pressure is applied to the airway tube, the pressure is transmitted through the tube and mask into the baby's trachea. No instruments are required to insert a laryngeal mask and you do not need to visualize the vocal cords during insertion. Several variations of the basic design are commercially available, including reusable and disposable versions, devices with a pre-curved airway tube and a gastric drain port, and a mask that creates a seal without an inflatable cuff. At this time, only the size-1 laryngeal mask is small enough for use in newborns weighing less than 5 kg.

When should you consider using a laryngeal mask?

Because the laryngeal mask does not require a tight seal against the face, bypasses the tongue, and does not require visualization of the vocal cords for placement, it may be an effective alternative when attempts at mask ventilation and endotracheal intubation are unsuccessful. When you "can't ventilate and can't intubate," a laryngeal mask may provide a successful rescue airway.

Common examples when a laryngeal mask should be considered during resuscitation include the following:

- Newborns with congenital anomalies involving the mouth, lip, tongue, palate or neck, where achieving a good seal with a face mask is difficult and visualizing the larynx with a laryngoscope is difficult or unfeasible
- Newborns with a small mandible or large tongue, where face-mask ventilation and intubation are unsuccessful. Common examples include the Robin sequence and Trisomy 21.
- When PPV provided with a face mask is ineffective and attempts at intubation are not feasible or are unsuccessful

What are the limitations of a laryngeal mask?

Laryngeal masks have several limitations to consider during neonatal resuscitation.

- The device has not been studied for suctioning secretions from the airway.
- If you need to use high ventilation pressures, air may leak through the seal between the pharynx and the mask, resulting in insufficient pressure to inflate the lungs.
- Few reports describe the use of a laryngeal mask during chest compressions. However, if endotracheal intubation is unsuccessful, it is reasonable to attempt compressions with the device in place.

- There is insufficient evidence to recommend using a laryngeal mask to administer intratracheal medications. Intratracheal medications may leak from the mask into the esophagus and not enter the lung.
- Laryngeal masks cannot be used in very small newborns. Currently, the smallest laryngeal mask is intended for use in babies who weigh more than approximately 2,000 g. Many reports describe its use in babies who weigh 1,500 to 2,000 g. Some reports have described using the size-1 laryngeal mask successfully in babies who weigh less than 1,500 g.

Remember to request help from a provider with expertise in airway management as soon as it becomes apparent that a small baby, or baby with a craniofacial anomaly, may require assisted ventilation.

How do you place a laryngeal mask?

The following instructions apply to one example of a disposable laryngeal mask with a pre-curved, anatomically shaped airway tube and a gastric drain port. Devices vary by manufacturer and you should refer to the manufacturer's instructions for the specific device used at your institution. If you are using a reusable laryngeal mask, refer to the manufacturer's instructions for proper cleaning and maintenance procedures.

Note: If you think that the stomach is distended in a baby in whom you have decided to place a laryngeal mask that does not have a gastric drain port, an orogastric tube should be placed and air in the stomach should be aspirated before inserting the laryngeal mask.

Prepare the laryngeal mask.

1. Wear gloves and follow standard precautions. Using clean technique, remove the size-1 device from the sterile package.
2. Quickly inspect the device to ensure that the mask, aperture bars, airway tube, 15-mm connector, and pilot balloon are intact without cuts, tears, or kinks.
3. Attach a syringe to the inflation port and completely deflate the cuff surrounding the mask, creating a vacuum inside the cuff, so that the mask achieves a wedge shape (Figure 5.34). Maintaining tension, disconnect the syringe from the inflation port.
4. Some clinicians lubricate the back of the laryngeal mask with a water-soluble lubricant. If you choose to do so, be careful to keep the lubricant away from the openings on the inside of the mask.

Figure 5.34. Deflate the mask to form a wedge shape and then remove the syringe.

Get ready to insert the laryngeal mask.

5. Stand at the baby's head and position the head in the "sniffing" position as you would for endotracheal intubation.

6. Hold the device as illustrated (Figure 5.35). You may hold the laryngeal mask in your right or left hand.

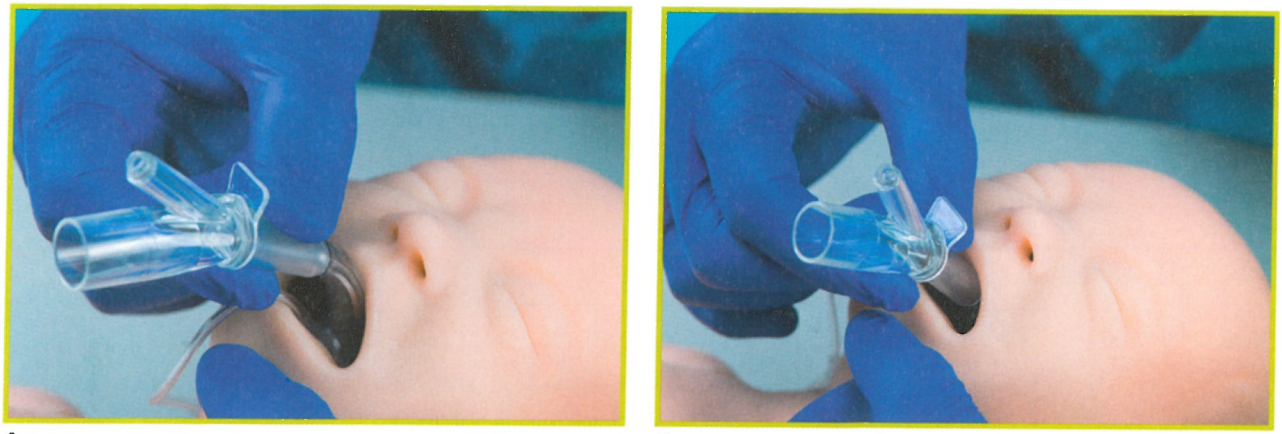
Figure 5.35. Preparing for insertion

Insert the laryngeal mask.

7. Gently open the baby's mouth and press the leading tip of the mask against the baby's hard palate (Figure 5.36).

Figure 5.36. Press the tip against the palate.

8 While maintaining pressure against the palate, advance the device inward with a circular motion (Figure 5.37). The mask will follow the contour of the mouth and palate. Advance until you feel resistance.



A B

Figure 5.37. Advance the device following the contour of the mouth and palate.

Inflate the laryngeal mask.

9 Inflate the cuff by injecting just enough air into the inflation port to achieve a seal. After inflating the cuff, remove the syringe. Follow the manufacturer's recommendation for maximum inflation volume. The maximum inflation for the mask demonstrated is 5 mL (Figure 5.38). You can assess the inflation of the cuff by looking at the pilot balloon. The laryngeal mask will move slightly outward when it is inflated. **Never inflate the mask with more than the manufacturer recommended volume of air.**

Figure 5.38. Inflate the cuff with air.

