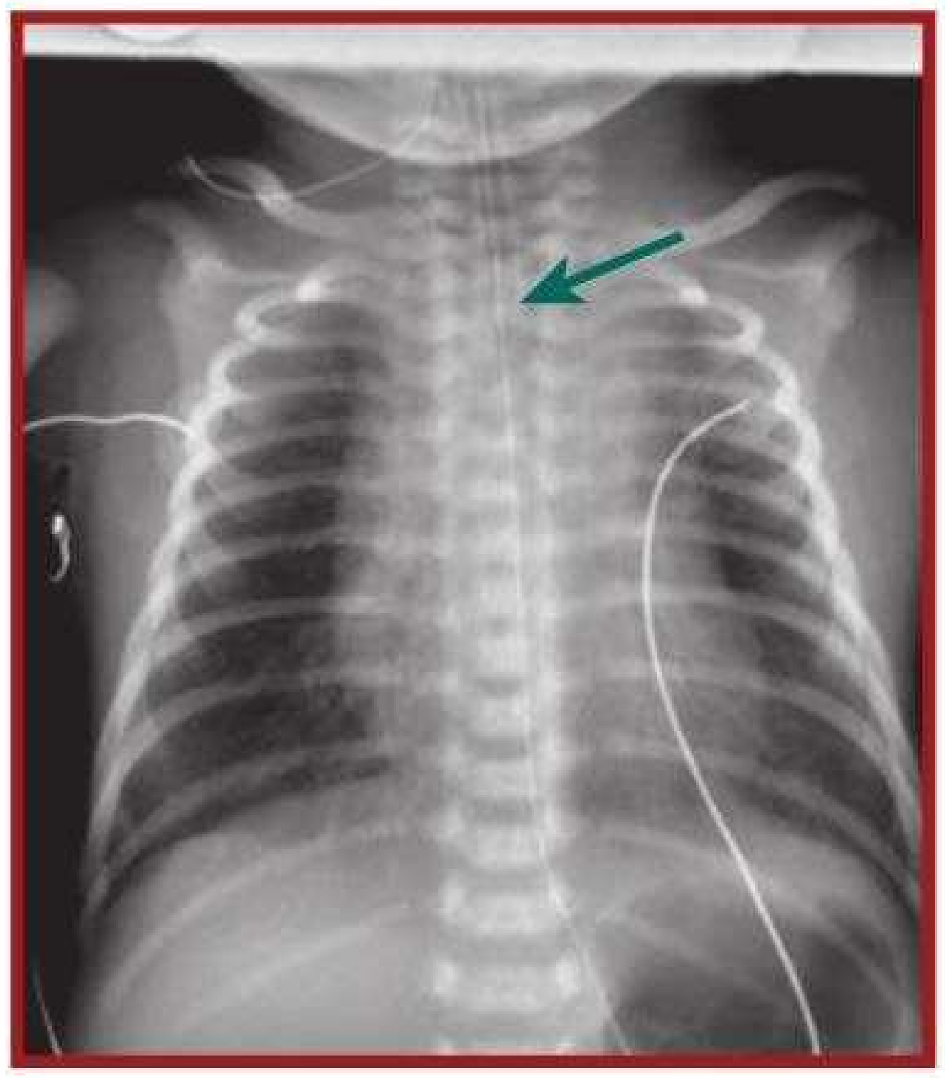


Figure 5.28. Correct placement. The tip of the endotracheal tube is adjacent to the second thoracic vertebra.

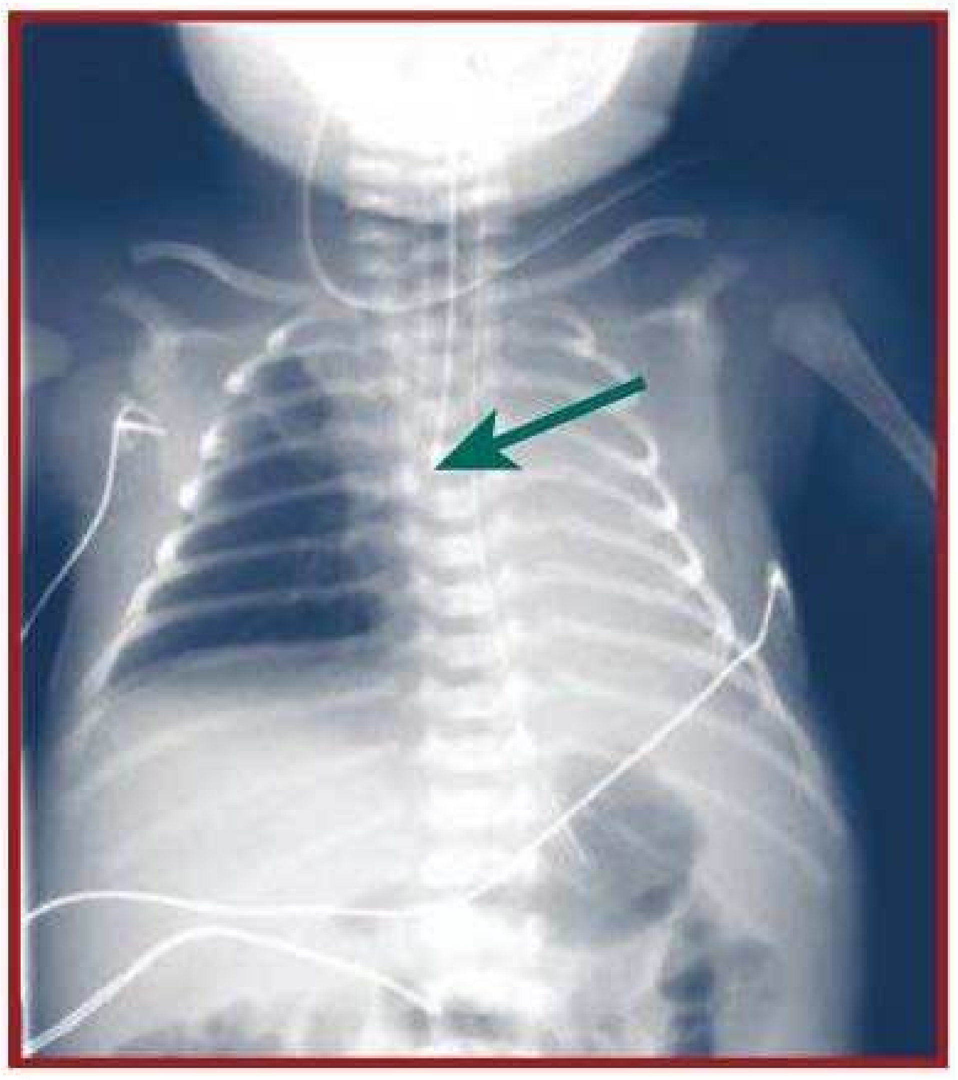


Figure 5.29. Incorrect placement. The tip of the endotracheal tube is inserted too far. It is touching the carina, approaching the right mainstem bronchus, and the left lung is collapsed.

What can an assistant do to help the operator during the intubation procedure?

Effective teamwork is required to complete the intubation procedure quickly and efficiently. A skilled assistant can perform multiple steps that improve teamwork, shorten the duration of the intubation procedure, and increase the likelihood of first-attempt success.

O Check that the laryngoscope is working.

f) Check that suction is set at 80 to 100 mm Hg.

E) Prepare the tape or tube-securing device.

8 Attach chest leads and begin cardiac monitoring if not already done.

0 Ensure that the correct-sized laryngoscope blade and endotracheal tube are selected based on the newborn's expected gestational age or weight.

O Communicate with the operator about what method will be used to estímate the endotracheal tube insertion depth-the NTL or the estimated insertion depth table.

O Check that the stylet, if used, <loes not protrude beyond the tube's side or end hole.

O Ensure that the newborn and bed are correctly positioned before starting the procedure and maintained in the correct position throughout the procedure.

O Hold equipment and pass as directed so that the operator <loes not need to look away from anatomic landmarks to suction secretions or grasp the tube in preparation for insertion.

E) Monitor the newborn's heart rate and alert the operator if the intubation attempt lasts longer than 30 seconds.

4D Provide thyroid and cricoid pressure as directed.

0 After endotracheal tube insertion, carefully remove the stylet and attach the $C0_2$ detector.

O, Listen for increasing heart rate and assess $C0_2$ detector color change.

4D Check the tip-to-lip insertion depth.

G, Listen for breath sounds in both axillae and assess chest movement with PPV.

Assist with securing the tube.

How do you use an endotracheal tube to suction thick secretions from the trachea?

If a baby's condition has not improved and you have not been able to achieve chest movement despite all the ventilation corrective steps and a properly i11serted e11dotracheal tube, there may be thick secretions obstructing the airway. Thick secretions may be from blood, cellular debris, vernix, or meconium. You may attempt to clear the airway using a suction catheter inserted through the endotracheal tube (Table 5-2).

If you cannot quickly clear the airway with the suction catheter, you may be able to clear the airway by applying suction directly to the endotracheal tube using a tracheal aspirator. Although this device is often called a meconium aspirator, it may be used for any thick secretions that are obstructing the airway.

Once the endotracheal tube has been inserted,

O Connect a tracheal aspirator, attached to a suction source (80-100 mm Hg suction), directly to the endotracheal tube connector. Several types of tracheal aspirators are commercially available. Sorne endotracheal tubes have an integrated suction port.

f) Occlude the suction-control port on the aspirator with your finger and gradually withdraw the tube over 3 to 5 seconds as you continue suctioning secretions in the trachea (Figure 5.30).

E) Be prepared to resume face-mask PPV, inserta laryngeal mask, or re-intubate with a clean tube.

How many times should suctioning be repeated if thick secretions prevent you from achieving effective ventilation through an endotracheal tube?

If the airway is obstructed by secretions that have prevented you from achieving effective ventilation, you must repeat the procedure until you have cleared the airway sufficiently to intlate the lungs and achieve effective ventilation.

Figure 5.30. Suctioning thick secretions that obstruct ventilation using an endotracheal tube and tracheal aspirator

What problems should you consider if a baby's condition worsens after endotracheal intubation?

If a baby's condition suddenly worsens after intubation, the endotracheal tube may be inadvertently displaced. It may have been advanced too far into the airway or pulled back into the pharynx and outside the trachea. The tube may be obstructed by blood, meconium, or other thick secretions. The baby may have developed a tension pneumothorax that collapses the lungs and prevents gas exchange. Additional information about this complication is discussed in Lesson 10 (Special Considerations). Finally, the device used to provide PPV may have become disconnected from the endotracheal tube or compressed gas source, or it may have developed a leak.

The mnemonic *"DOPE"* can be used to help remember these potential problems (Table 5-5).

Table 5-5. **Sudden Deterioration After Intubation**

The *DOPE* mnemonic	
D	Displaced endotracheal tube
O	Obstructed endotracheal tube
p	Pneumothorax
E	Equipment failure

Adapted from Kleinman ME, Chameides L, Schexnayder SM, et al. Part 14: Pediatric advanced life support: 201 O American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. *Circulation. 201 0; 122(18 Suppl):5876-5908.*

Focus on Teamwork

Inserting an endotracheal tube highlights several opportunities for effective teams to use the Neonatal Resuscitation Program® (NRP®) Key Behavioral Skills.

Behavior	Example
Call for additional help when needed.	If unanticipated intubation is required, you will likely need 3 or more health care providers to quickly perform ali of the required tasks without delay.
Communicate effectively.	When preparing to insertan alternative airway, clearly and calmly request the desired supplies.
Maintain professional behavior.	Confirm the insertion depth with your team members before securing the tube.
Delegate workload optimally.	Determine which team member(s} will perform important tasks such as inserting the endotracheal tube, providing thyroid and cricoid pressure, monitoring the baby's heart rote, placing the CO_2 detector, auscultating breath sounds, assisting with securing the tube, and documenting events.
Allocate attention wisely.	Maintain situation awareness. At ali times, a team member needs to be monitoring the baby's condition, the number of insertion attempts, the duration of insertion attempts, and alerting the operators to any important changes (eg, heart rote, oxygen saturation).

Behavior	Example
Use available resources.	If an alternative airway is needed, but initial intubation attempts are unsuccessful, do not make repeated intubation attempts. Use your other resources, such as another individual with intubation expertise, a laryngeal mask, or a video laryngoscope. Allow all team members to use their unique skills during the resuscitation process. For example, respiratory therapists may hove valuable skills specific to intubation. Using the respiratory therapist's skills during intubation may allow another provider to focus attention on preparing equipment for vascular access and medications.

Quality Improvement Opportunities

Ask yourself the following questions and begin a discussion with your team if you find a difference between the NRP recommendations and what is currently done in your own hospital setting. Consider using the suggested process and outcome measures to guide your data collection, identify areas for improvement, and monitor if your improvement efforts are working.

Quality improvement questions

0 Who is responsible for checking and preparing intubation supplies and equipment before every birth?

f) Who are the providers that have intubation skills in your delivery room setting?

E) Is someone with intubation skills immediately accessible if needed?

8 How often do providers practice their intubation skills?

0 Do assistants know how to measure and secure an endotracheal tube?

Process and outcome measures

0 How often are newborns intubated in your delivery room setting?

f) When intubation is required, how often is a skilled provider present at the time of birth?

E) How often is intubation successful on the first attempt?

8 How often <loes intubation require more than 30 seconds?

0 How often do adverse events occur during intubation?

Frequently Asked Questions

Why should I insert an endotracheal tube before starting chest compressions? Does that just delay the initiation of chest compressions?

In most situations, this program recommends inserting an endotracheal tube prior to starting chest compressions to ensure maximum ventilation efficacy both before and after chest compressions begin. In many cases, the baby's heart rate will increase during the 30 seconds of ventilation following intubation and compressions will not be necessary.

Can the provider with intubation skills be on call outside the hospital or in a distant location?

No. A person with intubation skills should be in the hospital and available for immediate assistance if needed. If the need for intubation is anticipated, this person should be present in the delivery room at the time of birth. It is not sufficient to have someone on call at home or in a remote area of the hospital.

Should sedative premedication be used before intubation?

When emergency intubation is performed as part of resuscitation, there is generally insufficient time or vascular access to administer sedative premedication. This program focuses on resuscitation of the newly born baby and, therefore, the details of premedication are not included. Premedication is recommended for non-emergent intubation in the neonatal intensive care unit (NICU).

Can a video laryngoscope be useful for neonatal intubation?

Yes, a video laryngoscope may be a helpful device for training novice operators and for intubating a baby with a difficult airway. A video laryngoscope is a laryngoscope that has an integrated camera that displays a magnified view of the airway structures on a video screen. Several different types are available, including devices that are shaped like a traditional laryngoscope and others that have a more pronounced curve. When using a video laryngoscope, an instructor can watch the video screen and see what the trainee is seeing directly through the laryngoscope. This allows the instructor to give advice and feedback and confirm that the operator has inserted the tube into the glottis. Studies have shown that trainees have improved first-attempt intubation success when guided by an instructor using a video laryngoscope. Some video laryngoscopes have a recording function that can be used for debriefing after the procedure is completed. For a newborn with a difficult airway, a video laryngoscope may allow the operator to see the airway structures more easily with less airway manipulation. Using a video laryngoscope does require training and practice, and the smallest blade on some video laryngoscopes is too large for very premature newborns.

LESSON 5 REVIEW

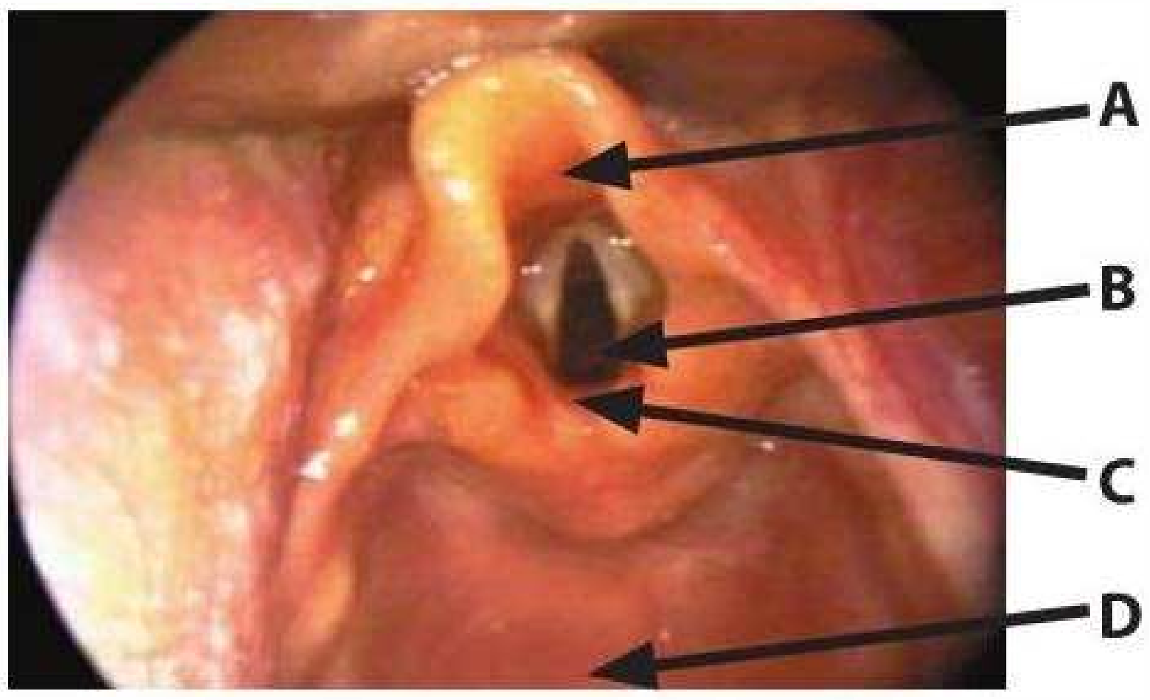
1. A newborn has been receiving face-mask ventilation but is not improving. Despite performing the first 5 ventilation corrective steps, the heart rate is not rising and there is poor chest movement. An alternative airway, such as an endotracheal tube or a laryngeal mask, (should)/(should not) be inserted immediately.

2. For babies weighing less than 1 kg, the recommended endotracheal tube size is (2.5 mm)/(3.5 mm).

3. If using a stylet, the tip of the stylet (must)/(must not) extend beyond the endotracheal tube's side and end holes.

4. The preferred laryngoscope blade size for use in a term newborn is (No. 1)/(No. 0).

5. In the photograph, which arrow is pointing to the epiglottis?

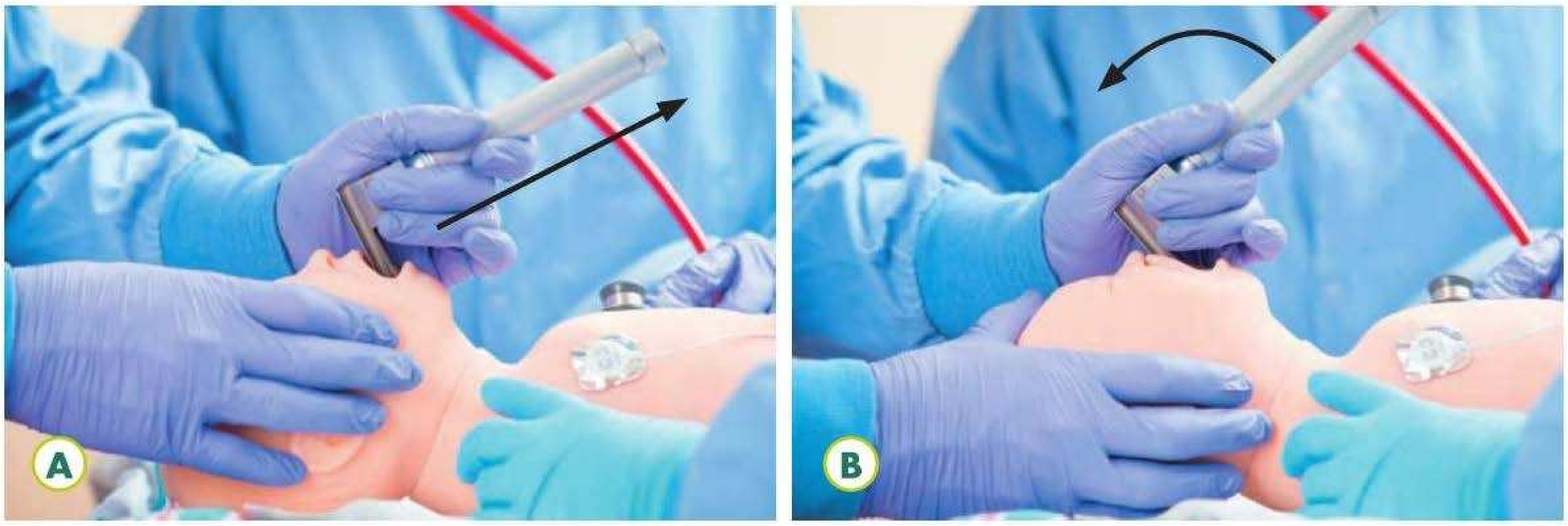


6. You should try to take no longer than (30)/(60) seconds to complete the endotracheal intubation procedure.

7. If a baby's condition worsens after endotracheal intubation, list 4 possible causes.

   1.__________, 2. __________, 3. ___________, 4. __________

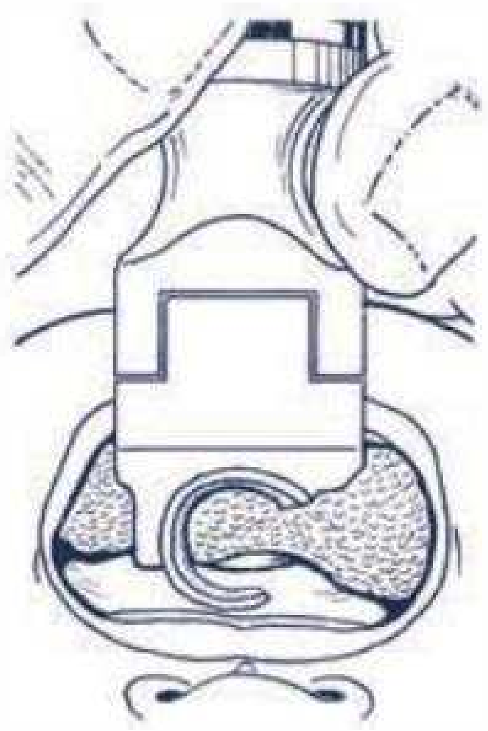
8. Which image shows the correct way to lift the tongue out of the way and expose the larynx?



9. You have inserted an endotracheal tube and are giving positive-pressure ventilation through it. The CO_2 detector does not change color and the baby's heart rate is decreasing. The tube is most likely inserted in the (esophagus)/(trachea).

10. The 2 most important indicators that the endotracheal tube has been inserted in the trachea are demonstrating exhaled _________ and observing a rapidly increasing ______________.

11. You have inserted a laryngoscope and are attempting intubation. You see the view depicted in the following illustration. The correct action is to (advance the laryngoscope farther)/(withdraw the laryngoscope).



Answers

1. An alternative airway, such as an endotracheal tube or a laryngeal mask, should be inserted immediately.
2. For babies weighing less than 1 kg, the recommended endotracheal tube size is 2.5 mm.
3. The tip of the stylet must not extend beyond the endotracheal tube's side and end holes.
4. The preferred laryngoscope blade size for use in a term newborn is No. 1.
5. Arrow A is pointing to the epiglottis.
6. You should try to take no longer than 30 seconds to complete the endotracheal intubation procedure.
7. Possible causes include (1) displaced endotracheal tube, (2) obstructed endotracheal tube, (3) pneumothorax, (4) equipment failure.
8. Image A shows the correct way to lift the tongue out of the way and expose the larynx.
9. The tube is most likely inserted in the esophagus.
10. The 2 most important indicators that the endotracheal tube has been inserted in the trachea are demonstrating exhaled CO_2 (CO_2 detector changes to yellow) and observing a rapidly increasing heart rate.
11. The correct action is to advance the laryngoscope farther.

LESSON 5: PRACTICE SCENARIOS

Endotracheal Intubation

Learning Objectives

- Identify the newborn that requires endotracheal intubation.
- Demonstrate preparation for intubation, including choosing the correct-sized tube for the newborn's estimated weight.
- Demonstrate correct technique for inserting an endotracheal tube (operator).
- Demonstrate the role of the assistant during intubation.
- Demonstrate strategies to determine if the endotracheal tube is in the trachea, including increasing heart rate, color change of carbon dioxide (CO_2) detector, bilateral breath sounds, and chest movement with positive-pressure ventilation (PPV).
- Demonstrate how to use a tracheal aspirator to suction thick secretions from the trachea.
- List pertinent Neonatal Resuscitation Program (NRP) Key Behavioral Skills related to successful endotracheal intubation.

These Practice Scenarios are for review/practice and evaluation.

This is the suggested Practice Scenario sequence.

- **Review the Knowledge Check Questions** with your NRP instructor.
  a. What are the indications for endotracheal intubation during resuscitation?
  b. How do you determine what size endotracheal tube should be used for various gestational ages and weights?
  c. What 2 strategies can be used to determine depth of insertion of the endotracheal tube?
  d. What are the primary indicators that determine correct insertion of the endotracheal tube? What additional indicators can be used?

e. What is the role of the assistant duri11g intubation?

f. What are indications for an obstructed airway and what is the recommended intervention?

f.) **Practice/review these skills** with your NRP instructor.

a. Locate and assemble the supplies and equipment needed for intubation, including the cognitive aids available to help you, such as the endotracheal tube size chart for babies of various ages and weights and the chart of initial endotracheal tube insertion depth, if used.

b. Practice or assist with the steps of intubation, including PPV delivery and assessing proper insertion of the endotracheal tube in the trachea.

c. Practice your unit's method for securing the endotracheal tube in the delivery room.

d. Practice using a suction catheter and/or tracheal aspirator in case thick secretions obstruct the airway.

Q **Practice the scenario(s) as the individual who intubates the newborn or as the assistant** until you need little or no assistance or coaching.

O **Pass the Lesson** 5 **Practice Scenario evaluation** by leading practice scenario(s) and performing intubation as the operator or the assistant.

0 When you can lead the scenario(s) and perform the skills with little or no instructor coaching, you may proceed to the next lesson's practice scenario.

Practice Scenarios

Two scenario options are offered. The number of people attending the birth scenarios and their qualifications are determined by the instructor and based on hospital policy.

O Term newborn with risk factors requires endotracheal intubation

f.) Newborn of 37 weeks' gestation with risk factors requires intubation and tracheal aspiration for suspected airway obstruction

Option 1: Term newborn with risk factors requires endotracheal intubation

"You are called to attend a birth complicated by a Category III fetal heart rate pattern. The laboring mother is a 28-year-old primigravida at 39 weeks' gestation. Demonstrate how you would prepare for the birth of this baby. As you work, say your thoughts and actions aloud so I will know what you are thinking and doing."

✓	Critical Performance Steps	
Assess perinatal risk.		
	Assesses perinatal risk (learner asks 4 pre-birth questions and the instructor ["OB provider"] responds)	
	Gestational age?	**"39 weeks' gestation."**
	Clear fluid?	**"Amniotic fluid is clear."**
	Additional risk factors?	**"Mom has a fever."**
	Umbilical cord management plan? **"I will delay cord clamping. If the baby is not crying, I'll take a moment to stimulate the baby. If there's no response, I'll clamp and cut the cord."**	
Assemble team.		
	Assembles team based on perinatal risk factors. If risk factors are present, at least 2 qualified people should be present solely to manage the baby. The number of team members and qualifications vary depending on risk.	
Perform a pre-resuscitation briefing:		
	Identifies team leader. Assesses risk factors, delegates tasks, identifies who will document events, determines supplies and equipment needed, knows how to call for additional help.	
Perform equipment check (includes checking supplies and equipment for intubation).		
	"The baby has been born."	
Rapid evaluation.		
	Asks 3 rapid evaluation questions:	
	• Term?	**"Appears term."**
	• Muscle tone?	**"No tone."**
	• Breathing or crying?	**"No breathing."**
Initial steps at radiant warmer.		
	Receives baby at radiant warmer, dries and removes linen, stimulates briefly by rubbing the baby's back, positions airway, suctions mouth and nose	
Assess breathing. If breathing, assess heart rate.		
	Is the baby breathing?	**"No."** (Heart rate per auscultation = 40 bpm, if assessed)
	Indicates need for PPV	
Begin PPV within 60 seconds of birth.		
	Positions head in sniffing position	
	Applies mask correctly	
	Starts PPV in 21% oxygen (room air) at 20 to 25 cm H_2O (positive end-expiratory pressure [PEEP] of 5 cm H_2O if using T-piece resuscitator, flow-inflating bag, or self-inflating bag with PEEP valve); rate 40 to 60 breaths/min	
	Requests pulse oximeter sensor placement on baby's right hand or wrist	

<table>
<tr><th></th><th colspan="2">Critical Performance Steps (cont)</th></tr>
<tr><td></td><td colspan="2">Requests cardiac monitor (optional at this time)</td></tr>
<tr><td></td><td colspan="2">Within 15 seconds of beginning PPV, learner asks assistant to state heart rote and if it is increasing.
Heart rate = 40 bpm and not increasing **"Pulse oximeter has no signal."**
Asks assistant to assess chest movement
"No chest movement."</td></tr>
<tr><td colspan="3">Perform ventilation corrective steps (MR. SOPA).</td></tr>
<tr><td></td><td colspan="2">Performs M and R, S and O, and P steps; assesses for increasing heart rote and chest movement after PPV following each step
Heart rote= 40 bpm and not increasing.
"No chest movement." **"Pulse oximeter has no signal."**
Places cardiac monitor leads and connect to monitor in anticipation of intubation (if not already done).</td></tr>
<tr><td colspan="3">Preparation for intubation. (Most of these tasks are included in the pre-birth equipment check.)</td></tr>
<tr><td></td><td>Operator (Intubator)</td><td>Operator's Assistant</td></tr>
<tr><td></td><td>Prepares for intubation
• Requests correct-sized tube
• Requests correct-sized laryngoscope blade
• Communicates preference for stylet usage</td><td>• Ensures suction set at 80 to 100 mm Hg
• Selects correct-sized tube
• Chooses correct laryngoscope blade (size 1 [term], size 0 [preterm])
• Checks laryngoscope light
• Inserts stylet correctly *(stylet optional)*
• Obtains CO_2 detector
• Prepares tape or tube-securing device</td></tr>
<tr><td colspan="3">Intubating the newborn.</td></tr>
<tr><td></td><td>Operator (Intubator)</td><td>Operator's Assistant</td></tr>
<tr><td></td><td>• Holds laryngoscope correctly in left hand
• Opens baby's mouth with finger and inserts blade to base of tongue
• Lifts blade correctly (no rocking motion)
• Requests cricoid pressure if needed
• Identifies landmarks, takes corrective action to visualize glottis if needed
• Inserts tube from right side, not down center of laryngoscope blade
• Aligns vocal cord guide with vocal cords
• Removes laryngoscope then removes stylet while firmly holding tube against baby's palote
• Holds tube against baby's palote</td><td>• Positions newborn's head in sniffing position, body straight, table at correct height for operator
• Monitors heart rote and announces if attempt lasts longer than 30 seconds
• Applies cricoid pressure if requested
• Hands endotracheal tube to operator
• Removes stylet (if used)
• Connects CO_2 detector and PPV device to endotracheal tube
• Hands PPV device to operator</td></tr>
<tr><td colspan="3">Positive-pressure ventilation and confirming endotracheal tube insertion.</td></tr>
<tr><td></td><td>• Administers PPV
• Observes for symmetrical chest movement</td><td>• Auscultates for increasing heart rote and assesses CO_2 detector color change
• Listens for bilateral breath sounds, notes symmetrical chest movement with PPV, and **reports findings**</td></tr>
</table>

	Critical Performance Steps (cont)
	If endotracheal tube is <u>not</u> successfully inserted, **"Color is not changing on the CO_2 detector. The chest is not moving."** **Heart rate = 60 bpm and not increasing** • Removes endotracheal tube • Resumes PPV by face mask • Repeats intubation attempt or indicates need for laryngeal mask
	If endotracheal tube successfully inserted, **"Color is changing on the CO_2 detector."** **Heart rate slowly increases to about 70 bpm.** • Operator continues PPV x 30 seconds • Assistant checks tip-to-lip depth using gestational age/weight table or nasal-tragus length (NTL} measurement. - If using NTL, measures distance from the nasal septum to the ear tragus (insertion depth [cm]= NTL + 1 cm) • Assistant secures endotracheal tube
Vital signs.	
	Checks heart rote after 30 seconds of PPV through endotracheal tube **"Baby is apneic. Pulse oximeter has a signal now."** **Heart rote = 70 bpm and increasing** SpO_2 = 67%
	Continues PPV and adjusts oxygen concentration per pulse oximetry
	Checks heart rote after 30 seconds of PPV **"Baby is apneic."** **Heart rote is > 100 bpm and increasing** SpO_2 = 72% **and increasing slowly**
End scenario.	
	Supports baby with PPV and supplemental oxygen per Target Oxygen Saturation Table. Monitors heart rote, respiratory effort, oxygen saturation, activity, temperature. Prepares to move baby to post-resuscitation care setting. Communicates with perinatal team. Updates parents and informs them of next steps.

Option 2: Newborn of 37 weeks' gestation with risk factors requires intubation and tracheal aspiration for suspected airway obstruction

"You are called to attend a birth complicated by a Category III fetal heart rate pattern. The laboring mother is a 39-year-old primigravida at 37 weeks' gestation. Demonstrate how you would prepare for the birth of this baby. As you work, say your thoughts and actions aloud so I will know what you are thinking and doing."

	Critical Performance Steps
Assess perinatal risk.	
	Assesses perinatal risk (learner asks 4 pre-birth questions and instructor ["OB provider"] responds) Gestational age? **"37 weeks' gestation."** Clear fluid? **"Amniotic fluid is clear."** Additional risk factors? **"Category III fetal heart rote pattern and maternal chronic hypertension."** Umbilical cord management plan? **"I will delay cord clamping. If the baby is not crying, I'll take a moment to stimulate the baby. If there's no response, I'll clamp and cut the cord."**

	Critical Performance Steps (cont)
Assemble team.	
	Assembles team based on perinatal risk factors. If risk factors are present, at least 2 qualified people should be present solely to manage the baby. The number of team members and qualifications vary depending on risk.
Perform a pre-resuscitation briefing.	
	Identifies team leader. Assesses risk factors, delegates tasks, identifies who will document events, determines supplies and equipment needed, knows how to call for additional help.
Perform equipment check (includes checking supplies and equipment to prep for intubation).	
	"The baby has been born."
Rapid evaluation.	
	Asks 3 rapid evaluation questions: • Term? **"Appears about 37 weeks' gestation as expected."** • Muscle tone? **"No tone."** • Breathing or crying? **"No breathing."**
Initial steps at radiant warmer.	
	Receives baby at radiant warmer, dries and removes linen, stimulates briefly by rubbing the baby's back, positions airway, suctions mouth and nose
Assess breathing. If breathing, assess heart rote.	
	Is the baby breathing? **"No."** **(Heart rate=40 bpm, if assessed)**
	Indicates need for PPV
Begin PPV within 60 seconds of birth.	
	Positions head in sniffing position
	Applies mask correctly
	Starts PPV in 21% oxygen (room air) at 20 to 25 cm H_2O (PEEP of 5 cm H_2O if using T-piece resuscitator or flow-inflating bag, or self-inflating bag with PEEP valve); rote 40 to 60 breaths/min
	Requests pulse oximeter sensor placement on baby's right hand or wrist
	Requests cardiac monitor (optional at this time)
	Within 15 seconds of beginning PPV, learner asks assistant to state heart rote and if it is increasing **Heart rote = 40 bpm and not increasing** **"Pulse oximeter has no signal."**
	Asks assistant to assess chest movement **"No chest movement."**
Perform ventilation corrective steps (MR. SOPA).	
	Performs M and R, S and O, and P steps; assesses for increasing heart rote and chest movement after PPV following each step **Heart rote = 40 bpm and not increasing.** **"No chest movement."** **"Pulse oximeter has no signal."**
	Place cardiac monitor leads and connect to monitor in anticipation of intubation (if not already done).

Critical Performance Steps (cont)

Operator (Intubator)	Operator's Assistant
Preparation for intubation. (Most of these tasks are included in the pre-birth equipment check.)	
Prepares for intubation • Requests correct-sized tube • Requests correct-sized laryngoscope blade • Communicates preference for stylet usage	• Ensures suction set at 80 to 100 mm Hg • Selects correct-sized tube • Chooses correct laryngoscope blade (size 1 [term], size 0 [preterm]) • Checks laryngoscope light • Inserts stylet correctly *(stylet optional)* • Obtains CO_2 detector • Prepares tape or tube-securing device
Intubating the newborn.	
Operator	**Operator's Assistant**
• Holds laryngoscope correctly in left hand • Opens baby's mouth with finger and inserts blade to base of tengue • Lifts blade correctly (no rocking motion) • Requests cricoid pressure if needed • Identifies landmarks, takes corrective action to visualize glottis if needed • Inserts tube from right side, not down center of laryngoscope blade • Aligns vocal cord guide with vocal cords • Removes laryngoscope then removes stylet while firmly holding tube against baby's palote • Holds tube against baby's palote	• Positions newborn's head in sniffing position, body straight, table at correct height for operator • Applies cricoid pressure if requested • Hands endotracheal tube to operator • Monitors heart rote and announces if attempt lasts longer than 30 seconds • Removes stylet (if used) • Connects CO_2 detector and PPV device to endotracheal tube • Hands PPV device to operator
Positive-pressure ventilation and confirming endotracheal tube insertion.	
• Administers PPV • Observes for symmetrical chest movement	• Auscultates for increasing heart rote and assesses CO_2 detector color change • Listens for bilateral breath sounds, notes symmetrical chest movement with PPV, and **reports findings**
Heart rote =40 bpm and not increasing **"Chest is <u>not moving</u> with PPV. No audible breath sounds.** **"Color is not changing on the CO_2 detector."**	
"In this scenario, the endotracheal tube has been correctly inserted, but there is no chest movement with PPV. What is your next step?"	
Suspect airway obstruction and use tracheal aspirator.	
• Connects a tracheal aspirator to a suction source (80-100 mm Hg suction) and directly to the endotracheal tube connector or occludes integrated suction port • Occludes the tracheal aspirator with a finger or occludes the suction-control port on the endotracheal tube and gradually withdraws the endotracheal tube over 3 to 5 seconds while continuing to suction secretions in the trachea	

	Critical Performance Steps (cont)
After tracheal suction, re-intubate baby with a clean endotracheal tube. (Learner may also resume face-mask PPV or insert a laryngeal mask.)	
	After re-intubation, if endotracheal tube is <u>not</u> successfully inserted, **"Color is not changing on the CO_2 detector."** **Heart rote= 40 bpm and not increasing** • Removes endotracheal tube • Resumes PPV by face mask • Repeats intubation attempt or indicates need for laryngeal mask
	After re-intubation, if endotracheal tube is successfully inserted, **"Color is changing on the CO_2 detector."** **Heart rate = 60 bpm and increasing** **Pulse oximeter displays signal as heart rote increases to more than 60 bpm** • Operator continues PPV x 30 seconds • Assistant checks tip-to-lip depth using gestational age/weight table or NTL measurement - If using NTL, measures distance from the nasal septum to the ear tragus (insertion depth [cm]= NTL + l cm} •Assistant secures endotracheal tube
Vital signs.	
	Checks heart rote after completing 30 seconds of PPV **Heart rate = 70 bpm and increasing** **"Apneic."** **$5Po_2$ = 68%and increasing**
	Continues PPV and adjusts oxygen concentration per pulse oximetry
	Checks heart rote after 30 more seconds of PPV **Heart rate is > 100 bpm and increasing** **"Apneic."** **$SP0_2$ = 72% and increasing**
End scenario.	
	Supports baby with PPV and supplemental oxygen per Target Oxygen Saturation Table. Monitors heart rote, respiratory effort, oxygen saturation, activity, temperature. Prepares to move baby to post-resuscitation care setting. Communicates with perinatal team. Updates parents and informs them of next steps. Debriefs the resuscitation.

Sample Debriefing Questions

0 What went well during this resuscitation?

f) What is the most important issue to discuss during this debriefing?

8 At what point <lid you decide to use a cardiac monitor to assess the heart rate? How <lid that help you? When is a cardiac monitor recommended during neonatal resuscitation?

0 What will you do differently when faced with intubation in a future scenario?

0 (Option 2) After inserting an alternative airway, there was still no chest movement with PPV. How <lid the leader/team members help each other to manage this emergency? As a leader/team member, what was the most difficult aspect of this scenario? In an actual resuscitation, what if a team member had suggested beginning chest compressions before achieving chest movement with PPV?

0 Do you have additional comments or suggestions for your team? For the team leader?

0 Give me an example of how you used at least one of the NRP Key Behavioral Skills.

NRP Key Behavioral Skills

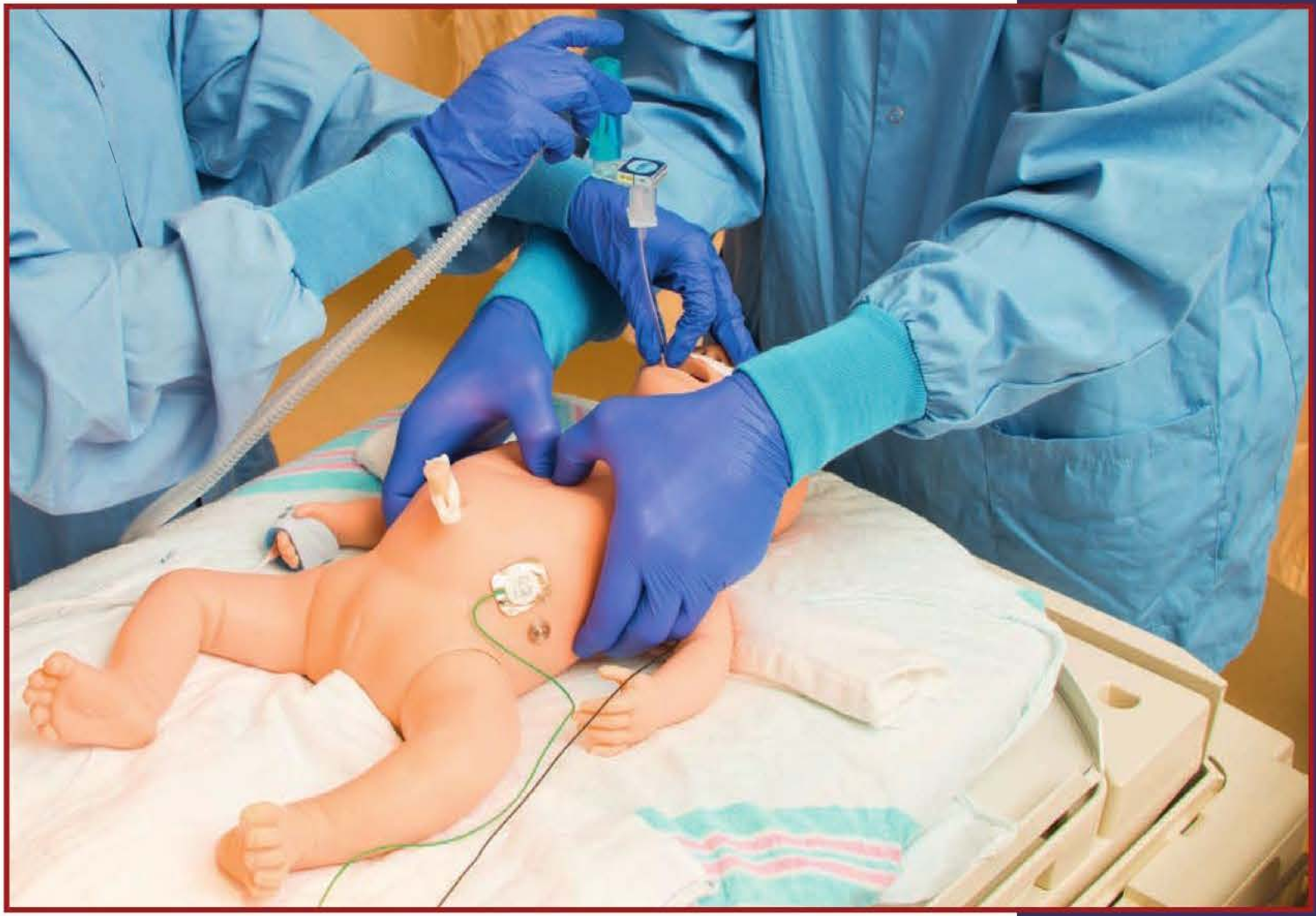
- Know your environment.
- Use available information.
- Anticipate and plan.
- Clearly identify a team leader.
- Communicate effectively.
- Delegate the workload optimally.
- Allocate attention wisely.
- Use available resources.
- Call for additional help when needed.
- Maintain professional behavior.

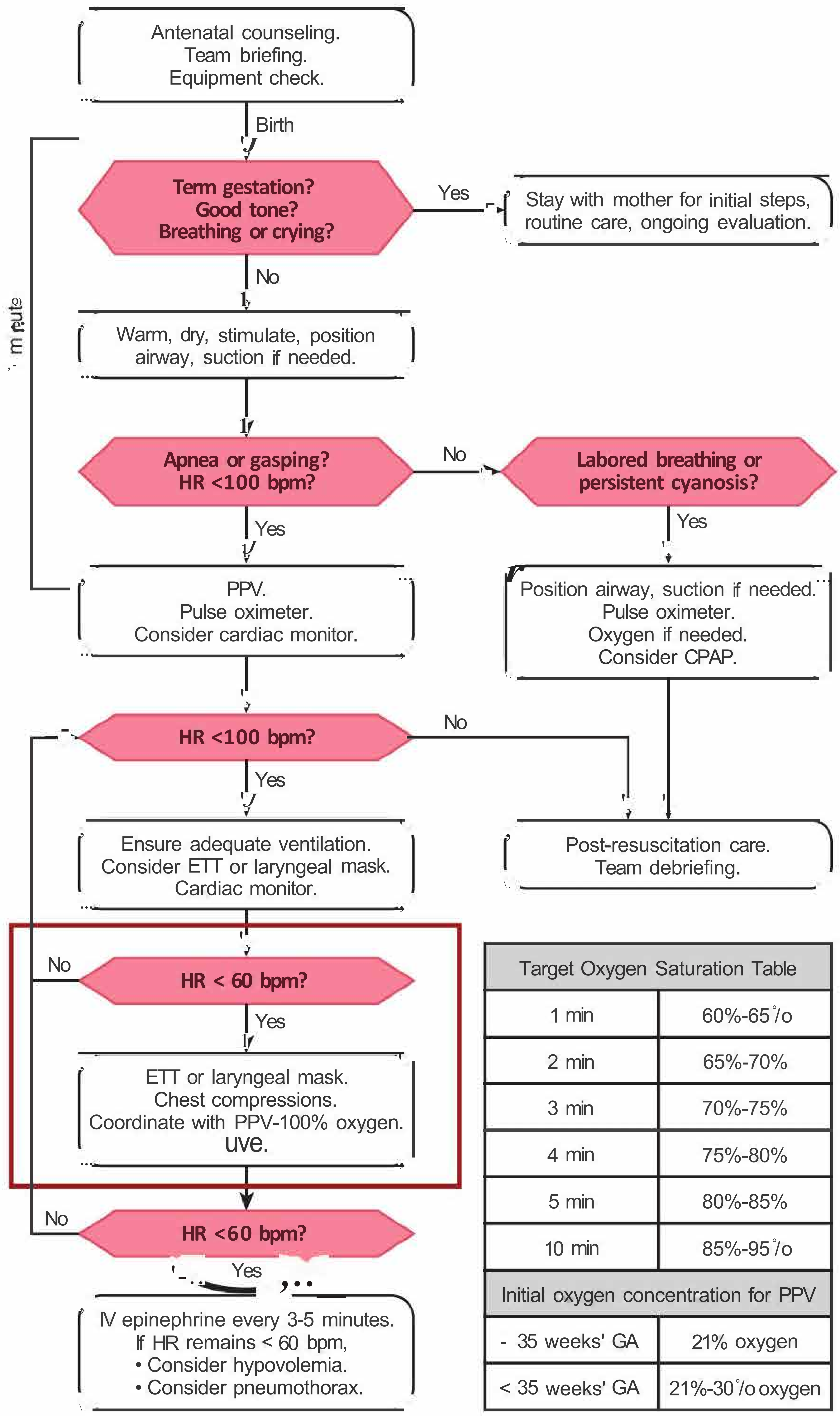
6

Chest Compressions

What you will learn

- When to begin chest compressions
- How to administer chest compressions
- How to coordinate chest compressions with positive-pressure ventilation
- When to stop chest compressions





Target Oxygen Saturation Table	
1 min	60%-65%
2 min	65%-70%
3 min	70%-75%
4 min	75%-80%
5 min	80%-85%
10 min	85%-95%
Initial oxygen concentration for PPV	
≥ 35 weeks' GA	21% oxygen
< 35 weeks' GA	21%-30% oxygen

Key Points

0 Chest compressions are indicated when the heart rate remains less than 60 beats per minute (bpm) despite at least 30 seconds of positive-pressure ventilation (PPV) that inflates the lungs (chest movement). In most cases, you should have given ventilation through a properly inserted endotracheal tube or laryngeal mask.

8 Inaccurate assessment of heart rate can result in un11ecessary cardiac compressions. If perinatal risk factors suggest the likelihood of complex resuscitation, consider placing cardiac monitor leads once PPV starts.

E) If the chest is not moving with PPV, the lungs have not been inflated and chest compressions are not yet indicated. Continue to focus on achieving effective ventilation.

8 Once the endotracheal tube or laryngeal mask is secure, move to the head of the bed to give chest compressions. This provides space for safe insertion of an umbilical venous catheter and has mechanical advantages that result in less compressor fatigue.

0 If the heart rate is less than 60 bpm, the pulse oximeter may not have a reliable signal. When chest compressions begin, ventilate using 100% oxygen until the heart rate is at least 60 bpm and the pulse oximeter has a reliable signal.

9 To administer chest compressions, place your thumbs on the sternum, in the center, just below an imaginary line connecting the baby's nipples. Encircle the torso with both hands. Support the back with your fingers. Your fingers do not need to touch each other.

0 Use enough downward pressure to depress the sternum approximately one-third of the anterior-posterior (AP) diameter of the chest.

0 The compression rate is 90 compressions per minute and the breathing rate is 30 breaths per minute.

a. This is a slower ventilation rate than used during assisted ventilation without compressions.

b. To achieve the correct rate, use the rhythm: "One-and-Two-and-*Three-and-Breathe-and....*"

f) After 60 seconds of chest compressions and ventilation, briefly stop compressions and check the heart rate. A cardiac monitor is the preferred method for assessing heart rate during chest compressions. You may also assess the baby's heart rate by listening with a stethoscope. If necessary, you may briefly stop ventilation to auscultate the heart rate.

If the heart rate is 60 bpm or greater, discontinue compressions and resume PPV at 40 to 60 breaths per minute. When a reliable pulse oximeter signal is achieved, adjust the oxygen concentration to meet the target oxygen saturation guidelines.

4D If the baby's heart rate remains less than 60 bpm despite 60 seconds of effective ventilation and high-quality, coordinated chest compressions, epinephrine administration is indicated and emergency vascular access is needed.

Case: Late preterm newborn that does not respond to effective ventilation

Your team is called to attend an emergency cesarean birth for a woman at 36 weeks' gestation because of fetal distress. The amniotic fluid is clear. You complete a pre-resuscitation briefing, assign roles and responsibilities, and prepare your supplies and equipment. After birth, the obstetrician dries and stimulates the baby to breathe, but the baby remains limp and apneic. The umbilical cord is clamped and cut, and the baby is moved to a radiant warmer. You position the baby's head and neck, suction the mouth and nose, and provide brief additional stimulation, but the baby remains apneic. You begin positive-pressure ventilation (PPV) with 21% oxygen, while other team members assess the baby's heart rate with a stethoscope, place a pulse oximeter sensor on the right hand, and document the events as they occur. The pulse oximeter <loes not have a reliable signal and cardiac monitor leads are placed on the baby's chest. The heart rate is 40 beats per minute (bpm), not increasing, and the baby's chest is not moving with PPV. You proceed through the ventilation corrective steps, including increasing the ventilation pressure, but the chest still <loes not move with ventilation and the baby's heart rate <loes not increase.

A team member inserts and secures an endotracheal tube, and ventilation resumes. The carbon dioxide (CO_2) detector <loes not change color; however, there is good chest movement with PPV through the tube, and breath sounds are equal in the axillae. Anticipating a prolonged resuscitation, a team member applies a servo-controlled temperature sensor to the baby's skin to monitor and control the baby's body temperature. Ventilation through the endotracheal tube is continued for 30 seconds, but the heart rate remains 40 bpm. Your team increases the oxygen concentration (FIO_2) to 100%, begins chest compressions coordinated with PPV, and calls

for additional help. During compressions and coordinated ventilation, the CO_2 detector changes color to yellow, and, within 60 seconds, the heart rate increases to greater than 60 bpm. You stop compressions and continue PPV as the heart rate continues to increase. Your team members frequently reevaluate the baby's condition and share their assessments with each other. The pulse oximeter shows a reliable signal and the FIO_2 is adjusted to meet the oxygen saturation target. As the baby's tone improves, you observe intermittent spontaneous respiratory effort and the baby's heart rate increases to 160 bpm. The parents are updated and the baby is moved to the special care nursery for post-resuscitation care. Shortly afterward, your team members conduct a debriefing to review their preparation, teamwork, and communication.

What are chest compressions?

Babies who do not respond to ventilation that inflates their lungs are likely to have very low blood oxygen levels, significant acidosis, and insufficient blood flow in their coronary arteries. As a result, cardiac muscle function is severely depressed. Improving coronary artery blood flow is crucial for restoring the heart's function.

The heart lies in the chest between the lower third of the sternum and the spine. Rhythmically depressing the sternum compresses the heart against the spine, pushes blood forward, and increases the blood pressure in the aorta. When pressure on the sternum is released, the heart refills with blood and blood flows into the coronary arteries (Figure 6.1). By compressing the chest and ventilating the lungs, you help to restore the flow of oxygenated blood to the heart muscle and the lungs.

