TEACHING AIDS FOR

FACILITY BASED NEWBORN CARE AT DISTRICT LEVEL

IN

NEONATAL RESUSCITATION
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Overview and Principles of Resuscitation

The Neonatal Resuscitation Program (NRP) will help you learn to resuscitate newborns. By studying this book and practicing the skills, you will learn to be a valuable member of the resuscitation team.

Many concepts and skills are taught in the program. However, the single most important concept of NRP, which is emphasized throughout the program, is that:

Ventilation of the baby's lungs is the most important and effective action in neonatal resuscitation

In Lesson 1 you will learn the

- Changes in physiology that occur when a baby is born
- Sequence of steps to follow during resuscitation
- Risk factors that can help predict which babies will require resuscitation
- Equipment and personnel needed to resuscitate a newborn
Why learn neonatal resuscitation?

Birth asphyxia accounts for about 19% of the approximately 5 million neonatal deaths that occur each year worldwide (World Health Organization, 1995). For many of these newborns, appropriate resuscitation was unavailable. Therefore the outcomes of thousands of newborns per year might be improved by more widespread use of the resuscitation techniques taught in this program.

Which babies require resuscitation?

Approximately 10% of newborns require some assistance to begin breathing at birth; about 1% need extensive resuscitative measures to survive. In contrast, at least 90% of newly born babies make the transition from intrauterine to extrauterine life without difficulty. They require little to no assistance initiating spontaneous and regular respirations and completing transition from the fetal to the neonatal blood-flow pattern.

The “ABCs” of resuscitation are the same for babies as for adults. Ensure that the Airway is open and clear. Be sure that there is Breathing, whether spontaneous or assisted. Make certain that there is adequate Circulation of oxygenated blood. Newly born babies are wet following birth and heat loss is great. Therefore, it also is important to maintain body temperature during resuscitation.

The diagram below illustrates the relationship between resuscitation procedures and the number of newly born babies who need them. At the top are the procedures needed by all newborns. At the bottom are procedures needed by very few.
How does a baby receive oxygen before birth?

Oxygen is essential for survival both before birth and after birth. Before birth, all of the oxygen used by a fetus diffuses across the placental membrane from the mother’s blood to the baby’s blood.

What normally happens at birth to allow a baby to get oxygen from the lungs?

Normally, three major changes begin immediately after birth.

1. The fluid in the alveoli is absorbed into lung tissue and replaced by air (Figure 1.2). Because air contains 21% oxygen, filling the alveoli with air provides oxygen that can diffuse into the blood vessels that surround the alveoli.

2. The umbilical arteries and vein constrict and then are clamped. This removes the low-resistance placental circuit and increases systemic blood pressure.

3. As a result of the gaseous distention and increased oxygen in the alveoli, the blood vessels in the lung tissue relax, decreasing resistance to blood flow (Figure 1.3). This relaxation, together with the increased systemic blood pressure, results in a lower pressure in the pulmonary arteries than in the systemic circulation and leads to a dramatic increase in pulmonary blood flow and a decrease in flow through the ductus arteriosus. The oxygen from the alveoli is absorbed by the blood in the pulmonary vessels, and the oxygen-enriched blood returns to the left side of the heart, where it is pumped to the tissues of the newborn’s body.

Figure 1.1. Fluid-filled alveoli and constricted blood vessels in the lung before birth

Figure 1.2. Fluid replaced by air in alveoli
Figure 1.3. Dilation of pulmonary blood vessels at birth

Figure 1.4. Cessation of shunt through ductus arteriosus after birth, as blood preferentially flows to the lungs
What can go wrong during transition?

A baby may encounter difficulty before labor, during labor, or after birth. If the difficulty begins in utero, either before or during labor, the problem usually reflects compromise in the uterine or placental blood flow. The first clinical sign can be a deceleration of the fetal heart rate, which may return to normal even after blood flow has been significantly compromised. Problems encountered after birth are more likely to involve the baby’s airway and/or lungs. The following are some of the problems that may disrupt normal transition:

• The baby may not breathe sufficiently to force fluid from the alveoli or foreign material, such as meconium may block air from entering the alveoli. As a result, the lungs may not fill with air, and oxygen will not be available to blood circulating through the lungs (hypoxemia).
• Excessive blood loss may occur, or there may be poor cardiac contractility or bradycardia from hypoxia and ischemia so that the expected increase in blood pressure cannot occur (systemic hypotension).
• A failure of gaseous distension of the lungs or lack of oxygen may result in sustained constriction of the pulmonary arterioles, Thus decreasing the blood flow to the lungs and oxygen supply to body tissues. In some cases, the pulmonary arterioles may fail to relax even after the lungs are filled with air/oxygen (persistent pulmonary hypertension of the newborn, frequently abbreviated as PPHN).

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

Normally, newborns will make vigorous efforts to inhale air into the lungs. The pressure created assists fetal lung fluid to move out of the alveoli and into the surrounding lung tissue. This also brings oxygen to the pulmonary arterioles and causes the arterioles to relax. If this sequence is interrupted, the pulmonary arterioles can remain constricted, the alveoli remained filled with fluid instead of air, and the systemic arterial blood may not become oxygenated.

When oxygen supply is decreased, the arterioles in the bowels, kidneys, muscles, and skin constrict, while blood flow to the heart and brain remains stable or increases to maintain oxygen delivery. This redistribution of blood flow helps preserve function of the vital organs. However, if oxygen deprivation continues, myocardial function and cardiac output deteriorate, blood pressure falls and blood flow to all organs is reduced. The consequence of this lack of adequate blood perfusion and tissue oxygenation can be irreversible brain damage, damage to other organs, or death.

The compromised baby may exhibit one or more of the following clinical findings:

• Poor muscle tone from insufficient oxygen delivery to the brain, muscles, and other organs.
• Depression of respiratory drive from insufficient oxygen delivery to the brain.
• Bradycardia (slow heart rate) from insufficient delivery of oxygen to the heart muscle or brain stem
• Low blood pressure from insufficient oxygen to the heart muscle, blood loss, or insufficient blood return from the placenta before or during birth
• Tachypnea (rapid respirations) from failure to absorb fetal lung fluid
• Cyanosis from insufficient oxygen in the blood
The resuscitation flow diagram

This flow diagram describes all of the NRP resuscitation procedures. The diagram begins with the birth of the baby. Each resuscitation step is shown in a block. Below each block is a decision point to help you decide if you need to proceed to the next step.

Study the diagram as you read the description of each step and decision point. This diagram will be repeated in later lessons. Use it to help you remember the steps involved in a resuscitation.

**Initial Assessment Block.** At the time of birth, you should ask yourself four questions about the newborn. These questions are shown in the Assessment block of the diagram. If any answer is “No,” you should continue to the initial steps of resuscitation.

**A Block A (Airway).** These are the initial steps you take to establish an Airway and begin resuscitating a newborn.

- Provide warmth.
- Position the baby’s head to open the airway; clear the airway as necessary.
- Dry the skin, stimulate the baby to breath, and reposition the baby’s head to open the airway.

Note how quickly you evaluate the baby and take the initial steps. As the time line shows, you should complete these blocks in about 30 seconds.

**Evaluation of the effect of Block A.** You evaluate the newborn after about 30 seconds. You should simultaneously evaluate respirations, heart rate, and color. If the newborn is not breathing adequately (has apnea or is gasping), has a heart rate of less than 100 bpm or appears blue (cyanotic), you proceed to 1 of the 2 Blocks B.

**B Block B (Breathing).** If the baby has apnea or has a heart rate below 100 bpm, you assist the baby’s Breathing by providing positive-pressure ventilation. If he is cyanotic, you may give him supplemental oxygen.

**Evaluation of the effect of Block B.** After about 30 seconds of ventilation and/or supplemental oxygen, you evaluate the newborn again. If the heart rate is below 60 bpm, you proceed to Block C.

**C Block C (Circulation).** You support Circulation by starting chest compressions while continuing positive-pressure ventilation.

**Evaluation of the effect Block C.** After about 30 seconds of chest compressions and positive pressure ventilation, you evaluate the newborn again. If the heart rate is still below 60 bpm, you proceed to Block D.

**D Block D (Drug).** You administer epinephrine as you continue positive-pressure ventilation and chest compressions.

**Evaluation of Block D.** If the heart rate remains below 60 bpm, the actions in Blocks C and D are continued and repeated. This is indicated by the curved arrow.
Be sure that each step is being performed correctly and effectively before proceeding to the next step.
When the heart rate improves and rises above 60 bpm, chest compressions are stopped. Positive-pressure ventilation is continued until the heart rate is above 100 bpm and the baby is breathing.

Please note the following important points about the flow diagram:

- There are two heart rates to remember: 60 bpm and 100 bpm. In general, a heart rate below 60 bpm indicates that additional resuscitation steps are needed. A heart rate above 100 bpm usually indicates that resuscitation procedures beyond those in Block A can be stopped, unless the patient is apneic.

- The asterisks (*) in the flow diagram indicate points at which endotracheal intubations may be needed. These points will be described in later lessons.

- The time line beside the flow diagram indicates how quickly resuscitation proceeds from step to step. If you are sure resuscitation is being performed effectively, do not continue a step beyond about 30 seconds when a newborn shows no improvement. Instead, proceed to the next step in the flow diagram. If you feel that any step is not being delivered effectively, you may need to take longer than 30 seconds to correct the problem.

- The primary actions in neonatal resuscitation are aimed at getting oxygen into the baby’s lungs (Blocks A and B). Once this has been accomplished, heart rate, blood pressure and pulmonary blood flow will usually improve spontaneously. However, if blood and tissue oxygen levels are low, cardiac output may have to be assisted by chest compressions and epinephrine (Blocks C and D) for blood to reach the lungs to pick up oxygen.

Now take time to become familiar with the flow diagram and learn the order of steps that will be presented in the following lessons. Also learn the heart rates you use to decide if the next step is needed.

**How do you prioritize your actions?**

A very important cycle repeated throughout resuscitation consists of evaluating the newborn, deciding what action to take, and taking action. Then repeat the evaluation using the new vital signs as the basis for more decisions and further actions.

Evaluation is based primarily on the following three signs:

- Respirations
- Heart rate
- Color

You will decide whether a particular step is effective by assessing each of these 3 signs. Although you will evaluate all 3 signs simultaneously, a seriously low heart rate is most important for determining whether you should proceed to the next step. This process of evaluation, decision, and action is repeated frequently throughout resuscitation.
Why is the Apgar score not used to guide resuscitation?

The Apgar score is an objective method of quantifying the newborn’s condition and is useful for conveying information about the newborn’s overall status and response to resuscitation. However, resuscitation must be initiated before the one minute score is assigned. Therefore, the Apgar score is not used to determine the need for resuscitation, what resuscitation steps are necessary, or when to use them. The three signs that you will use to decide how and when to resuscitate (respirations, heart rate, and color) do form part of the score.

How do you prepare for a resuscitation?

At every birth, you should be prepared to resuscitate a newborn because the need for resuscitation can come as a complete surprise. For this reason, every birth should be attended by at least one person skilled in neonatal resuscitation whose sole responsibility is management of the newborn. Additional personnel will be needed if more complex resuscitation is anticipated.

With careful consideration of risk factors, more than half of all newborns who will need resuscitation can be identified prior to birth. If you anticipate the possible need for neonatal resuscitation, you can

- Recruit additional skilled personnel to be present.
- Prepare the necessary equipment.

What equipment should be available?

