



Postintubation Procedures

11

Objectives

Cognitive Objectives

- 2-1.36 Describe the indications, contraindications, advantages, disadvantages, complications, equipment, and technique of tracheobronchial suctioning in the intubated patient. (p 230)
- 2-1.38 Identify special considerations of tracheobronchial suctioning in the intubated patient. (p 231)
- 2-1.73 Describe methods of assessment for confirming correct placement of an endotracheal tube. (p 232)
- 2-1.75 Describe the indications, contraindications, advantages, disadvantages, complications, equipment, and technique for extubation. (p 241)

Psychomotor Objectives

- 2-1.82 Perform end-tidal CO₂ detection. (p 236) (Skill Drill 11-2)
- 2-1.89 Perform tracheobronchial suctioning in the intubated patient by selecting a suction device, catheter, and technique. (p 232) (Skill Drill 11-1)
- 2-1.108 Perform extubation. (p 242) (Skill Drill 11-3)

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People often relax once they have intubated a patient, but this is not the time to become complacent! Remember, the goal is oxygenation and ventilation! First, you must ensure that the tube is in the right place, and then you should ensure that it stays there by securing it properly. Of course, the patient must be ventilated effectively. Finally, you must ensure that the tube and airways remain free from solid or liquid obstructions. The order and priorities of these postintubation procedures will be dictated by the situation, and require judgment and experience.

Tracheobronchial Suctioning

After a patient has been intubated, it is important to ensure that you are able to provide adequate ventilation and oxygenation. Copious secretions in the trachea and upper airway that are not removed will be forced into the lungs during ventilation, thus impairing adequate ventilation and oxygenation. As a result, hypoxia will develop and the patient's condition could potentially worsen. This is a situation that can easily be avoided by suctioning the trachea via the endotracheal tube (► Skill Drill 11-1).

Suction Apparatus

Either a fixed or portable mechanical suction device can be used when performing tracheobronchial suctioning. Fixed suction devices are permanently mounted on the wall of the ambulance and operate off of the vacuum generated by the vehicle engine's manifold (▼ Figure 11-1). Fixed suction devices should be capable of furnishing an air intake of at least 40

L/min and a vacuum of at least 300 mm Hg when the suction tubing is occluded or clamped.

The fixed suction device should be mounted in a location where it is easily accessible should tracheobronchial suctioning need to be performed during transport of the patient. In most ambulances, the device is mounted to the immediate right of the patient's head.

The portable mechanical suction device, whether it is powered by oxygen, air, or electricity, should be able to furnish an air intake of at least 20 L/min in order to be effective (▼ Figure 11-2).

Suction Catheters

For tracheobronchial suctioning, the soft, flexible suction catheter, also called a "whistle-tip" catheter, should be used (► Figure 11-3). The **whistle-tip catheter** is designed to slide down the endotracheal tube easily. It has holes on the side and molded ends that will minimize trauma of the tracheal and



Figure 11-1 Fixed suction device.



Figure 11-2 Portable mechanical suction device.



Figure 11-3 Whistle-tip suction catheter.

bronchial walls. A port on the proximal end of the catheter is occluded with the thumb to generate suction. Prior to performing tracheobronchial suctioning, the whistle-tip catheter should be prelubricated with a water-soluble gel.

Special Considerations

It is important to realize that any time suctioning is performed, especially via the endotracheal tube, ventilations must be interrupted; therefore, it is imperative to limit tracheobronchial suctioning to a maximum of 15 seconds. Additionally, if the patient is not already on a cardiac monitor, one should be applied in order to monitor the patient for hypoxia-related cardiac arrhythmias, which can occur during the suctioning procedure. The patient's oxygen saturation level should also be monitored with a pulse oximeter. If arrhythmias develop or the level of oxygen saturation begins to drop, suctioning must be discontinued immediately and ventilations resumed, even if you have not cleared all secretions.