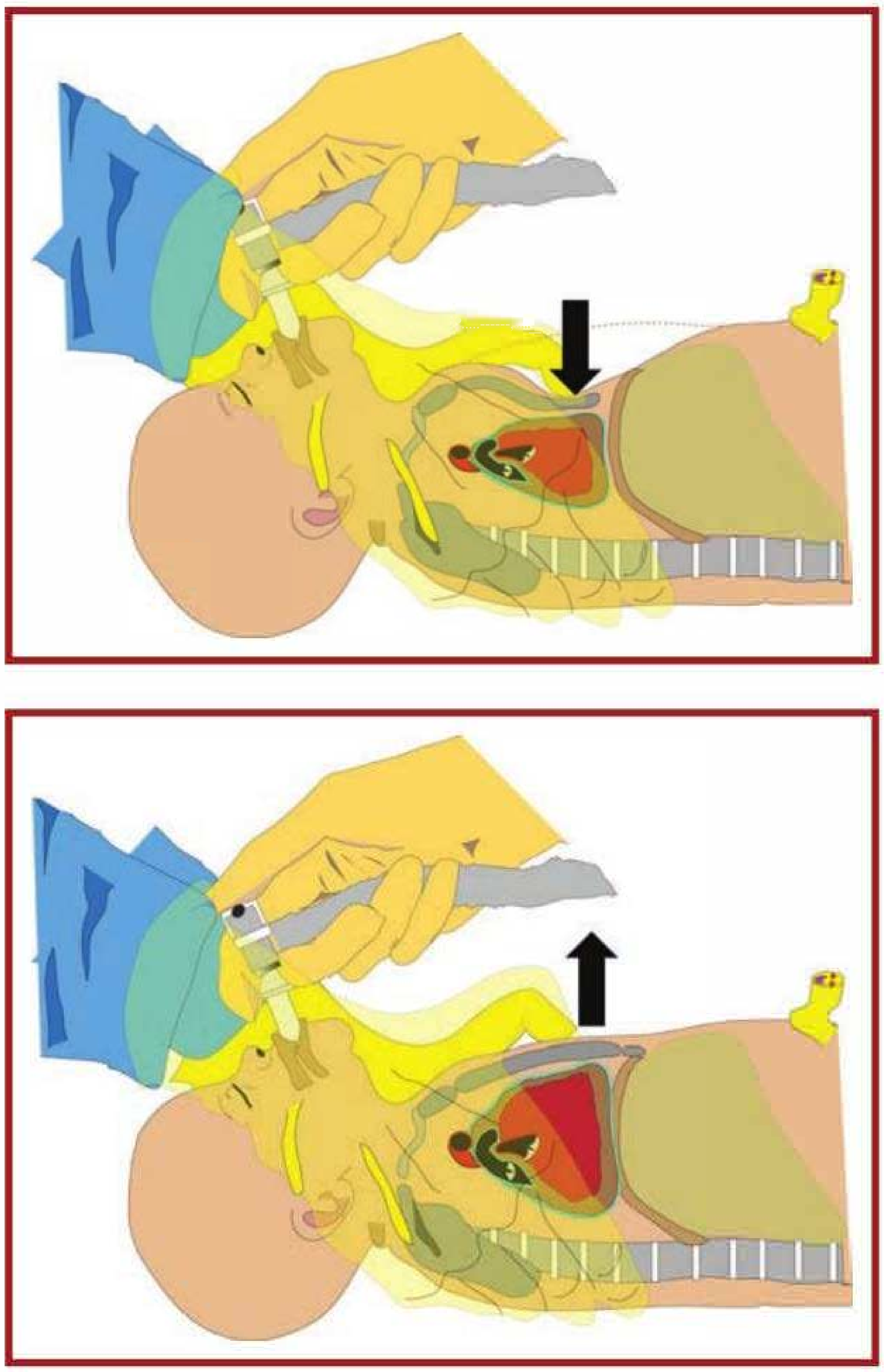
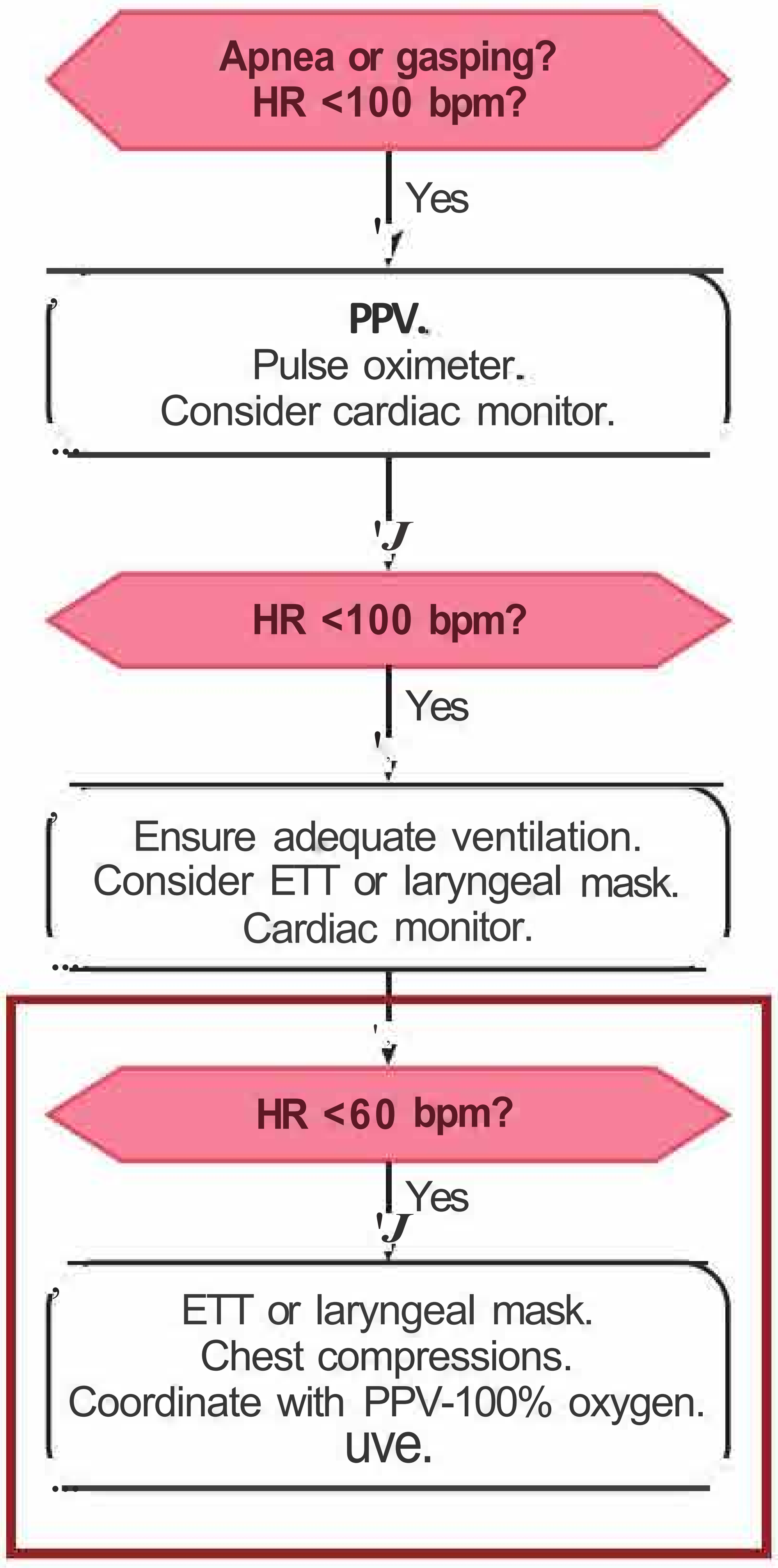


Figure 6.1. Compression (top) and release (bottom) phases of chest compressions

When do you begin chest compressions?

- Chest compressions are indicated if the baby's heart rate remains **less than 60 bpm** after at least 30 seconds of PPV that inflates the lungs, as evidenced by chest movement with ventilation.
- In most cases, you should have given at least 30 seconds of ventilation through a properly inserted endotracheal tube or laryngeal mask.



- If compressions are started, **call for help** if needed as additional personnel may be required to prepare for vascular access and epinephrine administration.

If the lungs have been adequately ventilated, it is rare for a newborn to require chest compressions. Only approximately 1 to 2 per 1,000 newborns are expected to require chest compressions. Do not begin chest compressions unless you have achieved chest movement with your ventilation attempts. If the chest is not moving, you are most likely not providing effective ventilation. Focus your attention on the ventilation corrective steps, ensuring that you have an unobstructed airway, before starting compressions. This program recommends ventilating through an endotracheal tube or laryngeal mask for 30 seconds before starting chest compressions.

Sometimes a newborn receives unnecessary chest compressions because the heart rate is inaccurately assessed. If perinatal risk factors suggest the likelihood of a complex resuscitation, consider placing cardiac monitor leads once PPV starts. The cardiac monitor can then be used to assess the heart rate and support critical decision-making, such as beginning chest compressions and administering medication.

Where do you stand to administer chest compressions?

When chest compressions are started, you may be standing at the side of the warmer. One of your team members, standing at the head of the bed, will be providing coordinated ventilations through an endotracheal tube.

Figure 6.2. Compressor standing at the head of the bed

If chest compressions are required, there is a high probability that you will also need to insert an emergency umbilical venous catheter for intravascular access. It is difficult to insert an umbilical venous catheter if the person administering compressions is standing at the side of the warmer with their arms encircling the baby's chest. Once intubation is completed and the tube is secure, the compressor should move to the head of the bed while the person operating the PPV device moves to the side (Figure 6.2). In addition to providing space for umbilical venous catheter insertion, this position has mecl1anical advantages that result in less fatigue for the compressor.

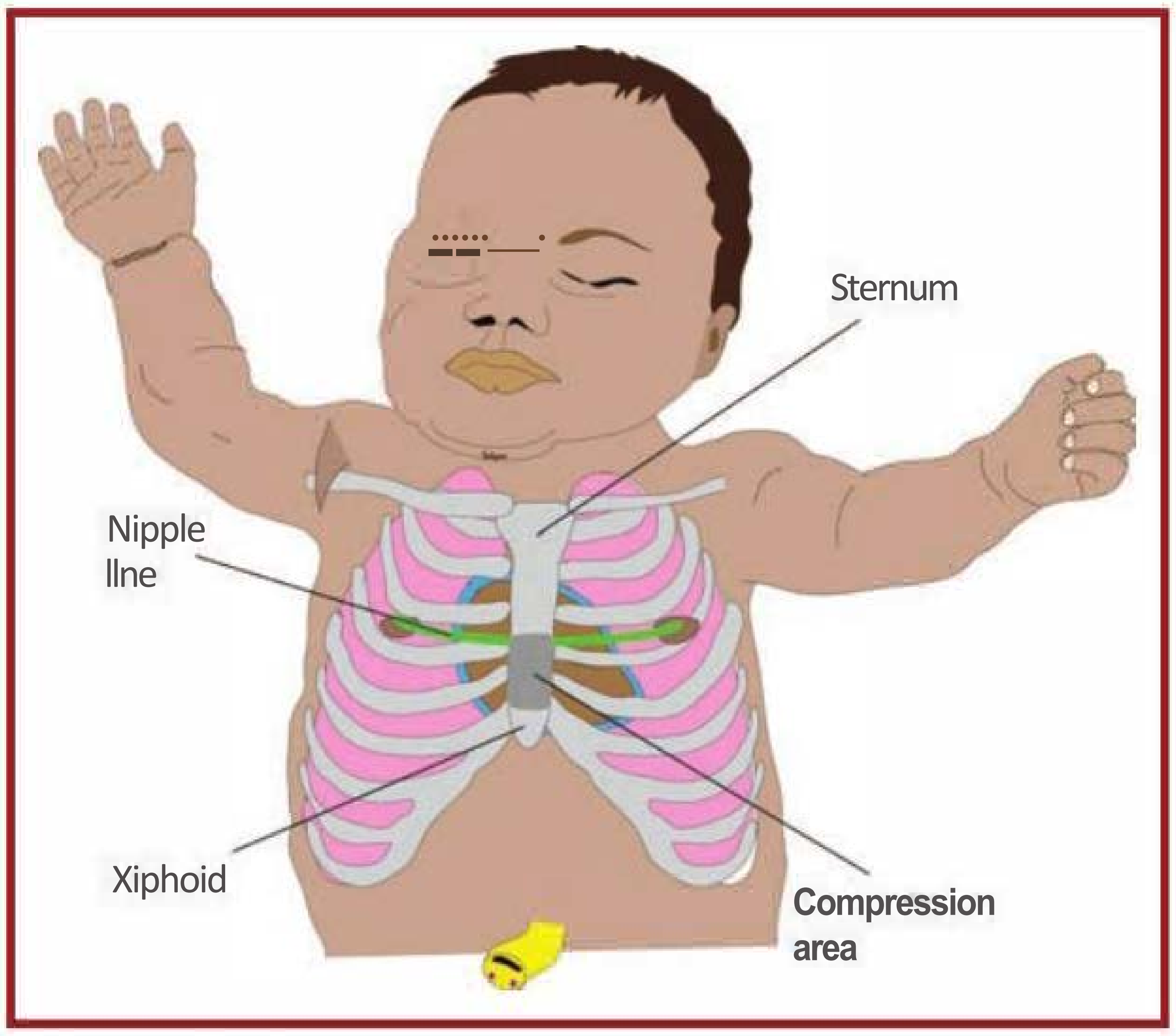


Figure 6.3. Landmarks for chest compressions

Figure 6.4. Chest compressions using 2 thumbs from the head of the bed. Thumbs are placed over the lower third of the sternum, hands encircling the chest.

Where do you position your hands during chest compressions?

During chest compressions, apply pressure to the lower third of the sternum. Place your thumbs on the center of the sternum, either side-by-side or one on top of the other, just below an imaginary line connecting the baby's nipples (Figure 6.3). Do not place your thumbs on the ribs or on the xiphoid. The xiphoid is the small, pointed projection at the bottom of the sternum where the lower ribs meet at the midline.

Encircle the baby's chest with your hands. Place your fingers under the baby's back to provide support (Figure 6.4). Your fingers do not need to touch.

How deeply do you compress the chest?

Using your thumbs, press the sternum downward to compress the heart between the sternum and the spine. Do not squeeze the chest with your encircling hands. With your thumbs correctly positioned, use enough pressure to depress the sternum ***approximately one-third of the anterior-posterior (AP) diameter of the chest*** (Figure 6.5), and then release the pressure to allow the heart to refill. One compression consists of the downward stroke plus the release. The actual distance compressed will depend on the size of the baby.

Your thumbs should remain in contact with the chest during both compression and release. Allow the chest to fully expand by lifting your thumbs sufficiently during the release phase to permit the chest

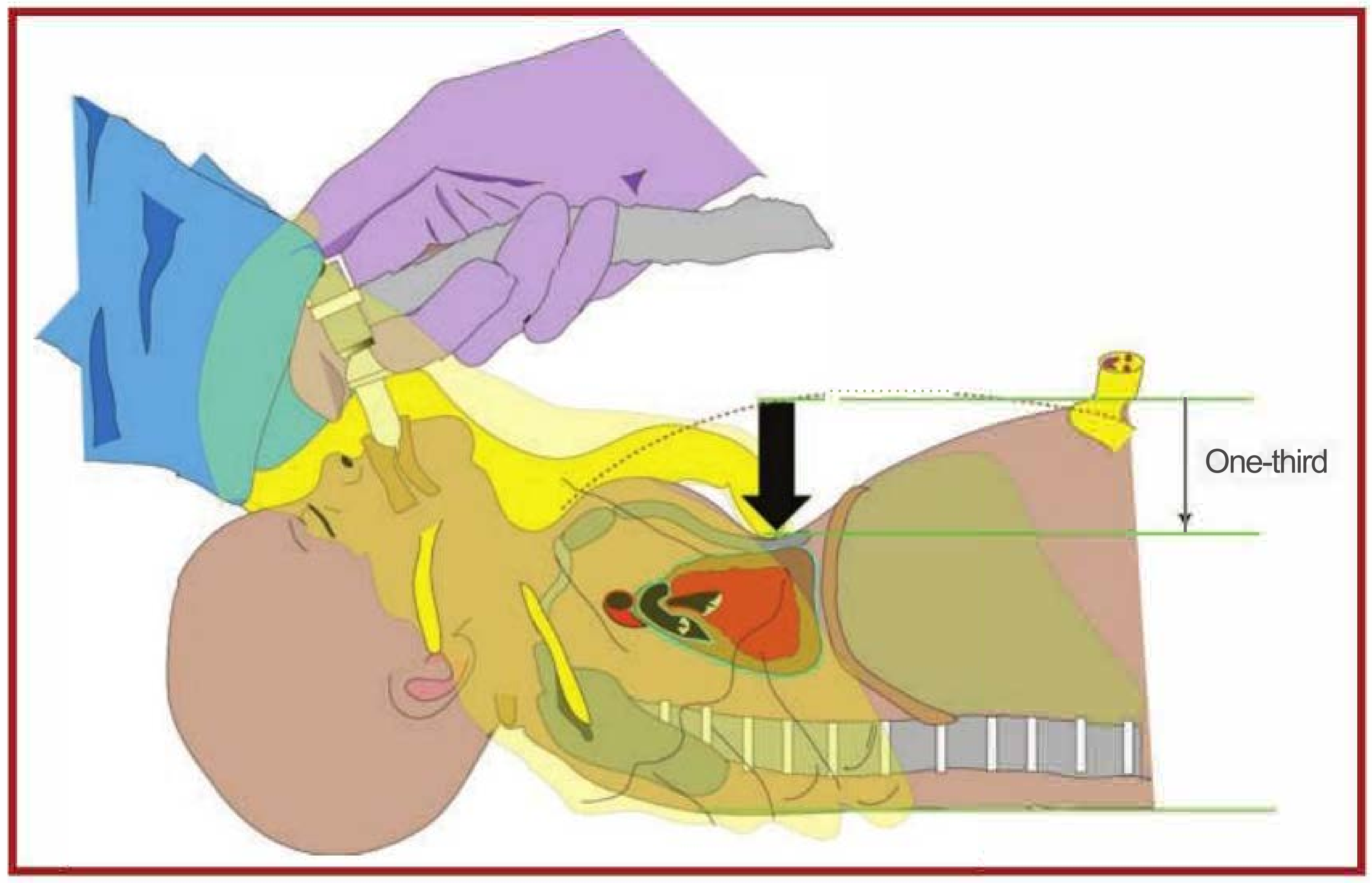


Figure 6.5. Compression depth is approximately one-third of the anterior-posterior diameter of the chest.

to expand; however, do not lift your thumbs completely off the chest between compressions.

What is the compression rate?

The compression rate is 90 compressions per minute. To achieve this rate, you will give 3 rapid compressions and 1 ventilation during each 2-second cycle.

How are compressions coordinated with positive-pressure ventilation?

During neonatal cardiopulmonary resuscitation, chest compressions are always accompanied by coordinated PPV. Give 3 rapid compressions followed by 1 ventilation.

Coordinated Compressions and Ventilations

3 compressions + 1 ventilation every 2 seconds

To assist coordination, the person doing compressions should count the rhythm out loud. Speak loudly enough for the person ventilating to hear the rhythm, but not so loud that the rest of the team members cannot hear each other as they share information. The goal is to give 90 compressions per minute and 30 ventilations per minute (90 + 30 = 120 events per minute). This is a rapid rhythm. Achieving good coordination requires practice.

Learn the rhythm by counting out loud: *"One-and-Two-and-Three-**and-Breathe-and;** One-and-Two-and-Three-and-Breathe-and; One-and-Two-and-Three-and-Breathe-and."*

- Compress the chest with each counted number *("One, Two, Three").*
- Release the chest between each number *("-and-").*
- Pause compressions and give a positive-pressure breath when the compressor calls out *"breathe-and."*

Inhalation occurs during the "breathe-and" portion of the rhythm, and exhalation occurs during the downward stroke of the next compression. Note that during chest compressions, the ventilation rate is slower than you used when giving only assisted ventilation. This slower rate is used to provide an adequate number of compressions and avoid simultaneous compressions and ventilation.

3:1 Compression:Ventilation Rhythm

One-and-Two-and-Three-and-Breathe-and;
One-and-Two-and-Three-and-Breathe-and;
One-and-Two-and-Three-and-Breathe-and

What oxygen concentration should be used with positive-pressure ventilation during chest compressions?

- When chest compressions are started, **increase the FiO_2 to 100%.**
- Once the heart rate is greater than 60 bpm and a reliable pulse oximeter signal is achieved, adjust the FiO_2 to meet the target oxygen saturation guidelines.

The ideal FiO_2 to use during chest compressions is an area of active research, and this recommendation is based on expert opinion. Oxygen is essential for organ function. During chest compressions, blood flow to vital organs may be decreased, and using a higher oxygen FiO_2 concentration may improve oxygen uptake and delivery. In addition, circulation may be so poor that the pulse oximeter will not give a reliable signal, and targeting an oxygen saturation may not be possible. However, once heart function has recovered, continuing to use 100% oxygen may increase the risk of tissue damage from excessive oxygen exposure.

When should you check the baby's heart rate after starting compressions?

Wait ***60 seconds*** **after starting coordinated chest compressions and ventilation** before briefly pausing compressions to reassess the heart rate.

Studies have shown that it may take a minute or more for the heart rate to increase after chest compressions are started. When compressions are stopped, coronary artery perfusion is decreased and requires time to recover once compressions are resumed. It is, therefore, important to avoid unnecessary interruptions in chest compressions because each time you stop compressions, you may delay the heart's recovery.

How should you assess the baby's heart rate response during compressions?

Briefly pause compressions to assess the baby's heart rate. If necessary, briefly pause PPV. A cardiac monitor is the preferred method for assessing heart rate during chest compressions. You may assess the baby's heart rate by listening with a stethoscope or using a pulse oximeter. There are limitations to each of these methods.

- During resuscitation, auscultation can be difficult, prolonging the interruption in compressions, and potentially giving inaccurate results.
- If the baby's perfusion is very poor, a pulse oximeter may not reliably detect the baby's pulse.
- A cardiac monitor displays the heart's electrical activity and may shorten the interruption in compressions, but electrical activity may be present without the heart pumping blood. This unusual finding is called *pulseless electrical activity (PEA),* and is suspected when the cardiac monitor shows electrical activity but the baby continues to deteriorate without palpable pulsations in the umbilical cord, audible heart sounds on auscultation, or a signal on the pulse oximeter. In the newborn, PEA is treated the same as absent electrical activity (heart rate = 0 or asystole).

When do you stop chest compressions?

Stop chest compressions when the heart rate is **60 bpm or greater.**

Once compressions are stopped, return to giving PPV at the faster rate of 40 to 60 breaths per minute. When a reliable pulse oximeter signal is achieved, adjust the FIO_2 to meet the target oxygen saturation guidelines.

What do you do if the heart rate is *not* improving after 60 seconds of compressions?

While continuing to administer chest compressions and coordinated ventilation, your team needs to quickly assess the quality of your ventilation and compressions. In most circumstances, endotracheal intubation or laryngeal mask insertion should have been performed. If not, one of these procedures should be performed now.

Quickly ask each of the 5 questions in Table 6-1 out loud and confirm your assessment as a team. You can use the mnemonic "CARDIO" to remember the 5 questions.

Table 6-1. Questions to Ask When Heart Rate Is Not Improving With Compressions and Ventilation (Mnemonic CARDIO)

1. **Chest** movement: Is the chest moving with each breath?
2. **Airway:** Is the airway secured with an endotracheal tube or laryngeal mask?
3. **Rote:** Are 3 compressions coordinated with l ventilation being delivered every 2 seconds?
4. **Depth:** Is the depth of compressions one-third of the AP diameter of the chest?
5. **Inspired Oxygen:** Is l00% oxygen being administered through the PPV device?

If the baby's heart rate remains less than 60 bpm despite 60 seconds of effective ventilation and high-quality, coordinated chest compressions, epinephrine administration is indicated and emergency vascular access is needed.

Focus on Teamwork

Providing chest compressions highlights several opportunities for effective teams to use the Neonatal Resuscitation Program® (NRP®) Key Behavioral Skills.

Behavior	Example
Anticípate and plan.	Ensure that you hove enough personnel present at the time of delivery based on the risk factors you identified. If there is evidence of severe fetal distress, be prepared for the possibility of a complex resuscitation, including chest compressions. If chest compressions are required, there is a high likelihood of also needing vascular access and epinephrine. Plan for this possibility during your team briefing. If compressions are started, a team member should immediately prepare the equipment necessary for emergency vascular access (umbilical venous catheter or intraosseous needle) and epinephrine. If a complex resuscitation is anticipated, prepare to apply a servo-controlled temperature sensor to the baby's skin to monitor and control the baby's body temperature.
Call for additional help when needed. Delegate workload optimally.	If chest compressions are required, you may need 4 or more health care providers. Performing ali of the tasks quickly, including PPV, auscultation, placing a pulse oximeter, intubating the airway, administering compressions, monitoring the quality of compressions and ventilations, monitoring the baby's response, preparing emergency vascular access, documenting events as they occur, and supporting the baby's family, requires multiple team members.

Behavior	Example
Clearly identify a team leader. Allocate attention wisely.	The team leader needs to maintain situation awareness, paying attention to the entire situation, and not becoming distracted by any single activity or procedure. This means that leadership may need to shift to another person if the team leader is performing a procedure that occupies their attention. It is important for someone to monitor the quality of ventilation and compressions while also monitoring the baby's heart rote.
Use available resources.	If the compressor becomes fatigued, hove another team member take over compressions. A respiratory therapist can administer PPV, enabling a nurse or physician to prepare for emergency vascular access and medication administration.
Communicate effectively. Maintain professional behavior.	During compressions, the compressor and ventilator need to coordinate their activity and maintain correct technique. They cannot perform other roles or hove conversations while compress1ons are 1n progress. If a correction is required, make a clear, calm, and directed statement. Speak clearly, directly, and loudly enough for team members to hear you, but avoid extraneous conversation or unnecessarily loud communication that may be distracting. Share information with the individual documenting events so they can be accurately noted.

Quality Improvement Opportunities

Ask yourself the following questions and begin a discussion with your team if you find a difference between the NRP recommendations and what is currently done in your own hospital setting. Consider using the suggested process and outcome measures to guide your data collection, identify areas for improvement, and monitor if your improvement efforts are working.

Quality improvement questions

0 Who are the providers that have chest compression skills in your delivery room setting?

8 Is someone with chest compression skills immediately accessible if needed?

Q How often do providers practice their chest compression and coordinated ventilation skills?

0 Is a cardiac monitor accessible in your delivery room setting for use when a baby requires intubation and chest compressions?

Process and outcome measures

0 How often do newborns receive chest compressions in your delivery room setting?

8 When compressions are required, how often is a skilled provider present at the time of birth?

E) How often <loes a baby have an endotracheal tube or laryngeal mask inserted before chest compressions are started?

O How often is the Fro$_2$ increased to 100% when compressions begin?

Frequently Asked Questions

What are the potential complications of chest compressions?

Chest compressions can cause trauma to the baby. Two vital organs lie within the rib cage-the heart and lungs. As you perform chest compressions, you must apply enough pressure to compress the heart between the sternum and spine without damaging underlying organs. The liver lies in the abdominal cavity partially under the ribs. Pressure applied directly over the xiphoid could cause laceration of the liver.

Chest compressions should be administered with the force directed straight down on the middle of the sternum. Do not become distracted and allow your thumbs to push on the ribs connected to the sternum. By following the procedure outlined in this lesson, the risk of injuries can be minimized.

Why does the Neonatal Resuscitation Program Algorithm follow A-8-C (Airway-Breathing-Compressions) when other programs follow C-A-8 (Compressions-Airway-Breathing)?

The NRP focuses on establishing effective ventilation, rather than starting chest compressions because the vast majority of newborns who require resuscitation have a healthy heart. The underlying problem is respiratory failure with impaired gas exchange; therefore, ventilation of the baby's lungs is the single most important and effective step during neonatal resuscitation. Very few babies will require chest compressions once effective ventilation has been established. Other programs focus on chest compressions because adults are more likely to have a primary cardiac problem causing cardiorespiratory collapse. Teaching a single approach for children and adults simplifies the educational process.

Why does the Neonatal Resuscitation Program use a 3:1 compression-to-ventilation ratio instead of the 15:2 ratio used in other programs?

Neonatal animal studies have shown that the 3:1 ratio shortens the time to return of spontaneous circulation. Alternative ratios, as well as asynchronous (uncoordinated) ventilations after intubation, are routinely used outside the newborn period but have not been shown to improve recovery in newborns. Additional chest compression techniques and ratios are currently being studied, but there is insufficient evidence to recommend them at this time.

In the case at the beginning of the lesson, the CO_2 detector did not change color even though the endotracheal tube was correc y inserted. Why?

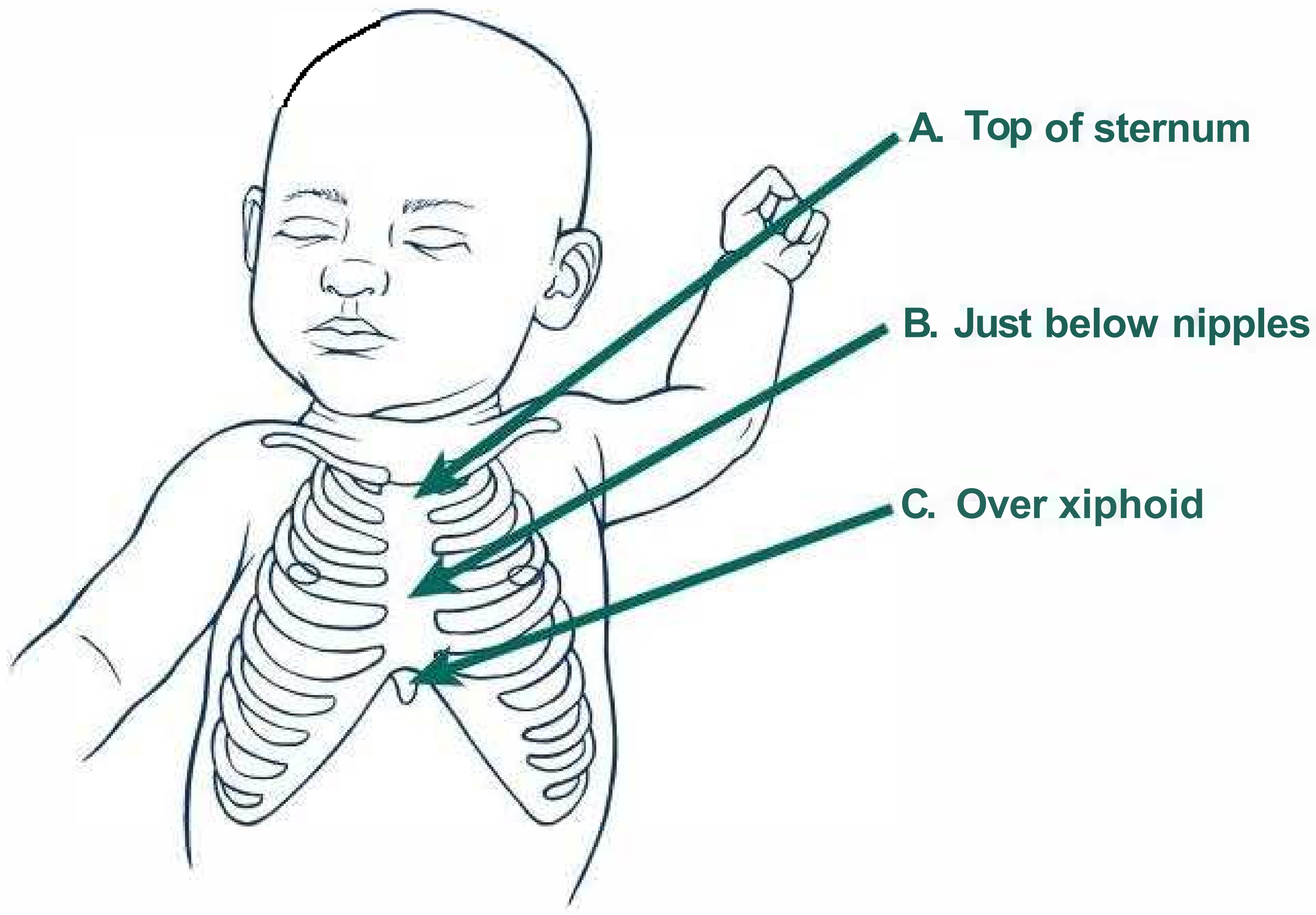
If a baby has a very low heart rate or very poor cardiac function, there may not be enough CO_2 carried to the lungs to change the detector's color. In this case, you will need to use other indicators (chest movement and breath sounds) to determine if the endotracheal tube is correctly inserted. If the CO_2 detector begins to change color during compressions, this may be an indication of improving cardiac function.

LESSON 6 REVIEW

1. A newborn is apneic at birth. The baby does not improve with the initial steps, and positive-pressure ventilation is started. After 30 seconds, the heart rate has increased from 40 beats per minute (bpm) to 80 bpm. Chest compressions (should)/(should not) be started. Positive-pressure ventilation (should)/(should not) continue.

2. A newborn is apneic at birth. The baby does not improve with the initial steps or positive-pressure ventilation. An endotracheal tube is inserted properly, the chest moves with ventilation, bilateral breath sounds are present, and ventilation has continued for another 30 seconds. The heart rate remains 40 beats per minute. Chest compressions (should)/(should not) be started. Positive-pressure ventilation (should)/(should not) continue.

3. Mark the area on this baby where you would apply chest compressions.



4. The correct depth of chest compressions is approximately
   a. One-fourth of the anterior-posterior diameter of the chest
   b. One-third of the anterior-posterior diameter of the chest
   c. One-half of the anterior-posterior diameter of the chest
   d. Two inches

5. The ratio of chest compressions to ventilation is (3 compressions to 1 ventilation)/(1 compression to 3 ventilations).

6. What phrase is used to achieve the correct rhythm for coordinating chest compressions and ventilation? ____.

7. You should briefly stop compressions to check the baby's heart rate response after (30 seconds)/(60 seconds) of chest compressions with coordinated ventilations.

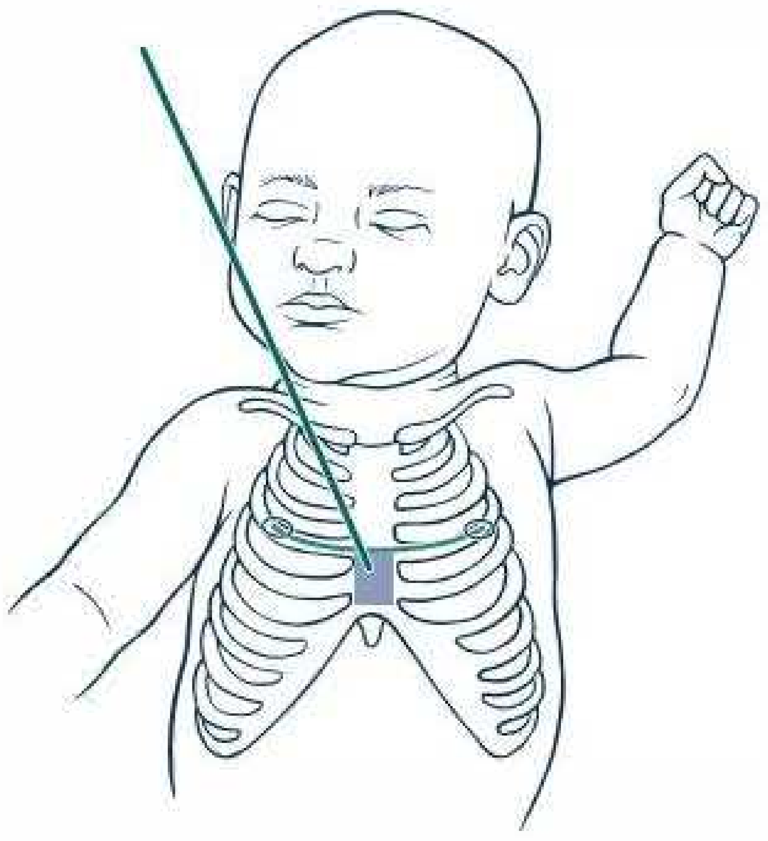
8. Chest compressions can be discontinued when the heart rate is greater than (100 beats per minute)/(60 beats per minute).

Answers

1. Chest compressions should not be started. Positive-pressure ventilation should continue.

2. Chest compressions should be started. Positive-pressure ventilation should continue.

3. Compression area (B) just below the nipples.



4. The correct depth of chest compressions is approximately one-third of the anterior-posterior diameter of the chest.

5. The ratio of chest compressions to ventilation is 3 compressions to 1 ventilation.

6. ((One-and-Two-and-Three-and-Breathe-and...."

7. You should briefly stop compressions to check the baby's heart rate response after 60 seconds of chest compressions with coordinated ventilations.

8. Discontinue chest compressions when the heart rate is greater than 60 beats per minute.

LESSON 6: PRACTICE SCENARIO

Chest Compressions

Learning Objectives

O Identify the newborn that requires chest compressions.

f) Interpret the meaning of a carbon dioxide (CO_2) detector that does not change color even though there are other clinical signs that indicate lung inflation with positive-pressure ventilation (PPV).

E) Demonstrate the correct technique for performing chest compressions.

O Identify the sign that indicates chest compressions should be discontinued.

0 Demonstrate behavioral skills to ensure clear communication and teamwork during this critical component of newborn resuscitation.

This Practice Scenario is for review/practice and evaluation.

This is the suggested Practice Scenario sequence.

O **Review the Knowledge Check Questions** with your Neonatal Resuscitation Program (NRP) instructor.

a. What are the indications for beginning chest compressions?

b. What oxygen concentration is used when chest compressions are required?

c. How long are chest compressions administered before checking a heart rate?

d. When can chest compressions be discontinued?

f) **Practice/review these skills** with your NRP instructor.

a. Move to the head of the baby to perform compressions when intubation is complete and the tube is secure. The person providing PPV moves to the side.

b. Position your hands in correct position on the baby's chest.

c. Provide compressions at the correct rate and depth.

d. Count the chest compression rhythm out loud and coordinate chest compressions with ventilation.

e. Apply a servo-controlled temperature sensor and adjust the radiant warmer.

E) **Practice this scenario** with your NRP instructor and your team until you need little or no assistance or coaching.

O **Pass the Lesson 6 Practice Scenario evaluation** by leading a practice scenario and performing chest compressions and other skills relevant to your role and responsibilities. If a technical skill included in a scenario is not within your scope of responsibility, delegate the skill to a qualified team member and perform the role of assistant if appropriate.

0 When you can lead the scenario(s) and perform the skills with little or no instructor coaching, proceed to the next lesson's practice scenar10.

Practice Scenario

"You are called to attend an emergency cesarean birth due to fetal bradycardia. How would you prepare for the resuscitation of the baby? As you work, say your thoughts and actions aloud so I will know what you are thinking and doing."

	Critical Performance Steps
Assess perinatal risk.	
	Assesses perinatal risk (learner asks 4 pre-birth questions and instructor ["OB provider"] responds) Gestation? **"Term."** Fluid clear? **"Fluid is clear."** Additional risk factors? **"Fetal bradycardia for the last 3 minutes."** Umbilical cord management plan? **"We'll assess the baby at birth. If the baby's not vigorous, 1'11give brief stimulation, and if there's no improvement, 1'11clamp the cord and bring the baby to the radiant warmer."**
Assemble team.	
	Assembles team based on perinatal risk factors. If risk factors are present, at least 2 qualified people should be present solely to manage the baby. The number of team members and qualifications vary depending on risk.
Perform a pre-resuscitation briefing.	
	Identifies team leader. Assesses risk factors, delegates tasks, identifies who will document events as they occur, determines supplies and equipment needed, identifies how to cal! for additional help.
Perform equipment check. (Leamers may prep for intubation, umbilical venous catheter insertion, and medication.)	
	"The baby has been born."
Rapid evaluation.	
	• Term? **"Appears term."** • Tone? **"No tone."** • Breathing or crying? **"No breathing."**
Initial steps.	
	Receives baby at radiant warmer, dries, stimulates, positions airway, suctions mouth and nose

Critical Performance Steps (cont)

Assess breathing. If breathing, assesses heart rate.

Checks breathing
"Baby is apneic." **(Heart rote = 40 bpm, if assessed)**

Begin PPV within 60 seconds of birth.

Begins PPV in 21 % oxygen (room air). Within 15 seconds of beginning PPV, learner asks assistant to check heart rote and assess if heart rote is rising.
Heart rote = 40 bpm, not increasing **"Pulse oximeter has no signal."**
Applies cardiac monitor (optional at this time).

Assess chest movement.

- If chest movement observed, continues PPV x 15 seconds (for total of 30 seconds PPV).
- If no chest movement observed, proceeds through corrective steps (MR. SOPA) until chest movement is achieved (instructor may determine how many steps are required); then administers PPV x 30 seconds. Heart rote will remain less than 60 bpm.
- *If no chest movement is achieved after M and R, S and O, and P steps, learner indicates need for alternative airway and proceeds directly to intubation or laryngeal mask insertion.*

Check heart rote after 30 seconds of PPV that moves the chest.

Checks heart rote.
Heart rate = 40 bpm and not increasing
Indicates need for alternative airway.

Places cardiac monitor leads and connects to monitor in anticipation of alternative airway (if not already done)

Insert alternative airway (endotracheal tube or laryngeal mask).

- Intubates (size 1 blade and size 3.5 endotracheal tube) or inserts laryngeal mask (size 1)
- Checks for rising heart rote, CO_2 detector color change, bilateral breath sounds, and chest movement with PPV
- For endotracheal intubation: Checks tip-to-lip insertion depth using nasal-tragus length or insertion depth chart
- Asks assistant to secure endotracheal tube or laryngeal mask

If PPV device not successfully inserted:
"Color is not changing on the CO_2 detector, chest is not moving, and heart rote is not increasing."
- Removes device
- Resumes PPV by face mask
- Repeats insertion attempt

If device successfully inserted:
Note: Color might not change on the CO_2 detector due to low heart rate.
Heart rote = 40 bpm and not increasing
"Chest is moving with PPV, pulse oximeter has no signal."
- Continues PPV x 30 seconds

Check heart rote after 30 seconds of PPV with alternative airway.

Checks heart rote after 30 seconds of PPV that moves the chest
Heart rote = 40 bpm and not increasing **"Pulse oximeter has no signal."**

Begin chest compressions.

Calls for additional help if necessary.
Asks assistant to increase oxygen to 100%.
Asks assistant to place servo-controlled temperature sensor on baby and adjust the radiant warmer to maintain baby's temperature 36.5°C to 37.5°C.
May ask team member to prepare for umbilical venous catheter insertion and epinephrine administration.

	Critical Performance Steps (cont)
	Compressor moves to head-of-bed position, ventilator to side of bed
	Places thumbs on sternum (lower third, below imaginary line connecting nipples); fingers under back, supporting spine (fingers do not need to touch)
	Compresses sternum one-third of the anterior-posterior diameter of chest, straight up and down • Compressor counts cadence "One-and-two-and-three-and-breathe-and" • Positive-pressure ventilation administered during compression pause ("breathe-and") • One cycle of 3 compressions and 1 breath every 2 seconds
Check heart rote after l minute.	
	Pauses compressions, continues PPV, and checks heart rote after 60 seconds of compressions and ventilations **Heart rote = 70 bpm and rising** **"Pulse oximeter has o signal. No spontaneous respirations."**
Discontinue compressions-Continue PPV.	
	• Discontinues chest compressions • Continues PPV with higher ventilation rote (40-60 breaths/min) • Adjusts oxygen concentration per target oxygen saturation **Heart rote is > l00 bpm and increasing** **SP02=78%** **"No spontaneous respirations."**
Check vital signs.	
	Continues PPV and adjusts oxygen concentration per oximetry **Heart rote is > l00 bpm** **SP02=90%** **"Muscle tone improving. Sorne spontaneous respirations."**
End scenario.	
	Supports baby with PPV and supplemental oxygen per Target Oxygen Saturation Table. Monitors heart rote, respiratory effort, oxygen saturation, activity, temperature. Prepares to move baby to post-resuscitation care setting. Communicates with perinatal team. Updates parents and informs them of next steps. Debriefs the resuscitation.

Sample Debriefing Questions

O What went well during this resuscitation?

8 What is the most important issue to discuss during this debriefing?

Q What will you do differently when faced with chest compressions in a future scenario?

8 Do you have additional comments or suggestions for your team? For the leader?

0 Give me an example of how you used at least one of the NRP Key Behavioral Skills.

If significant errors were made, consider asking the learners

- What happened? What should have happened? What could you have done to make the right things happen?
- What NRP Key Behavioral Skills might have been helpful in this situation?

NRP Key Behavioral Skills

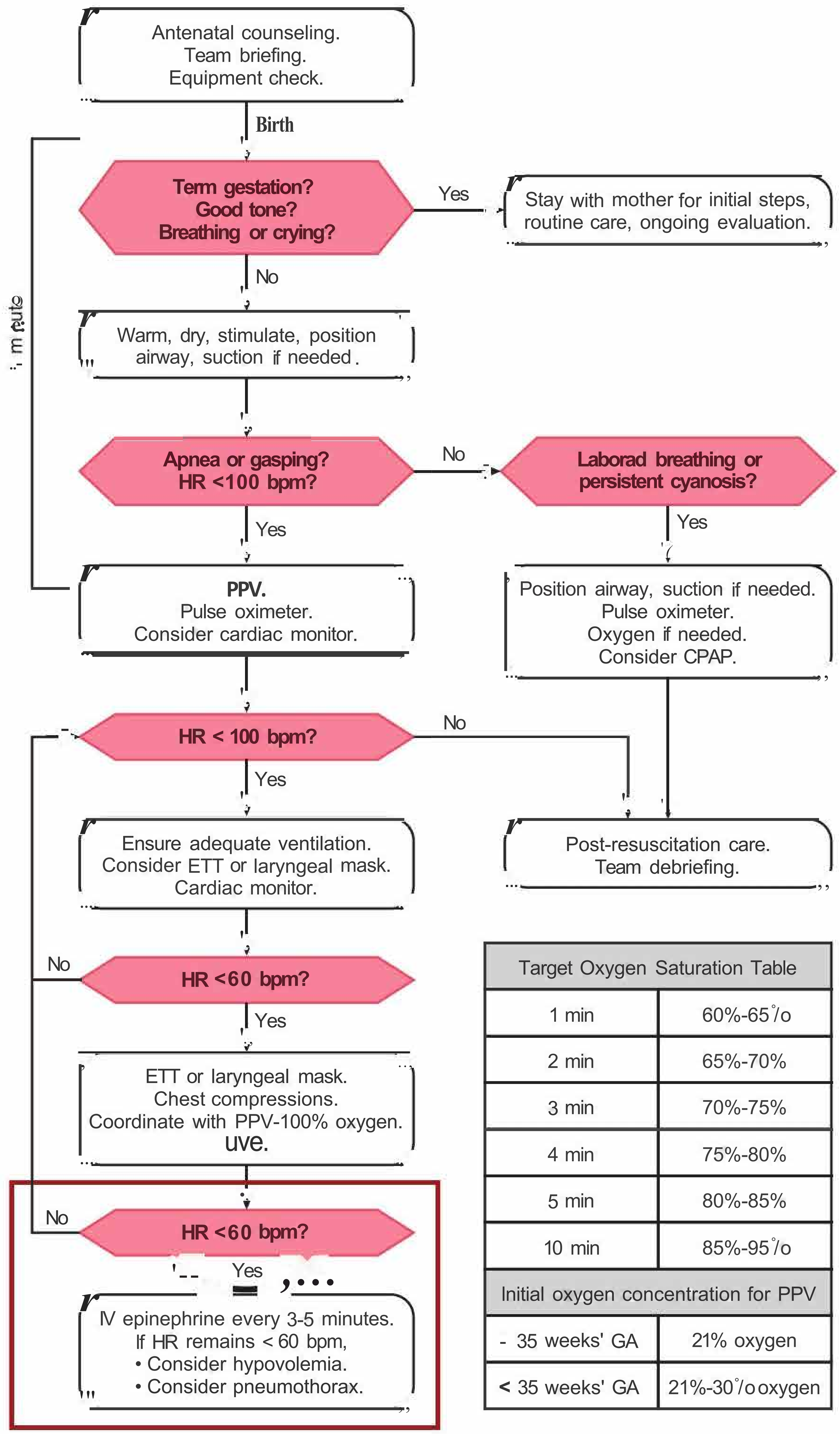
- Know your environment.
- Use available information.
- Anticipate and plan.
- Clearly identify a team leader.
- Communicate effectively.
- Delegate the workload optimally.
- Allocate attention wisely.
- Use available resources.
- Call for additional help when needed.
- Maintain professional behavior.

Medications

7

What you will learn

- When to give epinephrine during resuscitation
- How to administer epinephrine
- When to give a volume expander during resuscitation
- How to administer a volume expander
- What to do if the baby is not improving after giving intravenous epinephrine and volume expander
- How to insertan emergency umbilical venous catheter
- How to insertan intraosseous needle



Target Oxygen Saturation Table	
1 min	60%-65°/o
2 min	65%-70%
3 min	70%-75%
4 min	75%-80%
5 min	80%-85%
10 min	85%-95°/o
Initial oxygen concentration for PPV	
- 35 weeks' GA	21% oxygen
< 35 weeks' GA	21%-30°/o oxygen

Key Points

0 Epinephrine is indicated if the baby's heart rate remains **less than 60 beats per minute (bpm)** after:

a. At least 30 seconds of positive-pressure ventilation (PPV) that inflates the lungs as evidenced by chest movement **and**

b. Another 60 seconds of chest compressions coordinated with PPV using 100% oxygen.

c. In most cases, ventilation should have been provided through a properly inserted endotracheal tube or laryngeal mask.

8 Epinephrine is not indicated before you have established ventilation that effectively inflates the lungs, as evidenced by chest movement.

E) Epinephrine recommendations

a. Concentration: 0.1 mg/mL = 1 mg/10 mL

b. Route: Intravenous *(preferred)* or intraosseous

i. The central venous circulation may be rapidly accessed using either an umbilical venous catheter or an intraosseous needle. Por babies requiring vascular access at the time of delivery, the umbilical vein is recommended.

ii. One endotracheal <lose may be considered while vascular access is being established.

c. Preparation:

i. Intravenous or Intraosseous: 1-mL syringe (labeled *Epinephrine-IV)*

ii. Endotracheal: 3- to 5-mL syringe (labeled *Epinephrine-ET ONLY)*

d. Dose:

i. Intravenous or intraosseous = 0.02 mg/kg (equal to 0.2 mL/kg)

a. May repeat every 3 to 5 minutes

b. Range = 0.01 to 0.03 mg/kg (equal to 0.1 to 0.3 mL/kg)

c. Rate: *Rapidly-as* quickly as possible

d. Flush: Follow intravenous or intraosseous <lose with a 3-mL saline flush

ii. Endotracheal = 0.1 mg/kg (equal to 1 mL/kg)

a. Range = 0.0S to 0.1 mg/kg (0.5 to 1 mL/kg)

b. If no response, recommend intravenous or intraosseous for subsequent doses

0 Administration of a volume expander is indicated if the baby is not responding to the steps of resuscitation **and** there are signs of shock or a history of acute blood loss.

0 Volume expansion recommendations

a. Solution: Normal saline (NS) or type O Rh-negative blood

b. Route: Intravenous or intraosseous

c. Preparation: 30- to 60-mL syringe (labeled NS or O- blood)

d. Dose: 10 mL/kg

e. Rate: Over 5 to 10 minutes

0 If there is a confirmed absence of heart rate after ali appropriate steps of resuscitation have been performed, cessation of resuscitation efforts should be discussed with the team and family. A reasonable time frame for considering cessation of resuscitation efforts is around 20 minutes after birth; however, the decision to continue or discontinue should be individualized based on patient and contextual factors.

Case: Resuscitation with positive-pressure ventilation, chest compressions, and medications

Your team is called to attend the birth of a woman at 36 weeks' gestation who arrived complaining of decreased fetal movement and vaginal bleeding. Fetal bradycardia is noted on the monitor. Your resuscitation team quickly assembles in the delivery room, completes a pre-resuscitation team briefing, and prepares supplies and equipment. An endotracheal tube, umbilical venous catheter, epinephrine, and volume replacement are prepared because an extensive resuscitation is anticipated. An emergency cesarean birth is performed and the obstetrician reports bloody amniotic fluid. The umbilical cord is immediately clamped and cut, and a limp, pale baby is handed to the resuscitation team. A team member begins documenting the resuscitation events as they occur.