All the equipment necessary for a complete resuscitation must be in the delivery room and be fully operational. When a high-risk newborn is expected, appropriate equipment should be ready to use. A complete list of neonatal resuscitation equipment is in the Appendix at the end of this lesson.

What do you do after resuscitation?

Babies who have required resuscitation are at risk for deterioration after their vital signs have returned to normal.

Routine Care: Nearly 90% of newborns are vigorous term babies with no risk factors and clear amniotic fluid. They do not need to be separated from their mothers after birth in order to receive the initial steps of resuscitation. Thermoregulation can be provided by putting the baby directly on the mother’s chest, drying, and covering with dry linen. Warmth is maintained by direct skin-to-skin contact with the mother. Clearing of the upper airway can be provided as necessary by wiping the baby’s mouth and nose. While the initial steps can be provided in modified form, ongoing observation of breathing, activity, and color must be carried out to determine the need for additional intervention.

Observational Care: Babies with risk factors, who have meconium staining of the amniotic fluid or skin, have depressed breathing or activity, and/or are cyanotic will need closer observation. These babies should be evaluated and managed initially under a radiant warmer and should receive the initial steps as appropriate. These babies are still at risk for developing problems and should be evaluated frequently during the immediate neonatal period.

Post-resuscitation Care: Babies who required positive-pressure ventilation or more extensive resuscitation may require ongoing support, are at high risk for recurrent deterioration. These babies generally should be managed in an environment where ongoing evaluation and monitoring are available. Transfer to an intensive care nursery may be necessary.
Key Points

1. Most newly born babies are vigorous. Only about 10% percent require some kind of assistance and only 1% need major resuscitative measures (intubation, chest compression and/or medications) to survive.

2. The most important and effective action in neonatal resuscitation is to ventilate baby’s lungs.

3. Lack of ventilation of the newborn’s lungs result in sustained constriction of the pulmonary arterioles, preventing systemic arterial blood from becoming oxygenated. Prolonged lack of adequate perfusion and oxygenation to the baby’s organs can lead to brain damage, damage to other organs, or death.

4. When a fetus/newborn first becomes deprived of oxygen, an initial period of attempted rapid breathing is followed by primary apnea and dropping heart rate that will improve with tactile stimulation. If oxygen deprivation continues, secondary apnea ensues, accompanied by a continued fall in heart rate and blood pressure. Secondary apnea cannot be reversed with stimulation; assisted ventilation must be provided.

5. Initiation of effective positive-pressure ventilation during secondary apnea usually results in rapid improvement in heart rate.

6. The majority of, but not all, neonatal resuscitation can be anticipated by identifying the presence of antepartum and intrapartum risk factors associated with the need for neonatal resuscitation.

7. All newborns require initial assessment to determine whether resuscitation is required.

8. Every birth should be attended by at least 1 person whose only responsibility is the baby and who is capable of initiating resuscitation. Either that person or someone else who is immediately available should have the skills required to perform a complete resuscitation. When resuscitation is anticipated, additional personnel should be present in the delivery room before the delivery occurs.

9. Resuscitation should proceed rapidly.

   • You have approximately 30 seconds to achieve a response from one step before deciding whether you need to go on to the next step.

   • Evaluation and decision making are based primarily on respirations, heart rate, and color.
Key Points - continued

10. The steps of neonatal resuscitation are as follow:

A. Initial steps.
   - Provide warmth.
   - Position head and clear airway as necessary.*
   - Dry and stimulate the baby to breathe.
   - Evaluate respirations, heart rate, and color.

B. Provide positive-pressure ventilation with a resuscitation bag and supplemental oxygen.*

C. Provide chest compressions as you continue assisted ventilation.*

D. Administer epinephrine as you continue assisted ventilation and chest compressions.*

*Consider intubation of the trachea at these points.
In Lesson 2 you will learn how to

- Decide if a newborn needs to be resuscitated.
- Open the airway, and provide the initial steps of resuscitation.
- Resuscitate a newborn when meconium is present.
- Provide free-flow oxygen when it is needed.

Birth

- Term gestation?
- Clear of meconium?
- Breathing or crying? Yes
- Good muscle tone?

Routine care
- Provide warmth
- Clear airway
- Dry
- Assess color
How do you determine whether the baby requires resuscitation?

- **Was the baby born at term?**

- **Was the baby clear of meconium?**

If meconium is present and the baby is not vigorous, it will be necessary to intubate the trachea to clear it of meconium before the baby takes many breaths. If the amniotic fluid is clear or if the meconium stained baby is vigorous, suctioning the trachea will not be necessary. No more than a few seconds should elapse while you make this determination.

- **Is the baby breathing or crying?**

A vigorous cry also indicates breathing. However, don’t be misled by a baby who is gasping. **Gasping is a series of deep single or stacked inspirations that occur in the presence of hypoxia and/or ischemia.** It is indicative of severe neurologic and respiratory depression and requires same intervention as apnea.

- **Is there good muscle tone?**

Healthy term babies should have flexed extremities and be active.

What are the initial steps and how are they administered?

If the baby is term and vigorous, the initial steps may be provided in modified form, as described in Lesson 1 (under “Routine Care”).

Once you decide that resuscitation is required, all of the initial steps should be initiated within a few seconds. Although they are listed as “initial” and are given in a particular order, they should continue to be applied throughout the resuscitation process.

- **Provide warmth**

The baby should be placed under a radiant warmer, where the resuscitation team will have easy access to the baby and the radiant heat will help to reduce heat loss (Figure 2.1). The baby should not be covered with blankets or towels. Leave the baby uncovered to allow full visualization and to permit the radiant heat to reach the baby.

Figure 2.1. Radiant warmer for resuscitating newborns
• Position by slightly extending the neck

The baby should be positioned on the back or side, with the neck slightly extended in the “sniffing” position. This will bring the posterior pharynx, larynx, and trachea in line, which will facilitate unrestricted air entry. This alignment in the supine position is also the best position for assisted ventilation with a bag and mask and/or to place an endotracheal tube. The goal is to move the baby’s nose as far anterior as possible, thus creating a “sniffing” position.

Care should be taken to prevent hyperextension or flexion of the neck, since either may restrict air entry (Figure 2.2).

To help maintain the correct position, you may place a rolled blanket or towel under the shoulders (Figure 2.3). This shoulder roll may be particularly useful if the baby has a large occiput (back of head) resulting from molding, edema, or prematurity.

• Clear airway (as necessary)

After delivery, the appropriate method for clearing the airway further will depend on the

1. The presence of meconium
2. The baby’s level of activity

Study the flow diagram below to understand how you suction newborns with meconium.
“Vigorous” is defined as strong respiratory efforts, good muscle tone, and a heart rate greater than 100 bpm. The technique of determining the heart rate is described at the end of this lesson.

What do you do if meconium is present and the baby is not vigorous?

If the baby born with meconium-stained fluid has depressed respirations, depressed muscle tone, and/or a heart rate less than 100 bpm, direct suctioning of the trachea soon after delivery is indicated before many respiration have occurred. The following steps can reduce the chances of the baby developing meconium aspiration syndrome—a very serious respiratory disorder:

- Insert a laryngoscope and use a 12F or 14F suction catheter to clear the mouth and posterior pharynx so that you can visualize the glottis (Figure 2.4)
- Insert an endotracheal tube into the trachea.

*Figure 2.4. Visualizing the glottis and suctioning meconium from the trachea using a laryngoscope and endotracheal tube (see Lesson 5 for details)*
• Attach the endotracheal tube to a suction source. (A special aspirator device will be needed.) (Figure 2.4)

• Apply suction as the tube is slowly withdrawn.

• Repeat as necessary until little additional meconium is recovered, or until the baby’s heart rate indicates that resuscitation must proceed without delay.

What do you do if meconium is present and the baby is vigorous?

If the baby born with meconium-stained fluid has a normal respiratory effort, normal muscle tone, and a heart rate greater than 100 bpm, simply use bulb syringe or large-bore suction catheter (12F or 14F) to clear secretions and any meconium from the mouth and nose.

How do you clear the airway if no meconium is present?

Secretions may be removed from the airway by wiping the nose and mouth with a towel or by suctioning with a bulb syringe or suction catheter. 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 easily.

When using suction from the wall or from a pump, the suction pressure should be set so that when the suction tubing is blocked, the negative pressure (vacuum) reads approximately 100 mm Hg.

The mouth is suctioned before the nose to ensure that there is nothing for the newborn to aspirate if he or she should gasp when the nose is suctioned. You can remember “mouth before nose” by thinking “M” comes before “N” in the alphabet (Figure 2.5). If material in the mouth and nose is not removed before the newborn breathes, the material can be aspirated into the trachea and lungs. When this occurs, the respiratory consequences can be serious.

Caution: When you suction, particularly when using a catheter, be careful not to suction vigorously or deeply. Stimulation of the posterior pharynx during the first few minutes after birth can produce a vagal response, causing severe bradycardia or apnea. Brief, gentle suctioning with a bulb syringe is usually adequate to remove secretions.

If bradycardia occurs during suctioning, stop suctioning and reevaluate the heart rate.

Suctioning, in addition to clearing the airway to allow unrestricted air entry to the lungs, also provides a degree of stimulation. In some case this is all the stimulation needed to initiate respirations in the newborn.
Once the airway is clear, what should be done to stimulate breathing and prevent further heat loss?

- **Dry, stimulate to breathe, and reposition**

Often, positioning the baby and suctioning secretions will provide enough stimulation to initiate breathing. Drying will also provide stimulation. Drying the body and head will also help to prevent heat loss. If 2 people are present, the second person can be drying the baby while the first person is positioning and clearing the airway.

As part of preparation for resuscitation, you should have several per-warmed absorbent towels or blankets available. The baby initially can be placed on one of these towels, which can be used to dry most of the fluid. This towel should then be discarded, and fresh pre-warmed towels or blankets should be used for continued drying and stimulation.

While you dry the baby, and thereafter, be sure to keep the head in the “sniffing” position to maintain a good airway (Figure 2.6).

**Figure 2.6.** Drying and removing wet linen to prevent heat loss and repositioning the head to ensure an open airway
What other forms of stimulation may help a baby breathe?

Both drying and suctioning stimulate the newborn. For many newborns, these steps are enough to induce respirations. If the newborn does not have adequate respirations, additional tactile stimulation may be provided briefly to stimulate breathing.

It is important for you to understand the correct methods of tactile stimulation. Stimulation may be useful not only to encourage a baby to begin breathing during initial steps of resuscitation, but also may be used to stimulate continued breathing after positive-pressure ventilation.

Safe and appropriate methods of providing additional tactile stimulation include

- Slapping or flicking the soles of the feet
- Gently rubbing the newborn’s back, trunk, or extremities (Figure 2.7)
Now that you have warmed, positioned, cleared the airway, dried, stimulated, and repositioned baby’s head, what do you do next?

**Evaluate the baby**

Your next step is to evaluate the newborn to determine if further resuscitation actions are indicated. The vital signs that you evaluate are as follows:

- **Respirations**
  There should be good chest movements, and the rate and depth of respirations should increase after a few seconds of tactile stimulation.

  *Remember, gasping respirations are ineffective and require the same intervention as for apnea.*

- **Heart rate**
  The heart rate should be more than 100 bpm. The easiest and quickest method of determining the heart rate is to feel for a pulse at the base of the umbilical cord, where it attaches to the baby’s abdomen (Figure 2.8). However, sometimes the umbilical vessels are constricted so that the pulse is not palpable. Therefore, if you cannot feel a pulse, you should listen for the heart beat over the left side of the chest using stethoscope. If you can feel a pulse or hear the heartbeat, tap it out on the bed so that others will also know the heart rate.