Preoxygenation

Prior to performing **tracheobronchial suctioning**, the patient must be preoxygenated for at least 5 minutes (► Figure 11-4). Preoxygenation of the patient with 100% oxygen will minimize the risk of significant hypoxia during the procedure.

Suctioning Technique

Prior to performing tracheobronchial suctioning, it may be necessary to inject 3 to 5 mL of sterile water or saline down the endotracheal tube in order to loosen any thick secretions. After preoxygenating the patient as previously described, the suction catheter is gently inserted into the endotracheal tube using sterile technique, until resistance is felt. Resistance indicates that the tip of the catheter is

Case Study

Case Study, Part 1

You and your paramedic partner are dispatched to a residence for a 50-year-old man in acute respiratory distress. When you enter the residence, you find the patient in obvious distress, sitting upright on the corner of his bed. Cyanosis is noted around the patient's lips as are traces of dried blood. He tells you that he was suddenly awakened by the feeling that he was "suffocating." The fire department, with first responders, arrives at the scene a short time later.

You make the following determinations on your initial assessment:

Initial Assessment

Recording time
0 minutes

Appearance

Leaning forward, struggling to breathe

Level of consciousness

Appears alert

Airway

Coarse rhonchi are audible without a stethoscope.

Breathing

His ventilations are rapid and labored.

Circulation

A weak, rapid radial pulse is detected.

Question 1: On the basis of your initial assessment findings, what is your immediate management for this patient?

CASE STUDY



Figure 11-4 Preoxygenate the patient.

Skill Drill

11-1 Performing Tracheobronchial Suctioning



1 Check, prepare, and assemble your equipment.



2 Lubricate the suction catheter.



3 Preoxygenate the patient.



4 Detach the ventilation device and inject 3 to 5 mL of sterile water down the endotracheal tube.

about at the level of the carina. Suction is then applied while removing the catheter by occluding the proximal port. You should rotate the catheter as suction is being applied. *Remember to suction only while you are withdrawing the catheter and for no longer than 15 seconds.*

After suctioning has been completed, immediately reconnect the ventilation device to the endotracheal tube and resume ventilation and oxygenation. Should you need to resuscitate the patient, preoxygenation should occur for at least 30 seconds.

Determining Tube Placement

The most difficult part of intubating is the decision-making processes surrounding the procedure, not the procedure itself. The first challenge is to determine when to intubate. In some cases the answer is obvious, whereas in others it may be difficult to weigh the relative benefits and risks. The next challenge, which is even more important, is to determine exactly where the tube is. In some cases its location is obvious, but in other cases the findings can be



5 Gently insert the catheter into the endotracheal tube until resistance is felt.



6 Suction in a rotating motion while withdrawing the catheter. Monitor the patient's cardiac rhythm and oxygen saturation during the procedure.



7 Reattach the ventilation device and resume ventilation and oxygenation.

conflicting or confusing. Incorrectly interpreting assessment findings about a tube's position can place the patient in tremendous jeopardy.

In this age of high technology, it is unfortunate that a method of rapidly confirming an endotracheal tube's placement with absolute certainty has not yet been developed. **No single test for endotracheal tube placement is 100% accurate.** A lot of new "gadgets" have been invented, but they all have limitations. Each test has to be evaluated on its sensitivity and specificity. Sensitivity is the probability

Paramedic Safety Tip

Unrecognized esophageal intubation is lethal. Failure to recognize that the endotracheal tube was either placed into or has moved into the esophagus is inexcusable and indefensible. When you take the responsibility of intubating a patient, you also assume responsibility for ensuring that the tube is properly placed and that it remains in the trachea.

