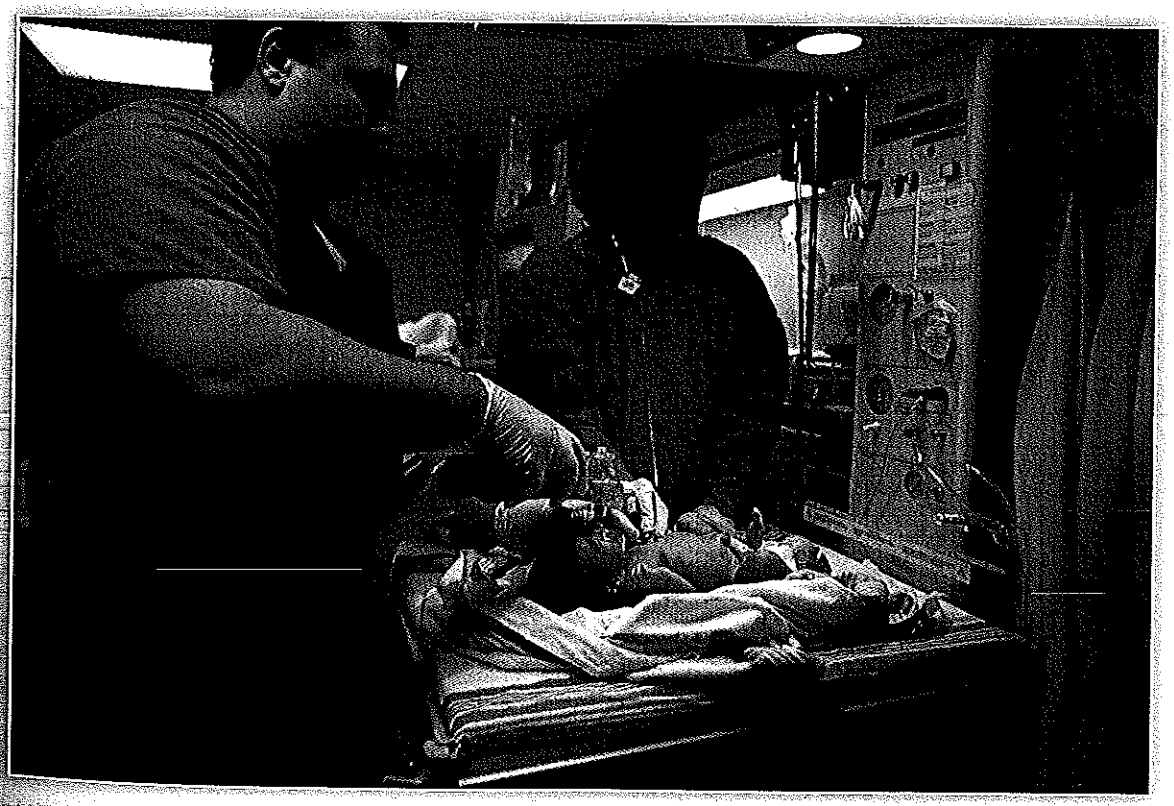
LESSON 3

Use of Resuscitation Devices for Positive-Pressure Ventilation

In Lesson 3 you will learn

- When to give positive-pressure ventilation
- The similarities and differences among *flow-inflating bags, self-inflating bags,* and *T-piece resuscitators*
- How to assess oxygenation and manage oxygen delivery in babies receiving positive-pressure ventilation
- The correct placement of a mask on the newborn's face
- How to test and troubleshoot devices used to provide positive-pressure ventilation
- How to administer positive-pressure ventilation with a face mask and positive-pressure device and assess effective ventilation



The following case is an example of how positive-pressure ventilation (PPV) is provided during resuscitation. As you read the case, imagine yourself as part of the resuscitation team. The details of how to deliver PPV are then described in the remainder of the lesson.

Case 3. Resuscitation with positive-pressure ventilation using bag and mask

A 20-year-old woman with pregnancy-induced hypertension has labor induced at 38 weeks' gestation. Several late decelerations of fetal heart rate are noted, but labor progresses quickly and a baby boy is soon delivered.

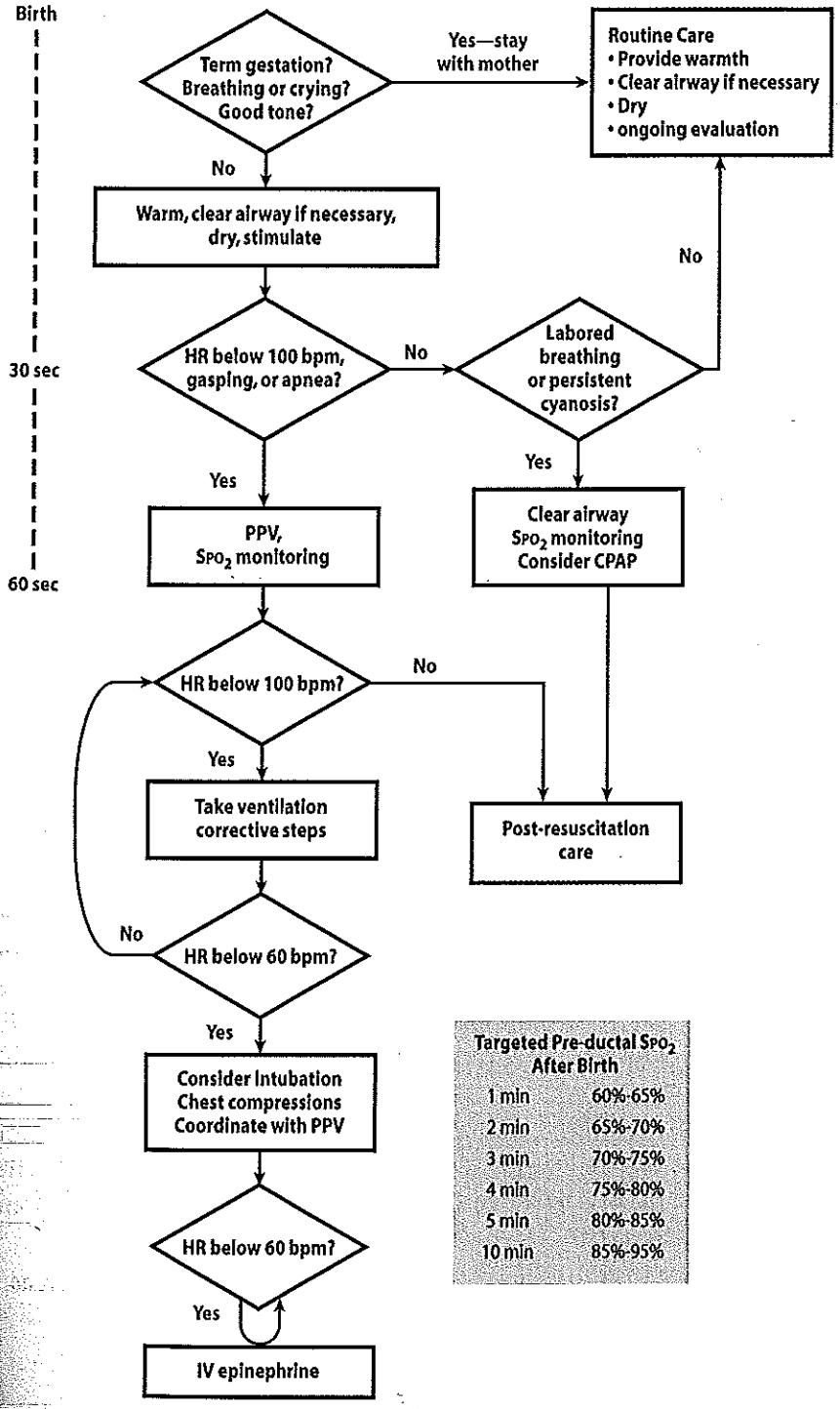
He is limp and apneic and is taken to the radiant warmer, where a nurse appropriately positions his head to open his airway, while his mouth and nose are cleared of secretions with a bulb syringe. He is dried with warm towels, wet linen is removed, his head is repositioned, and he is further stimulated to breathe by flicking the soles of his feet.

No spontaneous respirations are noted after these actions; therefore, positive-pressure ventilation (PPV) is provided with a bag and mask and 21% oxygen (room air). A second person comes to assist; she places an oximeter probe on the baby's right hand, and connects it to a pulse oximeter. The assistant auscultates the chest and reports that the heart rate is 70 beats per minute (bpm) and not rising, oxygen saturation is 63% and not increasing, and breath sounds are not audible on either side of the chest.

The nurse initiates corrective ventilation steps by reapplying the mask to the face and repositioning the baby's head to open the airway. The assistant reports that there is still no chest movement and no audible breath sounds. The nurse stops ventilating and quickly suctions the mouth and nose, opens the baby's mouth, and reattempts PPV; however, there is still no evidence of effective ventilation. The nurse increases inspiratory pressure while her assistant auscultates the newborn's chest, but reports no bilateral breath sounds or chest rise. Pressure is increased again to about 30 cm H_2O. The assistant reports bilateral breath sounds and chest movement with each ventilation. The baby is about 2 minutes old; the heart rate is 80 bpm and oxygen saturation is 64%. The assistant increases the oxygen concentration to 40%.

The assistant monitors the baby's respiratory effort, heart rate, and oxygen saturation, while the nurse ventilates the baby effectively for an additional 30 seconds. At this point, the baby has an occasional spontaneous breath, heart rate is 120 bpm, and oxygen saturation is 82% at 3 minutes of age. The oxygen blender is turned down to 25%. The assistant quickly inserts an orogastric tube. The nurse decreases her ventilation rate and watches for improving respiratory efforts while the

assistant stimulates the baby to breathe. When the newborn is 4 minutes of age, he is breathing spontaneously, the heart rate is 140 bpm, oxygen saturation is 87%, and PPV is discontinued. Free-flow supplemental oxygen is discontinued as the saturation remains above 85% and the orogastric tube is removed. He is shown to his mother, and she is encouraged to hold him while the next steps are explained. After a few more minutes of observation, the baby is moved to the nursery for post-resuscitation care, where vital signs, oximetry, and the baby's overall status are monitored closely for further problems.



Targeted Pre-ductal SpO_2 After Birth	
1 min	60%-65%
2 min	65%-70%
3 min	70%-75%
4 min	75%-80%
5 min	80%-85%
10 min	85%-95%

What will this lesson cover?

In this lesson, you will learn how to prepare and use a resuscitation bag and mask and/or a T-piece resuscitator to deliver PPV. The option of delivering continuous positive airway pressure (CPAP) by mask will be covered in more detail in Lesson 8.

You learned in Lesson 2 how to determine within a few seconds whether some form of resuscitation is required and how to perform the initial steps of resuscitation. You learned that, if the baby is breathing but has persistent central cyanosis, you attach an oximeter to confirm low oxygen saturation and administer free-flow supplemental oxygen.

This lesson will cover what to do next if the baby is not breathing effectively or is bradycardic after you have performed the initial steps.

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

What are the indications for positive-pressure ventilation?

If the baby is not breathing (apneic) or is gasping, the heart rate is below 100 beats per minute (bpm) even with breathing, and/or the saturation remains below target values despite free-flow supplemental oxygen being increased to 100%, the next step is to provide PPV.

What terms do you need to know when giving positive-pressure ventilation?

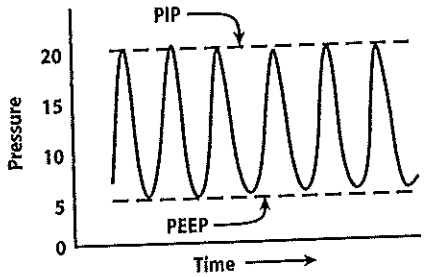


Figure 3.1 Pressure tracing during positive-pressure ventilation.
PIP = Peak Inspiratory Pressure;
PEEP = Positive-End Expiratory Pressure.

This lesson will address the following components of PPV (Figure 3.1):

- Peak inspiratory pressure (PIP): This is the pressure delivered with each breath, such as the pressure at the end of a squeeze of a resuscitation bag or at the end of the breath with a T-piece resuscitator.
- Positive end-expiratory pressure (PEEP): This is the gas pressure remaining in the system between breaths, such as occurs during relaxation and before the next squeeze.
- Continuous positive airway pressure (CPAP): This is the same as PEEP, but is the term used when the baby is breathing spontaneously and not receiving positive-pressure breaths. It is the pressure in the system at the end of a spontaneous breath when a mask is held tightly on the baby's face, but the bag is not being squeezed.
- Rate: The number of assisted breaths being administered, such as the number of times per minute that the bag is squeezed.

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

Three types of devices are available to ventilate newborns, and they work in different ways.

1. The ***self-inflating bag*** fills spontaneously after it has been squeezed, pulling gas (air or oxygen or a mixture of both) into the bag.

2. The ***flow-inflating bag*** (also called an anesthesia bag) fills only when gas from a compressed source flows into it and the outlet of the bag is occluded by being placed tightly against a surface (for testing) or against the baby's face with a mask, or is connected to the baby's airway via an endotracheal tube.

3. The ***T-piece resuscitator*** provides flow-controlled and pressure-limited breaths and works only when gas from a compressed source flows into it.

Find out what kind of resuscitation device is used in your hospital. If your hospital uses the T-piece resuscitator in the delivery area, you should still learn the details of whichever of the 2 types of bags are commonly used outside of the delivery area.

A self-inflating bag should be readily available as a backup wherever resuscitation may be needed, in case a compressed gas source fails or the T-piece device malfunctions. Details of all 3 devices are found in the Appendix to this lesson. You should read those section(s) of the Appendix that apply to the device(s) used in your hospital.

The ***self-inflating bag,*** as its name implies, inflates automatically without a compressed gas source (Figure 3.2). It remains inflated at all times, unless being squeezed. The concentration of oxygen being delivered using a self-inflating bag may not be consistent unless a reservoir is attached to the gas inlet. Peak inspiratory pressure (ie, peak inflation pressure) is controlled by how hard the bag is squeezed. Positive end-expiratory pressure can be administered only if an additional valve is attached to the self-inflating bag. Continuous positive airway pressure cannot be delivered reliably with a self-inflating bag. To help ensure that appropriate pressure is used when providing PPV in a newborn, you should use a self-inflating bag that has an integral ***pressure gauge or, if there is a site for attaching a pressure gauge (manometer), you should make sure one is attached.***

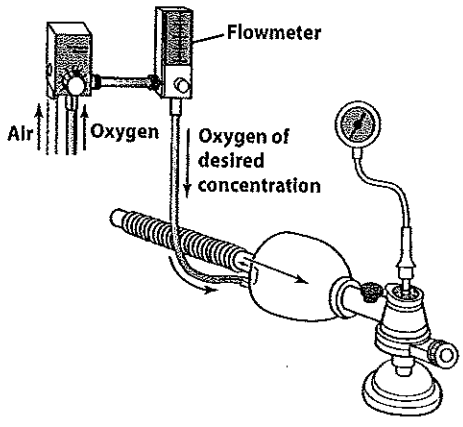
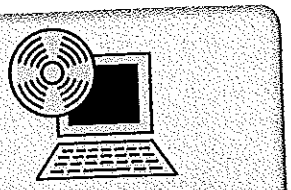


Figure 3.2. Self-inflating bag remains inflated without gas flow and without having the mask sealed on the face



You are encouraged to view this video on the DVD that accompanies this textbook: ***CPAP Administration***

The ***flow-inflating bag*** is collapsed like a deflated balloon when not in use (Figure 3.3). It inflates only when a gas source is forced into the bag and the opening of the bag is sealed, as when the mask is placed tightly on a baby's face, or when the baby has been intubated and the bag is attached to the endotracheal tube. Peak inspiratory pressure is controlled by the flow rate of incoming gas, adjustment of the flow-control valve, and how hard the bag is squeezed. Positive end-expiratory pressure or CPAP is controlled by an adjustable flow-control valve.

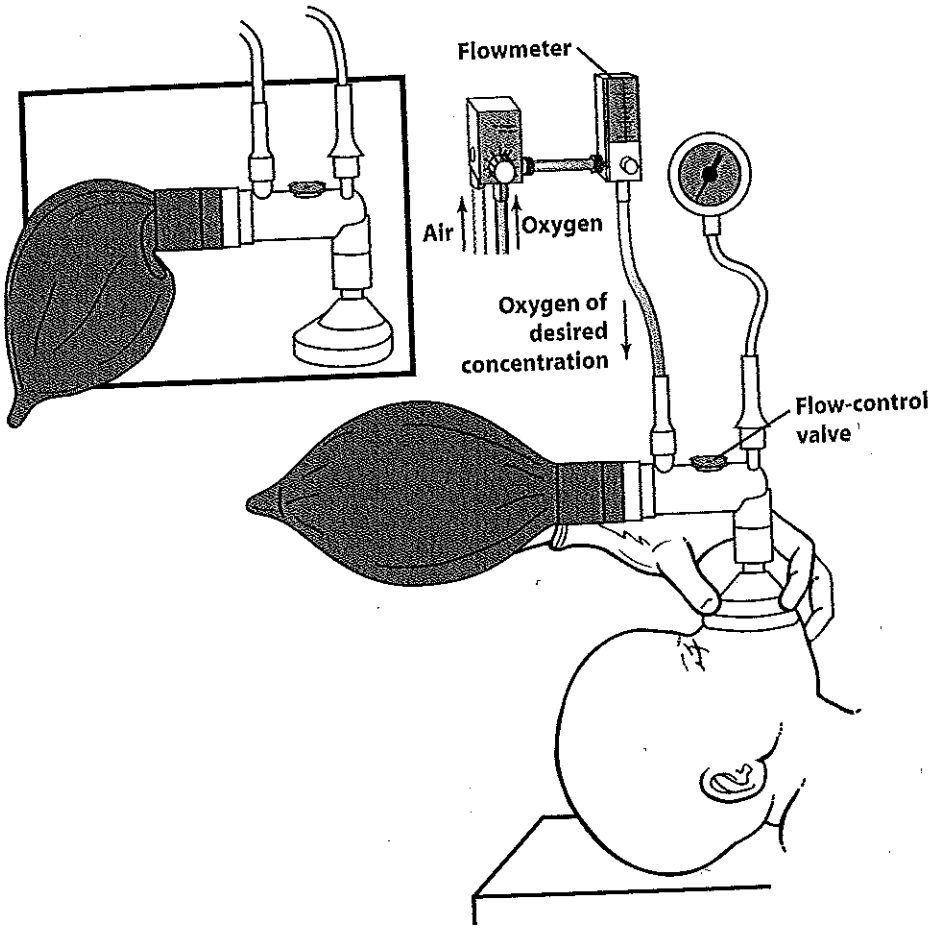


Figure 3.3 Flow-inflating bag inflates only with a compressed gas source and with mask sealed on face; otherwise, the bag remains deflated (inset)

The *T-piece resuscitator* (Figure 3.4) is flow controlled and pressure limited. Like the flow-inflating bag, this device requires a compressed gas source. Peak inspiratory pressure and positive end-expiratory pressure (PEEP or CPAP), if desired, are set manually with adjustable controls. Breaths are delivered when the operator alternately occludes and opens the aperture on the device connected to the mask or endotracheal tube.

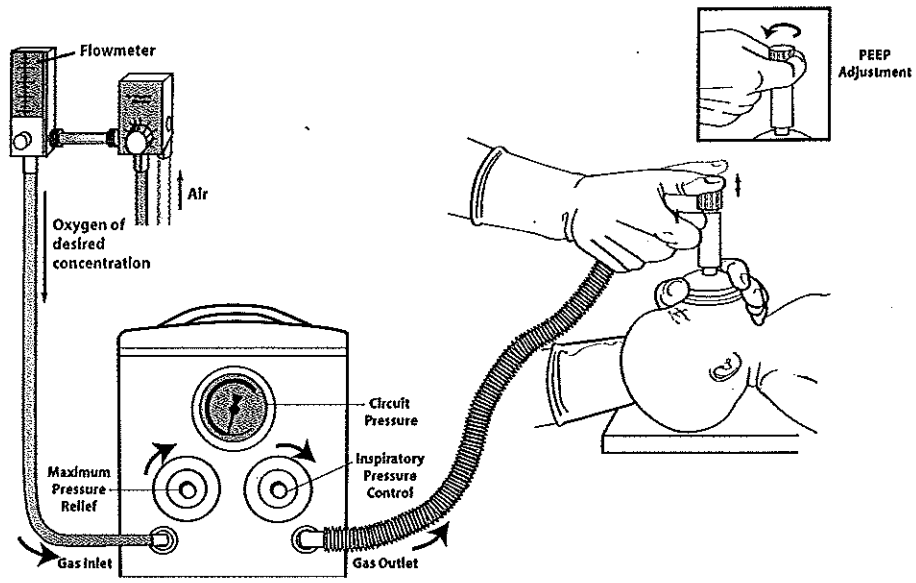


Figure 3.4. Flow-controlled, pressure-limited device (T-piece resuscitator). Pressures are pre-set by adjusting controls on the device and are delivered by occluding and opening the aperture in the PEEP cap.

What are the advantages and disadvantages of each assisted-ventilation device?

The ***self-inflating bag*** (Figure 3.5) is found more commonly in the hospital delivery room and resuscitation cart than the flow-inflating bag. It often is considered easier to use because it reinflates completely after being squeezed; this happens even if it is not attached to a compressed gas source and even if its mask is not on a patient's face. The disadvantage of this is that you will be less likely to know if you have achieved a good seal between the mask and the baby's face, which is required for the pressure from the squeezed bag to result in effective gas flow delivered to the baby's lungs. It cannot be used to administer free-flow or "blow-by" oxygen reliably through the mask and cannot be used to deliver CPAP.

When a self-inflating bag is not being squeezed, the amount of gas or oxygen flow that comes out of the patient outlet depends on the relative resistance and leaks in valves within the bag. Even when the self-inflating bag is connected to a 100% oxygen source, most of the oxygen is directed out of the back of the bag, and an unpredictable amount is directed toward the patient unless the bag is being squeezed.

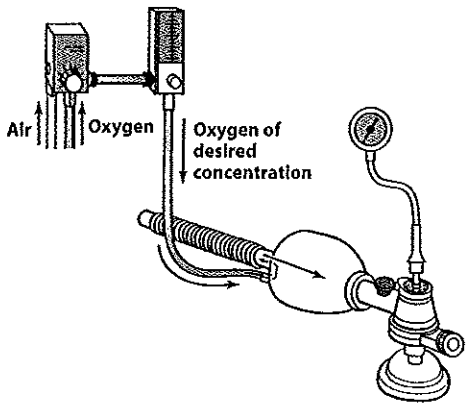


Figure 3.5. Self-inflating bag

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 oxygen reservoir to provide high concentration of oxygen
- Cannot be used to deliver free-flow oxygen reliably through the mask
- Cannot be used to deliver continuous positive airway pressure (CPAP) and can deliver positive end-expiratory pressure (PEEP) only when a PEEP valve is added and pressurized gas is entering the bag

Therefore, the self-inflating bag cannot be used to deliver free-flow oxygen through the mask. In addition, as was described in Lesson 2, the self-inflating bag must have an oxygen reservoir attached to deliver a high concentration of oxygen, even while PPV is being provided.

In some situations, providers may want to deliver PEEP to a baby who is receiving PPV, or CPAP to a spontaneously breathing baby. Positive end-expiratory pressure can be delivered with a self-inflating bag if a special "PEEP valve" is used, but there must be pressurized gas entering the bag to generate the PEEP. Also, CPAP cannot be administered with a self-inflating bag, even if a PEEP valve is present.

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. However, the pressure at which the valve "pops off" can vary considerably from the manufacturer's specifications; therefore, the only reliable way to monitor the pressure being delivered to the baby and to prevent the use of excessive pressures is to attach a pressure gauge (manometer) to the bag. You should use a self-inflating bag that has an integral ***pressure gauge or, if there is a site for attaching a pressure gauge (manometer), you should make sure one is attached.***

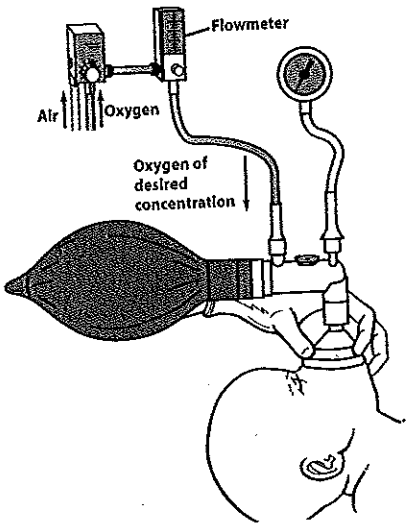


Figure 3.6. Flow-inflating bag

Advantages

- Can deliver up to 100% oxygen, depending on the source
- Easy to determine when there is a seal on the patient's face
- Can be used to deliver free-flow oxygen at concentrations up to 100%, depending on the source

Disadvantages

- Requires a tight seal between the mask and the patient's face to remain inflated
- Requires a gas source to inflate
- Requires use of a pressure gauge to monitor pressure being delivered with each breath

The ***flow-inflating bag*** (Figure 3.6) requires a compressed gas source for inflation. When the gas flows into the device, it will take the path of least resistance and either flow out the patient outlet or into the bag. To make the bag inflate, you need to keep the gas from escaping by having the face mask sealed tightly against the newborn's face. Therefore, when a newborn is being resuscitated, the bag will not fill unless there is gas flow **and** the mask is tightly sealed over the baby's mouth and nose, or the device is attached to an endotracheal tube inserted into the baby's airway. Absent or partial inflation of the flow-inflating bag indicates that a tight seal has not been established.

In addition, because the oxygen concentration that exits a flow-inflating bag is the same as that which enters the bag, the flow-inflating bag can reliably be used to deliver free-flow oxygen at any concentration up to 100% oxygen if desired.

The main disadvantage of using a flow-inflating bag is that it takes more practice to use it effectively. In addition, because a compressed gas source is required to inflate the bag, it is sometimes not available for use as quickly as a self-inflating bag. This may become an issue when the need for resuscitation is unanticipated.

Because most flow-inflating bags do not have a safety valve, it is important to watch for the degree of chest movement with each assisted breath to avoid underinflation or overinflation of the lungs. The pressure being delivered can be adjusted using the flow-control valve. The use of a pressure gauge is recommended to provide a more

objective assessment of peak inspiratory pressure and to help maintain consistency of each assisted breath.