  Counting the number of beats in 6 seconds and multiplying by 10 can provide a quick estimate of the beats per minute.

- **Color**
  The baby should have pink lips and a pink trunk. Once adequate heart rate and ventilation are established, there should not be central cyanosis, which indicates hypoxemia.
What do you do if respirations or heart rate are abnormal?

The most effective and important action in resuscitating a compromised newborn is to assist ventilation.

No matter which vital sign is abnormal, almost all compromised newborns respond to establishment or improvement of ventilation. Take a few seconds to minimize heat loss, clear airway, and try to stimulate respirations. If the baby is still apneic, the next appropriate action is to assist ventilation.

*Remember, the entire resuscitation process up to this point should take no more than 30 seconds* (or perhaps a bit longer if suctioning of meconium from trachea was required).

Administering free-flow oxygen or continuing to provide tactile stimulation to a non-breathing newborn or to a newborn whose heart rate is less than 100 bpm is of little or no value and only delays appropriate treatment.
What do you do if the baby is breathing, but has central cyanosis?

A baby’s skin color, changing from blue to pink, can provide the most rapid and visible indicator of adequate breathing and circulation. The baby’s skin color is best determined by looking at the central part of the body. Cyanosis caused by too little oxygen in the blood will appear as a blue hue to the lips, tongue and central trunk. Acrocyanosis which is a blue hue to only the hands and feet does not generally indicate that the baby’s blood oxygen level is low and should not, by itself, be treated with oxygen. Only central cyanosis requires intervention.

If the baby is breathing but appears blue, administration of supplemental oxygen is indicated.

- **Give free-flow oxygen**
  Give a flow of 5 L/min with a tubing by cupped hand or a mask kept closer to the face (Figure 2.9 & 2.10).

  Free-flow oxygen cannot be given reliably by a mask attached to a self-inflating bag.
How do you know when to stop giving oxygen?

When the newborn no longer has central cyanosis, gradually withdraw the supplemental oxygen until the newborn can remain pink while breathing room air, or wean the oxygen as indicated by pulse oximetry.

If cyanosis persists despite administration of free-flow oxygen, the baby may have significant lung disease, and a trial of positive-pressure ventilation may be indicated (see Lesson 3).

Key Points

1. If meconium is present and the newborn is not vigorous, suction the baby’s trachea before proceeding with any other steps. If the newborn is vigorous, suction the mouth and nose only, and proceed with resuscitation as required.

2. “Vigorous” is defined as a newborn who has strong respiratory efforts, good muscle tone, and a heart rate greater than 100 beats per minutes.

3. Open the airway by positioning the newborn in a “sniffing” position.

4. Appropriate forms of tactile stimulation are
   • Slapping or flicking the soles of the feet
   • Gently rubbing the back

5. Continued use of tactile stimulation in an apneic newborn wastes valuable time. For persistent apnea, begin positive-pressure ventilation promptly.

6. Free-flow oxygen is indicated for central cyanosis. Acceptable methods for administering free-flow oxygen are
   • Oxygen mask held firmly over baby’s face
   • Mask from a flow-inflating bag or T-piece resuscitator held
easily over baby’s mouth and nose
   • Oxygen tubing cupped closely over the baby’s mouth and nose

7. Free-flow oxygen cannot be given reliably by a mask attached to a self-inflating bag

8. Decisions and actions during newborn resuscitation are based on newborn’s
   • Respiration   • Heart rate   • Color

9. Determine a newborn’s heart rate by counting how many beats are in 6 seconds, then multiply by 10. For example, if you count 8 beats in 6 seconds, announce the baby’s heart rate as 80 beats per minute.
Use of a Resuscitation Devices for Positive-Pressure Ventilation

In Lesson 3 you will learn

• When to give positive-pressure ventilation

• The operation of self inflating bag to provide positive-pressure ventilation

• The correct placement of masks on the newborn’s face

• How to test and troubleshoot devices used to provide positive-pressure ventilation

• How to evaluate the success of positive-pressure ventilation

Indications of Positive pressure Ventilation

• Baby is not breathing or is gasping,

• Heart rate is less than 100 bpm,

• Persistent central cyanotic despite supplemental oxygen

Ventilation of the lungs is the single most important and most effective step in cardiopulmonary resuscitation of the compromised newly born baby.
What will this lesson cover?

In this lesson you will learn how to prepare and use a resuscitation bag and mask or a T-piece resuscitator to deliver positive-pressure ventilation.

You learned in Lesson 2 how to determine within a few seconds whether some form of resuscitation will be required and how to take the initial steps of resuscitation. You begin resuscitation by minimizing heat loss; positioning; clearing the airway; stimulating the baby to breathe by drying as you reposition the head; and assessing respirations, heart rate, and color. If the baby is breathing but has central cyanosis you administer free-flow supplemental oxygen.

Indications of Positive Pressure Ventilation

- If the baby is not breathing or is gasping,
- the heart rate is less than 100 bpm, and/or
- the color remains cyanotic despite supplemental oxygen

*Ventilation of the lungs is the single most important and most effective step in cardiopulmonary resuscitation of the compromised newly born baby.*
Use of Self Inflating bag to ventilate newborns?

The self-inflating bag, as its name implies, inflates automatically without a compressed gas source (Figure 3.1). It remains inflated at all times, unless being squeezed. Peak inspiratory pressure (PIP) (or peak inflation pressure) is controlled by how hard the bag is squeezed.

![Figure 3.1](image1)

**Figure 3.1.** Self-inflating bag remains inflated without gas flow and without having the mask sealed on the face. However, it is shown with an oxygen line attached since oxygen may be needed during neonatal resuscitation.

Advantages and disadvantages of Self Inflating Bag?

The self-inflating bag (Figure 3.4) is more commonly found in the hospital delivery room and resuscitation cart. It is somewhat easier to learn to use, as it will refill after being squeezed, even if it is not attached to oxygen and even if its mask is not on a patient’s face. The disadvantage of this, of course, is that you will be less likely to know if the oxygen line has become disconnected or if you have not achieved a good seal between the mask and the baby’s face-both of which are necessary for effective resuscitation.

![Figure 3.4](image2)

**Figure 3.4.** Self-inflating bag

**Advantages**
- Will always refill after being squeezed even with no compressed gas source
- Pressure-release valve makes overinflation less likely

**Disadvantages**
- Will inflate even if there is not a seal between the mask and the patient’s face
- Requires a reservoir attachment to provide high concentration of oxygen
- Cannot be used to deliver 100% free-flow oxygen reliably
As a safety precaution, most self-inflating bags have a pressure release valve (pop-off valve) that limits the peak inspiratory pressure that can be delivered. If a self-inflating bag does not have a pressure release valve, then a gauge is needed to monitor peak inspiratory pressure.

**What are the important characteristics of resuscitation devices used to ventilate newborns?**

The equipment should be specifically designed for newborns. Consideration should be given to the following:

**Appropriately sized masks**

A variety of mask sizes, appropriate for babies of different sizes, should be available at every delivery, since it may be difficult to determine the appropriate size before birth. The mask should cover the chin, mouth, and nose, but not the eyes, while still being small enough to create a tight seal on the face.

**Capability to deliver a variable oxygen concentration up to 100%**

This program recommends that babies who require positive-pressure ventilation at birth initially be ventilated with high concentration of oxygen. This can be accomplished by attaching a 100% oxygen source to a self-inflating bag with an oxygen reservoir. High oxygen concentration cannot be achieved with a self-inflating bag without a reservoir.

**Appropriately sized bag**

Bags used for newborns should have volume of 200 to 750mL. Term newborns require only 15 to 25mL with each ventilation (5 to 8mL/Kg). Bags larger than 750mL, which are designed for older children and adults, make it difficult to provide such small volumes. Bags that are too small will not permit long inflation times.

**Safety features**

To minimize complications resulting from high ventilation pressures, resuscitation devices should have certain safety features to prevent or guard against inadvertent use of high pressures.

**What safety features prevent the pressures in the device from getting too high?**

You will attach a resuscitation device to either a mask, which will be held tightly against the patient’s face, or to an endotracheal tube, which will be in the patient’s trachea. In either case, if you ventilate with high pressure and/or rate, the lungs could become over inflated, causing rupture of alveoli and a resulting air leak, such as pneumothorax.

**Self-inflating bags** should have a pressure-release valve (commonly called *pop-off valve*) (Figure 3.7), which generally is set by the manufacturer at 30 to 40 cm H2O. If peak inspiratory pressures greater than 30 to 40 cm H2O are generated, the valve opens, limiting the pressure being transmitted to the newborn.

In some self-inflating bags, the pressure-release valve can be temporarily occluded or bypassed to allow higher pressures to be administered. This is usually not necessary, but can be done to ventilate a newborn’s non-aerated lungs when the usual pressures are not effective, especially with the first few breaths. Care must be taken not to use excessive pressure during first few ventilations while the pressure-release valve is bypassed.
What characteristics of face masks make them most effective for ventilating newborns?

Masks come in a variety of shapes, sizes, and materials. Selection of a mask for use with a particular newborn will depend on how well the mask fits the newborn’s face. The correct mask will achieve a tight seal between the mask and the newborn’s face.

Resuscitation masks have rims that are either **cushioned** or **noncushioned**.

The rim on a **cushioned** mask (Figure 3.12) is made from either a soft, flexible material, such as foam rubber, or an air-inflated ring. A cushioned-rim mask has several advantages over a mask without a cushioned rim.

- The rim conforms more easily to the shape of the newborn’s face, making it easier to form a seal.
- It requires less pressure on the newborn’s face to obtain a seal.
- There is less chance of damaging the newborn’s eyes if the mask is incorrectly positioned.

Some masks are constructed without a padded, soft rim. Such a mask usually has a very firm edge to the rim. A mask with a noncushioned rim can cause several problems.

- It is more difficult to obtain a seal, because it does not easily conform to the shape of the baby’s face.
- It can damage the eyes if the mask is improperly positioned.
- It can bruise the newborn’s face if the mask is applied too firmly.

Masks also come in two shapes: round and anatomically shaped (Figure 3.13). Anatomically shaped masks are shaped to fit the Contours of the face. They are made to be placed on the face with the most pointed part of the mask fitting over the nose.

Masks also come in several sizes. Masks suitable for small premature babies as well as for term babies should be available for use.

For the mask to be of the correct size, the rim will cover the tip of the chin, the mouth, and the nose but not the eyes (Figure 3.14).

- Too large—may cause possible eye damage and will not seal well
- Too small—will not cover the mouth and nose and may occlude the nose

Be sure to have various-sized masks available. Effective ventilation of a preterm baby with a term-infant size mask is impossible.
How do you prepare the resuscitation device for an anticipated resuscitation?

Assemble equipment
The positive-pressure ventilation device should be assembled and connected to oxygen so that it can provide the necessary 90% to 100% concentration, if needed. If a self-inflating bag is used, be sure the oxygen reservoir is attached. Anticipate the size of the baby at delivery, and be sure you have appropriate-sized masks. Check the masks carefully for any cracks or defects in the rim. With each of the resuscitation devices using an oxygen-air blender will facilitate adjustment of oxygen delivery after initial resuscitation, although a blender is not essential to successfully resuscitate a newborn.