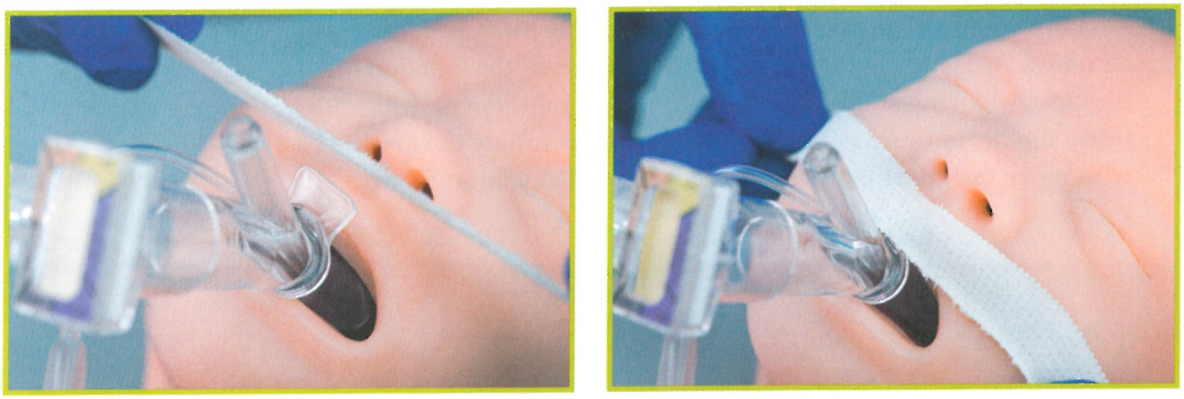
Ventilate through the laryngeal mask.

⑩ Attach a PPV device and CO_2 detector to the airway tube and begin PPV (Figure 5.39).

Figure 5.39. Start PPV and confirm placement.

Secure the laryngeal mask.

⑪ Press a piece of tape horizontally across the airway tube's fixation tab, pressing downward so that the tape adheres to the baby's cheeks and gently presses the device inward (Figure 5.40).



A B

Figure 5.40. Press tape downward across the fixation tab and across the baby's cheeks.

How do you confirm that the laryngeal mask is properly placed?

As soon as you insert the laryngeal mask and begin PPV, connect a CO_2 detector and confirm the presence of CO_2 during exhalation (Figure 5.39). If the laryngeal mask is correctly placed and you are providing

ventilation that inflates the lungs, you should detect exhaled CO_2 within 8 to 10 positive-pressure breaths. Similar to a properly placed endotracheal tube, you should notice a prompt increase in the baby's heart rate, chest wall movement, equal breath sounds when you listen with a stethoscope, and an increasing Spo_2. You should not hear a large leak of air coming from the baby's mouth or see a growing bulge in the baby's neck.

The laryngeal mask does not obstruct the vocal cords; therefore, you may hear grunting or crying through the device when the baby begins breathing spontaneously.

Insert a gastric drain tube (optional). You may lubricate a size 5F or 6F gastric tube and carefully insert it down the gastric drain port attached to the airway tube (Figure 5.41). Attach a syringe and gently aspirate air and stomach contents. Disconnect the syringe and leave the gastric tube open to air.

Figure 5.41. Insert a size 5F or 6F gastric tube through the gastric drain port.

When should you remove the laryngeal mask?

The laryngeal mask can be removed when the baby establishes effective spontaneous respirations or when an endotracheal tube can be inserted successfully. Babies can breathe spontaneously through the device. If necessary, the laryngeal mask can be attached to a ventilator or continuous positive airway pressure (CPAP) device during transport. When you decide to remove the laryngeal mask, suction secretions from the mouth and throat before you deflate and remove the device.

What complications may occur with a laryngeal mask?

The device may cause soft-tissue trauma, laryngospasm, or gastric distension from air leaking around the mask. Prolonged use over hours or days has been infrequently associated with oropharyngeal nerve damage or tongue swelling in adults; however, no information is available on the incidence of these complications in newborns.

Focus on Teamwork

Inserting an alternative airway highlights several opportunities for effective teams to use the Neonatal Resuscitation Program® (NRP®) Key Behavioral skills.

Behavior	Example
Call for additional help when needed.	If an alternative airway is required, you will likely need 3 to 4 or more health care providers to quickly perform all of the tasks, including preparing and testing several pieces of equipment, positioning the baby, holding the endotracheal tube, providing thyroid and cricoid pressure, monitoring the baby during the procedure, attaching a CO_2 detector, attaching a PPV device, auscultating breath sounds, securing the airway, and documenting events.
Communicate effectively. Maintain professional behavior.	When preparing to insert an alternative airway, clearly and calmly request the desired supplies. Confirm the insertion depth (endotracheal tube) or inflation volume (laryngeal mask) with your team members before securing the tube.
Delegate workload optimally.	Determine who will insert the endotracheal tube, who will provide thyroid and cricoid pressure, who will monitor the baby's heart rate, who will place the CO_2 detector, and who will auscultate breath sounds.
Allocate attention wisely.	Maintain situational awareness. At all times, a team member needs to be monitoring the baby's condition, the number of insertion attempts, the duration of insertion attempts, and alerting the operators to any important changes (eg, heart rate, oxygen saturation).
Use available resources.	If an alternative airway is needed, but initial intubation attempts are unsuccessful, do not make repeated intubation attempts. Use your other resources, such as another individual with intubation expertise or a laryngeal mask. Allow all team members to use their unique skills during the resuscitation process. For example, respiratory care practitioners (RCP) have valuable skills specific to intubation. Using the RCP's skills during intubation may allow another provider to focus attention on preparing equipment for vascular access and medications.

Frequently Asked Questions

Why should I place an endotracheal tube before starting chest compressions? Does that delay the initiation of chest compressions?

In most situations, this program recommends placing an endotracheal tube prior to starting chest compressions to ensure maximum ventilation efficacy both before and after chest compressions begin. In many cases, the baby's condition will improve during the 30 seconds of ventilation following intubation and compressions will not be necessary.

Can the provider with intubation skills be on call outside the hospital or in a distant location?

No. A person with intubation skills should be in the hospital and available to be called for immediate assistance if needed. If the need for resuscitation is anticipated, this person should be present at the time of birth. It is not sufficient to have someone "on call" at home or in a remote area of the hospital.

Should sedative premedication be used before intubation?

Prior to a non-emergent intubation in the NICU, premedication is recommended because it alleviates pain, decreases the number of attempts needed to complete the procedure, and minimizes the potential for intubation-related airway trauma. When emergency intubation is performed as part of resuscitation, there is generally insufficient time or vascular access to administer sedative premedication. This program focuses on resuscitation of the newly born baby and, therefore, the details of premedication are not included.