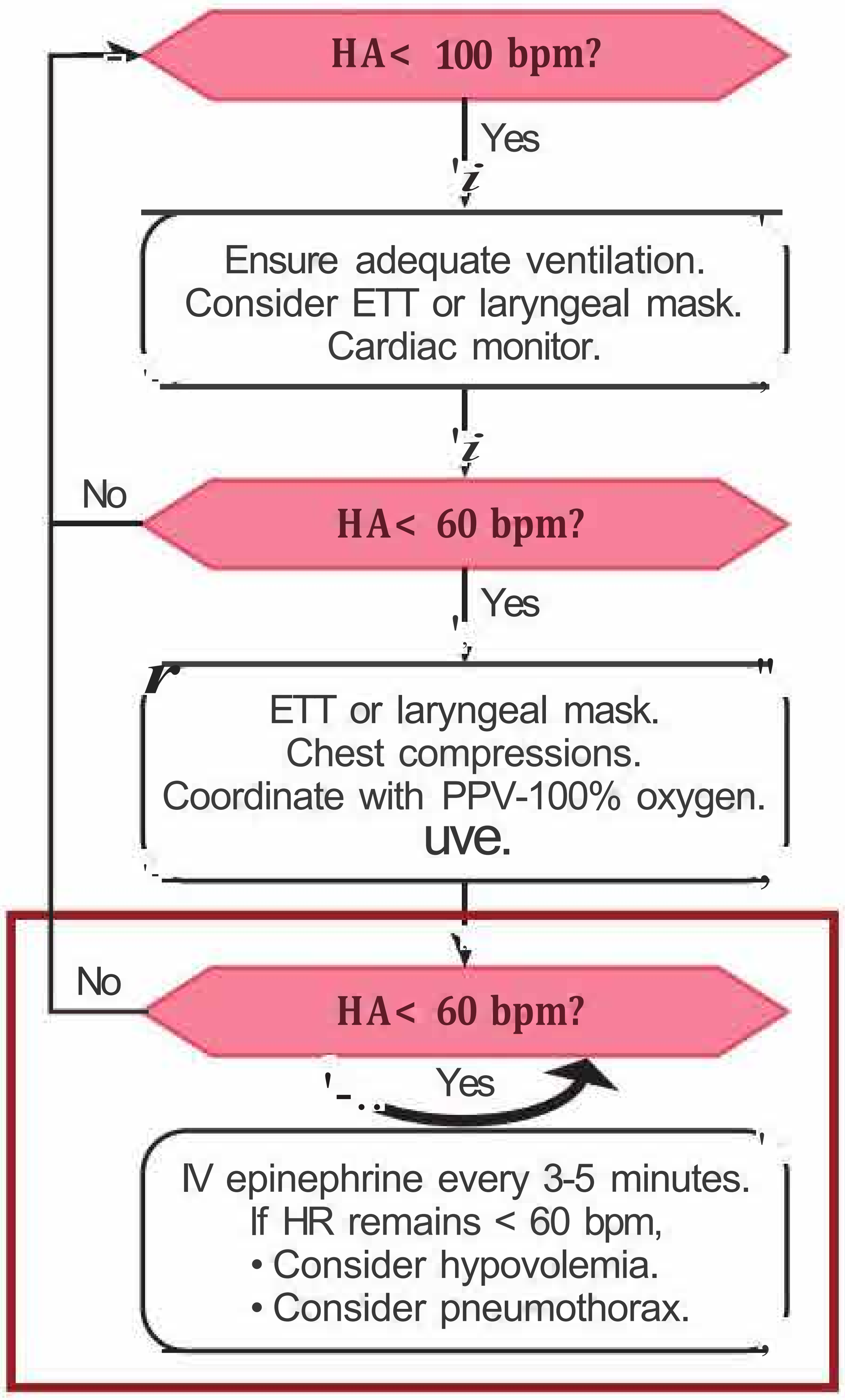
You perform the initial steps under a radiant warmer; however, the baby remains limp without spontaneous respirations. You begin positive-pressure ventilation (PPV) with 21% oxygen, a pulse oximeter sensor is placed on the baby's right hand, and cardiac monitor leads are placed on the chest. The baby's heart rate is 40 beats per minute (bpm) by cardiac monitor and auscultation, but the pulse oximeter does not display a reliable signal. Despite PPV that moves the baby's chest, the heart rate does not improve. The baby is successfully intubated and PPV through the endotracheal tube is continued for 30 seconds, but the heart rate remains 40 bpm. Chest compressions are performed with coordinated PPV using 100% oxygen. A team member confirms the quality of compressions and ventilation, but, after 60 seconds, the baby's heart rate has slowed to 30 bpm.

One team member quickly inserts an umbilical venous catheter and another administers epinephrine and a saline flush through the catheter. Ventilation and compressions are continued, and, 1 minute later, the baby's heart rate has increased to greater than 60 bpm. Chest compressions are stopped. As the heart rate continues to increase, the pulse oximeter begins to detect a reliable signal and shows oxygen saturation 70% and rising. Assisted ventilation continues and the oxygen concentration is adjusted to maintain the baby's oxygen saturation within the target range. By 10 minutes after birth, the baby makes an initial gasp. The baby is transferred to the nursery for post-resuscitation care. Shortly afterward, your team members conduct a debriefing to discuss their preparation, teamwork, and communication.

A very small number of newborns will require emergency medication.

Most newborns requiring resuscitation will improve without emergency medications. Before administering medications, you should ensure the accuracy of your heart rate assessment and check the effectiveness of ventilation and compressions. In most cases, you should have inserted an endotracheal tube or a laryngeal mask to improve the efficacy of ventilation.

Despite inflating the lungs and augmenting cardiac output with chest compressions, a very small number of newborns (approximately 1 per 1,000 newborns) will still have a heart rate less than 60 bpm. This occurs when blood flow into the coronary arteries is severely decreased, resulting in such low oxygen delivery to the newborn's heart that it cannot contract effectively. These newborns should receive epinephrine to improve coronary artery perfusion and oxygen delivery (Figure 7.1). Newborns with shock from acute blood loss (eg, bleeding vasa previa, fetal trauma, cord disruption, severe cord compression) may also require emergency volume expansion.



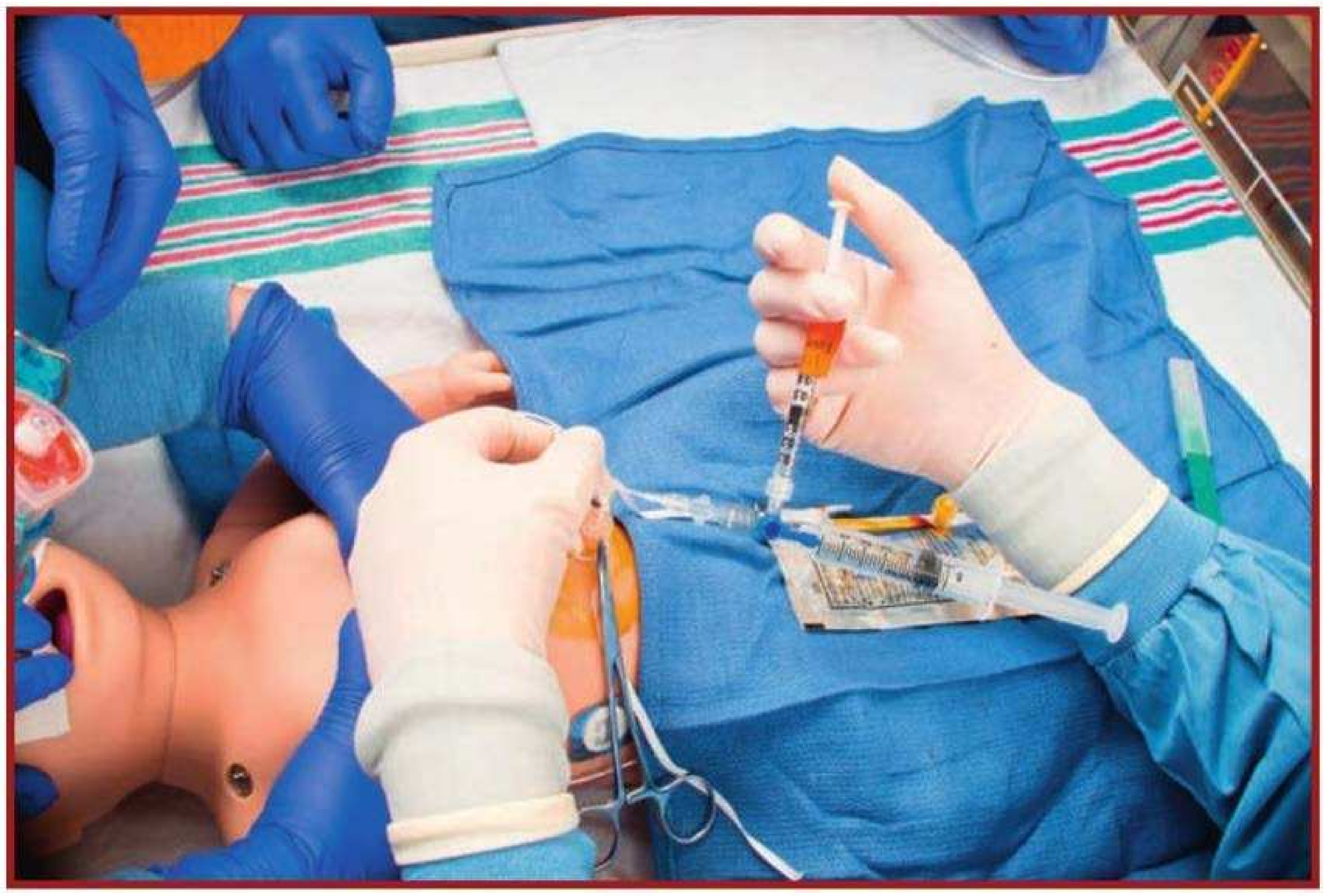


Figure 7.1. Few newborns require emergency medication to regain cardiac function.

What is epinephrine and what does it do?

Epinephrine is a cardiac and vascular stimulant. It causes constriction of blood vessels outside of the heart, which increases blood flow into the coronary arteries. Blood flowing into the coronary arteries carries the oxygen required to restore cardiac function. In addition, epinephrine increases the rate and strength of cardiac contractions.

When is epinephrine indicated and how should it be administered?

Indication

Epinephrine is indicated if the baby's heart rate remains **less than 60** bpm **after**

- At least 30 seconds of PPV that inflates the lungs as evidenced by chest movement, **and**
- Another 60 seconds of chest compressions coordinated with PPV using 100% oxygen.

In most cases, ventilation should have been provided through a properly inserted endotracheal tube or laryngeal mask. Epinephrine is **not** indicated before you have established ventilation that effectively inflates the lungs.

Concentration

Caution: Epinephrine is available in 2 concentrations.

The only concentration that should be used for neonatal resuscitation is **labeled either 0.1 mg/mL or 1 mg/10 mL.** It is usually supplied in a 10-mL glass vial that is packaged in a box with an injection device.

Do not use the higher concentration epinephrine that may be stocked with emergency supplies for pediatric and adult resuscitation. This is often supplied in a small glass vial with a breakable top that <loes not have an injection device.

Route

Intravenous *(preferred)* or intraosseous: Epinephrine needs to rapidly reach the central venous circulation. Medications reach the central venous circulation quickly when administered into either an umbilical venous catheter or an intraosseous needle. For babies requiring vascular access at the time of delivery, the umbilical vein is recommended. When umbilical venous access is not feasible or successful, the intraosseous route is a reasonable alternative.

Attempting insertion of a peripheral intravenous catheter is not recommended for emergency medication administration in the setting of cardiovascular collapse. It is likely to be unsuccessful, result in epinephrine extravasation into the tissue, and delay the administration of potentially lifesaving therapy.

Endotracheal *{less effective):* Sorne clinicians may choose to give a <lose of epinephrine into the endotracheal tube while vascular access is established. Although it may be faster to give endotracheal epinephrine than intravenous epinephrine, studies suggest that absorption is unreliable and the endotracheal route is less effective. For this reason, the intravenous and intraosseous routes are recommended.

Preparation

Use a sterile connector or stopcock to transfer epinephrine from the glass vial injector to a syringe (Figure 7.2).

Intravenous/Intraosseous: Prepare intravenous or intraosseous epinephrine in a labeled **1-mL syringe. Clearly label the syringe:** ccEpinephrine-lV."

Endotracheal: Prepare endotracheal epinephrine in a **3- to 5-mL syringe.** Clearly label the syringe: ccEpinephrine-ET ONLY." Be certain not to use this larger syringe for intravenous or intraosseous administration.

Figure 7.2. Use a connector or stopcock to transfer epinephrine.

Dose

Intravenous or intraosseous: The suggested initial **intravenous or intraosseous dose** is **0.02 mg/kg** (equal to 0.2 mL/kg). You will need to estímate the baby's weight after birth.

- The recommended dose range for intravenous or intraosseous administration is 0.01 to 0.03 mg/kg (equal to 0.1 to 0.3 mL/kg).

Endotracheal: If you decide to give an endotracheal dose while vascular access is being established, the **suggested endotracheal dose is 0.1 mg/kg (equal to 1 mL/kg).** The recommended dose range is 0.05 to 0.1 mg/kg (equal to 0.5 to 1 mL/kg). This higher dose is **only** recommended for endotracheal administration. **DO NOT give the higher dose via the intravenous or intraosseous route.**

Administration

IV/IO Rate: Rapidly-give epinephrine as quickly as possible.

IV/IO Flush: Follow **IV or 10** doses with a **3-mL** flush of normal saline.

Endotracheal: When giving endotracheal epinephrine, be sure to give the drug directly into the tube, being careful not to leave it deposited in the tube connector. Because you will be giving a large fluid volume of epinephrine into the endotracheal tube, you should follow the drug with several positive-pressure breaths to distribute the drug into the lungs. No flush is recommended.

Closed-loop communication

Use closed-loop communication when giving a medication order. State individual digits for numbers. Say the leading zero and the decimal point, but do not say trailing digits. Avoid using abbreviations during medication orders.

Por example:

- The medical provider (Liz) and person administering medications (Taylor) first agree on an estimated weight.
  - *Liz:* "Taylor, I estímate the baby's weight is three kilograms."
  - *Taylor:* "Weight is three kilograms."
- The medical provider then gives the medication name, concentration, dose, and route. The order is repeated back by the person administering the medication.
  - *Liz:* "Taylor, give epinephrine, one milligram in ten milliliters concentration, zero-point-zero-two milligrams per kilogram, rapidly through the umbilical venous catheter, then give three milliliters of saline flush."
  - *Taylor:* "I have epinephrine, one milligram in ten milliliters (show box). I'm giving zero-point-zero-two milligrams per kilogram, which is equal to zero-point-two milliliters per kilogram. The baby weighs three kilograms, so I will give zero-point-six milliliters (show syringe). I'm giving it rapidly through the umbilical venous catheter. Then I will flush with three milliliters of saline (show syringe)."
- Once completed.
  - *Taylor:* "Liz, epinephrine has been given and the flush is completed."

What should you expect to happen after giving epinephrine?

Assess the baby's heart rate 1 minute after epinephrine administration. As you continue PPV with 100% oxygen and chest compressions, the heart rate should increase to 60 bpm or higher within approximately 1 minute of intravenous or intraosseous epinephrine administration.

If the heart rate is less than 60 bpm after the first dose of intravenous or intraosseous epinephrine, continue coordinated ventilation and compressions. You can repeat the epinephrine dose every 3 to 5 minutes. If you started with the suggested initial dose of 0.02 mg/kg or lower, you should consider increasing subsequent doses. Do not exceed the maximum recommended dose. If there is not a satisfactory response after intravenous or intraosseous epinephrine, consider other problems such as hypovolemia and tension pneumothorax.

The response may take longer, or may not occur, if you give endotracheal epinephrine. If the first dose is given by the endotracheal route and there is not a satisfactory response, a repeat dose should be given as soon as an umbilical venous catheter or intraosseous needle is inserted. Do not delay. If the heart rate is less than 60 bpm, you do not need to wait for 3 minutes after an endotracheal <lose to give the first intravenous or intraosseous <lose. Once an umbilical venous catheter or intraosseous needle has been inserted, ali subsequent doses should be given by the intravenous or intraosseous route.

In addition, check to be certain that

- A cardiac monitor is being used for the most accurate assessment of heart rate.
- The lungs are being adequately ventilated as indicated by chest movement. Insertion of an endotracheal tube or a laryngeal mask should be strongly considered if not already done. If PPV is provided through an endotracheal tube or a laryngeal mask, there should be equal breath sounds.
- The endotracheal tube is not displaced, bent, or obstructed by secretions.
- Chest compressions are being given at the correct depth (one-third of the anterior-posterior [AP] diameter of the chest) and correct rate (90/min).
- Interruptions in chest compressions are minimized because each interruption decreases coronary artery perfusion.

Epinephrine Summary

Concentration
0.1 mg/ml epinephrine = 1 mg/10 ml
Route
Intravenous *(preferred)* **or Intraosseous**
Option: Endotracheal only while intravenous or intraosseous access is being established
Preparation
Intravenous or Intraosseous: 1-ml syringe labeled "Epinephrine-IV"
• Prepare a 3-ml saline flush
Endotracheal: 3- to 5-ml syringe labeled "Epinephrine-ET only"
Dose
Intravenous or Intraosseous = 0.02 mg/kg (equal to 0.2 ml/kg).
• *Range=0.01 to 0.03 mg/kg (equal to 0.1 to 0.3 mL/kg)*
Endotracheal = 0.1 mg/kg (equal to 1 ml/kg)
• *Range =0.05 to 0.l mg/kg (equal to 0.5 to l mL/kg)*
Administration
Intravenous or Intraosseous • **Rapidly-as** quickly as possible. • **Flush with 3 ml normal saline.** • **Repeat every 3 to *5* minutes if heart rote remains less than 60 bpm.**
Endotracheal: Administer PPV breaths to distribute into lungs. No flush.

When should you consider administering a volume expander?

If there has been an acute fetal-maternal hemorrhage, bleeding vasa previa, extensive vaginal bleeding, a placenta! laceration, fetal trauma, an umbilical cord prolapse, a tight nuchal cord, or blood loss from the umbilical cord, the baby may be in hypovolemic shock. The baby may have a persistently low heart rate that <loes not respond to effective ventilation, chest compressions, and epinephrine.

Babies with hypovolemic shock may appear pale, have delayed capillary refill, and/or have weak pulses. In sorne cases, there will be signs of shock with no obvious evidence of blood loss.

- Administration of a volume expander is indicated if the baby is **not responding** to the steps of resuscitation **and there are signs of shock or a history of acute blood loss.**
- Volume expanders **should not be given routinely** during resuscitation in the absence of shock or a history of acute blood loss. Giving a large volume load to a heart that is already injured may actually worsen cardiac output and further compromise the newborn.

What volume expanders should be considered and how should they be administered?

Crystalloid fluid

The recommended crystalloid solution for acutely treating hypovolemia is normal saline (0.9% NaCl).

Lactated Ringer solution is an acceptable alternative but is not as commonly available. It co11tains sodium, potassium, calcium, and lactate. Because it contains calcium, it cannot be infused in the same intravenous line as packed red blood cells.

Packed red blood cells

Packed red blood cells should be considered for volume replacement when severe fetal anemia is suspected. If fetal anemia was diagnosed before birth, the donor unit can be cross-matched to the mother to ensure compatibility with any maternal antibodies transferred to the baby. If cross-matched blood is not immediately available, use *emergency, non-cross-matched, type* O *Rh-negative packed red blood cells.*

Dose

The initial <lose of the selected volume expander is 1OmL/kg. If the baby <loes not improve after the first <lose, you may need to

give an additional 10 mL/kg. In unusual cases of large blood loss, administration of additional volume may be considered.

Route

Options for emergency access to the vascular system during hypovolemic shock include an umbilical venous catheter or an intraosseous needle. Attempting insertion of a peripheral intravenous catheter is not recommended for emergency volume administration in the setting of cardiovascular collapse.

Preparation

Fill a large syringe (30-60 mL) with the selected volume expander.

If using crystalloid fluid, label the syringe to clearly identify its contents.

Administration

In most cases, acute hypovolemia resulting in a need for resuscitation should be corrected quickly. No clinical trials have established a preferred infusion rate, but, in most cases, a steady infusion over 5 to 10 minutes is reasonable.

In preterm newborns less than 32 weeks' gestation, volume boluses given during the first day of life, volume boluses given rapidly, and volume boluses greater than 10 mL/kg have been associated with an increased risk of intracranial hemorrhage.

Volume Expander Summary

Solution
Normal Saline (0.9% NaCl) *Suspected severe anemia: Type O Rh-negative packed red blood cells*
Route
Intravenous or Intraosseous
Preparation
30- to 60-ml syringe (labeled NS or O- blood)
Dose
10 ml/kg
Administration
Over 5 to 10 minutes *(Use caution with preterm newborns less than 32 weeks' gestation.)*

What do you do if the baby is not improving after giving intravenous epinephrine and volume expander?

While continuing to administer chest compressions and ventilation, your team needs to quickly reassess the quality of ventilation and compressions. Intravenous epinephrine may be repeated every 3 to 5 minutes.

If you have not inserted an alternative airway, this procedure should be performed now. In addition, a STAT chest x-ray may provide valuable information. If necessary, call for additional expertise.

Quickly ask each of the questions in Table 7-1 and confirm your assessment as a team.

Table 7-1 • Questions to Ask When Heart Rate Is Not Improving With Compressions, Ventilation, Epinephrine, and Volume Expansion

1. Is the chest moving with each breath?
2. Is the airway secured with an endotracheal tube or a laryngeal mask?
3. Are 3 compressions coordinated with 1 ventilation being delivered every 2 seconds?
4. Is the depth of compressions one-third of the AP diameter of the chest?
5. Is 100% oxygen being administered through the PPV device?
6. Was the correct dose of epinephrine given intravenously?
7. Is the umbilical venous catheter or intraosseous needle in place or has it been dislodged?
8. Is a pneumothorax present?

You have followed the Neonatal Resuscitation Program® (NRP®) Algorithm, but the newly born baby still has no detectable heart rate (Apgar 0). For how long should you continue?

Newly born babies with no detectable heart rate after 10 to 20 minutes of resuscitation frequently do not survive, and those who survive frequently have serious neurologic disabilities, but survival without neurodevelopmental impairment is possible. A small number of newborns who experienced return of circulation and survived without severe disabilities despite an absent heart rate for 20 or more minutes after birth have been reported. The decision to discontinue resuscitative efforts must balance the possibility of stopping too early, when return of circulation and long-term survival may still be achievable, and continuing too long, when return of circulation is not possible and continued interventions offer no benefit or the baby may survive but with a significant burden of neurologic injury.

When making the decision to discontinue resuscitation, variables to be considered may include

- Uncertainty about the duration of asystole
- Whether ali appropriate interventions have been performed
- The baby's gestational age
- The presence of serious congenital anomalies
- The specific circumstances prior to birth such as the presumed etiology and timing of the perinatal events leading to cardiorespiratory arrest
- The family's stated preferences and values
- The availability of post-resuscitative resources such as neonatal intensive care and therapeutic hypothermia

Given these considerations, it is unlikely that a single time interval after birth or a uniform duration of cardiopulmonary resuscitation will be appropriate for all newborns.

- If there is a confirmed absence of heart rate after all appropriate steps of resuscitation have been performed, cessation of resuscitation efforts should be discussed with the team and family.
- A reasonable time frame for considering cessation of resuscitation efforts is around 20 minutes after birth; however, the decision to continue or discontinue should be individualized based on patient and contextual factors.

There are other situations, such as prolonged bradycardia without improvement, where, after complete a1ldadequate resuscitation efforts, discontinuation of resuscitation may be appropriate. However, there is not enough information on outcomes in these situations to make specific recommendations. Decisions on how to proceed in these circumstances must be made on a case-by-case basis. If possible, emergency consultation with a colleague or individual with additional expertise may be helpful.

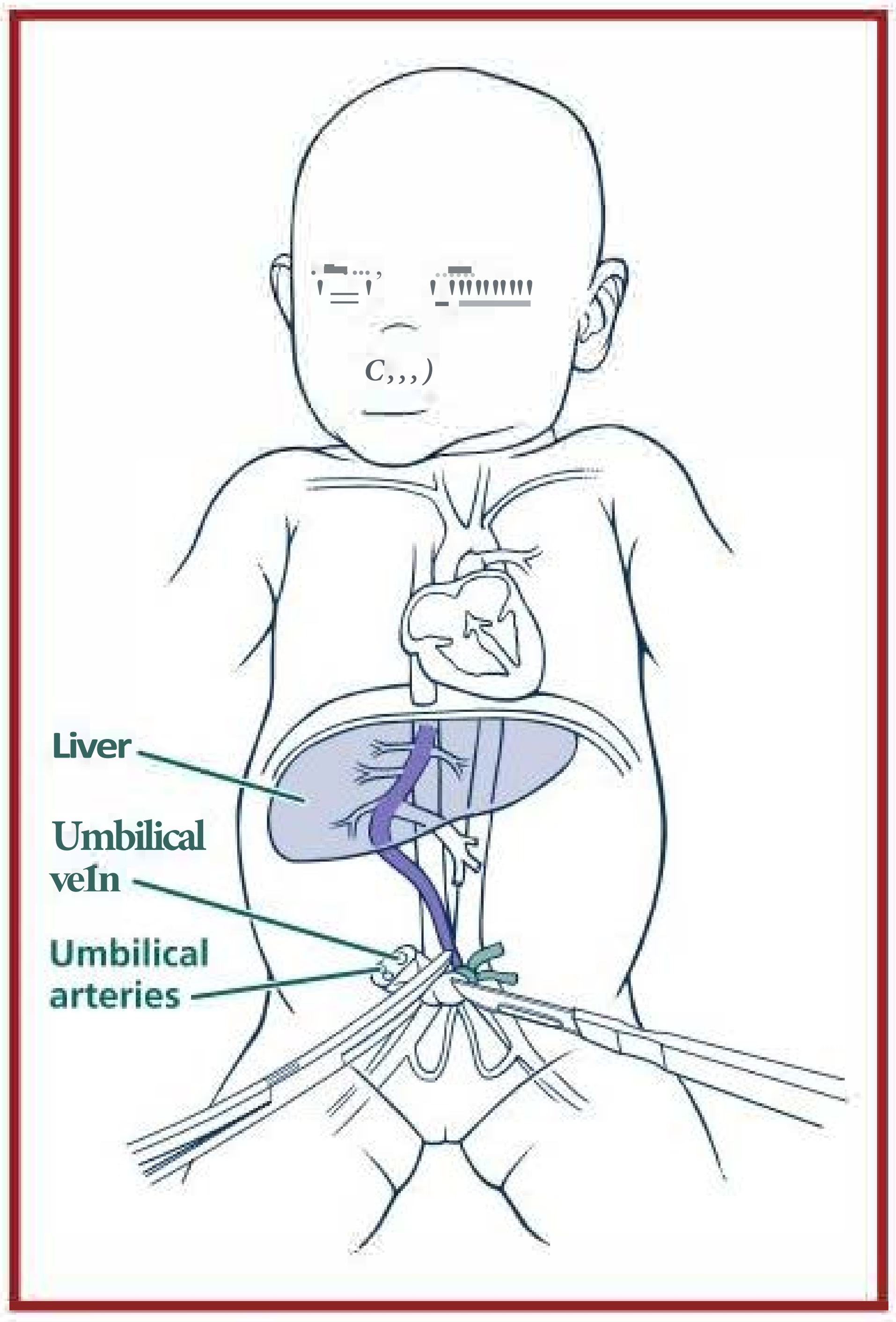


Figure 7.3. The umbilical vein travels through the liver to join the central venous circulation.

How do you establish rapid intravascular access during resuscitation?

The umbilical vein

The umbilical vein is a rapidly accessible, direct intravenous route in the newborn (Figure 7.3). If the use of epinephrine can be anticipated because the baby is not responding to PPV, a member of the resuscitation team should prepare to insert an umbilical venous catheter while others continue to provide PPV and chest compressions.

Emergency umbilical venous catheter insertion

O Put on gloves and quickly prepare an area for your equipment (Figure 7.4). Although you should attempt to use sterile technique, you must balance the need to rapidly secure emergency venous access with the risk of possibly introducing infection. If central venous access will be needed after stabilization, the emergency umbilical venous catheter will be removed and a new catheter will be inserted using full sterile technique.

f) Fill a 3.SF or SF single lumen umbilical catheter with normal saline using a syringe (3-10 mL) connected to a stopcock. Once filled, close the stopcock to the catheter to prevent fluid loss and air entry (Figure 7.4). Be certain that you know which direction is «off„ on the stopcock used in your practice setting.

Figure 7.4. Umbilical catheter (inside the plastic sleeve) prepared for emergency insertion

E) Quickly clean the umbilical cord with an antiseptic solution. Place a loose tie at the base of the umbilical cord (Figure 7.5) around Wharton's jelly or the skin margin. This tie can be tightened if there is excessive bleeding after you cut the cord. If the tie is placed around the skin, be sure that it <loes not compromise skin perfusion.

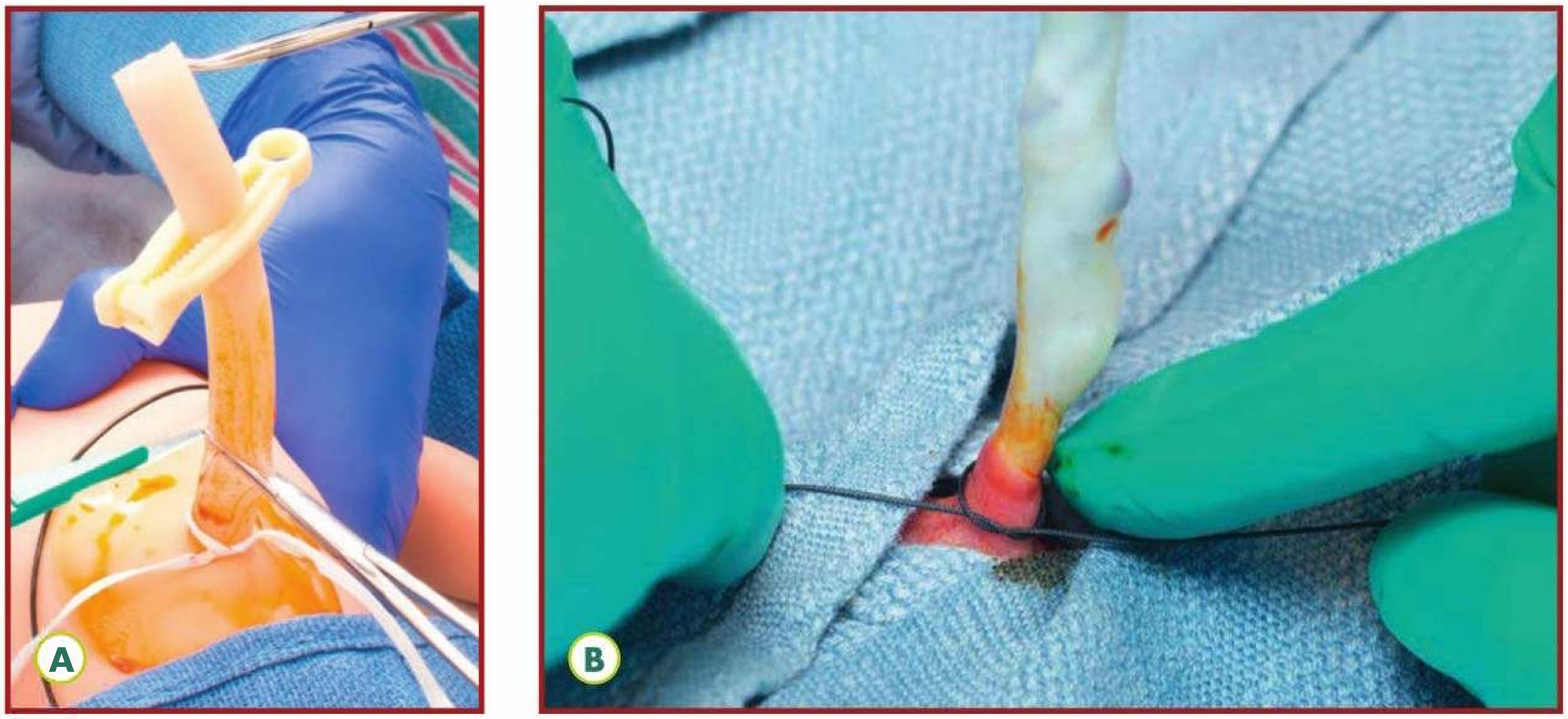


Figure 7.5. Tie placed around Wharton's jelly (A) or the skin margin (B). (Figure 7.5B used with permission of Mayo Foundation for Medica! Education and Research.)

0 Briefly stop chest compressions and caution the team that a scalpel is entering the field. Cut the cord with a scalpel below the umbilical clamp and about 1 to 2 cm above the skin line (Figure 7.6). Attempt to cut straight across the cord rather than at an angle.

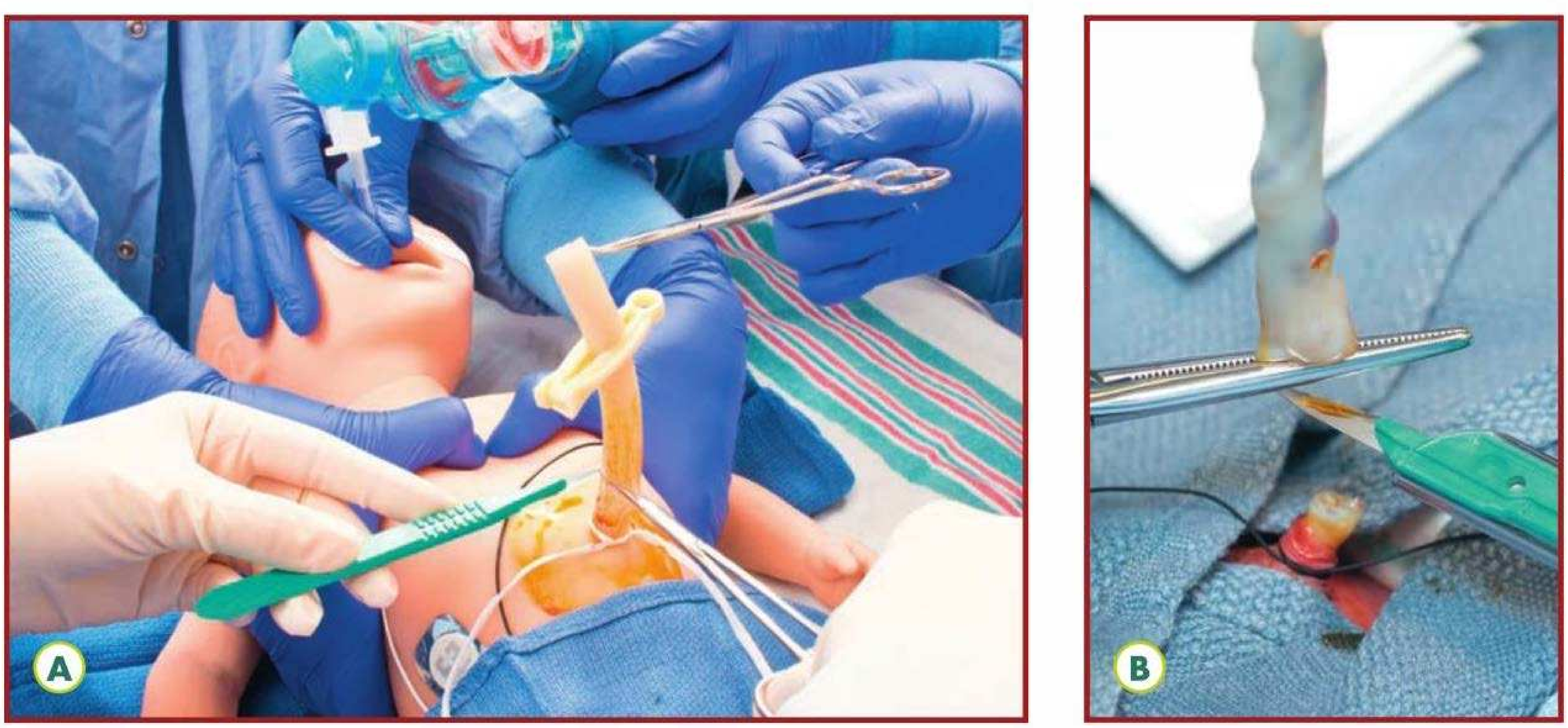


Figure 7.6. Cut the umbilical cord 1 to 2 cm above the skin line. (Figure 7.6B used with permission of Mayo Foundation for Medica! Education and Research.)

0 The umbilical vein will be seen as a larger, thin-walled structure, often near the 12-o'clock position. The 2 umbilical arteries are smaller, have thicker walls, and frequently lie close together

(Figure 7.7). The arteries coil within the cord and their position will vary depending on where you cut the cord.

O Insert the catheter into the umbilical vein (Figures 7.8 and 7.9).

a. Continue inserting the catheter 2 to 4 cm until you get free flow of blood when the stopcock between the baby and the syringe is opened and gently aspirated.

b. Por emergency use, the tip of the catheter should be located only a short distance into the vein-only to the point at which blood can be aspirated. If the catheter is inserted farther, there is risk of infusing medications directly into the liver, which may cause hepatic injury (Figure 7.10).

c. Continue to hold the catheter securely in place with 1 hand until it is either secured or removed.

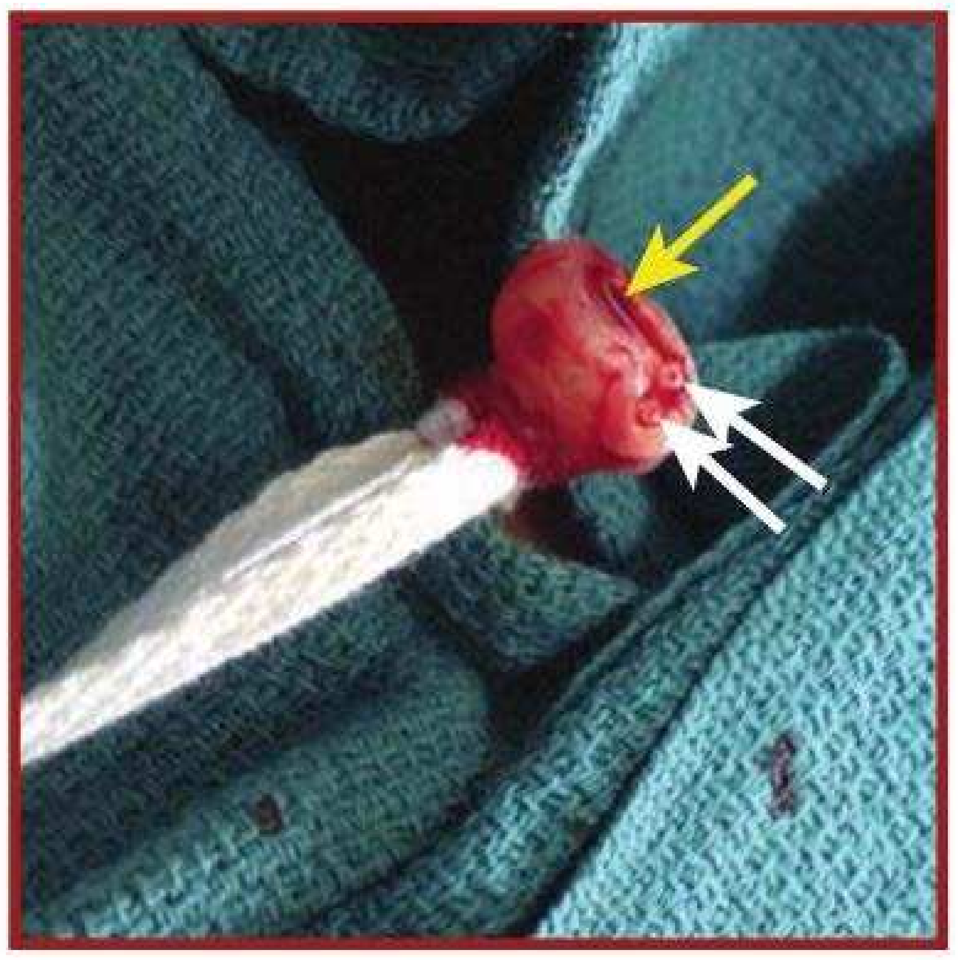


Figure 7.7. The umbilical cord ready for catheter insertion. The umbilical vein is shown by the yellow arrow. The 2 umbilical arteries are shown by the white arrows.

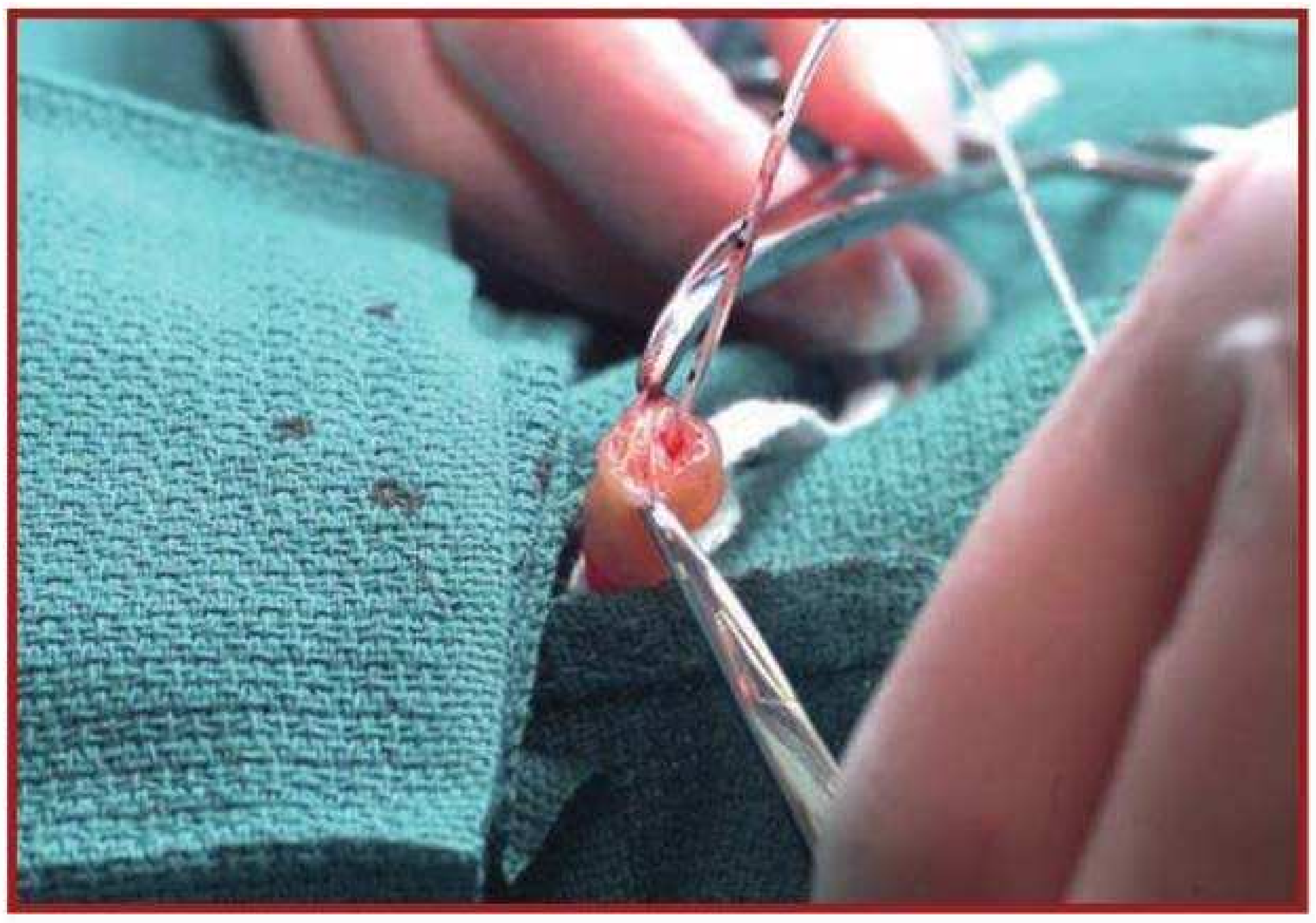


Figure 7.8. Saline-filled catheter inserted into the umbilical vein. Note the black centimeter markings on the catheter.

Figure 7.9. Advance the catheter until blood can be aspirated and the catheter can be easily flushed.

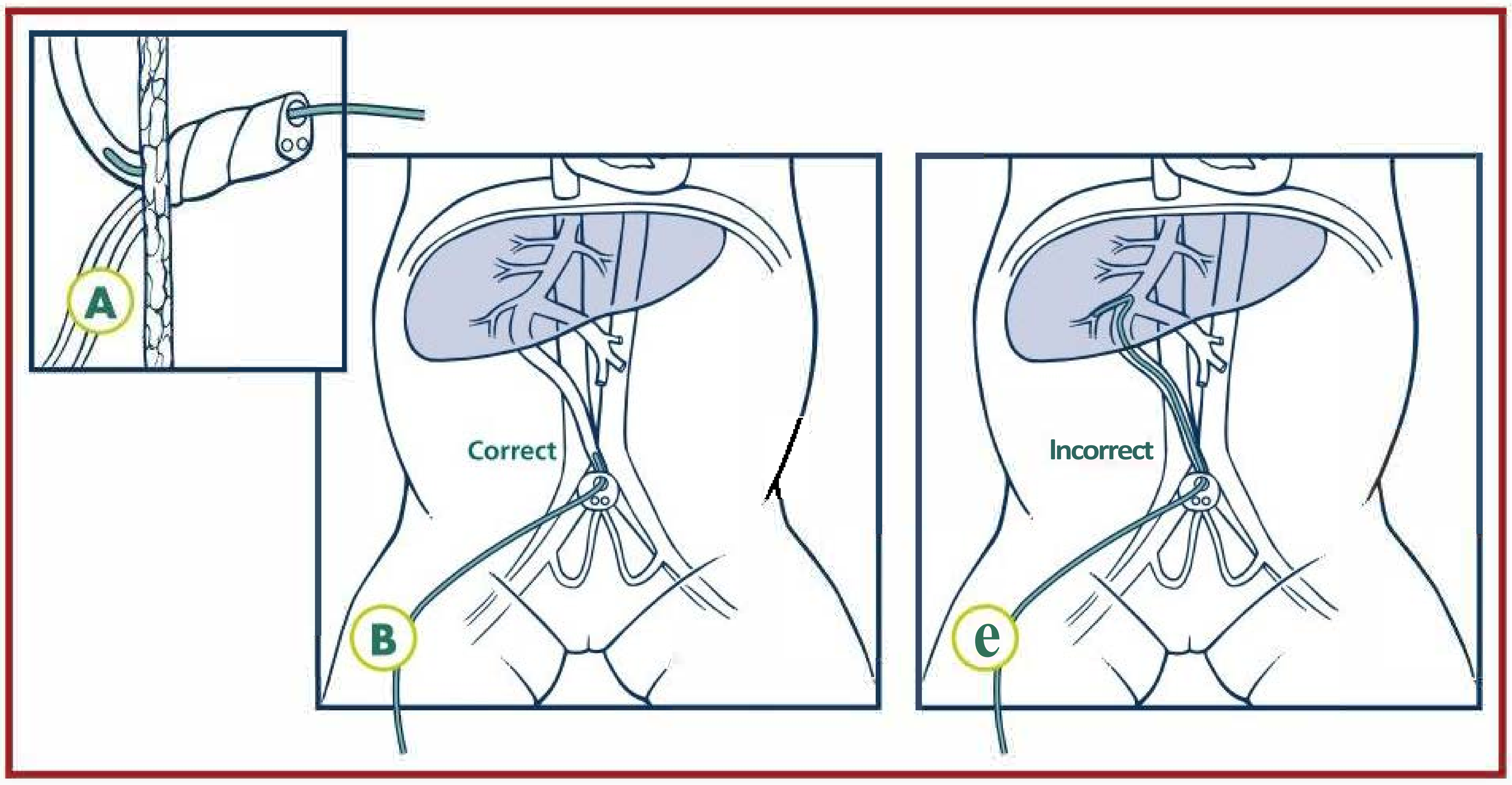


Figure 7.1 O. Correct (A and B) and incorrect (C) umbilical venous catheter insertion

0 Attach the syringe containing either epinephrine or volume expander to the available stopcock port, turn the stopcock so that it is open between the syringe and the catheter, ensure that there are no air bubbles in the syringe or catheter, administer the appropriate <lose, and flush the catheter (Figure 7.11). Avoid dislodging the catheter by asking an assistant to infuse the medication while the operator holds the catheter in place.

0 After medications have been administered, either remove the catheter or secure it for temporary intravenous access as the baby is transported to the nursery. If you decide to leave the catheter in place during stabilization or transport, it should be secured. A clear adhesive dressing can be used to temporarily secure the line to the newborn's abdomen (Figure 7.12). Suturing and "goal post" tape are effective methods for securing the catheter for prolonged use, but they take time and may not be the best choice during resuscitation.

Figure 7.11. Open the stopcock toward the baby and infuse the medication.

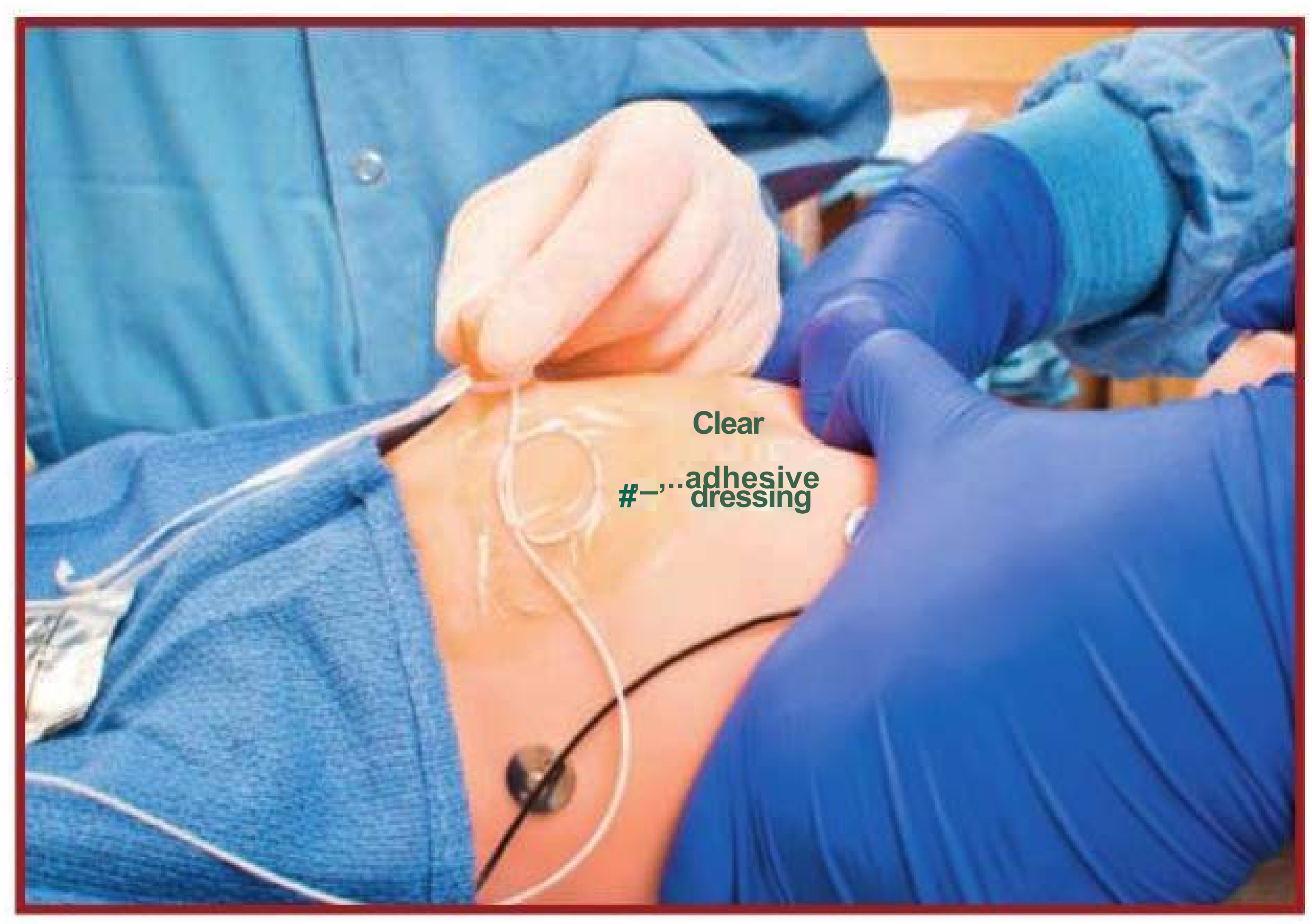


Figure 7.12. Temporarily secure the umbilical catheter with a clear adhesive dressing.

f) If the umbilical venous catheter is not removed, the insertion site should remain uncovered and visible to monitor for bleeding.

G) If you remove the catheter, do it slowly and be prepared to control bleeding by tightening the cord tie, squeezing the umbilical stump, or applying pressure above the umbilicus.

The intraosseous needle

Although an umbilical venous catheter is typically the preferred method of obtaining emergency vascular access in the delivery room, an intraosseous needle is a reasonable alternative if umbilical venous access is unsuccessful or not feasible. Intraosseous needles are frequently used for emergency access in prehospital settings and emergency departments. An intraosseous needle (Figure 7.13) is inserted through the skin into the flat portion of a large bone and advanced into the bone marrow cavity (Figure 7.14). When medications and fluids are infused, they quickly reach the central venous circulation and have the same hemodynamic effect as intravenous administration. Ali medications and fluids that can be infused into an umbilical venous catheter can be infused into an intraosseous needle. Small case series have shown that intraosseous needles are feasible to insert in term and preterm newborns, have similar efficacy to intravenous routes, and can be inserted quickly. However, there is a risk of severe complications, including infections, bone fractures, and limb ischemia. The rate of successful insertion in very premature newborns is unknown.

Figure 7.13. Examples of intraosseous needles. Sorne needles are inserted with a dril! (left) and others are inserted manually (right).

Severa! different types of intraosseous needles are commercially available. Sorne are intended to be manually inserted using a twisting motion to penetrate the skin and bone. Other needles are inserted using a battery-operated drill. Consult the manufacturer,s literature to identify the correct-sized needle for your patient. The intraosseous needle will have a stylet that is used during insertion and must be removed before infusion.