Test the equipment
Once the equipment has been selected and assembled, check the bag and mask to be sure they function properly. Success in using a bag and mask requires more than up-to-date equipment and a skilled operator—the equipment must be in working order. Bags that have cracks or tears, valves that stick or leak, or mask that are cracked or deflated must not be used. The equipment should be checked before each delivery. The operator should check it again just before its use. There are different things to check on each of devices, as described in the respective appendices.

What do you need to check before beginning positive-pressure ventilation?

Select the appropriate-sized mask.
Remember, the mask should cover the mouth, nose, and tip of the chin, but not the eyes (Figure 3.15).

Be sure there is a clear airway.
You may want to suction the mouth and nose one more time to be certain there will be no obstruction to the assisted breaths that you will be delivering.

Position the baby’s head.
As described in Lesson 2, the baby’s neck should be slightly extended (but not overextended) into the “sniffing position” to maintain an open airway. One way to accomplish this is to place a small roll under the shoulders (Figure 3.16).

If the baby’s position has shifted, reposition the baby before continuing.
Position yourself at the bedside

You also will need to position yourself at the baby’s side or head to use a resuscitation device effectively (Figure 3.17). Both positions leave the chest and abdomen unobstructed for visual monitoring of the baby, for chest compressions, and for vascular access via umbilical cord should these procedures become necessary. If you are right-handed, you probably will feel most comfortable controlling the resuscitation device with your right hand and the mask with your left hand. If you are left-handed you probably will want to control the resuscitation device with your left hand and hold the mask with your right hand. The mask may be swiveled to orient it properly.

How do you position the bag and mask on the face?

The mask should be placed on the face so that it covers the nose and mouth, and the tip of the chin rests within the rim of the mask. You may find it helpful to begin by cupping the chin in the mask and then covering the nose (Figure 3.18.)

The mask usually is held on the face with the thumb, index, and/or middle finger encircling much of the rim of the mask, while the ring and fifth fingers bring the chin forward to maintain a patent airway.

Anatomically shaped masks should be positioned with the pointed end over the nose. Once the mask is positioned, an airtight seal can be formed by using light downward pressure on the rim of the mask and/or gently squeezing the mandible up towards the mask (Figure 3.19).

Care should be taken in holding the mask. Observe the following precautions:

- Do not “jam” the mask down on the face. Too much pressure can mold (flatten) the back of the head and bruise the face.
- Do not allow your fingers or parts of your hand to rest on the baby’s eyes.
Why is establishing a seal between the mask and the face so important?
An airtight seal between the rim of the mask and the face is essential to achieve the positive pressure required to inflate the lungs with the resuscitation devices.

How do you know how much inflation pressure to deliver?
The best indicator that the mask is sealed and the lungs are being adequately inflated is an improvement in heart rate, color, and muscle tone.

Rapid rise in the baby’s heart rate and subsequent improvement in color and muscle tone are the best indicators that inflation pressures are adequate. If these signs are not improving, you should look for the presence of chest movements with each positive-pressure breath and have an assistant listen to both sides of the lateral areas of the chest with a stethoscope to assess breath sounds. Abdominal movement due to air entering the stomach may be mistaken for effective ventilation.

If the baby appears to be taking very deep breaths, the lungs are being overinflated, you are using too much pressure, and there is a danger of producing pneumothorax. Remember that the volume of a normal newborn breath is much smaller than the amount of gas in your resuscitation bag: one tenth of 240-ml self-inflating bag; one thirtieth of a 750-ml flow-inflating bag (Figure 3.20).

How often should you squeeze the bag?
During the initial stages of neonatal resuscitation, breaths should be delivered at a rate of 40 to 60 breaths per minute, or slightly less than once a second.

Breathe ................... Two .................. Three .................. Breathe ................... Two .................. Three ..................
(squeeze) (release ..................) (squeeze) (release ..................)

Figure 3.21. Counting out loud to maintain a rate of 40 to 60 breaths per minute
How do you know if the baby is improving and that you can stop positive pressure ventilation?

Improvement is indicated by the following 4 signs:

- Increasing heart rate
- Improving color
- Spontaneous breathing
- Improving muscle tone

Check the 4 signs for improvement after 30 seconds of administering positive pressure. If the heart rate remains below 60 bpm, you need to proceed to the next step of chest compressions as described in the next lesson. But if the heart rate is above 60 bpm, you should continue to administer positive-pressure ventilation and assess the 4 signs every 30 seconds.

As the heart rate increases towards normal, continue ventilating the baby at a rate of 40 to 60 breaths per minute. With improvement, the baby also should become pink and muscle tone should improve. Monitor the movement of the chest and breath sounds to avoid overinflation or underinflation of the lungs.

When the heart rate stabilizes above 100 bpm, reduce the rate and pressure of assisted ventilation until you see effective spontaneous respirations. When color improves, supplemental oxygen also can be weaned as tolerated.

What do you do if the heart rate, color, and muscle tone do not improve and baby’s chest is not moving during positive-pressure ventilation?

If the heart rate, color, and muscle tone do not improve, check to see if the chest is moving with each positive-pressure breath and ask the second person to listen with the stethoscope for breath sounds. If the chest does not expand adequately and there are poor breath sounds, it may be due to one or more of the following reasons:

- The seal is inadequate
- The airway is blocked
- Not enough pressure is being given

Inadequate seal

If you hear or feel air escaping from around the mask, reapply the mask to the face and try to form a better seal. Use a little more pressure on the rim of the mask and lift the jaw a little more forward. Do not press down hard on the baby’s face. The most common place for a leak to occur is between the cheek and bridge of the nose (Figure 3.22).

Blocked airway

Another possible reason for insufficient ventilation of the baby’s lungs is a blocked airway. To correct this,

- Check the baby’s position and extend the neck a bit farther.
- Check the mouth, oropharynx, and nose for secretions; suction the mouth and nose if necessary.
- Try ventilating with the baby’s mouth slightly open (especially helpful in extremely small premature babies with very small nares).
Use of a Resuscitation Devices for Positive-Pressure Ventilation

Not enough pressure
You may be providing inadequate inspiratory pressure.

- Increase the pressure. If using a resuscitation device with a pressure gauge, note the amount of pressure required to achieve improvements in heart rate, color, breath sounds, and perceptible chest movements.

- If using a bag with pressure-release valve, increase the pressure until the valve actuates. If more pressure is required and it is possible to occlude the pressure release valve, do so, and cautiously increase the pressure.

- If physiologic improvements still cannot be achieved, endotracheal intubation may be required.

In summary, if you do not observe physiologic improvement, check for chest movement. If there is no improvement, try the following steps until the chest expands:

<table>
<thead>
<tr>
<th>Condition</th>
<th>Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Indequate seal</td>
</tr>
<tr>
<td>2</td>
<td>Blocked airway</td>
</tr>
<tr>
<td>3</td>
<td>Not enough pressure</td>
</tr>
</tbody>
</table>

If you still are unable to obtain physiologic improvement and adequate chest movement after going through this sequence, endotracheal intubation and positive-pressure ventilation through the endotracheal tube are usually required.
Is there anything else to do if positive-pressure with a mask is to be continued for more than several minutes?

Newborns requiring positive-pressure ventilation with a mask for longer than several minutes should have an orogastric tube inserted and left in place.

During positive-pressure ventilation with a mask, gas is forced into the oropharynx, where it can enter both the trachea and the esophagus. Proper positioning of the newborn will transmit most of the air into the trachea and the lungs. However, some gas may enter the esophagus and be forced into the stomach (Figure 3.23).

Gas forced into the stomach interferes with ventilation in the following ways:

- A stomach distended with gas puts upward pressure on the diaphragm, preventing full expansion of the lungs.
- Gas in the stomach may cause regurgitation of gastric contents, which may then be aspirated during positive-pressure ventilation.

The problems related to gastric/abdominal distention and aspiration of gastric contents can be reduced by inserting an orogastric tube, suctioning gastric contents, and leaving the gastric tube in place and uncapped to act as a vent for stomach gas throughout the remainder of the resuscitation.
How do you insert an orogastric tube?

The equipment you will need to place an orogastric tube during ventilation includes

- 8F feeding tube
- 20-mL syringe

The major steps are as follows:

1. First measure the amount of tube you want to insert. It must be long enough to reach the stomach but not so long as to pass beyond it. The length of the inserted tube should be equal to 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 3.24).

2. Insert the tube through the mouth rather than the nose (Figure 3.25A). The nose should be left open for ventilation. Ventilation can be resumed as soon as the tube has been placed.

3. Once the tube is inserted the desired distance, attach a syringe and quickly but gently remove the gastric contents.

4. Remove the syringe from the tube and leave the end of the tube open to provide a vent for air entering the stomach.

5. Tape the tube to the baby’s cheek to ensure that the tip remains in the stomach and is not pulled back into the esophagus.

The tube will not interfere with the mask-to-face seal if an 8F feeding tube is used and the tube exits from the side of the mask over the soft area of baby’s cheek. A large tube may make it difficult to obtain a seal, particularly in premature infants. A smaller tube can easily become occluded by secretions.
**What do you do if the baby is not improving?**

The vast majority of babies requiring resuscitation will improve if given adequate positive-pressure ventilation. Therefore, you should ensure that the lungs are being adequately ventilated with supplemental oxygen. If the baby still is not improving, consider the following:

**Is chest movement adequate?**

Check for adequacy of chest movement, and use a stethoscope to listen for bilateral breath sounds.

- Is the face-mask seal tight?
- Is the airway blocked because of improper head position or secretions in the nose, mouth, or pharynx?
- Is the resuscitation equipment working properly?
- Is adequate pressure being used?
- Is air in the stomach interfering with chest expansion?

**Is adequate oxygen being administered?**

- Is the oxygen tubing attached to the ventilation device *and* to the oxygen source?
- Is gas flowing through the flowmeter?
- If using a self-inflating bag, is the oxygen reservoir attached?
- If using a tank (rather than wall oxygen), is there oxygen in the tank?

These all seem obvious. However, in the atmosphere of urgency created by a new-born needing resuscitation, some of these points may be overlooked.

Positive-pressure ventilation with mask generally is not as effective as positive-pressure ventilation through an endotracheal tube. A mask does not seal on the face as tightly as an endotracheal tube seals in the larynx. Also with a mask, some of the positive pressure will escape down the esophagus into the stomach.
Therefore, if you have checked all of these factors and chest expansion is still not satisfactory, or if you don’t hear good breath sounds bilaterally, it usually will be necessary to insert an endotracheal tube at this time. T

Establishing effective ventilation is the key to nearly all successful neonatal resuscitations.

Key Points

1. Ventilation of the lungs is the single most important and most effective step in cardiopulmonary resuscitation of the compromised newborn.

2. Indications for positive-pressure ventilation are
   - Apnea/gasping
   - Heart rate less than 100 beats per minute even if breathing
   - Persistent central cyanosis despite 100% free-flow oxygen

3. Self-inflating bags
   - Fill spontaneously after they are squeezed, pulling oxygen or air into the bag
   - Remain inflated at all times
   - Must have a tight face-mask seal to inflate the lungs
   - Can deliver positive-pressure ventilation without a compressed gas source; user must be certain the bag is connected to an oxygen source for the purpose of neonatal resuscitation.
   - Require attachment of an oxygen reservoir to deliver 90% to 100% oxygen
   - Cannot be used to administer free-flow oxygen reliably through the mask

4. Every resuscitation device must have
   - A pressure release (“pop-off”) valve and/or a pressure gauge manometer

5. An oxygen reservoir must be attached to deliver high concentrations of oxygen using a self-inflating bag. Without the reservoir the bag delivers only about 40% oxygen, which may be insufficient for neonatal resuscitation.