The ***T-piece resuscitator*** (Figure 3.7) has many similarities to the flow-inflating bag, with the added feature of mechanically controlling airway pressures. Like the flow-inflating bag, the T-piece resuscitator requires gas flow from a compressed gas source and has an adjustable flow-control valve to regulate the desired amount of CPAP or PEEP. The T-piece resuscitator also requires a tight mask-to-face seal to deliver a breath and can deliver up to 100% free-flow oxygen. The device also requires some preparation time for set-up prior to use, and pressure limits must be estimated based on the expected needs of the newborn.

The T-piece resuscitator differs from the flow-inflating bag in that the peak inspiratory pressure is controlled by a mechanical adjustment instead of by the amount of squeeze on the bag. Gas flow is directed to the baby or the environment when you alternately occlude and open the aperture in the PEEP cap with your finger or thumb. The T-piece resuscitator provides more consistent pressure with each breath than either the self-inflating or flow-inflating bag, and is not subject to operator fatigue that may occur while squeezing a bag. However, there is a risk of delivering breaths with a longer than desired inspiratory time if the operator does not monitor the duration of occlusion of the PEEP cap with each breath.

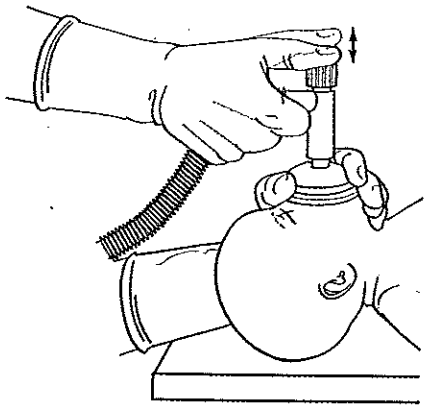


Figure 3.7 T-piece resuscitator

Advantages
- Consistent pressure
- Reliable control of peak inspiratory pressure and positive end-expiratory pressure
- Reliable delivery of 100% oxygen
- Operator does not become fatigued from bagging

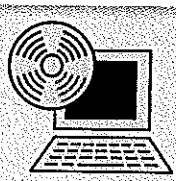
Disadvantages
- Requires compressed gas supply
- Requires pressures to be set prior to use
- Changing inflation pressure during resuscitation is more difficult
- Risk of prolonged inspiratory time

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

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

Appropriate-sized masks

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



You are encouraged to view this video on the DVD that accompanies this textbook: ***Using the T-piece Resuscitator***

Targeted Pre-ductal SpO_2 After Birth	
1 min	60%-65%
2 min	65%-70%
3 min	70%-75%
4 min	75%-80%
5 min	80%-85%
10 min	85%-95%

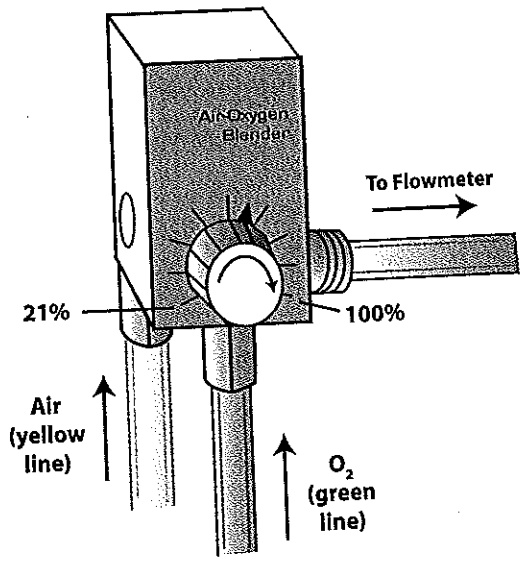


Figure 3.8A Mixing oxygen and air with an oxygen blender. The control knob dials in the desired oxygen concentration.

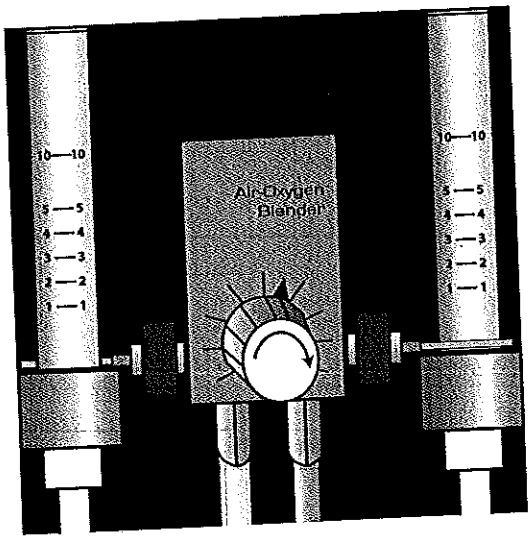


Figure 3.8B Mixing oxygen and air with an oxygen blender with double output for 2 flowmeters. One flowmeter can be connected to a bag-and-mask device, while the other can be connected to oxygen tubing used to give free-flow oxygen.

Capability to deliver variable oxygen concentrations during resuscitation

As described in Lesson 2, when PPV or supplemental oxygen is used, you should use an oximeter to judge the baby's state of oxygenation and to guide you in the concentration of oxygen to use. The recommended target to achieve is an oxygen saturation (SpO_2) similar to that of a healthy term baby following birth.

You will need the following equipment to deliver variable oxygen concentrations during resuscitation:

- ***Compressed air and oxygen source***

You will need a source of compressed air (either from a built-in wall source or compressed gas tank) to mix with a 100% oxygen source to achieve oxygen concentrations between 21% (room air) and 100%.

- ***Oxygen blender*** (Figure 3.8A and 3.8B)

An oxygen blender is needed to deliver an oxygen concentration between 21% and 100%. High-pressure hoses run from the oxygen and air sources to the blender, which has a dial that adjusts the gas mixture to achieve oxygen levels between 21% and 100% oxygen. The blender then connects to an adjustable flowmeter so that gas flow rates of 0 to 20 L/min of the desired oxygen concentration can be delivered directly to the baby or to the positive-pressure device. Management of oxygen delivery will be discussed later in this lesson.

Capability to control peak pressure, end-expiratory pressure, and inspiratory time

Establishing adequate ventilation is the most important step in resuscitating newborns. The amount of positive pressure required will vary, based on the state of the newborn's lungs. Delivery of excessive positive pressure can injure the lung, while use of inadequate pressure may delay establishment of effective ventilation. Adding PEEP when assisting ventilation with intermittent positive pressure, or administering CPAP to babies who are breathing spontaneously, may be helpful in establishing effective lung inflation, especially in babies with immature lungs, as will be discussed in Lesson 8. The presence of a pressure gauge is helpful to monitor the peak and end-expiratory pressures being delivered.

The duration of the inspiratory time is one factor that contributes to inflating the lungs. Increasing the inspiratory time is accomplished by squeezing a flow-inflating bag for a longer time or by keeping your finger on the PEEP cap of the T-piece resuscitator longer. However, the optimum inspiratory time to use during resuscitation of a newborn has not been determined.

Appropriate-sized bag

Bags used for newborns should have a minimum volume of about 200 mL and a maximum of 750 mL. Term newborns require only 10 to 25 mL with each ventilation (4 to 6 mL/kg). Bags larger than 750 mL, which are designed for older children and adults, make it difficult to provide such small volumes and deliver controlled peak pressure. Bags that are too small will not adequately reinflate between breaths when rates of 40 to 60 breaths/minute are used.

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. These features will be different for each type of device.

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

You will attach a resuscitation device to 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 overinflated, causing rupture of the alveoli and a resulting air leak, such as a pneumothorax.

Self-inflating bags should have a pressure-release valve (commonly called a ***pop-off valve***) (Figure 3.9), which generally is set by the manufacturer to 30 to 40 cm H_2O. If peak inspiratory pressures greater than 30 to 40 cm H_2O are generated, the valve opens, limiting the pressure being transmitted to the newborn. There may be wide variation in the point at which a pressure-release valve opens. The make and age of the bag as well as the method with which a non-disposable bag has been cleaned affect the opening pressure of the valve.

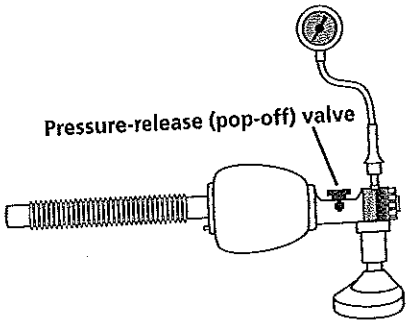


Figure 3.9 Self-inflating bag with pressure-release (pop-off) valve

In some self-inflating bags, the pressure-release valve can be temporarily occluded or bypassed to allow higher pressures to be administered. This usually is 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 while the pressure-release valve is bypassed.

Self-inflating bags also should be equipped with a pressure gauge (manometer) or a port to attach a pressure gauge to allow you to monitor the peak inspiratory pressure as you squeeze the bag.

Flow-inflating bags have a flow-control valve (Figure 3.10), which can be adjusted to deliver the desired PEEP. If the flow-control valve is adjusted incorrectly, it is possible to overinflate the baby's lungs inadvertently. An attached pressure gauge should be used to avoid giving excessive pressures.

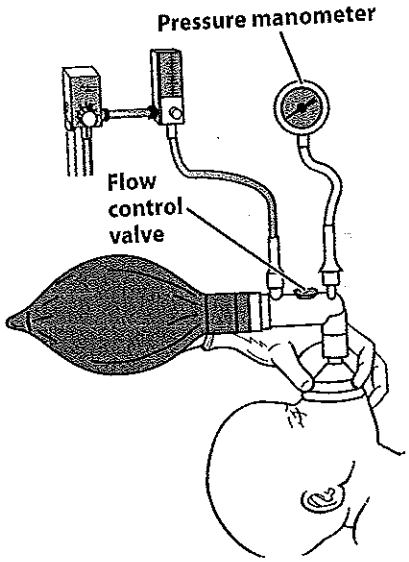


Figure 3.10 Flow-inflating bag with flow-control valve and attached manometer

Be certain to connect the oxygen supply line to the correct connection site as indicated by the bag's manufacturer. Connection of the oxygen supply line to the pressure gauge port has been reported to result in inadvertent high-inflating pressures being delivered to the patient and may result in a pneumothorax.

T-piece resuscitators have 2 controls to adjust the inspiratory pressure. The *inspiratory pressure* control sets the amount of pressure delivered during a normal assisted breath. The *peak inspiratory pressure* control is a safety feature that prevents the pressure from exceeding a preset value (usually 40 cm H_2O, but adjustable*). Excessive pressure also can be avoided by watching the circuit pressure gauge (Figure 3.11).

* Note: Some manufacturers recommend that the maximum relief control be adjusted to an institution-defined limit when the device is put into original service and not be readjusted during regular use.

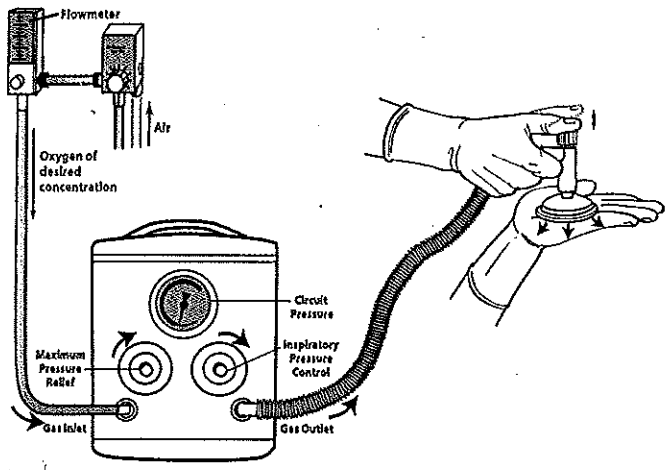


Figure 3.11. Maximum pressure relief and inspiratory pressure controls on T-piece resuscitator

Table 3-1. Features of devices used for positive-pressure ventilation during neonatal resuscitation

Characteristic	Self-Inflating Bag	Flow-Inflating Bag	T-piece Resuscitator
Appropriate-sized Masks	Available	Available	Available
Oxygen Concentration: • 90%–100% capability • Variable concentration	• Only with reservoir • Only with blender plus reservoir • Amount of oxygen delivered with no reservoir attached unpredictable	• Yes • Only with blender	• Yes • Only with blender
Peak Inspiratory Pressure	Amount of squeeze measured by the recommended pressure gauge	Amount of squeeze measured by pressure gauge	Peak inspiratory pressure determined by adjustable mechanical setting
Positive End-expiratory Pressure (PEEP)	No direct control (unless optional PEEP valve attached)	Flow-control valve adjustment	PEEP control
Inspiratory Time	Duration of squeeze	Duration of squeeze	Duration that PEEP cap is occluded
Appropriate-sized Bag	Available	Available	Not applicable
Safety Features	• Pop-off valve • Pressure gauge	• Pressure gauge	• Maximum pressure relief valve • Pressure gauge

Each of these characteristics will be described in the Appendix, under the detailed description of each device.

Review

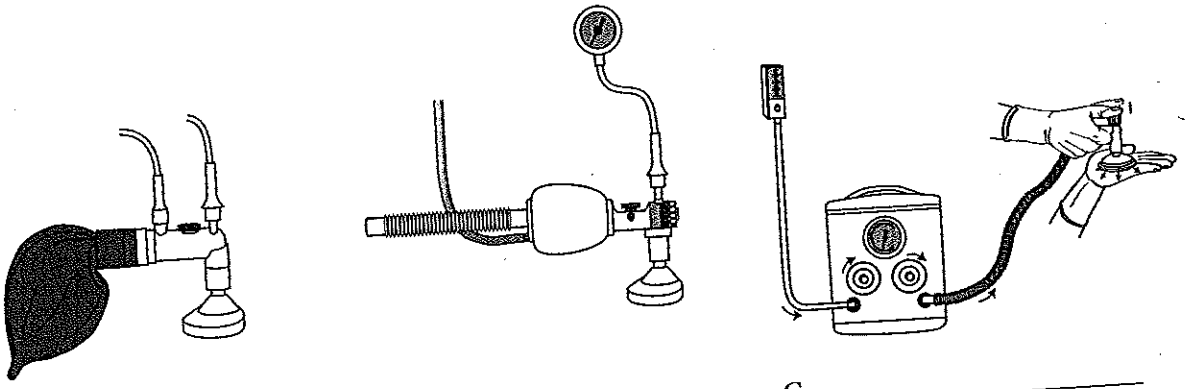
(The answers are in the preceding section and at the end of the lesson.)

1. Flow-inflating bags (will) (will not) work without a compressed gas source.

2. A baby is born apneic and cyanotic. You clear her airway and stimulate her. Thirty seconds after birth, she has not improved. The next step is to (stimulate her more) (begin positive-pressure ventilation).

3. The single most important and most effective step in neonatal resuscitation is (stimulation) (ventilating the lungs).

4. Label these bags "flow-inflating," "self-inflating," or "T-piece resuscitator."



A. _____ B. _____ C. _____

5. Masks of different sizes (do) (do not) need to be available at every delivery.

6. Self-inflating bags require the attachment of a(n)_____ to deliver a high concentration of oxygen.

7. T-piece resuscitators (will) (will not) work without a compressed gas source.

8. Neonatal ventilation bags are (much smaller than) (the same size as) adult ventilation bags.

9. List the principal safety features for each of the following devices:

   Self-inflating bag: _____ and _____

   Flow-inflating bag: _____

   T-piece resuscitator: _____ and _____

How do I assess the effectiveness of positive-pressure ventilation?

Rising heart rate is the most important indicator of successful resuscitation efforts. Every time PPV is initiated, heart rate is assessed first, along with oxygen saturation, if pulse oximetry is functioning.

If heart rate is not rising with PPV, you will assess for effective ventilation by listening for bilateral breath sounds and looking for chest movement with each positive-pressure breath. Positive-pressure ventilation that achieves bilateral breath sounds and chest movement is considered effective, even if the baby does not respond with rising heart rate and improved oxygen saturation.

However, most newborns respond to effective ventilation with a rising heart rate that exceeds 100 bpm, improvement in oxygen saturation, and, finally, spontaneous respiratory effort.

If you watch for these important signs, PPV can be provided effectively with any of the positive-pressure devices described in this lesson. The choice of which one(s) to employ should be determined by individual facilities.

The most important indicator of successful positive-pressure ventilation is rising heart rate.

What concentration of oxygen should be used when giving positive-pressure ventilation during resuscitation?

Several recent studies suggest that resuscitation of term newborns with 21% oxygen (room air) is just as successful as resuscitation with 100% oxygen. There is also some evidence that exposure to 100% oxygen during and following perinatal asphyxia may be harmful. However, since asphyxia involves deprivation of oxygen to body tissues, and pulmonary blood flow improves when oxygen concentration is increased, there is a theoretical possibility that using supplemental oxygen during resuscitation of newborns with asphyxia will result in more rapid restoration of tissue oxygen and, perhaps, less permanent tissue damage and improved blood flow to the lungs.

As described in Lesson 2, in an attempt to balance the hazards possibly associated with these 2 extremes of oxygenation, this program recommends that your goal during and following resuscitation of a newborn should be to achieve an oxyhemoglobin saturation as measured by pulse oximetry that closely mimics the saturation measured in uncompromised babies born at term as they establish air breathing during the first few minutes of extrauterine life.

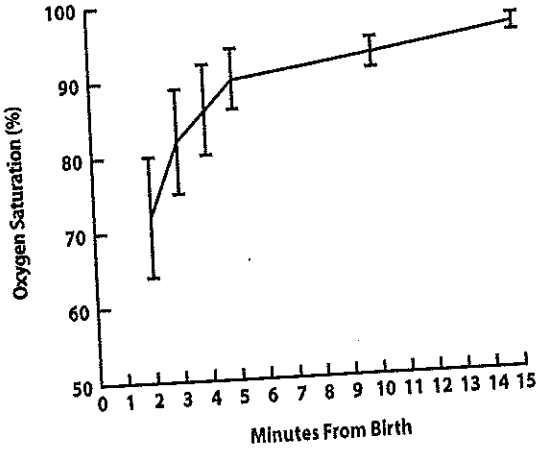


Figure 3.12 Pre-ductal oxygen saturation changes following birth (median and interquartile range). (From Mariani G, Dik PB, Ezquer A, et al. Pre-ductal and post-ductal O_2 saturation in healthy term neonates after birth. *J Pediatr.* 2007;150:418-421.)

Before birth and throughout intrauterine development, the fetus lives in an environment that results in a blood oxygen saturation that remains consistently at approximately 60%. After the first breath of room air is taken and the umbilical cord is cut, the normal newborn delivered at term gradually increases his or her oxygen saturation to greater than 90% (Figure 3.12). However, even healthy newborns may take 10 minutes or longer to reach this normal extrauterine saturation.

To match this normal gradual increase of saturation when resuscitating a baby who is compromised at birth, you will need to attach an oximeter as soon as possible, to help guide you in how much supplemental oxygen to use, if any. While the oximeter is being attached, you can begin resuscitation with 21% oxygen in term newborns; preterm newborns may achieve normal oxygen saturations more quickly if you start with a somewhat higher oxygen concentration. If you have had adequate time to prepare for the resuscitation (such as with a baby being born preterm), you may decide to start with an intermediate concentration to help you achieve the desired saturation more quickly, without resulting in periods of too low or too high a saturation.

Targeted Pre-ductal SpO_2 After Birth	
1 min	60%-65%
2 min	65%-70%
3 min	70%-75%
4 min	75%-80%
5 min	80%-85%
10 min	85%-95%

Ventilation of the lungs is the single most important and most effective step, regardless of the concentration of oxygen being used.

Once the oximeter is giving a reliable reading, as indicated by the monitor's pulse light, adjust the blender up or down to try to achieve an SpO_2 reading in the saturation range shown in the table.

Can you give free-flow oxygen using a resuscitation device?

Self-inflating bag:

*Free-flow oxygen cannot be given via the mask of a **self-inflating bag-and-mask device** (Figure 3.13).*

The oxygen flow entering a self-inflating bag will, normally, be diverted to the air inlet, through its attached oxygen reservoir, and then evacuated either out the end of the oxygen reservoir or out a valve that is attached to the reservoir. The amount of oxygen sent to the patient will depend on the relative resistance of the various valves and, therefore, may not reach the patient unless the bag is being squeezed. If your hospital is equipped with self-inflating bags, you may need to have a separate setup available for delivering free-flow oxygen, as described in Lesson 2.

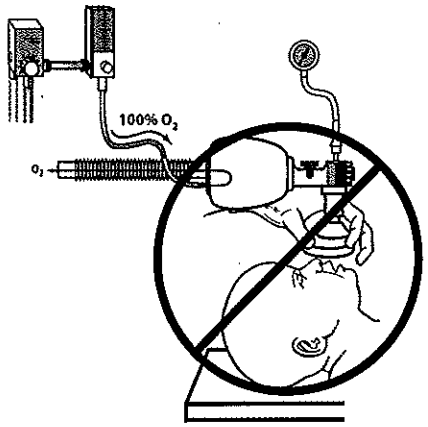


Figure 3.13. Free-flow oxygen cannot be given reliably by self-inflating bag; bag must be squeezed for reliable oxygen delivery so a separate set-up may be necessary to deliver free-flow oxygen

Flow-inflating bag/T-piece resuscitator:

*A **flow-inflating bag or T-piece resuscitator** can be used to deliver free-flow oxygen (Figure 3.14).*

The mask should be placed loosely on the face, allowing some gas to escape around the edges. If the mask is held tightly to the face, pressure will build up in the bag or in the T-piece device and be transmitted to the newborn's lungs in the form of CPAP or PEEP. If a flow-inflating bag is used, the bag should not inflate when used to provide free-flow oxygen. An inflated bag indicates that the mask is tight against the face and positive pressure is being provided.

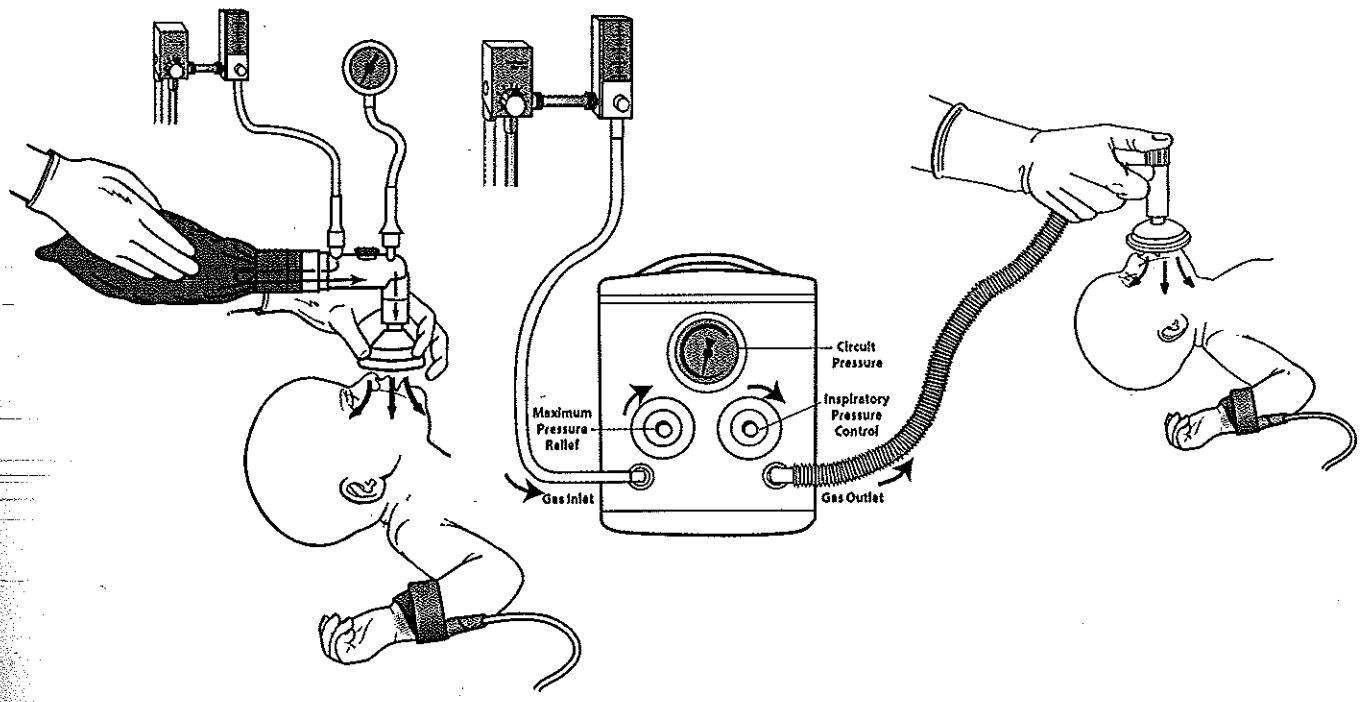


Figure 3.14. Free-flow oxygen given by flow-inflating bag (left) and by T-piece resuscitator (right). Note that mask is not held tightly on the face. Administration of less than 100% oxygen will require compressed air and a blender.

What characteristics of face masks make them effective for ventilating newborns?

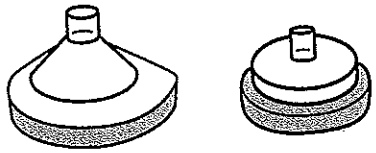


Figure 3.15 Face masks with rims

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

The rim on masks for newborns is cushioned (Figure 3.15) and is made from either a soft, flexible material, such as foam rubber, or an air-inflated ring. The rim conforms to the shape of the newborn's face, making it easier to form a seal.

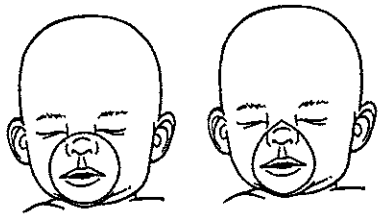


Figure 3.16 Round (left) and anatomically shaped (right) face masks

Masks also come in 2 shapes—round and anatomically shaped (Figure 3.16). 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.