Can a nurse or respiratory care practitioner place a laryngeal mask?

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

Key Points

1. Insertion of an endotracheal tube or laryngeal mask should be considered
   a. If positive-pressure ventilation (PPV) with a face mask does not result in clinical improvement
   b. If PPV lasts more than a few minutes
2. Insertion of an endotracheal tube is strongly recommended
   a. If chest compressions are necessary. If intubation is not successful or feasible, a laryngeal mask may be used.
   b. In special circumstances, such as (1) stabilization of a newborn with a suspected diaphragmatic hernia, (2) for surfactant administration, and (3) for direct tracheal suction if the airway is obstructed by thick secretions.
3. A person with intubation skills should be in the hospital and available to be called for immediate assistance if needed. If the need for resuscitation is anticipated, this person should be present at the time of birth. It is not sufficient to have someone "on call" at home or in a remote area of the hospital.
4. The equipment necessary to place an alternative airway should be kept together and readily accessible. Anticipate the need for airway insertion and prepare the equipment before a high-risk delivery.
5. The appropriate endotracheal tube size is estimated from the baby's weight or gestational age.
6. The appropriate laryngoscope blade for a term newborn is size No. 1. The correct blade for a preterm newborn is size No. 0 (size No. 00 *optional* for very preterm newborn).
7. The intubation procedure ideally should be completed within 30 seconds. Effective teamwork is required to perform this procedure quickly.
8. For intubation, the baby should be placed on a flat surface with the head in the midline, the neck slightly extended, and the body straight. If possible, adjust the bed so the baby's head is level with the operator's upper abdomen or lower chest.
9. Demonstrating exhaled CO_2 and observing a rapidly increasing heart rate are the primary methods of confirming endotracheal tube placement within the trachea.

⑩ Endotracheal tube insertion depth (cm) can be estimated using the NTL + 1 cm (NTL = distance from nasal septum to ear tragus) or the baby's gestational age; however, the depth estimate should be confirmed by equal breath sounds. If the tube is to remain in place, obtain a chest x-ray for final confirmation.

⑪ If a baby's condition has not improved and you have not achieved chest movement with ventilation through a properly placed endotracheal tube, there may be thick secretions obstructing the airway. Clear the airway using a suction catheter inserted through the endotracheal tube. If you cannot quickly clear the airway with the suction catheter, you may be able to clear the airway by applying suction directly to the endotracheal tube using a meconium aspirator.

⑫ If a baby's condition worsens after endotracheal intubation, the tube may have become **D**isplaced or **O**bstructed, there may be a **P**neumothorax or positive-pressure ventilation **E**quipment failure (*DOPE* mnemonic).

⑬ Avoid repeated unsuccessful attempts at endotracheal intubation. A laryngeal mask may provide a rescue airway when PPV with a face mask fails to achieve effective ventilation and intubation is unsuccessful.

LESSON 5 REVIEW

1. A newborn has been receiving face-mask ventilation, but is not improving. Despite performing the first 5 ventilation corrective steps, the heart rate is not rising and there is poor chest movement. An alternative airway, such as an endotracheal tube or a laryngeal mask, (should)/(should not) be inserted immediately.

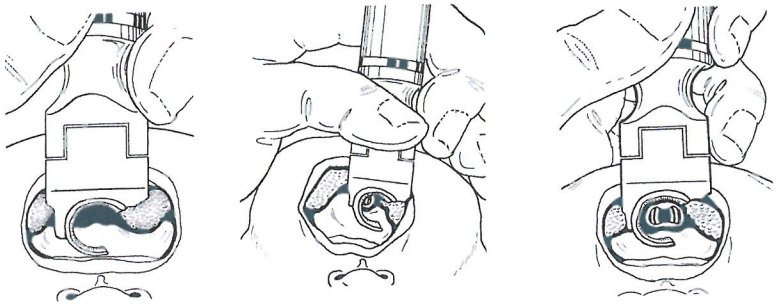
2. For babies weighing less than 1,000 g, the endotracheal tube size should be (2.5 mm)/(3.5 mm).

3. If using a stylet, the tip of the stylet (must)/(must not) extend beyond the endotracheal tube's side and end holes.

4. The preferred laryngoscope blade size for use in a term newborn is (No. 1)/(No. 0).

5. The vocal cord guide on an endotracheal tube (does)/(does not) reliably predict the correct insertion depth.

6. Which illustration shows the view of the oral cavity that you should see if you have the laryngoscope correctly placed for intubation?



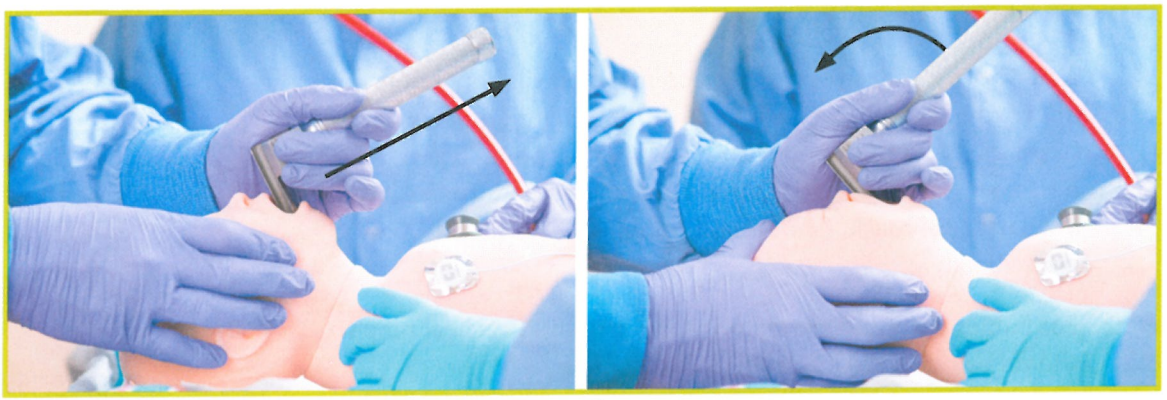
A B C

7. Both right- and left-handed people should hold the laryngoscope in their (right)/(left) hand.

8. You should try to take no longer than (30)/(60) seconds to complete the endotracheal intubation procedure.

9. If you have not completed endotracheal intubation within the recommended time limit, you should (continue the intubation attempt for another 30 seconds using free-flow oxygen to support the baby)/(stop, resume positive-pressure ventilation with a mask, then try again or insert a laryngeal mask).