6. If there is no physiologic improvement and no perceptible chest expansion during assisted ventilation,
   - Reapply mask to face using light downward pressure and lifting the mandible up toward the mask.
   - Reposition the head.
   - Check for secretions, suction mouth and nose.
   - Ventilate with the baby’s mouth slightly open.
   - Increase pressure of ventilations.
   - Recheck or replace the resuscitation bag.
   - After reasonable attempts fail, intubate the baby.

7. Improvement during positive-pressure ventilation with a mask is indicated by a rapid increase in heart rate and subsequent improvement in
   - Color and oxygen saturations
   - Muscle tone
   - Spontaneous breathing
Chest Compressions

In Lesson 4 you will learn

• When to begin chest compression during a resuscitation
• How to administer chest compressions
• How to coordinate chest compressions with positive-pressure ventilation
• When to stop chest compressions
What are chest compressions?

Chest compressions, sometimes referred to as external cardiac massage, consist of rhythmic compressions of the sternum that

- Compress the heart against the spine.
- Increase the intrathoracic pressure.
- Circulate blood to the vital organs of the body

The heart lies in the chest between the lower third of the sternum and the spine. Compressing the sternum compresses the heart and increases the pressure in the chest, causing blood to be pumped into the arteries (Figure 4.1)

When pressure on the sternum is released, blood enters the heart from the veins.

What are the indications for beginning chest compressions?

Chest compressions should be started whenever the heart rate remains less than 60 bpm despite 30 seconds of effective positive-pressure ventilation.

Why perform chest compressions?

Babies who have a heart rate below 60 bpm, despite stimulation and 30 seconds of positive-pressure ventilation, probably have very low blood oxygen levels and significant acidosis. As a result, the myocardium is depressed and unable to contract strongly enough to pump blood to the lungs to pick up the oxygen that you have now ensured is in the lungs. Therefore, you will need to mechanically pump the heart while you simultaneously continue to ventilate the lungs until the myocardium becomes sufficiently oxygenated to recover adequate spontaneous function. This process also will help to restore oxygen delivery to the brain.

Endotracheal intubation at this time may help to ensure adequate ventilation and facilitate the coordination of ventilation and chest compressions.

Lesson 4

NEONATAL RESUSCITATION 4-3
How many people are needed to administer chest compressions, and where should they stand?

Remember that chest compressions are of little value unless the lungs are also being ventilated with oxygen. Therefore, 2 people are required to administer effective chest compressions—one to compress the chest and one to continue ventilation.

The person performing chest compressions must have access to the chest and be able to position his or her hands correctly. The person assisting ventilation will need to be positioned at the baby’s head to achieve an effective mask-face seal (or to stabilize the endotracheal tube) and watch for effective chest movement (Figure 4.2).

How do you position your hands on the chest to begin chest compressions?

You will learn 2 different techniques for performing chest compression. These techniques are

• **Thumb technique**, where the 2 thumbs are used to depress the sternum, while the hands encircle the torso and the fingers support the spine (Figure 4.3A).

• **2-finger technique**, where the tips of the middle finger and either the index finger or ring finger of one hand are used to compress the sternum, while the other hand is used to support the baby’s back (unless the baby is on a very firm surface) (Figure 4.3B)

What are the advantages of one technique over the other?

Each technique has advantages and disadvantages. The thumb technique is preferred because it usually is less tiring, and you can generally control the depth of compression somewhat better. This technique is superior in generating peak systolic and coronary perfusion pressure. It also is preferable for individuals with long fingernails. However, the 2-finger technique is more convenient if the baby is large or your hands are small. The 2-finger technique also is preferable to provide access to the umbilicus when medications need to be given by the umbilical route. Therefore, you should learn both techniques.

The two techniques have the following things in common:

• Position of the baby
  - Firm support for the back
  - Neck slightly extended.

• Compressions
  - Same location, depth, and rate
Where on the chest should you position your thumbs or fingers?

When chest compressions are performed on a newborn, pressure is applied to the lower third of the sternum, which lies between the xyphoid and a line drawn between the nipples (Figure 4.4). The xyphoid is the small projection where the lower ribs meet at the midline. You can quickly locate the correct area on the sternum by running your fingers along the lower edge of the ribs until you locate the xyphoid. Then place your thumbs or fingers immediately above the xyphoid. Care must be used to avoid putting pressure directly on the xyphoid.

How do you position your hands using the thumb technique?

The thumb technique is accomplished by encircling torso with both hands and placing the thumbs on the sternum and the fingers under the baby’s back supporting the spine (Figure 4.5).

The thumbs can be placed side by side or, on a small baby, one over the other (Figure 4.5).
The thumbs will be used to compress the sternum, while your fingers provide the support needed for the back. The thumbs should be flexed at the first joint and pressure applied vertically to compress the heart between the sternum and the spine (Figure 4.6).

**Figure 4.6. Correct and incorrect application of pressure with thumb technique of chest compressions**

**How do you position your hands using the 2-finger technique?**

In the 2-finger technique, the tips of your middle finger and either the index or ring finger of one hand are used for compressions (Figure 4.7). Position the 2 fingers perpendicular to the chest as shown, and press with your fingertips.

Your other hand should be used to support the newborn’s back so that the heart is more effectively compressed between the sternum and spine. With the second hand supporting the back, you can more easily judge the pressure and the depth of compressions.

As with the thumb technique, you should apply pressure vertically to compress the heart between the sternum and the spine (Figure 4.8A).

You may find the 2-finger technique to be more tiring than the thumb technique if chest compressions are required for a prolonged period. However, the 2-finger technique can be used regardless of the size of the baby or the size of your hands. An additional advantage of this technique is that it leaves the umbilicus more accessible in case medications must be administered via the umbilical route.

**Figure 4.8. Correct and incorrect application of pressure with 2-finger technique**
How much pressure do you use to compress the chest?

Controlling the pressure used in compressing the sternum is an important part of the procedure.

With your fingers and hands correctly positioned, you should use enough pressure to depress the sternum to a depth of approximately one third of the anterior-posterior diameter of the chest (Figure 4.9), 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.

The duration of the downward stroke of the compression should also be somewhat shorter than the duration of the release for generation of maximum cardiac output.

Your thumbs or the tips of your fingers (depending on the method you use) should remain in contact with the chest at all times during both compression and release (Figure 4.10). Allow the chest to fully expand by lifting your thumbs or fingers during the release phase to permit blood to reenter the heart from the veins. However, do not lift your thumb or fingers completely off the sternum after compression (Figure 4.11). If you take your thumbs or fingers completely off the sternum after compression, then

• You waste time relocating the compression area.
• You lose control over the depth of compression.
• You may compress the wrong area, producing trauma to the chest or underlying organs.
Are there dangers associated with administering chest compressions?

Chest compressions can cause trauma to the baby.

Two vital organs lie within the ribcage—the heart and lungs. The liver lies partially under the ribs, although it is in the abdominal cavity. As you perform chest compressions, you must apply enough pressure to compress the heart between the sternum and spine without damaging underlying organs. Pressure applied too low, over the xyphoid, can cause laceration of the liver (Figure 4.12).

Also, the ribs are fragile and can easily be broken.

By following the procedure outlined in this lesson, the risk of these injuries can be minimized.

How often do you compress the chest and coordinate compressions with ventilation?

During cardiopulmonary resuscitation, chest compressions must always be accompanied by positive-pressure ventilation. Avoid giving a compression and ventilation simultaneously, because one will decrease the efficacy of the other. Therefore, the 2 activities must be coordinated, with one ventilation interposed after every third compression, for a total of 30 breaths and 90 compressions per minute (Figure 4.13).

The person doing the compressions should take over the counting out loud from the person who is doing the ventilating. The compressor should count “One-and-Two-and-Three-and-Breathe-and” while the person ventilating squeezes during “Breathe-and” and release during “One-and.” Note that exhalation occurs during the down-ward stroke of the next compression. Counting the cadence will help develop a smooth and well-coordinated procedure.

One cycle of events will consist of 3 compressions plus one ventilation.

- There should be approximately 120 “events” per 60 seconds (1 minute) - 90 compressions plus 30 breaths.
Note that, during chest compressions the ventilation rate is actually 30 breaths per minute rather than the rate you previously learnt for positive-pressure ventilation, which was 40 to 60 breaths per minute. This lower ventilatory rate is needed to provide an adequate number of compressions and avoid simultaneous compressions and ventilation. To ensure that the process can be coordinated, it is important to practice with another person and to practice the roles of both the compressor and the ventilator.

**How can you practice the rhythm of chest compressions with ventilation?**

Imagine that you are the person giving chest compressions. Repeat the words several times while you move your hand to compress the chest on “One-and,” “Two-and,” “Three-and.” Do not press when you say, “Breath-and.” Do not remove your fingers from the surface you are pressing, but be sure to relax your pressure on the chest to permit adequate ventilation during the breath.

Now time yourself to see if you can say and do these five cycles of events in 10 seconds. Remember not to press on the “Breathe-and.”

Practice saying the words and compressing the chest.


**One-and-Two-and-Three-and-Breathe-and**

Now imagine that you are the person administering bag-and-mask ventilation. This time you want to squeeze your hand when you say “Breathe-and” but not when you say “One-and,” “Two-and,” “Three-and.”

Now time yourself to see if you can say and do these five events in 10 seconds. Remember, squeeze your hand only when you say “Breathe and”

**One-and-Two-and-Three-and-Breathe-and**

**One-and-Two-and-Three-and-Breathe-and**

**One-and-Two-and-Three-and-Breathe-and**

**One-and-Two-and-Three-and-Breathe-and**

In a real situation, there will be 2 rescuers, with one doing the compressions and one doing the bagging. The person compressing will be speaking “One-and-Two-and-...” out loud. Therefore, it will be helpful for you to practice with a partner, taking turns in each of the roles.
When do you stop chest compressions?

After approximately 30 seconds of well-coordinated chest compressions and ventilation, you should stop compressions long enough to determine the heart rate again. If you can feel the pulse easily at the base of the cord, you will not need to stop ventilation. Otherwise, you will need to stop both compressions and ventilation for a few seconds to allow you to listen to the chest with a stethoscope.

*If the heart rate is now above 60 bpm, then*

You can discontinue chest compressions, but continue positive-pressure ventilation now at the more rapid rate of 40 to 60 breaths per minute. You should not continue chest compressions, since the cardiac output is probably adequate and the compressions may decrease the effectiveness of the positive-pressure ventilation.

Once the heart rate rises above 100 bpm and the baby begins to breathe spontaneously, you should slowly withdraw positive-pressure ventilation as described in Lesson 3, and move the baby to the nursery for post-resuscitation care.
What do you do if the baby is not improving?

While chest compressions and positive-pressure ventilation are being delivered, there is a higher likelihood that air will enter the stomach, compared with ventilation alone. Therefore, unless you have already done so, it now may be advisable to pass an orogastric tube to vent the stomach. Also, many individuals will have chosen to insert an endotracheal tube by this time to eliminate the risk of stomach inflation and to improve the efficacy of ventilation.

While you are administering chest compressions and coordinated ventilation, you should continue to ask yourself the following questions:

- Is chest movement adequate? (Have you considered or performed endotracheal intubation? If so, is the endotracheal tube in the correct position?)
- Is supplemental oxygen being given?
- Is the depth of chest compression approximately one third of the diameter of the chest?
- Are the chest compressions and ventilation well coordinated?