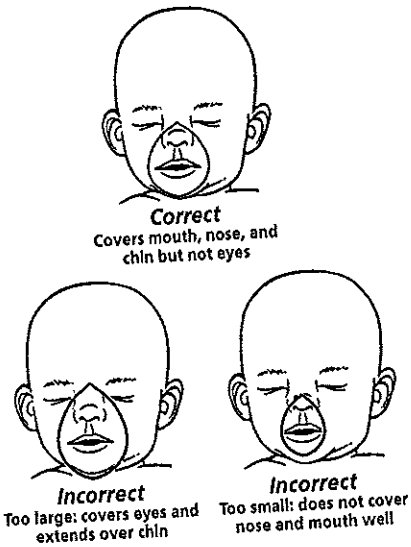


Figure 3.17 Correct (top) and incorrect (bottom) mask sizes

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

If the mask is the correct size, the rim will cover the tip of the chin, the mouth, and the nose, but not the eyes (Figure 3.17).

- Too large—may cause 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-newborn size mask is impossible.

How do you prepare the resuscitation device for an anticipated resuscitation?

Assemble the equipment

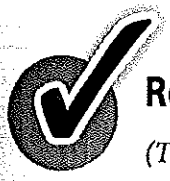
Estimate the size of the baby and be sure you have appropriate-sized masks. The PPV device should be assembled and connected to a blender that has both an oxygen and an air supply. The oxygen blender enables you to provide any concentration of oxygen from 21% (room

air) up to 100% oxygen, if needed. If a self-inflating bag is used, be sure the oxygen reservoir is attached. Prepare the oximeter and be certain that a neonatal-sized probe is available. (Note: If an oxygen blender and pulse oximeter are not immediately available, start PPV with 21% oxygen [room air] while you are obtaining an air-oxygen source and an oximeter.)

Test the equipment

Once the equipment has been selected and assembled, check the device and mask to be sure they function properly. Bags that have cracks or holes, valves that stick or leak, devices that do not function properly, or defective masks must not be used. The equipment should be checked when rooms are stocked, and again before each delivery. The operator should check it again just before its use. There is a specific checklist for each of the devices, as described in the respective appendices.

Be very familiar with the type of resuscitation device(s) you are using. Know exactly how to check it quickly to determine whether it is functioning properly.



Review

(The answers are in the preceding section and at the end of the lesson.)

10. Free-flow oxygen can be delivered reliably through the mask attached to a (flow-inflating bag) (self-inflating bag) (T-piece resuscitator).

11. When giving free-flow oxygen with a flow-inflating bag and mask, it is necessary to place the mask (securely) (loosely) on the baby's face to allow some gas to escape around the edges of the mask.

12. Before an anticipated resuscitation, the ventilation device should be connected to a(n) _____, which enables you to provide oxygen in any concentration, from room air up to 100% oxygen.

13. Resuscitation of the term newborn may begin with _____% oxygen. The oxygen concentration used during resuscitation is guided by the use of _____, which measures oxygen saturation.

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

Figure 3.18. Correct-sized mask covers mouth, nose, and tip of chin, but not the eyes

If you are alone, call for a second person to provide assistance.
Your assistant applies the pulse oximeter and monitors heart rate and breath sounds with a stethoscope.

Select the appropriate-sized mask.
Remember, the mask should cover the mouth, nose, and tip of the chin, but not the eyes (Figure 3.18).

Be sure there is a clear airway.
You may want to suction the mouth and nose to be certain there will be no obstruction to PPV that you will be delivering. When the baby is apneic, airway obstruction may not be clinically apparent.

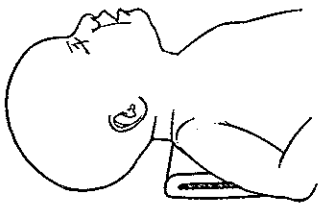


Figure 3.19. Correct position for assisted ventilation

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 rolled towel or small blanket under the shoulders (Figure 3.19).

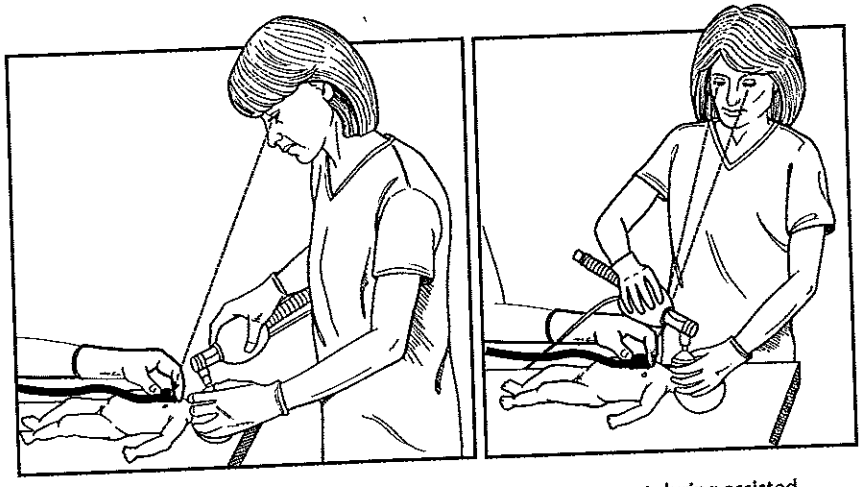


Figure 3.20. Two correct positions for visualizing chest movement during assisted ventilation

Position yourself at the bedside.
You will need to position yourself at the baby's side or head to use a resuscitation device effectively (Figure 3.20). Both positions leave the chest and abdomen unobstructed for visual monitoring of the baby, for chest compressions, and for vascular access via the 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 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 3.21).

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 toward the mask (Figure 3.22).

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 lift the chin forward to maintain a patent airway.

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 bruise the face and inadvertently flex the baby's neck.
- Be careful not to rest your fingers or hand on the baby's eyes.
- Recheck the position of the mask and the baby's head at intervals while providing PPV to make sure they are still correctly positioned.

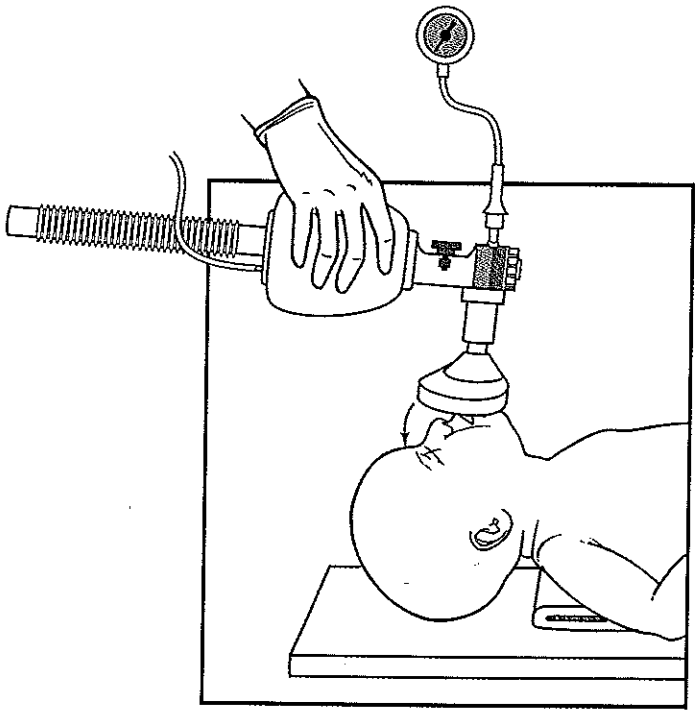


Figure 3.21 Cup the chin in the mask and then cover the nose

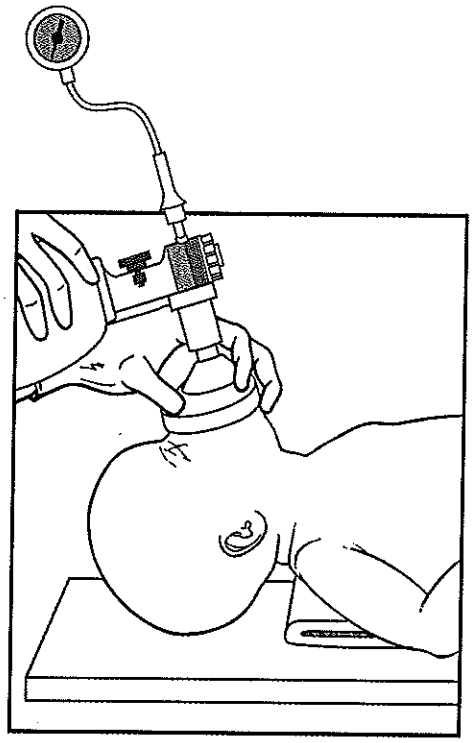


Figure 3.22 Correctly positioned mask on face. Light pressure on the mask will help create a seal. Anterior pressure on the posterior rim of the mandible (not shown) may also help.

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 any of the resuscitation devices.*

Although a self-inflating bag will remain inflated despite an inadequate seal, you will not be able to generate pressure to inflate the lungs when you squeeze the bag.

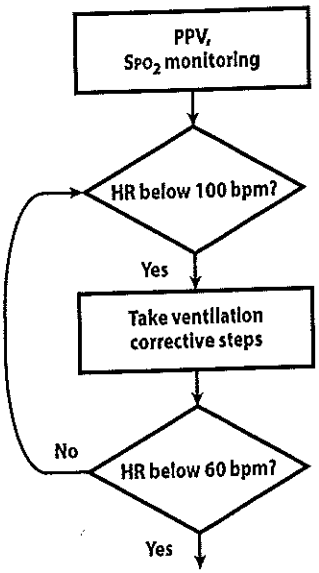
A flow-inflating bag will not inflate without a good mask-to-face seal and, therefore, you will not be able to squeeze the bag to create the desired pressure.

A T-piece resuscitator will not deliver positive pressure unless there is a good mask-to-face seal.

Remember,

- A tight seal is required for a flow-inflating bag to inflate.
- A tight seal is required for each of the resuscitation devices to generate positive pressure to inflate the lungs.

How do you know how much inflation pressure to deliver?



The lungs of a fetus are filled with fluid, but the lungs of a newborn must be filled with air. The first few breaths may need to be delivered with higher than usual pressures to fill the lungs with air. However, excessively high lung volumes and airway pressures can cause lung injury; therefore, it is important to squeeze the resuscitation bag just enough so that heart rate and oxygen saturation increase.

Start with an inspiratory pressure of about 20 cm H_2O. Rising heart rate (along with rising oxygen saturation if pulse oximetry is functional at this point) and audible bilateral breath sounds are the best indicators that inflation pressures are adequate.

Each breath might move the baby's chest; however, it is possible to provide adequate ventilation without visible chest movement, especially if the newborn is preterm.

The best indication that the mask is sealed and the lungs are being adequately inflated is rising heart rate and audible bilateral breath sounds. When pulse oximetry has a reliable signal, oxygen saturation should also rise, and you will likely see chest movement with ventilation.

If the baby appears to be taking very deep breaths during PPV, the lungs are being overinflated. You are using too much pressure, and there is danger of producing a pneumothorax. Remember that the volume of a normal breath in a term newborn is much smaller than the amount of gas in your resuscitation bag: one-tenth of a 240-mL self-inflating bag or one-thirtieth of a 750-mL flow-inflating bag (Figure 3.23). Preterm babies require even smaller gas volumes to inflate the lungs and avoid injury (Chapter 8).

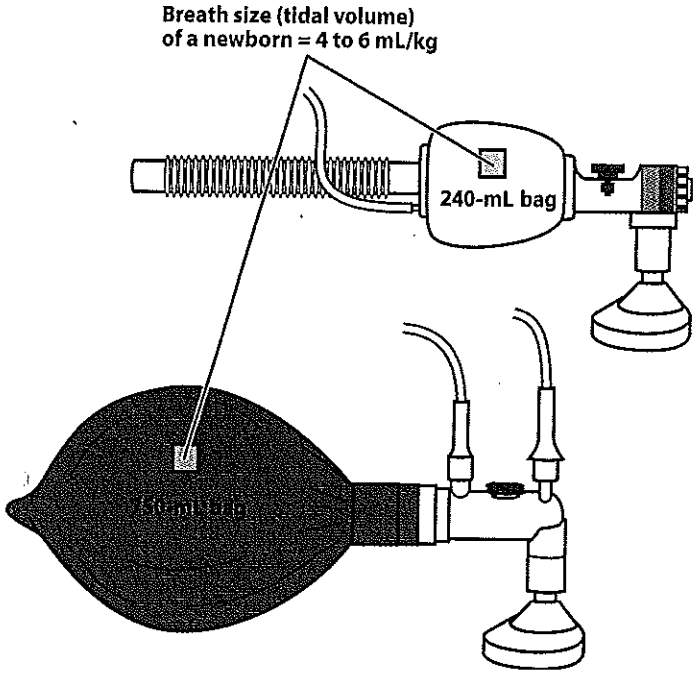


Figure 3.23. Relative sizes of normal breath and common resuscitation bags

What do you do if the baby's heart rate and oxygen saturation are not rising and you do not hear bilateral breath sounds or see chest movement?

The recommended steps are summarized in Table 3.2. You have squeezed the bag or set the T-piece resuscitator to deliver 20 cm H_2O pressure. If heart rate and oximetry do not improve quickly **(within the first 5 to 10 breaths)**, look for the presence of chest movement with each positive-pressure breath and ask your assistant to listen with a stethoscope for bilateral breath sounds. Be careful not to mistake abdominal movement because of air entering the stomach for effective ventilation of the lungs.

If the chest is not moving with each breath and there are poor breath sounds, begin the ventilation corrective sequence. There are 3 possible reasons for ineffective ventilation:

- An inadequate seal between the mask and the baby's face.
- The baby's airway is blocked.
- Not enough pressure is being used to inflate the lungs.

Inadequate seal

If you hear or feel air escaping from around the mask, or if the 4 signs are not improving, reapply the mask to the face 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 3.24).

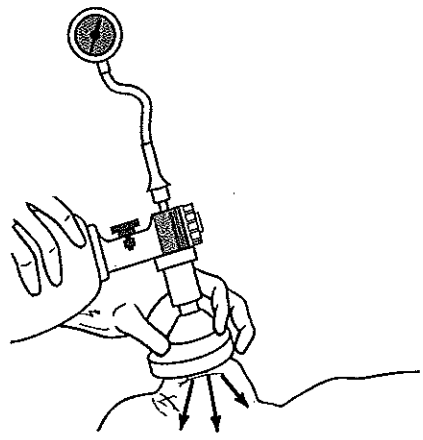


Figure 3.24. Inadequate seal of mask on face may result in poor chest movement

Blocked airway

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

- Reposition the baby's head.
- 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).

Repositioning the mask on the face to ensure a good seal and readjusting the baby's head to ensure an open airway usually solves the problem. The next attempt to ventilate the newborn usually results in effective ventilation.

Not enough pressure

Increasing the amount of positive pressure to 30 cm H_2O or greater is occasionally necessary if no improvement occurs. The use of a pressure gauge makes it easier to avoid high lung volumes and airway pressure, to assess compliance of the lungs, and to guide selection of subsequent ventilator settings, if necessary.

- Gradually increase the pressure every few breaths until there are bilateral breath sounds and visible chest movement with each breath. With chest movement, the heart rate and oxygen saturation also should improve. Remember to adjust the oxygen concentration to meet the target saturations in the table. Note the amount of pressure required to achieve improvements in heart rate, SpO_2 and color, breath sounds, and perceptible chest movement.
- When using a self-inflating bag, if the pressure-release valve "pops off" or releases before 40 cm H_2O is achieved, it is possible to occlude the pressure-release valve to achieve higher pressure. Do so, and cautiously increase the pressure up to a maximum of 40 cm H_2O.
- If you cannot achieve chest movement and an increase in heart rate, you should consider inserting a more effective airway—either an endotracheal tube or a laryngeal mask airway. (See Lesson 5.) This may require calling for help from a colleague with the necessary expertise.

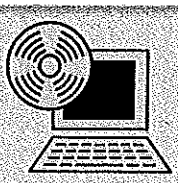
Once the gaseous volume (functional residual capacity) has been established in the newborn's lungs, lower pressures can be used for subsequent breaths. Cautiously reduce the inspiratory pressure as long as chest movement is adequate and clinical condition remains stable. Adjust oxygen concentration to meet the target saturations in the table printed with the flow diagram.

Table 3-2. Technique for improving positive-pressure ventilation by mask

Consider using the acronym "MR SOPA" to recall the ventilation corrective steps. The first 2 steps (M-R) should be addressed first, then the next 2 steps (S-O). Then if there is not adequate chest movement, move to the next 2 (P-A).

	Corrective Steps	Actions
M	Mask adjustment.	Be sure there is a good seal of the mask on the face.
R	Reposition airway.	The head should be in the "sniffing" position.
S	Suction mouth and nose.	Check for secretions; suction if present.
O	Open mouth.	Ventilate with the baby's mouth slightly open and lift the jaw forward.
P	Pressure increase.	Gradually increase the pressure every few breaths, until there are bilateral breath sounds and visible chest movement with each breath.
A	Airway alternative.	Consider endotracheal intubation or laryngeal mask airway.

If you still are unable to obtain physiologic improvement and adequate chest movement with mask ventilation techniques, you will need to use an alternative airway, such as an endotracheal tube, or, if that is not possible, a laryngeal mask airway.



You are encouraged to view this video on the DVD that accompanies this textbook: *MR SOPA: Ventilation Corrective Steps*

What ventilation rate should you provide during positive-pressure ventilation?

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. Faster rates often result in less effective breaths and should be consciously avoided.

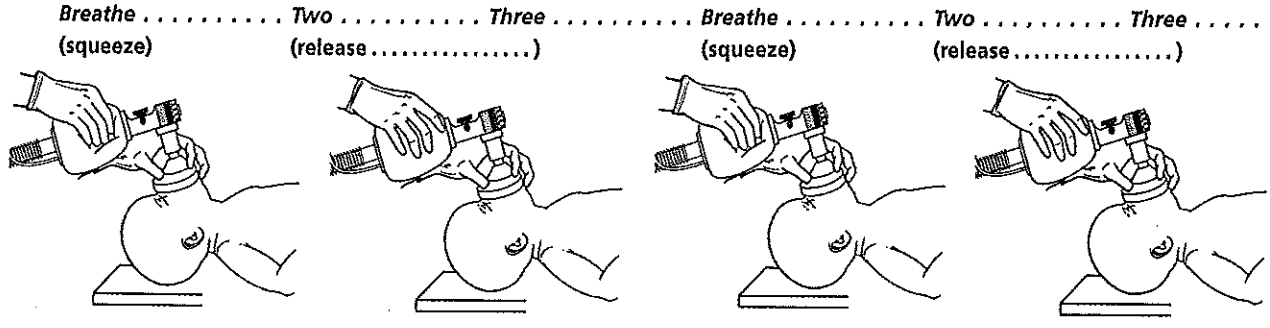
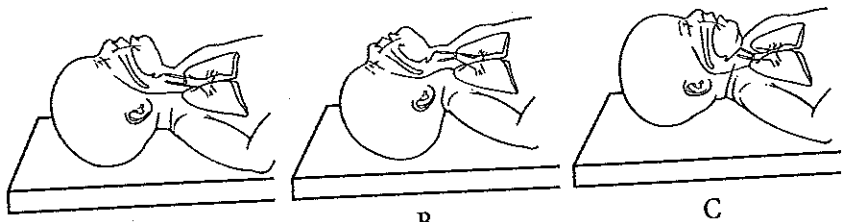


Figure 3.25 Count out loud to help maintain a rate of 40 to 60 breaths per minute. Say "Breathe" as you squeeze the bag or occlude the PEEP cap of the T-piece resuscitator, and release while you say "Two, Three."

Review

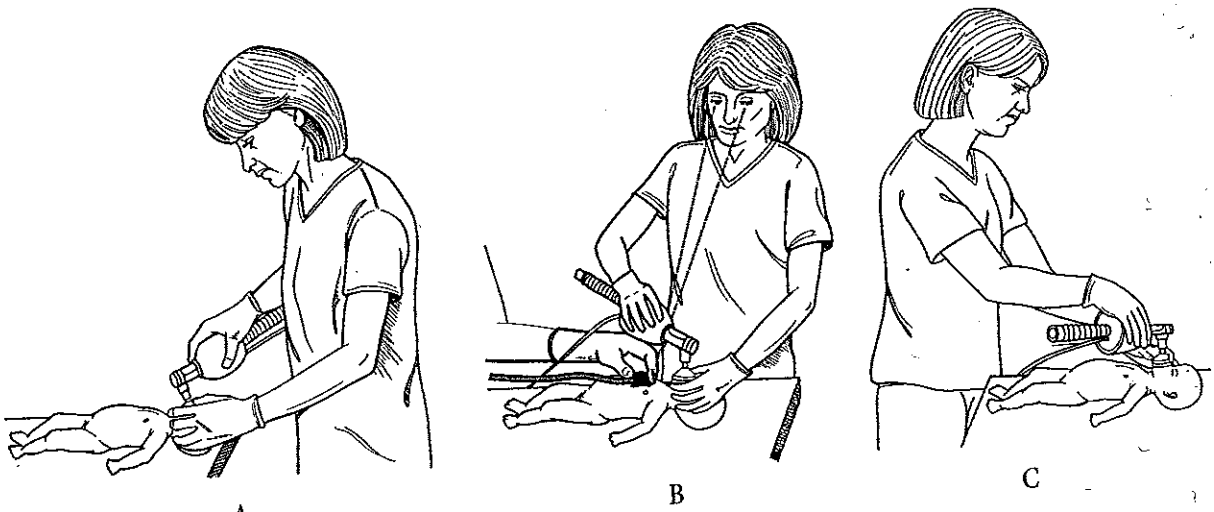
(The answers are in the preceding section and at the end of the lesson.)

14. Which baby is positioned properly for positive-pressure ventilation?



A B C

15. Which illustration(s) shows the correct position for assisting positive-pressure ventilation?



A B C

16. You must hold the resuscitation device so that you can see the newborn's _____ and _____.

17. An anatomically shaped mask should be positioned with the (pointed) (rounded) end over the newborn's nose.

18. If you notice that the baby's chest looks as if he is taking deep breaths, you are (overinflating) (underinflating) the lungs, and it is possible that a pneumothorax may occur.

19. When ventilating a baby, you should provide positive-pressure ventilation at a rate of _____ to _____ breaths per minute.

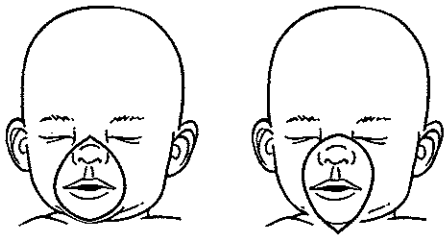
20. Begin positive-pressure ventilation with an initial inspiratory pressure of ___ cm H_2O.

21. "MR SOPA" stands for:

M = _____
R = _____
S = _____
O = _____
P = _____
A = _____

22. Your assistant assesses effectiveness of positive-pressure ventilation by first assessing the _____ and _____ along with listening for _____ _____. If these signs are not acceptable, you should look for _____ movement.

23. Which mask is correctly placed on the newborn's face?



A B

24. You have started positive-pressure ventilation on an apneic newborn. The heart rate is not rising, oxygen saturation is not improving, and your assistant does not hear bilateral breath sounds. List 3 possibilities of what may be wrong.

(1) _____

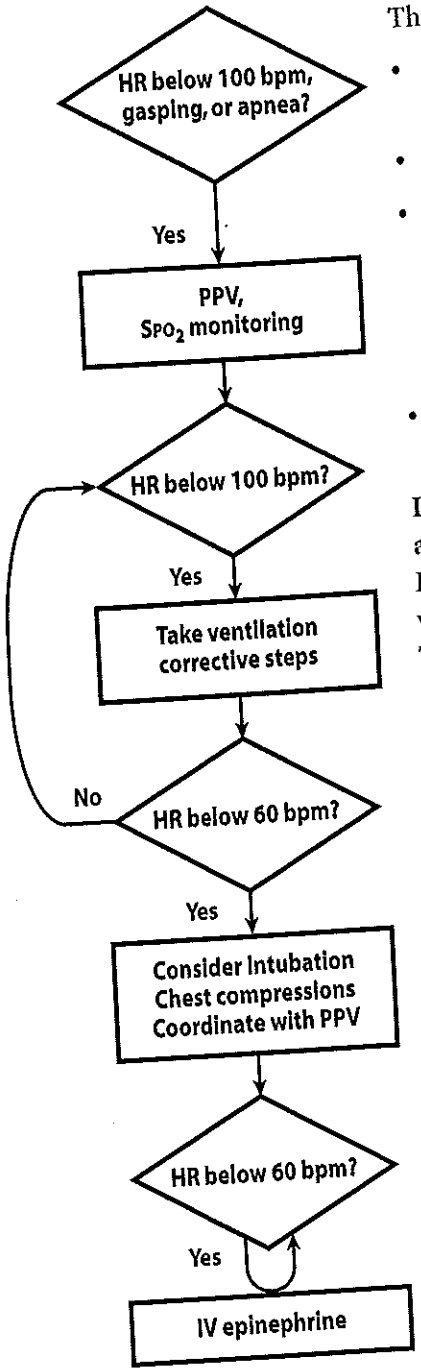
(2) _____

(3) _____

25. If, after performing the ventilation corrective sequence and making appropriate adjustments, you are unable to obtain a rising heart rate or bilateral breath sounds or see chest movement with positive-pressure ventilation, you usually will have to insert a(n)

_____ or _____.

What do you do if the baby is not improving?



Targeted Pre-ductal SpO_2 After Birth	
1 min	60%-65%
2 min	65%-70%
3 min	70%-75%
4 min	75%-80%
5 min	80%-85%
10 min	85%-95%

This is what you have done so far:

- Initiated PPV with an inspiratory pressure of about 20 cm H_2O, at a rate of 40 to 60 breaths per minute.
- Called for assistance.
- Your assistant attached a pulse oximeter probe to the baby's right hand or wrist, and then listened for rising heart rate and assessed for improving oxygen saturation. If those signs were not evident, your assistant listened for bilateral breath sounds and looked for chest movement with each positive-pressure breath.
- If this was not immediately evident in the first 5 to 10 breaths, you initiated the ventilation corrective steps (MR SOPA).