10. Which image shows the correct way to lift the tongue out of the way and expose the larynx?



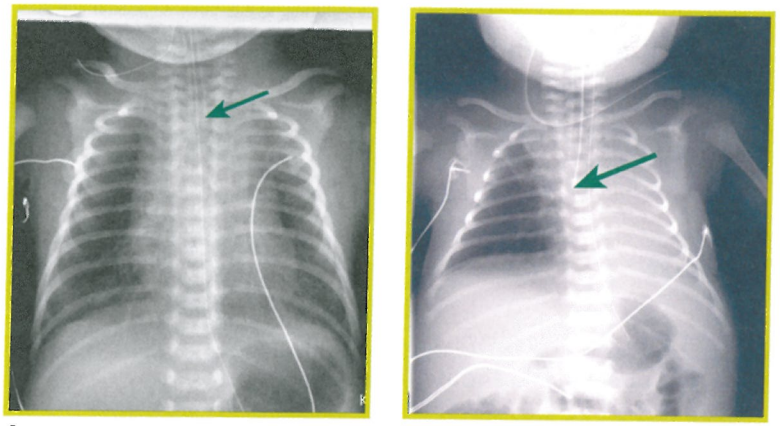
A B

11. You have the glottis in view, but the vocal cords are closed. You (should)/(should not) wait until they are open to insert the tube.

12. You inserted an endotracheal tube and the CO_2 detector changed color when you gave positive-pressure breaths. You hear breath sounds with your stethoscope only on the right side of the chest. You should (withdraw)/(advance) the tube slightly and listen with the stethoscope again.

13. You have inserted an endotracheal tube and are giving positive-pressure ventilation through it. The CO_2 detector does not change color and the baby's heart rate is decreasing. The tube is most likely placed in the (esophagus)/(trachea).

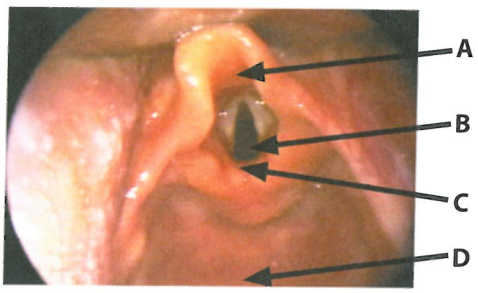
14. Which x-ray shows the correct placement of the endotracheal tube?



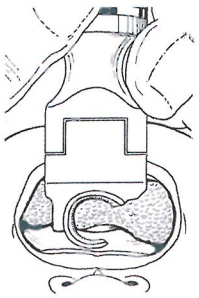
A B

15. A baby is born at term with a bilateral cleft lip and palate and a very small mandible. She requires positive-pressure ventilation. You are unable to achieve a seal with bag and mask. You have tried to intubate twice but have not been successful. Insertion of a laryngeal mask (is)/(is not) indicated.

16. In the photograph, which arrow is pointing to the epiglottis?



17. You have inserted a laryngoscope and are attempting intubation. You see the view depicted in the following illustration. The correct action is to (advance the laryngoscope farther/withdraw the laryngoscope).



18. If a baby's condition worsens after endotracheal intubation, list 4 possible causes.

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

Answers

1. An alternative airway, such as an endotracheal tube or a laryngeal mask, should be inserted immediately.
2. For babies weighing less than 1,000 g, the endotracheal tube size should be 2.5 mm.
3. The tip of the stylet must not extend beyond the endotracheal tube's side and end holes.
4. The preferred laryngoscope blade size for use in a term newborn is No. 1.
5. The vocal cord guide on an endotracheal tube does not reliably predict the correct insertion depth.
6. Image C shows the view of the oral cavity that you should see if you have the laryngoscope correctly placed for intubation.
7. Both right- and left-handed people should hold the laryngoscope in their left hand.
8. You should try to take no longer than 30 seconds to complete the endotracheal intubation procedure.
9. If you have not completed tracheal intubation within the recommended time limit, you should stop, resume positive-pressure ventilation with a mask, and then try again or insert a laryngeal mask.

10. Image A shows the correct way to lift the tongue out of the way and expose the larynx.
11. You should wait until they are open to insert the tube.
12. You should withdraw the tube slightly and listen with the stethoscope again.
13. The tube is most likely placed in the esophagus.
14. X-ray A shows the correct placement of the endotracheal tube.
15. Insertion of a laryngeal mask is indicated.
16. Arrow A is pointing to the epiglottis.
17. The correct action is to advance the laryngoscope farther.
18. Possible causes include (1) displaced endotracheal tube, (2) obstructed endotracheal tube, (3) pneumothorax, (4) equipment failure.

Additional Reading

Blayney MP, Logan DR. First thoracic vertebral body as reference for endotracheal tube placement. *Arch Dis Child Fetal Neonatal Ed.* 1994;71(1):F32-F35

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

Mainie P, Carmichael A, McCullough S, Kempley ST. Endotracheal tube position in neonates requiring emergency interhospital transfer. *Am J Perinatol.* 2006;23(2):121-124

Rotschild A, Chitavat D, Puterman ML, Phang MS, Ling E, Baldwin V. Optimal positioning of endotracheal tubes for ventilation of preterm infants. *Am J Dis Child.* 1991;145(9):1007-1012

Shukla HK, Hendricks-Munoz KD, Atakent Y, Rapaport S. Rapid estimation of insertional length of endotracheal intubation in newborn infants. *J Pediatr.* 1997;131(4):561-564

Thayvil S, Nagakumar P, Gowers H, Sinha A. Optimal endotracheal tube tip position in extremely premature infants. *Am J Perinatol.* 2008; 25(1):13-16

Trevisanuto D, Doglioni N, Gottardi G, Nardo D, Micaglio M, Parotto M. Laryngeal mask: beyond neonatal upper airway malformations. *Arch Dis Child Fetal Neonatal Ed.* 2013;98(2):F185-F186

Whyte KL, Levin R, Powls A. Clinical audit: Optimal positioning of endotracheal tubes in neonates. *Scott Med J.* 2007;52(2):25-27

Lesson 5: Performance Checklist

Alternative Airways

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.

Note: If the learner's institution uses a T-piece resuscitator or flow-inflating bag, the learner should also demonstrate proficiency with a self-inflating bag to be used in case of emergency (loss of compressed gas).

Knowledge Check

1. What are the indications for endotracheal intubation during resuscitation?
2. How do you determine what size of endotracheal tube should be used for various gestational ages and weights?
3. What 2 strategies can be used to determine depth of insertion of the endotracheal tube?
4. What indicators determine correct placement of the endotracheal tube?
5. What is the role of the assistant during intubation?
6. When should you consider using a laryngeal mask?
7. List at least 3 limitations of the laryngeal mask.
8. What indicators are used to determine correct placement of the laryngeal mask?
9. When and how should you remove the laryngeal mask?