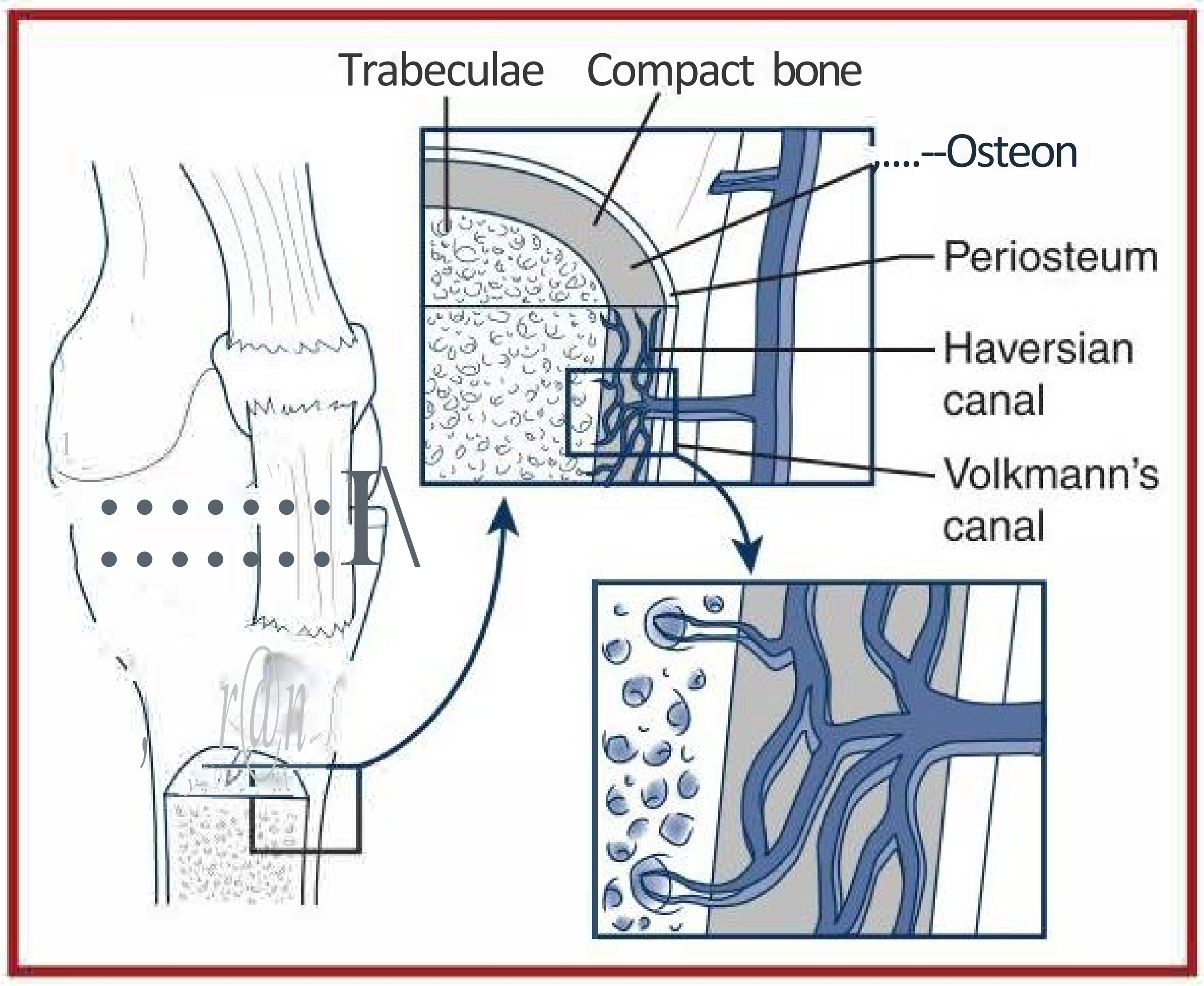


Figure 7.14. Intraosseous needle in the bone marrow cavity. Infused medications and fluids reach the central venous circulation quickly. (Adapted from Teleflex Incorporated. ©2016 Teleflex Incorporated. All rights reserved.)

Intraosseous needle insertion

O Identify the insertion site. For term newborns, the preferred site is the flat surface of the lower leg, approximately 2 cm below and 1 to 2 cm medial to the tibial tuberosity (the bony bulge below the kneecap) (Figure 7.15).

Figure 7.15. Needle insertion site along the flat anteromedial surface of the tibia

f) Clean the insertion site with antiseptic solution (Figure 7.16).

Figure 7.16. Ouickly clean the insertion site.

E) Hold the intraosseous needle perpendicular to the skin and advance the needle through the skin to the surface of the bone (periosteum) (Figure 7.17).

Figure 7.17. Insertion using an intraosseous drill

8 Direct the needle perpendicular to the bone and advance the needle through the bone cortex into the marrow space. If advancing the needle by hand, use strong downward pressure with a twisting motion. If advancing the needle with an electric drill, press the trigger while holding downward pressure as described in the manufacturer's instructions. When the needle enters the marrow space, a distinct change in resistance ("pop") is noticeable.

0 Follow the manufacturer's instructions for removing the stylet and securing the needle (Figure 7.18).

Figure 7.18. Remove the intraosseous needle stylet.

0 Connect an infusion set (prefilled with normal saline) to the needle's hub, open the stopcock toward the needle, flush the needle with 3 to 5 mL of norn1al saline to open the bone marrow space, and administer the medication and saline flush (Figure 7.19).

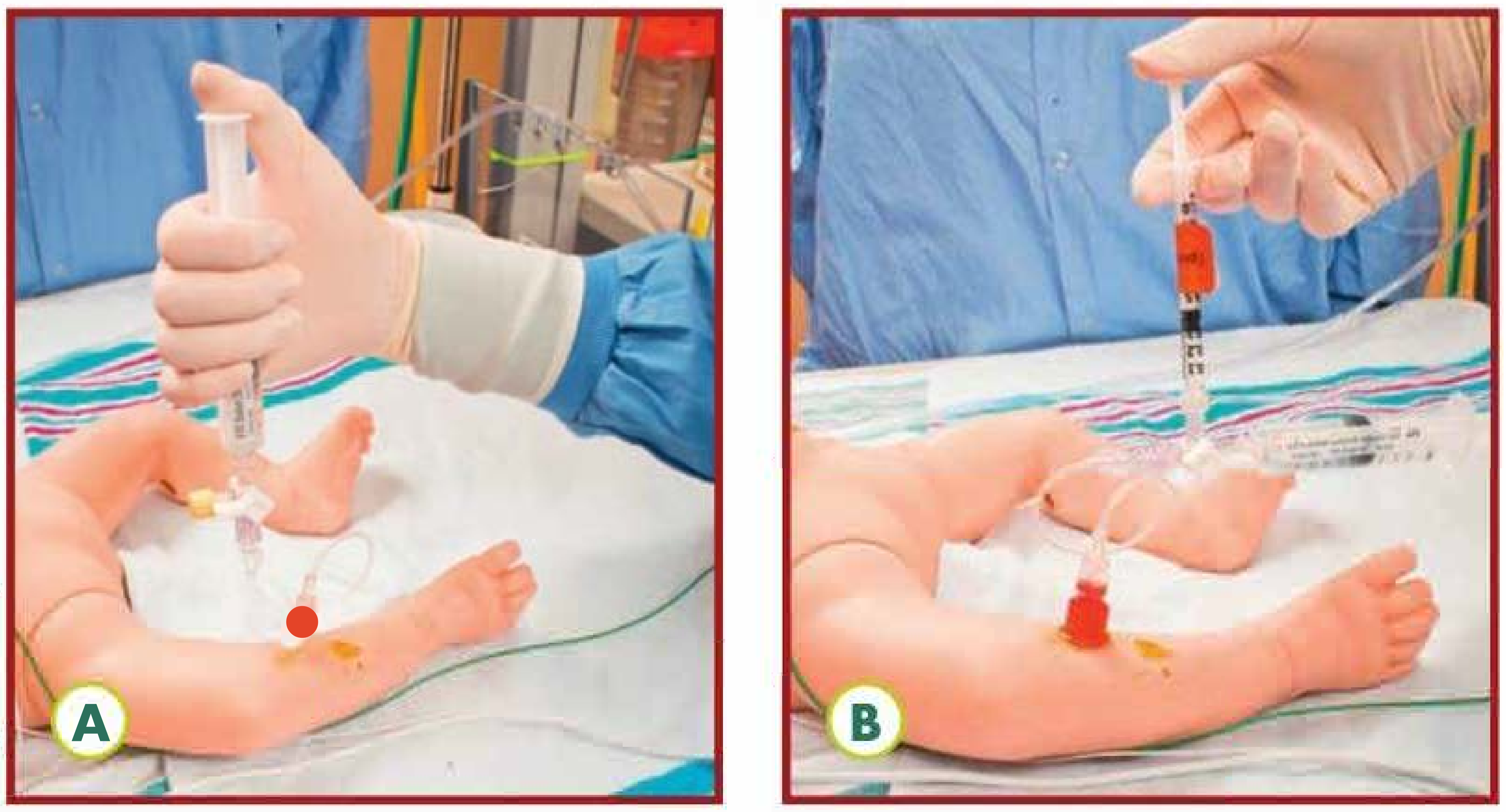


Figure 7.19. Connect an infusion set to the intraosseous needle, open the stopcock toward the needle, flush the needle (A), and infuse the medication or fluid (B).

0 Monitor the insertion site for evidence of swelling or fluid extravasation.

Focus on Teamwork

The administration of epinephrine and a volume expander during resuscitation highlights severa! opportunities for effective teams to use the NRP Key Behavioral Skills.

Behavior	Example
Anticípate and plan. Use available information.	If perinatal risk factors suggest that the fetus may hove experienced acute blood loss or hove severe cardiorespiratory compromise (eg, prolonged fetal bradycardia), prepare an umbilical venous catheter or an intraosseous needle, epinephrine, and fluid for volume expansion before the birth. Emergency insertion of an umbilical venous catheter or intraosseous needle and blood administration are infrequently used skills, and teams must practice them frequently to be certain that they can be performed correctly and efficiently during an emergency. If a baby requires chest compressions, it is likely that epinephrine also will be required. Once compressions are started, a team member should prepare epinephrine and an umbilical venous catheter oran intraosseous needle so that intravascular epinephrine can be administered without delay.
Know your environment.	Your team needs to know where emergency type O Rh-negative blood is stored, how it will be obtained when needed, and what additional equipment will be needed to prepare and infuse it without delay. Your team needs to know where the emergency vascular access equipment is stored.
Call for additional help when needed.	If epinephrine or volume expansion is required, you will need additional help. It will likely take more than 4 team members to continue effective ventilation and compressions, quickly insert and secure emergency vascular access, prepare and administer epinephrine or fluid, monitor the passage of time, monitor the quality of compressions and ventilations, document events as they occur, and provide support for the baby's family.
Allocate attention wisely. Clearly identify a team leader.	If the team leader becomes involved in umbilical catheter insertion, their attention is focused primarily on that task and they may not be able to pay full attention to the baby's condition, the passage of time, or the adequacy of ventilation and compress1ons. Any team member who has mastered the NRP Algorithm and has strong leadership skills can become the team leader. Clearly announce the change in leadership when it occurs.
Use available resources.	If you hove difficulty inserting an emergency umbilical venous catheter, use an intraosseous needle.
Communicate effectively. Maintain professional behavior.	Use efficient, directed, closed-loop communication when epinephrine or volume expanders are requested. When you give an instruction, direct the request to a specific individual, call the team member by name, make eye contact, and speak clearly. After giving an instruction, ask the receiver to report back as soon as the task is completed. After receiving an instruction, repeat the instruction back to the sender. During a complex resuscitation, it is easy for the quality of communication to deteriorate. It is critically important for the leader to establish and maintain calm and professional behavior.

Quality Improvement Opportunities

Ask yourself the following questions and begin a discussion with your team if you find a difference between the NRP recommendations and what is currently done in your own hospital setting. Consider using the suggested process and outcome measures to guide your data collection, identify areas for improvement, and monitor if your improvement efforts are working.

Quality improvement questions

O Who are the providers that can insert an umbilical venous catheter and intraosseous needle in your delivery room setting?

f) Is someone with these skills immediately accessible if needed?

8 Is a kit with ali necessary supplies for emergency vascular access immediately accessible if needed?

0 Do providers know where to obtain an intraosseous needle?

0 Does your emergency medication cart/box only include the dilute (O.l mg/mL) solution of epinephrine for newborn resuscitation, or <loes it also have the concentrated (1 mg/mL) solution?

O How often do NRP providers practice how to calculate and prepare a <lose of epinephrine for neonatal resuscitation?

O Do you have a weight-based emergency medication chart/table near each radiant warmer?

0 Do NRP providers know how to access emergency type O Rh-negative blood in your delivery room setting? Do they know the procedure for blood administration?

Process and outcome measures

O How often do newborns receive epinephrine in your delivery room setting?

f) How often do newborns receive volume expanders in your delivery room setting?

8 When emergency medications are required, how often is a skilled provider present at the time of birth?

0 How often is the first <lose of epinephrine given by the intravascular route?

0 What percentage of resuscitation team members have demonstrated that they can properly calculate and prepare emergency epinephrine in a simulation setting each year?

Frequently Asked Questions

Why has the suggested dose of epinephrine been changed to a single dose instead of using the full range?

The new suggested <lose for epinephrine is based on a desire to simplify the dosing for educational efficiency. This single <lose may be easier for NRP providers to remember in an emergency, may improve teamwork by allowing the team member preparing epinephrine to anticipate the requested <lose, and may allow easier preparation across a wide range of newborn weights. Although sorne studies suggest that the lower end of the dosing range may be less effective, the current suggested <lose is not based on evidence of superior efficacy and <loes not represent an endorsement of any particular <lose within the recommended dosing range. The ideal epinephrine <lose for persistent, severe neonatal bradycardia and asystole remains an important knowledge gap and additional research is needed.

Why has the flush volume after intravascular epinephrine administration been increased from 1 ml to 3 ml?

Evidence from an animal study has suggested that a 1-mL flush volume may leave a significant amount of epinephrine in the umbilical vein or liver instead of carrying it to the heart. Pending additional studies to identify the ideal flush volume in newly born humans, this program recommends a 3-mL flush volume for babies of all gestational ages after intravascular epinephrine administration.

When ordering emergency epinephrine, is it safer to express the dose as a mass (mg/kg) or a volume (ml/kg)?

Because this question has not been fully resolved, this program describes the <lose using both mass (mg/kg) and volume (mL/kg) expressions. Each method has risks and benefits. If the <lose is expressed using the mass method, the team member preparing the

<lose will need to convert milligrams to milliliters, and there is a risk of making a decimal point error. If the <lose is expressed using the volume method, the provider preparing the <lose <loes not have to convert between units, but there is a risk of giving a 1O-times overdose if the provider accidently uses the concentrated (1 mg/mL) epinephrine solution. This medication error is preventable by ensuring that the dilute (0.1 mg/mL) solution of epinephrine is the ONLY concentration included in neonatal emergency supplies.

Whichever dosing method is used, the providers should use closed-loop communication, repeat back the intended <lose, include the desired units and the baby's estimated weight when ordering and preparing the <lose, confirm the concentration of the epinephrine solution used by showing the box to another team member, and compare the prepared <lose with a weight-based chart or table to ensure accuracy.

Why is the intravenous route for epinephrine administration preferred over the endotracheal route? Isn't the endotracheal route easier and faster?

Epinephrine given into the endotracheal tube may be absorbed by the lungs and enter blood that drains directly into the heart. Although it may be faster to give epinephrine to an intubated baby through the endotracheal tube, the process of absorption by the lungs makes the response time slower and more unpredictable than if epinephrine is given directly into the blood. Data from both animal models and clinical studies suggest that the standard intravenous <lose is ineffective if given via the endotracheal tube. There is sorne evidence in animal models that giving a higher <lose can compensate for the delayed absorption from the lungs; however, no studies have confirmed the efficacy or safety of this practice in newborns. If the need for medications is anticipated, advance preparation of an umbilical venous catheter, before delivery, allows rapid administration of intravenous epinephrine without delay.

After intraosseous needle insertion, is it necessary to aspirate the syringe before infusing fluid?

No. In the newborn, aspiration of the intraosseous needle is not a reliable indicator of correct needle insertion and is not necessary. If the needle is correctly inserted, it should feel firmly secured in the bone and not "wiggle:' When fluid is infused, the soft tissue surrounding the bone should not swell.

Previous editions of the *Textbook of Neonatal Resuscitation* suggested that it may be reasonable to stop resuscitative efforts if the heart rote was undetectable after 10 minutes of resuscitation. Why does this edition suggest that the time interval to consider stopping resuscitative efforts should be around 20 minutes?

Since the last recommendation was published, additional studies have been completed. Although the scientific evidence is weak because of incomplete reporting, a recent systematic review completed by the International Liaison Committee on Resuscitation (ILCOR) found that stopping resuscitative effort at 10 minutes may preclude survival of sorne newborns who would have survived without significant disabilities. Improvements in neonatal intensive care and the availability of neuroprotective interventions, such as therapeutic hypothermia, may be improving the long-term outcome for these newborns. Extending the time frame to consider discontinuing resuscitative efforts may allow the resuscitation team more time to complete ali appropriate interventions, achieve the correct balance between continuing too long and stopping too soon, make an individualized decision, and include the family in decision-making and care for their newborn.

LESSON 7 REVIEW

1. Ventilation that moves the chest has been performed through an endotracheal tube for 30 seconds, followed by coordinated chest compressions and 100% oxygen for an additional 60 seconds. Epinephrine is indicated if the baby's heart rate remains less than (60 beats per minute)/(80 beats per minute).

2. The preferred route for epinephrine is (intravenous)/(endotracheal).

3. Your team is resuscitating a baby born at term. The baby's heart rate is 40 beats per minute after 30 seconds of ventilation through an endotracheal tube and an additional 60 seconds of coordinated chest compressions and ventilation using 100% oxygen. You determine that epinephrine is indicated. Your team should (quickly attempt to insert a peripheral intravenous catheter in the baby's right hand)/(insert an umbilical venous catheter).

4. The recommended concentration of epinephrine for newborns is (0.1 mg/mL)/(1 mg/mL).

5. The suggested initial intravenous <lose of epinephrine is (0.02 mg/kg)/(0.1 mg/kg).

6. Intravenous epinephrine should be administered (slowly)/(as quickly as possible), followed by a (3-mL)/(l-n1L) normal saline flush.

7. If the baby's heart rate remains less than 60 beats per minute, you can repeat the <lose of epinephrine every (3 to 5 minutes)/(8 to 10 minutes).

8. If an emergency volume expander is indicated, the initial <lose is (1 mL/kg)/(10 mL/kg).

Answers

1. Epinephrine is indicated if the baby's heart rate remains less than 60 beats per minute.

2. The preferred route for epinephrine is intravenous.

3. Your team should insert an umbilical venous catheter or an intraosseous needle. During cardiopulmonary collapse, a peripheral intravenous catheter is unlikely to be successful and attempts at insertion may delay appropriate therapy.

4. The recommended concentration of epinephrine for newborns is 0.1 mg/mL.

5. The suggested initial intravenous <lose of epinephrine is 0.02 mg/kg.

6. Intravenous epinephrine should be administered as quickly as possible, followed by a 3-mL normal saline flush.

7. If the baby's heart rate remains less than 60 beats per minute, you can repeat the <lose of epinephrine every 3 to 5 minutes.

8. The initial <lose is 1OmL/kg.

LESSON 7: PRACTICE SCENARIO

Medications

Comprehensive Skills TestScenario for Neonatal Resuscitation Program (NRP) Advanced Providers

Learning Objectives

O Identify when the newborn requires epinephrine and a volume expander during resuscitation.

8 Demonstrate preparation and administration of epinephrine and volume expander.

8 Demonstrate preparation and insertion/assistance with insertion of an emergency umbilical venous catheter.

9 Demonstrate how to secure an emergency umbilical venous catheter.

0 Practice NRP Key Behavioral Skills to ensure effective communication and teamwork during this critica! component of neonatal resuscitation.

This Practice Scenario is for review/practice and evaluation. This scenario may also be used as the Comprehensive Skills Test("test out") option for NRP Advanced providers during a Provider Course.

This is the suggested Practice Scenario sequence.

O **Review the Knowledge Check Questions** with your NRP instructor.

a. What are the indications for epinephrine during neonatal resuscitation?

b. What epinephrine concentration is used during neonatal resuscitation?

c. What is the preferred route of administration? What is the alternative route while vascular access is being established?

d. What is the correct <lose range for each route? Where is the pre-calculated drug dosage chart our hospital uses during a neonatal code?

e. How quickly should you expect to see a rising heart rate after giving intravenous epinephrine? How often can you repeat epinephrine?

f. If the heart rate does not respond to intravenous epinephrine, what clinical conditions might be considered?

g. What are signs of shock in a newborn, indicating the need for volume expander?

h. What volume expanders are used? What is the <lose of the selected volume expander?

i. What is the route of the volume expander and how fast is it administered?

f) **Practice/review these skills** with your NRP instructor.

a. Draw up epinephrine for administration via endotracheal tube and emergency umbilical venous catheter using a 3-way stopcock and/or connector.

b. Prepare the emergency umbilical venous catheter for use.

c. Perform the procedure or assist with insertion of the emergency umbilical venous catheter.

d. Apply a clear adhesive dressing to secure the emergency umbilical venous catheter during resuscitation.

e. Practice giving and/or confirming an order for intravenous epinephrine using closed-loop communication.

f. Draw up normal saline for volume administration.

E) **Practice the scenario** with your NRP instructor and team until you need little or no assistance or coaching.

8 **Pass the Lesson 7 Practice Scenario evaluation** by leading practice scenario(s) and performing the skills relevant to your role and responsibilities. If a technical skill included in a scenario is not within your scope of responsibility, delegate the skill to a qualified team member and perform the role of assistant if appropriate.

0 When you can lead the scenario(s) and perform the skills with little or no instructor coaching, learners may proceed to the Simulation and Debriefing component of the Provider Course.

Practice Scenario

"You are called to attend an emergency cesarean birth due to umbilical cord prolapse with fetal bradycardia. How would you prepare for the resuscitation of the baby? As you work, say your thoughts and actions aloud so I will know what you are thinking and doing."

	Critical Performance Steps
Assess perinatal risk.	
	Assesses perinatal risk (learner asks the 4 pre-birth questions and instructor ["OB provider"] responds) Gestation? **"Term."** Fluid clear? **"Fluid is clear."** Additional risk factors? **"Cord prolapse and fetal bradycardia for the last 3 minutes."** Umbilical cord management plan? **"We'll assess the baby at birth. If the baby's not vigorous, 1'11give brief stimulation, and if there's no improvement, 1'11clamp the cord and bring the baby to the radiant warmer."**
Assemble team.	
	Assembles team based on perinatal risk factors. If risk factors are present, at least 2 qualified people should be present solely to manage the baby. The number of team members and qualifications vary depending on risk.
Perform a pre-resuscitation briefing.	
	Identifies team leader. Assesses risk factors, delegates tasks, identifies who will document events as they occur, determines supplies and equipment needed, identifies how to call for additional help.
Perform equipment check.	
	"The baby has been born."
Rapid evaluation.	
	• Term? **"Appears term."** • Tone? **"No tone."** • Breathing or crying? **"No breathing."**
Initial steps.	
	Receives baby at radiant warmer, dries, stimulates, positions airway, suctions mouth and nose
Assess breathing. If breathing, assess heart rote.	
	Checks breathing **"The baby is apneic."** **(Heart rote = 50 bpm, if assessed)**
Begin PPV within 60 seconds of birth.	
	Begins PPV in 21 % oxygen (room air). Within 15 seconds of beginning PPV, learner asks the assistant to assess the heart rote and state if heart rote is rising. **Heart rote = 40 bpm, not increasing**
Assess chest movement.	
	• If chest movement observed, continues PPV x 15 seconds (for total of 30 seconds) • If no chest movement observed, proceeds through corrective steps (MR. SOPA) until chest movement; then administers PPV x 30 seconds • *If no chest movement with corrective steps M and R, S and O, and P, learner indicates need for alternative airway and proceeds directly to intubation or faryngeaf mask insertion*

	Critical Performance Steps (cont)
	Check heort rote after 30 seconds of PPV that moves the chest.
	Checks heart rate **Heort rote = 30 bpm, not increasing** Indicates need for alternative airway
	Places cardiac monitor leads and connect to monitor in anticipation of alternative airway (if not already done).
	Insert alternative airway (endotracheal tube [preferred] or laryngeal mask). **NOTE: Administration of epinephrine into a laryngeal mask is not recommended.**
	• Intubates (size 1 blade and size 3.5 endotracheal tube) or inserts laryngeal mask (size 1) • Checks for CO_2 detector color change, rising heart rote; also checks for bilateral breath sounds and chest movement with PPV • For endotracheal tube: checks tip-to-lip insertion depth using nasal-tragus length (NTL) or insertion depth chart • Asks assistant to secure endotracheal tube or laryngeal mask
	If device <u>not</u> successfully inserted, **"Color is not changing on the CO_2 detector and the chest is not moving."** **Heort rote = 30 bpm and not increasing** • Removes device • Resumes PPV by face mask • Repeats insertion attempt
	If device successfully inserted, **Note: Color might not change on the CO_2 detector dueto low heart rote.** **Heort rote = 30 bpm, not increosing** **"The baby's chest is moving, breath sounds are equal, pulse oximeter has no signal."** • Operator continues PPV x 30 seconds • Assistant checks tip-to-lip depth using gestational age/weight table or NTL measurement - If using NTL, measures distance from the nasal septum to the ear tragus (insertion depth [cm] = NTL + 1 cm) • Assistant secures endotracheal tube
	Check heart rote after 30 seconds of PPV with alternative airway.
	Checks heart rate by observing cardiac monitor (may also auscultate heart rote) after 30 seconds of PPV that moves the chest with an alternative airway **Heort rote = 30 bpm and not increasing** **"Pulse oximeter has no signal."**
	Begin chest compressions.
	• Calls for additional help • Asks assistant to increase oxygen to 100% • Asks assistant to place servo-controlled temperature sensor on baby, if not already done, and adjust to maintain baby's temperature 36.5°C to 37.5°C • Administers compressions from head of bed with coordinated ventilation (thumbs on lower one-third of sternum, compressions one-third of the anterior-posterior [AP] diameter of the chest, 3 compressions: 1 ventilation every 2 seconds)

Critical Performance Steps (cont)

Check heart rate after 60 seconds.

Pauses compressions, continues PPV, and checks heart rote after 60 seconds of compressions and ventilations.
Heart rate = 30 bpm and not increasing
Indicates need for emergency vascular access.

Medication administration vio endotracheal tube (optional, while umbilical venous catheter is being established}.

Requests epinephrine vio endotracheal tube   Concentration: 0.1 mg/ml= I mg/10 ml
Suggested endotracheal tube dese: 0.1 mg/kg (I ml/kg)

- Requests estimated weight: **"The baby's estimated weight is 3 kg."**
- Orders epinephrine for endotracheal tube for a baby weighing 3 kg:
  0.3 mg epinephrine vio the endotracheal tube (equal to 3 ml in syringe)
- Uses closed-loop communication with confirmation of medication, dese, and route
- Assistant checks medication label, opens medication, attaches stopcock or syringe connector and 5-ml syringe
- Assistant prepares correct volume, labels syringe with medication name and intended route

Administers endotracheal epinephrine (can be performed by assistant or operator)

- Gives the epinephrine directly into the endotracheal tube, does not leave it deposited in the tube connector.
- Follows the drug with several positive-pressure breaths to distribute the drug into the lungs.
- Announces *"ET epinephrine given."*

Requests heart rote check after 60 seconds. Pauses compressions briefly and observes cardiac monitor; may also auscultate heart rote.
Heart rote = 30 bpm and not increasing
Continues PPV and compressions.

Prepare emergency umbilical venous catheter (may be performed by assistant or operator).

- Obtains syringe with normal saline flush
- Attaches 3-way stopcock to umbilical venous catheter
- Flushes catheter and stopcock with normal saline
- Closes stopcock to catheter

Insert emergency umbilical venous catheter.

- Cleans lower segment of umbilical cord with antiseptic solution
- Ties umbilical tape loosely at base of cord
- Cuts cord about I to 2 cm above base (may request compressions pause)
- Inserts catheter into vein, opens stopcock and gently aspirates syringe, advances catheter approximately 2 to 4 cm until blood return is detected
- Flushes catheter and closes stopcock toward catheter
- Ensures catheter is being held in place; may secure with clear adhesive dressing

Administer medication via umbilical venous catheter.

Requests epinephrine vio umbilical venous catheter   Concentration: 0.1 mg/ml = I mg/I O ml
Suggested intravenous dese: 0.02 mg/kg (0.2 ml/kg) every 3 to 5 minutes.

- Requests estimated weight if not already known: **"The baby's estimated weight is 3 kg."**
- Orders epinephrine for umbilical venous catheter for a baby weighing 3 kg:
  .06 mg epinephrine vio the umbilical venous catheter (equal to 0.6 ml in syringe)
- Uses closed-loop communication with confirmation of medication, dese, and route
- Assistant checks medication label, opens medication, attaches stopcock or syringe connector and I-ml syringe
- Assistant prepares correct volume, labels syringe with medication name and intended route

Critical Performance Steps (cont)

Administer medication vio umbilical venous catheter (cont).

Administers epinephrine vio the umbilical venous catheter (can be performed by assistant or operator)

- Ensures that catheter is being held in place; attaches syringe to stopcock, opens stopcock to catheter and syringe, administers epinephrine rapidly without air bubbles.
- Flushes umbilical venous catheter with 3 ml of normal saline.
- Announces "IV epinephrine given."

Check heort rote ofter 60 seconds.

- Continues PPV and compressions
- Pauses compressions and checks heart rote 60 seconds after intravenous epinephrine

Heort rote= 50 bpm **"Pulse oximeter has no signol. The baby is pole."**

- Continues PPV and compressions

Administer volume exponder.

Requests 30 ml (10 ml/kg) of normal saline per umbilical venous catheter over 5 to 10 minutes using closed-loop communication

- Draws up correct vol ume or uses prefilled syringes. Numbers more than one syringe (# 1, #2, #3).
- Ensures that catheter is being held in place; attaches syringe to stopcock, opens stopcock to catheter and syringe, administers volume in slow infusion over 5 to 10 minutes without air bubbles (or use an infusion pump).

Check heort rote every 60 seconds.

- Continues PPV and compressions.
- Monitors heart rote vio cardiac monitor while volume administered. May also auscultate heart rote.
- Pauses compressions, continues PPV while heart rote is assessed.

NOTE: The instructor may compress time and announce, *"The 30-mL infusion of normal saline has been given."*
Heort rote = 80 bpm and increasing **SPO_2 = 68%**
"Color is changing on CO_2 detector. Pulse oximeter has a reliable signal."

Discontinue compressions-Continue PPV.

- Discontinues chest compressions
- Continues PPV with higher ventilation rote (40-60 breaths/min)

Heort rote is > 100 bpm **SPO_2 = 80%** **"There ore no spontaneous respirations."**

Check vital signs.

Continues PPV and adjusts oxygen concentration per pulse oximetry
Heort rote is > 100 bpm **SPO_2 = 90%**
"The baby has fair muscle tone and some spontaneous respirations."

End scenario.

Supports baby with PPV and supplemental oxygen per Target Oxygen Saturation Table.
Monitors heart rote, respiratory effort, oxygen saturation, activity, and temperature.
Prepares to move baby to post-resuscitation care setting.
Communicates with perinatal team.
Updates parents and informs them of next steps.
Debriefs the resuscitation.

Sample Debriefing Questions

O What went well during this resuscitation?

f) What will you do differently when faced with this complex resuscitation in a future scenario?

8 Do you have additional comments or suggestions for your team? For the leader?

O Why <lid this baby receive volume expander?

0 Give me an example of how you used at least one of the NRP Key Behavioral Skills.

NRP Key Behavioral Skills

- Know your environment.
- Use available information.
- Anticípate and plan.
- Clearly identify a team leader.
- Communicate effectively.
- Delegate the workload optimally.
- Allocate attention wisely.
- Use available resources.
- Call for additional help when needed.
- Maintain professional behavior.

Resuscitation and Stabilization of Babies Born Preterm

8

What you will learn

- Why babies born preterm are at higher risk of medical complications
- The additional resources needed to prepare for a preterm birth
- Additional strategies to maintain the preterm baby's body temperature
- How to assist ventilation when a preterm baby has difficulty breathing
- Additional considerations for oxygen management in a preterm baby
- Ways to decrease the chances of lung and brain injury in preterm babies
- Special precautions to take after the initial stabilization period
- How to present information to parents before the birth of an extremely premature baby

(Used with permission of Mayo Foundation for Medical Education and Research.)

Key Points

- Preterm newborns are at increased risk for requiring resuscitation and assistance with transition after birth.
- Preterm newborns are at increased risk of complications because of rapid heat loss, immature organ systems, small blood volume, and vulnerability to hypoglycemia.
- Additional resources (including skilled personnel, a polyethylene plastic bag or wrap, a hat, thermal mattress, temperature sensor and cover for a servo-controlled radiant warmer, preterm-sized masks and endotracheal tubes, a positive-pressure device that can provide positive-end expiratory pressure [PEEP] and continuous positive airway pressure [CPAP], and surfactant) should be available.
- The temperature in the room where resuscitation takes place should be 23°C to 25°C (74°F-77°F).
- If the baby is less than approximately 32 weeks' gestation, a polyethylene plastic bag or wrap and a thermal mattress should be prepared.
- If positive-pressure ventilation (PPV) is required, use the lowest inflation pressure necessary to achieve and maintain an adequate heart rate response. It is preferable to use a device that can provide PEEP.
- Consider using CPAP immediately after birth if the baby is breathing spontaneously with a heart rate of at least 100 beats per minute (bpm) but has labored respirations or low oxygen saturation.
- To decrease the risk of neurologic injury, handle the baby gently, avoid positioning the baby's legs higher than the head, avoid high PPV or CPAP pressures, use a pulse oximeter and blood gases to adjust ventilation and oxygen concentration, and avoid rapid intravenous fluid infusions.

The following 2 cases describe the birth and resuscitation of preterm babies. As you read the cases, imagine yourself as part of the team from the anticipation of the delivery through the resuscitation, stabilization, and transfer to an intensive care nursery.

Case 1: Stabilization of a baby born very preterm

A woman is in premature labor at 29 weeks' gestation with ruptured membranes and clear amniotic fluid. A vaginal birth is anticipated. The resuscitation team leader meets with the obstetrician and parents to discuss the care plan. Anticipating the possibility of a complex resuscitation, your resuscitation team is assembled and reviews each team member's role. Using a written checklist, your team ensures that ali supplies and equipment needed to resuscitate and stabilize a preterm baby are ready for use. One team member attaches a preterm-sized mask to the T-piece resuscitator. The peak inflation pressure (PIP) is adjusted to 20 cm H_20 and positive end-expiratory pressure (PEEP) is set to 5 cm H_20. Next, a laryngoscope with a size Oblade and both a 3.0-mm and 2.5-mm endotracheal tube are prepared. The oxygen blender is adjusted to deliver 21% oxygen. Additional team members increase the delivery room temperature, turn on the radiant warmer, obtain polyethylene plastic wrap, activate a thermal mattress, and cover the mattress with a cotton blanket. The obstetrician prepares a warm blanket.

At the time of birth, the baby has flexed extremities but <loes not cry. The obstetrician holds the baby on the warm blanket, provides gentle tactile stimulation, and gently suctions secretions from the mouth and nose. After 15 seconds, the baby begins to take spontaneous breaths. By 30 seconds, the baby has sustained respirations and is actively moving. An assistant clamps and cuts the umbilical cord 60 seconds after birth and the baby is handed to your resuscitation team. The baby is carried to the radiant warmer, placed on the blanket-covered thermal mattress, and wrapped in the plastic sheet. A servo-controlled temperature sensor is applied to the baby's skin to monitor and control the baby's body temperature, and a hat is placed on the baby's head. The baby is breathing and has a heart rate greater than 100 beats per minute (bpm), but breathing is labored and breath sounds are decreased. A team member attaches a pulse oximeter sensor to the baby's right hand and cardiac monitor leads to the chest. Continuous positive airway pressure (CPAP) with 21% oxygen is administered using the face mask and T-piece resuscitator. The baby's breath sounds and work of breathing improve, but the oxygen saturation (SPo_2) is below the target range. The oxygen concentration ($F1o_2$) is gradually increased to 30% and the SPo_2 begins to rise. Nasal CPAP prongs are placed. Your team continues to adjust the oxygen blender based on pulse oximetry and, by 15 minutes of age, the $F1o_2$ has been decreased to 21%.

The parents are updated by the team leader, they have an opportunity to see and touch their baby, and the baby is moved to the intensive care nursery in a pre-warmed transport incubator. Shortly afterward, team members co1lduct a debriefing to review their preparation, teamwork, and communication.

Case 2: Resuscitation and stabilization of a baby born extremely preterm

A woman is in preterm labor at 24 weeks' gestation with ruptured membranes and clear amniotic fluid. Your resuscitation team leader meets with the obstetrician and parents to discuss current outcome data and the procedures that may be required to resuscitate and stabilize an extremely premature newborn. After the discussion, they develop a care plan based on the parents' assessment of their baby's best interest. The parents and health care providers agree to provide intensive medica} care, including endotracheal intubation, chest compressions, and emergency medication, if necessary. Despite tocolysis, labor progresses anda vaginal birth is anticipated. Your resuscitation team is assembled for a pre-resuscitation team briefing to review each member's roles and responsibilities. Using a written checklist, the team prepares the necessary supplies and equipment.

At the time of birth, the baby is flaccid and does not cry. The obstetrician holds the baby on the warm blanket, provides gentle tactile stimulation, and gently suctions secretions from the mouth and nose, but the baby's tone remains poor and the baby is not breathing. The umbilical cord is clamped and cut and the baby is handed to your resuscitation team. The baby is carried to the radiant warmer, placed on the blanket-covered thermal mattress, and wrapped in the plastic sheet. A servo-controlled temperature sensor is applied to the baby's skin to monitor and control the baby's body temperature, and a hat is placed on the baby's head. The baby remains limp without respiratory effort. You administer positive-pressure ventilation (PPV) using the T-piece resuscitator and 30% oxygen. A team member attaches a pulse oximeter sensor to the right wrist and cardiac monitor leads to the chest. The baby's heart rate is 60 bpm and the chest is not moving with PPV. The ventilation corrective steps are performed, including incrementally increasing the inflation pressure from 20 cm H_20 to 30 cm H_20, but the heart rate still <loes not improve. A 2.5-mm endotracheal tube is inserted and placement is confirmed with a carbon dioxide ($C0_2$) detector. Positive-pressure ventilation is continued with the T-piece resuscitator, breath sounds are equal

bilaterally, and the heart rate promptly increases. The nasal-tragus length (NTL) is 4.5 cm and the endotracheal tube is secured with the 5.5-cm mark adjacent to the baby's lip. The FIO_2 is gradually adjusted to meet the oxygen saturation target, and the T-piece PIP is adjusted to maintain gentle chest movement with each breath. A short time later, surfactant is administered through the endotracheal tube. By 20 minutes, the FIO_2 has been decreased to 25%.

The parents are updated by the team leader, they have an opportunity to see and touch their baby, and the baby is moved to the intensive care nursery in a pre-warmed transport incubator with blended oxygen and continuous monitoring. Shortly afterward, your team members conduct a debriefing to review their preparation, teamwork, and communication.

Preterm Birth

In the previous lessons, you learned a systematic approach to neonatal resuscitation. When birth occurs before term gestation (less than 37 weeks' gestation), additional challenges make the transition to extrauterine life more difficult. The likelihood that a preterm newborn will need help making this transition is related to gestational age. Babies born at lower gestational ages are more likely to require additional interventions. Because preterm newborns are also more vulnerable to injury from resuscitation procedures, it is important to find the correct balance between initiating resuscitation without delay and avoiding unnecessarily invasive procedures. Your management during these first minutes may decrease the risk of both short- and long-term complications. This lesson focuses on the additional problems associated with preterm birth and the actions you can take to prevent or manage them.

Why do preterm babies have a higher risk of complications?

Sorne complications result from the underlying problem that caused the preterm birth while others reflect the baby's anatomic and physiologic immaturity.

- Thin skin, decreased subcutaneous fat, large surface area relative to body mass, and limited metabolic response to cold lead to rapid heat loss.
- Weak chest muscles, poorly compliant (stiff) lungs, and flexible ribs decrease the efficiency of spontaneous breathing efforts.

- Immature lungs that lack surfactant are more difficult to ventilate and are at greater risk of injury from PPV.
- Immature tissues are more easily damaged by oxygen.
- Infection of the amniotic fluid and placenta (chorioamnionitis) may initiate preterm labor, and the baby's immature immune system increases the risk of developing severe infections such as pneumonia, sepsis, and meningitis.
- A smaller blood volume increases the risk of hypovolemia from blood loss.
- Immature blood vessels in the brain cannot adjust to rapid changes in blood flow, which may cause bleeding or damage from insufficient blood supply.
- Limited metabolic reserves and immature compensatory mechanisms increase the risk of hypoglycemia after birth.

What additional resources do you need for resuscitating a preterm newborn?

The chance that a preterm baby will require resuscitation is significantly higher than for a baby born at full term. This is true even for late-preterm babies born at 34 through 36 weeks' gestation.

- If the baby is anticipated to be less than 32 weeks' gestation, prepare a polyethylene bag or wrap and a thermal mattress as described in the next section.
- A servo-controlled radiant warmer with a temperature sensor helps to maintain the baby's temperature within the normal range.
- An oxygen blender and a pulse oximeter with an appropriate-sized sensor should be available for all preterm births.
- A cardiac monitor with 3 chest leads or limb leads provides a rapid and reliable method of continuously displaying the baby's heart rate if the pulse oximeter has difficulty acquiring a signal.
- A resuscitation device capable of providing PEEP and CPAP, such as a T-piece resuscitator or flow-inflating bag, is preferred.
- A preterm-sized resuscitation mask, size 0 laryngoscope blade (size 00 optional), and appropriate-sized endotracheal tubes (3.0 mm and 2.5 mm) should be prepared.
- Consider having surfactant available if the baby is expected to be less than 30 weeks' gestation.
- A pre-warmed transport incubator with blended oxygen and a pulse oximeter is important for maintaining the baby's temperature and oxygenation within the target range if the baby will be moved after the initial stabilization.

How do you keep the preterm newborn warm?

Preterm newborns have a high risk of developing hypothermia (body temperature below 36.S$^\circ$C) and complications from cold stress. While drying with warm towels, skin-to-skin contact, and early breastfeeding may be sufficient to maintain normal temperature for term newborns and sorne vigorous late-preterm newborns, additional measures are required for more premature newborns and those requiring assistance after birth. When a preterm birth is expected, anticípate that temperature regulation will be challenging and prepare for it.

- Set the temperature in the room where the baby will be resuscitated and receive initial careto approximately 23°C to 25°C (74°F to 77°F).
- Preheat the radiant warmer well before the time of birth.
- After delivery, quickly place a hat on the baby's head.
- Use a pre-warmed transport incubator if the baby will be moved after initial care is completed.
- Maintain the baby's axillary temperature between 36.S$^\circ$C and 37.S$^\circ$C.

Additional steps for thermoregulation of babies less than 32 weeks' gestation*

- Use a thermal mattress as an additional heat source.

  Portable thermal mattresses release heat when a chemical gel inside the mattress is activated to form crystals.

  - The thermal mattress should be stored and activated at room temperature (19°C to 28°C or 66°F to 82°F). If the mattress is stored or activated at a warmer temperature, it may exceed the target surface temperature.
  - Following the manufacturer's recommendations, squeeze the pad to actívate the gel approximately 5 minutes before the baby is born. Once activated, it will reach the target surface temperature within 5 minutes and maintain that temperature for 1 hour after activation.
  - Once the thermal mattress is activated, place it on the radiant warmer and cover it with a blanket (Figure 8.1) so the mattress is not directly exposed to radiant heat and the heated surface is not in direct contact with the baby's skin.

Figure 8.1. Thermal mattress placed under a blanket on the resuscitation table

*Note: Depending on the baby's birth weight and environmental conditions, sorne babies up to 35 weeks' gestation may benefit from the use of a tl1ermal mattress and plastic bag/wrap.

- Wrap the baby in a polyethylene plastic bag or wrap.
  - Drying the body is not necessary. Instead of drying the body with towels, very premature newborns should be wrapped up to their neck in polyethylene plastic immediately after birth.
  - You may use a food-grade reclosable 1-gallon plastic bag, a large plastic surgical bag, food wrap, a commercially available plastic poncho, or sheets of commercially available polyethylene plastic (Figure 8.2).
  - If using a reclosable bag, you may cut the bottom open, slide the baby into the bag through the cut side, and close the bag below the baby's feet.
  - If using a plastic sheet or food wrap, you may either wrap the baby in a single sheet or use 2 sheets and place the baby between the sheets.
  - It is important to keep the newborn fully covered during resuscitation and stabilization. If the newborn requires insertion of an umbilical catheter, cut a small hole in the plastic and pull the umbilical cord through the hole rather than uncovering the newborn.
- Monitor the baby's temperature frequently because overheating has been described while using a combination of warming methods.
  - Consider placing a temperature sensor and sensor cover on the newborn and using the warmer's servo-control mode to adjust the radiant heat.

Figure 8.2. Polyethylene plastic bag {A) and wrap (B) for reducing heat loss. (Figure 8.2B used with permission of Mayo Foundation for Medica! Education and Research.)

How do you assist ventilation?

Preterm babies have immature lungs that may be difficult to ventilate and are more susceptible to injury from PPV. Use the same criteria for initiating PPV with a preterm baby that you have learned for a term baby (apnea, or gasping, or heart rate less than 100 bpm within 60 seconds of birth despite the initial steps).

The following are special considerations for assisting ventilation of preterm babies:

- **If the baby is *breathing spontaneously,* consider using CPAP rather than intubating.**

  If the baby is breathing spontaneously and has a heart rate of at least 100 bpm, but has labored respirations or oxygen saturation below the target range, administration of CPAP may be helpful. Using early CPAP, you may be able to avoid the need for intubation and mechanical ventilation. CPAP alone is **NOT** appropriate therapy for a baby who is not breathing **or** whose heart rate is less than 100 bpm.

- **If PPV is required, use the lowest inflation pressure necessary to achieve and maintain a heart rate greater than 100 bpm.**

  The baby's heart rate response is the best indicator of effective ventilation. An initial inflation pressure of 20 to 25 cm H_2O is adequate for most preterm newborns. The volume of air required to ventilate a preterm baby's lungs is very small and may not result in perceptible chest movement.

  Use the lowest inflation pressure necessary to maintain a heart rate of at least 100 bpm and gradually improve oxygen saturation. The maximum inflation pressure used for a baby born at term may be too high for preterm newborn. Use your judgment when increasing ventilation pressure; however, it is reasonable to limit face-mask ventilation to a maximum inflation pressure of 30 cm H_2O. If face-mask ventilation at this pressure does not result in clinical improvement, providing ventilation through an endotracheal tube may improve the efficacy of PPV and allow you to decrease the ventilating pressure.

  Airway obstruction and face-mask leak are common problems during face-mask ventilation with preterm newborns, and very small changes in the head and neck position may lead to significant changes in ventilation. A CO_2 detector placed between the mask and PPV device may provide a visual cue to help identify when you have achieved the correct mask and neck position. The CO_2 detector will change color when ventilation successfully exchanges gas within the baby's lungs and CO_2 is exhaled through the mask.

- **If PPV is required, it is preferable to use a device that can provide PEEP.**

  Using PEEP (5 cm H_2O) helps the baby's lungs to remain inflated between positive-pressure breaths. This is particularly important if you are using an endotracheal tube for ventilation. Both the T-piece resuscitator and flow-inflating bag can provide PEEP during ventilation through either a face mask or an endotracheal tube. If a PEEP valve is attached, a self-inflating bag may provide PEEP during endotracheal tube ventilation. It is difficult to maintain PEEP during face-mask ventilation with most self-inflating bags.

- **Consider administering surfactant if the baby requires intubation for respiratory distress or is extremely preterm.**

  After initial stabilization, preterm babies who need intubation and mechanical ventilation because of respiratory distress syndrome should be given surfactant.

  Studies completed prior to the common use of antenatal steroids and early CPAP concluded that babies born at less than approximately 30 weeks' gestation would benefit from intubation and prophylactic surfactant treatment before they developed respiratory distress. Subsequent studies indicate that CPAP used immediately after birth should be considered as an alternative to routine intubation and prophylactic surfactant administration. Many preterm babies can be treated with early CPAP and avoid the risks of intubation and mechanical ventilation.

  Surfactant can be selectively administered to babies who fail a trial of CPAP. In some cases, you may be able to administer surfactant through a thin tube while the baby remains on CPAP (Less Invasive Surfactant Administration [LISA] or Minimally Invasive Surfactant Treatment [MIST]) or remove the endotracheal tube immediately after surfactant administration and return to CPAP for ongoing respiratory support (INtubate-SURfactant-Extubate [INSURE]). Some experts still recommend prophylactic surfactant for extremely premature newborns (less than 26 weeks' gestation) because the likelihood of CPAP failure in this subgroup is relatively high. Criteria for CPAP failure and the administration of surfactant should be developed in coordination with local experts.

  If the resuscitation team does not have expertise in surfactant administration, it may be preferable to wait for the arrival of more experienced providers.

How much oxygen should you use?

You have learned in previous lessons that injury during transition may result from inadequate blood flow and oxygen delivery and that restoring these factors are important goals during resuscitation. However, research indicates that administering excessive oxygen after perfusion has been restored can result in additional injury. Preterm babies may be at higher risk for this reperfusion injury because fetal tissues normally develop in a low-oxygen environment and the mechanisms that protect the body from oxygen-associated injury have not yet fully developed. Nevertheless, many preterm newborns will require supplemental oxygen to achieve the gradual increase in oxygen saturation that occurs after a healthy term birth.

When stabilizing a preterm baby, it is important to balance the desire to rapidly correct low oxygen saturation against avoiding exposure to excessive levels of oxygen. The current recommendation is to initiate resuscitation of preterm newborns (less than 35 weeks' gestational age) with 21% to 30% oxygen and use a pulse oximeter and oxygen blender to maintain oxygen saturation within the same target range described for full-term newborns (Table 8-1).

Table 8-1. Target Pre-Ductal Oxygen Saturation

Target Oxygen Saturation Table	
1 min	60%-65%
2 min	65%-70%
3 min	70%-75%
4 min	75%-80%
5 min	80%-85%
10 min	85%-95%
Initial Oxygen Concentration for PPV	
≥35 weeks' GA	21% oxygen
<35 weeks' GA	21%-30% oxygen

What can you do to decrease the chances of neurologic injury in preterm newborns?

Before approximately 32 weeks' gestation, a preterm newborn has a fragile network of capillaries in their brain that are prone to rupture and bleeding. Obstruction of venous drainage from the head or rapid changes in blood CO_2 levels, blood pressure, or blood volume may increase the risk of rupturing these capillaries. Bleeding in the brain may cause tissue damage and lead to lifelong disability. Inadequate blood flow and oxygen delivery may cause damage to other areas of the brain even in the absence of hemorrhage, while excessive oxygen administration may cause damage to the developing retina, leading to vision loss.

An organized care plan that is practiced during simulation can help you to cluster interventions and complete them efficiently while minimizing disturbances to the preterm newborn.

Consider the following precautions when resuscitating a preterm newborn:

- **Handle the baby gently.**

  While this may seem obvious, this aspect of care may be forgotten when members of the resuscitation team are trying to perform many steps quickly. If possible, avoid multiple intubation attempts, frequent tracheal suctioning, and other painful, noisy, or irritating stimuli.

- **Do not position the baby's legs higher than the head (Trendelenburg position).**

  Placing the legs higher than the head may increase cerebral venous pressure and the risk of bleeding. It may be helpful to place the baby in a midline, supine (on the back) position with the head slightly elevated to avoid obstruction of venous drainage.

- **Avoid using high pressure during PPV or CPAP.**

  Excessive pressure can create a pneumothorax or interfere with venous return from the head. Both of these complications have been associated with an increased risk of brain hemorrhage.

- **Use a pulse oximeter and blood gases to monitor and adjust ventilation and oxygen concentration.**

  Continuously monitor SpO_2 until you are confident that the baby can maintain normal oxygenation while breathing room air. If the baby requires continued assistance with ventilation, a blood gas should be obtained to guide therapy. Rapid changes in CO_2 levels can increase the risk of bleeding. If your hospital does not have the resources to manage preterm babies who require ongoing assisted ventilation, arrange transfer to an appropriate facility.

- **Do not rapidly infuse intravenous fluids.**

  If volume expansion is needed, infuse the fluid slowly over at least 5 to 10 minutes. Hypertonic intravenous solutions, such as sodium bicarbonate, should be avoided or given very slowly.

What special precautions should be taken after the initial stabilization period?

During the last trimester of pregnancy, the fetus undergoes physiologic changes in preparation for extrauterine survival. If a baby is born prematurely, many of these adaptations have not occurred. Consider the following:

- **Monitor the baby's temperature.**

  Continue to carefully monitor the baby's temperature after the initial resuscitation and stabilization period. A servo-controlled warmer or incubator that uses a skin sensor to adjust the heat output based on the baby's skin temperature may be helpful. Very premature babies should remain wrapped in polyethylene plastic until they have been moved to a warmed and humidified incubator. Even moderate and late preterm newborns remain at risk for hypothermia and should be carefully monitored.

- **Monitor blood glucose.**

  Babies born very prematurely have lower amounts of stored glucose than babies born at term. If resuscitation is required, it is more likely that these stores will be depleted quickly and the baby may become hypoglycemic. Promptly secure intravenous access, initiate a dextrose infusion, and monitor the baby's blood glucose.

- **Monitor the baby for apnea and bradycardia.**

  Respiratory control is often unstable in preterm babies. Significant apnea and bradycardia during the stabilization period may be the first clinical sign of an abnormality in body temperature, oxygenation, CO_2, electrolytes, blood glucose, or blood acid levels.

Focus on Teamwork

The resuscitation and stabilization of babies born preterm highlights severa! opportunities for effective teams to use the Neonatal Resuscitation Program® (NRP®) Key Behavioral Skills.