If the baby's condition continues to deteriorate or fails to improve, and the heart rate is below 60 bpm despite 30 seconds of effective PPV (defined by audible bilateral breath sounds and chest movement with ventilation), your next step will be to begin chest compressions. This will be described in Lesson 4. When chest compressions begin, increase the oxygen concentration to 100%. When the heart rate rises above 60 bpm and the pulse oximeter is available and reliable, adjust the oxygen concentration to meet the target saturation range indicated in the table shown below the flow diagram.

If the heart rate is more than 60 bpm but less than 100 bpm, continue to administer PPV as long as the baby is showing steady improvement.

- Monitor oxygen saturation and adjust the oxygen concentration to meet the target saturation range indicated in the table shown below the flow diagram.
- Consider inserting an orogastric tube if ventilation continues (discussed in the next section).
- Consider decreasing inspiratory pressure if chest expansion now seems too much.
- As ventilation continues, reassess respiratory effort, heart rate, and oxygen saturation continuously, or at least every 30 seconds.

If the heart rate is more than 60 bpm but less than 100 bpm,

- **Ensure effective ventilation.**
- Call for additional expertise.
- Consider that other complications, such as a pneumothorax or hypovolemia, also may be present. These will be described in Lessons 6 and 7.

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

What else should you do if positive-pressure ventilation with a mask is to be continued for more than several minutes?

If a newborn requires PPV with a mask for longer than several minutes, consider placing an orogastric tube and leaving it in place.

During PPV 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 3.26).

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 into the lungs during PPV.

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.

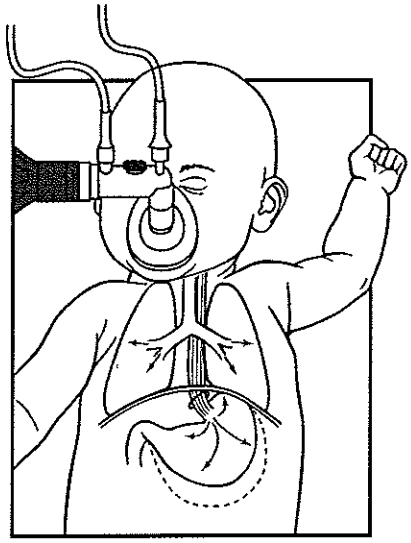


Figure 3.26 Excess gas in stomach resulting from bag-and-mask ventilation

How do you insert an orogastric tube?

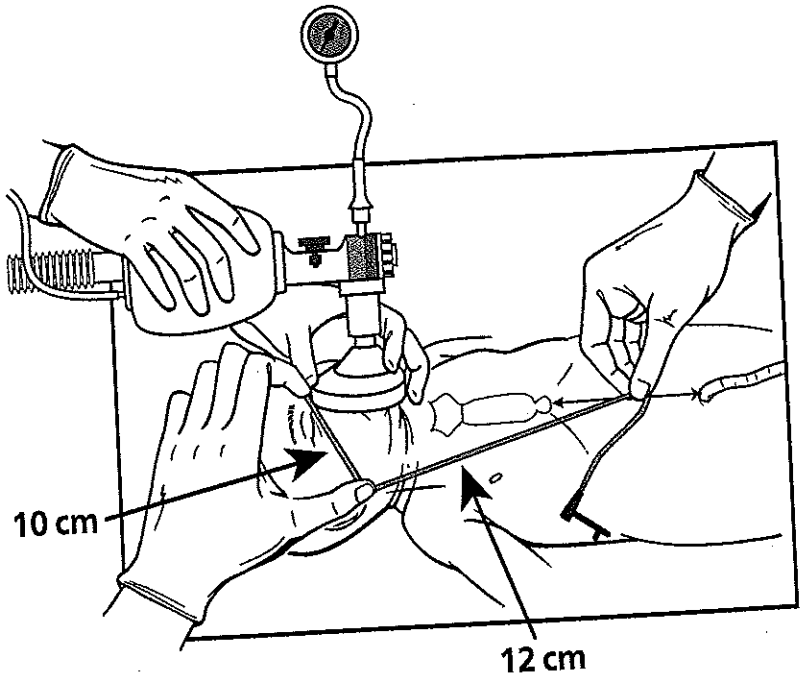


Figure 3.27 Measuring the correct distance for inserting an orogastric tube. In this example, the orogastric tube should be inserted 10 + 12 = 22 cm.

The equipment needed to place an orogastric tube during ventilation includes

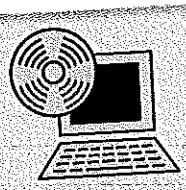
- 8F feeding tube
- 20-mL syringe

One member of the team should prepare and place the orogastric tube while the other members of the team continue to provide PPV and assess the baby's heart rate, oxygen saturation, and appearance of spontaneous respirations every 30 seconds.

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 3.27).

To minimize interruption of ventilation, measurement of the orogastric tube can be approximated with the mask in place.



You are encouraged to view this video on the DVD that accompanies this textbook: ***Orogastric Tube Placement***

② Insert the tube through the ***mouth*** rather than the nose (Figure 3.28A). 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 (Figure 3.28B).

④ Remove the syringe from the tube and leave the end of the tube *open* to provide a vent for air entering the stomach (Figure 3.28C).

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 (Figure 3.28D).

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 the baby's cheek. A larger tube may make it difficult to obtain a seal, particularly in premature newborns. A smaller tube can become occluded by secretions easily.

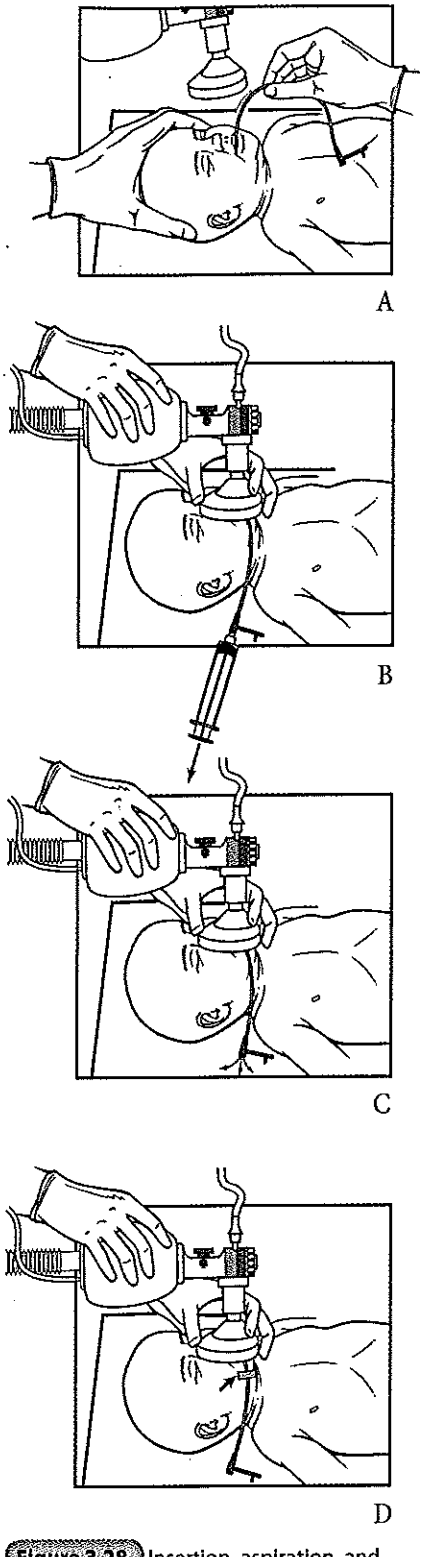


Figure 3.28 Insertion, aspiration, and taping of an orogastric tube (top to bottom)

How do you know if the baby has improved enough that you can stop positive-pressure ventilation?

As the heart rate increases toward normal, continue ventilating the baby at a rate of 40 to 60 bpm. With improvement, the baby's SpO_2 should gradually improve. Continue to monitor the movement of the chest and breath sounds to avoid overinflation or underinflation of the lungs.

When the heart rate is above 100 bpm and stable, reduce the rate and pressure of PPV while observing for effective spontaneous respirations and stimulating the baby to breathe effectively. Positive-pressure ventilation may be discontinued when the baby has

- A heart rate continuously over 100 bpm
- Sustained spontaneous breathing

Once the oximetry reading is in the target range, supplemental oxygen, if used, also can be weaned as tolerated.

Review

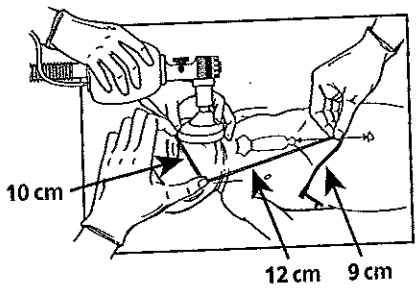
(The answers are in the preceding section and at the end of the lesson.)

26. You have administered positive-pressure ventilation (with bilateral breath sounds and chest movement) for 30 seconds. What do you do if the newborn's heart rate is now

- Below 60 beats per minute: _____
- More than 60 beats per minute and less than 100 beats per minute but steadily improving with effective positive-pressure ventilation: _____
- More than 60 beats per minute and less than 100 beats per minute and not improving with effective positive-pressure ventilation: _____

27. Assisted ventilation may be discontinued when

1. _____
2. _____



28. If you must continue positive-pressure ventilation with a mask for more than several minutes, a(n) _____ should be inserted to act as a vent for the gas in the stomach during the remainder of the resuscitation.

29. How far should this orogastric catheter be inserted? _____ cm

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 below 100 beats per minute even if breathing
   - Persistent central cyanosis and low SpO_2 despite free-flow supplemental oxygen increased to 100%

3. Resuscitation of term newborns may begin with 21% oxygen (room air); resuscitation of preterm newborns may begin with a somewhat higher oxygen concentration. Pulse oximetry is used to help adjust the amount of supplemental oxygen to avoid giving too much or too little oxygen.

4. 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 mask-to-face seal to inflate the lungs
   - Can deliver positive-pressure ventilation (PPV) 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 high oxygen concentration
   - Cannot be used to administer free-flow oxygen reliably through the mask and cannot be used to deliver continuous positive airway pressure (CPAP)
   - Should have an integral pressure gauge, or, if there is a site for attaching a pressure gauge (manometer), it should be attached

5. Flow-inflating bags
   - Fill only when gas from a compressed source flows into them
   - Depend on a compressed gas source
   - Must have a tight mask-to-face seal to inflate
   - Use a flow-control valve to regulate pressure/inflation
   - Should have a pressure gauge (manometer)
   - Look like a deflated balloon when not in use
   - Can be used to administer free-flow oxygen and CPAP

6. The flow-inflating bag will not work if
   - The mask is not properly sealed over the newborn's nose and mouth.
   - There is a hole in the bag.
   - The flow-control valve is open too far.
   - The pressure gauge is missing or the port is not occluded.

7. T-piece resuscitators
   - Depend on a compressed gas source.
   - Must have a tight mask-to-face seal to inflate the lungs.
   - Require selection of a maximum pressure, peak inspiratory pressure, and positive-end expiratory pressure (PEEP).
   - May require adjustment of peak inspiratory pressure during resuscitation to achieve physiologic improvement, audible breath sounds, and perceptible chest movements.
   - Provide positive pressure when operator alternately occludes and opens the aperture in the PEEP cap.
   - Can be used to deliver free-flow oxygen and CPAP.

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

9. The PPV device should be assembled and connected to a blender so that any concentration of oxygen from 21% (room air), up to 100% oxygen, can be provided.

10. If an oxygen blender and pulse oximeter are not immediately available, start PPV with 21% oxygen (room air) while you obtain an air-oxygen source and an oximeter.

11. Using pulse oximetry, supplemental oxygen concentration should be adjusted to achieve the target values for pre-ductal saturations summarized in the table on the Neonatal Resuscitation Program™ (NRP™) flow diagram.

12. If you cannot detect audible bilateral breath sounds and see no perceptible chest expansion during assisted ventilation, check or correct the following:
   - **M:** Mask adjustment.
   - **R:** Reposition airway.
   - **S:** Suction mouth and nose.
   - **O:** Open mouth.
   - **P:** Pressure increase.
   - **A:** Airway alternative.

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

14. Effective ventilation is defined by the presence of
- Bilateral breath sounds
- Chest movement (heart rate may rise without visible chest movement, especially in preterm newborns)

15. Signs that PPV has been effective, and indications that PPV may be discontinued, are
- Heart rate rises to over 100 breaths per minute
- Improvement in oxygen saturation
- Onset of spontaneous respirations

Lesson 3 Review

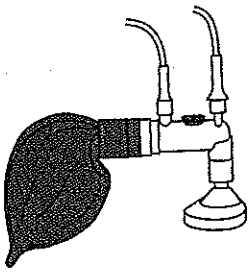
(The answers follow.)

1. Flow-inflating bags (will) (will not) work without a compressed gas source.

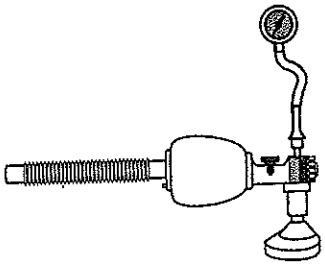
2. A baby is born apneic and cyanotic. You clear her airway and stimulate her. Thirty seconds after birth, she has not improved. The next step is to (stimulate her more) (begin positive-pressure ventilation).

3. The single most important and most effective step in neonatal resuscitation is (stimulation) (ventilating the lungs).

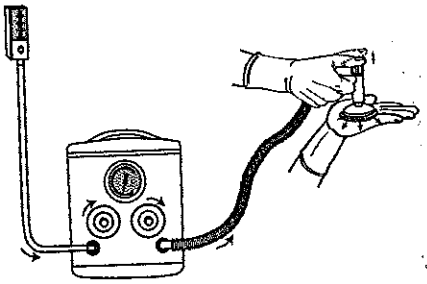
4. Label these bags "flow-inflating," "self-inflating," or "T-piece resuscitator."



A. _____



B. _____



C. _____

5. Masks of different sizes (do) (do not) need to be available at every delivery.

6. Self-inflating bags require the attachment of a(n)_____ to deliver a high concentration of oxygen.

7. T-piece resuscitators (will) (will not) work without a compressed gas source.

8. Neonatal ventilation bags are (much smaller than) (the same size as) adult ventilation bags.

9. List the principal safety feature for each of the following devices:

   Self-inflating bag: _____ and _____

   Flow-inflating bag: _____

   T-piece resuscitator: _____ and _____

Lesson 3 Review—*continued*

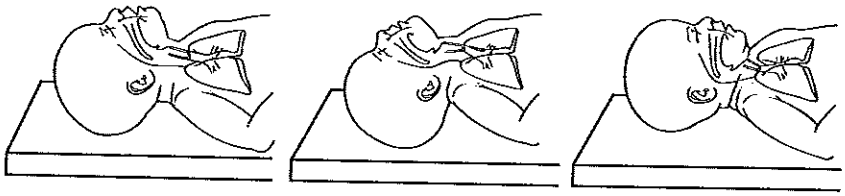
10. Free-flow oxygen can be delivered reliably through the mask attached to a (flow-inflating bag) (self-inflating bag) (T-piece resuscitator).

11. When giving free-flow oxygen with a flow-inflating bag and mask, it is necessary to place the mask (securely) (loosely) on the baby's face to allow some gas to escape around the edges of the mask.

12. Before an anticipated resuscitation, the ventilation device should be connected to a(n) _____, which enables you to provide oxygen in any concentration, from room air up to 100% oxygen.

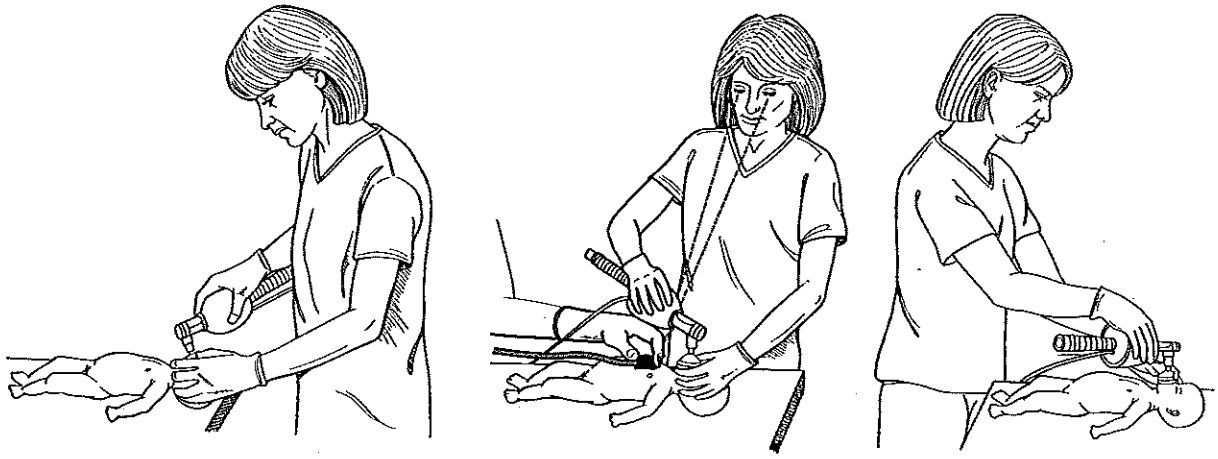
13. Resuscitation of the term newborn may begin with _____% oxygen. The inspired oxygen concentration used during resuscitation is guided by the use of a(n) _____, which measures oxygen saturation.

14. Which baby is positioned properly for positive-pressure ventilation?



A B C

15. Which illustration(s) shows the correct position for assisting positive-pressure ventilation?



A B C

Lesson 3 Review—*continued*

16. You must hold the resuscitation device so that you can see the newborn's _____ and _____.

17. An anatomically shaped mask should be positioned with the (pointed) (rounded) end over the newborn's nose.

18. If you notice that the baby's chest looks as if he is taking deep breaths, you are (overinflating) (underinflating) the lungs, and it is possible that a pneumothorax may occur.

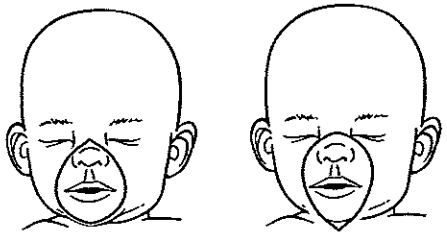
19. When ventilating a baby, you should provide positive-pressure ventilation at a rate of _____ to _____ breaths per minute.

20. Begin positive-pressure ventilation with an initial inspiratory pressure of ___ cm H_2O.

21. "MR SOPA" stands for:
    M = _____
    R = _____
    S = _____
    O = _____
    P = _____
    A = _____

22. Your assistant assesses effectiveness of positive-pressure ventilation by first assessing the _____ and _____ along with listening for _____ _____. If these signs are not acceptable, you should look for _____ movement.

23. Which mask is correctly placed on the newborn's face?



A B

Lesson 3 Review—*continued*

24. You have started positive-pressure ventilation on an apneic newborn. The heart rate is not rising, oxygen saturation is not improving, and your assistant does not hear bilateral breath sounds. List 3 possibilities of what may be wrong.

1. _____
2. _____
3. _____

25. If, after performing the ventilation corrective sequence and making appropriate adjustments, you are unable to obtain a rising heart rate or bilateral breath sounds or see chest movement with positive-pressure ventilation, you usually will have to insert a(n) _____ or a(n) _____.

26. You have administered positive-pressure ventilation (with bilateral breath sounds and chest movement) for 30 seconds. What do you do if the baby's heart rate is now

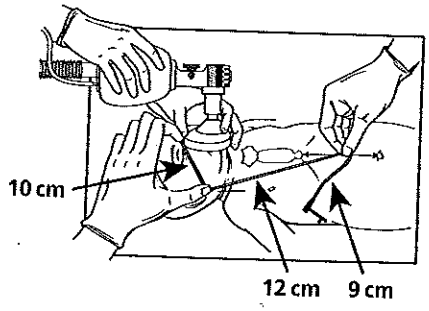
- Below 60 beats per minute? _____
- More than 60 beats per minute and less than 100 beats per minute but steadily improving with effective positive-pressure ventilation? _____
- More than 60 beats per minute and less than 100 beats per minute and not improving with effective positive-pressure ventilation? _____

27. Assisted ventilation may be discontinued when

1. _____
2. _____

28. If you must continue positive-pressure ventilation with a mask for more than several minutes, a(n) _____ should be inserted to act as a vent for the gas in the stomach during the remainder of the resuscitation.

29. How far should this orogastric catheter be inserted? _____ cm



Lesson 3 Answers to Questions

1. Flow-inflating bags **will not** work without a compressed gas source.
2. The next step is to **begin positive-pressure ventilation.**
3. **Ventilating the lungs** is the most important and effective step in neonatal resuscitation.
4. A. **flow-inflating;** B. **self-inflating;** C. **T-piece resuscitator**
5. Masks of different sizes **do** need to be at every delivery.
6. Self-inflating bags require the attachment of an **oxygen reservoir** to deliver a concentration of oxygen greater than approximately 40%.
7. T-piece resuscitators **will not** work without a compressed gas source.
8. Neonatal ventilation bags are **much smaller than** adult ventilation bags.
9. Self-inflating bag: **Pop-off valve** and **pressure gauge**

   Flow-inflating bag: **Pressure gauge**

   T-piece resuscitator: **Maximum pressure relief control** and **pressure gauge**
10. Free-flow oxygen can be delivered reliably with a **flow-inflating bag and T-piece resuscitator,** but not through the mask of a self-inflating bag.
11. When giving free-flow oxygen, place the mask **loosely** on the baby's face to allow some gas to escape around the edges of the mask.
12. The device should be connected to a **blender** to enable adjustment of inspired oxygen from 21% to 100%.
13. Resuscitation of the baby born at term may be started with **21%** oxygen. Subsequent oxygen concentration should be guided by an **oximeter,** which measures oxygen saturation.
14. Position A is the correct position. B and C are overextended and underextended, respectively.
15. **Illustrations A and B** are both correct.
16. You should be able to see the newborn's **chest** and **abdomen.**

Answers to Questions—*continued*

17. An anatomically shaped mask should be positioned with the **pointed** end over the newborn's nose.

18. You are **overinflating** the lungs, and there is danger you will produce a pneumothorax.

19. Squeeze the resuscitation bag at a rate of **40** to **60** breaths per minute.

20. Begin positive-pressure ventilation with an initial inspiratory pressure of **20** cm H_2O.

21. M = **Mask adjustment**
R = **Reposition airway**
S = **Suction mouth and nose**
O = **Open mouth**
P = **Pressure increase**
A = **Airway alternative**

22. Your assistant should note improvement in **heart rate** and **oximetry** and listen for **breath sounds.** You should look for **chest** movement.

23. Mask A is positioned correctly.

24. **There may be an inadequate seal of the mask on the face, the head may need to be repositioned to open the airway,** or **secretions may need to be suctioned.**

25. You usually will have to insert an **endotracheal tube** or a **laryngeal mask airway.**

26. Below 60 beats per minute: **Begin chest compressions and consider intubation.**

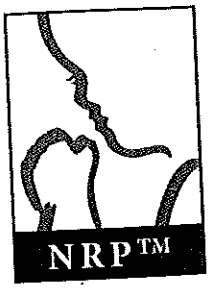
Between 60 beats per minute and 100 beats per minute and improving: **Adjust oxygen, gradually decrease pressure as heart rate improves, insert orogastric tube, continue monitoring.**

Between 60 beats per minute and 100 beats per minute and not improving: **Repeat MR SOPA and consider intubation.**

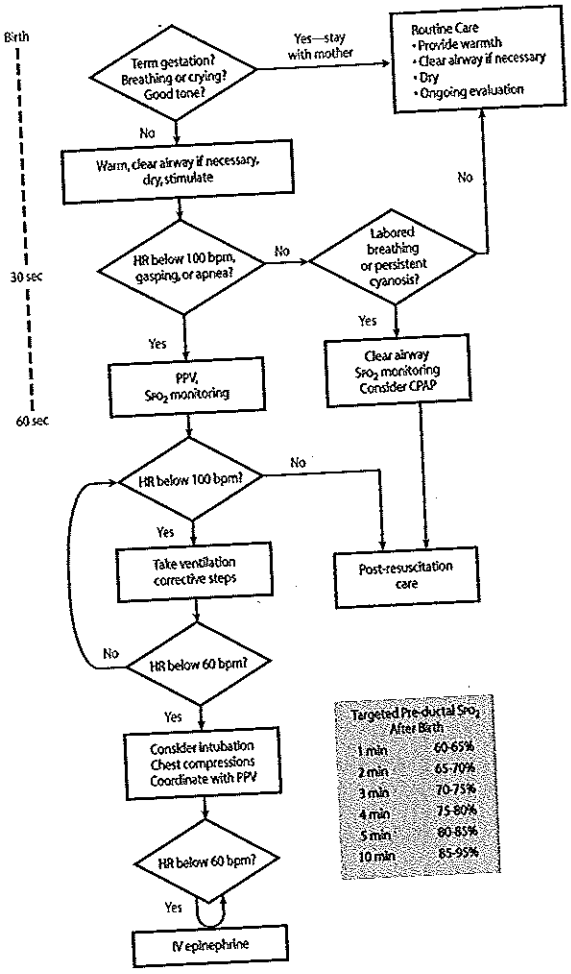
27. Discontinue assisted ventilation when the **heart rate is above 100 breaths per minute** and the **baby is breathing.**

28. An **orogastric tube** should be inserted to act as a vent for the gas in the stomach.

29. The orogastric catheter should be inserted **22** cm (10 cm + 12 cm).



Lesson 3: Positive-Pressure Ventilation Performance Checklist



The Performance Checklist Is a Learning Tool

The learner uses the checklist as a reference during independent practice, or as a guide for discussion and practice with a Neonatal Resuscitation Program™ (NRP™) instructor. When the learner and instructor agree that the learner can perform the skills correctly and smoothly without coaching and within the context of a scenario, the learner may move on to the next lesson's Performance Checklist.

If the institution policy is that a T-piece resuscitator normally is used in the delivery room, the learner should demonstrate proficiency with that device. However, he or she also should demonstrate ability to use a bag and mask.