*If the heart rate remains below 60 bpm, then you should insert an umbilical catheter and give epinephrine, as described in Lesson 6.*

As illustrated in Case 4 at the beginning of this lesson, by this point in a resuscitation you most likely will have intubated the trachea. The technique of endotracheal intubation will be described in Lesson 5.
**Key Points**

1. Chest compressions are indicated when the heart rate remains less than 60 beats per minute despite 30 seconds of effective positive-pressure ventilation.

2. Chest compressions
   - Compress the heart against the spine.
   - Increase intrathoracic pressure.
   - Circulate blood to the vital organs, including the brain.

3. There are 2 acceptable techniques for chest compressions - the thumb technique and the 2-finger technique, but the thumb technique is usually preferred.

4. Locate the correct area for compressions by running your fingers along the lower edge of the rib cage until you locate the xyphoid. Then place your thumbs or fingers on the sternum, above the xyphoid and on a line connecting the nipples.

5. To ensure proper rate of chest compressions and ventilation, the compressor repeats “One-and-Two-and-Three-and-Breathe-and…”

6. During chest compressions, the breathing rate is 30 breaths per minute and the compression rate is 90 compressions per minute. This equals 120 “events” per minute. One cycle of 3 compressions and one breath takes 2 seconds.

7. During chest compressions, ensure that
   - Chest movement is adequate during ventilation
   - Supplemental oxygen is being used.
   - Compression depth is one third the diameter of the chest.
   - Pressure is released fully to permit chest recoil during relaxation phase of chest compression.
   - Thumbs or fingers remain in contact with the chest at all times.
   - Duration of the downward stroke of the compression is shorter than duration of the release.
   - Chest compressions and ventilation are well coordinated.

8. After 30 seconds of chest compressions and ventilation, check the heart rate. If the heart rate is:
   - Greater than 60 beats per minute, discontinue compressions and continue ventilation at 40 to 60 breaths per minute.
   - Greater than 100 beats per minute, discontinue compressions, and gradually discontinue ventilation if the newborn is breathing spontaneously.
   - Less than 60 beats per minute, intubate the newborn, if not already done and give epinephrine, preferably intravenously. Intubation provides a more reliable method of continuing ventilation.
Endotracheal Intubation

In Lesson 5 you will learn

• The indications for endotracheal intubation during resuscitation

• How to select and prepare the appropriate equipment for endotracheal intubation

• How to use the laryngoscope to insert an endotracheal tube

• How to determine if the endotracheal tube is in the trachea

• How to use the endotracheal tube to suction meconium from the trachea

• How to use the endotracheal tube to administer positive-pressure ventilation
When is endotracheal intubation required?

Endotracheal intubation may be performed at various points during a resuscitation as indicated by the asterisks in the flow diagram. Case 2 (Lesson 2, page 2-3) illustrated one such point, where the trachea was intubated to suction meconium. Case 4 (Lesson 4 page 4-2) illustrated another point, where bag and mask ventilation was ineffective and the trachea was intubated to improve ventilation and to facilitate the coordination of ventilation and chest compressions. The timing of intubation will be determined by many factors, one of which is the intubation skill of the resuscitator. People who are not adept at intubation should call for help and focus on providing effective ventilation with positive-pressure device and mask, rather than wasting valuable time trying to intubate. Other factors influencing the timing of intubation include the following:

- If there is meconium and the baby has depressed respirations, muscle tone, or heart rate, you will need to intubate the trachea as the very first step, before any other resuscitation measures are started.

- If positive-pressure ventilation is not resulting in adequate clinical improvement, if there is not good chest rise, or if the need for positive-pressure ventilation lasts beyond a few minutes, you may decide to intubate simply to improve the efficacy and ease of assisted ventilation.

- If chest compressions are necessary, intubating may facilitate coordination of chest compressions and ventilation and maximize the efficiency of each positive-pressure breath.

- As you will learn in the next lesson, if epinephrine is required to stimulate the heart, one common route to administer the epinephrine is directly into the trachea while intravenous route is being established. This, too, will require endotracheal intubation.
What equipment and supplies are needed?

The supplies and equipment necessary to perform endotracheal intubation should be kept together and readily available. Each delivery room, nursery, and emergency department should have at least one complete set of the following items (Figure 5.2):

1. Laryngoscope with an extra set of batteries and extra bulbs
2. Blades: No. 1 (term newborn), No.0 (preterm newborn), No.00 (optional for extremely preterm newborn). Straight rather than curved blades are preferred.
3. Endotracheal tubes with inside diameters of 2.5, 3.0, 3.5, and 4.0 mm
4. Stylet (optional) that fits into the endotracheal tubes in this kit.
5. Carbon dioxide (CO2) monitor or detector
6. Suction setup with 10F or larger suction catheters, plus sizes 5F or 6F and 8F for suctioning the endotracheal tube.
7. Roll of tape, ½ or 3/ inch or endotracheal securing device (optional)
8. Scissor.
10. Meconium aspirator.
11. Stethoscope (neonatal head preferred).
12. Positive-pressure device, pressure gauge (optional for self-inflating bag), and oxygen tubing. Self-inflating bag must have oxygen reservoir.
Endotracheal tubes are supplied in sterile packages and should be handled with clean technique. They should be of uniform diameter throughout the length of the tube, not tapered near the tip (Figure 5.3). One disadvantage of the tapered tube is that, during intubation, your view of the tracheal opening is easily obstructed by the wide part of the tube. Also, tubes with shoulders are more likely to become obstructed and cause trauma to the vocal cords.

Most endotracheal tubes for newborns have a black line near the tip of the tube, which is called a “vocal cord guide” (Figure 5.4). Such tubes are meant to be inserted so that the vocal cord guide is placed at the level of the vocal cords. This usually positions the tip of the tube above the bifurcation of the trachea (carina).

The length of the trachea in a premature newborn is less than that in a term newborn – 3 cm versus 5 to 6 cm. Therefore, the smaller the tube, the closer the vocal cord guide is to the tip of the tube. However, there is some variability among tube manufacturers regarding the placement of the vocal cord guide.

Although tubes are available with cuffs at the level of the vocal cord guide, cuffs are not recommended when endotracheal intubation is required for resuscitation of newborns.

Most endotracheal tubes made for newborns come with centimeter markings along the tube, identifying the distance from the tip of the tube. Later, you will learn to use these markings to identify the appropriate depth of insertion of the tube.

What kind of endotracheal tubes are best to use?

Endotracheal tubes are supplied in sterile packages and should be handled with clean technique. They should be of uniform diameter throughout the length of the tube, not tapered near the tip (Figure 5.3). One disadvantage of the tapered tube is that, during intubation, your view of the tracheal opening is easily obstructed by the wide part of the tube. Also, tubes with shoulders are more likely to become obstructed and cause trauma to the vocal cords.

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Endotracheal Intubation

How do you prepare the endotracheal tube for use?

Select the appropriate-sized tube.

<table>
<thead>
<tr>
<th>Tube Size (mm) (inside diameter)</th>
<th>Weight (g)</th>
<th>Gestational Age (wks)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5</td>
<td>Below 1,000</td>
<td>Below 28</td>
</tr>
<tr>
<td>3.0</td>
<td>1,000-2,000</td>
<td>28-34</td>
</tr>
<tr>
<td>3.5</td>
<td>2,000-3,000</td>
<td>34-38</td>
</tr>
<tr>
<td>3.5-4.0</td>
<td>Above 3,000</td>
<td>Above 38</td>
</tr>
</tbody>
</table>

Table 5-1. Endotracheal tube size for babies of various weights and gestational age

Time will be limited once resuscitation is underway. Therefore, preparation of equipment before a high-risk delivery is important.

The approximate size of the endotracheal tube is determined from the baby’s weight. The Table 5 – 1 gives the tube size for various weight and gestational age categories. Study the table. Later you will be asked to recall the suggested tube size for babies of various weights. It may be helpful to post the table in each delivery room, on or near the radiant warmers.

Consider cutting the tube to a shorter length.

Many endotracheal tubes come from the manufacturer much longer than necessary for orotracheal use. The extra length will increase resistance to airflow.

Some clinicians find it helpful to shorten the endotracheal tube before insertion (Figure 5.5). The endotracheal tube may be shortened to 13 to 15 cm to make it easier to handle during intubations and lessen the chance of inserting the tube too far. A 13- to 15-cm tube will provide enough tube extending beyond the baby’s lips for you to adjust the depth of insertion if necessary, and to properly secure the tube to the face. Remove the connector (note that the connection to the tube may be tight), and then cut the tube diagonally to make it easier to reinsert the connector.

Replace the endotracheal tube connector. The fitting should be tight so that the connector does not inadvertently separate during insertion or use. Ensure that the connector and the tube are properly aligned so that kinking of the tube is avoided. Connectors are made to fit a specific tube. They cannot be interchanged between tubes of different sizes.

Others prefer to leave the tube long initially and then cut the tube to length after insertion if it is decided to leave it in place for longer than the immediate resuscitation.

*Note: The 15-cm length may be preferred to accommodate some types of endotracheal tube securing devices.
How do you prepare the laryngoscope and additional supplies?

Select blade and attach to handle.
First, select the appropriate-sized blade and attach it to the laryngoscope handle.
- No 0 for preterm newborns
- No 1 for term newborns

Check light
Next, turn on the light by clicking the blade into the “open” position to determine that the batteries and bulb are working. Check to see that bulb is screwed in tightly to ensure that it will not flicker or fall out during the procedure.

Prepare suction equipment.
Suction equipment should be available and ready for use.
- Adjust the suction source to 100 mm Hg by increasing or decreasing the level of suction while occluding the end of the suction tubing.
- Connect a 10F (or larger) suction catheter to the suction tubing so that it will be available to suction secretions from the mouth and nose.
- Smaller suction catheters (5F, 6F, or 8F, depending on the size of the endotracheal tube) should be available for suctioning the tube if it becomes necessary to leave the endotracheal tube in place. Appropriate sizes are listed in Table 5–2.

Prepare device for administering positive-pressure.
A resuscitation bag and mask or T-piece resuscitator capable of providing 90% to 100% oxygen should be on hand to ventilate the baby between intubation attempts or if intubation is unsuccessful. The resuscitation device without the mask will be required to ventilate the baby after intubation to initially check tube placement and to provide continued ventilation if necessary. Check the operation of the resuscitation device as described in Lesson 3.

Turn on oxygen.
The oxygen tubing should be connected to an oxygen source and be available to deliver up to 100% free-flow oxygen and to connect to the resuscitation bag. The oxygen flow should be turned on to 5 to 10 l/min.

Get stethoscope.
A stethoscope will be needed to check for bilateral breath sounds.

Cut tape or prepare stabilizer.
Cut a strip of adhesive tape to secure the tube to the face, prepare an endotracheal tube holder, if used at your hospital.

<table>
<thead>
<tr>
<th>Endotracheal Tube Size</th>
<th>Catheter Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5</td>
<td>5F or 6F</td>
</tr>
<tr>
<td>3.0</td>
<td>6F or 8F</td>
</tr>
<tr>
<td>3.5</td>
<td>8F</td>
</tr>
<tr>
<td>4.0</td>
<td>8F or 10F</td>
</tr>
</tbody>
</table>

Table 5-2 Suction catheter size for endotracheal tubes of various inner diameter
How do you hold the laryngoscope?