Behavior	Example
Anticipate and plan. Delegate workload optimally.	Multiple procedures may be performed in a brief period of time. Work with a multidisciplinary team to develop and practice a systematic approach to the first hours of care by predefining roles and responsibilities.
Use available information. Clearly identify a team leader.	Complete a pre-resuscitation team briefing to review the prenatal and intrapartum history, identify a team leader, review roles and responsibilities of each team member, and plan the approach to respiratory support.
Know your environment.	Know where polyethylene plastic bags/wraps and thermal mattresses are stored. Know how to use the temperature sensor on your radiant warmer. Know how to set up a device to administer CPAP.
Allocate attention wisely.	If the team leader becomes involved in endotracheal intubation, their attention is focused primarily on that task and they may not be able to pay full attention to the baby's condition or the passage of time. A different team leader who can maintain situation awareness may need to be identified.
Communicate effectively. Maintain professional behavior.	Share your assessments aloud so that all members of the team are aware of the baby's condition and response to treatment. The importance of effective communication continues after the resuscitation is completed. A post-resuscitation team debriefing is an important opportunity to review the team's performance, identify oreas for improvement, practice effective communication skills, and improve teamwork. If the baby will be transferred to another hospital after birth, develop a plan for efficiently communicating the maternal and newborn history. Designate a team member to communicate progress updates and plans with parents.

Quality Improvement Opportunities

Ask yourself the following questions and begin a discussion with your team if you find a difference between the NRP recommendations and what is currently done in your own hospital setting. Consider using the suggested process and outcome measures to guide your data collection, identify areas for improvement, and monitor if your improvement efforts are working.

Quality improvement questions

- Where are polyethylene plastic bags/wraps stored in your delivery setting?
- Can you increase the room temperature in your delivery setting?
- Do you have a protocol or checklist to organize the first hour of post-resuscitation care for a baby born very preterm?
- Has your team simulated the resuscitation and stabilization of a very preterm newborn to assess your preparedness?

Process and outcome measures

- How often are preterm newborns hypothermic (temperature < 36.5°C) at 1 hour of age?
- How often are preterm newborns hypoglycemic at 1 hour of age?
- How often do parents receive an update on their baby's condition and have the opportunity to see and touch their baby within the first 30 to 60 minutes?
- How often does your team complete a debriefing after the resuscitation and stabilization of a preterm newborn?
- How soon after giving birth are mothers instructed how to express or pump breast milk?

Frequently Asked Questions

Should delayed umbilical cord clamping be considered for preterm newborns?

Early cord clamping (< 30 seconds after birth) may interfere with healthy transition from fetal to neonatal circulation, as it leaves fetal blood in the placenta rather than filling the newborn's circulating blood volume. Preterm newborns who have delayed umbilical cord clamping are less likely to receive medications for hypotension or receive a blood transfusion. Delayed umbilical cord clamping for preterm newborns may increase the probability of survival, but this evidence is less certain.

Before birth, establish the plan for the timing of umbilical cord clamping with the obstetric providers. For most vigorous preterm newborns, the current evidence suggests that it is reasonable to delay clamping the umbilical cord for at least 30 to 60 seconds after birth. By carefully coordinating with the obstetric providers, the initial steps of newborn care, including clearing the airway if necessary and providing gentle stimulation, can be performed with the umbilical cord intact.

If the mother is hemodynamically unstable or the placenta! circulation is not intact, such as after a placenta! abruption, bleeding placenta previa, bleeding vasa previa, or cord avulsion, the cord should be clamped immediately after birth.

There is not enough evidence to make a definitive recommendation whether umbilical cord clamping should be delayed in preterm newborns who are not vigorous after birth. If the placenta! circulation is intact, it may be reasonable to briefly delay umbilical cord clamping while the obstetric provider clears the airway and gently stimulates the baby to breathe. If the baby <loes not begin to breathe during this time, additional treatment is required. The umbilical cord should be clamped and the baby should be brought to the radiant warmer. Research studies are investigating whether it is feasible and beneficia! to initiate resuscitation adjacent to the mother with the umbilical cord intact.

For newborns less than 28 weeks' gestation, umbilical cord milking is not recommended because it has been associated with an increased risk of intraventricular hemorrhage.

How do you counsel parents before the birth of an extremely preterm baby?

Meeting with parents before the birth of an extremely preterm baby is important for both the parents and the neonatal care providers. Prenatal discussions are an opportunity to provide parents with important information, discuss goals of care, and establish a trusting relationship that will support shared decision-making for their baby.

These discussions can be difficult because of the challenges inherent in communicating a large amount of complex information during a stressful time. You should be prepared with accurate information about available treatment options and the anticipated short- and long-term outcomes for the specific situation. You should be familiar with both national and local outcome data and understand the limitations of each. If necessary, consult with specialists at your regional referral center to obtain up-to-date information. Ideally, both the obstetric provider and the neonatal provider should be present to talk with the parents. The obstetric and neonatal perspectives may be different. These differences should be discussed before meeting with the parents so that the information presented is consistent.

If possible, meet with both parents (or the mother and her chosen support person) at the same time and allow enough time for them to consider the content of your discussion and ask questions. Try to meet with the parents before the mother has received medications that might make it difficult for her to understand or remember your conversation and before the final stages of labor. If you are called when the woman is in active labor, there may not be time for an extended discussion, but it is still helpful to introduce yourself and briefly describe potential issues and your preliminary treatment plan. Use clear language without medical abbreviations or jargon. Be cautious about describing outcomes in terms of risk ratios, proportions, or percentages because parents may have limited understanding of mathematical concepts. In addition, quoting these data may give the impression that your estimates are more precise than they actually are. It is important to present a balanced and objective picture of the range of possible outcomes while avoiding excessively negative or unrealistically positive descriptions. Use an appropriately trained medical interpreter, not a friend or family member, if the family is not proficient in the language spoken by the health care team or includes someone with a hearing disability. Visual aids and written materials, including pictures and graphs, can supplement your discussion and help the parents remember the topics that you discussed. Offer to give the parents time alone to discuss what you have told them. Sorne parents may want to consult with other family members or clergy. If time allows, offer to make a return visit to confirm both their understanding of what may occur and your understanding of their wishes.

After you meet with the parents, document a summary of your conversation in the mother's chart. Review what you discussed with the obstetric care providers and the other members of your delivery room resuscitation team. If it was decided that resuscitation would not be initiated, ensure that all members of your team, including on-call personnel and the obstetric care providers, are informed and in agreement with this decision. If disagreements occur, discuss them in advance and consult additional professionals, including legal and ethics consultants, if necessary.

LESSON 8 REVIEW

1. You have turned on the radiant warn1er in anticipation of the birth of a baby at 27 weeks' gestation. List 4 additional steps that will help maintain this baby's temperature.

   a. ______________________

   b. ______________________

   c. ______________________

   d. ______________________

2. A baby is born at 26 weeks' gestation. The initial steps of care, including gentle stimulation, have been completed and the baby is nearly 1 minute old. The baby is not breathing and the heart rate is 80 beats per minute. You should (start continuous positive airway pressure [CPAP] with a face mask)/(start positive-pressure ventilation).

3. A baby is delivered at 30 weeks' gestation. At 5 minutes of age, the baby is breathing, has a heart rate of 140 beats per minute, and is receiving CPAP with 30% oxygen. A pulse oximeter on the right hand is reading 95% and is increasing. You should (decrease the oxygen concentration)/(begin positive-pressure ventilation).

4. A (self-inflating bag)/(T-piece resuscitator) can provide CPAP for a spontaneously breathing baby.

5. You are preparing for the birth of a baby of 34 weeks' gestation. You set the positive-pressure ventilation device so that the peak inflation pressure is (20 to 25 cm H_2O)/(25 to 30 cm H_2O) and positive end-expiratory pressure (PEEP) is (5 cm H_2O)/(10 cm H_2O).

6. Initiate resuscitation of the preterm baby (< 35 weeks' gestational age) with (21% to 30% oxygen)/(60% to 100% oxygen).

7. You may *decrease* the risk of neurologic injury in a premature newborn during and after resuscitation by (tilting the bed so the baby's legs are higher than the head)/(adjusting the bed *so* that the baby's legs are even with or lower than the head).

8. Compared with term newborns, preterm newborns have a (higher)/(lower) risk of developing hypoglycemia shortly after resuscitation.

Answers

1. You can increase the room temperature to 23°C to 25°C (74°F to 77°F), prepare a thermal mattress, prepare a polyethylene plastic bag or wrap, and pre-warm a transport incubator if the baby will be moved after birth.

2. You should start positive-pressure ventilation.

3. You should decrease the oxygen concentration.

4. A T-piece resuscitator can provide CPAP for a spontaneously breathing baby. A self-inflating bag **cannot** be used to provide CPAP.

5. Set the peak inflation pressure to 20 to 25 cm H_2O and positive end-expiratory pressure (PEEP) to 5 cm H_2O.

6. Initiate resuscitation of the preterm baby with 21% to 30% oxygen.

7. You may *decrease* the risk of neurologic injury in a premature newborn during and after resuscitation by adjusting the bed so that the baby's legs are even with or lower than the head.

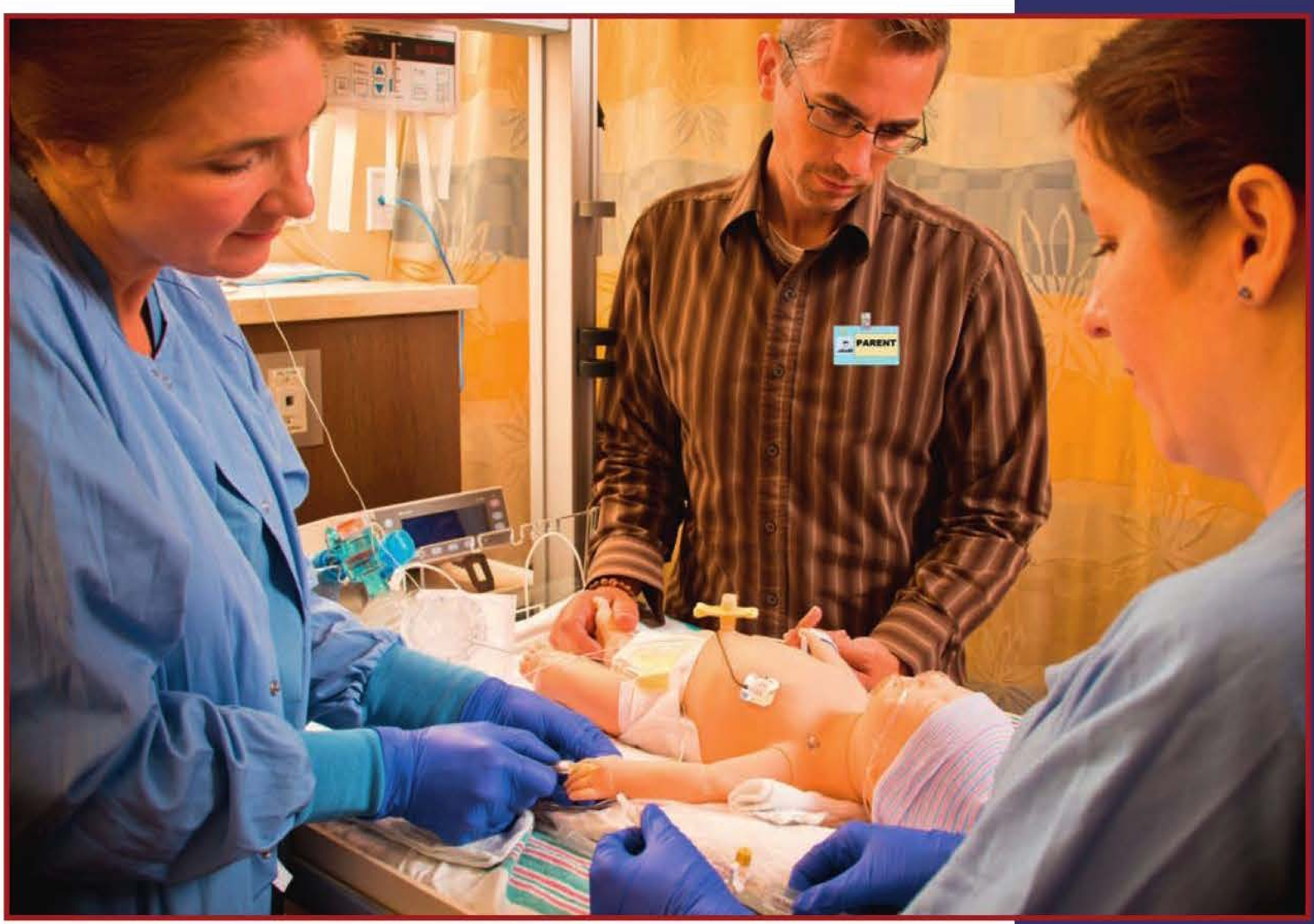
8. Preterm newborns have a higher risk of developing hypoglycemia shortly after resuscitation.

9

Post-resuscitation (are

What you will learn

- What to do after neonatal resuscitation
- Medica! conditions that may occur following neonatal resuscitation
- Management considerations following neonatal resuscitation
- The role of therapeutic hypothermia in post-resuscitation care



Key Points

O A baby who required resuscitation must have close monitoring and frequent assessment of respiratory effort, oxygenation, blood pressure, blood glucose, electrolytes, urine output, neurologic status, and temperature during the immediate neonatal period.

f.) Be careful to avoid overheating the baby during or after resuscitation.

E) If indicated, therapeutic hypothermia must be initiated promptly; therefore, every birth unit should have a system for identifying potential candidates and contacting appropriate resources.

Case: An early term pregnancy with fetal distress

A baby was born at 37 weeks' gestation by emergency cesarean section because of maternal fever with signs of fetal distress during labor. After birth, the baby was limp and apneic, and did not respond to the initial steps of newborn care. Positive-pressure ventilation (PPV) was started and continued for 3 minutes until effective spontaneous respiratory effort was established. During the next several minutes, the baby developed labored breathing and required supplemental oxygen to maintain oxygen saturation within the target range. The team leader updated the parents, explained the baby's condition, and described the post-resuscitation care plan.

The newborn arrives in the nursery where vital signs, including temperature, oxygen saturation, and blood pressure are recorded. The baby continues to require supplemental oxygen with labored breathing, anda chest x-ray is requested. A team member obtains a blood sample for glucose, bacteria! culture, and blood gas testing. An intravenous catheter is inserted and the baby receives fluids and parenteral antibiotics. The health care providers discuss their plan for close monitoring and frequent assessment. The baby's father arrives at the bedside where he touches and comforts his baby. The medica! provider gives the father an interval update and explains the treatment plan. Shortly afterward, the team members conduct a debriefing to review their preparation, teamwork, and communication.

Postnatal (are

The physiologic transition to extrauterine life continues for several hours after birth. Babies who required resuscitation may have problems making this transition even after their vital signs appear to return to normal. Medical complications after resuscitation may involve multiple organ systems. Many of these complications can be anticipated and promptly addressed by appropriate monitoring.

This program refers to 2 broad categories of postnatal care. The intensity of monitoring and the interventions required for individual babies will vary within these categories.

- **Routine care**

  Nearly 90% of newborns are vigorous term babies with no risk factors and they should remain with their mothers to promote bonding, initiate breastfeeding, and receive routine newborn care (Figure 9.1). Similarly, a baby with certain prenatal or intrapartum risk factors, who responded well to the initial steps of newborn care, may only need close observation and <loes not need to be separated from the mother. Ongoing observation of breathing, thermoregulation, feeding, and activity are important to determine if additional interventions are required. The frequency of these evaluations will be determined by the specific perinatal risk factors and the baby's condition.

Figure 9.1. Routine care. (Used with permission of Mayo Foundation for Medical Education and Research.)

- **Post-resuscitation care**

  Babies who required supplemental oxygen, PPV, or co11tinuous positive airway pressure (CPAP) after delivery will need closer assessment. They may develop problems associated with abnormal transition and should be evaluated frequently during the immediate newborn period. In addition to routine newborn care, they often require ongoing respiratory support, such as supplemental oxygen, nasal CPAP, or mechanical ventilation. Many will require admission to a nursery environment where continuous cardiorespiratory monitoring is available and vital signs can be measured frequently (Figure 9.2). Sorne will require transfer to a neonatal intensive care unit. If a newborn requires post-resuscitation care in a location outside of the mother's room, the parents should be encouraged to see and touch their baby as soon as it is feasible. The period of time needed for close observation is dependent on the newborn's condition, progress toward normal transition, and the presence of identifiable risk factors.

Figure 9.2. Post-resuscitation care in a setting where continuous cardiorespiratory monitoring is available and vital signs can be measured frequently

What medical conditions may occur in babies who required resuscitation?

Abnormalities in multiple organ systems may occur following neonatal resuscitation. Anticipated clinical signs, laboratory findings, and management considerations are summarized in Table 9-1. Individual circumstances will determine which of these management considerations are appropriate.

Temperature instability

After resuscitation, babies may become too cold (hypothermic) or too warm (hyperthermic). Premature newborns are at high risk of hypothermia and this has been associated with increased mortality. Special techniques for maintaining body temperature in preterm newborns are addressed in Lesson 8. Babies may become hyperthermic if their mother has a fever or chorioamnionitis, if the baby has an

Table 9-1 ● Clinical Signs, Laboratory Findings, and Management Considerations

Organ System	Clinical Signs and Laboratory Findings	Management Considerations
Constitutional	Hypothermia	Delay bathing.
Respiratory	Tachypnea, grunting, retractions, nasal flaring, low oxygen saturation, pneumothorax	Maintain adequate oxygenation and ventilation. Monitor for signs of pulmonary hypertension. Avoid unnecessary suctioning. Cluster care to allow periods of rest. Consider antibiotics. Consider x-ray and blood gas. Consider surfactant therapy. Consider delayed initiation of feedings with use of intravenous fluids.
Cardiovascular	Hypotension, tachycardia, metabolic acidosis, poor perfusion	Monitor blood pressure and heart rate. Consider volume replacement or inotrope administration if baby is hypotensive.
Endocrine-Metabolic	Metabolic acidosis, hypoglycemia (low glucose}, hypocalcemia (low calcium}, hyponatremia (low sodium}, hyperkalemia (high potassium)	Monitor blood glucose. Monitor serum electrolytes as indicated. Consider intravenous fluids. Replace electrolytes as indicated.
Gastrointestinal	Feeding intolerance, vomiting, abdominal distention, abnormal liver function tests, gastrointestinal bleeding	Consider abdominal x-ray. Consider delayed initiation of feedings. Consider use of intravenous fluids. Consider parenteral nutrition.
Renal	Decreased urine output, edema, electrolyte abnormalities	Monitor urine output. Monitor serum electrolytes as indicated. Monitor weight. Restrict fluids if baby has decreased urine output and vascular volume is adequate.
Neurologic	Apnea, seizures, irritability, poor tone, altered neurologic examination, poor feeding coordination	Monitor for apnea. Support ventilation as needed. Monitor glucose and electrolytes. Avoid hyperthermia. Consider anticonvulsant therapy. Consider therapeutic hypothermia. Consider delayed initiation of feedings. Consider using intravenous fluids.
Hematologic	Anemia, thrombocytopenia, delayed clotting, pallor, bruising, petechiae	Monitor hematocrit, platelets, jaundice, bilirubin, and coagulation studies as indicated.

infection, or if the radiant warmer is not used properly. Hyperthermia has been associated with worsened outcomes and should be avoided.

Pneumonia and other respiratory problems

The need for resuscitation may be an early sign that a newborn has pneumonia, a perinatal infection, or an aspiration event. Neonatal pneumonia (Figure 9.3B) may present with tachypnea and other signs of respiratory distress such as grunting, nasal flaring, and

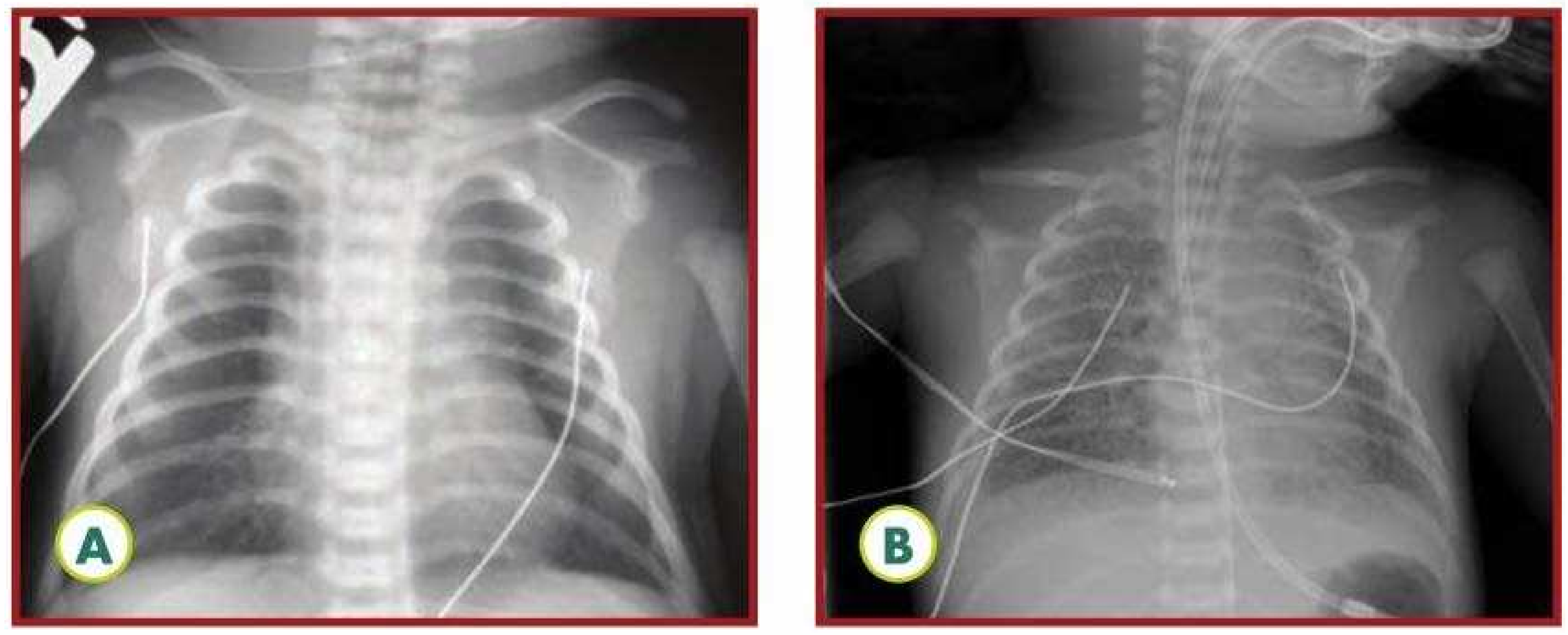


Figure 9.3. Neonatal chest x-rays: (A) normal, (B) pneumonia

Figure 9.4. Right pneumothorax

retracting. It can be difficult to differentiate between respiratory distress syndrome, retained fetal lung fluid, and neonatal pneumonia by chest x-ray. If a baby who required resuscitation continues to show signs of respiratory distress or requires supplemental oxygen, consider evaluating the baby for pneumonia and perinatal infection. Obtain appropriate laboratory tests and begin parenteral antibiotics.

If acute respiratory deterioration occurs during or after resuscitation, consider the possibility that the baby has a pneumothorax (Figure 9.4). Lesson 10 includes details about managing a pneumothorax. If the baby is intubated and develops acute respiratory deterioration, ensure that the endotracheal tube has not become dislodged or obstructed by secretions.

Pulmonary hypertension

As described in Lesson 1, blood vessels in the fetal lungs are tightly constricted. After birth, the pulmonary vessels relax and blood flows into the lungs where hemoglobin can be saturated with oxygen for delivery to the tissues and organs.

The pulmonary blood vessels may remain constricted after birth. This condition is called persistent pulmonary hypertension of the newborn (PPHN) and is most often seen in babies greater than or equal to 34 weeks' gestational age. PPHN usually is managed with supplemental oxygen and, in sorne cases, mechanical ventilation. Severe PPHN may require special therapies such as high-frequency mechanical ventilation, inhaled nitric oxide, and extracorporeal membrane oxygenation (ECMO).

After resuscitation, the baby's pulmonary vascular tone can be labile and may increase in response to sudden decreases in oxygen saturation or unintentional hypothermia; therefore, avoid unnecessary suction, excessive stimulation, and immediate bathing. While avoiding sudden decreases in saturation may be beneficia!, intentionally maintaining very high blood levels of oxygen is not likely to be helpful and may cause additional complications. A pulse oximeter should be used to guide ox:ygen therapy. In the setting of suspected PPHN, an arterial blood gas provides additional useful information that cannot be determined from pulse oximetry alone.

Hypotension

Hypotension during the post-resuscitation phase may occur for multiple reasons. Low oxygen levels around the time of birth can decrease both cardiac function and blood vessel tone. If the baby had significant blood loss, the circulating blood volume may be low and contribute to hypotension. Babies with sepsis may have normal or high cardiac output, but they may become hypotensive because of dilation of peripheral blood vessels.

Babies who require significant resuscitation should have their blood pressure monitored until it is stable within an acceptable range. If there is evidence of hypovolemia, volume expansion with a crystalloid solution, or blood transfusion, may be indicated. Routine volume expansion without evidence of hypovolemia is not recommended. Sorne babies may require a medication such as dopamine, dobutamine, or epinephrine to improve cardiac output and increase systemic blood flow.

Hypoglycemia

Glucose consumption is increased when metabolism occurs without adequate oxygen (anaerobic metabolism). Hypoglycemia may occur because glucose stores are depleted rapidly during perinatal stress. A transiently high glucose level may occur in sorne stressed newborns before the blood glucose level begins to fall. Glucose is an essential fuel for brain function in newborns and prolonged hypoglycemia may contribute to brain injury after resuscitation.

Babies who require resuscitation need to have their blood glucose level checked soon after resuscitation and then at regular intervals until it remains stable and within normal limits. Intravenous dextrose may be necessary to maintain normal blood glucose levels until oral feedings are established.

Feeding problems

The newborn's gastrointestinal tract is very sensitive to decreased oxygen and blood flow. Feeding intolerance, poor motility, inflammation, bleeding, and perforation of the intestinal wall can occur after resuscitation. In addition, sucking patterns and oral feeding coordination may be affected for severa! days because of neurologic dysfunction. Alternative methods for providing nutrition may be required during this interval.

Ideally, feedings should be initiated with breast milk. If the baby is born very preterm or is unable to start breastfeeding, work with the mother's health care providers to develop a plan that supports expressing and storing breast milk as soon as possible after birth.

Renal failure

Hypotension, hypoxia, and acidosis can decrease blood flow to the kidneys and cause either temporary or permanent renal failure. Acute tubular necrosis (ATN) is usually a temporary form of renal failure that may occur after resuscitation. It can cause fluid retention and significant electrolyte abnormalities. Babies initially may have low urine output and require fluid restriction for several days. During the recovery phase, they may develop very high urine output and require additional fluid.

Babies who require significant resuscitation should have their urine output, body weight, and serum electrolyte levels checked frequently. Adjust fluid and electrolyte intake based on the baby's urine output, body weight changes, and laboratory results.

Metabolic acidosis

Metabolic acidosis is a common finding after resuscitation because acids are produced when tissues receive insufficient oxygen and blood flow. Severe acidosis may interfere with heart function and worsen pulmonary hypertension. In most cases, the acidosis will gradually resolve as the baby's respiratory and circulatory systems recover. The most important intervention is to identify and correct the underlying cause of the metabolic acidosis.

Seizures or apnea

Newborns with hypotension, hypoxemia, and acidosis may develop signs of brain injury. This injury is called hypoxic-ischemic encephalopathy (HIE). Initially, the baby may have decreased muscle tone, lethargy, poor respiratory effort, or apnea. Seizures may appear after several hours. Babies who have required extensive resuscitation should be carefully examined for signs of HIE. A standardized neurologic assessment is a useful tool. Consultation with a specialist should be considered.

Lethargy, apnea, and seizures may be signs of other conditions such as exposure to maternal narcotics or anesthetics, infection, electrolyte disturbances, or metabolic abnormalities.

When should therapeutic hypothermia (cooling) be considered?

Studies have demonstrated that therapeutic hypothermia (cooling) after resuscitation reduces the risk of death and improves neurologic outcomes in late preterm and term babies with moderate to severe HIE.

If your hospital does not have a neonatal hypothermia program, contact the closest referral center that provides this therapy as soon as you suspect that a baby may be a candidate. Work with your referral center to develop an organized plan to identify candidates for therapy and quickly arrange for transport. Delay in the recognition or referral of a baby that qualifies for cooling could mean that treatment cannot be initiated because the baby is outside of the therapeutic window. If the decision is made to transport the baby to another center, follow instructions from the referral center to avoid unintentional hyperthermia while awaiting transport.

Focus on Teamwork

Post-resuscitation care highlights several opportunities for effective teams to use the Neonatal Resuscitation Program® (NRP®) Key Behavioral Skills.

Behavior	Example
Anticipate and plan.	Plan where post-resuscitation care will take place at your institution. Discuss what type of post-resuscitation care will be provided in the mother's room and when care should be transferred to a transitional orea or intensive care nursery. Plan who will be responsible for ongoing monitoring and who to contact if the baby's condition changes. Develop a plan to rapidly recognize babies who may qualify for therapeutic hypothermia and who to contact if this therapy may be indicated. Practice how to initiate therapeutic hypothermia or the process for promptly transferring the baby to a referral center with the required expertise.
Know your environment.	Know what equipment is available in your institution to obtain a blood gas, electrolytes, and serum glucose level. Know how to use the temperature sensor on your radiant warmer.
Delegate workload optimally.	Many procedures need to be performed during the first hour after a successful resuscitation. Plan who will perform each task to avoid unnecessary delays.
Communicate effectively.	Bring the care team together for a post-resuscitation debriefing to reinforce good teamwork habits and identify areas for improvement. Identifying small changes may result in significant improvements in your team's performance and patient safety.

Quality Improvement Opportunities

Ask yourself the following questions and begin a discussion with your team if you find a difference between the NRP recommendations and what is currently done in your own hospital setting. Consider using the suggested process and outcome measures to guide your data collection, identify areas for improvement, and monitor if your improvement efforts are working.

Quality improvement questions

- If a baby has received oxygen, PPV, or CPAP during the initial stabilization, who will be responsible for post-resuscitation care and continued assessments?
- What resources are available to care for a baby who requires advanced neonatal care?
- What challenges <loes your team face when transporting a newborn from the delivery location to an environment where continuous cardiorespiratory monitoring is available and vital signs can be measured frequently?
- Have neonatal care providers been trained to identify babies that may be candidates for therapeutic hypothermia?
- Do you know who to contact if you believe a baby is a candidate for therapeutic hypothermia?
- Do you have a process to support the mother's breastfeeding plan when the newborn requires ongoing monitoring?

Process and outcome measures

- How often is a resuscitation record completed that documents ali interventions performed during resuscitation and stabilization?
- How often <loes the resuscitation team complete a post-resuscitation debriefing?
- How often are babies hypoglycemic after resuscitation?
- How often are babies transferred from the delivery location to an advanced care nursery/unit?

0 How often <loes the receiving medical center conduct a collaborative review with the referring medical center of babies transported to its facility?

Frequently Asked Questions

Can post-resuscitation care and monitoring be performed in the mother's room?

The location of post-resuscitation care is less important than ensuring that appropriate monitoring occurs, medical conditions that require intervention are promptly recognized, and the necessary treatment is initiated. In n1any institutions, this will require transfer to a transitional nursery or intensive care setting.

Should sodium bicarbonate routinely be given to babies with metabolic acidosis?

No. Infusing a chemical buffer, like sodium bicarbonate, may appear to be a helpful intervention; however, there is currently no evidence to support this routine practice. Sodium bicarbonate infusion has several potential side effects. When sodium bicarbonate mixes with acid, carbon dioxide (CO_2) is formed. If the baby's lungs cannot rapidly exhale the additional CO_2, the acidosis will worsen. Although the blood measurement of acid (pH) may appear to improve, sodium bicarbonate n1ay interfere with other acid buffering systems and actually worsen the acidosis inside of cells. In addition, rapid administration of sodium bicarbonate may increase the risk of intraventricular hemorrhage in preterm newborns.

LESSON 9 REVIEW

1. A baby born at 36 weeks' gestation received positive-pressure ventilation and oxygen supplementation in the delivery room. This baby (does)/(does not) need frequent evaluation of respiratory effort and oxygenation during the immediate neonatal period.

2. If a newborn requires admission to a neonatal intensive care unit, the parent(s) (should)/(should not) be encouraged to see and touch their baby.

3. A full-term newborn had significant birth depression and required a complex resuscitation. The baby has continued respiratory failure with carbon dioxide retention and metabolic acidosis. Sodium bicarbonate (should)/(should not) be infused immediately after resuscitation.

4. Among babies who required complex resuscitation and have signs of neurologic injury, aggressive warming and hyperthermia (improves)/(worsens) the outcome and should be (encouraged)/(avoided).

Answers

1. This baby <loes need frequent evaluation of respiratory effort and oxygenation during the immediate neonatal period.

2. The parent(s) should be encouraged to see and touch their baby.

3. Sodium bicarbonate should not be infused immediately after resuscitation.

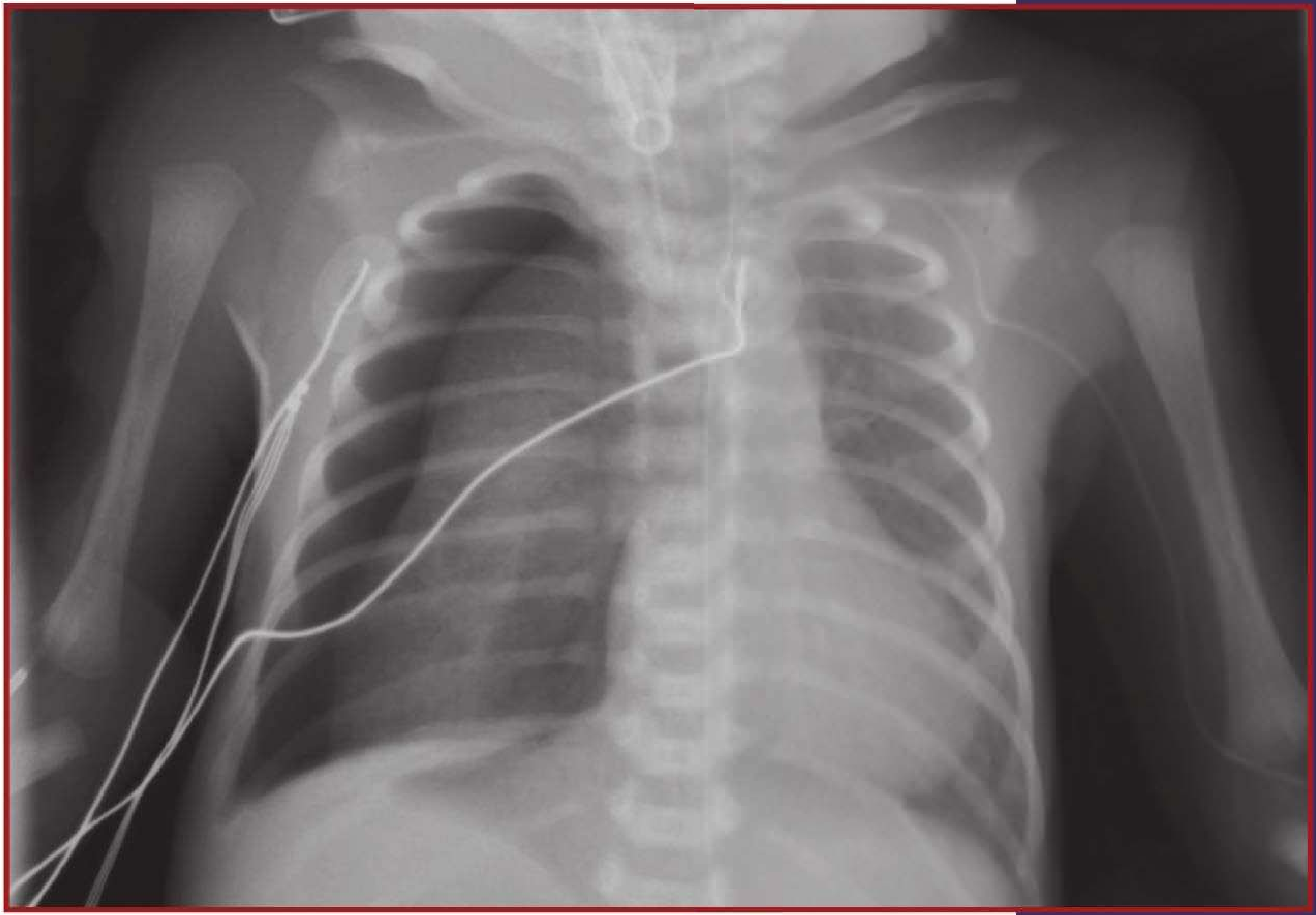
4. Aggressive warming and hyperthermia worsens the outcome and should be avoided.

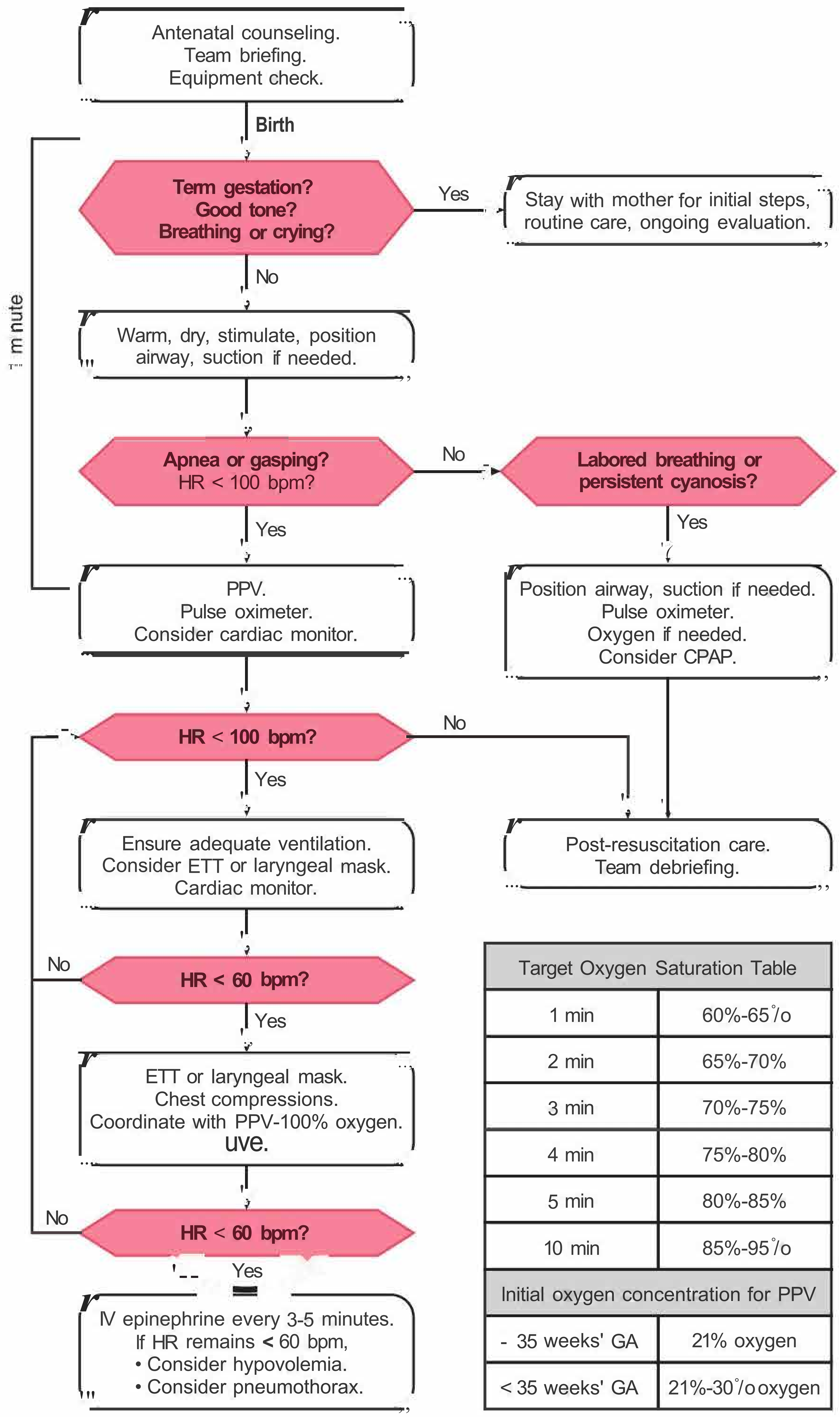
10

Special Considerations

What you will learn

- When to suspect a pneumothorax or a pleural effusion
- How to manage a life-threatening pneumothorax or pleural effusion
- How to manage a newborn with an airway obstruction
- How to manage congenital lung abnormalities that may complicate resuscitation
- How to manage the newborn with complications from maternal opiate or anesthetic exposure
- How to manage a newborn with myelomeningocele
- How to manage a newborn with an abdominal wall defect





Target Oxygen Saturation Table	
1 min	60%-65%
2 min	65%-70%
3 min	70%-75%
4 min	75%-80%
5 min	80%-85%
10 min	85%-95%
Initial oxygen concentration for PPV	
- 35 weeks' GA	21% oxygen
< 35 weeks' GA	21%-30% oxygen

Key Points

O Suspect a pneumothorax if a baby fails to improve despite resuscitative measures or suddenly develops severe respiratory distress. In an emergency, a pneumothorax may be detected by decreased breath sounds and increased transillumination on the affected side.

f) Suspect a pleural effusion if a newborn has respiratory distress and generalized edema (hydrops fetalis).

Q A pneumothorax or pleural effusion that causes cardiorespiratory compromise is treated by aspirating the air or fluid with a needle-catheter-stopcock assembly attached to a syringe and inserted into the chest.

8 If thick secretions obstruct the airway despite a correctly positioned endotracheal tube, attempt to remove the secretions using a suction catheter (SF-8F) inserted through the endotracheal tube. If the obstruction persists, directly suction the trachea with a tracheal aspirator attached to the endotracheal tube. In most circumstances, establish an open airway and ventilation that inflates the lungs before proceeding to chest compressions.

0 Respiratory distress associated with the Robin sequence can be improved by placing the baby prone and inserting a small endotracheal tube (2.5 mm) into the nose so the tip is in the pharynx. If this <loes not result in adequate air movement, a laryngeal mask may provide a lifesaving airway. Endotracheal intubation is frequently difficult in this situation.

O Respiratory distress associated with bilateral choanal atresia can be improved by inserting a modified feeding nipple or pacifier, with the end cut off, into the baby's mouth or an endotracheal tube into the mouth with the tip in the posterior pharynx.

O If a congenital diaphragmatic hernia is suspected, avoid positive-pressure ventilation with a face mask. Quickly intubate the trachea in the delivery room and insert an orogastric tube with continuous or intermittent suction to decompress the stomach and intestines.

O If a mother received opiates in labor and her baby is not breathing, provide airway support and assisted ventilation until the baby has adequate spontaneous respiratory effort.

- Avoid placing newborns with myelomeningocele (spina bifida) on their back. Position the newborn lying on their side, on their stomach, or on a "doughnut,, made from towels or latex-free foam.

- Place the lower body and abdomen of a newborn with gastroschisis or omphalocele in a sterile, clear plastic bowel bag and secure the bag across the baby,s chest. Position the baby on the right side to optimize bowel perfusion.

This lesson reviews less common circumstances that you may encounter during neonatal resuscitation. Because these scenarios do not occur frequently, it is important to be able to recognize them and be prepared to respond quickly and efficiently. As you read the following case, imagine yourself as part of the resuscitation team.

Case: A newborn with tension pneumothorax

A woman is admitted in labor at 40 weeks' gestation with clear fluid and a Category 111fetal heart rate pattern. An emergency cesarean birth is planned. Your resuscitation team assembles in the operating room, completes a pre-resuscitation team briefing, and prepares equipment and supplies for a complex resuscitation. After birth, the umbilical cord is clamped and cut and a limp, apneic baby is handed to the team. One team member begins documenting the resuscitation events as they occur.

The initial steps are performed, but the baby remains limp without spontaneous respirations. You begin positive-pressure ventilation (PPV) with a face mask, but the heart rate does not improve. You perform the ventilation corrective steps and achieve chest movement after increasing the ventilating pressure; however, the baby's heart rate remains 40 beats per minute (bpm). Team members place a pulse oximeter sensor on the baby's right hand and cardiac monitor leads on the baby's chest. An endotracheal tube is rapidly inserted for continued PPV, but there is no improvement in heart rate. Your team increases the oxygen concentration (FIO_2) to 100% and begins chest compressions while an umbilical venous catheter is prepared and inserted. The baby's heart rate does not improve after 60 seconds of coordinated compressions and ventilation. A dose of intravenous epinephrine is given through the umbilical catheter, followed by a normal saline flush, but the baby's condition still does not improve. The team reevaluates the insertion of the endotracheal tube and the efficacy of ventilation and compressions while considering special circumstances that may complicate resuscitation. Listening to the chest, you recognize that breath sounds are absent on the right side. Your team suspects a life-threatening tension pneumothorax. Rapid transillumination of the chest confirms the suspicion and a team member quickly prepares a catheter-over-needle aspiration device. Chest compressions are stopped while a catheter is inserted and air is aspirated from the chest. Upon decon1pression of the pneumothorax, the baby's heart rate rapidly improves. The team continues PPV and the $F10_2$ is adjusted based on pulse oximetry. A small amount of air continues to flow through the catheter aspiration system and the baby is transferred to the nursery for a chest x-ray and additional treatment. Shortly afterward, you update the parents and conduct a debriefing to review your team's preparation, teamwork, and communication.

How do you identify a newborn with an air or a fluid collection around the lung?

Abnormal air or fluid collections that prevent the newborn's lung from fully expanding within the chest can lead to severe respiratory distress and persistent bradycardia.

Pneumothorax

It is not uncommon for small air leaks to develop as the newborn's lung fills with air. When air collects in the pleural space surrounding the lung, it is called a pneumothorax (Figure 10.1). Although a pneumothorax may occur spontaneously, the risk is increased by PPV, particularly in preterm babies, babies with meconium aspiration, and babies with other lung abnormalities.

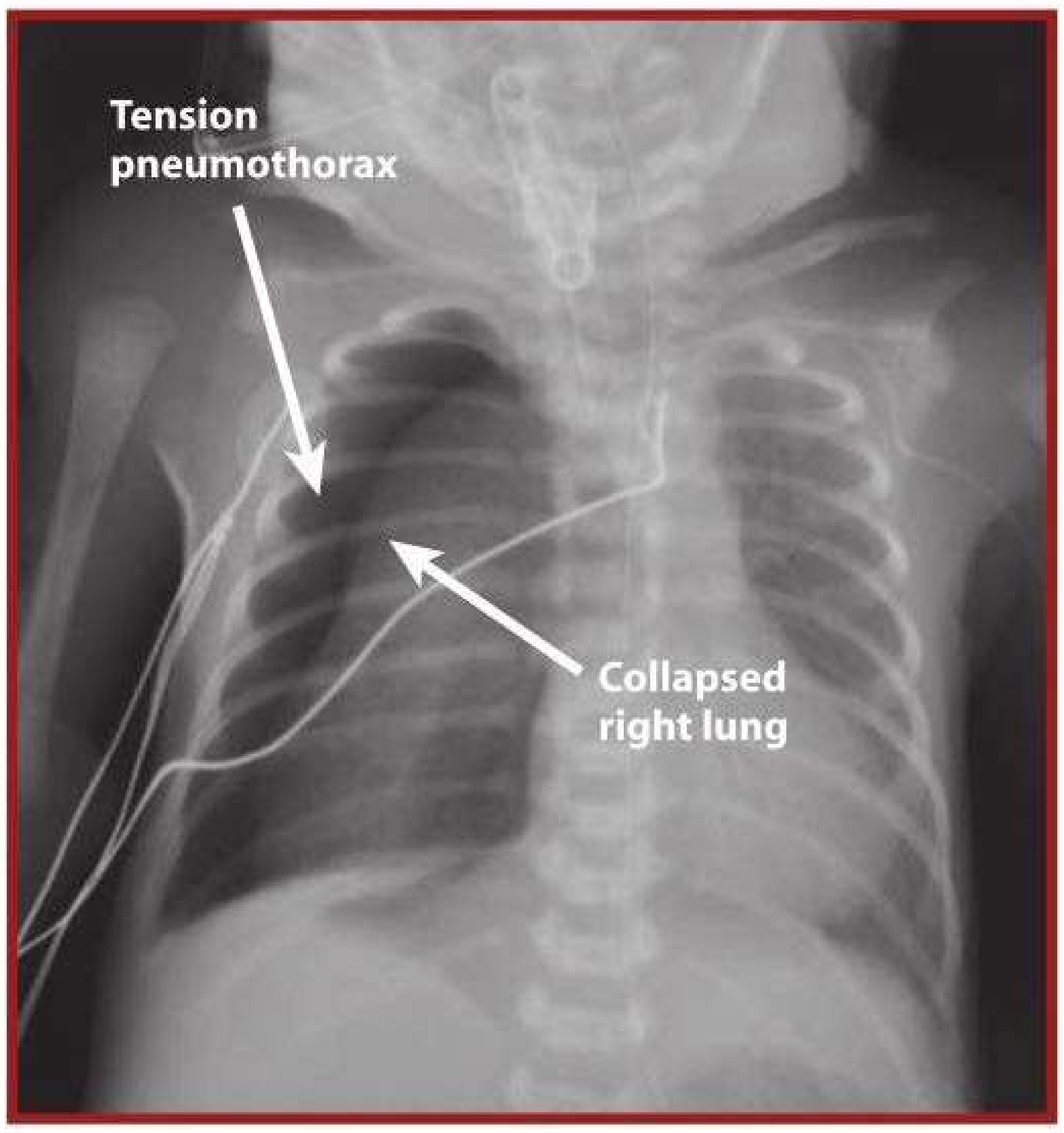


Figure 10.1. Pneumothorax causing collapse of the right lung

A small pneumothorax may be asymptomatic or cause only mild respiratory distress. If the pneumothorax becomes larger, the pressure from the trapped air can cause the lung to collapse. If the pneumothorax becomes large enough, it can interfere with blood flow within the chest causing severe respiratory distress, oxygen desaturation, and bradycardia. This is called a tension pneumothorax. It is a life-threatening emergency and requires urgent treatment to evacuate the air.

You should consider the possibility of a pneumothorax if a baby fails to improve despite resuscitative measures or if a baby suddenly develops severe respiratory distress. Breath sounds may be diminished on the side of the pneumothorax, but breath sounds can be misleading because they are easily transmitted across the baby's chest and can sound normal even in the presence of a pneumothorax. On the other hand, decreased breath sounds on the left side may be caused by an endotracheal tube inserted into the right main bronchus (Table 10-1).

Table 10-1 • Causes of Diminished Breath Sounds

- Inadequate ventilation technique
- PPV device leak or equipment failure
- Malpositioned endotracheal tube
- Pneumothorax
- Pleural effusion
- Tracheal obstruction
- Congenital diaphragmatic hernia
- Pulmonary hypoplasia or agenes1s
- Enlarged heart

Transillumination of the chest is a rapid screening test that may be helpful. In a darkened room, hold a high-intensity fiber-optic light against the chest wall and compare the transmission of light on each side of the chest (Figure 10.2). During transillumination, light on the side with a pneumothorax will appear to spread further and glow brighter than the opposite side. In a life-threatening situation, a positive transillumination test can help to direct immediate treatment. Be careful when interpreting the results of transillumination in very premature babies because their thin skin may cause the chest to appear bright even in the absence of a pneumothorax. If a transilluminator is not immediately available and the baby is in severe distress, you may proceed with emergency treatment based on your clinical suspicion. If the baby is stable, the definitive diagnosis of a pneumothorax is made with a chest x-ray.

Figure 10.2. Positive transillumination of a left-sided pneumothorax. The light spreads and glows across a wide orea.

A small pneumothorax usually will resolve spontaneously and often <loes not require treatment. The baby should be monitored for worsening distress. If the baby is maintaining normal oxygen saturation, supplemental oxygen is not indicated and <loes not result in faster resolution of the pneumothorax. If a pneumothorax causes significant respiratory distress, bradycardia, or hypotension, it should be relieved urgently by inserting a catheter into the pleural space and evacuating the air. If the baby has ongoing respiratory distress, insertion of a thoracostomy tube attached to continuous suction may be required.