Learning Objectives

1. Recognize the newborn that requires endotracheal intubation.

2. Demonstrate preparation for intubation, including choosing the correct-sized tube for the newborn's estimated weight.
3. Demonstrate correct technique for placing an endotracheal tube (operator).
4. Demonstrate the role of the assistant during intubation (assistant).
5. Demonstrate strategies to determine if the endotracheal tube is in the trachea.
6. Demonstrate how to use a suction catheter or meconium aspirator to suction thick secretions from the trachea.
7. Identify when placement of a laryngeal mask is indicated.
8. List the limitations of the laryngeal mask.
9. Demonstrate correct technique for placing and removing a laryngeal mask.
10. Practice behavioral skills to ensure clear communication and teamwork during this critical component of newborn resuscitation.

Endotracheal Intubation

Scenario

"You are called to attend a birth complicated by a Category III fetal heart rate pattern. The laboring mother is a 28-year-old primigravida at 39 weeks' gestation. Demonstrate how you would prepare for the birth of this baby. As you work, say your thoughts and actions aloud so I will know what you are thinking and doing."

✔	Critical Performance Steps
	Assesses perinatal risk (Learner asks 4 basic questions.) Gestational age? **"39 weeks' gestation."** Clear fluid? **"Amniotic fluid is clear."** How many babies? **"One baby is expected."** Additional risk factors? **"Mom has a fever."**
	Assembles team, identify leader, delegate tasks
	Performs equipment check

✔	Critical Performance Steps	
	"The baby has been born."	
Rapid Evaluation		
	Term? Tone? Breathing or crying? **"Appears term, no tone, no breathing."**	
Initial Steps		
	Position, suction mouth and nose, dry, remove linen, stimulate	
Vital Signs		
	Checks breathing **"Baby is apneic."**	
Positive-Pressure Ventilation		
	Positions head, applies mask, starts PPV at 20 to 25 cm H_2O; rate 40 to 60 breaths/min, requests pulse oximetry, requests ECG monitor (optional)	
	Within 15 seconds of beginning PPV, requests check to assess if heart rate is rising **"Heart rate about 40 bpm, not increasing."**	
	Assesses chest movement • If chest movement observed, continues PPV × 15 seconds • If no chest movement observed, proceeds through corrective steps (MR. SOPA) until chest movement; then administers PPV × 30 seconds • *If no chest movement with corrective steps, indicates need for alternative airway and proceeds directly to intubation*	
Heart Rate		
	Checks heart rate **"Heart rate about 40 bpm, still not increasing."** Indicates need for alternative airway	
Preparation for Intubation		
	Operator	**Assistant**
	Prepares for intubation • Requests correct-sized tube • Requests correct-sized laryngoscope blade • Communicates preference for stylet usage	• Ensures suction set at 80 to 100 mm Hg • Selects correct-sized tube • Chooses correct laryngoscope blade (size 1 [term], size 0 [preterm]) • Checks laryngoscope light • Inserts stylet correctly *(stylet optional)* • Obtains CO_2 detector • Prepares tape or securing device • Places electronic cardiac (ECG) monitor leads and connects to monitor *(optional)*

✔	Critical Performance Steps	
Intubating the Newborn		
	Operator	**Assistant**
	• Holds laryngoscope correctly in left hand • Opens mouth with finger and inserts blade to base of tongue • Lifts blade correctly (no rocking motion) • Requests cricoid pressure if needed • Identifies landmarks, takes corrective action to visualize glottis if needed • Inserts tube from right side, not down center of laryngoscope blade • Aligns vocal cord guide with vocal cords • Removes laryngoscope • Holds tube against baby's palate	• Positions newborn in "sniffing" position, body straight, table at correct height • Monitors heart rate and announces if attempt lasts longer than 30 seconds • Applies cricoid pressure if requested • Hands endotracheal tube to operator • Removes stylet (if used) • Connects CO_2 detector and PPV device to endotracheal tube • Hands PPV device to operator
Positive-Pressure Ventilation and Confirming Endotracheal Tube Placement		
	• Administers PPV • Observes for symmetrical chest movement	• Assesses CO_2 detector color change • Listens for increasing heart rate and bilateral breath sounds and **reports breath sound findings**
	If endotracheal tube not successfully placed, **"Color is not changing on the CO_2 detector and heart rate is not increasing."** • Removes endotracheal tube • Resumes PPV by face mask • Repeats intubation attempt or indicates need for laryngeal mask	
	If endotracheal tube successfully placed, **"Color is changing on the CO_2 detector and heart rate is increasing."** • Operator continues PPV × 30 seconds • Assistant checks tip-to-lip depth using gestational age/weight table or NTL measurement. – If using NTL, measures distance from the nasal septum to the ear tragus. Insertion depth (cm) = NTL + 1 cm • Assistant secures endotracheal tube	
Vital Signs		
	Checks heart rate after 30 seconds of PPV through endotracheal tube **"Heart rate is >100 bpm; baby remains apneic. Oxygen saturation is 72%."** Continues PPV and adjust oxygen concentration per oximetry	
	Prepares for transport to nursery Updates parents	

Laryngeal Mask

Scenario

"A 17-year-old woman with no prenatal care has been admitted to the hospital in active labor. The woman believes she is at approximately 36 weeks' gestation.

You walk into the room a few minutes after the birth. The first responders could not achieve chest movement with face-mask ventilation. They have tried intubating twice without success. The newborn's heart rate is 40 bpm and not increasing. The newborn has a small mandible and large tongue and you suspect Robin sequence. You decide to insert a laryngeal mask."

✔	Critical Performance Steps
Laryngeal Mask Placement	
	Obtains size-1 laryngeal mask and 5-mL syringe
	Quickly inspects the device to ensure no cuts, tears, or kinks
	Attaches a syringe and completely deflates the cuff. Maintaining tension, disconnects syringe from inflation port.
	Lubricates back of the mask with water-soluble lubricant *(optional)*
	Places baby's head in sniffing position
	Opens mouth and presses the leading tip of the mask against the baby's hard palate
	Advances the device inward along palate with a circular motion until resistance is felt
	Attaches syringe, inflates cuff (2-5 mL air) per manufacturer's recommendation
	Assistant attaches PPV device and CO_2 detector to the adaptor
Positive-Pressure Ventilation and Confirming Laryngeal Mask Placement	
	Holds laryngeal mask in place, administers PPV Assistant confirms placement by color change on CO_2 detector, auscultating heart rate, bilateral breath sounds, and observing symmetrical chest movement.
	If laryngeal mask not successfully placed, **"Color is not changing on the CO_2 detector and heart rate is not increasing."** • Removes laryngeal mask • Resumes PPV by face mask • Repeats laryngeal mask insertion attempt
	If laryngeal mask successfully placed, **"Color is changing on the CO_2 detector and heart rate is increasing."** • Operator continues PPV × 30 seconds • Assistant secures laryngeal mask by pressing tape across the fixation tab and the baby's cheeks
Vital Signs	
	Checks heart rate after 30 seconds of PPV **"Heart rate is >100 bpm; baby remains apneic. Oxygen saturation is 72%."** Continues PPV and adjusts oxygen concentration per oximetry
	Prepares for transport to nursery Updates parents

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

1. What went well during this resuscitation?
2. What will you do differently when faced with this situation in a future scenario?
3. Do you have additional comments or suggestions for your team?
4. Give me an example of how you used at least one of the NRP Key Behavioral Skills.