Turn on the laryngoscope light and hold the laryngoscope in your left hand, between your thumb and first two or three fingers, with the blade pointing away from you (Figure 5.11). One or 2 fingers should be left free to rest on the baby’s face to provide stability.

The laryngoscope is designed to be held in the left hand – by both right and left handed persons. If held in the right hand, the closed curved part of the blade will block your view of the glottis, as well as make insertion of the endotracheal tube impossible.

How do you visualize the glottis and insert the tube?

The next few steps will be described in detail. However, during an actual resuscitation, they will need to be completed very quickly–within approximately 20 seconds. The baby will not be ventilated during this process, so quick action is essential. Photos of this procedure can be found on page C in the center section of the book.

**First,** stabilize the baby’s head with your right hand (Figure 5.12). It may be helpful to have a second person hold the head in the desired “sniffing” position. Free-flow oxygen should be delivered throughout the procedure.

*Note: Although this program recommends a goal of 20 seconds to perform endotracheal intubation, studies have shown that a somewhat longer time may be required in clinical practice. The important concept is that the procedure be accomplished as quickly as possible. If the patient appears to be compromised, it is usually preferable to stop, resume positive-pressure ventilation with a mask, and then try again.
Second, slide the laryngoscope blade over the right side of the tongue, pushing the tongue to the left side of the mouth and advance the blade until the tip lies in the vallecula, just beyond the base of the tongue (Figure 5.13). You may need to use your right index finger to open the baby’s mouth to make it easier to insert the laryngoscope.

Note: Although this lesson describes placing the tip of the blade in the vallecula, some prefer to place it directly on the epiglottis, gently compressing the epiglottis against the base of the tongue.

Third, lift the blade slightly, thus lifting the tongue out of the way to expose the pharyngeal area (Figure 5.14).

When lifting the blade, raise the entire blade by pulling up in the direction the handle is pointing (Figure 5.15).

Do not elevate the tip of the blade by using a rocking motion and pulling the handle toward you.

Rocking rather than elevating the tip of the blade will not produce the view of the glottis you desire and will put excessive pressure on the alveolar ridge.
Fourth, look for landmarks (Figure 5.16). (Also, see Figure C-2a, C-2b, C2c, and C2d in the center of the book.)

If the tip of the blade is correctly positioned in the vallecula, you should see the epiglottis at the top, with the glottis opening below. You also should see the vocal cords appearing as vertical stripes on each side of the glottis or as an inverted letter “V” (Figure 5.9).

If these structures are not immediately visible, quickly adjust the blade until the structures come into view. Applying downward pressure to the cricoid (the cartilage that covers the larynx) may help bring the glottis into view (Figure 5.17). The pressure may be applied with your own little finger or by an assistant.

Suctioning of secretions also may be helpful to improve your view (Figure 5.18). Inadequate visualization of the glottis is the most common reason for unsuccessful intubation.
**Fifth**, insert the tube (Figure 5.19).

Holding the tube in your right hand, introduce it into the right side of the baby’s mouth with the curve of the tube lying in the horizontal plane. This will prevent the tube from blocking your view of the glottis.

Keep the glottis in view and, when the vocal cords are apart, insert the tip of the endotracheal tube until the vocal cord guide is at the level of the cords. If the cords are together, wait for them to open. Do not touch the closed cords with the tip of the tube because it may cause spasm of the cords. Never try to force the tube between closed cords. If the cords do not open within 20 seconds, stop and ventilate with a bag and mask. After the heart rate and color have improved, you can then try again.

Be careful to insert the tube only so far as to place the vocal cord guide at the level of the vocal cords (Figure 5.20). This positions the tube in the trachea approximately halfway between the vocal cords and the carina.

Note the markings on the tube that align with the baby’s lip.
Sixth, stabilize the tube with one hand, and remove the laryngoscope with the other (Figure 5.21).

With the right hand held against the face, hold the tube firmly at the lips and/or use a finger to hold the tube against the baby’s hard palate. Use your left hand to carefully remove the laryngoscope without displacing the tube.

If a stylet was used, remove it from the endotracheal tube – again be careful to hold the tube in place while you do so (Figure 5.22).

**Although it is important to hold the tube firmly, be careful not to press the tube so tightly that the tube becomes compressed and obstructs airflow.**

You are now ready to use the tube for the reason you inserted it.

- If the purpose was to suction meconium, then you should use the tube to suction meconium, as described on the next page.

- If the purpose was to ventilate the baby, then you should quickly attach a ventilation bag or T-piece resuscitator to the tube, take steps to be certain the tube is in the trachea, and resume positive pressure ventilation with 100% oxygen (Figure 5.23).
What do you do next if the tube was inserted to suction meconium?

As described in Lesson 2, if there is meconium in the amniotic fluid and the baby has depressed muscle tone, depressed respirations, or a heart rate less than 100 beats per minute (bpm), (i.e. not vigorous) the trachea should be intubated and suctioned.

As soon as the endotracheal tube has been inserted and the stylet, if used, has been removed,

- Connect the endotracheal tube to a meconium aspirator, which has been connected to a suction source (Figure 5.24). Several alternative types of meconium aspirators are available commercially, some of which include the endotracheal tube as part of the device.

- Occlude the suction-control port on the aspirator to apply suction to the endotracheal tube, and gradually withdraw the tube as you continue suctioning any meconium that may be in the trachea.

- Repeat intubation and suction as necessary until little or no additional meconium is recovered or until the baby’s heart rate indicates that positive-pressure ventilation is needed.

For how long do you try to suction meconium?

Judgment is required when suctioning meconium. You have learned that you should suction the trachea only if the meconium-stained baby has depressed respirations or muscle tone or has a heart rate less than 100 bpm. Therefore, at the time you begin to suction the trachea, it is likely that the baby will already be significantly compromised and will eventually need resuscitation. You will need to delay resuscitation for a few seconds while you suction meconium, but you do not want to delay more than is absolutely necessary.

The following are a few guidelines:

- Do not apply suction to the endotracheal tube for longer than 3 to 5 seconds as you withdraw the tube.

- If no meconium is recovered, don’t repeat the procedure; proceed with resuscitation.

- If you recover meconium with the first suction, check the heart rate. If the baby does not have significant bradycardia, reintubate and suction again. If the heart rate is low, you may decide to administer positive pressure without repeating the procedure.
Checking Tube Placement

If the tube is positioned correctly, you should observe the following:

- Improvement in heart rate and color
- Breath sounds over both lung fields but decreased or absent over the stomach (Figure 5.26)
- No gastric distention with ventilation
- Vapor condensing on the inside of the tube during exhalation
- Symmetrical movement of chest with each breath

When listening to breath sounds, be sure to use a small stethoscope and place it laterally and high on the chest wall (in the axilla). A large stethoscope, or a stethoscope placed too central or too low, may transmit sounds from the esophagus or stomach. Observe for absence of gastric distension and movement of both sides of the chest with each ventilated breath.

Listening for bilateral breath sounds and observing symmetrical chest movement with positive-pressure ventilation provide secondary confirmation of correct endotracheal tube placement in the airway with tip of the tube positioned above the carina. A rapid increase in heart rate is indicative of effective positive-pressure ventilation.

Figure 5.26. Breath sounds should be audible in both axillae but not over stomach (see asterisks.)
What do you do if you suspect that the tube may not be in the trachea?

Be certain that the tube is in the trachea. A misplaced tube is worse than having no tube at all.

The tube is not likely to be in the trachea if

• The newborn remains cyanotic and bradycardic despite positive-pressure ventilation.
• The CO₂ detector does not indicate the presence of CO₂
• You do not hear good breath sounds over the lungs.
• The abdomen appears to become distended.
• You do hear air noises over the stomach.
• There is no mist in the tube.
• The chest is not moving symmetrically with each positive-pressure breath.

If you suspect the tube is not in the trachea, you should do the following:

• Use your right hand to hold the tube in place while you use your left hand to reinsert the laryngoscope so that you can visualize the glottis and see if the tube is passing between the vocal cords.

and/or

• Remove the tube, use a resuscitation device and mask to stabilize the heart rate and color, and then repeat the intubation procedure.

Note: The CO2 monitor may not change color if the cardiac output is very low or absent (e.g., cardiac arrest). If there is no detectable heartbeat, do not use the CO2 monitor as an indicator of correct or incorrect placement of the endotracheal tube.
How do you continue resuscitation while you intubate?

Unfortunately, you cannot continue most resuscitation actions while intubating.

• Ventilation must be discontinued because the bag and mask must be removed from the airway during the procedure.

• Chest compressions generally must be interrupted because compressions cause movement and prevent you from seeing landmarks.

Therefore, you should make every effort to minimize the amount of hypoxia imposed during intubation. The following will be helpful:

• Pre-oxygenate before attempting intubation.
  Oxygenate the baby appropriately with resuscitation device and mask before beginning intubation and between repeated intubation attempts. This will not be possible when intubation is being performed for suctioning meconium or when a baby is being intubated to improve ineffective positive-pressure ventilation.

• Deliver free-flow oxygen during intubation
  Hold 100% free-flow oxygen by the baby’s face while the intubator is clearing the airway and trying to visualize the landmarks. Then if the baby makes any spontaneous respiratory efforts during the procedure, he will be breathing oxygen-enriched air.

• Limit attempts to 20 seconds.
  Don’t try to intubate for longer than approximately 20 seconds. If you are unable to visualize the glottis and insert the tube within 20 seconds, remove the laryngoscope and attempt to oxygenate the baby with bag-and-mask ventilation using 100% oxygen. Ensure that the baby is stable, then try again.

Key Points

1. A person experienced in endotracheal intubation should be available to assist at every delivery.

2. Indications for endotracheal intubation include the following:
   • To suction trachea in presence of meconium when the newborn is not vigorous
   • To improve efficacy of ventilation after several minutes of bag-and-mask ventilation or ineffective bag-and-mask ventilation
   • To facilitate coordination of chest compressions and ventilation and to maximize the efficiency of each ventilation
   • To administer epinephrine if required to stimulate the heart while intravenous access is being established

3. The laryngoscope is always held in the operator’s left hand.

4. The correct-sized laryngoscope blade for a term newborn is
   No. 1. The correct-sized blade for a preterm newborn is No. 0

5. Choice of the proper endotracheal tube size is based on weight.
### Endotracheal Intubation

<table>
<thead>
<tr>
<th>Tube Size (mm)</th>
<th>Weight (g)</th>
<th>Gestational Age (wks)</th>
</tr>
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</tr>
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<td>3.5-4.0</td>
<td>Above 3,000</td>
<td>Above 38</td>
</tr>
</tbody>
</table>

6. The intubation procedure ideally should be completed within 20 seconds.

7. The steps for intubating a newborn are as follows:
   - Stabilize the newborn’s head in the “sniffing” position. Deliver free-flow oxygen during procedure.
   - Slide laryngoscope over the right side of the tongue, pushing the tongue to the left side of the mouth, and advancing the blade until the tip lies just beyond the base of the tongue.
   - Lift the blade slightly. Raise the entire blade, not just the tip.
   - Look for landmarks. Vocal cords should appear as vertical stripes on each side of the glottis or as an inverted letter “V”
   - Suction if necessary for visualization.
   - Insert the tube into the right side of the mouth with the curve of the tube lying in the horizontal plane.
   - If the cords are closed, wait for them to open. Insert the tip of the endotracheal tube until the vocal cord guide is at the level of the cords.
   - Hold the tube firmly against the baby’s palate while removing the laryngoscope. Hold the tube in place while removing the stylet if one was used.