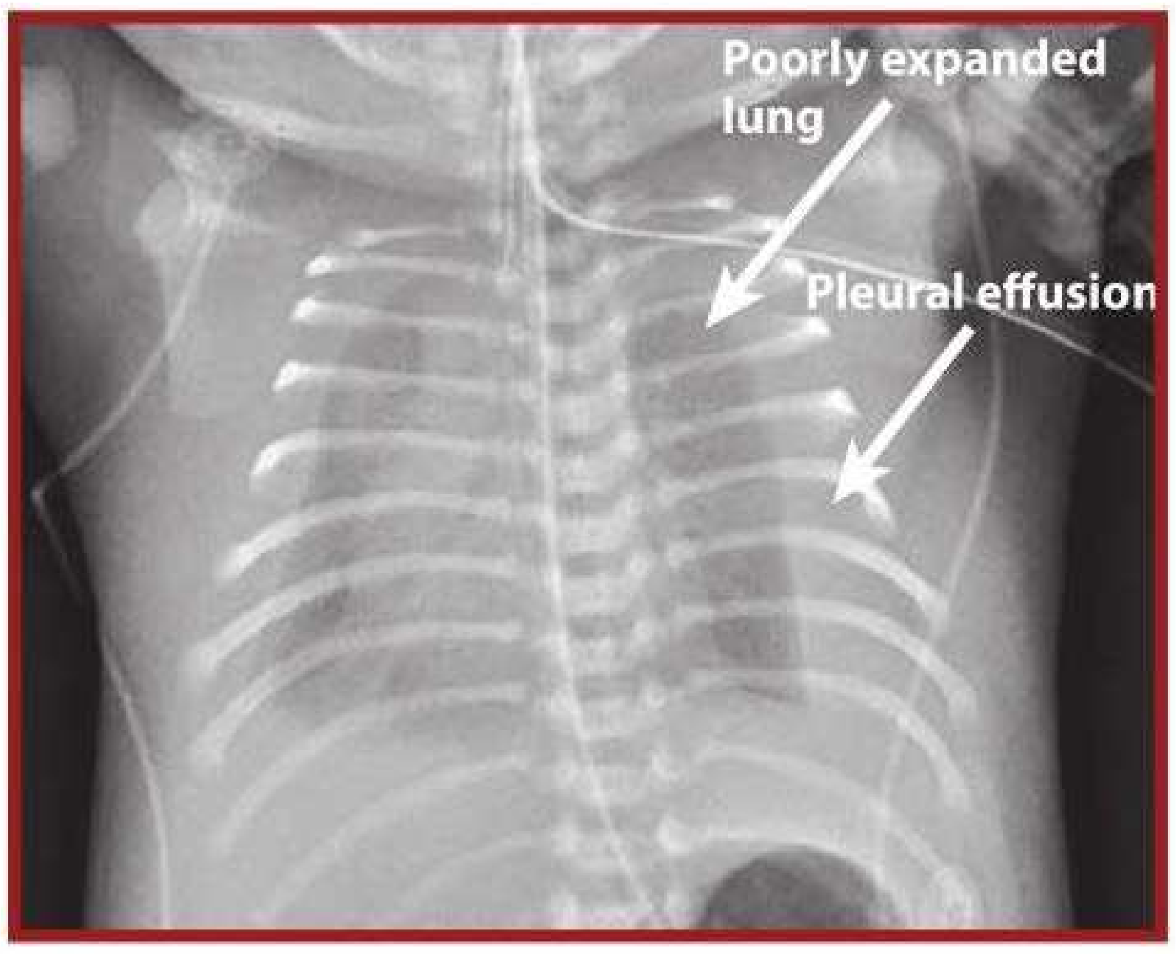


Figure 10.3. large bilateral pleural effusions

Pleural effusion

Fluid that collects in the pleural space is called a pleural effusion (Figure 10.3). Similar to a pneumothorax, a large pleural effusion can prevent the lung from expanding. The fluid may be caused by edema, infection, or leakage from the baby's lymphatic system. Frequently, large pleural effusions are diagnosed before birth by ultrasound. There may be a history of severe fetal anemia, twin-to-twin transfusion, cardiac arrhythmia, congenital heart disease, congenital infection, or a genetic syndrome. You should suspect a pleural effusion if a newborn has respiratory distress and generalized body edema (hydrops fetalis). Excess fluid may also be present in the baby's abdomen (ascites) and around the baby's heart (pericardial effusion). Because the fluid collection interferes with lung expansion, breath sounds may be decreased on the affected side. The definitive diagnosis of a pleural effusion is made with a chest x-ray or ultrasound.

A small pleural effusion may not require treatment. If respiratory distress is significant and <loes not resolve with intubation and PPV, you may need to inserta catheter into the pleural space to drain the fluid. If a large pleural effusion is identified before birth, the obstetrician may remove fluid before delivery. In addition, emergency drainage may be required after birth. If time allows, a baby with a large pleural effusion identified by antenatal testing should be born in a facility where emergency airway management and fluid drainage by an experienced team is immediately available in the delivery room.

How do you evacuate a pneumothorax or pleural effusion?

The air or fluid is aspirated by inserting a catheter into the pleural space on the affected side. This procedure is called *thoracentesis.* Ideally, thoracentesis should be performed using sterile technique with appropriate anesthetic for pain management; however, modifications may be required during emergency aspiration of a tension pneumothorax.

O Take a brief "time-out" and confirm the side that you plan to aspirate.

f) Aspiration site and positioning.

a. For a pneumothorax, the aspiration site is either the fourth intercostal space at the anterior axillary line or the second intercostal space at the mid-clavicular line (Figure 10.4). Using a small blanket roll, position the baby on their back (supine) with the affected side directed slightly upward to allow the air to rise to the upper (superior) portion of the chest.

b. For a pleural effusion, the aspiration site is the fifth or sixth intercostal space along the posterior axillary line. Place the baby on their back (supine) to allow the fluid to collect in the lower (posterior) portion of the chest (Figure 10.5).

8 Prepare the insertion site with topical antiseptic and sterile towels.

Figure 10.4. Locations for percutaneous aspiration of a pneumothorax. Fourth intercostal space at the anterior axillary line (A), second intercostal space at the mid-clavicular line (B). Cardiac monitor leads and skin temperature sensor not shown.

Figure 10.5. Location for aspiration of a pleural effusion

9 Insert an 18- or 20-gauge percutaneous catheter-over-needle device* perpendicular to the chest wall and just over the top of the rib. The needle is inserted over the top of the rib, rather than below the rib, to avoid puncturing the blood vessels located under each rib.

a. Por a pneumothorax, direct the catheter slightly upward toward the front of the chest (Figure 10.6).

b. For a pleural effusion, direct the catheter slightly downward toward the back.

0 Once the pleural space is entered, the needle is removed and a large syringe (20-60 mL) connected to a 3-way stopcock is attached to the catheter (Figure 10.7).

a. When the stopcock is opened between the syringe and the catheter, the air or fluid can be evacuated.

b. When the syringe is full, the stopcock may be closed to the chest while the syringe is emptied.

c. After the syringe is emptied, the stopcock can be reopened to the chest and more fluid or air may be aspirated until the baby's condition has improved.

d. To avoid accidental reinjection of air or fluid into the chest cavity, care must be taken when manipulating the stopcock.

e. When evacuating a pleural effusion, maintain a sample of the fluid for diagnostic evaluation.

0 An x-ray should be obtained to document the presence or absence of residual pneumothorax or effusion.

*Note: If an appropriate catheter-over-needle device is not available, a small "butterfly" needle may be used. In this case, the syringe and stopcock will be connected to the tubing attached to the needle.

Figure 10.6. Aspiration of a pneumothorax. The needle is inserted over the rib and directed slightly upward toward the front of the chest. Note: The aspiration site is not covered with sterile towels for photographic purposes; however, modified sterile technique is acceptable for emergency aspiration.

Figure 10.7. Syringe and stopcock assembly used to aspirate pneumothorax. The stopcock is opened between the catheter and syringe during aspiration. The stopcock is closed if the syringe becomes full and must be emptied. The sorne assembly is used to drain a pleural effusion.

How do you manage a newborn with an airway obstruction?

Airway obstruction is a life-threatening emergency. The newborn's airway may be obstructed by thick secretions or a congenital anomaly that leads to an anatomic obstruction.

Thick secretions

Thick secretions, such as meconium, blood, mucus, or vernix, may cause complete tracheal obstruction. If you are attempting PPV, but the baby is not improving and the chest is not moving, perform each of the ventilation corrective steps (MR. SOPA) until you have successfully inflated the lungs.

If you have correctly inserted an endotracheal tube for ventilation, but still can11ot achieve chest movement, the trachea 1nay be obstructed by thick secretions. As described in Lesson 5, you may attempt to remove secretions from the trachea using a suction catheter (5F-8F) inserted through the endotracheal tube.

If the secretions are thick enough to completely obstruct the airway, you may not be able to clear them using a thin suction catheter. In this case, directly suction the trachea with a tracheal aspirator attached toan endotracheal tube (Figure 10.8). Set the suction pressure to 80 to 100 mg Hg, connect suction tubing to the aspirator, and attach the aspirator directly to the endotracheal tube connector. Sorne endotracheal tubes have an integrated aspiration device designed for suctioning the trachea. Occlude the aspirator's suction-control port

Figure 10.8. Suctioning thick secretions that obstruct ventilation using an endotracheal tube and tracheal aspirator

with your finger. You may need to gradually withdraw the tube to remove secretions from the trachea and posterior pharynx before reinserting a new endotracheal tube for ventilation. In most circumstances, establish an open airway and ventilation that inflates the lungs before proceeding to chest compressions.

Anatomic obstructions

Robin Sequence

The Robin sequence describes a combination of facial anomalies that occur because the lower jaw (mandible) does not develop normally. The lower jaw is small and set back in relation to the upper jaw. The baby's tongue is positioned further back in the pharynx than normal and obstructs the airway (Figure 10.9). It is common for babies with the Robin sequence to also have a cleft palate. This combination of findings may be isolated or part of a genetic syndrome.

If a baby with Robin sequence has labored breathing, turn the baby onto their stomach (prone). In this position, the tongue may move forward and open the airway. If prone positioning is not successful, insert a small endotracheal tube (2.5 mm) through the nose with the tip positioned deep in the posterior pharynx, past the base of the tongue, and above the vocal cords. It is not inserted into the trachea (Figure 10.10) and a laryngoscope is not required to do this. This helps to relieve the airway obstruction and facilitates spontaneous breathing.

If the baby has severe difficulty breathing and requires resuscitation, face-mask ventilation and endotracheal intubation may be very difficult. If none of the previous procedures results in adequate air movement, and attempts at face-mask ventilation and endotracheal intubation are unsuccessful, a laryngeal mask may provide a lifesaving rescue airway.

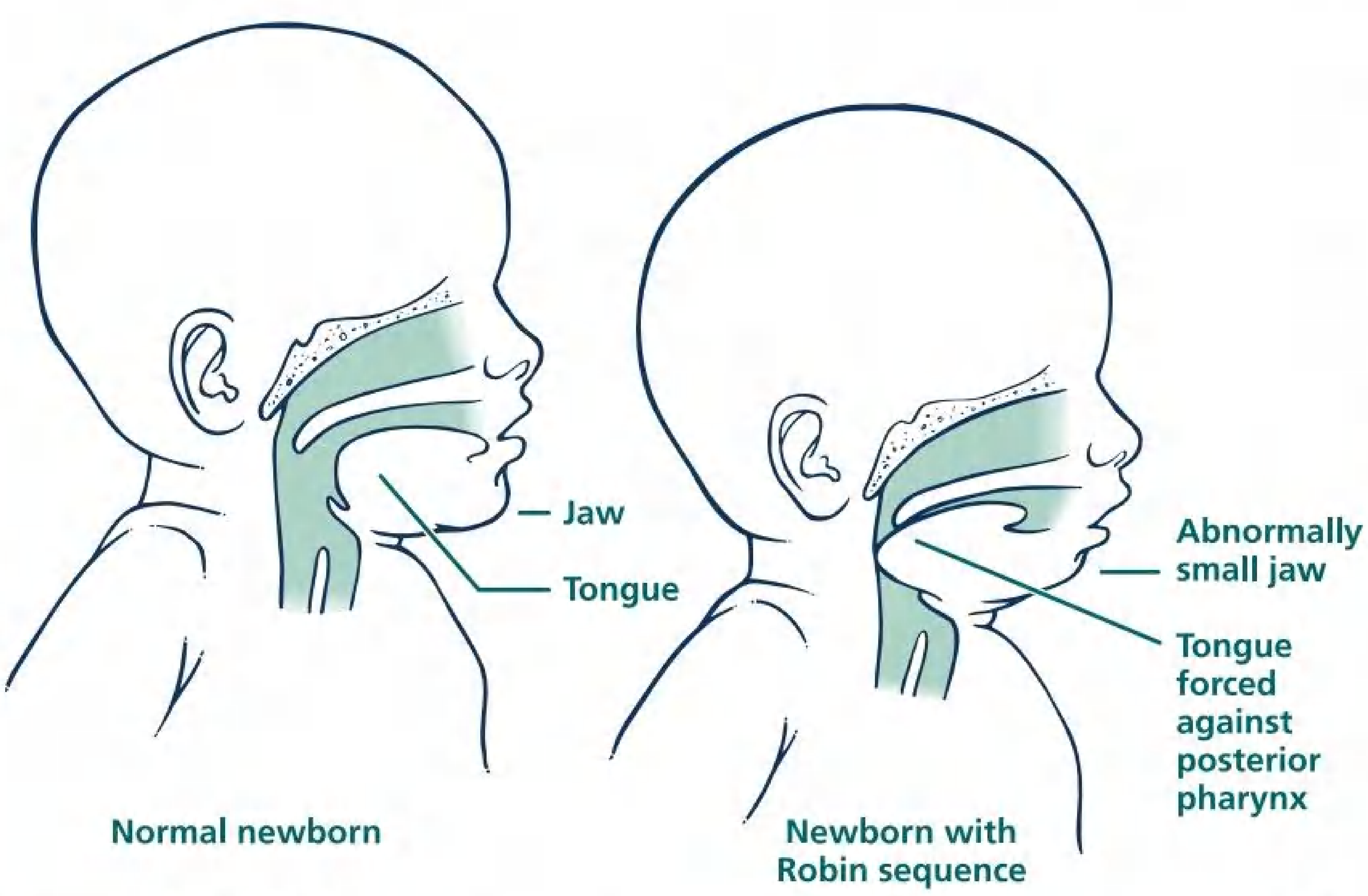


Figure 10.9. Newborn with normal anatomy (left) and newborn with Robin sequence (right)

Choanal Atresia

Choanal atresia is a condition where the nasal airway is obstructed by bone or soft tissue (Figure 10.11). Because newborns normally breathe through their nose, babies with choanal atresia may have difficulty breathing unless they are crying and breathing through their mouth. In most cases, the obstruction occurs only on one side and does not cause significant symptoms in the newborn period.

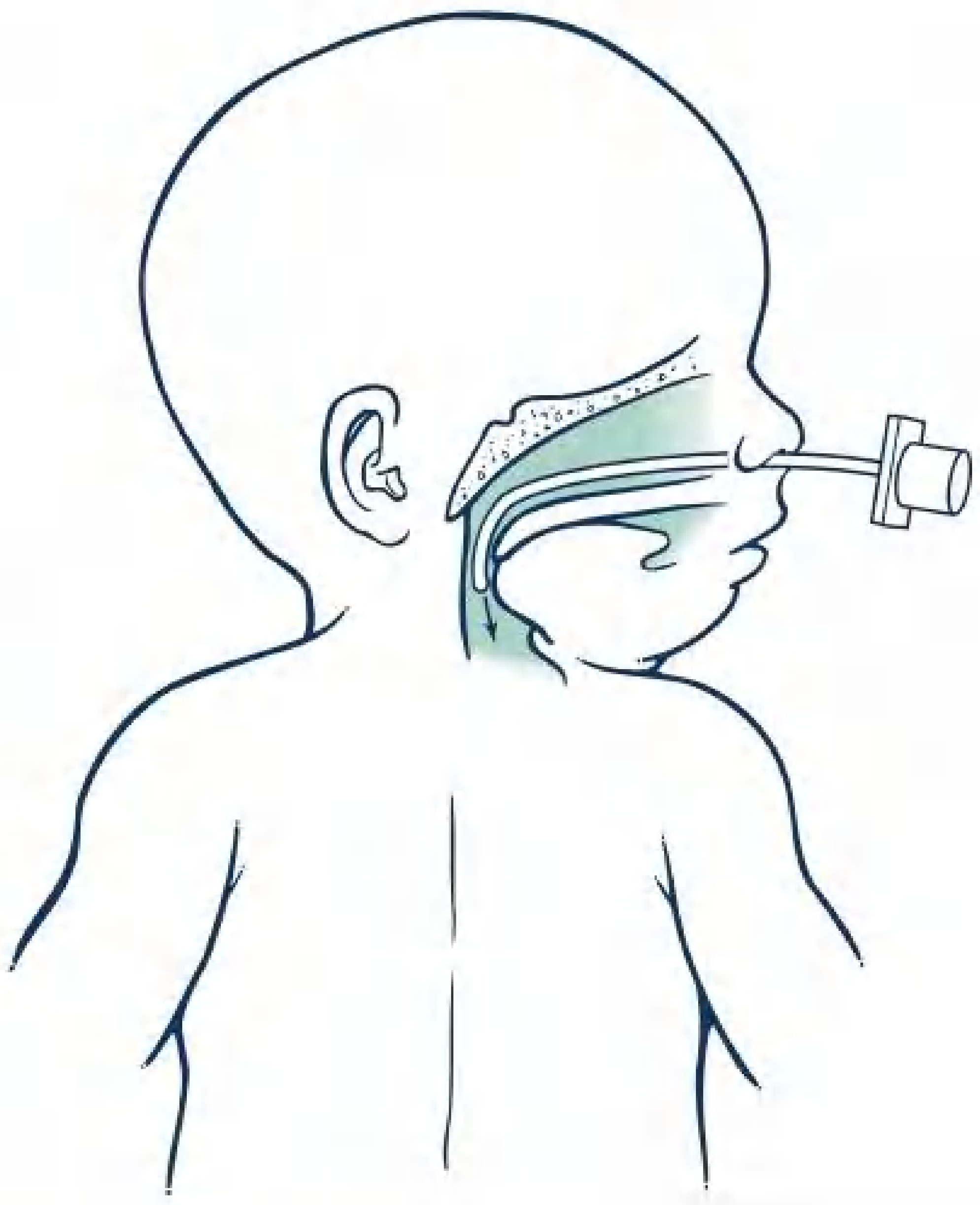


Figure 10.10. Endotracheal tube inserted deep in posterior pharynx for relief of airway obstruction in a newborn with Robin sequence. The tip of the tube is in the nasopharynx, above the vocal cords, NOT in the trachea.

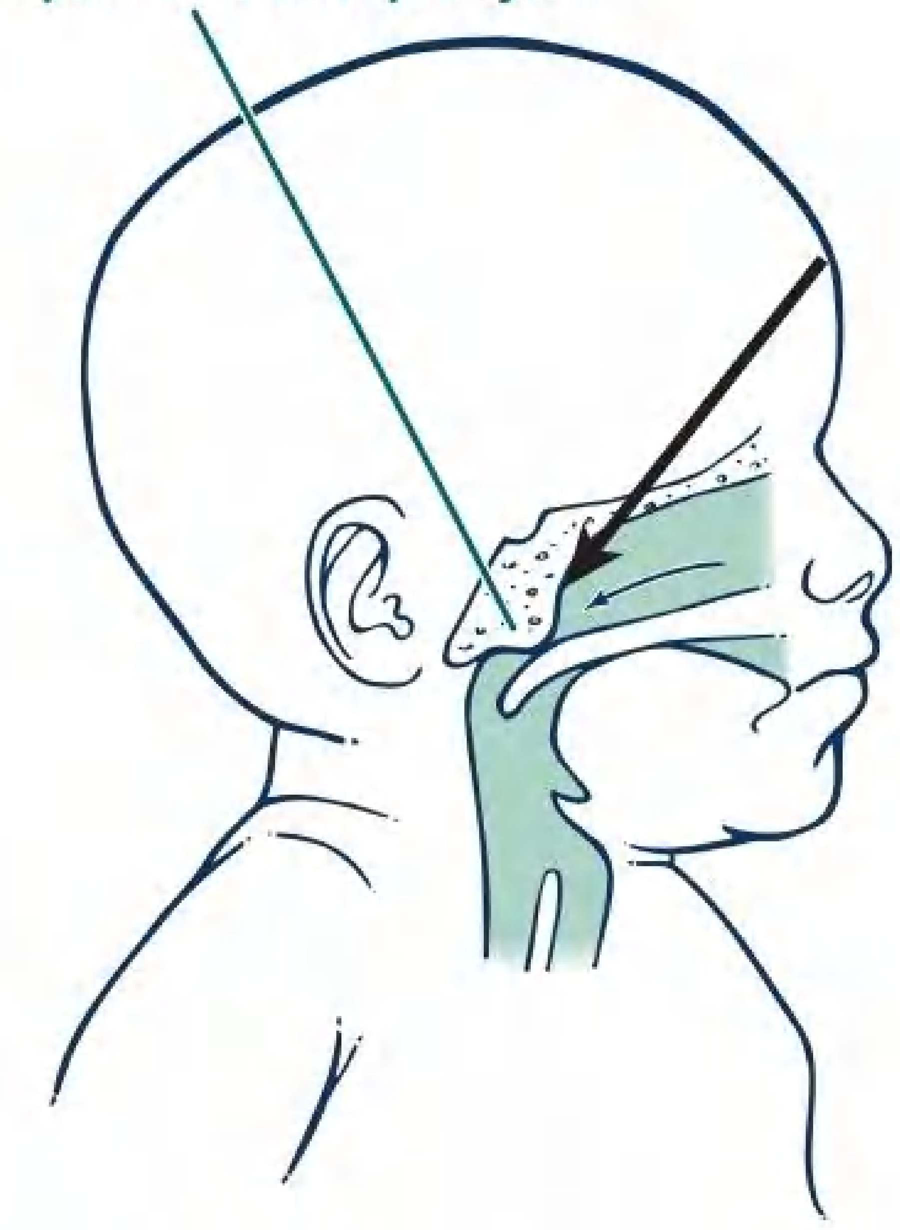


Figure 10.11. Choanal atresia causing obstruction of the nasal airway

Babies with choanal atresia may present with cyclic episodes of obstruction, cyanosis, and oxygen desaturation that occur when they are sleeping or feeding and resolve when they are crying. If the obstruction is bilateral, the baby may have difficulty breathing immediately after birth; however, the presence of choanal atresia should not prevent you from achieving effective PPV with a face mask.

You can test for choanal atresia by passing a thin suction catheter into the posterior pharynx through the nares. If the catheter will not pass, choanal atresia may be present.

If the baby has bilateral choanal atresia and respiratory distress, you can keep the mouth and airway open by inserting one of the following into the baby's mouth: a feeding nipple or pacifier modified by cutting off the end (McGovern nipple) and secured with ties around the occiput (Figure 10.12) or an endotracheal tube positioned with the tip just beyond the tongue in the posterior pharynx. Each of these measures provides temporary stabilization until the baby can be evaluated by a specialist.

Other Rare Conditions

Other conditions, such as oral, nasal, or neck masses (Figure 10.13); laryngeal and tracheal anomalies; and vascular rings that compress the trachea within the chest, have been reported as rare causes of airway compromise in the newborn. Some of these malformations will be evident by external examination. Depending on the location of the obstruction, it may be very difficult or impossible to achieve successful face-mask ventilation or to insert an endotracheal tube.

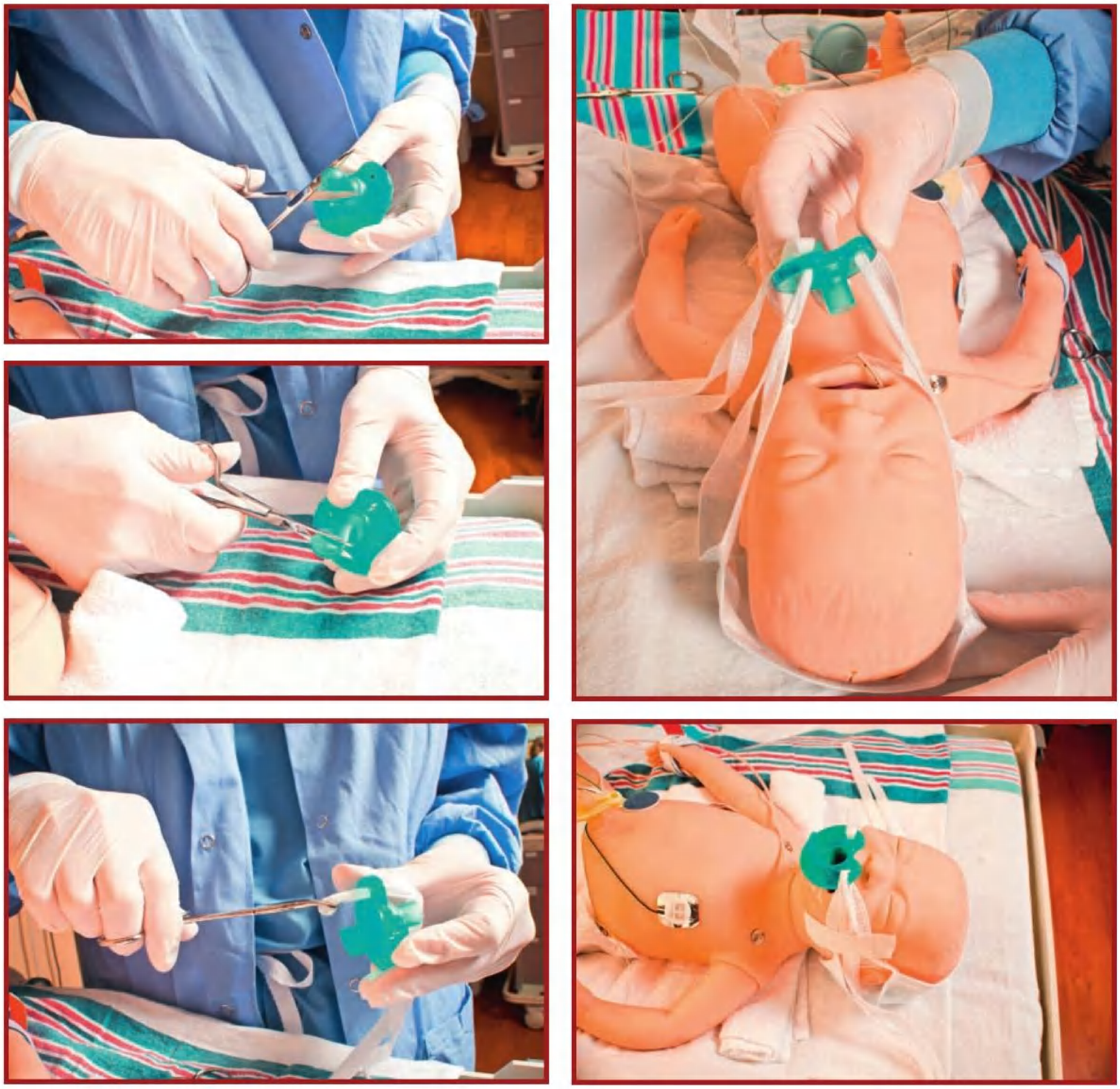


Figure 10.12. Modified pacifier (McGovern nipple) for temporary relief of airway obstruction in choanal atresia

Special expertise and equipment may be required for successful intubation. If the obstruction is above the level of the vocal cords and you cannot ventilate or intubate the baby, insertion of a laryngeal mask may provide a lifesaving rescue airway. If such problems are identified before birth, and time allows, the baby should be born in a facility where emergency management of the airway by a trained multidisciplinary team is immediately available in the delivery room.

Figure 10.13. Newborn with a neck mass (cystic hygroma). (From Boyle KB, Anderson JM. A newborn who has a neck mass and scalp abrasion. *NeoReviews.* 2006;7[4]:e211-e216.)

What abnormalities of fetal lung development can complicate resuscitation?

Congenital diaphragmatic hernia

The diaphragm normally separates the abdominal and thoracic contents. When the diaphragm does not form correctly, the intestines, stomach, and liver can enter the chest and prevent the lungs from developing normally (Figure 10.14). This defect is called a congenital diaphragmatic hernia (CDH). The most common type of CDH occurs on the baby's left side. Frequently, the defect is identified by antenatal ultrasound, and the baby's birth can be planned to occur at a high-risk center.

The baby may present with an unusually flat-appearing (scaphoid) abdomen, respiratory distress, and hypoxemia. If PPV is administered by face mask, gas enters the stomach and intestines. As these structures expand within the chest, lung inflation will be increasingly inhibited and breath sounds will be diminished on the side of the hernia. If the ventilating pressure is increased in an attempt to improve inflation, the baby may develop a pneumothorax. Pulmonary hypertension is commonly associated with a CDH and may contribute to severe hypoxemia.

Avoid face-mask PPV for babies with a diaphragmatic hernia.

Promptly intubate the trachea and insert a large orogastric catheter (10F) to intermittent or continuous suction to prevent gaseous distention (Figure 10.15). A double-lumen sump tube (Replogle tube) is most effective.

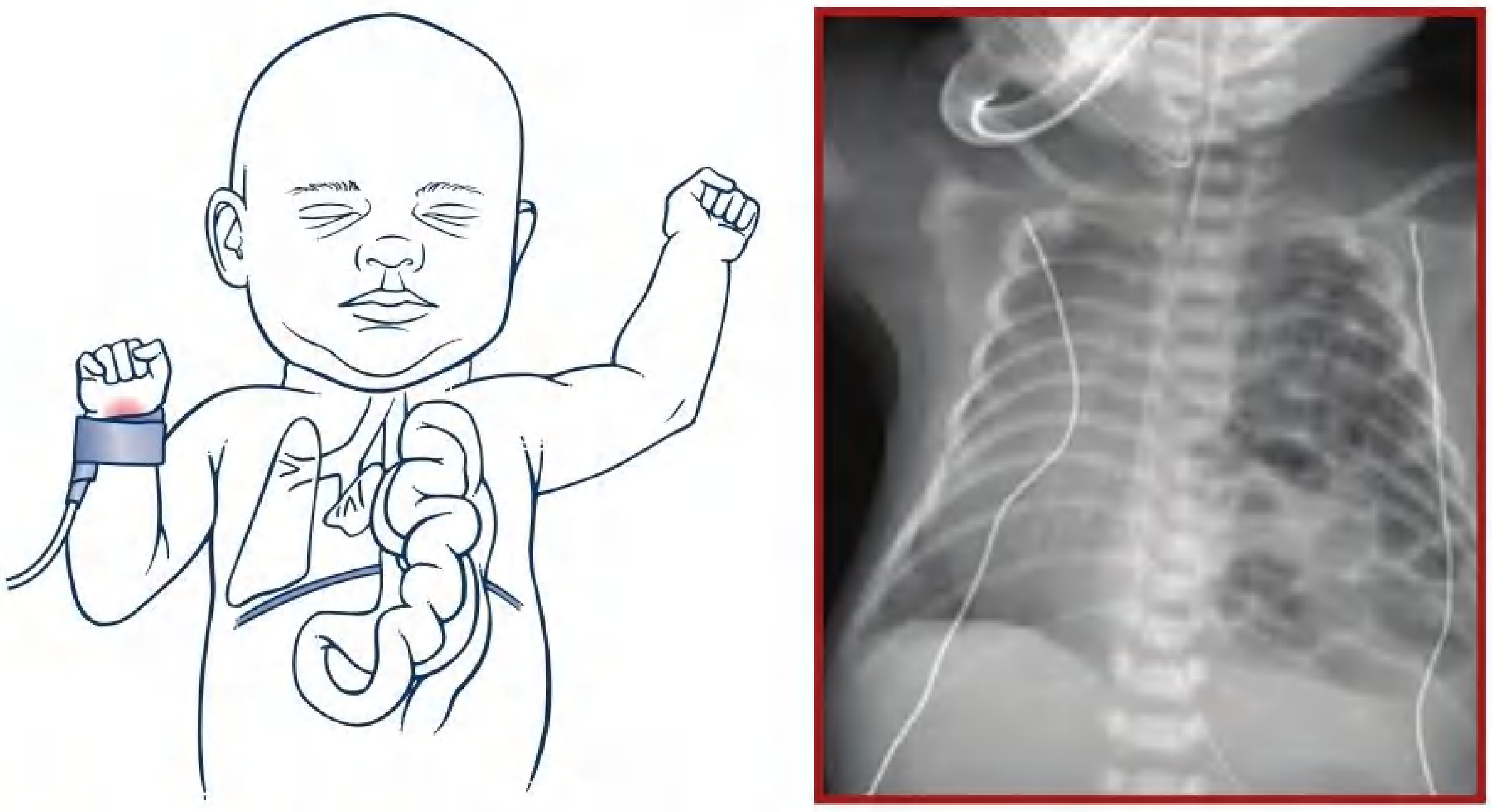


Figure 10.14. Congenital diaphragmatic hernia

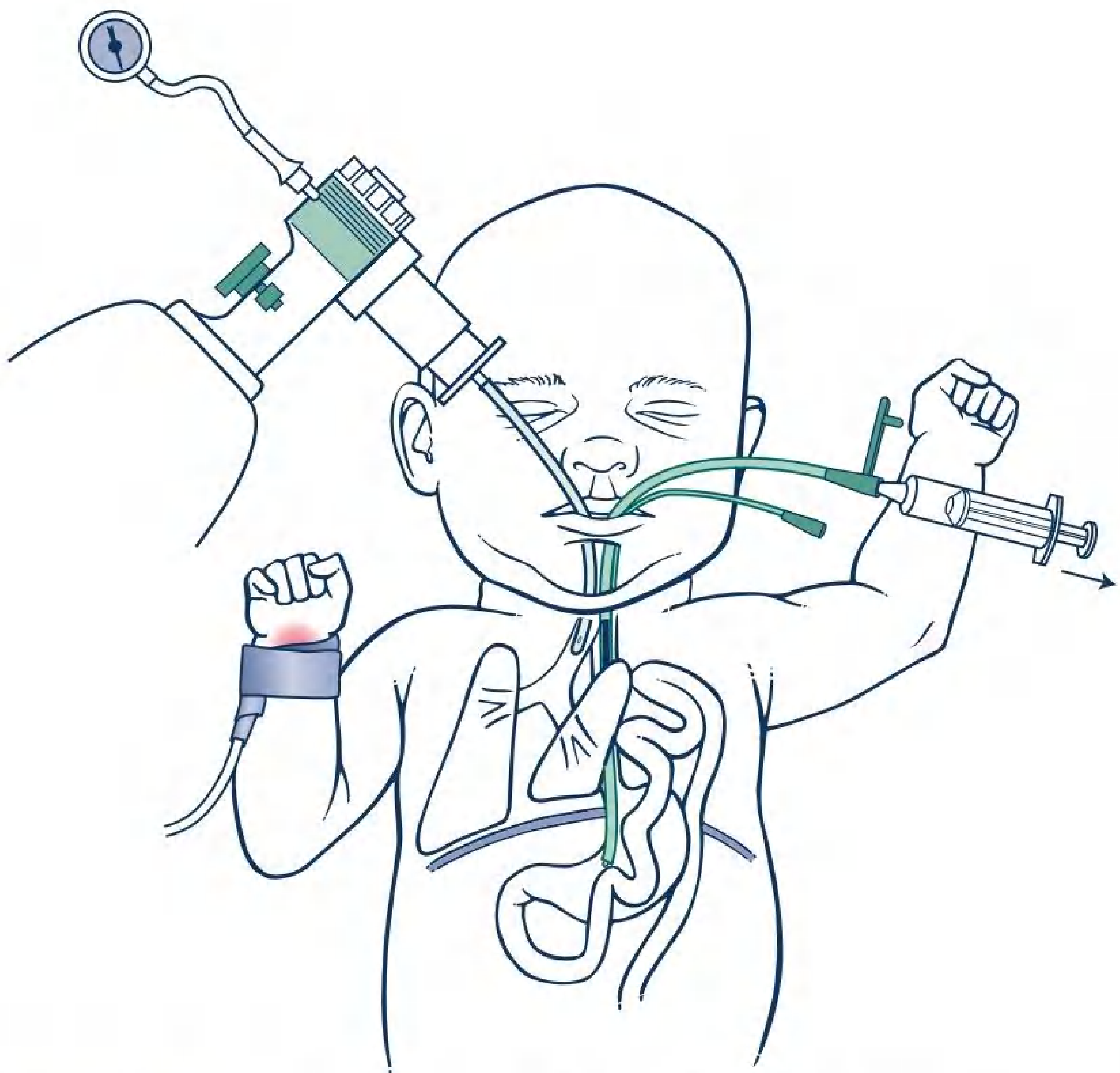


Figure 10.15. Stabilizing treatment for a baby with a CDH. An endotracheal tube is in the trachea and a double-lumen sump tube (Replogle tube) is in the stomach. The sump tube is aspirated intermittently or attached to vacuum suction. Both tubes are secured (tape and cardiac monitor leads not shown).

Pulmonary hypoplasia

Normal lung development requires adequate space within the chest. Any condition that occupies space in the chest or causes a prolonged, severe decrease in amniotic fluid (oligohydramnios) may cause the lungs to be incompletely developed. This is called pulmonary hypoplasia. Examples of conditions causing pulmonary hypoplasia include CDH and obstruction or absence of both fetal kidneys. At the time of birth, the baby's chest may appear small and bell-shaped. If pulmonary hypoplasia was caused by oligohydramnios, the baby may have deformities of the hands, feet, nose, and ears caused by compression within the uterus. High inflating pressures may be required to inflate the baby's lungs, and this increases the risk of developing pneumothoraces. Alternative methods of mechanical ventilation available in high-risk centers may be required immediately after birth. Severe pulmonary hypoplasia may be incompatible with survival.

What if the mother received an opiate during labor and her newborn is apneic or lethargic at birth?

Opiates given to the laboring mother to relieve pain may cross the placenta and decrease the newborn's activity and respiratory drive. If a newborn has respiratory depression after maternal opiate exposure, manage the baby's airway and provide respiratory support with PPV as described in previous lessons. If the baby has prolonged apnea, insertion of an endotracheal tube or laryngeal mask may be required for ongoing respiratory support.

Although the opiate antagonist naloxone has been used in this setting, there is insufficient evidence to evaluate the safety and efficacy of this practice. Very little is known about the pharmacology of naloxone in the newborn. Animal studies and case reports have raised concerns about complications from naloxone, including pulmonary edema, cardiac arrest, and seizures.

What if a baby does not breathe or has decreased activity and the mother did not receive an opiate during labor?

Other causes of neonatal depression should be considered. If PPV results in a normal heart rate and oxygen saturation, but the baby does not breathe spontaneously, the baby may have depressed respiratory drive or muscle activity due to a medication self-administered by the mother, hypoxia, severe acidosis, a structural brain abnormality, or a neuromuscular disorder. Medications given to the mother, such as magnesium sulfate and general anesthetics, can depress respirations in the newborn. There are no medications that reverse the effects of these drugs. Again, the focus is to provide airway support and effective ventilation until the medication's effect has resolved. Transport the baby to the nursery for further evaluation and management while administering PPV and monitoring the baby's heart rate and oxygen saturation.

What special care is required for a newborn with myelomeningocele (spina bifida)?

Myelomeningocele is a type of neural tube defect that affects the spinal cord and vertebrae (Figure 10.16). It most commonly involves the lower back (lumbar area). The defect occurs during the first few weeks of fetal development when the precursor of the spinal cord, the neural tube, does not completely close. A sac of fluid containing part of the spinal cord and nerves may protrude through an opening in the baby's back. It is important to protect the sac and the neural tissue from trauma. Babies with myelomeningocele may also have hydrocephalus and a defect of the brainstem and cerebellum (Arnold Chiari malformation) that can cause apnea or vocal cord paralysis.

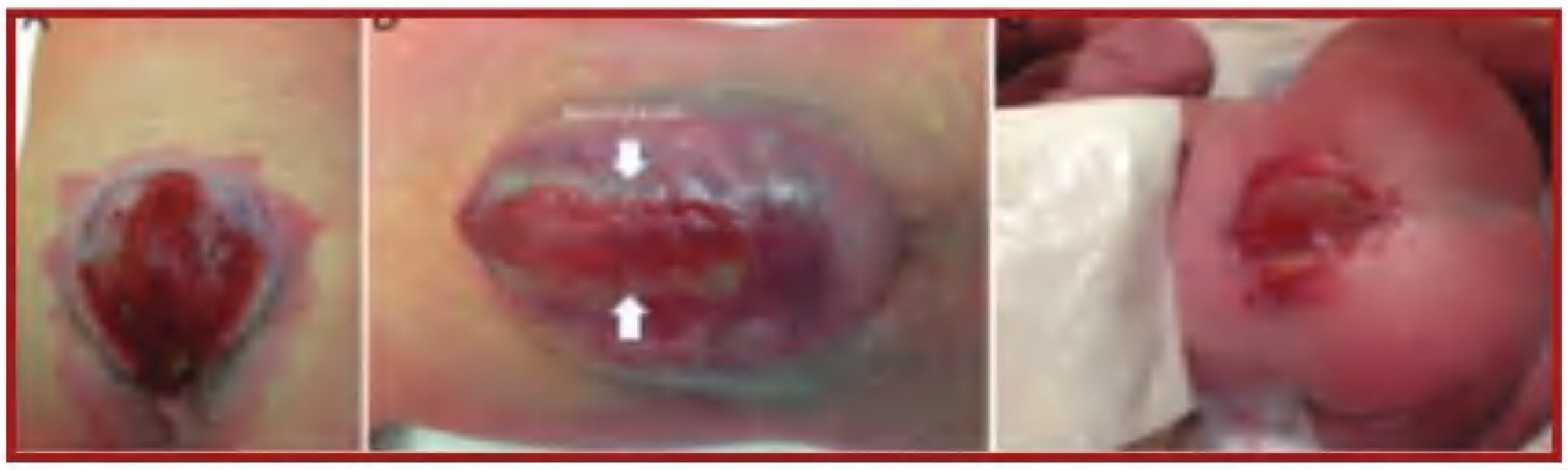


Figure 10.16. Newborns with open myelomeningocele. (From Birgisson NE, Lober RM, Grant GA. Prenatal evaluation of myelomeningocele: a neurosurgical perspective. *NeoReviews.* 2016;17[1]:e28-e36.)

- Before birth, prepare a "donut" with towels or latex-free foam covered with towels in case the baby must be positioned on their back (supine). This will allow the defect to be placed within the "donut hole."
- Newborns with neural tube defects are at risk of developing latex allergy. Use only latex-free equipment and supplies when caring for newborns with a neural tube defect.
- After birth, place the newborn lying on their side or on their stomach (prone) to avoid pressure on the fluid sac and its contents. If it is necessary to place the baby supine for airway management, position the baby on the prepared "donut" with the defect over the open "donut hole."
- Avoid drying or rubbing the defect during the initial steps of newborn care.
- Proceed with resuscitation steps as needed.
- Once the baby is stable, follow local guidelines for covering the lesion. Some experts recommend placing non-latex, transparent plastic wrap across the lesion and wrapping it around the baby's abdomen/waist (with or without a non-adherent, moist gauze between the lesion and the plastic wrap).
- Use caution to avoid rupturing the sac.

What special care is required for a newborn with an abdominal wall defect?

The most common abdominal wall defects found in newborns are gastroschisis and omphalocele. Both are often identified by prenatal ultrasound, and birth can be planned at a high-risk center.

Gastroschisis (Figure 10.17A) is a defect where the baby's bowel protrudes through an opening in the abdominal wall. Most often, the defect is found on the right side of a normal-appearing umbilical cord. Although babies with gastroschisis are often born preterm or small for gestational age, most do not have any other anomalies.

Omphalocele is a defect in the abdominal wall that includes the umbilical cord (Figure 10.17B). The baby's bowel is often contained within a large membranous sac that may contain other abdominal organs. The sac may rupture before or after delivery, exposing the abdominal contents. Babies with omphalocele frequently have other congenital anomalies or genetic syndromes.

For both defects, it is important to protect the bowel and abdominal organs from trauma.

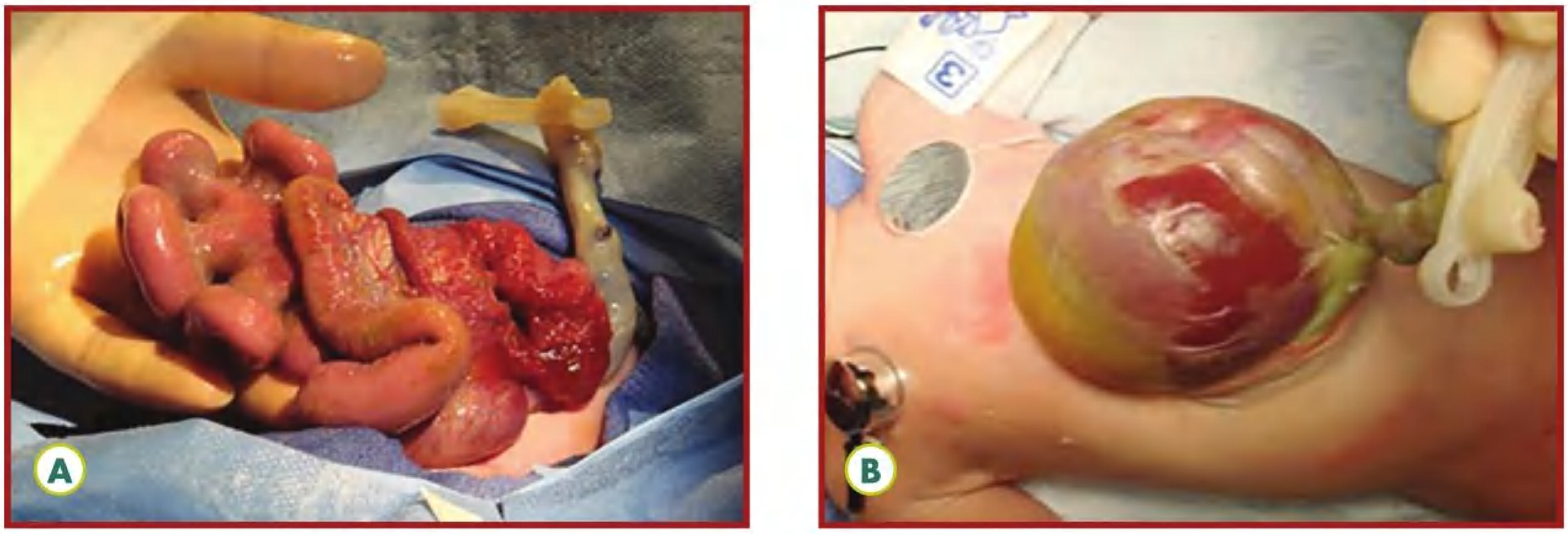


Figure 10.17. Abdominal wall defects. Gastroschisis (A) with no sac covering the protruding bowel. The defect is to the right of the umbilicus. Omphalocele (B) with abdominal contents within a sac. The defect involves the umbilical cord. (From Slater BJ, Pimpalwar A. Abdominal wall effects. *NeoReviews.* 2020;21[6]:e383-e391.)

The following are special considerations for gastroschisis:

- Ask the obstetric provider to clamp and cut the umbilical cord at least 10 to 20 cm (4-8 inches) from the baby because the cord may be used as part of the surgical repair.
- Place the baby and the exposed bowel in a sterile, clear plastic bowel bag and secure the bag across the baby's chest.
- Position the baby and exposed bowel on the right side to optimize perfusion.
- Cardiac monitor leads can be placed on the baby's upper chest and arms.
- Avoid prolonged face-mask ventilation to prevent air from distending the bowel. If assisted ventilation is necessary, consider inserting an endotracheal tube or laryngeal mask.
- Insert a large orogastric catheter (8F or 10F) and use low intermittent or continuous suction to prevent gaseous distention of the bowel. A double-lumen sump tube (Replogle tube) is most effective.
- Minimize handling of the exposed bowel but frequently monitor its color to identify worsening perfusion.
- In an emergency, an umbilical venous catheter can be inserted, however; attempt to leave as much intact umbilical cord length as possible to assist the surgical repair.
- The exposed bowel increases heat and fluid losses. Careful attention to temperature management and fluid administration is necessary.

The following are special considerations for omphalocele:

- Be cautious to clamp and cut the umbilical cord well above the bowel or abdominal organs enclosed within the defect.
- Place the baby's lower body, including the omphalocele, in a sterile, clear plastic bowel bag and secure the bag across the baby's chest.
- Position the baby and omphalocele on the right side to optimize perfusion.
- Cardiac monitor leads can be placed on the baby's upper chest and arms.
- Insert a large orogastric catheter (8F or 10F) and use intermittent or continuous suction to prevent gaseous distention of the bowel. A double-lumen sump tube (Replogle tube) is most effective.
- Handle the omphalocele gently to avoid rupturing the sac or injuring the abdominal contents.

- Assess the baby's respiratory status. Newborns with large omphaloceles may require respiratory support, including continuous positive airway pressure (CPAP) or mechanical ventilation.
- An umbilical venous catheter cannot be used for emergency vascular access. If emergency access is required during resuscitation, an intraosseous needle can be used.

Focus on Teamwork

The special considerations described in this lesson highlight several opportunities for effective teams to use the NRP Key Behavioral Skills.

Behavior	Example
Anticipate and plan. Use available information. Communicate effectively.	Through effective communication with the obstetric team, identify important antenatal risk factors, such as maternal narcotic exposure, abnormal amniotic fluid volume, and the results of prenatal ultrasound examinations. Share the information with your team so that you can anticipate high-risk deliveries and adequately prepare for resuscitation.
Use available resources.	Be aware of what resources are available to stabilize a newborn with a difficult airway. Where is the equipment stored?

Quality Improvement Opportunities

Ask yourself the following questions and begin a discussion with your team if you find a difference between the NRP recommendations and what is currently done in your own hospital setting. Consider using the suggested process and outcome measures to guide your data collection, identify areas for improvement, and monitor if your improvement efforts are working.

Quality improvement questions

1. Who are the health care professionals that can perform an emergency thoracentesis?
2. Is someone with these skills immediately accessible if needed?
3. Is a kit with all necessary supplies for emergency thoracentesis immediately accessible if needed?
4. Do you have latex-free equipment and supplies in your delivery area?
5. Do you have sterile, clear plastic bowel bags in your delivery area?

6. How does your team know that a baby with a serious congenital anomaly will be born?

7. Does your obstetric team have a mechanism for communicating with your resuscitation team and planning for the birth and immediate newborn care?

Process and outcome measures

1. How often are newborns with serious congenital anomalies diagnosed only after birth?

2. How often are newborns at your hospital diagnosed with a pneumothorax?

3. How long does it take to assemble a team qualified to manage an unanticipated newborn emergency?

LESSON 10 REVIEW

1. A newborn's heart rate is 50 beats per minute and has not improved with ventilation through a face mask or properly inserted endotracheal tube. The baby's chest is NOT moving with positive-pressure ventilation. You should (suction the trachea using a 5F to 8F suction catheter or tracheal aspirator)/(proceed immediately to chest compressions).

2. A newborn has respiratory distress after birth. The baby has a small lower jaw and a cleft palate. The baby's respiratory distress may improve if you insert a small endotracheal tube in the nose, advance it into the pharynx, and position the baby (supine [on the back])/(prone [on the stomach]).

3. You attended the birth of a baby that received positive-pressure ventilation during the first minutes of life. The baby improved and has been monitored in the nursery. A short time later, the baby developed acute respiratory distress. You should suspect (a pneumothorax)/(a congenital heart defect) and should rapidly prepare (a needle aspiration device)/(epinephrine).

4. You attend the birth of a baby with antenatally diagnosed congenital diaphragmatic hernia. Promptly after birth, you should (begin face-mask ventilation and insert an orogastric tube in the

stomach)/(intubate the trachea and insert an orogastric tube in the stomach).

5. A mother received an opiate medication for pain relief 1 hour before delivery. After birth, the baby does not have spontaneous respirations and does not improve with stimulation. Your first priority is to (start positive-pressure ventilation)/(administer the opiate antagonist naloxone).

6. After birth, position a newborn with myelomeningocele on their (back)/(stomach or side).

7. After birth, place a newborn with gastroschisis in a sterile, clear plastic bowel bag and position the baby on their (back)/(right side).

Answers

1. You should suction the trachea using a 5F to 8F suction catheter or tracheal aspirator.

2. The baby's respiratory distress may improve if you insert a small endotracheal tube in the nose, advance it into the pharynx, and position the baby prone (on the stomach).

3. You should suspect a pneumothorax and should rapidly prepare a needle aspiration device.

4. Promptly after birth, you should intubate the trachea and insert an orogastric tube in the stomach.

5. Your first priority is to start positive-pressure ventilation.

6. Position a newborn with myelomeningocele on their stomach or side.

7. Position a newborn with gastroschisis on their right side.

Ethics and Care at the End of Life

11

What you will learn

- The ethical principles associated with neonatal resuscitation
- When it may be appropriate to withhold resuscitation
- What to do when the prognosis is uncertain
- What to do when a baby dies
- How to help parents and staff through the grieving process

Key Points

1. The ethical principles of neonatal resuscitation are the same as those followed in resuscitating an older child or adult.
2. Parents are generally considered the best surrogate decision makers for their babies and should be involved in shared decision-making whenever possible. For parents to fulfill this responsibility, they need comprehensive, relevant, and up-to-date information about the risks and benefits of each treatment option.
3. Parents need to be informed that, despite your best efforts, the ability to give an accurate prognosis for an extremely preterm baby remains limited either before or immediately after birth.
4. The primary consideration for decisions regarding life-sustaining treatment for seriously ill newborns should be what is best for the newborn.
5. If the responsible physicians believe that there is no chance for survival, initiation of resuscitation is not an ethical treatment option and should not be offered.
6. In conditions associated with a high risk of mortality or significant burden of morbidity for the baby, parents should participate in the decision whether attempted resuscitation is in their baby's best interest. If there is agreement that intensive medical care will not improve the chances for the newborn's survival or will pose an unacceptable burden on the child, it is ethical to withhold resuscitation.
7. There may be laws in the area where you practice that apply to the care of newborns in the delivery room. If you are uncertain about the laws in your area, consult your hospital ethics committee or attorney.
8. Humane, compassionate, and culturally sensitive palliative care should be provided for all newborns for whom resuscitation is not initiated or is not successful.

About this lesson

Although this lesson is directed at the resuscitation team member who guides medical decision-making, all members of the resuscitation team should understand the reasoning behind the decisions. As much as possible, there should be unified support of the parents during their very personal period of crisis. This lesson refers to "parents," although it is recognized that sometimes the mother(s), father(s), or partner(s) may be alone during the crisis and, other times, support will be available through extended family or significant others. This lesson is applicable to health care providers who participate in all aspects of care of pregnant women and newborns, including antenatal care providers, pediatricians doing preconception and prenatal consultations, inpatient perinatal care providers, and professionals providing care to families who have experienced a neonatal death.

It is important to recognize that the recommendations made in this lesson are determined, to an extent, by the cultural context and available resources in the United States and Canada and may require adaptation before being applied to other cultures and countries. These recommendations were based on mortality and morbidity data available at the time of publication. Decisions regarding initiation or non-initiation of resuscitation should be based on current local data and available therapies.

The following case is an example of the ethical considerations involved in neonatal resuscitation and how end-of-life care may be provided. As you read the case, imagine yourself as part of the care team.

Case: A baby who could not be resuscitated

A woman is admitted to the hospital at 23 weeks' gestation with contractions, fever, fetal tachycardia, and ruptured membranes leaking purulent amniotic fluid. She has had consistent prenatal care and the gestational age was estimated by a first-trimester ultrasound. You meet with the obstetric care provider and discuss the pregnancy history. Together, you review current national and local data describing the anticipated short- and long-term outcomes at this extremely early gestation. Afterward, both of you meet with the parents to provide information, discuss goals, explain the treatment options, and develop a care plan. You explain that some parents might decide that attempting resuscitation and life-sustaining medical treatment is not in their baby's best interest in view of the high risk of mortality and morbidity and might, instead, choose palliative care focusing on the baby's comfort after birth. After considering the content of your discussion, the parents indicate that they want a trial of resuscitation and life-sustaining therapy with assisted ventilation, including intubation, but they do not want chest compressions or emergency medications administered. The parents request the presence of the hospital clergy during resuscitation, and this is quickly arranged. You document your discussion in the medical chart and meet with your resuscitation team to review the care plan.