Neonatal Resuscitation Program Key Behavioral Skills

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

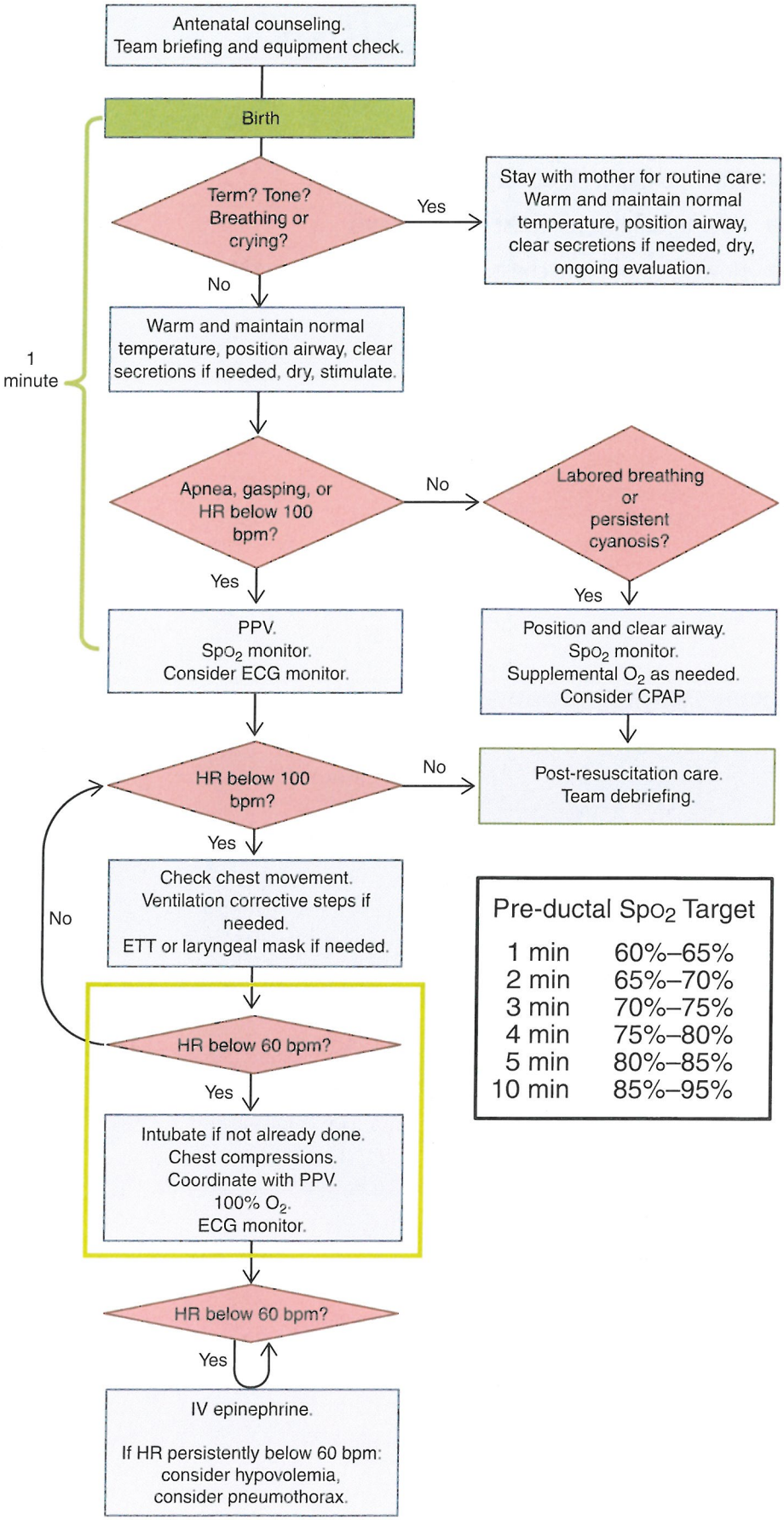
LESSON

6

Chest Compressions

What you will learn

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



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.

Case: Late preterm newborn that does not respond to effective ventilation

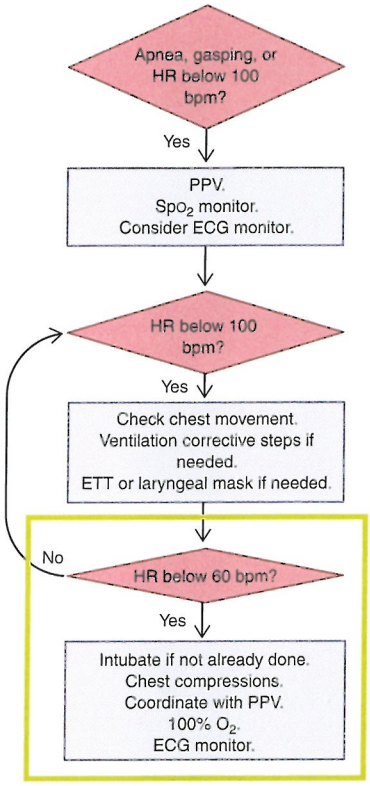
Your team is called to attend an emergency cesarean birth at 36 weeks' gestation because of fetal distress. You perform a pre-resuscitation team briefing, assign roles and responsibilities, and complete an equipment check. After birth, the obstetrician stimulates the baby girl to breathe, but she remains limp and apneic. The umbilical cord is clamped and cut and she is moved to a radiant warmer. After performing the initial steps, she is still limp and apneic. You begin positive-pressure ventilation (PPV) with 21% oxygen, another team member listens to the baby's heart rate with a stethoscope, while a third team member places a sensor on her right hand and attaches it to a pulse oximeter. An assistant documents the events as they occur. The heart rate is 40 beats per minute (bpm), not increasing, and her chest is not moving with PPV. You proceed through the ventilation corrective steps, but the baby does not improve. A team member inserts an endotracheal tube and secures it, and ventilation is resumed. The carbon dioxide (CO_2) detector does not change color; however, there is good chest movement with PPV through the tube, and the breath sounds are equal in the axillae with each assisted breath. Electronic cardiac (ECG) monitor leads are placed on the chest and attached to an ECG monitor. Ventilation through the tube is continued for 30 seconds, but the heart rate remains 40 bpm. You increase the oxygen concentration to 100%, begin chest compressions coordinated with PPV, and call for additional help. During compressions and coordinated ventilation, the CO_2 detector changes color, and, within 60 seconds, the heart rate increases to 80 bpm. You stop compressions and continue PPV. Your team members frequently reevaluate the baby's condition and share their assessments with each other. The oxygen concentration is adjusted based on pulse oximetry. As the baby's tone improves, she begins to have intermittent spontaneous respiratory effort and her heart rate increases to 160 bpm. Her parents are updated and the baby is moved to the intensive care nursery for further evaluation. Shortly afterward, your team members conduct a debriefing to review their preparation, teamwork, and communication.