8. Correct placement of the endotracheal tube is indicated by
   - Improved vital signs (heart rate, color, activity)
   - Breath sounds over both lung fields but decreased or absent over the stomach
   - No gastric distention with ventilation
   - Vapor in the tube during exhalation
   - Chest movement with each breath
   - Tip-to-lip measurement: add 6 to newborn’s weight in kilograms
   - Direct visualization of the tube passing between the vocal cords
Medications

In Lesson 6 you will learn

• What medications to give during resuscitation
• When to give medications during resuscitation
• Where to give medications during resuscitation
• How to insert an umbilical venous catheter
• How to administer epinephrine
• When and how to administer fluids intravenously to expand blood volume during a resuscitation
If the heart rate remains below 60 bpm despite administration of ventilation and chest compressions, your first action should be to ensure that ventilation and compressions are being given optimally and that you are using 100% oxygen.

Despite good ventilation of the lungs with positive-pressure ventilation and improved cardiac output from chest compressions, a small number of newborns (fewer than 2 per 1,000 births) will still have a heart rate below 60 bpm. The heart muscle of these babies may have been deprived of oxygen for so long that it will not contract effectively despite now being perfused with oxygenated blood. These babies may benefit from receiving epinephrine to stimulate the heart. If there has been acute blood loss, they may benefit from volume replacement.
How do you establish intravenous access during resuscitation of a newborn?

**The umbilical vein**

The umbilical vein is the most quickly accessible direct intravenous route in the newborn. If the use of epinephrine is anticipated because of unresponsiveness of the baby to the earlier steps of resuscitation, one member of the resuscitation team should begin work on placing an umbilical venous catheter, while others continue the other steps of resuscitation.

- Clean the cord with an antiseptic solution. Place a loose tie of umbilical tape around the base of the cord. This tie can be tightened if there is excessive bleeding after you cut the cord.

- Pre-fill a 3.5F or 5F umbilical catheter with normal saline using a 3 mL syringe connected to a stopcock. The catheter should have a single end-hold. Close the stopcock to the catheter to prevent fluid loss and air entry.

- Using sterile technique, cut the cord with a scalpel below the clamp and about 1 to 2 cm from the skin line (Figure 6.1). Make the cut perpendicular rather than at an angle.

![Figure 6. 1. Cutting the umbilical stump in preparation for inserting umbilical catheter](image)

- The umbilical vein will be seen as a large, thin-walled structure, usually at the 11-to 12-o’clock position. The 2 umbilical arteries have thicker walls and usually lie close together somewhere in the 4 to 8-o’clock position. However, the arteries coil within the cord. Therefore, the longer the cord stump below your cut, the greater the likelihood that the vessels will not lie in the position described.

- Insert the catheter into the umbilical vein (Figure 6.2). The course of the vein will be up, toward the heart, so this is the direction you should point the catheter. Continue inserting the catheter 2 to 4 cm (less in preterm babies) until you get free flow of blood when you open the stopcock to the syringe and gently aspirate. For emergency use during resuscitation, the tip of the catheter should be located only a short distance into the vein – only to the point at which the blood is first able to the aspirated. If the catheter is inserted farther, there is risk of infusing solutions into the liver and possibly causing damage.
Are there alternatives to intravenous access for administration of medications during resuscitation of a newborn?

The endotracheal tube
Epinephrine given into the endotracheal tube may be absorbed by the lungs and enter blood that drains directly into the heart. Although this may be the fastest way to give epinephrine in an intubated baby, the process of absorption by the lungs makes the response time slower and more unpredictable than if epinephrine is given directly into the blood. Research in animal models suggests that the standard intravenous dose is ineffective if given endotracheally. There is some evidence that giving a higher dose can compensate for the delayed absorption from the lungs; however, no studies have confirmed the efficacy or safety of this practice. Nevertheless, since the endotracheal route is the most readily accessible, some clinicians believe that an endotracheal dose should be considered while the intravenous route is being established. If endotracheal epinephrine is given, a larger dose will be needed and, therefore, a larger syringe will be necessary. The large syringe should clearly labeled “For Endotracheal Use Only,” to avoid inadvertently giving the higher dose intravenously. While this program will mention the endotracheal technique, the intravascular route is recommended as the best choice.

What is epinephrine and when should you give it?
Epinephrine hydrochloride (sometimes referred to as adrenaline chloride) is a cardiac stimulant. Epinephrine increases the strength and rate of cardiac contractions and causes peripheral vasoconstriction, which may increase blood flow through the coronary arteries and to the brain.

Epinephrine is indicated when the heart rate remains below 60 bpm after you have given 30 seconds of effective assisted ventilation and another 30 seconds of coordinated chest compressions and ventilation.
How should you prepare epinephrine, and how much should you give?

Although epinephrine is available in both 1:1,000 and 1:10,000 concentrations, the 1:10,000 concentrations is recommended for newborns, eliminating the need for dilution.

Epinephrine should be given intravenously, although administration may be delayed by the time required to establish intravenous access. The endotracheal route is usually quicker, but this route results in lower and unpredictable blood levels that may not be effective. Some clinicians may choose to give a dose of endotracheal epinephrine while the umbilical venous line is being placed.

The recommended intravenous dose in newborns is 0.1 to 0.3 mL/kg of a 1:10,000 solution (equal to 0.01 to 0.03 mg/kg). You will need to estimate the baby’s weight after birth.

When giving epinephrine by endotracheal tube, be sure to give the drug directly into the tube, being careful not to leave it deposited in the endotracheal tube connector or along the walls of the tube. Some people prefer to use a catheter to give the drug deeply into the tube. Because you will need to give a higher dose endotracheally, you will be giving a relatively large volume of fluid into the endotracheal tube (up to 1mL/kg). You should follow the drug with several positive-pressure breaths to distribute the drug throughout the lungs for absorption.

When the drug is given intravenously through a catheter, you should follow the drug with a 0.5 to 1 mL flush of normal saline to be sure that the drug has reached the blood.
What should you expect to happen after giving epinephrine?

Check the baby’s heart rate 30 seconds after administering epinephrine. As you continue positive-pressure ventilation and chest compressions, the heart rate should increase to more than 60 bpm within 30 seconds after you give epinephrine.

If this does not happen, you can repeat the dose every 3 to 5 minutes. However, any repeat doses should be given intravenously if possible. In addition ensure that

- There is good air exchange as evidenced by adequate chest movement and presence of bilateral breath sounds.

- Chest compressions are given to a depth of one third the diameter of the chest and are well coordinated with ventilations.

Strongly consider placement of an endotracheal tube, if one has not already been inserted. Once in place, ensure that the tube has remained in the trachea during cardiopulmonary resuscitation activities.

If the baby is pale and there is evidence of blood loss, and there is a poor response to resuscitation, you will want to consider the possibility of volume loss. Treatment of hypovolemia is covered next.
What should you do if the baby is in shock, there is evidence of blood loss, and the baby is responding poorly to resuscitation?

If there has been a placental abruption, a placenta previa, or blood loss from the umbilical cord, the baby may be in hypovolemic shock. In some cases, the baby may have lost blood into the maternal circulation and there will be signs of shock with no obvious evidence of blood loss.

Babies in shock appear pale, have delayed capillary refill and have weak pulses. They may have a persistently low heart rate, and circulatory status often does not improve in response to effective ventilation, chest compressions, and epinephrine.

![If the baby appears to be in shock and is not responding to resuscitation, administration of a volume expander may be indicated.]

What can you give to expand blood volume? How much should you give? How can you give it?

The recommended solution for acutely treating hypovolemia is an isotonic crystalloid solution. Acceptable solutions include

- 0.9% NaCl ("Normal saline")
- Ringer’s lactate.
- O Rh-negative packed red blood cells should be considered as part of the volume replacement when severe fetal anemia is documented or expected. If timely diagnosis permits, the donor unit can be cross-matched to the mother who would be the source of any problematic antibody. Otherwise, emergency-release O-Rh negative packed cells may be necessary.

The initial dose is 10 mL/kg. However, if the baby shows minimal improvement after the first dose, you may need to give another dose of 10 mL/kg. In unusual cases of large blood loss additional dose might be considered.

A volume expander must be given into the vascular system. The umbilical vein is usually the most accessible vein in a newborn, although other routes (e.g., intraosseous) can be used.

If hypovolemia is suspected, fill a large syringe with normal saline or other volume expander while others on the team continue resuscitation.

Acute hypovolemia, resulting in a need for resuscitation should be corrected fairly quickly, although some clinicians are concerned that rapid administration in a newborn may result in intracranial hemorrhage, particularly in preterm infants. No clinical trials have been conducted to define and optimum rate, but a steady infusion rate over 5 to 10 minutes is reasonable.
What should you do if there is still no improvement?

If the baby has been severely compromised but all resuscitation efforts have gone smoothly, you should have reached the point of giving epinephrine relatively quickly. Approximately 30 seconds each should be required for a trial of each of the following four steps of resuscitation (additional time may be required to be certain that each step is being performed optimally).

- Assessment and initial steps
- Positive-pressure ventilation
- Positive-pressure ventilation and chest compressions
- Positive-pressure ventilation, chest compressions and epinephrine

Endotracheal intubation also likely would have been performed. You would have checked the efficacy of each of the steps, and you would have considered the possibility of hypovolemia.

If the heart rate is detectable but remains below 60 beats per minute, it is still likely that the baby will respond to resuscitation, unless the baby is either extremely immature or has a lethal congenital malformation. If you are certain that effective ventilation, chest compressions, and medications are being provided, you might then consider mechanical causes of poor response, such as an airway malformation, pneumothorax, diaphragmatic hernia, or congenital heart disease (discussed in Lesson 7).

If the heart rate is absent, or no progress is being made in certain conditions, such as extreme prematurity, it may be appropriate to discontinue resuscitative efforts. You should be confident that optimum technique has been administered for a minimum of 10 minutes before considering such a decision. How long to continue and the ethical considerations involved will be discussed in Lesson 9.
Key Points

1. Epinephrine, a cardiac stimulant, is indicated when the heart rate remains below 60 beats per minute, despite 30 seconds of assisted ventilation followed by another 30 seconds of coordinated chest compressions and ventilations.

2. Recommended epinephrine
   - Concentration: 1:10,000 (0.1 mg/mL)
   - Route: Intravenously. Endotracheal administration may be considered while intravenous access is being established.
   - Dose: 0.1 to 0.3 mL/kg (consider higher dose, 0.3 to 1 mL/kg, for endotracheal route only)
   - Preparation: 1:10,000 solution
   - Rate: Rapidly-as quickly as possible

3. Epinephrine should be given by umbilical vein. The endotracheal route is often faster and more accessible than placing an umbilical catheter, but is associated with unreliable absorption and may not be effective at the lower dose.

4. Indications for volume expander include
   - Baby is not responding to resuscitation
   - Baby appears in shock (pale color, weak pulses, persistently low heart rate, no improvement in circulatory status despite resuscitation efforts)
   - There is a history of condition associated with fetal blood loss (eg, extensive vaginal bleeding, abruptio placentae, placenta previa, twin-to-twin transfusion, etc).

5. Recommended volume expander
   - Solution: Normal saline, Ringer’s lactate or O-Rh negative blood.
   - Dose: 10ml/kg
   - Route: Umbilical vein
   - Preparation: Correct volume drawn into large syringe
   - Rate: Over 5 to 10 minutes