Knowledge Check

- How will you check the function of the positive-pressure ventilation (PPV) device you will use?
- What are the indicators for beginning PPV?
- What is the correct ventilation rate?
- Which 2 indicators are evaluated when you first begin PPV? If those 2 indicators are not improving, what 2 indicators are next in evaluating effective ventilation?
- How is pulse oximetry used during PPV?
- What are the ventilation corrective steps (MR SOPA)?
- What is the purpose of an orogastric tube and when is it placed?
- What are the indications for stopping PPV?

Learning Objectives

1. Identify the newborn who requires PPV.
2. Demonstrate correct technique for PPV, including placement of mask on the newborn's face, rate and pressure, and corrective steps (MR SOPA).
3. Demonstrate correct placement and interpretation of pulse oximetry.
4. Recognize improvement during PPV by first assessing for increasing heart rate and oxygen saturation; if those are not improving, recognize the need to perform ventilation corrective steps and achieve audible breath sounds and chest movement with ventilation.
5. Identify signs that PPV may be discontinued.
6. Demonstrate pertinent key behavioral skills to optimize team performance.

"You are called to attend the birth of a baby because of failure to progress and maternal fever. How would you prepare for the resuscitation of this baby? As you work, say your thoughts and actions aloud so your assistant and I will know what you are thinking and doing."

Instructor should check boxes as the learner responds correctly.

Participant Name:		
	☐ Obtains relevant perinatal history	Gestational age? Fluid clear? How many babies? Other risk factors?
	☐ Performs equipment check ☐ Ensures correct size mask, and depending on device, checks function and inspiratory pressure, turns on gas flow 5-10 L/min, sets oxygen blender setting per hospital protocol ☐ If obstetric (OB) provider indicates that meconium is present in amniotic fluid, prepares for intubation and tracheal suctioning	**Warm, Clear airway, Auscultate, Oxygenate, Ventilate** (check PPV device), **Intubate, Medicate, Thermoregulate**
"The baby has been born."		
Sample Vital Signs	**Performance Steps**	**Details**
Gestational age as indicated Apneic Limp	Completes initial assessment when baby is born ☐ Learner asks 3 questions • Term? • Breathing or crying? • Good tone?	Initial assessment determines whether or not baby will receive initial steps of resuscitation at the radiant warmer.
	☐ Receives newborn at radiant warmer	
	☐ Meconium management (optional)	Intubation and suction indicated if meconium-stained and not vigorous.
	☐ Performs initial steps	Warm, position airway, suction mouth and nose, dry, remove wet linen, stimulate.
Respiratory Rate (RR)-apneic Heart Rate (HR)-40 beats per minute (bpm)	☐ Evaluates breathing and heart rate	Auscultate or palpate umbilical pulse.
	☐ Applies mask correctly and starts PPV at 20 cm H_2O; rate 40-60 bpm	Begin PPV with ____% oxygen per hospital protocol.
	☐ Calls for additional help	PPV requires 2 resuscitators.
	☐ Requests pulse oximetry	Assistant places probe on right hand or wrist, then plugs into oximeter. Oximeter has no signal.
HR-40 bpm SpO_2 - - - -	☐ Requests HR and saturation response within 5-10 breaths	Assistant auscultates chest and monitors oximetry.
Poor breath sounds; no chest movement	☐ Assesses bilateral breath sounds and chest movement	

Sample Vital Signs	Performance Steps	Details
	Ventilation Corrective Steps **M**ask adjustment **R**eposition head **S**uction mouth and nose **O**pen mouth Increase **P**ressure Consider **A**lternative airway	Instructor may indicate chest movement and breath sounds at any step along sequence. Do **M, R** first and reattempt PPV If no breath sounds or chest movement, do **S and O** and reattempt PPV. If no breath sounds or chest movement, gradually increase **P**ressure every few breaths, until there are bilateral breath sounds and chest movement with each breath, up to maximum of 40 cm H_2O pressure. If no breath sounds or chest movement, consider endotracheal intubation or laryngeal mask airway. (Lesson 5 notes limitations of the laryngeal mask airway.)
	After achieving breath sounds and chest movement ☐ Administers effective PPV for 30 seconds	Monitor for overinflation of lungs as functional residual capacity is established with first effective breaths.
	☐ Assesses HR and SpO_2	Instructor chooses from options below.
Option 1		
HR-70 bpm RR-4 breaths per minute (gasping) SpO_2-67%	☐ Continues effective PPV as long as HR is rising ☐ If HR not rising, repeats all ventilation corrective steps (MR SOPA) to ensure effective ventilation ☐ Adjusts oxygen per oximetry ☐ Considers intubation if HR continues >60 bpm and <100 bpm	If HR rises >100 bpm, proceed to Option 2. Learner demonstrates continuous assessment of HR and SpO_2 and ability to problem solve based on newborn's response.
Option 2		
HR-120 bpm RR-10 breaths per minute (weak cry) SpO_2-74%	☐ Stimulates newborn to breathe spontaneously and slows PPV rate as breathing becomes effective ☐ Adjusts oxygen per oximetry	
HR-140 bpm RR-60 breaths per minute (grunting) SpO_2-97%	☐ Monitors newborn's respiratory effort, HR, and SpO_2 ☐ Gradually withdraws PPV and adjusts oxygen as SpO_2 rises and then discontinues free-flow oxygen	
	☐ Updates family ☐ Directs post-resuscitation care	

Sample Vital Signs	Performance Steps	Details
Option 3		
HR-40 bpm RR-apneic SpO_2 - - -	☐ Quickly assesses reasons why baby may not be responding ☐ If no apparent reason for poor response, indicate need to intubate and begin chest compressions	Consider equipment malfunction, oxygen concentration, need for orogastric tube, or other problem (pneumothorax, hypovolemia). Oximeter—no signal.

Instructor asks the learner reflective questions to enable self-assessment, such as,

1. How did you know the newborn required
   a. Initial steps at the radiant warmer?
   b. Positive-pressure ventilation?
   c. Corrective steps (MR SOPA)?
   d. Supplemental oxygen?
2. Tell me about how you used pulse oximetry to guide your actions.
3. At what point would you need to call for more help?
4. What are some examples of the Key Behavioral Skills you used to communicate clearly with your assistant?
5. What went well during this resuscitation?
6. Would you do anything differently when faced with this scenario (indicate which scenario) again?

Neonatal Resuscitation Program Key Behavioral Skills

Know your environment.
Anticipate and plan.
Assume the leadership role.
Communicate effectively.
Delegate workload optimally.
Allocate attention wisely.
Use all available information.
Use all available resources.
Call for help when needed.
Maintain professional behavior.

Appendix

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

A. Self-inflating resuscitation bags

What are the parts of a self-inflating bag?

There are 7 basic parts to a self-inflating bag (Figure 3A.1).

1. Air inlet and attachment site for oxygen reservoir
2. Oxygen inlet
3. Patient outlet
4. Valve assembly
5. Oxygen reservoir
6. Pressure-release (pop-off) valve
7. Pressure gauge (some devices incorporate the gauge into the body of the device)

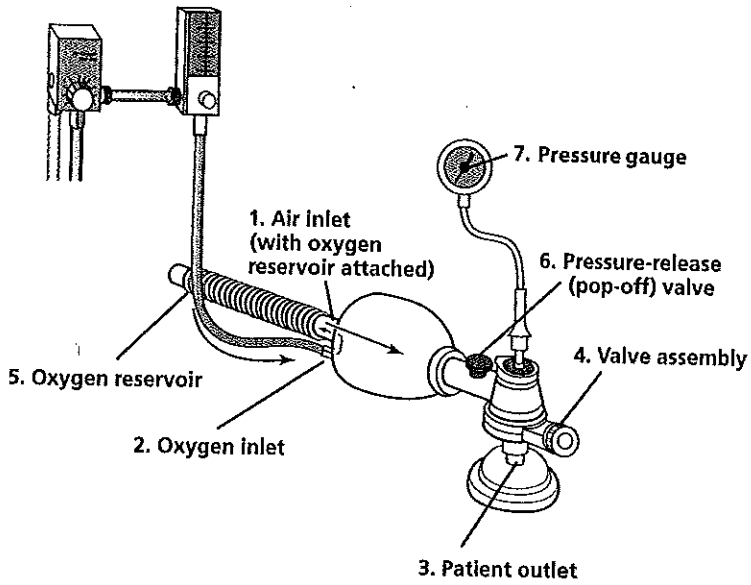


Figure 3A.1 Parts of a self-inflating bag

As the bag re-expands following compression, gas is drawn into the bag through a one-way valve that may be located at either end of the bag, depending on the design. This valve is called the ***air inlet.***

Every self-inflating bag has an ***oxygen inlet,*** which usually is located near the air inlet. The oxygen inlet is a small nipple or projection to which oxygen tubing is attached. In the self-inflating bag, an oxygen tube does not need to be attached for the bag to function. The oxygen tube should be attached when the bag is to be used for neonatal resuscitation.

The ***patient outlet*** is where gas exits from the bag to the baby and where the mask or endotracheal tube attaches.

Most self-inflating bags have a ***pressure-release valve*** that prevents excessive pressure buildup in the bag. To help ensure that appropriate pressure is used when providing positive-pressure ventilation (PPV) in a newborn, you should use self-inflating bags that have an integral ***pressure gauge (manometer), or, if there is a site for attaching a pressure gauge, you should make sure one is attached.*** The attachment site usually consists of a small hole or projection close to the patient outlet. Care should be taken to avoid connecting the oxygen inflow tubing to the site for attaching the pressure gauge, if present. High pressure may be generated in the baby and cause a pneumothorax or other air leak. Attach the oxygen tubing and pressure gauge according to manufacturer instructions.

Appendix—*continued*

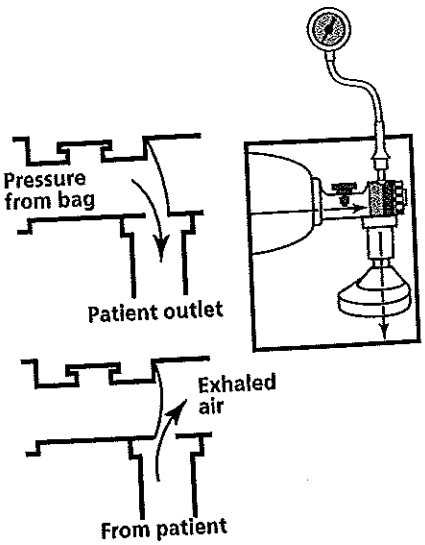


Figure 3A.2 Principle of valve assembly of a self-inflating bag

Self-inflating bags have a ***valve assembly*** positioned between the bag and the patient outlet (Figure 3A.2). When the bag is squeezed during ventilation, the valve opens, releasing oxygen/air to the patient. When the bag reinflates (during the exhalation phase of the cycle), the valve is closed. This prevents the patient's exhaled air from entering the bag and being re-breathed. You should become familiar with the valve assembly—what it looks like and how it responds as you squeeze and release the bag. If it is missing or malfunctioning, the bag should not be used.

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

Some babies who require resuscitation with assisted ventilation at birth also may benefit from administration of supplemental oxygen. The amount of supplemental oxygen to use during PPV should be determined by pulse oximetry.

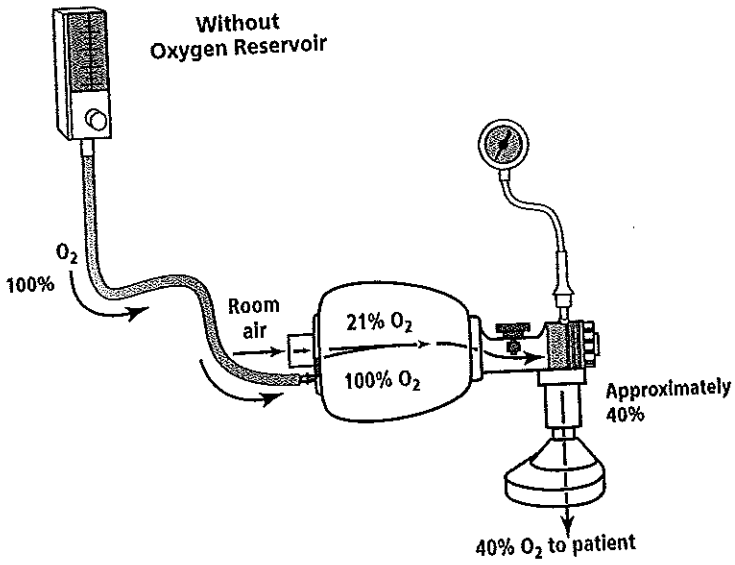


Figure 3A.3 Self-inflating bag without an oxygen reservoir and with an oxygen line connected to a 100% oxygen source. This system will deliver only approximately 40% oxygen to the patient and only when the bag is squeezed.

If a self-inflating bag is connected to a 100% oxygen source, the oxygen enters the bag through tubing connected between an oxygen source and the oxygen inlet port on the bag. However, each time the bag reinflates after you squeeze it, air (oxygen concentration 21%) is drawn into the bag through the air inlet. The air dilutes the concentration of oxygen in the bag. Therefore, even though you may have 100% oxygen flowing through the oxygen inlet, it is diluted by the air that enters each time the bag reinflates. As a result, the concentration of oxygen actually received by the patient is reduced and the exact concentration is unpredictable (Figure 3A.3). (The actual concentration will depend on the flow rate of oxygen coming from the source and how frequently the bag is squeezed.)

Appendix—*continued*

Concentrations of oxygen higher than is present in room air are most reliably delivered by using a blender and an ***oxygen reservoir.*** An oxygen reservoir is an appliance that can be placed over the bag's air inlet (Figure 3A.4). The reservoir allows the gas coming from the blender to collect at the inlet, thus preventing the gas from the blender from being diluted with room air. However, the flow of oxygen is delivered reliably to the patient only when the bag is squeezed. When the bag is not being squeezed, the gas escapes from the open end of the reservoir and never reaches the baby.

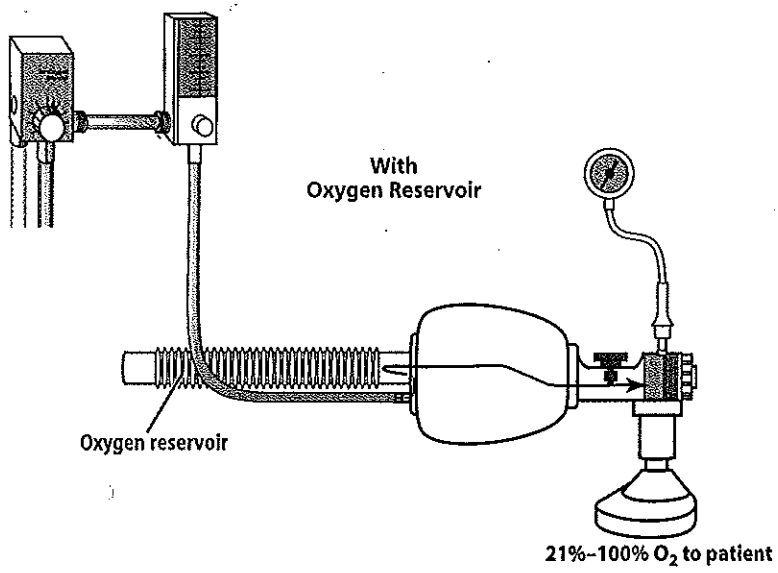


Figure 3A.4 Self-inflating bag with oxygen reservoir delivers from 21% to 100% oxygen to the patient, depending on setting on blender

Several different types of oxygen reservoirs are available, but they all perform the same function. Some have open ends and others have a valve that allows some air to enter the reservoir (Figure 3A.5). When using these devices, the concentration of oxygen achieved with a self-inflating bag with an oxygen reservoir attached will be close to the concentration set on the blender.

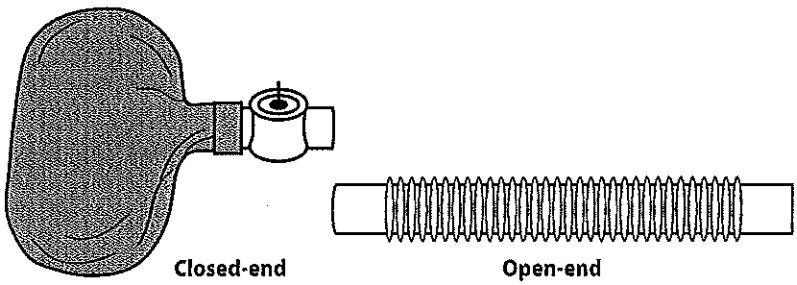


Figure 3A.5 Different types of oxygen reservoirs for self-inflating bags

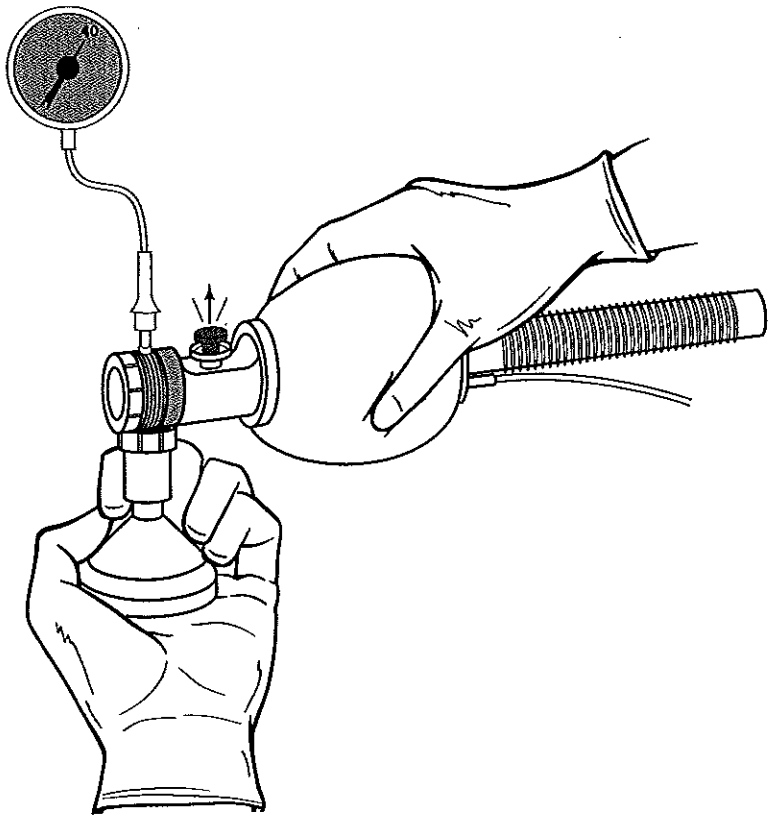


Figure 3A.6. Testing a self-inflating bag

Appendix—*continued*

How do you test a self-inflating bag before use?

First, be certain that the oxygen tubing and oxygen reservoir are connected. Adjust the flow to 5 to 10 L/min.

To check the operation of a self-inflating bag, block the mask or patient outlet with the palm of your hand and squeeze the bag (Figure 3A.6).

- Do you feel pressure against your hand?
- Can you force the pressure-release valve open?
- Does the pressure gauge (if present) register 30 to 40 cm H_2O pressure when the pressure-release valve opens?

If not,

- Is there a crack or leak in the bag?
- Is the pressure gauge missing, resulting in an open attachment site?
- Is the pressure-release valve missing or stuck closed?
- Is the patient outlet sufficiently blocked?

If your bag generates adequate pressure and the safety features are working while the mask-patient outlet is blocked,

- Does the bag reinflate quickly when you release your grip?

Self-inflating bags usually have more parts than flow-inflating bags. During cleaning, parts may be left out or assembled incorrectly. If parts remain moist after cleaning, they may stick together. If there is any problem with the bag, obtain a new one.

Appendix—*continued*

How do you control pressure in a self-inflating bag?

The amount of pressure delivered by a self-inflating bag is not dependent on the flow of oxygen entering the bag. When you seal the mask on the baby's face (or connect the bag to an endotracheal tube), there will be no change in the inflation of a self-inflating bag. The amount of pressure and volume delivered with each breath depends on the following 3 factors:

- How hard you squeeze the bag
- Any leak that may be present between the mask and the baby's face
- The set-point of the pressure-release valve

Review—Appendix A

(The answers are in the preceding section and at the end of the Appendix.)

A-1. A self-inflating bag with a pressure gauge site will work only if a pressure gauge is connected to the site or if the connection site is (left open) (plugged).

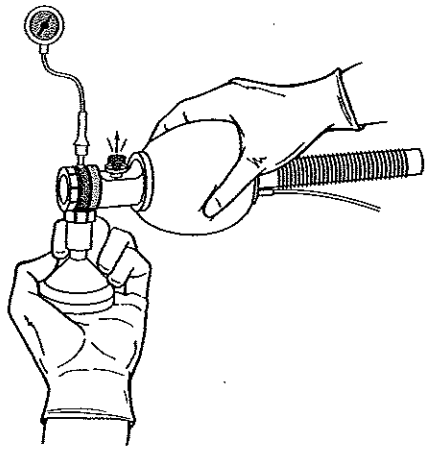
A-2. A self-inflating bag connected to a 100% oxygen source will deliver up to 100% oxygen (by itself) (only when an oxygen reservoir is attached).

A-3. A self-inflating bag connected to 100% oxygen, but without an oxygen reservoir attached to it, delivers only about _____% oxygen.

A-4. You are testing a resuscitation bag. When you squeeze the bag, you (should) (should not) feel pressure against your hand.

A-5. What number should the pressure gauge read in the illustration at the right when you squeeze the bag?

_____



A-6. List 3 important factors that determine the peak inspiratory pressure delivered from a self-inflating bag.

1. _____
2. _____
3. _____

Appendix—*continued*

B. Flow-inflating resuscitation bags

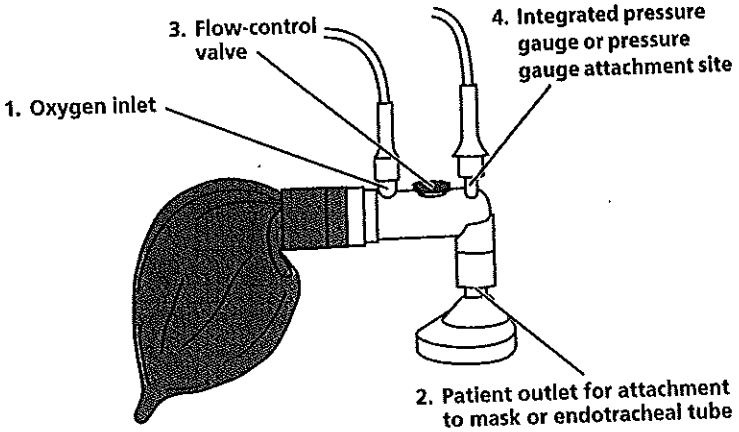


Figure 3B.1 Parts of a flow-inflating bag

What are the parts of a flow-inflating bag?

There are 4 parts to a flow-inflating bag (Figure 3B.1).

1. Oxygen inlet (from blender)
2. Patient outlet
3. Flow-control valve
4. Pressure gauge attachment site

Oxygen from a compressed source (or an oxygen-air mixture from a blender) enters the bag at the ***oxygen inlet.*** The inlet is a small projection designed to fit into the end of the tubing from the gas supply. The inlet may be at either end of the device, depending on the brand and model you use.

Oxygen (at whatever concentration entered at the inlet) exits from the bag to the patient at the ***patient outlet,*** where the mask or endotracheal tube attaches to the device. Remember that, even if you plan to use 21% oxygen (ie, air) for positive-pressure ventilation (PPV), you must have a compressed gas source to fill the flow-inflating bag.

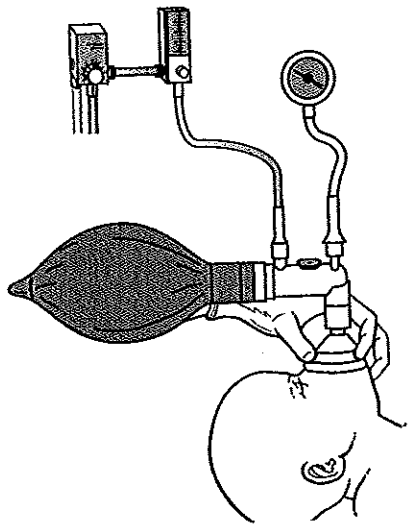
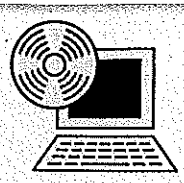


Figure 3B.2 Flow-inflating bag attached to oxygen source and pressure gauge

The ***flow-control*** valve provides an adjustable leak that allows you to regulate the pressure in the bag when the bag is connected to an endotracheal tube or the mask is held tightly on the patient's face. The adjustable opening provides an additional outlet for the incoming gas and allows excess gas to escape rather than overinflate the bag or be forced into the patient.

Flow-inflating bags usually have a ***site for attaching a pressure gauge*** (Figure 3B.2). The attachment site usually is close to the patient outlet. The pressure gauge registers the amount of pressure you are using to ventilate the newborn. If your flow-inflating bag has a connecting site for a pressure gauge, a gauge must be attached to the site, or the attachment site must be occluded with a plug. If not, the site will be a source of leak and the bag will not inflate properly.

Appendix—*continued*



You are encouraged to view this video on the DVD that accompanies this textbook: *Positive-Pressure Ventilation With a Flow-Inflating Bag*

How does a flow-inflating bag work?

For a flow-inflating bag to work properly, there must be adequate gas flow from the source and a sealed system. The bag will not inflate adequately if (Figure 3B.3)

- The mask is not properly sealed against the baby's face.
- The flow from the source is insufficient.
- There is a rip in the bag.
- The flow-control valve is open too far.
- The pressure gauge is not attached, or the tubing from the gas supply has become disconnected or occluded.

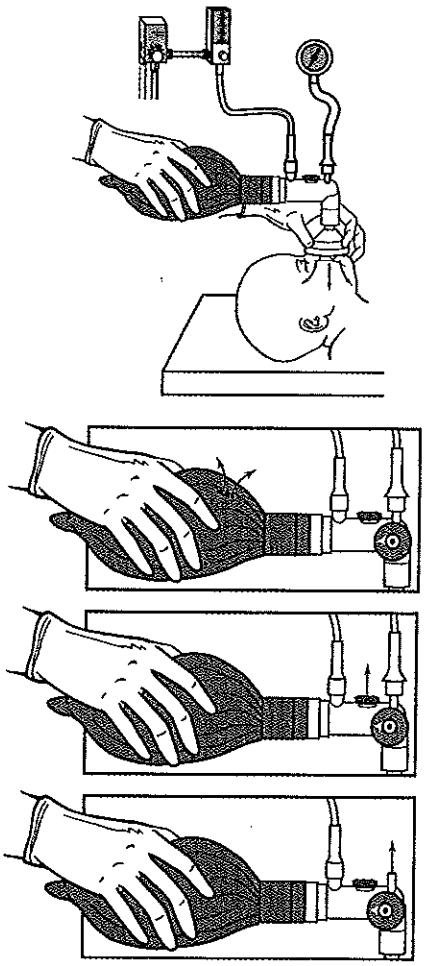


Figure 3B.3 Reasons for failure of the flow-inflating bag to inflate

Appendix—*continued*

How do you test a flow-inflating bag before use?