What are chest compressions?

Babies who do not respond to effective ventilation are likely to have very low blood oxygen levels, significant acidosis, and insufficient

blood flow in the coronary arteries. As a result, cardiac muscle function is severely depressed. Improving coronary artery blood flow is crucial for restoring the heart's function.

The heart lies in the chest between the lower third of the sternum and the spine. Rhythmically depressing the sternum compresses the heart against the spine, pushes blood forward, and increases the diastolic blood pressure in the aorta. When pressure on the sternum is released, the heart refills with blood and blood flows into the coronary arteries (Figure 6.1). By compressing the chest and ventilating the lungs, you help to restore the flow of oxygenated blood to the heart muscle.



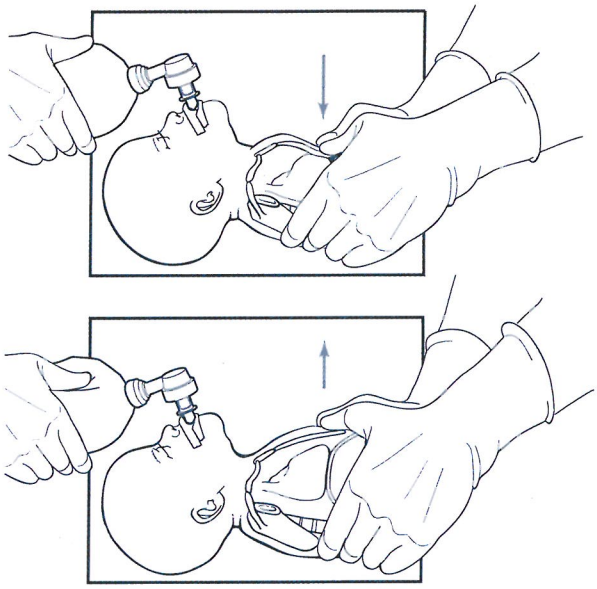


Figure 6.1. Compression (top) and release (bottom) phases of chest compressions

When do you begin chest compressions?

Chest compressions are indicated if the baby's heart rate remains **less than 60 bpm** after at least 30 seconds of PPV that inflates the lungs, as evidenced by chest movement with ventilation. In most cases, you should have given at least 30 seconds of ventilation through a properly inserted endotracheal tube or laryngeal mask.

If the lungs have been adequately ventilated, it is rare for a newborn to require chest compressions. Do not begin chest compressions unless you have achieved chest movement with your ventilation attempts. If the chest is not moving, you are most likely not providing effective ventilation. Focus your attention on the ventilation corrective steps, ensuring that you have an unobstructed airway, before starting compressions.

Indications for Chest Compressions

- Chest compressions are indicated when the heart rate remains **less than 60 bpm** after at least 30 seconds of PPV that inflates the lungs, as evidenced by chest movement with ventilation.
- In most cases, you should have given at least 30 seconds of ventilation through a properly inserted endotracheal tube or laryngeal mask.

Where do you stand to administer chest compressions?

When chest compressions are started, you may be standing at the side of the warmer. One of your team members, standing at the head of the bed, will be providing coordinated ventilations through an endotracheal tube.

If chest compressions are required, there is a high probability that you will also need to insert an emergency umbilical venous catheter for intravascular access. It is difficult to insert an umbilical venous catheter if the person administering compressions is standing at the side of the warmer with his arms encircling the chest. Once intubation is completed and the tube is secure, the compressor should move to the head of the bed while the person operating the PPV device moves to the side (Figure 6.2). In addition to providing space for umbilical venous catheter insertion, this position has mechanical advantages that result in less fatigue for the compressor.

Figure 6.2. Compressor standing at the head of the bed

Where do you position your hands during chest compressions?

During chest compressions, pressure should be applied to the lower third of the sternum (Figure 6.3). Place your thumbs on the sternum just below an imaginary line connecting the baby's nipples. Your thumbs should be placed either side-by-side or one on top of the other in the center of the sternum. Do not place your thumbs on the ribs or on the xiphoid. The xiphoid is the small, pointed projection where the lower ribs meet at the midline.

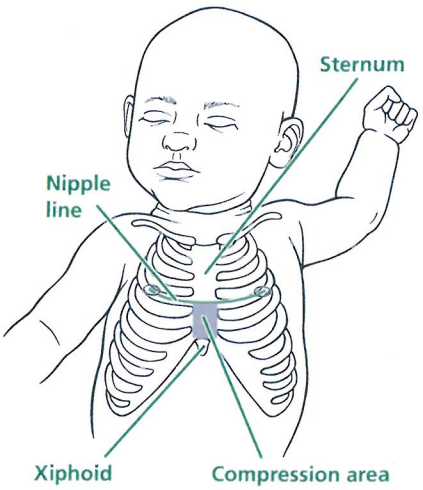


Figure 6.3. Landmarks for chest compressions

Encircle the baby's chest with your hands. Place your fingers under the baby's back to provide support (Figure 6.4). Your fingers do not need to touch.

A B

Figure 6.4. Chest compressions using 2 thumbs from the head of the bed (A) and side of the bed (B). Thumbs are placed over the lower third of the sternum, hands encircling the chest.

How deeply do you compress the chest?

Using your thumbs, press the sternum downward to compress the heart between the sternum and the spine. Do not squeeze the chest with your encircling hands. With your thumbs correctly positioned, use enough pressure to depress the sternum ***approximately one-third of the anterior-posterior (AP) diameter of the chest*** (Figure 6.5), and then release the pressure to allow the heart to refill. One compression consists of the downward stroke plus the release. The actual distance compressed will depend on the size of the baby.

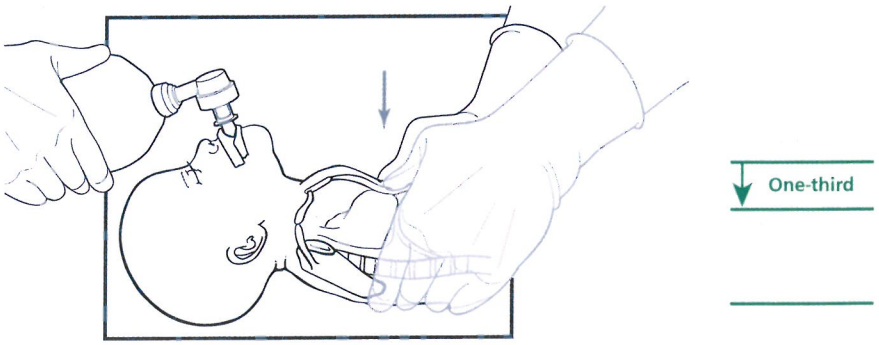


Figure 6.5. Compression depth is approximately one-third of the anterior-posterior diameter of the chest.