Your team performs a pre-resuscitation team briefing and prepares the supplies and equipment for a complex resuscitation. At the time of birth, the baby is limp and apneic, and has thin, gelatinous skin. The baby is carried to the radiant warmer, wrapped in polyethylene plastic, and placed on a thermal mattress, and a hat is placed on the baby's head. The initial steps are performed and positive-pressure ventilation (PPV) is administered. A team member places a pulse oximeter sensor and cardiac monitor leads. The baby's heart rate is 40 beats per minute (bpm) and not improving with face-mask ventilation that moves the chest. The baby is successfully intubated and PPV is continued; however, the heart rate does not increase and the oxygen saturation remains well below the target range. Despite appropriate ventilation, the baby's heart rate gradually decreases. You explain the baby's condition to the parents and your assessment that resuscitation will not be successful. You agree to remove the endotracheal tube, wrap the baby in a clean blanket, and bring the baby to the parents to be held and comforted. A ceremonial blessing is performed by the hospital clergy. Staff members and additional family provide ongoing support. The baby is pronounced dead when no signs of life remain.

Shortly afterward, you return to the parents' room, express condolences, answer their questions about the resuscitation attempt, and ask the parents about performing an autopsy. You offer to schedule a follow-up visit in several weeks to discuss the autopsy findings. The next day, a funeral home is identified. About 1 month later, you meet with the parents to discuss the results, answer questions, ask about problems the family may be having adjusting to their loss, and suggest grief counseling resources available in the community.

What ethical principles apply to neonatal resuscitation?

The ethical principles of neonatal resuscitation are the same as those followed in resuscitating an older child or adult. Common ethical principles that apply to all medical care include respecting an individual's rights to make choices that affect their life (autonomy), acting to benefit others (beneficence), avoiding harm (nonmaleficence), and treating people truthfully and fairly (justice). These principles underlie why we ask patients for informed consent before proceeding with treatment. Exceptions to this rule include life-threatening medical emergencies where there is inadequate time to obtain informed consent before proceeding with treatment and situations where patients are not competent to make their own decisions. These 2 exceptions are relevant to neonatal resuscitation. Sometimes neonatal resuscitations are associated with medical emergencies that interfere with the informed consent process, and newborns cannot make their own decisions.

What role should parents play in decisions about resuscitation?

Unlike adults, newborns cannot express their desires or make decisions for themselves. A surrogate decision maker must be identified to assume the responsibility of guarding the newborn's best interests. Generally, parents are considered to be the best surrogate decision makers for their own babies, and they should be involved in shared decision-making whenever possible. For parents to fulfill this responsibility, they need relevant, accurate, and honest information about the risks and benefits of each treatment option. In addition, they must have adequate time to thoughtfully consider each option, ask questions, and seek other opinions. Unfortunately, the need for resuscitation is sometimes an unexpected emergency with little opportunity to achieve fully informed consent before proceeding. Even when you have the opportunity to meet with parents, uncertainty about the extent of congenital anomalies, the actual gestational age, the likelihood of survival, and the potential for severe disabilities may make it difficult for parents to decide what is in their baby's best interest before the baby is born. Complete information may not be available until after birth and perhaps not for several hours or days. These uncertainties should be addressed with the parents when the initial treatment plan is developed, and contingencies should be discussed. Parents and health care providers must be prepared to reevaluate their goals and plans based on the findings after birth and the baby's response to treatment. Discussions about the newborn's best interests may continue well beyond the delivery room.

What are the considerations involved in the decision whether to initiate resuscitation of an extremely premature baby?

Parents should be provided with comprehensive, relevant, up-to-date prognostic information. Antenatal outcome estimates for survival and disability among extremely premature babies typically have been based on gestational age and estimated weight. Unless the pregnancy was conceived by assisted reproductive technology where the date of fertilization or implantation can be defined, techniques used for obstetric dating are accurate to 3 to 5 days if applied in the first trimester, but only to ±1 to 2 weeks subsequently. Estimates of fetal weight are accurate only to ±15% to 20% and may be misleading if there is intrauterine growth restriction. Even small discrepancies of 1 or 2 weeks between estimated and actual gestational age, or a 100- to 200-g difference in birth weight, may have implications for survival and long-term morbidity.

Maternal health, obstetric complications, and genetic factors also influence outcome. Scoring systems that include variables such as gender, use of antenatal steroids, and multifetal gestation have been developed in an effort to improve prognostic accuracy. Be cautious when interpreting results from different studies. Some investigators may describe the proportion of babies with each outcome based on the total number of live-born babies while others describe the same outcome based on the number of babies resuscitated, the number of babies admitted to the nursery, or the number surviving until discharge. By simply changing the inclusion criteria for the calculation, the likelihood of an adverse outcome will change.

Remember that prognostic scores provide a range of plausible outcomes based on a sample of babies; however, they cannot definitively predict the outcome for any individual baby. Outcomes reported in published studies may not reflect current treatment practices or outcomes at your institution. In addition, the baby's appearance at the time of birth is not an accurate predictor of survival or disability. Parents need to be informed that, despite your best efforts, the ability to give an accurate prognosis for a specific newborn either before or immediately after birth remains limited.

Guidelines for the care of infants born at an extremely low gestational age are complex and evolving. For the most comprehensive and up-to-date guidance, refer to the current Clinical Report published by the American Academy of Pediatrics Committee on Fetus and Newborn and the Obstetric Care Consensus published by the American College of Obstetricians and Gynecologists (ACOG).

Are there situations in which it is ethical not to initiate resuscitation?

The birth of extremely premature babies and those with significant chromosomal abnormalities or congenital malformations frequently raises difficult questions about the initiation of resuscitation. Although general recommendations can guide practice, each situation is unique, and decision-making should be individualized.

If the responsible physicians believe that there is no chance for survival, the initiation of resuscitation offers no benefit to the baby and should not be offered. Humane, compassionate, and culturally sensitive palliative care focused on ensuring the baby's comfort is the medically and ethically appropriate treatment.

In conditions associated with a high risk of mortality or significant burden of morbidity for the baby, caregivers should discuss the risks and benefits of life-sustaining medical treatment with the parents and involve them in decision-making about whether attempting resuscitation is in their baby's best interest. If there is agreement between the parents and the caregivers that attempts at life-sustaining medical treatment are not likely to be successful or will pose an unacceptable burden on the child, it is ethical to provide compassionate palliative care and not initiate resuscitation. If the parents' preferences regarding resuscitation are either unknown or uncertain, resuscitation should be initiated pending further discussions.

The following statement from the American Medical Association (AMA) Code of Medical Ethics (AMA Opinion 2.215, 2010-2011) summarizes this approach to decision-making and is endorsed by the Neonatal Resuscitation Program® (NRP®).

The primary consideration for decisions regarding life-sustaining treatment for seriously ill newborns should be what is best for the newborn.

Factors that should be weighed are as follows:

1. The chance that the therapy will succeed
2. The risks involved with treatment and nontreatment
3. The degree to which the therapy, if successful, will extend life
4. The pain and discomfort associated with the therapy
5. The anticipated quality of life for the newborn with and without treatment

What should you do if you are uncertain about the chances of survival or serious disability when you examine the baby after birth?

If parents are uncertain how to proceed, or your examination suggests that the prenatal assessment of disability was incorrect, initial resuscitation and stabilization allows you additional time to gather more complete clinical information and to review the situation with the parents and consultants.

Once you have resuscitated a baby, are you ethically obligated to continue life-sustaining therapies?

No, you are not ethically obligated to continue life-sustaining therapies. Withholding resuscitation and withdrawing life-sustaining treatment during or after resuscitation are ethically equivalent. If the responsible health care providers and parents determine that life-sustaining treatment is no longer in the baby's best interest, they may choose to redirect from life-sustaining treatment to palliative care and focus on ensuring the baby's comfort.

What laws apply to neonatal resuscitation?

Medical ethics provide guidelines describing how health care providers *should* act within a society. Based on these guiding principles, governments create and enforce laws that describe how individuals *must* act. There is currently no federal law in the United States mandating delivery room resuscitation in all circumstances. There may be laws in the area where you practice that apply to the care of newborns in the delivery room. If you are uncertain about the laws in your area, you should consult your hospital ethics committee or attorney. In most circumstances, it is ethically and legally acceptable to withhold or withdraw resuscitation efforts if the parents and health care providers agree that further medical intervention would be futile, would merely prolong dying, or would not offer sufficient benefit to justify the burdens imposed on the baby.

Specific rights and responsibilities of minors, fathers, and unmarried partners may vary between states. You should meet with your hospital's legal counsel if you have questions about the regulations in the location where you practice.

How do you inform parents that their baby is dying?

If the newborn in your care is not responding to treatment and is dying, your role is to support the parents by being honest and speaking in an empathic and caring manner. Ask if they have chosen a name for their baby and, if they have, refer to the baby by name. Explain what treatment you have provided and your assessment of the baby's current condition. State clearly and without euphemism that, despite treatment, their baby is dying. Explain how you plan to provide care for their dying baby and what options are available.

Some parents may be interested in pursuing organ or tissue donation. Although many neonatal deaths will not meet eligibility criteria because of small size or the time interval between withdrawal of life-sustaining therapy and death, many potentially eligible donations have been lost because the neonatal team failed to make a timely referral to their organ procurement agency. When a neonatal death is anticipated, it is important to consult your regional organ procurement agency regarding eligibility criteria so that you can advise the parents about potential donation options.

How do you take care of a baby who is dying?

The most important goal is to minimize suffering by providing humane and compassionate care. Offer to bring the baby to the parent(s). Silence the alarms on monitors and medical equipment before removing them. Remove any unnecessary tubes, tape, monitors, or medical equipment, and gently clean the baby's mouth and face. If the cause of the baby's death is uncertain or the death will be investigated by the coroner or medical examiner, it may be important to leave all medical devices and tubes in place. Wrap the baby in a clean, warm blanket. Opiates may be administered as needed, either orally, nasally, or intravenously, to relieve the baby's discomfort. Prepare the parents for what they may see, feel, and hear when they hold their dying baby, including the possibility of gasping, agonal respirations, color changes, persistent heartbeat, and continuing movements. If the baby has obvious congenital anomalies, briefly explain to the parents what they will see. Help them look beyond any deformities by pointing out a good or memorable feature. Some units prepare a memory box for the parents with the baby's handprints or footprints, photographs, and other items.

Parents should be offered private time with their baby in a comfortable environment, but a health care provider should check at intervals to see if anything is needed. The baby's chest should be auscultated intermittently for at least 60 seconds, as a very slow heart rate may persist for hours. Disturbing noises such as phone calls, pagers, monitor alarms, and staff conversations should be minimized. When the parents are ready for you to take the baby, the baby should be taken to a designated, private location until ready to be transported to the morgue.

A member of the neonatal team should discuss the locally available options for performing a complete or limited autopsy. An autopsy can help determine the precise cause of death, confirm prenatal diagnoses, and reveal important new diagnoses. By further delineating the cause of death, an autopsy may reduce parental concerns and provide additional insight into the potential implications for future pregnancies.

It is very helpful to understand the cultural and religious expectations surrounding death in the community you serve. Some families grieve quietly while others are more demonstrative; however, all modes are acceptable and should be accommodated. Some parents may prefer to be alone, while others may want their other children, their extended family, friends, community members, and/or clergy to be with them.

Families may request to take their baby to a hospital chapel or a more peaceful setting outside, or they may ask for help with arrangements for blessings or rites for their dead or dying baby. You should be as flexible as you can in responding to their wishes.

It is helpful to anticipate this difficult situation in advance and develop a protocol. Plan which staff members will be responsible for providing palliative care and how other members of the team can provide support. Members of the neonatal team may play an important role even if the baby is born so prematurely that life-sustaining therapy is not indicated. They may offer the parents reassurance that the gestational age assessment is correct and use their expertise to help provide comfort care for the baby. Many nurseries develop a package of helpful information for staff members, including phone numbers for key support staff, instructions for completing the required administrative tasks, reminders about how to prepare the baby's body, and bereavement information for the family.

What follow-up arrangements should be planned for the parents?

Before the parents leave the hospital, make sure you have contact information for them, and provide them with details about how to contact the attending physician, bereavement professionals, and, if available, a perinatal loss support group. If your institution does not provide these services, it may be helpful to contact your regional perinatal referral center to obtain contact information for the parents. It is important to involve the family's primary care physician and/or obstetric provider so they can provide additional support. The attending physician may schedule a follow-up appointment to answer any unresolved questions, review results of the autopsy or other studies pending at the time of death, and assess the family's needs. Parents should be directed to the obstetric provider if they have questions regarding events and care before birth. Some hospitals sponsor parent-to-parent support groups and plan an annual memorial service, bringing together families who have suffered a perinatal loss. Recognize that some families may not want any additional contact from the hospital staff. This desire must be respected. Unexpected communications, such as a quality assurance survey from the hospital, or newsletters about baby care, may be an unwanted reminder of the family's loss.

How do you support the staff in the nursery after a perinatal death?

Staff members who participated in the care of the baby and family also need support. They will have feelings of sadness and may be feeling anger and guilt. Consider holding a debriefing session shortly after the baby's death so you can openly discuss questions and feelings in a professional, supportive, and nonjudgmental forum. Some staff members may disagree with the parents' decisions. These feelings may be discussed during the debriefing but should not be expressed to the family. Questions and issues regarding care decisions and actions should be discussed only in a qualified peer review session and should follow hospital policy for such sessions.

Focus on Teamwork

The ethical considerations and end-of-life care described in this lesson highlight several opportunities for effective teams to use the NRP Key Behavioral Skills.

Behavior	Example
Anticipate and plan.	Plan how you will provide antenatal counseling and manage difficult ethical decisions. Develop a protocol to use when caring for a dying baby and supporting the grieving family.
Communicate effectively.	When counseling parents, use clear language and terminology that they will understand. Visual aids and written materials may be helpful. Use an appropriately trained medical interpreter if a family member is not proficient in the language spoken by the health care team or has a hearing disability.
Use available information.	Review both national and local outcome data and understand their limitations. Use all available prognostic information.
Use available resources. Call for additional help when needed.	Become familiar with the resources in your hospital and community that can help to resolve conflicts, answer legal questions, and provide bereavement services. If necessary, consult with specialists at your regional referral center to obtain up-to-date outcome information.
Maintain professional behavior.	Ensure that all members of the health care team understand the treatment plan. Disagreements should be discussed in an appropriate forum. Consult the hospital ethics committee or legal counsel if necessary.
Know your environment.	Understand the cultural and religious expectations surrounding death in your community.

Quality Improvement Opportunities

Ask yourself the following questions and begin a discussion with your team if you find a difference between the NRP recommendations and what is currently done in your own hospital setting. Consider using the suggested process and outcome measures to guide the data you can collect to identify areas for improvement and monitor if your improvement efforts are working.

Quality improvement questions

1. Is up-to-date prognostic information for extremely preterm babies and babies with serious congenital anomalies readily available for staff doing antenatal counseling?
2. Do you have a package of information for staff with instructions for helping the family make memories, completing administrative tasks, and preparing the baby's body?
3. Do you have a package of information about local resources for grieving families?
4. Do you know how to urgently contact clergy for families that desire religious counseling or blessings for their baby?
5. Do you know how to contact your hospital attorney to answer questions about laws related to resuscitation in your area?
6. Does your unit offer education and other programs to support staff providing palliative, end-of-life, and bereavement care?
7. Does your perinatal team meet to discuss how you will care for babies at the limits of viability to develop a consistent approach?
8. How are individual care plans that are developed before a baby is born communicated to the staff that will be present at a baby's birth?

Process and outcome measures

1. What percentage of parents meet with a neonatal care provider for antenatal consultation before an extremely preterm baby is born?
2. What percentage of high-risk births have a care plan documented in the mother's chart?
3. How often do grieving parents leave the hospital with an established follow-up plan?
4. How often is the organ procurement agency in your area contacted before a baby's death?
5. What percentage of neonatal deaths have documentation in the chart that the parents were asked about performing an autopsy?
6. What percentage of neonatal deaths have autopsies performed?

LESSON 11 REVIEW

1. In conditions associated with a high risk of mortality or significant burden of morbidity for the baby, parents (should)/(should not) participate in the decision whether attempted resuscitation is in their baby's best interest.
2. The ethical principles of neonatal resuscitation are the (same)/(different) as those followed in resuscitating an older child or adult.

Answers

1. In conditions associated with a high risk of mortality or significant burden of morbidity for the baby, parents should participate in the decision whether attempted resuscitation is in their baby's best interest.
2. The ethical principles of neonatal resuscitation are the same as those followed in resuscitating an older child or adult.

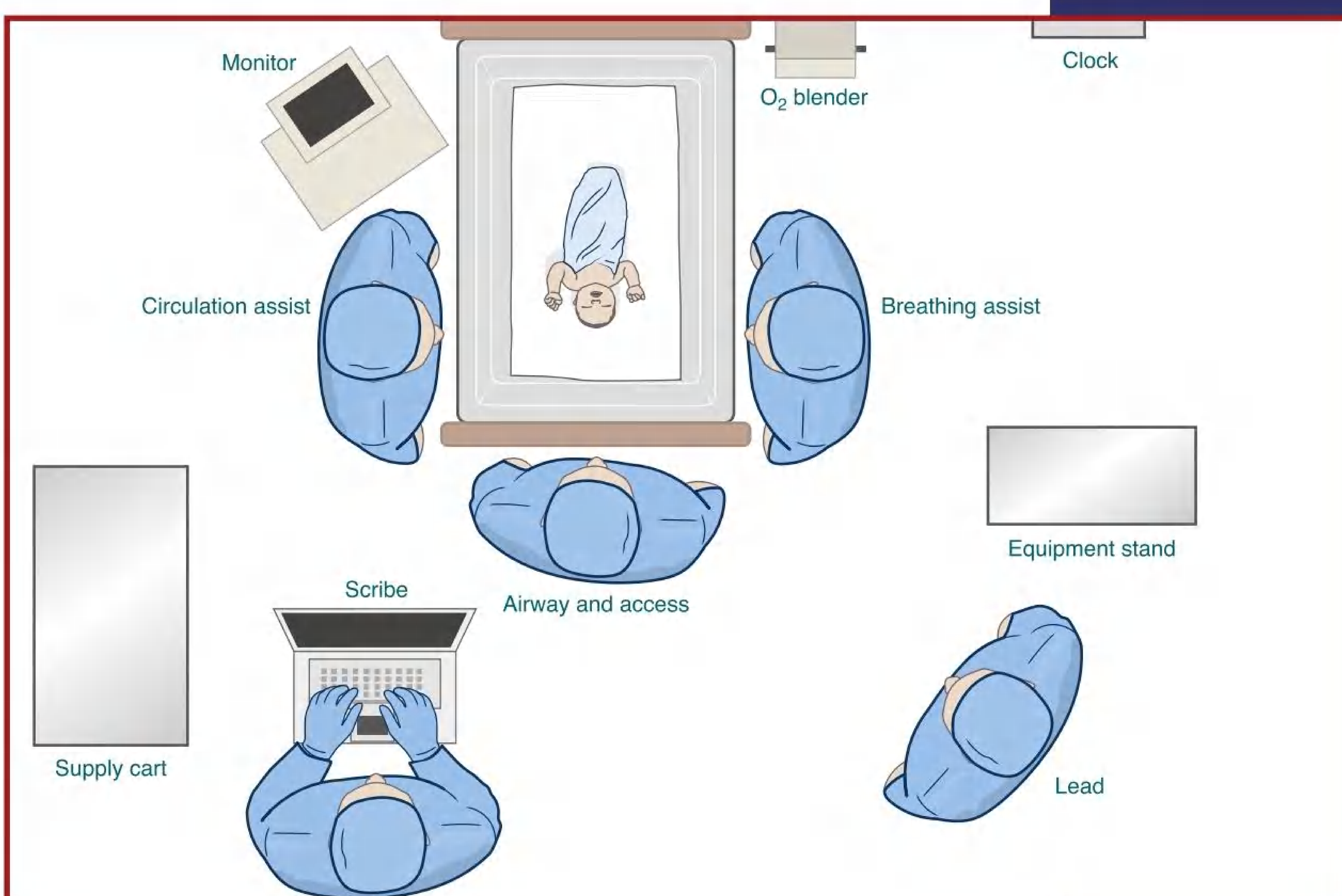
SUPPLEMENTAL LESSON

12

Improving Resuscitation Team Performance

What you will learn

- How attention to ergonomics and human factors improves resuscitation team performance
- The 3 essential elements of a pre-resuscitation team briefing
- How to develop resuscitation schemes by assigning team roles, tasks, and positions
- How to use simulation and debriefing to test and improve your resuscitation schemes



Key Points

1. Beyond individual team members learning the cognitive and technical skills of resuscitation, considering human factors and the ergonomics of resuscitation can further improve safety and performance.

2. By understanding how humans perform a series of tasks in a real work environment, teams can predict where errors may occur, design systems that prevent these errors, and optimize team performance.

3. During your pre-resuscitation briefing, define the situation, assign roles with standardized tasks, and position team members in the environment.

4. Assigning roles sets expectations, allows adult learners to practice tasks repeatedly, increases confidence in their ability to perform, decreases extraneous noise, and reduces cognitive load.

5. Schemes (descriptive plans or conceptual models) for delivery room resuscitation need to be individualized. Each hospital's role and task list will vary depending on the professional disciplines involved, the scope of practice for each discipline, and the number of resuscitation team members available for different resuscitation scenarios.

6. During a resuscitation, roles may need to be added or changed. How information is provided to arriving personnel and what roles they assume should be predetermined.

7. After you have created your schemes, conduct frequent simulated resuscitations to audit team performance, find weaknesses in your plan, and identify opportunities for improvement.

The role of ergonomics and human factors in neonatal resuscitation

This lesson focuses on improving resuscitation team performance. When resuscitation team members are assigned roles, and human factors and ergonomics are considered when assigning specific tasks to those roles, team members can work in synchrony. The resuscitation proceeds quickly and efficiently through an organized series of interventions and effective communication. The teamwork is so well organized that it appears choreographed.

The science of ergonomics analyzes human anatomy, physiology, and biomechanics to better understand how the work environment can be adapted to improve safety and performance. Ergonomics evaluates how equipment is used and what demands the equipment places on the user.

Over time, new technology has been added to the Neonatal Resuscitation Program® (NRP®) Algorithm. While new technology may improve the care we provide, it also adds to the amount of data we must interpret and may increase the cognitive load on team members. Increasing the number of devices, people, complexity of tasks, and cognitive load may correlate with an increase in noise, a decrease in effective communication, and an increase in deviations from the NRP Algorithm.

Often, simple adjustments to the working environment can make a significant difference in performance. During neonatal resuscitation, appropriate positioning of people and equipment is essential. For example,

- If the pulse oximeter has excessive glare on the screen or is obstructed from view and team members cannot see the display, they may not assess the baby's oxygen saturation and adjust the oxygen concentration (FIO_2).
- If the oxygen blender is on the right side of the radiant warmer, it is difficult for team members positioned at the head of the bed or on the left side to adjust the FIO_2.
- If a tall provider attempts to intubate a newborn with a low radiant warmer that has no height adjustment, their awkward body position may decrease the likelihood of successful intubation.
- Confirming endotracheal tube insertion is difficult if the radiant warmer is positioned in a corner of the room that is not easily accessible by an x-ray machine.

Human factors research investigates how humans interact with their environment, products, other humans, and technology. It combines an understanding of psychology, sociology, biomechanics, industrial design, and other related disciplines. Human factors research has taught us that individual team members may know the steps of resuscitation and have the technical skills to perform them, but that time can be wasted if roles are ambiguous and tasks are not assigned as team members duplicate some tasks and omit others. By understanding how humans will perform a series of tasks in a real work environment, human factors experts attempt to predict where errors may occur, design systems that prevent these errors, and optimize team performance. For example,

- Using tables with pre-calculated epinephrine dosages can decrease the risk of making mathematical errors during a stressful situation.
- Incorporating human factors into resuscitation simulation and team briefing before a high-risk birth increases provider confidence and decreases distractions and noise.

Table 12-1 lists strategies to improve safety and team performance by addressing common ergonomic and human factors obstacles.

Table 12-1. Strategies to Address Ergonomic and Human Factors Obstacles
Use cognitive aids such as the NRP Algorithm, Target Oxygen Saturation Table, and tables with endotracheal tube insertion depth and pre-calculated epinephrine dosages.
Use a standardized team briefing script.
Use a standardized supplies and equipment checklist.
Assign roles as part of a routine pre-resuscitation team briefing.
Create a standard description of the tasks that each role is expected to complete during a resuscitation.
Create standardized protocols and scripts for introducing additional team members arriving at a complex resuscitation.
Assign 1 team member the role of crowd control during a complex resuscitation.
Conduct frequent simulation training in the actual resuscitation environment.
Develop organized schemes to position personnel and equipment appropriately within the resuscitation environment.
Evaluate the accessibility and ergonomic function of resuscitation supplies and equipment.
Assess the tone and alarm volume on monitors used during resuscitation to be certain they can be heard but do not add to auditory overload.

How to perform a structured pre-resuscitation team briefing

You learned about the importance of conducting a pre-resuscitation team briefing in Lesson 2. The team briefing is used to review the risk factors and any plan of care developed during antenatal counseling. At this briefing, the team leader is identified, possible scenarios your team may encounter are discussed, and roles and responsibilities are assigned.

There are 3 essential elements when planning a pre-resuscitation team briefing.

- *Defining* the situation
- *Assigning* roles and setting clear, detailed expectations for each role
- *Positioning* each team member within the resuscitation environment

Standardizing the pre-resuscitation team briefing to include these essential elements will help decrease variability and increase reliability. Reliable systems improve team performance and outcomes.

When possible, the pre-resuscitation team briefing should occur well before the anticipated birth. One way to ensure teams get the opportunity to assemble prior to an event is to schedule a meeting with the obstetric team at the beginning of each shift to identify potential high-risk births. This allows both teams to have an opportunity to meet face-to-face, assign roles, answer questions, and create both primary and contingency plans.

The importance of assigning roles and setting expectations

The NRP Key Behavioral Skills promote preparation for, and successful coordination of, delivery room resuscitation. There is growing evidence that improved behavioral and team leadership skills improve resuscitation outcomes. Stress increases when team members do not know what to expect from one another and the team leader does not know, or incorrectly assumes, what team members are going to do. Assigning roles sets expectations and allows adult learners to practice these specific tasks repeatedly, which results in increased confidence in their ability to perform. When team members know their roles and expectations are set in advance, there is less extraneous noise during the resuscitation. The decreased noise translates into less distractions from required tasks and reduces cognitive load.

One method to standardize role assignments is to assign roles based on a team member's position at the radiant warmer. Each team member is given a specific role with a predefined list of tasks and a designated location at the radiant warmer that optimizes ergonomics. Role assignments take the guesswork out of who does what and have been shown to improve resuscitation performance.

What is a resuscitation scheme?

Schemes are detailed, systematic plans of action that may be illustrated in the form of outlines or conceptual models. A resuscitation scheme describes your plan for how to organize the personnel, equipment, and tasks during a resuscitation. The full resuscitation scheme includes planning what personnel will be present, what supplies and equipment will be available, what role each person will have, what tasks will be assigned to each role, and where each team member will be placed during the resuscitation. The scheme must consider how many tasks each team member can efficiently perform and whether the equipment required to perform those tasks is easily accessible within the resuscitation environment. A schematic is an illustration or table that describes your plan.

Designing schemes for a variety of resuscitation scenarios in your own environment is well worth the effort. High-performing teams with well-defined schemes experience less cognitive load, which allows them to focus their attention on other skills. Schemes for delivery room resuscitation need to be individualized to your specific location, equipment, and personnel.

Figure 12.1 is a sample schematic describing roles and pre-birth task assignments for a 5-member team preparing for a very preterm birth. The schematic describes where personnel stand and where important supplies are placed on the radiant warmer to ensure easy accessibility during resuscitation or post-resuscitation care. Figure 12.2 is a sample schematic for the placement of each team member by role based on the configuration of this particular hospital's resuscitation environment.

Time	Airway and Access (Head of bed)	Breathing (Right)	Circulation (Left)	Lead (Back right)	Scribe (Back left)
Pre-delivery	**Meet with OB:** ☐ Confirm 1. Pertinent history 2. Delayed cord clamping plan 3. OR temperature 4. Placement into plastic bag ☐ Talk to family ☐ Determine special equipment or personnel needs **At Warmer** ☐ Double-check: 1. Laryngoscope 2. ETTs 3. T-piece 4. CO_2 detector 5. Round mask (choose size) ☐ Raise height of bed to level of xiphoid process	**Prepare PPV:** ☐ Ventilator set-up ☐ Test T-piece: 20/5, 30% ☐ Round mask, small and extra small ☐ CO_2 detector on mask ☐ Pulse ox and cover (lower right) ☐ Stethoscope on **Prepare ETT:** ☐ Laryngoscope handle, size 0 and 00 blades ☐ 2.5 and 3.0 ETT and stylet (top right) ☐ ETT securing device (lower right) ☐ Measuring tape (lower right) **CPAP prep** ☐ CPAP at bedside set to 6 cm H_2O For infants < 28 weeks: ☐ Surfactant warming	**Prepare bed:** ☐ 1 blanket, 1 blue pad, 1 blanket, thermal blanket, blanket ☐ Warmer to max ☐ Temperature probe (lower left) ☐ Activate thermal blanket ☐ Hat (top left) ☐ Suction catheter at 80 mm Hg (right) ☐ Bulb syringe (top right) ☐ ECG leads (left) ☐ Two 4x4 gauze (lower right and lower left) ☐ Stethoscope on **Prepare monitor:** Audible ECG on	**Prepare line tray:** ☐ 3.5F umbilical artery catheter ☐ 3.5F umbilical venous catheter ☐ Umbilical venous catheter/umbilical artery catheter supply tray ☐ 2 stopcocks ☐ Equipment stand ☐ 2x3-mL syringes ☐ 3 sterile towels ☐ Prime IV lines	**Prepare supplies:** ☐ Humidity: add sterile H_2O to isolette ☐ 3x5-mL saline with heparin flushes ☐ Glucose meter ready ☐ 2x infusion pumps ☐ Pre-admission order set complete ☐ Very low birth weight IV fluids ordered ☐ Alert NICU unit clerk ☐ Confirm NICU attending called ☐ Calculator ☐ Computer on, Neonatal Resuscitation Log ready

Figure 12.1. Sample pre-birth task assignment schematic for a very preterm birth

Following the 5-member schematic demonstrated in Figure 12.2, examples of the tasks that may be assigned by role after birth are described in the following text.

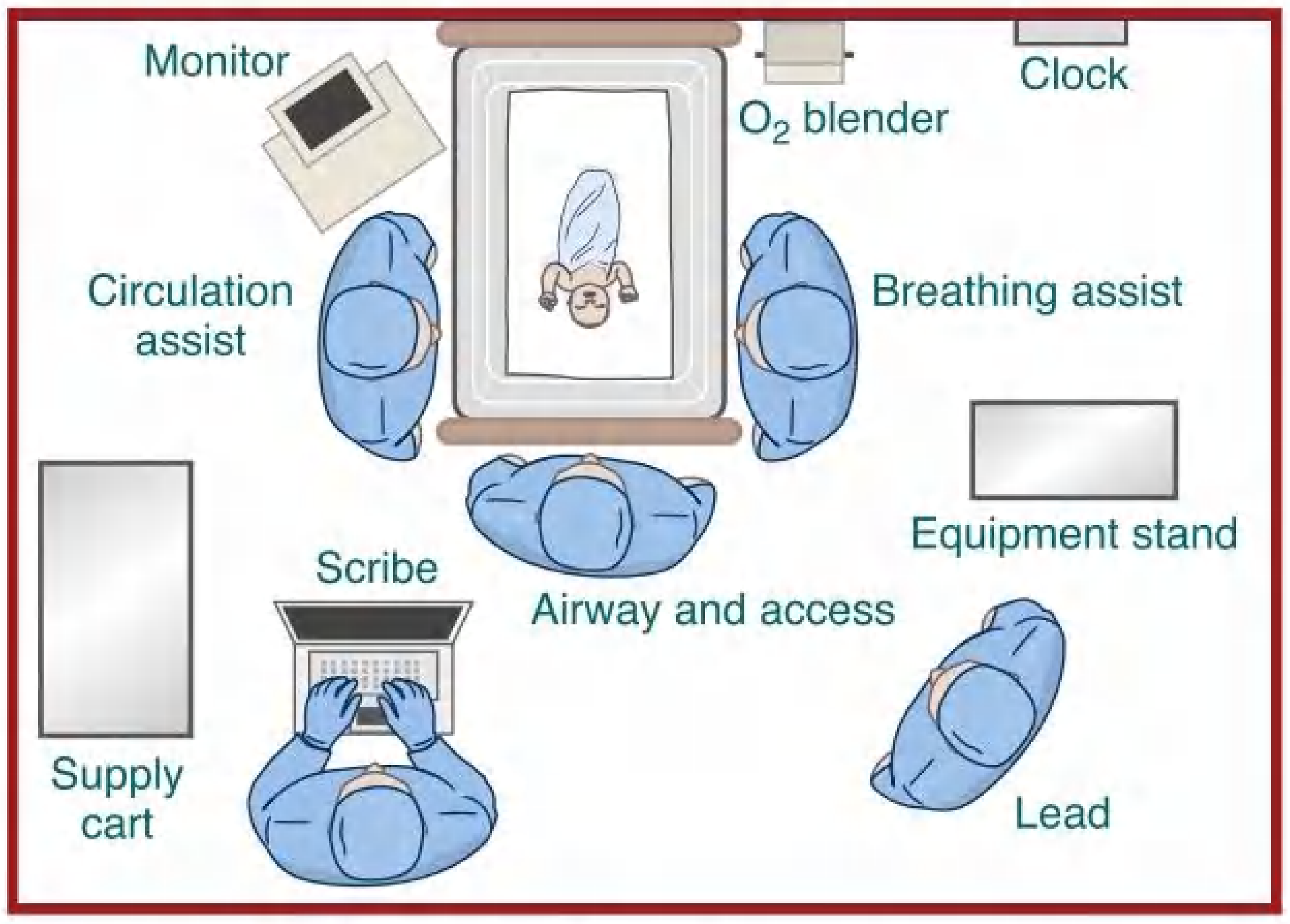


Figure 12.2. Sample 5-member team position schematic for a complex resuscitation

- **Airway and Access:** The person at the head of the bed is well positioned to manage the airway. Tasks assigned to this role may include applying a hat, positioning the newborn's head and neck, performing bulb suction, positioning the face mask, providing face-mask positive-pressure ventilation (PPV), and intubating the newborn if necessary. If chest compressions are needed, this team member hands over PPV to the Breathing Assist role, allows the Circulation Assist to move to the head of the bed to provide chest compressions, and then moves into position to insert an emergency umbilical venous catheter.
- **Breathing Assist:** The person on the right side of the bed is well positioned to access the right hand or wrist, monitor pulse oximetry, and adjust the oxygen blender. The team member in this role focuses on assisting with the assessment and support of breathing. Tasks assigned to this role may include turning on the Apgar timer, applying the pulse oximeter sensor, assisting with ventilation corrective steps, monitoring for chest movement, placing a carbon dioxide (CO_2) detector on the face mask if requested, monitoring for color change on the CO_2 detector, assisting with intubation and securing the endotracheal tube if needed, assessing breath sounds, monitoring oxygen saturation, and adjusting the FIO_2. If chest compressions are needed, this person takes over PPV through the endotracheal tube.
- **Circulation Assist:** The person on the left side of the bed is well positioned to see the baby's chest but cannot easily reach the baby's right hand or the oxygen blender. The team member in this role focuses on assisting with temperature control, assessing circulation, and providing chest compressions if needed. Tasks assigned to this role include placing cardiac monitor leads, assessing heart rate with a stethoscope, placing a temperature sensor, ensuring the polyethylene plastic bag or wrap remains over the newborn's shoulders, assisting with securing the endotracheal tube as needed, and administering chest compressions from the head of the bed.
- **Lead:** This person is ideally positioned to maintain situation awareness and lead the team. Ideally, the team member in this role is not assigned other tasks. Depending on the availability of additional personnel and scope of practice, the Lead may be needed to assist with emergency procedures. If this occurs, another team member must assume the Lead role.

- **Scribe:** This person is well positioned to see the monitors, clock, and all team members. The team member in this role documents events as they occur, notifies the team of critical time points, maintains critical communication with the Lead, and may call for additional support. In a 5-member team, if chest compressions are required and additional support is not available, this person will hand over recording to the Lead and assume the task of preparing and administering emergency medications.

At a hospital that has more personnel available, the same scenario may be managed using a 6- or 7-member team. In these schemes, the team may have designated Medication and Access roles. As the team gets larger, managing the number of people and equipment that can efficiently work in a small space becomes an important consideration. A larger team may include a Manager role whose tasks include crowd control, information dissemination (eg, laboratory results), parent support, and assigning roles as new personnel arrive.

How do roles in the scheme change if resuscitation is unexpected?

Roles may need to be added or changed in a planned and coordinated way depending on the baby's needs and the team members' scope of practice. How information is provided to arriving personnel and what roles they assume should be predetermined.

For example, if only 1 nurse attends the birth of a full-term baby who unexpectedly requires resuscitation, the nurse initially assumes the Airway and Lead role at the head of the bed, initiates PPV, and presses an emergency call button for immediate assistance. The first person who comes to assist (in this scenario, another nurse) is predesignated to assume the Breathing Assist role on the baby's right. This nurse places a pulse oximeter sensor, assesses the baby's response to PPV and adjusts the FiO_2 as needed, and places cardiac monitor leads if the baby is not showing improvement. The third person to arrive, an advanced practice provider, is directed by the Airway nurse to take the Circulation Assist role if face-mask PPV is effective or the Airway role if intubation is required. If the third person assumes the Airway role, the original nurse moves to the left side of the bed and assumes the Circulation Assist role. Staff arriving later may assume the Lead and Scribe roles.

The schematics in Figures 12.3 through 12.5 illustrate how these roles might evolve. In this hospital's environment, the pulse oximeter and oxygen blender are integrated within the radiant warmer and emergency supplies are stored in a drawer below the warmer.

How do we create our own hospital system for standardizing roles and tasks?

Each hospital's role and task list will vary depending on the professional disciplines involved, the scope of practice for each discipline, the placement of equipment around the warmer, and the number of resuscitation team members available for different resuscitation scenarios. Even hospitals that routinely provide only uncomplicated obstetric services must plan schemes for complex resuscitations because unanticipated complications can arise, such as a depressed newborn secondary to shoulder dystocia or placental abruption, deliveries complicated by meconium aspiration, undiagnosed congenital malformations, unanticipated preterm birth, or other complications resulting in neonatal respiratory or neurologic depression.

- The first step is to determine the personnel available to attend resuscitations of varying complexity at your facility.
- Next, make a comprehensive list of every task that must be done to prepare for the birth and resuscitation of newborns in these scenarios. For example, the list of tasks required to resuscitate a term newborn who requires brief PPV at birth and quickly recovers will be much shorter than the list of tasks required to prepare for and resuscitate a baby born at 26 weeks' gestation.
- Once you have determined the available personnel and the tasks to be performed, you can begin the process of assigning proposed roles and tasks. Decide where each person should stand and where supplies and equipment can be placed to ensure they are easily accessible to the person who must use them.
- Finally, simulate a series of carefully monitored scenarios, test your proposed role and task assignments, identify potential barriers or inefficient processes, make adjustments to optimize team performance, and test your new proposal until you develop a final plan that describes your scheme for each scenario.

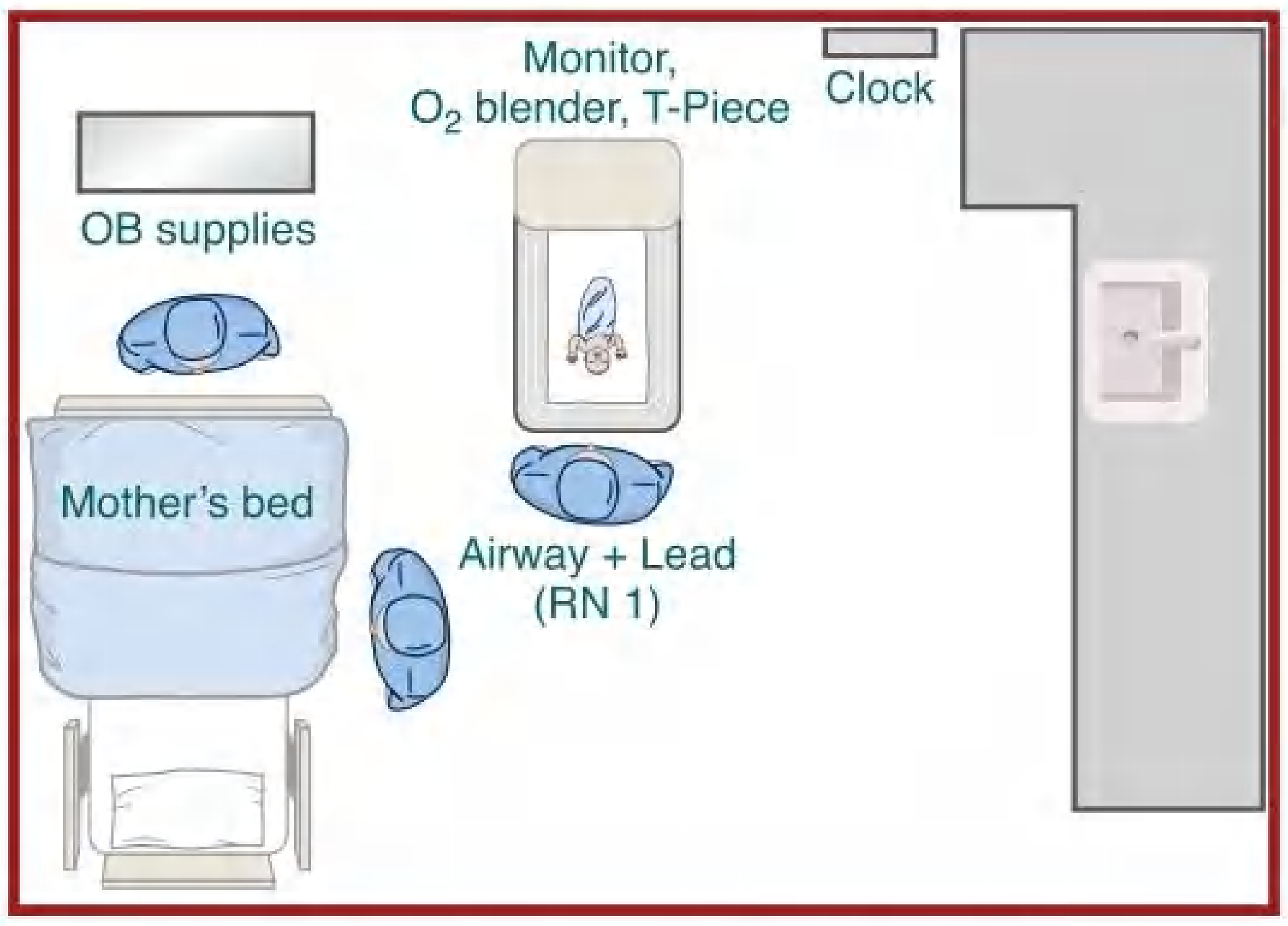


Figure 12.3. Evolution of roles and positions as personnel arrive for an unexpected resuscitation. A term newborn requires unanticipated PPV. One nurse (RN 1) is present for the birth.

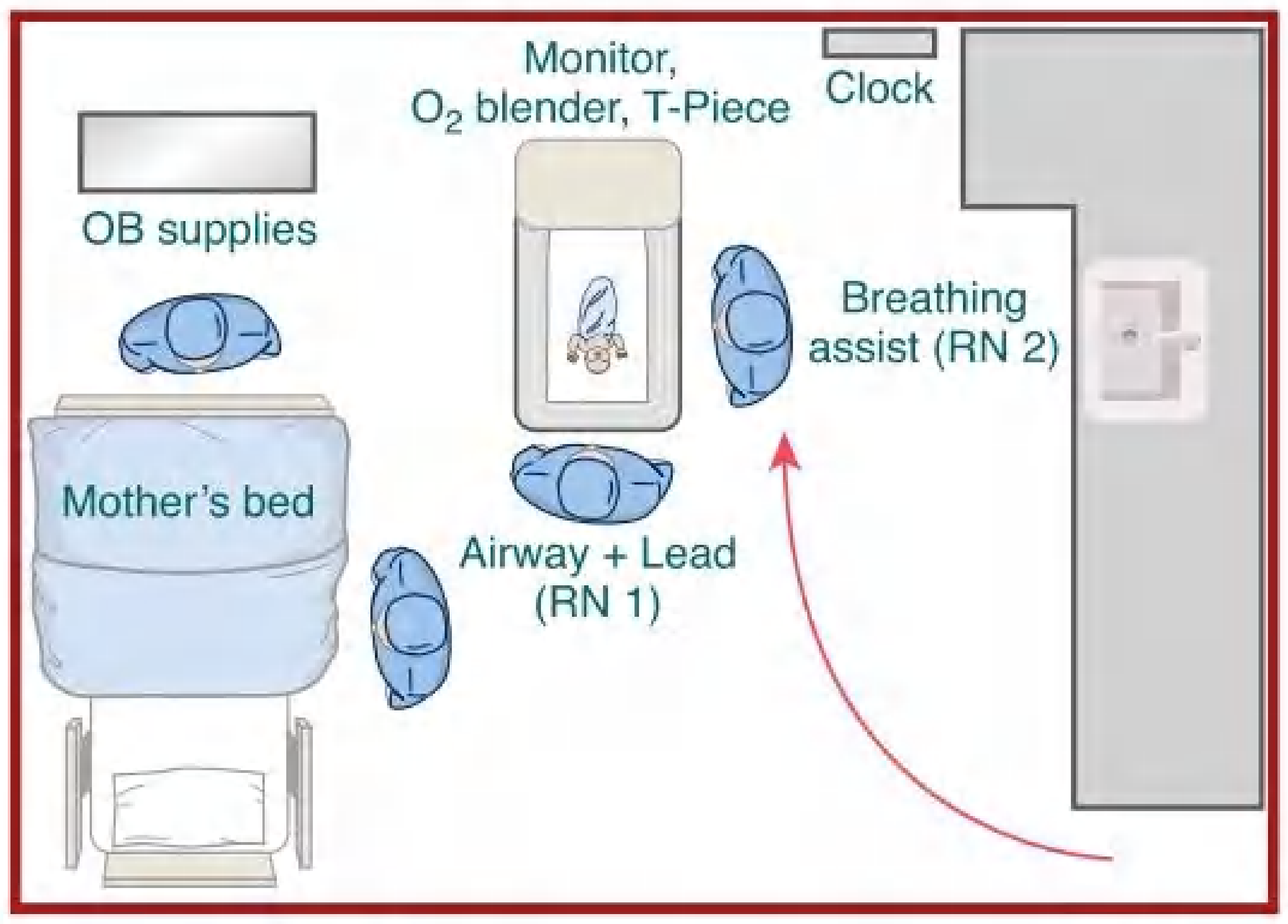


Figure 12.4. A second nurse arrives (RN 2) and assumes the Breathing Assist role.

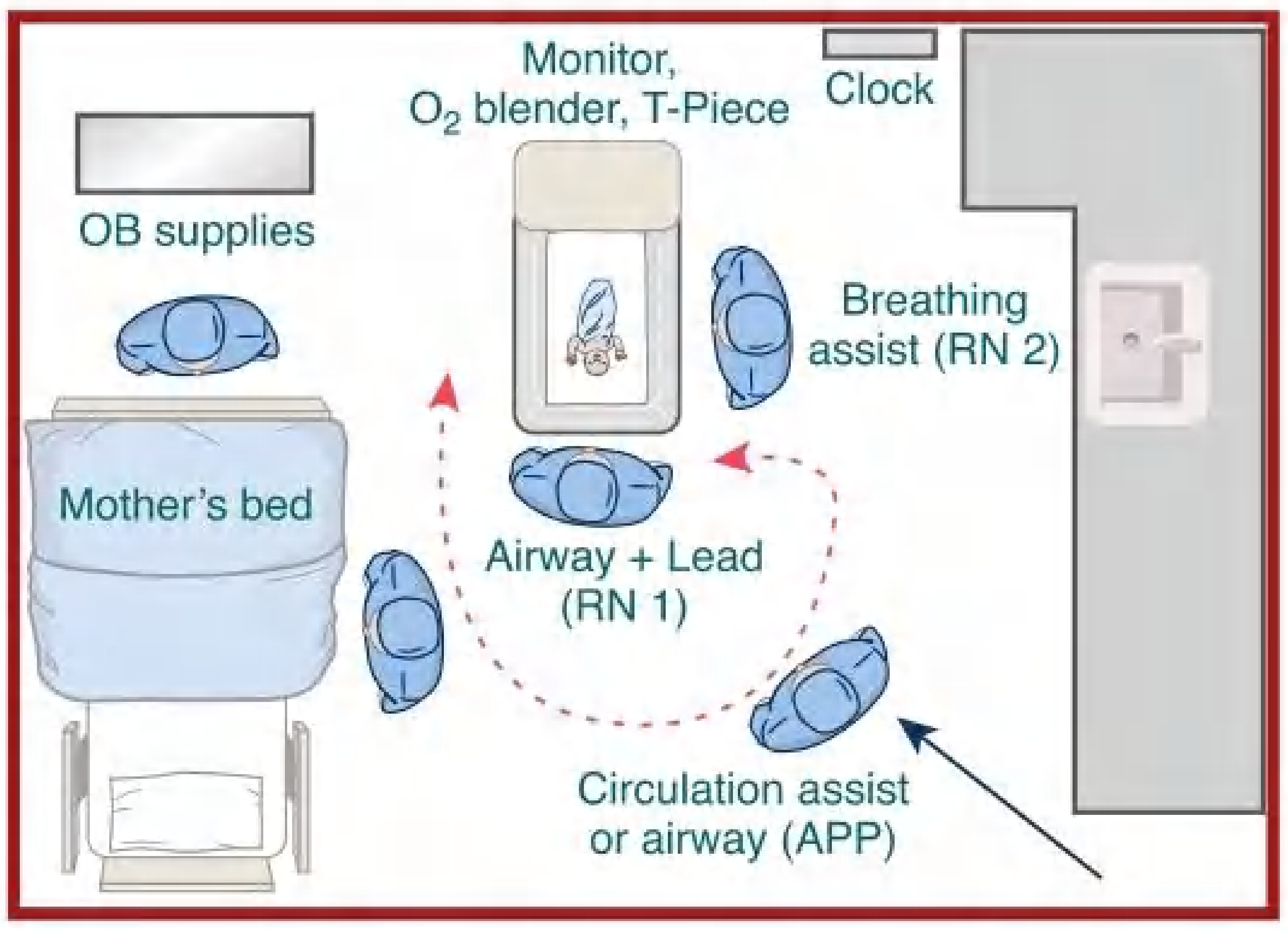


Figure 12.5. An advanced practice provider (APP) arrives and is directed to take the Circulation Assist role if face-mask PPV is effective or assume the Airway role if the baby needs to be intubated. If the APP assumes the Airway role to intubate, RN 1 will maintain the Lead role.

How will you assess the effectiveness of your new standardized system?

After you have created your schemes, conduct frequent simulated resuscitations using different scenarios to audit your performance, find weaknesses in your plan, and identify opportunities for improvement. Simulation can identify ergonomic and human factors issues, evaluate the effectiveness of your pre-resuscitation briefing, and reinforce team roles and responsibilities. Consider video-recording your scenarios to support detailed debriefings. Review the video recordings with your team and watch carefully for inefficient practices and potential safety threats.

- Begin with a simple PPV scenario, adjust your assigned tasks as needed, and work up to a complex resuscitation involving umbilical venous catheter insertion and medications.
- Adjust the tasks assigned to each role until team members are able to work quickly and efficiently without getting in each other's way. Your simulation may reveal a series of small problems that could be resolved with simple solutions. You may notice that the placement of monitors is not ideal for all team members, or discover that the supplies for an assigned task are not easily accessible. For example,
  - The person placing the pulse oximeter sensor on the baby's right hand or wrist should be on the baby's right side; otherwise, the team member has to reach over the baby.
  - The person adjusting the FIO_2 should be able to reach the dial on the oxygen blender.
  - The person calling for additional help should be able to reach the call button or phone without interfering with their existing tasks.
- Be sure to include the Scribe role during simulation because the Scribe must be able to see the baby, see the monitors, see and hear the team members, and see the time device being used for code documentation.

SUPPLEMENTAL LESSON

13

Resuscitation Outside the Delivery Room

What you will learn

- How to apply Neonatal Resuscitation Program® (NRP®) principles to newborns who require resuscitation outside the hospital setting
- How to apply NRP principles to babies who require resuscitation beyond the immediate newborn period
- How to apply NRP principles to babies who require resuscitation in the neonatal intensive care unit
- When to consider using Pediatric Advanced Life Support guidelines

Key Points

1. Although resuscitation outside the delivery room setting presents different challenges, the physiologic principles and basic steps of the Neonatal Resuscitation Program (NRP) Algorithm remain the same throughout the neonatal period.

2. Regardless of the location of birth, ventilation of the lungs is the initial priority for resuscitating the newborn.

3. Every location where newborns receive care, including each postpartum room, should have immediate access to a bulb syringe, a self-inflating bag, and appropriately sized face masks.

4. Ventilation of the lungs is the initial priority for resuscitating most babies during the neonatal period. Once adequate ventilation is ensured, obtain additional information about the baby's history to guide interventions.