To check a flow-inflating bag, attach it to a gas source. Adjust the flowmeter to 5 to 10 L/min. Block the patient outlet to make sure the bag fills properly (Figure 3B.4). Do this by making a seal between the mask and the palm of your hand. Adjust the flow-control valve so that the bag is not over-distended. Watch the pressure gauge, and adjust the valve so that there is approximately 5 cm H_2O pressure when the bag is not being squeezed (PEEP), and 30 to 40 cm H_2O peak inflation pressure when the bag is squeezed firmly (peak pressure).

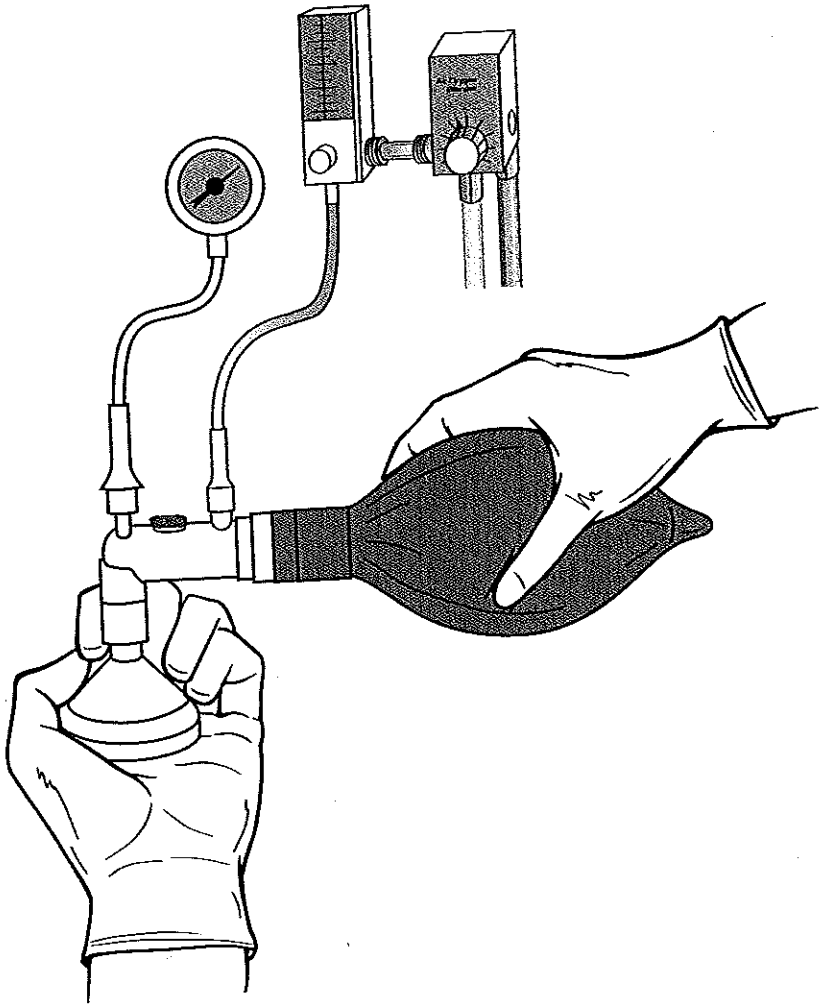


Figure 3B.4. Testing the integrity of a flow-inflating bag

Does the bag fill properly? If not,

- Is there a crack or tear in the bag?
- Is the flow-control valve open too far?
- Is the pressure gauge attached?
- Is the oxygen line connected securely?
- Is the patient outlet sufficiently blocked?

If the bag fills, squeeze the bag.

- Do you feel pressure against your hand?
- Does the pressure gauge register 5 cm H_2O pressure when not squeezed, and 30 to 40 cm H_2O when squeezed firmly?

During this test, squeeze the bag at a rate of 40 to 60 times per minute and a pressure of 40 cm H_2O. If the bag does not fill rapidly enough, readjust the flow-control valve or increase the gas flow from the flowmeter.

Then, check to be sure that the pressure gauge still reads 5 cm H_2O pressure of positive-end expiratory pressure (PEEP) when the bag is not being squeezed. You may need to make further adjustments in the flow-control valve to avoid excessive PEEP.

If the bag still does not fill properly or does not generate adequate maximum pressure, get another bag and begin again.

Appendix—*continued*

How do you adjust the oxygen flow, concentration, and pressure in a flow-inflating bag?

When using a flow-inflating bag, you inflate the bag with compressed gas (ie, an oxygen-air mixture from a blender) (Figure 3B.5). The flow from the flowmeter should be adjusted to 5 to 10 L/min and may need to be increased if the bag does not fill sufficiently. Once the gas enters the bag, it is not diluted as it is in a self-inflating bag without a reservoir. Therefore, whatever concentration of oxygen enters the bag is the same concentration delivered to the patient.

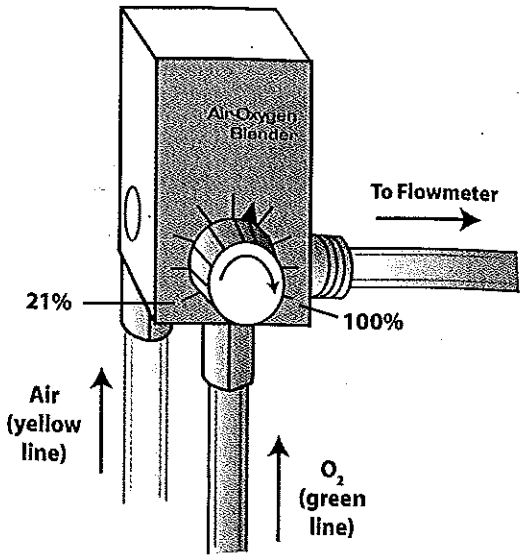


Figure 3B.5. Mixing oxygen and air with an oxygen blender. There is a control knob to dial in the desired oxygen concentration.

Once the mask is properly positioned on the baby's face (or the bag is connected to an endotracheal tube, as you will learn in Lesson 5), most of the gas coming from the wall or blender will be directed to the bag (and thus to the patient), with some coming out the flow-control valve. This will cause the bag to inflate (Figure 3B.6). There are 2 ways that you can adjust the pressure in the bag and thus the amount of inflation of the bag:

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

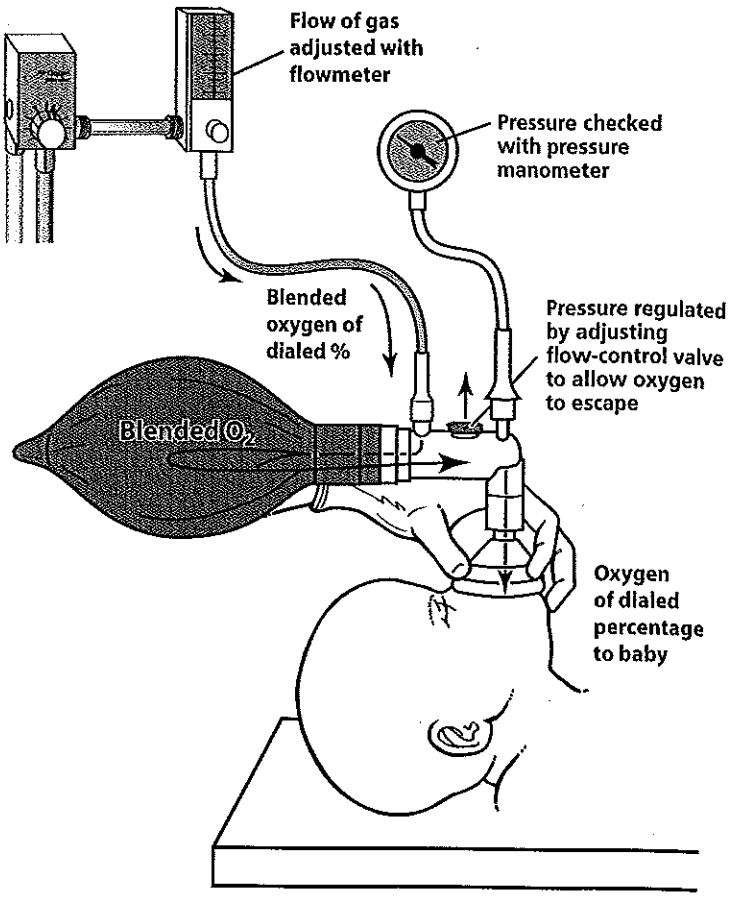
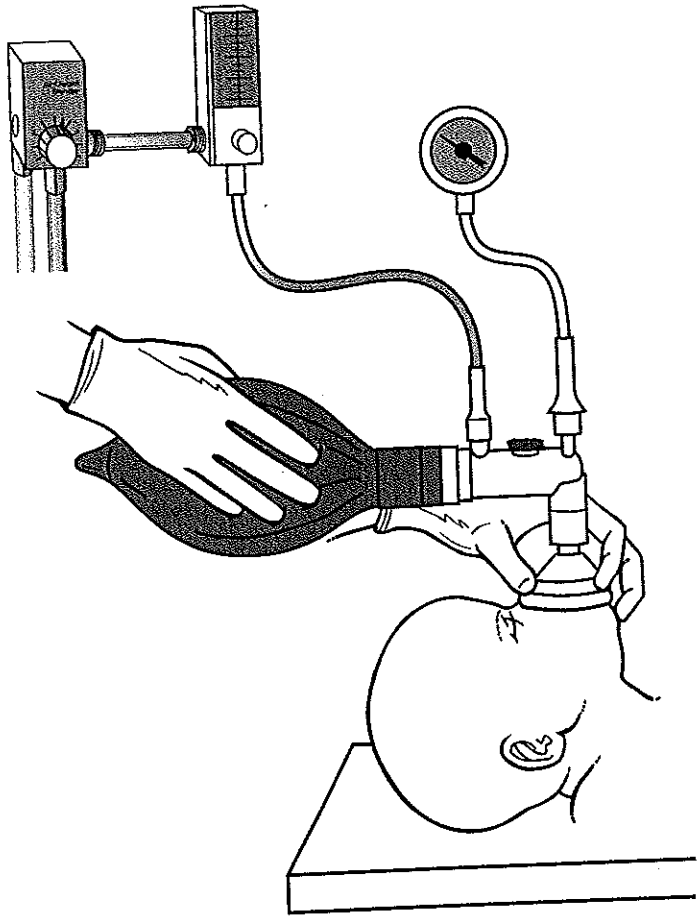


Figure 3B.6. Regulation of oxygen and pressure in flow-inflating bag

Appendix—*continued*



The flowmeter and flow-control valve should be set so that the bag is inflated to the point where it is comfortable to handle and does not completely deflate with each ventilation (Figure 3B.7).

An overinflated bag is difficult to manage and may deliver high pressure to the baby; a pneumothorax or other air leak may develop. An underinflated bag makes it difficult to achieve the desired inflation pressure (Figure 3B.8). With practice, you will be able to make the necessary adjustments to achieve a balance. If there is an adequate seal between the baby's face and the mask, you should be able to maintain the appropriate amount of inflation with the flowmeter set at 5 to 10 L/min.

Figure 3B.7 Correctly inflated bag

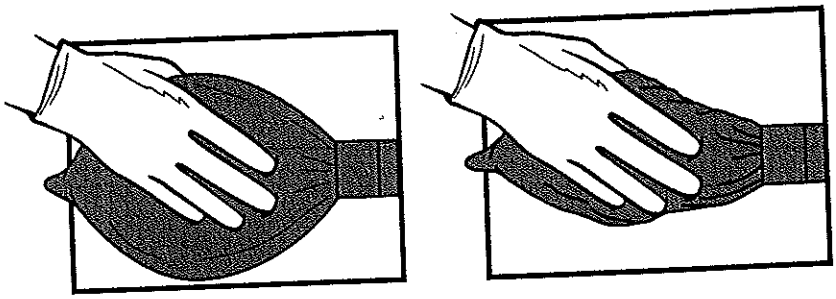


Figure 3B.8 Resuscitation bags that are overinflated (left) and underinflated (right)

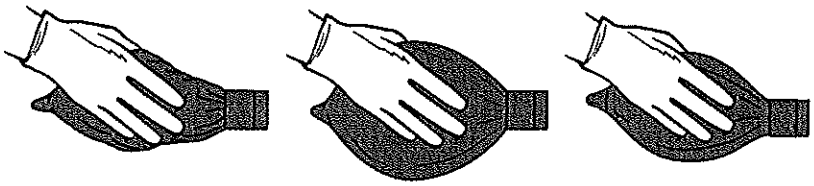
Review—Appendix B

(The answers are in the preceding section and at the end of the Appendix.)

B-1. List 4 reasons why the flow-inflating bag may fail to ventilate the baby.

1. _____
2. _____
3. _____
4. _____

B-2. Which flow-inflating bag is being used properly?



A B C

B-3. To regulate the pressure of the oxygen going to the baby with a flow-inflating bag, you may adjust either the flowmeter on the wall or the (flow-control valve) (pressure gauge).

B-4. If the gas flow through the flow-inflating bag is too high, there (is) (is not) an increased risk for pneumothorax.

Appendix—*continued*

C. T-piece Resuscitator

What are the parts of a T-piece resuscitator?

There are 6 parts to a flow-controlled, pressure-limited T-piece resuscitator (Figure 3C.1).

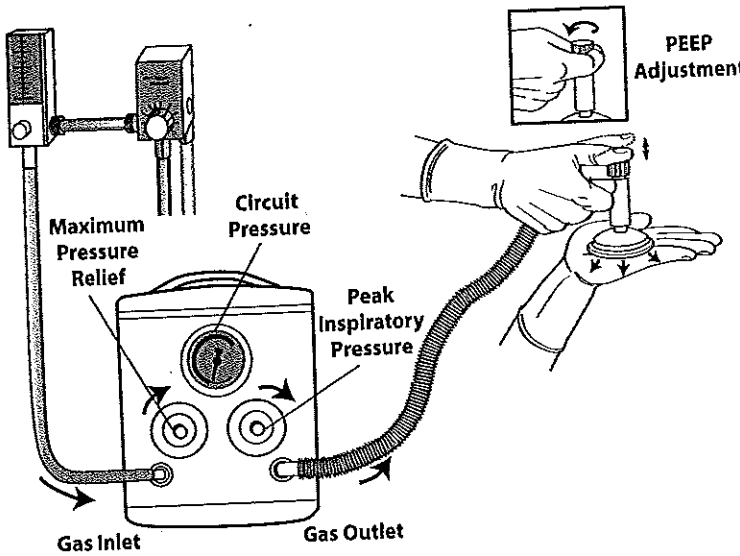


Figure 3C.1 Parts of the T-piece resuscitator

1. Gas inlet
2. Patient (gas) outlet
3. Maximum pressure relief control
4. Circuit pressure gauge
5. Peak inspiratory pressure
6. Patient T-piece with positive end-expiratory pressure (PEEP) cap

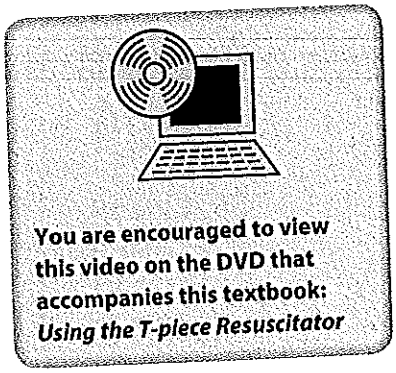
Gas from a compressed source enters the T-piece resuscitator at the ***gas inlet.*** The inlet is a small projection designed to fit oxygen tubing and is located under the ***maximum pressure relief control.*** The desired maximum pressure is set after occluding the PEEP cap and turning the maximum pressure relief control (see following text) to the maximum pressure limit. The manufacturer of one device has set the default level of 40 cm H_2O; however, this is adjustable. It should be set about 10 mm Hg higher than the maximum anticipated peak inspiratory pressure, thus about 40 mm Hg for term newborns, and about 30 mm Hg for preterm newborns.

Oxygen exits from the T-piece resuscitator ***patient (gas) outlet*** by the ***gas supply line*** to the ***patient T-piece,*** where the mask or endotracheal tube attaches.

The ***peak inspiratory pressure*** control is used to set the desired **peak inspiratory pressure.**

The ***PEEP cap*** is used to set the PEEP.

The ***circuit pressure gauge*** is used to set and monitor **peak inspiratory pressure,** PEEP, and maximum circuit pressure.



How does a T-piece resuscitator work?

The T-piece resuscitator is specially designed for neonatal resuscitation. Pressure controls for maximum pressure, desired **peak inspiratory pressure,** and PEEP must be set by the operator before use (see following text). When the PEEP valve is occluded by the operator, the preset **peak inspiratory pressure** is delivered to the patient for as long as the PEEP valve is occluded.

Appendix—*continued*

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

First, assemble the parts of the T-piece resuscitator as instructed by the manufacturer.

Second, attach a test lung to the patient outlet. The test lung is an inflatable balloon that should have been provided by the device manufacturer. Alternatively, the outlet can be occluded during testing, although the inflation time will be shorter than when in clinical use.

Third, connect the device to a gas source. This will be a tubing from a blender that permits adjustment of oxygen concentration from 21% (ie, air) to 100%.

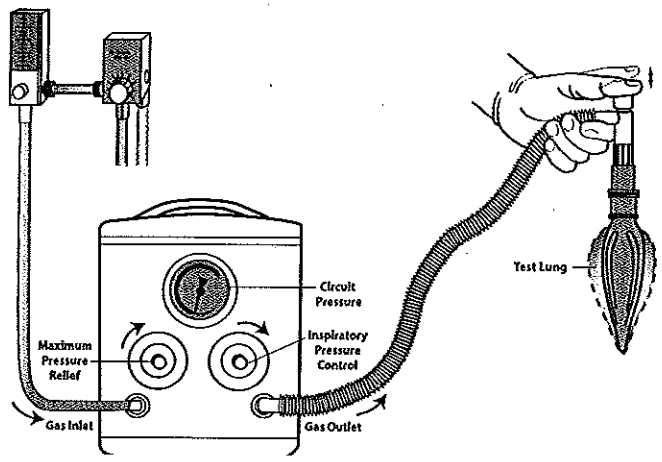


Figure 3C.2. Setting up a T-piece resuscitator

Fourth, adjust the pressure settings as follows:

- Adjust the flowmeter to regulate how much gas flows into the T-piece resuscitator (5 to 15 L/min recommended).
- Set the maximum circuit pressure by occluding the PEEP cap with your finger and adjusting the maximum pressure relief dial to a selected value (40 cm H_2O is the recommended maximum for term newborns, with a lower value for preterm newborns, as described in Chapter 8) (Figure 3C.2).*
- Set the desired **peak inspiratory pressure** by occluding the PEEP cap with your finger and adjusting the inspiratory pressure control to a selected **peak inspiratory pressure** (Figure 3C.3).
- Set the PEEP by removing your finger from the PEEP cap and adjusting the PEEP cap to the desired setting (2 to 5 cm H_2O is recommended). (See Lesson 8.)
- Remove the test lung and attach the patient T-piece resuscitator to a face mask or be prepared to attach it to an endotracheal tube after the trachea has been intubated. (See Lesson 5.)

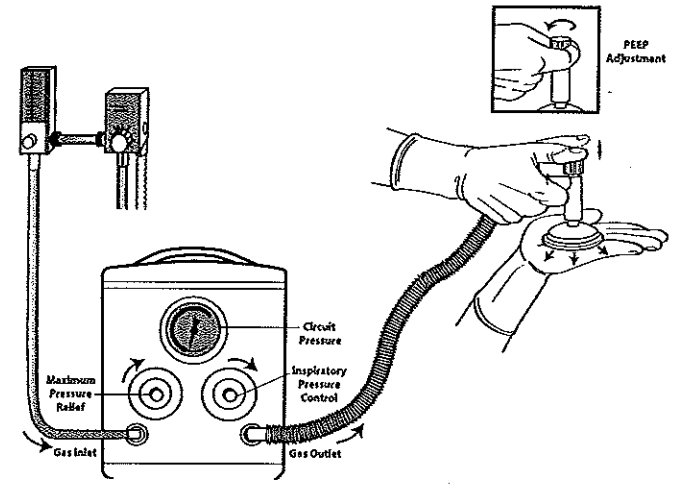


Figure 3C.3. Adjusting the maximum and peak pressure before use

When the device is used to ventilate the baby, either by applying the mask to the baby's face or by connecting the device to an endotracheal tube, you control the respiratory rate by intermittently occluding the hole in the PEEP cap during the "breathe" portion of your "breathe-two-three" cadence.

* Note: Some manufacturers recommend that the maximum relief control is adjusted to an institution-defined limit when the device is put into original service and not be readjusted during regular use.

Appendix—*continued*

If you want to change the peak inspiratory pressure, you will need to readjust the **peak inspiratory pressure** control. This can be done while you are ventilating the patient and will not require reattaching the test lung.

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

The concentration of oxygen delivered to the T-piece resuscitator is the same as that delivered to the baby. Therefore, if the T-piece resuscitator is connected to a source of 100% oxygen, 100% oxygen will be delivered to the baby. To deliver less than 100%, you will have to have a source of compressed air and have the device connected to an oxygen blender. The blender then can be adjusted to provide any concentration of oxygen between 21% and 100%.

What may be wrong if the baby does not improve or the desired peak pressure is not reached?

- The mask may not be properly sealed on the baby's face.
- The gas supply may not be connected or flow may be insufficient.
- The maximum circuit pressure, **peak inspiratory pressure,** or PEEP may be incorrectly set.

Can you give free-flow oxygen using a T-piece resuscitator?

Free-flow oxygen can be given reliably with a T-piece resuscitator (Figure 3C.4) if you occlude the PEEP cap and hold the mask loosely on the face. The flow rate of oxygen or gas entering the T-piece resuscitator is the same flow rate that exits the patient T-piece toward the baby when the PEEP cap is occluded. When the mask is held loosely on the face, the flow is maintained without generating pressure as the oxygen or gas diffuses into the environment around the mouth and nares.

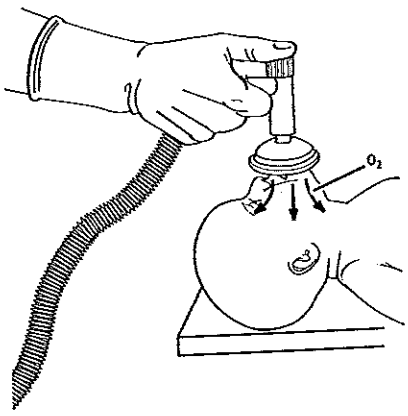


Figure 3C.4 Free-flow oxygen given by a T-piece resuscitator

Review—Appendix C

(The answers are in the preceding section and at the end of the Appendix.)

C-1. What pressures must be set before using a T-piece resuscitator?

- _____
- _____
- _____

C-2. The flow rate on a T-piece resuscitator may need to be (increased) (decreased) if the desired peak inspiratory pressure cannot be obtained.

C-3. Free-flow oxygen administered through a T-piece resuscitator requires the PEEP cap to be (open) (occluded).

C-4. T-piece resuscitators (will) (will not) work without a compressed gas source.

Answers to Questions in Appendix

A-1. For a self-inflating bag to work, either the pressure gauge must be connected or the connection site must be **plugged.**

A-2. A self-inflating bag can deliver 100% oxygen **only when an oxygen reservoir is attached to it.**

A-3. Without an oxygen reservoir, a self-inflating bag can deliver a maximum of only about **40%** oxygen.

A-4. When you squeeze the bag, you **should** feel pressure against your hand.

A-5. The pressure gauge should read **30 to 40 cm H_2O** because the pop-off valve is releasing.

A-6. The pressure delivered from a self-inflating bag is determined by (1) **how hard you squeeze the bag,** (2) **any leak that may be present between the mask and the baby's face,** and (3) **the set-point of the pressure-release valve.**

B-1. The flow-inflating bag may fail to ventilate the baby because of (1) **an inadequate seal between the mask and the face,** (2) **a tear in the bag,** (3) **the flow-control valve is open too far,** and/or (4) **the pressure gauge is not attached or the oxygen tubing is disconnected or occluded.**

B-2. Illustration C is correct.

B-3. Pressure may be regulated by adjusting either the flowmeter or the **flow-control valve.**

B-4. If the gas flow through the flow-inflating bag is too high, there **is** an increased risk for pneumothorax.

C-1. The pressures set on a T-piece resuscitator are

- **Maximum circuit pressure**
- **Peak inspiratory pressure**
- **Positive end-expiratory pressure**

C-2. The flow set on a T-piece resuscitator may need to be **increased** if the desired peak inspiratory pressure cannot be obtained.

C-3. Free-flow oxygen administered through a T-piece resuscitator requires the PEEP cap to be **occluded.**

C-4. T-piece resuscitators **will not** work without a compressed gas source.

LESSON 4

Chest Compressions

In Lesson 4 you will learn

- When to begin chest compressions during a resuscitation
- How to administer chest compressions
- How to coordinate chest compressions with positive-pressure ventilation
- When to stop chest compressions

The following case is an example of how chest compressions are delivered during a more extensive resuscitation. As you read the case, imagine yourself as part of the resuscitation team. The details of the chest compressions step will be described in the remainder of the lesson.