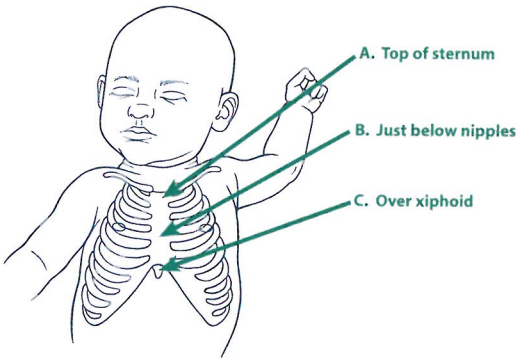
Your thumbs should remain in contact with the chest during both compression and release. Allow the chest to fully expand by lifting your thumbs sufficiently during the release phase to permit the chest to expand; however, do not lift your thumbs completely off the chest between compressions.

Review

1. A newborn is apneic. She does not improve with initial steps, and PPV is started. The first assessment of heart rate is 40 beats per minute. After 30 seconds of positive-pressure ventilation that moves the chest, 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. She does not improve with the initial steps or positive-pressure ventilation. Her heart rate remains 40 beats per minute. An endotracheal tube is placed properly, the chest is moving, bilateral breath sounds are present, and ventilation has continued for another 30 seconds. Her heart rate is still 40 beats per minute. Chest compressions (should)/(should not) be started. Positive-pressure ventilation (should)/(should not) continue.

3. Mark the area on this baby where you would apply chest compressions.



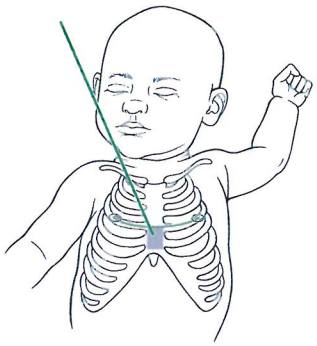
4. The correct depth of chest compressions is approximately
   a. One-fourth of the anterior-posterior diameter of the chest
   b. One-third of the anterior-posterior diameter of the chest
   c. One-half of the anterior-posterior diameter of the chest
   d. Two inches

Answers

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

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

3. Compression area (B) just below the nipples.



4. The correct depth of chest compressions is approximately one-third of the anterior-posterior diameter of the chest.

What is the compression rate?

The compression rate is 90 compressions per minute. To achieve this rate, you will give 3 rapid compressions and 1 ventilation during each 2-second cycle.

How are compressions coordinated with positive-pressure ventilation?

During neonatal cardiopulmonary resuscitation, chest compressions are always accompanied by coordinated PPV. Give 3 rapid compressions followed by 1 ventilation.

Coordinated Compressions and Ventilations
3 compressions + 1 ventilation every 2 seconds

To assist coordination, the person doing compressions should count the rhythm out loud. The goal is to give 90 compressions per minute and 30 ventilations per minute (90 + 30 = 120 "events" per minute). This is a rapid rhythm, and achieving good coordination requires practice.

Learn the rhythm by counting out loud: "*One-and-Two-and-Three-and-**Breathe-and**; One-and-Two-and-Three-and-**Breathe-and**; One-and-Two-and-Three-and-**Breathe-and**...*".

- Compress the chest with each counted number ("*One, Two, Three*").
- Release the chest between each number ("*-and-*").
- Pause compressions and give a positive-pressure breath when the compressor calls out "*breathe-and*".

Inhalation occurs during the "breathe-and" portion of the rhythm, and exhalation occurs during the downward stroke of the next compression. Note that during chest compressions, the ventilation rate is slower than you used when giving only assisted ventilation. This slower rate is used to provide an adequate number of compressions and avoid simultaneous compressions and ventilation.

3:1 Compression:Ventilation Rhythm

*One-and-Two-and-Three-and-**Breathe-and**;*
*One-and-Two-and-Three-and-**Breathe-and**;*
*One-and-Two-and-Three-and-**Breathe-and**...*

What oxygen concentration should be used with positive-pressure ventilation during chest compressions?

When chest compressions are started, increase the oxygen concentration to 100%.

During chest compressions, circulation may be so poor that the pulse oximeter will not give a reliable signal. Once the heart rate is greater than 60 bpm and a reliable pulse oximeter signal is achieved, adjust the oxygen concentration to meet the target oxygen saturation.

When should you check the baby's heart rate after starting compressions?

Wait ***60 seconds*** after starting coordinated chest compressions and ventilation before pausing briefly to reassess the heart rate.

Studies have shown that it may take a minute or more for the heart rate to increase after chest compressions are started. When compressions are stopped, coronary artery perfusion is decreased and requires time to recover once compressions are resumed. It is, therefore, important to avoid unnecessary interruptions in chest compressions because each time you stop compressions, you may delay the heart's recovery.

How should you assess the baby's heart rate response during compressions?

Briefly pause compressions and, if necessary, pause ventilation. An electronic cardiac (ECG) monitor is the preferred method for assessing

heart rate during chest compressions. You may assess the baby's heart rate by listening with a stethoscope or using a pulse oximeter. There are limitations to each of these methods.

- During resuscitation, auscultation can be difficult, prolonging the interruption in compressions and potentially giving inaccurate results.
- If the baby's perfusion is very poor, a pulse oximeter may not reliably detect the baby's pulse.
- An electronic cardiac (ECG) monitor displays the heart's electrical activity and may shorten the interruption in compressions, but slow electrical activity may be present without the heart pumping blood ("pulseless electrical activity"). In the newborn, pulseless electrical activity is treated the same as an absent pulse (asystole).

When do you stop chest compressions?

Stop chest compressions when the heart rate is **60 bpm or higher.**

Once compressions are stopped, return to giving PPV at the faster rate of 40 to 60 breaths per minute.

What do you do if the heart rate is *not* improving after 60 seconds of compressions?

While continuing to administer chest compressions and coordinated ventilation, your team needs to quickly assess the quality of your ventilation and compressions. In most circumstances, endotracheal intubation or laryngeal mask insertion should have been performed. If not, this procedure should be performed now.

Quickly ask each of the following questions out loud and confirm your assessment as a team:

- Is the chest moving with each breath?
- Are bilateral breath sounds audible?
- Is 100% oxygen being administered through the PPV device?
- Is the depth of compressions adequate (one-third of the AP diameter of the chest)?
- Is the compression rate correct?
- Are chest compressions and ventilations well-coordinated?