5. Many babies who require resuscitation in the neonatal intensive care unit (NICU) have underlying lung disease and may require higher ventilating pressures than recommended in the delivery room. In babies with established severe bronchopulmonary dysplasia (BPD), longer inflation times may also be required to achieve adequate ventilation.

6. In general, where differences exist between the NRP and Pediatric Advanced Life Support (PALS) recommendations, you should apply the NRP recommendations during the immediate newborn period and the initial hospitalization following birth. If a newborn has cardiopulmonary arrest in the NICU during this period, the NRP recommends using a 3:1 compression-to-ventilation ratio unless there is a reason to suspect a non-respiratory etiology such as a primary cardiac arrhythmia or an electrolyte disturbance.

The *Textbook of Neonatal Resuscitation,* 8th edition, focuses on resuscitation of the newborn in a hospital delivery room. However, not all neonatal resuscitation takes place in the delivery room. In this lesson, you will learn about strategies for resuscitating newly born babies outside the delivery room setting, babies who require resuscitation in the mother's postpartum room after the immediate transition period, and babies in the hospital nursery or neonatal intensive care unit (NICU).

Case 1: Newborn resuscitation after a home birth

At 36 weeks' gestation, a multiparous woman awakens when her membranes rupture and she has rapid onset of frequent, intense contractions. The nearest hospital is more than a 30-minute drive away, and her partner calls 911. The emergency operator advises the partner to increase the temperature in the room by turning the thermostat to 74°F and obtain towels to warm and dry the baby after birth.

Paramedics are dispatched and arrive at the home just as the baby's head is crowning. They quickly assemble supplies and equipment from their emergency childbirth kit, including personal protective equipment, warm towels and blankets, a cotton hat, umbilical cord clamps and sterile scissors, a bulb syringe, a stethoscope, a handheld Doppler ultrasound, a small self-inflating bag and neonatal face mask, a portable oxygen source, a pulse oximeter, and a size 1 laryngeal mask.

The baby is born with poor tone and does not cry. One member of the paramedic team uses a warm towel to dry and stimulate the baby by rubbing the baby's back, but the baby does not improve. The umbilical cord is clamped and cut, and the baby is moved to a covered, flat surface. The paramedic puts a hat on the baby's head, places the baby's head in the sniffing position, and clears secretions by suctioning the baby's mouth and nose. The baby remains limp and apneic. The paramedic begins positive-pressure ventilation (PPV) with a self-inflating bag and mask, using 21% oxygen, as additional emergency responders arrive. An assistant uses a stethoscope to listen to the baby's heart rate and applies a pulse oximeter sensor on the baby's right hand. Two minutes after birth, the baby's heart rate is 80 beats per minute (bpm) and increasing, but there is no respiratory effort and the oxygen saturation is below the target range. An assistant connects the self-inflating bag to a portable oxygen source. Three minutes later, the newborn's heart rate is greater than 100 bpm and the oxygen saturation is within the target range, but the baby still has poor tone and irregular, grunting spontaneous respiratory effort. The paramedic inserts a size 1 laryngeal mask and continues PPV while monitoring the baby's heart rate and oxygen saturation. The baby is wrapped in a thermal blanket and prepared for safe transport to the nearest hospital emergency department for further evaluation and treatment.

Are resuscitation techniques different for babies born outside the hospital setting?

Although newborn resuscitation scenarios encountered outside the hospital setting present different challenges, the physiologic principles and basic steps remain the same. **Regardless of the location of birth, ventilation of the lungs is the initial priority for resuscitating the newly born baby.**

What are some strategies needed to resuscitate babies born outside the hospital?

Temperature management

When a baby is born outside the delivery room environment, maintaining the baby's axillary temperature between 36.5°C and 37.5°C may become a challenge because you may not have a radiant warmer. Some suggestions for minimizing heat loss include the following:

- Increase the room temperature to 74°F to 77°F by adjusting the room's heat source.
- Dry the baby thoroughly with bath towels, a blanket, or clean clothing.
- Use the mother's body as a heat source. Consider placing the baby skin-to-skin on the mother's chest and covering both baby and mother with a warm blanket. If the baby is preterm or the environment is cold, consider covering the baby with a clean sheet of food-grade plastic wrap and then covering the baby with a warm blanket.
- Emergency response teams should consider having polyethylene plastic wrap and portable thermal mattresses to help maintain temperature. It is important that the thermal mattress be stored and activated at room temperature. If the mattress is already warm (from being stored in a hot vehicle), it may reach a higher temperature than intended after activation and increase the risk of overheating the newborn or causing thermal injury.

Clearing secretions from the airway

If resuscitation is required outside a delivery room or nursery, vacuum suction may not be readily available. If secretions are obstructing the airway, or if you need to begin PPV, use a bulb syringe or wipe the mouth and nose with a clean handkerchief or other cloth wrapped around your index finger.

Positive-pressure ventilation

Ventilation of the baby's lungs is the single most important and effective step during neonatal resuscitation. Most babies breathe spontaneously after birth, and many of those who do not will begin spontaneous respirations after receiving stimulation. Drying the newborn and rubbing the back and extremities are acceptable methods of stimulation. Some babies born outside the hospital setting may require PPV to inflate their lungs. The NRP recommends that all personnel who may need to resuscitate a newborn outside the hospital environment carry an appropriately sized self-inflating bag-and-mask device and portable oxygen source in case PPV is needed. Similar to the method described in Lesson 4, if the baby's heart rate does not increase rapidly after starting PPV and the baby's chest is not moving, use the ventilation corrective steps (MR. SOPA) to improve the effectiveness of PPV.

Assessing heart rate

Initially, the baby's heart rate should be assessed by auscultating the chest with a stethoscope. Emergency responders who attend out-of-hospital births should also carry a pulse oximeter. An appropriately sized oximeter sensor and sensor cover should be used. If the newborn's heart rate cannot be auscultated and pulse oximetry is not functioning, a handheld Doppler ultrasound (used to auscultate fetal heart rate prior to birth) can be held against the baby's chest to assess the heart rate, or a portable cardiac monitor with appropriate chest leads may be used.

Oxygen management

For a term baby, begin PPV with 21% oxygen. A self-inflating bag that is not attached to an oxygen source will deliver 21% oxygen. For a baby less than 35 weeks' gestation, you may begin PPV with an oxygen concentration (FIO_2) between 21% and 30%. In an out-of-hospital environment, you may not have access to an oxygen blender and may only have access to 100% oxygen directly from a portable oxygen tank. If pulse oximetry is available and indicates that the oxygen saturation is below the target range, and your oxygen tank has a flowmeter that can be adjusted incrementally between 0 L/min (oxygen off) and 10 L/min, you may be able to deliver between 21% oxygen (room air) and 85% to 95% oxygen (5-10 L/min) by simply adjusting the oxygen flow into the PPV device.

If the newborn is breathing and has a heart rate greater than 100 bpm, but the oxygen saturation is below target range, you can give free-flow oxygen through oxygen tubing or from the open reservoir (tail) of some self-inflating bags. Adjust the distance between the 100% oxygen flow and the baby's mouth and nose to maintain the oxygen saturation within the minute-specific target range.

Alternative airways

If an alternative airway is needed after an out-of-hospital birth of a baby who weighs at least 1.5 kg, this program suggests the use of a size 1 laryngeal mask, as described in Lesson 4. Endotracheal intubation is possible but may be more difficult and less successful for newborns in an out-of-hospital setting. Insertion of a laryngeal mask does not require additional instruments or visualization of the baby's vocal cords. Laryngeal masks can be inserted by appropriately trained providers with a high rate of first-attempt success, and have been shown to be an effective alternative to face-mask ventilation and endotracheal intubation. If the baby cannot be successfully ventilated with a face mask or if prolonged ventilation will be required during emergency medical transport to a hospital, a laryngeal mask may provide a successful airway.

Provide 30 seconds of PPV through the laryngeal mask, ensure that the chest is moving with PPV, and reassess the heart rate before beginning chest compressions. The laryngeal mask may improve the efficacy of PPV and increase the heart rate so that chest compressions are not necessary. Use the most accurate method available for assessing the baby's heart rate (such as a portable cardiac monitor or handheld Doppler ultrasound) to ensure appropriate decision-making and interventions.

Although laryngeal mask insertion is consistent with the general guidelines for nurse and respiratory therapist practice within hospitals, emergency response personnel should check with their state licensing board or regulatory agency regarding laryngeal mask insertion outside the hospital setting and their professional scope of practice.

Chest compressions

Chest compressions are indicated when the newborn's heart rate remains less than 60 bpm after at least 30 seconds of PPV that inflates the lungs, as evidenced by chest movement with ventilation, and preferably through an alternative airway. Regardless of the location of birth, this program recommends using a 3:1 compression-to-ventilation ratio with 120 events per minute (90 compressions + 30 ventilations). Chest compressions should be accompanied by coordinated ventilations using 100% oxygen, as described in Lesson 6.

Vascular access and medications

If the newborn's heart rate remains less than 60 bpm after 60 seconds of chest compressions and coordinated ventilations, epinephrine and possibly volume expansion are indicated, as described in Lesson 7. In this case, emergency vascular access is required. Emergency catheterization of the umbilical vein generally is not an option outside the hospital setting. In such cases, prompt insertion of an intraosseous needle into the flat surface of the tibia just below and medial to the tibial tuberosity (the bony bulge below the kneecap), as described in Lesson 7, is a reasonable alternative. Attempts at inserting a peripheral intravenous (IV) catheter are likely to be unsuccessful due to the baby's poor perfusion.

Emergency response personnel should check with their state licensing board or regulatory agency regarding emergency vascular access and medication administration outside the hospital setting and their professional scope of practice.

When should the newborn be transported to a medical facility for post-resuscitation care?

A newborn who requires PPV for more than 30 to 60 seconds should be transferred to a medical facility for close monitoring, post-resuscitation care, and evaluation.

In addition, any preterm newborn or newborn who has respiratory distress, persistent central cyanosis, poor tone, fever, hypothermia, difficulty feeding, or other signs of failing transition or illness should be immediately and safely transported to a medical facility.

What is the American Academy of Pediatrics position on planned home birth?

In 2020, the American Academy of Pediatrics (AAP) Committee on Fetus and Newborn published a Policy Statement, "Providing Care for Infants Born at Home."[1] The statement addressed resuscitation of the newborn after home birth, as well as initial care and follow-up. Both the AAP and the NRP believe that hospitals and accredited birth centers are the safest settings for birth in the United States because planned home births are associated with a twofold to threefold increase in perinatal mortality. Therefore, the AAP and NRP do not recommend planned home birth; however, the AAP and NRP recognize that women have the autonomy to choose the location of their baby's birth and some will choose a home birth. Women who choose a planned home birth should be fully informed that in the event of an unanticipated emergency, it is unlikely that the personnel, supplies, and equipment necessary to perform a complex neonatal resuscitation will be immediately available in the home environment, and any delay may result in an adverse outcome for the newborn.

Case 2: Resuscitation in the postpartum unit

A baby was delivered at term in the hospital following an uncomplicated pregnancy and labor. The transitional period was uneventful, and the baby stayed with the mother to begin breastfeeding. During breastfeeding, when the baby was approximately 6 hours of age, the mother noticed that the baby was limp, not breathing, and unresponsive. She activated the nurse call button and shouted for help, and a nurse from the postpartum unit responded immediately. The nurse turned on the room light, opened the blanket, and found the baby limp and apneic. She placed the baby on a safe, flat surface, provided stimulation by rubbing the baby's back, placed the baby's head in the sniffing position, and cleared the airway with a bulb syringe. The baby did not improve after these maneuvers. To get additional help, the nurse pushed the CODE button on the wall and began PPV with the self-inflating bag and mask that was kept in the postpartum room.

The neonatal resuscitation team arrived in the room, received information from the first-responder nurse, and quickly assessed the situation. One team member used a stethoscope to listen to the baby's heart rate and breath sounds. Another team member placed a pulse oximeter sensor on the baby's right hand and portable cardiac monitor leads on the baby's chest. The baby's heart rate was 80 bpm and rising, but the respiratory effort was irregular and oxygen saturation was low. The FIO_2 was adjusted to achieve an oxygen saturation greater than 90%. The baby soon developed consistent respiratory effort, the heart rate increased above 100 bpm, and PPV was gradually weaned. The baby received supplemental oxygen through the open tail reservoir of the self-inflating bag and was transferred to the nursery in a pre-warmed incubator for additional evaluation and treatment. A team member stayed with the baby's mother to obtain additional information, provide support, and answer questions. Shortly afterward, the care team conducted a debriefing to evaluate its readiness, teamwork, and communication.

Sudden unexpected postnatal collapse

The baby in the scenario experienced sudden unexpected postnatal collapse (SUPC), which is a clinical entity characterized by a need for resuscitation with PPV in an apparently healthy term newborn during the first 12 hours after birth in the hospital, and is one reason that a neonate may require resuscitation beyond the immediate newborn period. The event commonly occurs during skin-to-skin contact with the mother or during a breastfeeding session. Many newborns are in a prone position at the time of the event. Many affected newborns will require intensive care and some die. The reported incidence of SUPC ranges from 3 to 74 cases per 100,000 live births.[2] The etiology of SUPC is unknown and is likely multifactorial. Most cases are unexplained.

Are resuscitation techniques different for babies beyond the immediate newborn period?

Throughout this program, you have learned about resuscitating babies in the delivery room immediately after birth. Some babies, however, require resuscitation after the immediate newborn period. Although resuscitation scenarios encountered outside the immediate newborn period present unique challenges, the physiologic principles and basic steps remain the same. **Ventilation of the lungs is the initial priority for resuscitating most babies during the neonatal period.** Once adequate ventilation is ensured, obtain additional information about the baby's history to guide interventions.

What are some strategies to resuscitate babies outside the immediate newborn period?

Temperature management

Maintaining normal body temperature is easier in babies outside the immediate newborn period because the baby's body is not wet, and the risk of evaporative heat loss is lower. However, thermoregulation is still essential. To prevent hypothermia, resuscitate under a radiant warmer if available, use a hat, and wrap the baby in warm blankets for transport.

Clearing secretions from the airway

If you suspect that secretions are obstructing the airway and vacuum suction is not readily available, use a bulb syringe or wipe the mouth and nose with a clean handkerchief or cloth wrapped around your index finger. Suction the mouth and nose with a bulb syringe before initiating PPV.

Ventilation

A self-inflating bag and mask should be immediately available in every postpartum room and requires no compressed air for use. Ensure an open airway by placing the baby's head and neck in the sniffing position. Using the same principles taught in Lesson 4, troubleshoot ineffective PPV by using the ventilation corrective steps (MR. SOPA).

Assessing heart rate

If you are alone when you discover a limp, apneic newborn outside the delivery room, PPV is the highest priority. A resuscitation team member who arrives to help will assess the baby's heart rate. Initially, the baby's heart rate should be assessed by auscultating the chest with a stethoscope. If not immediately available in the postpartum room, the emergency resuscitation team should bring a pulse oximeter and cardiac monitor. These monitors should be applied to the baby as soon as possible so the team members have accurate data to inform their decisions.

Alternative airways

If an alternative airway is needed because face-mask ventilation is ineffective, either a laryngeal mask or endotracheal tube can be used. The laryngeal mask, described in Lesson 4, may be preferable if the baby is being resuscitated in a location that makes positioning for intubation difficult.

Chest compressions

Because most sudden cardiorespiratory events in the newborn period have an underlying respiratory etiology, this program recommends using a 3:1 compression-to-ventilation ratio with 120 events per minute (90 compressions + 30 ventilations) for newborns that require chest compressions during the initial newborn hospitalization. This recommendation may be modified by health care providers that have a reason to suspect a primary cardiac etiology. Based on current guidelines, chest compressions should be accompanied by coordinated ventilations, preferably using an endotracheal tube or laryngeal mask, with 100% oxygen.

Vascular access and medications

If the baby's heart rate remains less than 60 bpm after 60 seconds of chest compressions and coordinated ventilations, epinephrine and possibly volume expansion are indicated, as described in Lesson 7. In this case, emergency vascular access is required. Emergency catheterization of the umbilical vein may be successful during the first week after birth. Beyond the first week, this is generally not an option. In such cases, prompt insertion of an intraosseous needle into the flat surface of the tibia just below and medial to the tibial tuberosity (the bony bulge below the kneecap), as described in Lesson 7, is a reasonable alternative for emergency vascular access. Attempts at inserting a peripheral IV catheter are likely to be unsuccessful due to the baby's poor perfusion.

If a baby is found unresponsive in a mother's room in the postpartum unit, should resuscitation be initiated in the mother's room or should the baby be carried to the nursery?

When faced with a compromised baby in a mother's room, the decision to "scoop and run" to the nursery may seem like a reasonable approach, but this is not the best choice for several reasons. It is not safe to run down a hallway carrying a compromised newborn in your arms. This puts you and the newborn at risk for injury from a fall or a collision with another person, equipment, or passageway door.

In general, every location where newborns receive care should have ready access to the equipment necessary to initiate resuscitation. If there is a designated resuscitation space that is only steps away from every postpartum room, it may be appropriate to carefully move the compromised newborn directly to this location for immediate care. In all cases, the correct solution prioritizes a timely and efficient response and best serves the interests of the newborn's health and safety.

- Each hospital should evaluate its readiness for resuscitating newborns in locations outside the delivery room.
- Anticipate this potential scenario and develop a plan for how an emergency call will be initiated, how the appropriate team will be assembled, what equipment will be stored in the room, and what equipment will be stored in a nearby location (eg, code cart in the hallway).
- By simulating unusual or uncommon scenarios in different locations, you can make plans to address your system's weaknesses and improve your teamwork.

Case 3: Resuscitation in the neonatal intensive care unit

A baby who was born at 24 weeks' gestational age is now 18 weeks old (42 weeks' postmenstrual age). The baby has been in the NICU since birth and has developed severe bronchopulmonary dysplasia (BPD) with tracheobronchomalacia and pulmonary hypertension. The baby has been intubated and receiving respiratory support with a ventilator since birth. The baby has frequent episodes of oxygen desaturation and bradycardia secondary to airway collapse and obstruction. The baby is receiving multiple medications and continuous tube feedings. One evening, a nurse responds to an alarm in the room and finds the baby cyanotic and apneic. The baby's oxygen saturation is 60% and the baby's heart rate is 50 beats per minute (sinus rhythm). The nurse increases the FIO_2 on the ventilator to 100%, quickly determines that the ventilator is functioning and properly attached to the baby's endotracheal tube, and immediately calls for help by pushing the Staff Assist button in the room. The baby does not improve, so the nurse disconnects the ventilator and begins PPV with a T-piece resuscitator using 100% oxygen through the endotracheal tube.

Additional staff, including a respiratory therapist, arrive in the room. They quickly receive information from the bedside nurse and assess the situation. One team member uses a stethoscope to listen to the baby's breath sounds. Another team member brings the unit's code cart to the room. Their rapid assessment determines that the endotracheal tube is inserted correctly, and it is not obstructed by secretions. The respiratory therapist notices that the baby's breath sounds are significantly decreased bilaterally. She suggests increasing the peak inflation pressure and using a longer inflation time to overcome the suspected distal airway collapse. As these ventilation corrective steps are performed, team members prepare to perform chest compressions and secure emergency vascular access with an intraosseous needle, if needed. After approximately 30 seconds of ventilation with higher pressure and a longer inflation time, the baby's heart rate and oxygen saturation begin to improve. Over the next several minutes, the baby continues to improve and spontaneous respiratory effort resumes. A short time later, the baby is placed back on the ventilator and a comprehensive assessment is performed by the medical team. After the event, a team member calls the baby's family to let them know what happened, provide support, and answer questions. Shortly afterward, the NICU team conducts a debriefing to evaluate its readiness, teamwork, and communication.

What causes babies to require resuscitation in the NICU?

Acute cardiorespiratory events (oxygen desaturation, apnea, and bradycardia) occur frequently among babies admitted to the NICU. Most of these events have a respiratory etiology and resolve with stimulation, adjustment of a continuous positive airway pressure (CPAP) interface, PPV, endotracheal tube suction, or attention to complications such as unintended extubation or equipment failure. Studies report that approximately 1% to 2% of all babies admitted to a NICU will receive intensive cardiopulmonary resuscitation (chest compressions and emergency medications). These data suggest that the incidence of intensive cardiopulmonary resuscitation in the NICU is approximately 10 times higher than in the delivery room.

In the NICU, many babies who require intensive cardiopulmonary resuscitation are already intubated and receiving mechanical ventilation. At the time of the acute cardiorespiratory event, they may be critically ill and receiving multiple medications, including vasoactive drips. Potential underlying etiologies of the acute event include electrolyte abnormalities, septic shock, cardiac arrhythmias, cardiac tamponade, pneumothorax, and postsurgical bleeding complications. The wide range of potential causes can make intensive cardiopulmonary resuscitation in the NICU very complicated. Health care providers working in the NICU must be prepared to perform a complex resuscitation, including chest compressions, emergency vascular access, and medication administration.

Although this program is not intended to teach resuscitation in the NICU, some strategies for applying the principles you have learned are presented below.

What are some strategies to resuscitate babies in the NICU?

Temperature management

Most babies in the NICU are already receiving thermal support from a radiant warmer or incubator. However, maintaining normal body temperature remains a priority. During resuscitation, the baby is often fully exposed and can rapidly lose heat. Measures to prevent unintended cooling include applying a servo-controlled temperature sensor to the baby's skin to monitor and control the baby's body temperature and placing a hat on the baby's head.

Clearing secretions from the airway

In the NICU, in-wall (vacuum) suction is readily available. If secretions are obstructing the airway, a suction catheter attached to vacuum suction should be used to remove them. This is especially important for babies receiving respiratory support with CPAP or with an endotracheal tube and mechanical ventilator. Airway obstruction from thick secretions is a common etiology of acute cardiorespiratory events in the NICU.

Ventilation

Many babies resuscitated in the NICU are already intubated and receiving support from a mechanical ventilator when they require cardiopulmonary resuscitation. If a baby has an acute deterioration while receiving respiratory support with a mechanical ventilator, use the *DOPE* mnemonic (Displaced, Obstructed, Pneumothorax, Equipment failure) to rule out a reversible cause. When an intubated baby has a sudden deterioration, consider disconnecting the baby from the ventilator and providing manual breaths through the endotracheal tube with a flow-inflating bag, self-inflating bag, or T-piece resuscitator to ensure that the endotracheal tube is inserted correctly and patent. As noted above, if you suspect secretions are obstructing the endotracheal tube, use a suction catheter to clear the tube. Because multiple interventions may be required quickly, call for additional help.

Many babies who require resuscitation in the NICU have underlying lung disease and may require higher ventilating pressures than recommended in the delivery room. In babies with established severe BPD, longer inflation times may also be required to achieve adequate ventilation.

For babies that are not intubated, and those with an unintended extubation, face-mask ventilation should be provided using one of the previously described PPV devices. Similar to resuscitation in the delivery room, troubleshooting ineffective face-mask PPV should include the MR. SOPA steps.

Alternative airways

Endotracheal intubation is the most common method used to establish an alternative airway during NICU resuscitation. A laryngeal mask may be an effective alternative when intubation is not feasible or not successful. Studies have demonstrated a high first-attempt success rate even among newborns with airway anomalies. If endotracheal intubation is difficult, inserting a laryngeal mask may be a better option than repeated attempts at intubation. Insertion of a laryngeal mask may provide a safe and stable way to support ventilation while additional specialists, such as anesthesiologists or otolaryngologists, with advanced training and equipment are consulted.

Chest compressions

The NRP recommendations outlined in this textbook apply primarily to newly born babies transitioning from intrauterine to extrauterine life. However, the guidelines also may be applicable to neonates who have completed newborn transition and require resuscitation during the first weeks, and potentially months, after birth. Therefore, practitioners who resuscitate babies in the NICU should consider following these guidelines.

Current Pediatric Advanced Life Support (PALS) recommendations for infants recommend a chest compression-to-ventilation ratio of 30:2 (single-rescuer) or 15:2 (2 rescuers).[3] This ratio prioritizes compressions over ventilation and is appropriate for adults where the cause for sudden cardiac arrest is frequently a non-perfusing cardiac arrhythmia. Applying this ratio to infants was recommended to decrease the educational complexity of resuscitation education for health care providers working with multiple age groups and for lay rescuers.

At birth, almost all cardiopulmonary arrests are caused by impaired placental respiration resulting in a hypoxemic arrest. Therefore, restoring ventilation using PPV is the most important step in resuscitation of newly born babies. During the first weeks following birth, respiratory failure is still the cause of most cardiopulmonary arrests and this program recommends using a compression-to-ventilation ratio that prioritizes ventilation. In a neonate, the higher compression-to-ventilation ratio recommended by PALS may interfere with achieving adequate ventilation.

There is currently no evidence to identify a specific age after birth when babies in the NICU should receive chest compressions following PALS guidelines. In general, where differences exist between the NRP and PALS recommendations, you should apply the NRP recommendations during the immediate newborn period and the initial hospitalization following birth. If a newborn has cardiopulmonary arrest in the NICU during this period, the NRP recommends using a 3:1 compression-to-ventilation ratio unless there is a reason to suspect an alternate etiology such as a primary cardiac arrhythmia or electrolyte disturbance.

Vascular access and medications

Some babies who require intensive cardiopulmonary resuscitation in the NICU already have central venous access. This includes an umbilical venous catheter or a peripherally inserted central venous catheter (PICC or PCVC). If no IV access is in place at the time of the event, emergency catheterization of the umbilical vein may be successful during the first week after birth. Beyond the first week, this is generally not an option. In such cases, prompt insertion of an intraosseous needle into the flat surface of the tibia just below and medial to the tibial tuberosity (the bony bulge below the kneecap), as described in Lesson 7, is an effective alternative for emergency vascular access. An existing peripheral IV catheter may be used; however, attempts at inserting a peripheral IV are likely to be unsuccessful due to the baby's poor perfusion.

Medications, including epinephrine and volume expanders, should be used as outlined in Lesson 7 for cardiopulmonary events in the NICU secondary to hypoxemia and volume loss. Given the range of etiologies leading to acute cardiorespiratory deterioration in the NICU, intensive resuscitation may involve additional medications to treat respiratory failure, shock, and cardiac arrhythmias. A few examples of such medications include the use of beta-agonists to treat lower airway obstruction, antibiotics to treat septic shock, prostaglandin E_1 to treat ductal-dependent cardiogenic shock, calcium chloride to treat hyperkalemia, and antiarrhythmic medications such as adenosine. Use of these medications is beyond the scope of this program. For additional information, health care providers are directed to the American Heart Association's guidelines for PALS and the PALS course.

Should I use NRP or PALS for resuscitation in the NICU?

There is currently insufficient evidence to make a universal recommendation that is appropriate for all babies in the NICU. It is unlikely that there is a single post-conceptual age or number of days/weeks after birth when resuscitation following the PALS guidelines, compared with the NRP guidelines, leads to improved outcomes. The recommendations provided by the NRP are primarily intended to address the resuscitation of newly born babies transitioning from intrauterine to extrauterine life. However, portions of the NRP Algorithm are also applicable to babies in the NICU who have completed newborn transition and require resuscitation during the first weeks, and potentially months, after birth.

The PALS program provides recommendations on infant resuscitation that differ in several respects from the NRP. As noted previously, the recommendations related to chest compressions are the most commonly noted differences. The evidence evaluation process that leads to PALS guidelines is performed independently from the process that leads to neonatal resuscitation guidelines and considers a different body of evidence. Some PALS recommendations reflect a desire to decrease the educational complexity of resuscitation education for health care providers working with multiple age groups and for lay rescuers. Moreover, the science considered when making pediatric advanced resuscitation guidelines is intended to address a broader range of acute events, including cardiac arrhythmias, trauma, septic shock, drowning, and toxicological emergencies. The PALS algorithms include therapies and medications, such as defibrillation and amiodarone, that are not included in the NRP Algorithm. Rather than attempting to identify an age when NRP or PALS guidelines should be followed, considering the etiology of the acute event requiring resuscitation is likely to be more helpful.

At birth, and during the first weeks or months for many babies in the NICU, most acute cardiorespiratory events are caused by respiratory failure. Therefore, restoring ventilation using the principles outlined in this program is most appropriate. For babies that have an etiology for their cardiorespiratory arrest that is addressed in the PALS program, such as a primary cardiac arrhythmia or electrolyte disturbance, the principles outlined in the PALS program may be most appropriate. The practical implications for training staff working in the NICU must be considered. The leadership in each NICU must decide which resuscitation training is most appropriate for its staff based on the needs of their patient population. If the staff within a single unit is trained in both programs, it is essential to develop a plan to determine which resuscitation guidelines are being used and to clearly communicate this plan to the resuscitation team to avoid confusion.

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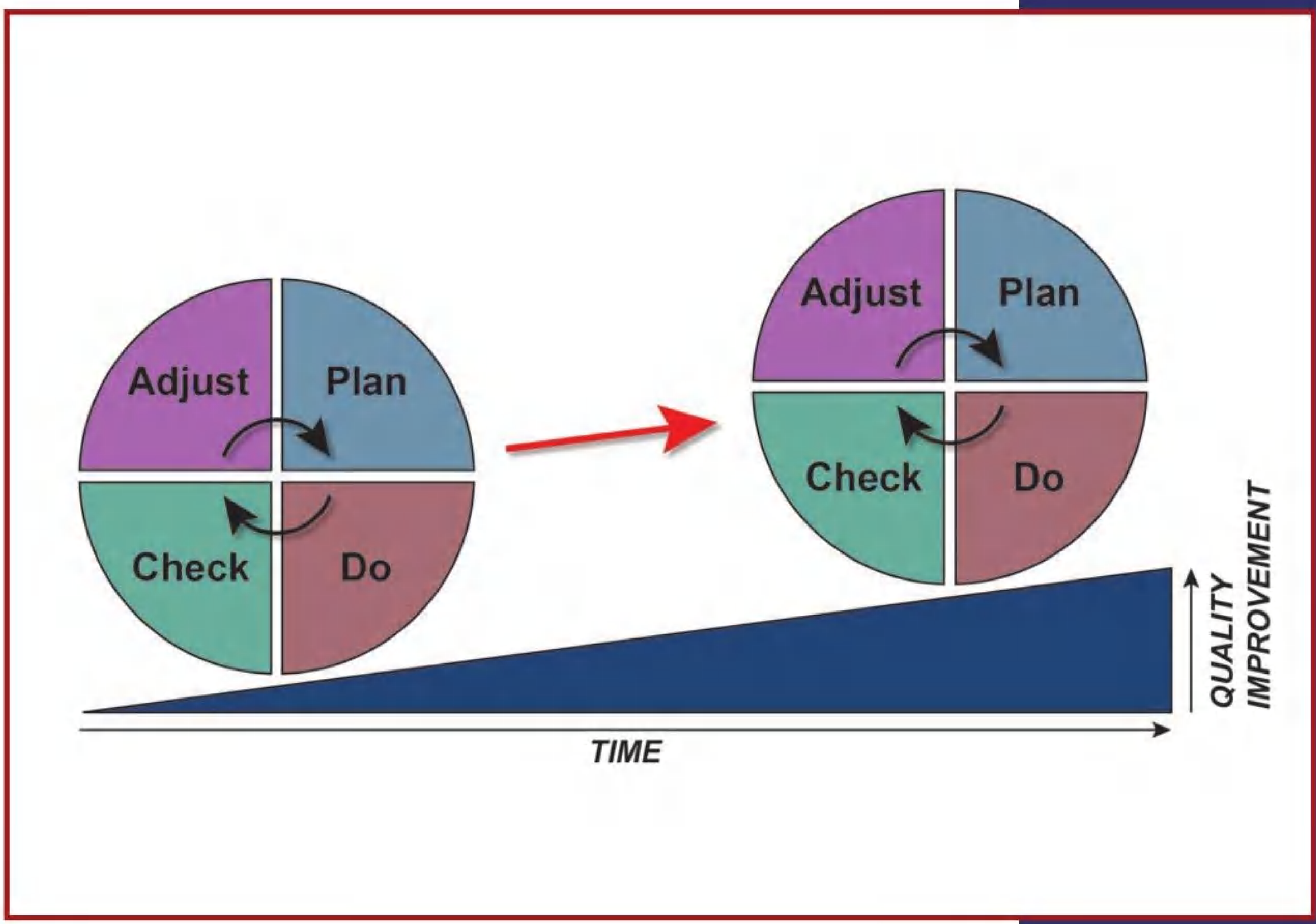
SUPPLEMENTAL LESSON

14

Bringing Quality Improvement to Your Resuscitation Team

What you will learn

- The rationale for introducing quality improvement (QI) methods into the delivery room
- Basic QI principles
- Potential QI projects for neonatal resuscitation teams



Key Points

1. In health care, multifaceted tasks such as neonatal resuscitation benefit from the application of quality improvement principles.
2. Quality improvement can address multiple aspects of neonatal resuscitation practice and outcomes.
3. A multidisciplinary team is a key component of effective quality improvement.
4. Project aims should be specific, measurable, achievable, realistic, and timely.
5. A balancing measure seeks to ensure that the quality improvement project is not leading to unintended adverse consequences.
6. Data collection and reporting can identify gaps and allow tracking of neonatal resuscitation performance.
7. As the team tracks data and develops ideas for changes to motivate improvement, a common method of testing change is the 4-phase Plan-Do-Check-Adjust (PDCA) cycle.

Case: A quality improvement project to reduce hypothermia in preterm newborns

A staff member who collects data for your hospital's participation in a statewide collaborative notices that several recent preterm newborns had hypothermia when they were admitted to your neonatal intensive care unit (NICU). The staff member brings this to the attention of the nurse manager and medical director. The team reviews data from the past 12 months and finds that the average temperature among the 20 babies born before 32 weeks' gestational age was 35.9°C. As admission hypothermia is associated with adverse outcomes for preterm newborns, a small, multidisciplinary quality improvement (QI) team is formed to address this problem. The team includes a neonatologist, neonatal nurse practitioner, NICU nurse, pediatric hospitalist, and respiratory therapist. The team also invites the hospital's quality improvement specialist to participate.

Upon further review of the data, the team found that 40% of the preterm newborns had an admission temperature below 36.5°C, meeting its definition of hypothermia. The team develops the following aim statement: We will decrease the rate of admission hypothermia in preterm newborns less than 32 weeks' gestational age from 40% to 20% during the next 12 months. A data collection form is created to track the implemented changes and their impact on the frequency of hypothermia. While reviewing its unit's practices, the QI team finds that thermoregulation practices vary according to the provider attending each delivery. The team reviews the literature and decides to standardize care by implementing a combination of interventions, including using polyethylene plastic wrap, a chemical warming mattress, and a cotton hat. In their hospital, 2 nurses attend each preterm delivery. The team decides that one of these nurses will be designated to be in charge of thermoregulation. This nurse will prepare the supplies, turn on the radiant warmer, place the temperature sensor, and monitor the steps of thermoregulation during resuscitation to ensure that the baby remains covered with plastic wrap.

The QI team meets monthly and reviews its data. The team posts a chart showing admission temperatures for all preterm newborns in a location where NICU staff can see it daily. After 3 months, the team finds that the average admission temperature has increased and there appears to be a trend toward a reduced rate of admission hypothermia. Looking more closely, they find that the improvement is noticeable for vaginal births but not cesarean births. Two representatives from the labor and delivery staff are invited to join the QI team. Over the next month, the QI team hosts educational huddles where the risk of admission hypothermia is discussed with the operating room staff. The team implements a process to increase the operating room temperature before preterm cesarean births. There is a steady improvement in admission temperatures, the team's aim is achieved, and the team focuses on strategies to sustain the improvement.

The role of quality improvement in neonatal resuscitation

A newborn who requires resuscitation or stabilization after birth relies on well-trained health care providers. This textbook reviews the cognitive and technical skills necessary to become proficient in neonatal resuscitation. Participating in simulation and debriefing enhances the communication, leadership, and behavioral skills that are necessary for effective teamwork. Ultimately, the performance of health care providers and the outcomes of patients also depend on the system in which the patients receive their care. This includes the physical environment, policies, and culture of the health care setting. Quality improvement in health care aims to address these underlying aspects of care.

In health care, multifaceted tasks benefit from the application of QI principles. Several aspects of neonatal resuscitation make it a particularly good area on which teams can focus their QI efforts.

- Neonatal resuscitation is a complex process that may require infrequently used supplies and equipment.
- Teams with varying composition often assemble to work together with little advance notice.
- Practice is guided by an algorithm.
- There are measurable data that are relevant for processes in care and important patient outcomes.

This lesson gives an overview of basic QI principles as they relate to training and practice in neonatal resuscitation.

Identifying and describing the problem

Begin your neonatal resuscitation quality improvement project by identifying a problem and describing the process that needs to be improved. You can identify problems in your neonatal resuscitation process by surveying parents in your nursery or NICU, asking your staff about things that cause them dissatisfaction, reviewing patient safety reports or patient complaints, or auditing charts and comparing your patient outcomes with those from published reports or established collaborations. Observe a series of neonatal resuscitations from a parent's point of view. Are there processes or activities that you would find confusing, upsetting, or frustrating? Next, observe resuscitations from a staff member's point of view. Are there processes or activities that are inefficient or distract staff members from important tasks?

Once you identify a potential problem, ask yourself a series of questions to further describe the problem. Following are some examples:

- What is the problem that we need to improve?
- Who are all of the people affected by this problem?
- During patient care, when does this problem happen?

Now that you have created a list of potential problems that could be improved, you need to prioritize them. Additional questions will help you judge the importance of potential QI projects.

- Is the problem an urgent patient safety issue?
- Do you have the experience and resources to solve a complex problem or do you need to start with a small project to improve the likelihood of success?
- Do you have access to the data needed to measure whether your project is successful?

Assembling a team to improve the problem

A multidisciplinary team is a key component of health care quality improvement, and this is particularly true for problems identified in delivery room care. While a specific process that needs improvement may be the target of a project that directly involves only 1 or 2 roles, other members of the delivery room team may have perspectives that provide helpful insights. A core QI team may include a physician/advanced practice provider, nurse, respiratory therapist, labor and delivery nurse, and patient advocate. Administrators, educators, lactation consultants, parents, and hospital-based QI experts can also be important members of a team. Specific projects may benefit from recruitment of other roles to the team. For example, a project aiming to improve management of the operating room environment or delayed umbilical cord clamping would benefit from other members of the obstetric team. A project that aims to ensure that the correct neonatal care providers are called to a delivery would benefit from involving unit clerks.

There are formal training programs and a broad literature base on the science and practice of quality improvement. Many hospitals will have clinicians and/or administrators with a substantial background in quality improvement who can provide valuable expertise even if they are not clinically involved in the delivery room.

Developing a specific aim

Next, develop a clearly stated and specific aim. The Institute of Medicine (IOM) has outlined 6 broad aims for health care improvement that can be used to help teams identify their own specific aims.[1] The IOM suggests that care should be

- **Safe:** Patients should not be injured by the care that is intended to help them.
- **Effective:** The care provided should be guided by scientific evidence.
- **Patient-Centered:** Decisions should be focused on the patient's best interest and goals.
- **Timely:** Care should be provided when it is needed and without delay.
- **Efficient:** Avoid wasting patient and staff time. Avoid wasting limited resources.
- **Equitable:** All patients deserve high-quality care, and we should work to eliminate disparities between racial, ethnic, and gender groups.

Your goal is to describe exactly what you hope to accomplish with this project. An acronym that has been used as a guide for developing a good aim is SMART. This acronym stands for Specific, Measurable, Achievable, Realistic, and Timely. It is based on principles outlined by the Model for Improvement from the Institute for Healthcare Improvement (Table 14-1).

Table 14-1. Steps for Developing SMART Aims

Step	Description
Specific	Have a precise goal. Example: *We will reduce the number of preterm newborns <32 weeks' gestational age who have hypothermia upon admission to the NICU by 20%.*
Measurable	Have a clear, understandable measurement that will make it possible to recognize an improvement. Example: *...defined as admission temperature <36.5°C.*
Achievable	Have actionable items that can be used to achieve the goal, such as evidence-based practices that have been shown to be effective. Example: *...using a bundle of preventive measures, including plastic wrap, chemical warming mattresses, cotton hats, and increasing ambient temperature.*
Realistic	Have appropriate resources, such as staff involvement, training, and equipment. Example: *...with plans for simulation training for all staff to implement strategies.*
Timely	Have a timeline that is realistic, yet creates a sense of urgency for the project. Example: *...within a time frame of 1 year.*
Final SMART Aim	*We will reduce the number of preterm newborns <32 weeks' gestational age with hypothermia upon admission to the NICU by 20%, defined as admission temperature <36.5°C, using a bundle of preventive measures, including plastic wrap, chemical warming mattresses, cotton hats, and increasing ambient temperature, with plans for simulation training for all staff to implement strategies, within a time frame of 1 year.*

Prioritizing your potential changes

Once your target for quality improvement has been identified and a specific aim has been described, the team can identify potential practice changes using evidence from published literature, interventions from similar QI projects at your own institution, practices in other local hospitals, and guidelines or toolkits developed by multicenter collaborative QI organizations. The team also can brainstorm about the specific circumstances in the local setting that have made it difficult to achieve the best outcomes for the targeted problem. This planning will help to inform the strategies in initiating and sustaining the project.

Data for quality improvement in neonatal resuscitation

Being able to track data efficiently and accurately is an important aspect of quality improvement. Depending on the targets of a project, some data may already be collected as part of clinical care, while other elements may be collected specifically for a project. In many situations, measures that describe a particular process in patient care, rather than the outcome of care, require additional data collection.

- For example, in a project to improve thermoregulation for preterm newborns, admission temperature may be routinely collected, but whether a thermal mattress was used in the delivery room may not be systematically collected.
- Another key process measure may be the actual ambient temperature of the operating room during a cesarean birth.

An important feature of data for quality improvement is the use of balancing measures. A balancing measure seeks to ensure that the QI project is not leading to unintended adverse consequences. For a project to reduce hypothermia, a balancing measure could be newborns who have hyperthermia upon admission to the NICU.

Tracking the improvement process

It is important to systematically follow the data collected through the improvement process. *Run charts and control charts* are common ways to track QI data.

A run chart is a simple method of visualizing change over time. It can help you identify trends and determine if the changes you made are leading to improvements. On the chart, the horizontal (x) axis represents time periods or cases in order, and the process or outcome being measured is plotted on the vertical (y) axis. The individual values are connected by a line.

- A run chart can be constructed relatively easily using a spreadsheet program, online tools, or even by hand.
- Two horizontal lines may be added to the chart. One line shows the mean (average) or median (middle) value of the process or outcome you are measuring during the monitoring period. The other line shows the goal or target chosen by your team for your SMART aim.
- For example, in a project tracking thermal management for preterm newborns, admission hypothermia would be the primary measurement being tracked (Figure 14.1). Baseline data prior to starting the QI project are necessary to have a sense of the goal, direction, and scale of change. Annotations can be made on the chart to show key time points when new processes were implemented.

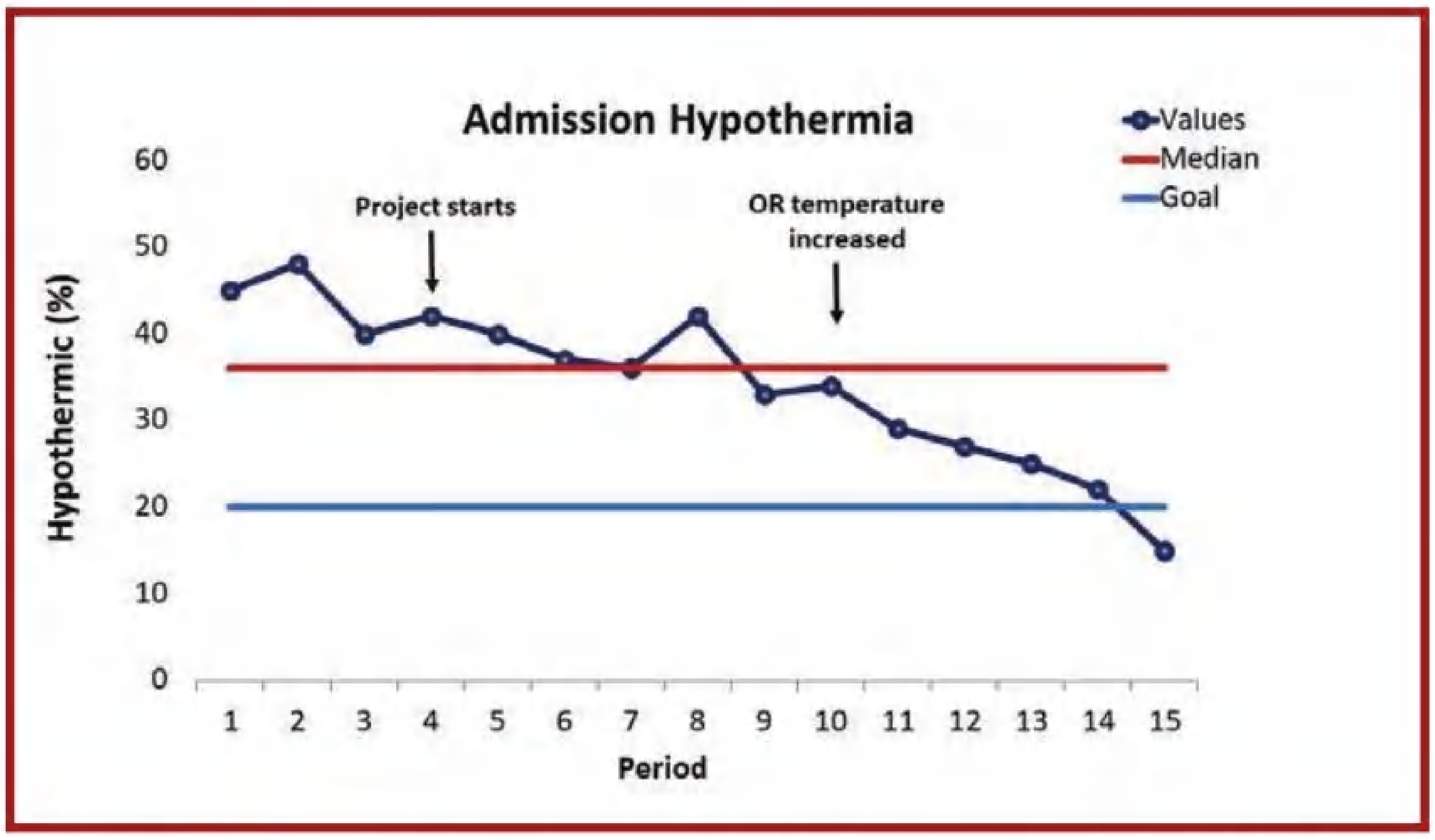


Figure 14.1. A sample run chart illustrating admission hypothermia over time. The plotted values represent the percentage of preterm babies admitted with hypothermia each month. The project goal and the median (middle) value during the entire monitoring period are shown with horizontal lines. Important process changes are annotated on the chart.

Rules have been published to help you determine if the trends visualized on the run chart represent chance (random) variation or can be attributed to the practice changes you made. If you are interested in learning more about these rules, see the Additional Resources section at the end of this lesson.

A limitation of a run chart is that it may not be able to give assurance whether the observed trend is stable ("in control") or changing. To get a better sense of whether the process being measured is in control, QI teams use *control charts* (also called statistical process control charts or SPC charts).

- A control chart is a version of the run chart that includes additional horizontal lines called *upper and lower control limits*. These control limits are determined from historical data.
- If the variation in the outcome being measured is contained within the 2 control limits, it is stable and not changing more than what can be explained by chance variation.
- The upper and lower control limits are calculated by spreadsheet programs or QI software.
- Calculating control limits requires the collection of some baseline data. Frequently, at least 15 to 20 points are recommended.
- Once the process has changed and your measured outcome shows a sustained improvement beyond what can be explained by chance variation, the QI team may choose to recalculate the control limits.

An example of a control chart for the data collected during the thermal management project is shown in Figure 14.2.

Plotting data over time and employing control charts will prevent the QI team from overreacting to outliers. These are situations where an unusual outcome occurred for reasons not directly related to the QI project. Reacting too quickly to an undesirable outcome may lead to a lack of ability to discern the true result of a QI intervention. It may be helpful to recruit a colleague to the team who has experience with software for quality improvement. This person does not necessarily have to be directly involved with the perinatal/neonatal setting to provide their expertise to complement the clinical expertise of the other team members.

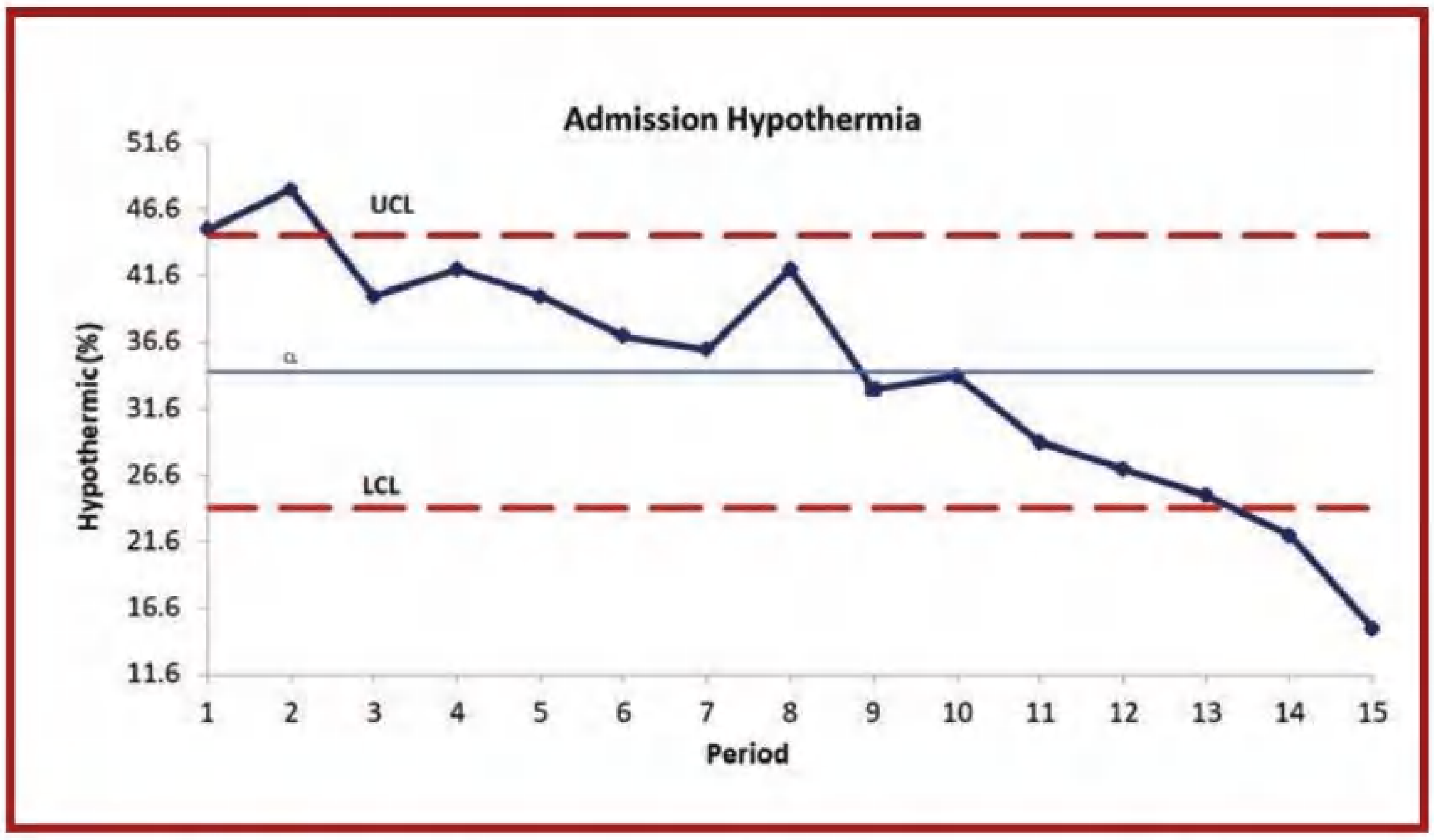


Figure 14.2. A sample control chart illustrating upper control limits (UCL) and lower control limits (LCL). After period 15, the team may choose to recalculate the control limits.

Cycles of improvement

As the team tracks data and develops ideas for changes to motivate improvement, a common method of testing change is the 4-phase Plan-Do-Check-Adjust (PDCA) cycle.[2] The *Plan* phase involves the team's efforts to review the relevant best practices in the context of the local setting and develop an initial set of changes designed to improve the problem. The *Do* phase involves the implementation of selected changes in processes, systems, or education. The *Check* phase includes tracking and reviewing data after the practice changes are implemented to determine if the goal has been achieved. In addition to reviewing the process or outcome in question, explore what you have learned from implementing the changes. Ask why improvement was observed or not observed. The *Adjust* phase involves taking action on what you have learned from this cycle, informing others of the results, implementing the tested changes widely and sustaining them if successful, or incorporating what you learned from this cycle into new changes that will inform the *Plan* phase of the next improvement cycle.

What is the difference between a research project and a quality improvement project?

A research project seeks to answer a question of whether a specific intervention leads to a better outcome. This may often involve randomizing a patient to the study intervention or a control intervention. In contrast, QI projects use existing evidence or best practices and seek to implement them for the appropriate patients more frequently, systematically, and efficiently. Usually, there is no randomization and no informed consent, as the interventions are already presumed to be beneficial to the patient. Quality improvement projects can be written into reports for the purpose of informing others to learn how to implement change in their setting.

Potential projects for quality improvement in neonatal resuscitation

The previous lessons have ended with lists of potential quality improvement opportunities. These and other potential projects are listed in Table 14-2.

Table 14-2. Potential Quality Improvement Opportunities in the Delivery Room
Having the appropriate team members at the time of delivery
Increasing the proportion of newborns with cord clamping delayed for 30-60 seconds
Having all of the ventilation corrective steps performed prior to alternative airway insertion
Decreasing delivery room intubation for preterm newborns by improving continuous positive airway pressure (CPAP) and positive-pressure ventilation (PPV) by mask
Having the target oxygen saturation in range at 5 minutes of age for preterm newborns
Providing 100% oxygen when initiating chest compressions

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Additional Resources

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