Case 4. Resuscitation with positive-pressure ventilation and chest compressions

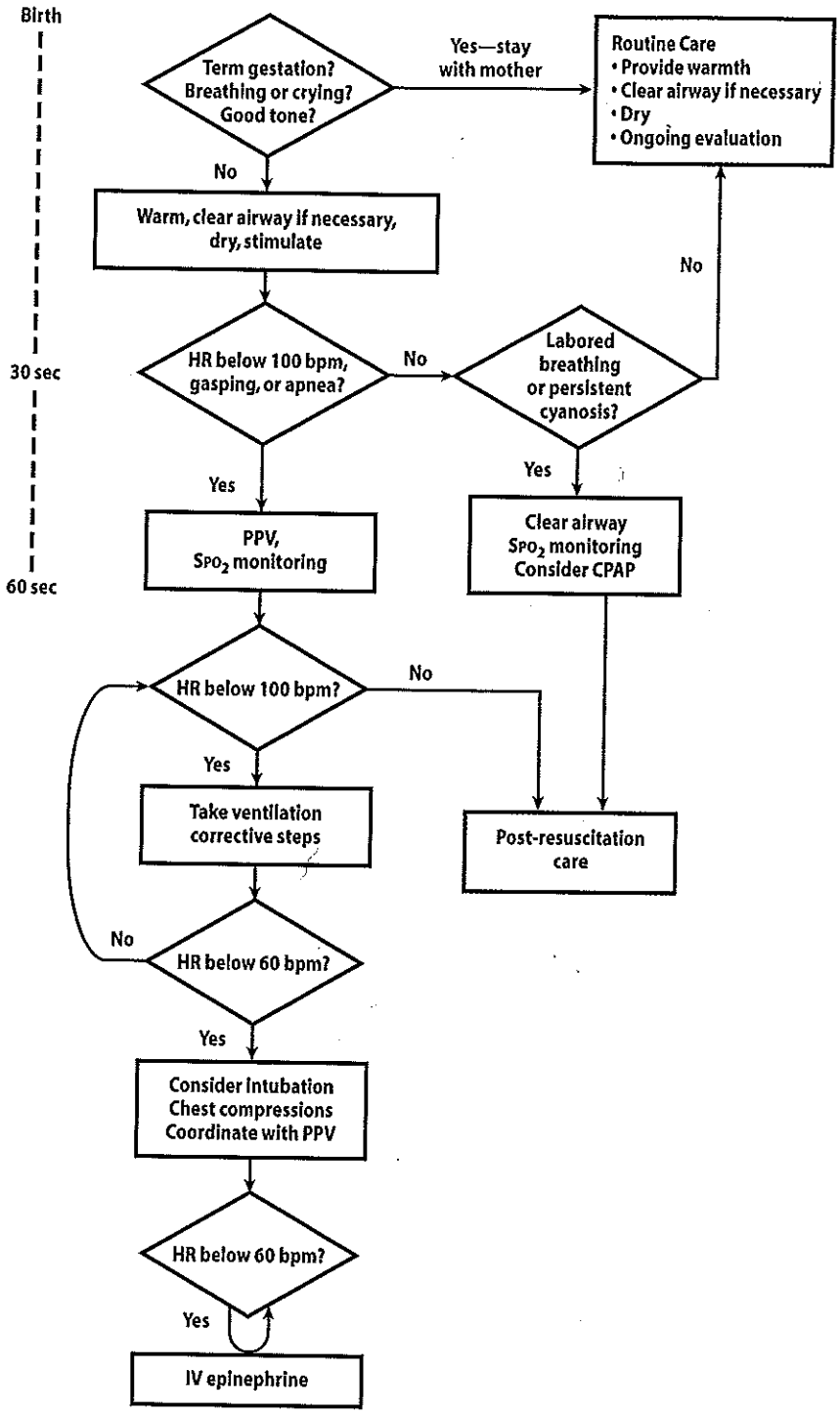
A pregnant woman contacts her obstetrician after noticing a pronounced decrease in fetal movements at 34 weeks' gestation.

She is admitted to the labor and delivery unit where persistent fetal bradycardia is noted. Additional skilled personnel are called to the delivery room, the radiant warmer is turned on, and resuscitation equipment is prepared. An emergency cesarean section is performed, and a limp, apneic baby is transferred to the neonatal team.

The team positions the baby's head, suctions her mouth and nose, stimulates her with drying and flicking the soles of her feet, and removes the wet linen. However, 30 seconds after birth, the baby is still limp, cyanotic, and without spontaneous respirations.

One member of the team begins positive-pressure ventilation (PPV) with a bag and mask, while a second team member feels the umbilical cord for the pulse and listens with a stethoscope for breath sounds. At the same time, a third member of the team places an oximetry probe on the baby's right hand. The heart rate remains below 60 beats per minute (bpm) despite the presence of breath sounds and a gentle rise and fall of the chest with each manual breath. After 30 seconds of PPV, the baby has a very low heart rate (20 to 30 bpm) and remains cyanotic and limp. The oximeter is not registering a heart rate or saturation.

Because the heart rate has not increased, a member of the team checks to make sure that the mask is fitting properly on the face, the ventilation rate is 40 to 60 breaths per minute, the airway is clear, the head is positioned correctly, and the chest is rising slightly with each breath. Despite increasing the pressure on the bag to increase the chest rise, the heart rate remains below 60 bpm, so the team leader intubates the trachea to ensure effective ventilation. The team begins chest compressions coordinated with PPV using a 3:1 ratio of compressions to ventilations and increasing the oxygen concentration to 100% since the oximeter is still not registering.



The baby finally makes an initial gasp. Chest compressions are stopped when the heart rate rises above 60 bpm. The team continues PPV, and the heart rate rises to more than 100 bpm as now recorded by the oximeter. The inspired oxygen concentration is adjusted based on pulse oximetry readings. After spontaneous respirations are observed, she is moved to the special care nursery for monitoring and further management.

What are the indications for beginning chest compressions?

Chest compressions are indicated whenever the heart rate is below 60 beats per minute, despite at least 30 seconds of effective positive-pressure ventilation (PPV).

Why perform chest compressions?

Babies who have a heart rate below 60 bpm, despite stimulation and 30 seconds of PPV, are likely to have very low blood oxygen levels and significant acidosis. As a result, myocardial function is depressed and the heart is 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 by providing PPV. Therefore, you will need to mechanically pump blood through 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 restore oxygen delivery to the brain. Although chest compressions can be delivered while ventilations are being administered with bag and mask, endotracheal intubation at this point will make ventilation more effective.

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

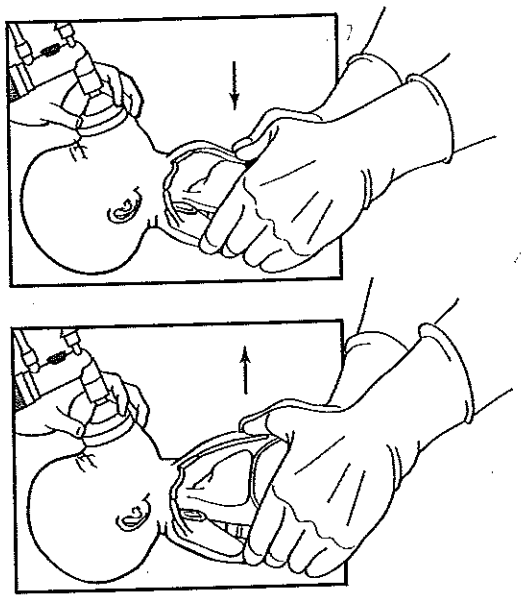


Figure 4.1 Compression (top) and release (bottom) phases of chest compressions

What are chest compressions?

Chest compressions 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.

How many people are needed to administer chest compressions, and where should they stand?

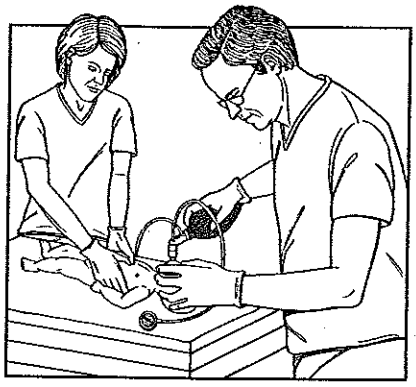
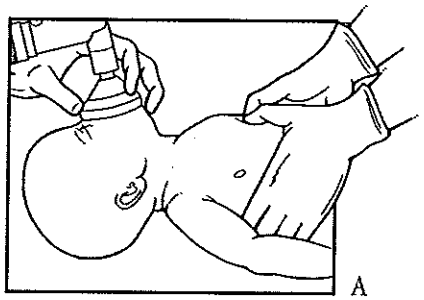


Figure 4.2. Two people are required when chest compressions are given

Remember that chest compressions are of little value unless the lungs are also being ventilated. Therefore, 2 people are required to administer effective chest compressions—one to compress the chest and one to continue ventilation. This second person may be the same person who came to monitor heart rate and breath sounds during PPV.

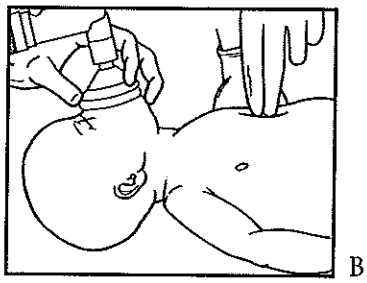
The person performing chest compressions must have access to the chest and be able to position his or her hands correctly. The person assisting ventilation should be positioned at the baby's head to be able to maintain an effective mask-face seal (or to stabilize the endotracheal tube) and watch for effective chest movement with ventilation (Figure 4.2). Other team members will be needed to ensure adequate functioning of the oximeter, and to prepare for vascular access and administration of medications, in case the heart rate does not improve with ventilation and chest compressions alone. (See Lesson 6.) To provide more room for another team member to insert an emergency umbilical venous catheter, the person administering chest compressions may need to move to the head of the bed, next to the team member giving ventilations.

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



A

Preferred technique



B

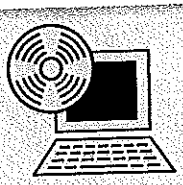
Figure 4.3. Two techniques for giving chest compressions: thumb (A) and 2-finger (B)

You will learn 2 different techniques for performing chest compressions. 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). This is the preferred technique.
- *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 (Figure 4.3B).

Why is the thumb technique preferred?

The thumb technique is preferred because you can control the depth of compression better than with the 2-finger technique and you can provide pressure that is more consistent. The thumb technique also



You are encouraged to view this video on the DVD that accompanies this textbook: *Chest Compressions: Head of Infant Positioning*

appears to be superior in generating peak systolic and coronary arterial perfusion pressure. It also is preferable for individuals with long fingernails. Thus, the thumb technique should be used in most situations.

Although the 2-finger technique has been used to permit a colleague easier access to the umbilicus for insertion of an umbilical catheter, with practice, the 2 people delivering compressions and ventilations can both position themselves at the head of the bed, allowing the more effective thumb technique to be used throughout the resuscitation. Performing chest compressions at the head of the bed is most easily accomplished if the trachea has been intubated.

The 2 techniques have the following things in common:

- Position of the baby
  - Firm support for the back is needed
  - Neck slightly extended
- Compressions
  - Location, depth, and rate of compressions

Where on the chest should you position your thumbs or fingers?

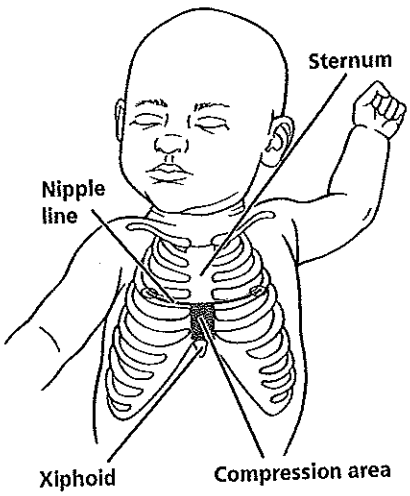


Figure 4.4 Landmarks for chest compressions

When chest compressions are performed on a newborn, pressure is applied to the lower third of the sternum, which lies between the xiphoid and a line drawn between the nipples (Figure 4.4). The xiphoid 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 rib cage until you locate the xiphoid. Then, place your thumbs or fingers immediately above the xiphoid. Care must be used to avoid putting pressure directly on the xiphoid.

How do you position your hands using the thumb technique?

The thumb technique is accomplished by encircling the torso with both hands. The thumbs are placed on the sternum and the fingers are 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 are 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 should be applied vertically to compress the heart between the sternum and the spine (Figure 4.6).

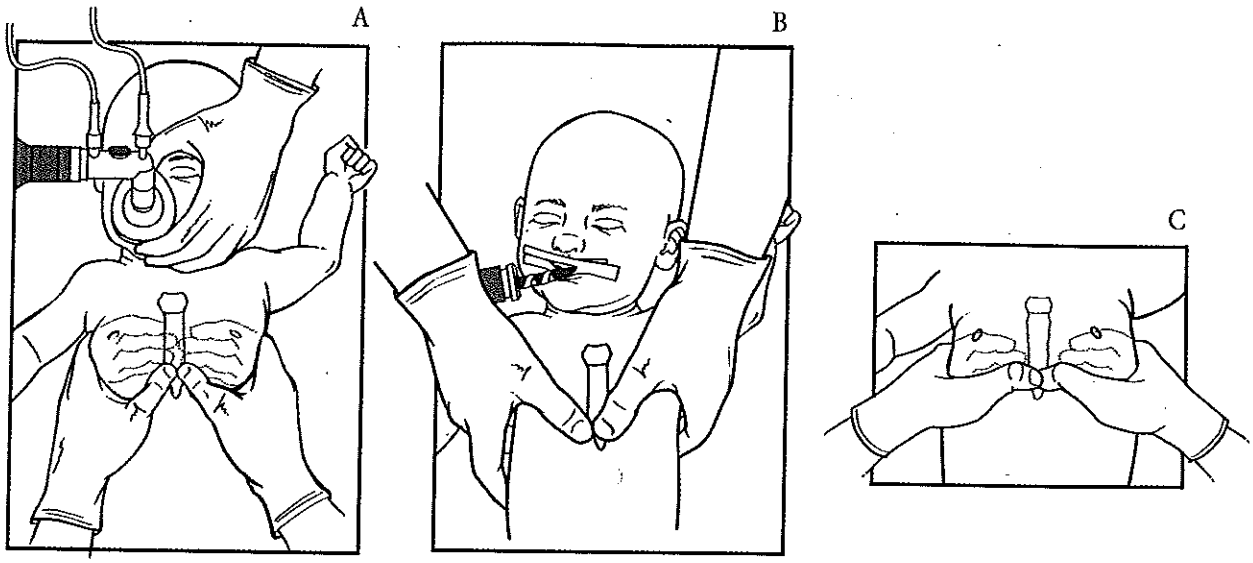


Figure 4.5. Thumb technique of chest compressions administered from the bottom (A), from the top (B), and for small chests, with thumbs overlapped (C)

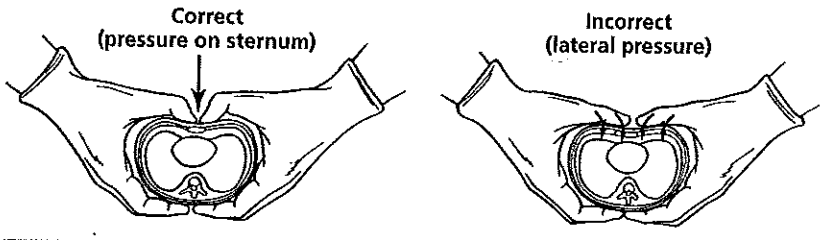


Figure 4.6. Correct and incorrect application of pressure with thumb technique of chest compressions

The thumb technique has some minor disadvantages. It cannot be used effectively if the baby is large or your hands are small. The required position of the rescuer's body also makes access to the umbilical cord somewhat more difficult when medications become necessary, unless the person administering compressions moves to the head of the bed.

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). You probably will find it easier to use your right hand if you are right-handed (or your left hand if you are left-handed). Position the 2 fingers perpendicular to the chest as shown, and press with your fingertips. If you find that your nails prevent you from using your fingertips, you should ventilate the newborn while your partner compresses the chest,

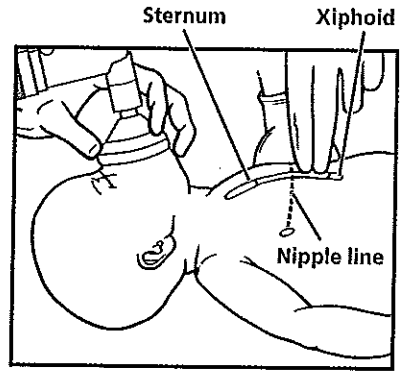


Figure 4.7. Correct finger position for 2-finger technique

or you could use the preferred thumb technique for performing chest compressions.

When using the 2-finger technique, your other hand must be placed flat under the center of 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 also can more easily judge the pressure and the depth of compressions.

When compressing the chest, only the 2 fingertips should rest on the chest. This way, you can best control the pressure you apply to the sternum and the spine (Figure 4.8A).

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.

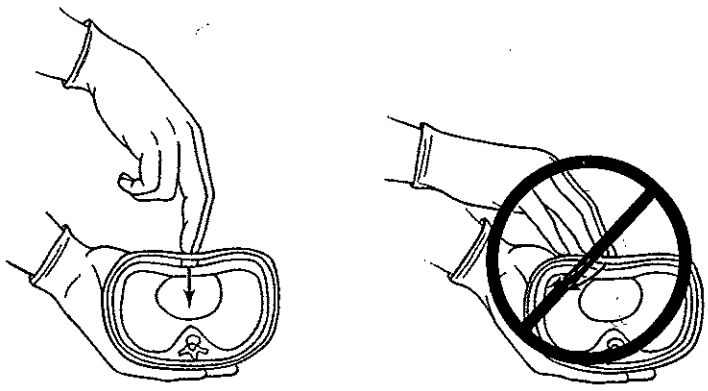


Figure 4.8. Correct and incorrect application of pressure with 2-finger technique

Review

(The answers are in the preceding section and at the end of the lesson.)

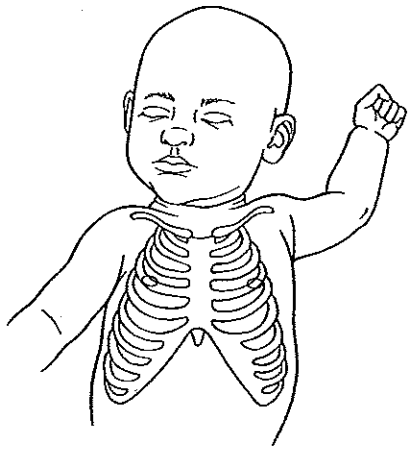
1. A newborn is apneic and bradycardic. Her airway is cleared, and she is stimulated. At 30 seconds, positive-pressure ventilation is begun. At 60 seconds, her heart rate is 80 beats per minute. Chest compressions (should) (should not) be started. Positive-pressure ventilation (should) (should not) continue.

2. A newborn is apneic and bradycardic. She remains apneic, despite having her airway cleared, being stimulated, receiving 30 seconds of positive-pressure ventilation, and ensuring that all ventilation techniques are optimal. Nevertheless, her heart rate is only 40 beats per minute. Chest compressions (should) (should not) be started. Positive-pressure ventilation (should) (should not) continue.

3. The heart rate is 40 beats per minute as determined by auscultation and the oximeter has stopped working. Chest compressions have begun, but the baby is still receiving room air oxygen. What should be done about oxygen delivery? (continue room air) (increase the oxygen concentration to 100%)

4. During the compression phase of chest compressions, the sternum compresses the heart, which causes blood to be pumped from the heart into the (veins) (arteries). In the release phase, blood enters the heart from the (veins) (arteries).

5. Mark the area on this baby (see illustration at right) where you would apply chest compressions.



6. The preferred method of delivering chest compressions is the (thumb) (2-finger) technique.

7. If you anticipate that the baby will need medication by the umbilical route, you can continue chest compressions by one of the following actions:

_____ or _____

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, 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

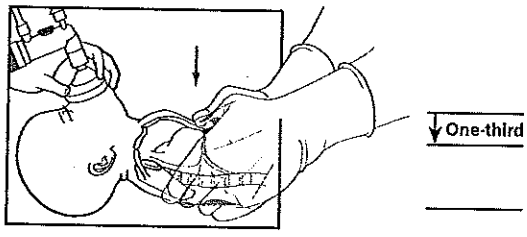


Figure 4.9 Compression depth should be approximately one-third of the anterior-posterior diameter of the chest

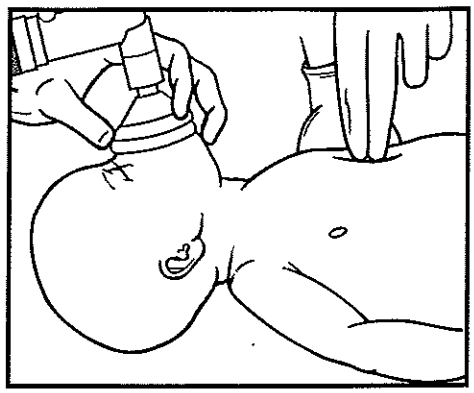


Figure 4.10 *Correct* method of chest compressions (fingers remain in contact with chest on release)

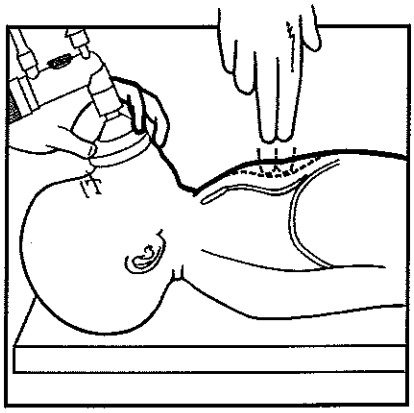


Figure 4.11 *Incorrect* method of chest compressions (fingers lose contact with chest on release)

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 also should 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 sufficiently during the release phase to permit blood to reenter the heart from the veins. However, ***do not*** lift your thumbs or fingers off the chest between compressions (Figure 4.11). If you take your thumbs or fingers completely off the sternum after compressions,

- 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 rib cage—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 xiphoid, can cause laceration of the liver (Figure 4.12).

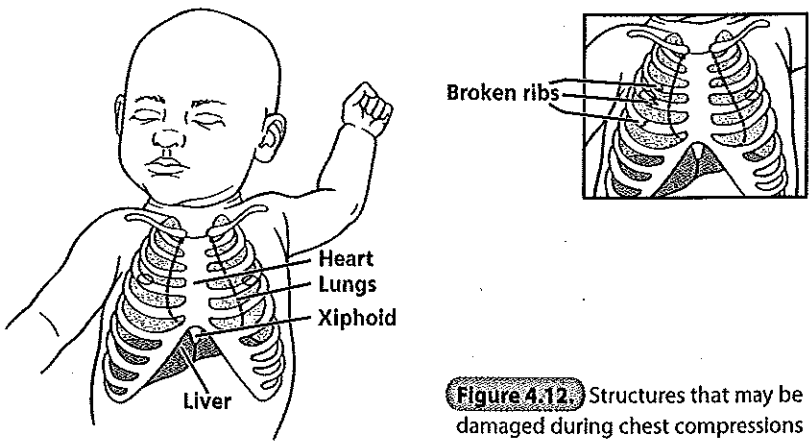


Figure 4.12 Structures that may be damaged during chest compressions

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

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

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

During cardiopulmonary resuscitation, chest compressions must always be accompanied by PPV. Avoid giving a compression and a 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).

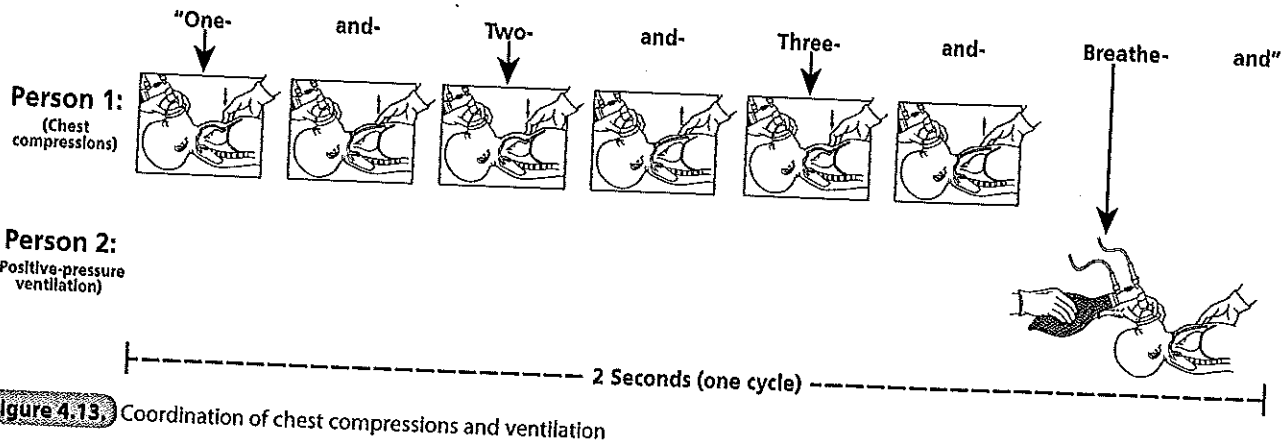


Figure 4.13 Coordination of chest compressions and ventilation

The person doing the compressions takes over the counting out loud from the person who is doing the ventilating. The compressor counts "One-and-Two-and-Three-and-Breathe-and" while the person ventilating squeezes during "Breathe-and" and releases during "One-and." Note that exhalation occurs during the downward stroke of the next compression. Counting the cadence will help develop a smooth and well-coordinated procedure.

One ***cycle of events*** consists of 3 compressions plus 1 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 learned for PPV, 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, "Breathe-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 5 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-***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

Now imagine that you are the person administering positive-pressure 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 5 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-***

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

In a real situation, there will be 2 team members performing resuscitation, with one doing the compressions and one doing the bagging. The person compressing will be speaking "One-and-Two-and-..." out loud. Therefore, it is helpful to practice with a partner, taking turns in each of the roles.

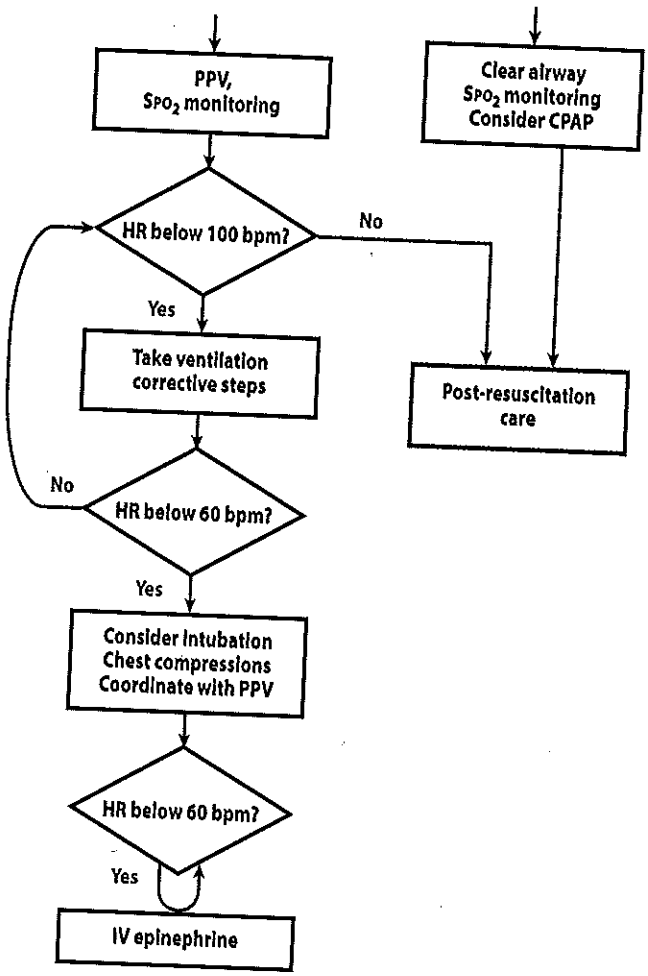
When do you stop chest compressions?

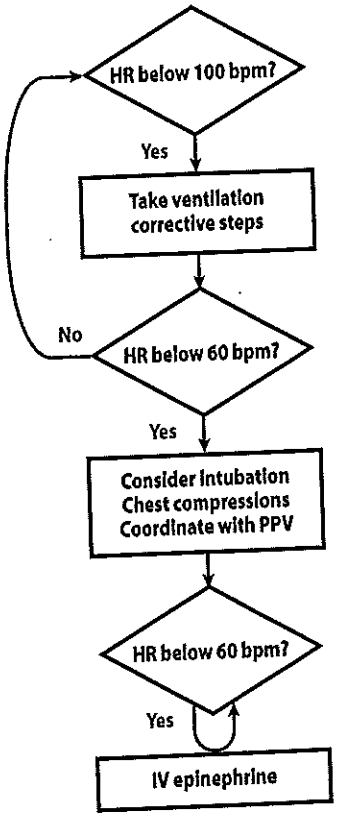
Although you were told earlier to reassess the effects of your actions approximately every 30 seconds, studies have shown that return of spontaneous circulation may take a minute or so after chest compressions are started. Also, any interruption of chest compressions required to check the heart rate may result in a decrease of perfusion pressure in the coronary arteries. Studies in adults and with animals suggest that there may be a delay of 45 seconds or longer after the compressions are resumed before the coronary perfusion pressure returns to its previous value. Therefore, you may want to wait at least 45 to 60 seconds after you have established well-coordinated chest compressions and ventilation before pausing briefly to determine the heart rate again. Use of an oximeter and a cardiac monitor may be helpful in assessing the heart rate without interrupting compressions; however, if perfusion is very low, the pulse oximeter may not detect a consistent pulse. You should stop administering chest compressions when the heart rate is greater than 60 bpm and concentrate on delivering effective ventilation at the higher rate of 40 to 60 breaths per minute.

If the heart rate increases to above 60 bpm while compressions are being provided,

You can discontinue chest compressions, but continue PPV at the rate of 40 to 60 breaths per minute rate. You should not continue chest compressions, since the cardiac output is probably adequate and the compressions may decrease the effectiveness of the PPV.

Once the heart rate rises above 100 bpm, if the baby begins to breathe spontaneously, you should gradually slow the rate and decrease the pressure of PPV, 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 continuing to administer chest compressions and coordinated ventilation, ask yourself the following questions:

- Is ventilation adequate? (Have you performed the ventilation corrective steps? Have you 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, you likely will have wanted to intubate the baby's trachea by this point in a resuscitation. Therefore, if intubation is not within your scope of practice, you will need to call for someone trained in endotracheal intubation to come to the delivery room as soon as you recognize that an extensive resuscitation may be needed. The technique of endotracheal intubation will be described in Lesson 5.

Key Points

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

2. Once the heart rate is below 60 beats per minute, the oximeter may stop working. You should increase the oxygen to 100% until return of the oximeter reading to guide you in the appropriate adjustment of delivered oxygen.

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

4. There are 2 acceptable techniques for chest compressions—the thumb technique and the 2-finger technique—but the thumb technique is preferred.

Key Points—*continued*

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

6. To ensure proper rate of chest compressions and ventilation, the compressor repeats "One-and-Two-and-Three-and-Breathe-and...."

7. 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 1 breath takes 2 seconds.

8. If you anticipate that the baby will need medication by the umbilical route, you can continue chest compressions by moving to the head of the bed to continue giving compressions using the thumb technique. Performing chest compressions from the head of the bed is most easily accomplished if the trachea has been intubated.

9. During chest compressions, ensure that
   - Chest movement is adequate during ventilation.
   - Supplemental oxygen is being used.
   - Compression depth is one-third of 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.

10. After 45 to 60 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.

Lesson 4 Review

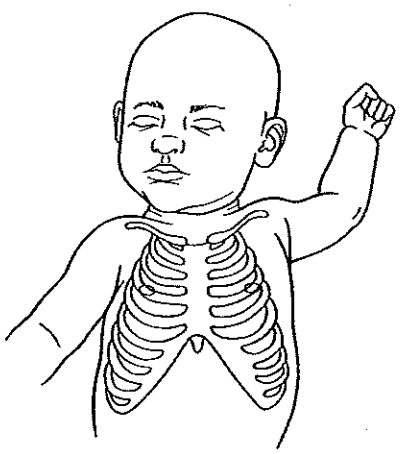
(The answers follow.)

1. A newborn is apneic and bradycardic. Her airway is cleared, and she is stimulated. At 30 seconds, positive-pressure ventilation is begun. At 60 seconds, her heart rate is 80 beats per minute. Chest compressions (should) (should not) be started. Positive-pressure ventilation (should) (should not) continue.

2. A newborn is apneic and bradycardic. She remains apneic, despite having her airway cleared, being stimulated, receiving 30 seconds of positive-pressure ventilation, and ensuring that all ventilation techniques are optimal. Nevertheless, her heart rate is only 40 beats per minute. Chest compressions (should) (should not) be started. Positive-pressure ventilation (should) (should not) continue.

3. The heart rate is 40 beats per minute as determined by auscultation, and the oximeter has stopped working. Chest compressions have begun, but the baby is still receiving room air oxygen. What should be done about oxygen delivery? (continue room air) (increase the oxygen concentration to 100%)

4. During the compression phase of chest compressions, the sternum compresses the heart, which causes blood to be pumped from the heart into the (veins) (arteries). In the release phase, blood enters the heart from the (veins) (arteries).



5. Mark the area on this baby (see illustration at left) where you would apply chest compressions.

6. The preferred method of delivering chest compressions is the (thumb) (2-finger) technique.

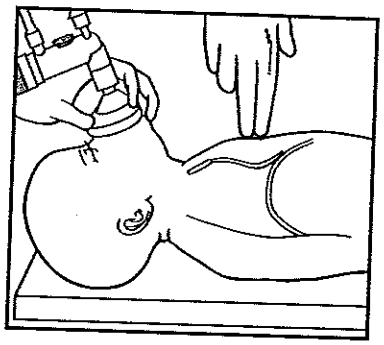
7. If you anticipate that the baby will need medication by the umbilical route, you can continue chest compressions by one of the following actions:

   _____ or _____

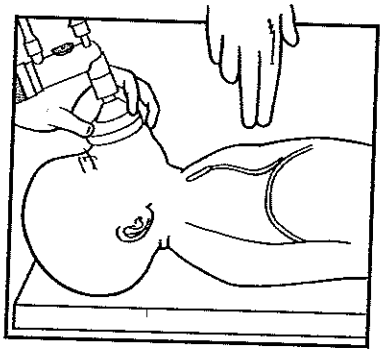
8. The correct depth of chest compressions is approximately
   A. One-fourth of the anterior-posterior diameter of the chest
   B. One-third of the anterior-posterior diameter of the chest
   C. One-half of the anterior-posterior diameter of the chest

Lesson 4 Review—*continued*

9. Which drawing shows the correct release motion?



A



B

10. What phrase is used to time and coordinate chest compressions and ventilation? _____.

11. The ratio of chest compressions to ventilation is _____ to _____.

12 During positive-pressure ventilation without chest compressions, the rate of breaths per minute should be _____ to _____ breaths per minute.

13. During positive-pressure ventilation with chest compressions, the rate of "events" per minute should be _____ "events" per minute.

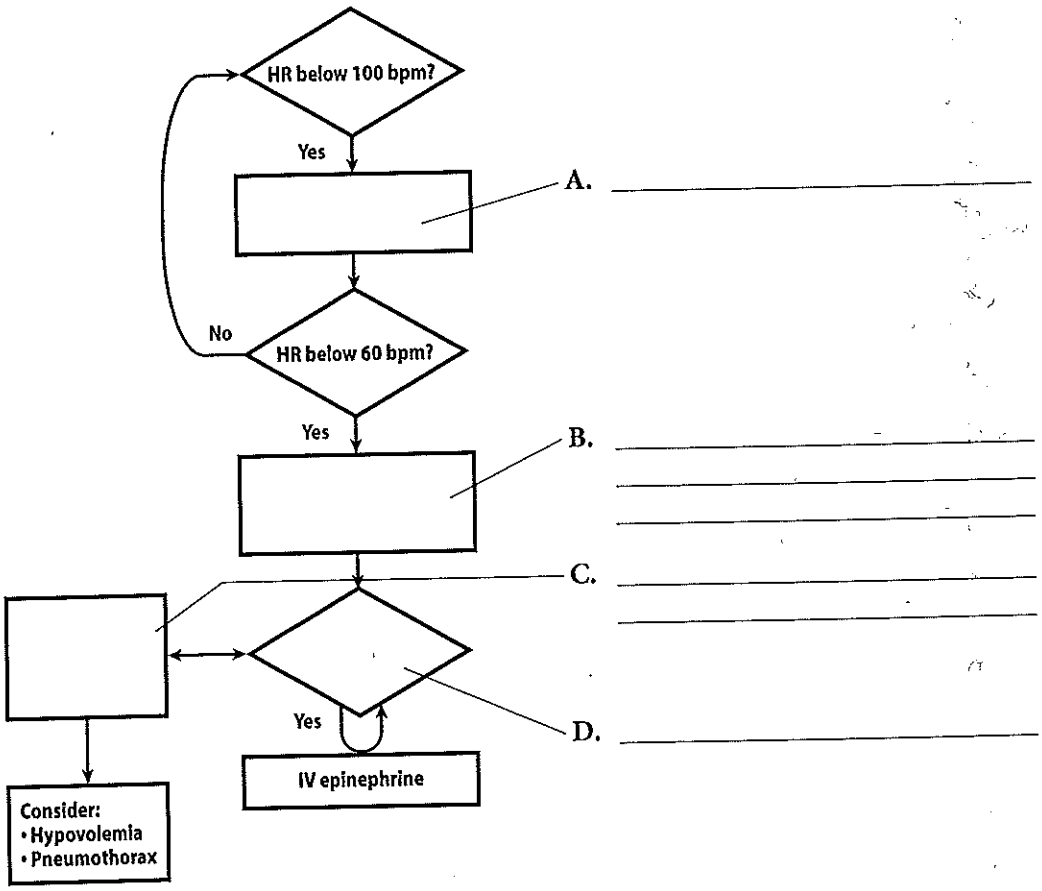
14. The count "One-and-Two-and-Three-and-Breathe-and" should take about _____ seconds.

15. A baby has required ventilation and chest compressions. After 30 seconds of chest compressions, you stop and count **8 heartbeats in 6 seconds.** The baby's heart rate is now _____ beats per minute. You should (continue) (stop) chest compressions.

16. A baby has required chest compressions and is being ventilated with bag and mask. The chest is not moving well. You stop and count **4 heartbeats in 6 seconds.** The baby's heart rate is now _____ beats per minute. You may want to consider _____, _____, and _____.

Lesson 4 Review—*continued*

17. Complete the chart.



Answers to Questions

1. Chest compressions **should not** be started. Positive-pressure ventilation **should** continue.

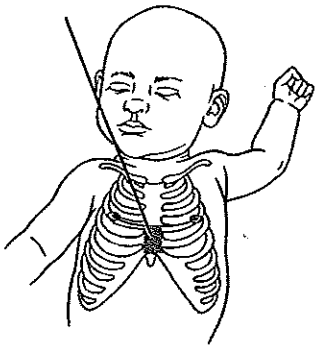
2. Chest compressions **should** be started. Positive-pressure ventilation **should** continue.

3. **Oxygen concentration should be increased to 100%** until the oximeter begins to work again, at which time it should be adjusted to match the table in the flow diagram.

4. Blood is pumped into the **arteries** during the compression phase, and from the **veins** during the release phase.

Answers to Questions—*continued*

5. Compression area.



6. The preferred method of delivering chest compressions is the **thumb** technique.

7. You can continue chest compressions by **moving to the head of the bed to continue the thumb technique** or **changing to the 2-finger technique.**

8. The correct depth of chest compressions is approximately **one-third of the anterior-posterior diameter of the chest** (B).

9. Drawing A is correct (fingers remain in contact during release).

10. **"One-and-Two-and-Three-and-Breathe-and ..."**

11. The ratio is **3:1.**

12. The rate of ventilation without chest compressions should be **40 to 60** breaths per minute.

13. There should be **120** "events" per minute during chest compressions.

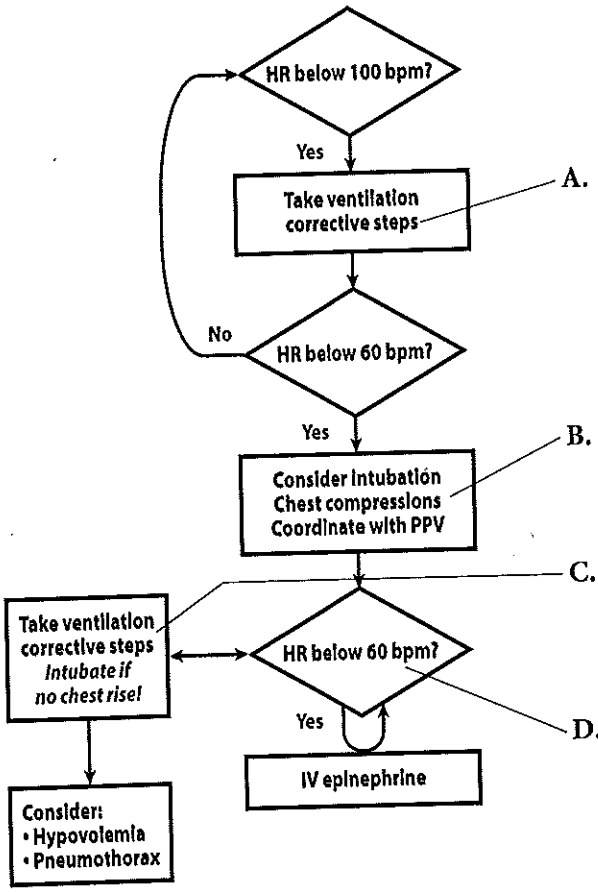
14. The count "One-and-Two-and-Three-and-Breathe-and" should take about **2** seconds.

15. Eight heartbeats in 6 seconds is **80** beats per minute. You should **stop** chest compressions.

16. Four heartbeats in 6 seconds is **40** beats per minute. You may want to consider **endotracheal intubation, insertion of an umbilical catheter,** and **administration of epinephrine.**

Answers to Questions—*continued*

17. The missing text is shown below:



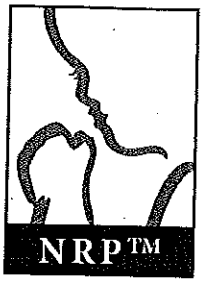
A. Take ventilation corrective steps

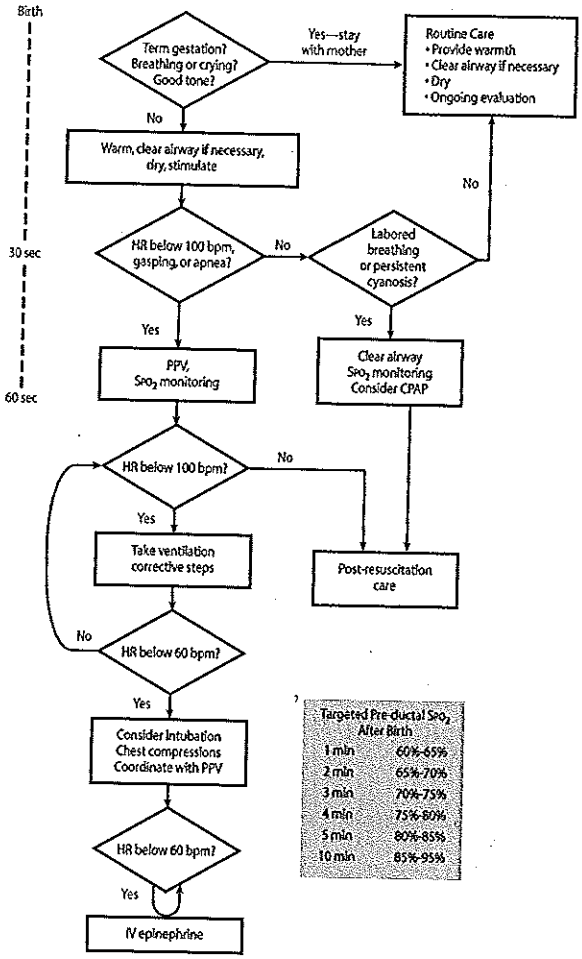
B. Consider intubation
Chest compressions
Coordinate with PPV

C. Take ventilation corrective steps
Intubate if no chest rise

D. Heart rate below 60 bpm

Lesson 4: Chest Compressions Performance Checklist





The Performance Checklist Is a Learning Tool

The learner uses the checklist as a reference during independent practice or as a guide for discussion and practice with a Neonatal Resuscitation Program™ (NRP™) instructor. When the learner and instructor agree that the learner can perform the skills correctly and smoothly without coaching and within the context of a scenario, the learner may move on to the next lesson's Performance Checklist.

Knowledge Check

- What are the indications for beginning chest compressions?
- Which method is preferred: 2-finger or thumb technique? Why?
- What is the indication for discontinuing chest compressions?

Learning Objectives

1. Identify the newborn who requires chest compressions.
2. Demonstrate correct technique for performing chest compressions.
3. Identify the sign that indicates chest compressions should be discontinued.
4. Demonstrate behavioral skills to ensure clear communication and teamwork during this critical component of newborn resuscitation.

"You are called to attend an emergency cesarean birth due to fetal bradycardia. How would you prepare for the resuscitation of this baby? As you work, say your thoughts and actions aloud so your assistant and I will know what you are thinking and doing."

Instructor should check boxes as the learner responds correctly.

Note: This scenario takes the learner from Lesson 1 through Lesson 4. The instructor who finds the "Details" column helpful for assessing performance may use this Performance Checklist as the Basic Integrated Skills Station Checklist (Lessons 1 through 4) instead of the more abbreviated Basic Integrated Skills Performance Checklist.

Participant Name:		
	☐ Obtains relevant perinatal history	Gestational age? Fluid clear? How many babies? Other risk factors?
	☐ Performs equipment check ☐ Assembles resuscitation team (at least one other person) and discusses plan and roles ☐ If obstetric provider indicates that meconium is present in amniotic fluid, prepares for intubation and suctioning meconium	Warm, Clear airway, Auscultate, Oxygenate, Ventilate, Intubate, Medicate, Thermoregulate
"The baby has just been born."		
Sample Vital Signs	**Performance Steps**	**Details**
Gestational age as indicated Apneic Limp	☐ Completes initial assessment ☐ Receives baby at radiant warmer	Asks 3 questions: Term? Breathing or crying? Good tone?

Sample Vital Signs	Performance Steps	Details
	Meconium management (optional)	
	☐ Performs initial steps	Warm, position airway, suction mouth and nose, dry, remove wet linen, stimulate.
Respiratory rate (RR)-apneic Heart rate (HR)-40 beats per minute (bpm)	☐ Evaluates respirations and heart rate	Auscultates apical pulse or palpates umbilicus.
	☐ Initiates positive-pressure ventilation (PPV)	Begins with ___% oxygen per hospital protocol at about 20 cm H_2O pressure. Rate = 40-60/min
	☐ Calls for additional help if necessary	A minimum of 2 resuscitators are necessary if PPV required. Team should be assembled before birth.
	☐ Requests pulse oximetry	Assistant places probe on right hand or wrist before plugging into monitor.
RR-apneic HR-40 bpm SpO_2 — — - - No breath sounds or chest movement	☐ Requests assessment of heart rate, pulse oximetry ☐ If not rising, requests assessment of bilateral breath sounds and chest movement	Pulse oximetry not functioning at low HR.
	☐ Takes ventilation corrective steps (MR SOPA)	**M**ask adjustment and **R**eposition airway (reattempt 5-10 breaths). **S**uction mouth and nose and **o**pen mouth (reattempt 5-10 breaths). Gradually increase the pressure every few breaths until there are bilateral breath sounds and visible chest movement with each breath, up to a maximum of 40 cm H_2O pressure, if necessary.
+ chest movement + breath sounds	☐ Requests evaluation of chest rise and breath sounds	If all corrective steps done but still no chest movement, breath sounds, or rising heart rate, learner indicates need for **a**lternative airway, such as intubation.
+ chest movement + breath sounds	☐ Performs 30 seconds of PPV; notes breath sounds and chest movement	Assistant notes bilateral breath sounds and chest movement.
HR-50 bpm SpO_2 — — —	☐ Evaluates heart rate and SpO_2	Assistant auscultates or palpates HR (oximetry not yet functioning due to low heart rate).
	☐ Calls for additional help ☐ Initiates chest compressions ☐ Increases oxygen to 100%	Team may already be present. Do not forget someone needs to document events on the code sheet. Leader delegates PPV and other tasks as necessary.
	☐ Locates appropriate position on lower third of sternum	

Sample Vital Signs	Performance Steps	Details
	☐ 2-finger technique: • Uses fingertips of middle and index or ring fingers ☐ Thumb technique: • Uses distal portion of both thumbs (one thumb over the other if baby is small)	Thumb technique is preferred because you can control the depth of compression better than with 2-finger technique. Thumb technique generates superior peak systolic and coronary arterial perfusion pressure.
	☐ Compresses sternum one-third of anterior-posterior diameter of chest, straight up and down. ☐ Keeps fingertips/thumbs on sternum during release. Allows chest expansion between compressions, but does not lift thumbs or fingers from chest.	Duration of downward stroke should be somewhat shorter than the duration of the release for generation of maximum cardiac output. During thumb technique, beware of tight grip around thorax that impedes ventilation.
	☐ Compressor counts cadence: "One-and-Two-and-Three-and-Breathe-and" ☐ Ventilates during pause at "Breathe-and"	One cycle of 3 compressions and 1 breath takes 2 seconds.
	☐ Provides 45-60 seconds of chest compressions and coordinated ventilations Assesses heart rate: ☐ Palpates umbilicus and continues ventilation Or, if no pulsations felt, ☐ Auscultates apical pulse and pauses ventilation	Heart rate assessment is a good place to ask learner and assistant to change places so learner can demonstrate roles of compressor and ventilator. Instructor chooses **Option 1:** Recovery to free-flow oxygen. **Option 2:** Indicate need to proceed to umbilical venous catheter (UVC) placement and administration of epinephrine.
Option 1		
HR-70 bpm SpO_2-67% Apneic + breath sounds + chest movement	☐ Discontinues compressions ☐ Continues ventilations ☐ Adjusts oxygen based on oximetry and newborn's age	Discontinue compressions when HR >60 bpm. Continue to monitor HR and SpO_2.

Sample Vital Signs	Performance Steps	Details
HR-120 bpm SpO_2-74% RR-10 breaths per minute HR-140 bpm SpO_2-97% RR-weak cry	☐ Provides additional 30 seconds of effective ventilation *without* chest compressions. ☐ Assesses newborn's respiratory effort, HR, pulse oximetry. ☐ Slows PPV rate as newborn breathes spontaneously. ☐ Gradually withdraws PPV and adjusts free-flow oxygen based on oximetry. Eventually discontinues free-flow oxygen based on oximetry.	Team should be noting newborn's improving vital signs and discussing next steps together.
	☐ Updates family ☐ Directs appropriate post-resuscitation care	
Option 2		
HR-40 bpm SpO_2 - - - (Oximeter—no signal)	☐ Provides additional 45-60 seconds of chest compressions and coordinated ventilations and considers reasons for poor response	Consider reasons for poor response: • Ineffective ventilation? • Dislodged endotracheal tube (or need to intubate now)? • Supplemental oxygen being given? • Appropriate compression technique (location, depth, rate)? • Coordinated compressions and ventilations?
HR-50 bpm SpO_2 - - - (Oximeter—no signal)	☐ Requests HR assessment after completing more than 45-60 seconds of coordinated compressions and PPV ☐ Communicates plan for next steps • Intubate if not yet done • Insert emergency UVC and give epinephrine	Team may need additional help to place emergency UVC and administer epinephrine and intubate newborn.

Instructor asks the learner Reflective Questions to enable self-assessment, such as:

1. What went well during this resuscitation?
2. Who assumed the leadership role in this scenario?
3. Did you (leader) get what you needed from your assistant(s)? What behavioral skills did you use to ensure good teamwork? Give me an example of what you did or said that used that behavioral skill.
4. When the baby did not respond to chest compressions and coordinated, effective ventilation, what did team members do to support (or not support) each other?
5. What would you do differently when faced with this scenario again?

Neonatal Resuscitation Program Key Behavioral Skills

Know your environment.	Allocate attention wisely.
Anticipate and plan.	Use all available information.
Assume the leadership role.	Use all available resources.
Communicate effectively.	Call for help when needed.
Delegate workload optimally.	Maintain professional behavior.