Paramedic Safety



Even if you put the tube in the trachea initially, it can become dislodged. Tubes (especially uncuffed pediatric tubes) *commonly* slip out of the trachea when you are removing the laryngoscope blade or securing the tube, or during ventilation or moving the patient. Simply flexing or extending the patient's head can move the tube tip as much as 5 cm, and rotation causes tube movement also. Many people advocate the immobilization of intubated patients with a cervical collar and head immobilization device to limit movement of the head, and thereby decrease the likelihood of the tube slipping out of the trachea while the patient is being moved.

that the test will correctly identify when the tube is in the trachea (the number of true positive results). Specificity is the probability that the test will correctly identify when the tube is not in the trachea (the number of true negative results).

The best way to be confident about the tube's location is to use a combination of different assessments to increase the accuracy of your interpretation. Do not be lulled into a false sense of security by relying on only one test to make a decision that is so important to the patient's survival.

Visualization

When you are performing endotracheal intubation by **direct laryngoscopy**, watching the tube pass through the cords is an important part of verifying that the tube is placed into the trachea. Unfortunately, you cannot always get a clear view of the glottic opening, and in some cases you cannot watch the tube actually pass through the cords. The tube may also become dislodged by removal of the laryngoscope. The fact that a tube was initially placed properly does not mean that it will stay in place.

Repeat visualization is an excellent way to reconfirm tube placement, but it is not as simple as some people think. If visualization was difficult in the first place, it will likely be difficult on subsequent attempts to confirm placement, when visualization is really useful. A technique to improve visualization of the glottic opening in intubated patients is to gently displace the tube posteriorly toward the palate. This action alters the direction of the tube and provides a better view of the passage of the tube through the vocal cords.

Another visualization technique uses a **bronchoscope**. The bronchoscope is inserted through the lumen of the endotracheal tube to identify the tracheal rings. The bronchoscope can also be used as an intubation guide for patients with an anticipated difficult airway. The use of fiberoptic bronchoscopes is effective for intubation confirmation, but this equipment is expensive and quite delicate, making it impractical in most prehospital settings.

Auscultation

Auscultation is an important part of confirming proper tube placement but can be difficult. Unfortunately, underlying pathologic conditions and large patient size can yield confusing or misleading findings. Because breath sounds are transmitted throughout the thoracic cage, they are more clearly transmitted through smaller patients with thinner chest walls. In obese patients, the large amount of chest wall tissue represents a significant barrier for the sound to traverse. Traumatic injuries (such as pneumothorax or obstructions), medical conditions (such as chronic obstructive pulmonary disease, bronchospasm, or pulmonary edema), or surgical interventions (such as pneumonectomy) can all make auscultation more difficult.

The movement of air through the esophagus may sound like adventitious breath sounds. The presence of gastric sounds does not always indicate esophageal intubation. Gastric distention that is present may have occurred prior to intubation.

To be effective, listen to the chest in at least six places: the right and left apices in the midclavicular line, the right and left bases in the midaxillary line, over the epigastrium, and at the sternal notch. You should hear bilaterally equal sounds in all lung fields, a quiet stomach, and a rush of air with ventilation at the sternal notch. More than any single auscultatory finding, gurgling in the stomach most likely indicates esophageal intubation. If you suspect esophageal intubation, immediately stop ventilating the patient and remove the tube.

There are two possible ways to auscultate to confirm tube placement:

1. If you are auscultating after direct laryngoscopy and you had good visualization of the tube passing through the cords, you are fairly confident that the tube is properly placed. In this case, listen to the left base first. If you hear breath sounds there, check the right base, left apex, right apex, stomach, and sternal notch. If you hear no breath sounds at the left base, check the stomach next. If you hear gurgling, remove the tube.

If the stomach is quiet, but you have breath sounds on the right side and not the left side, the right mainstem has been intubated. Place the stethoscope over the left apex, and auscultate as you ventilate while slowly withdrawing the tube. As breath sounds return to the left side, secure the tube.

2. If you are auscultating after direct laryngoscopy and had poor visualization or are using a blind technique (nasal or digital), check the epigastrium first. If it is quiet, check the four lung fields and the sternal notch.

Observation and Palpation of the Chest

Observing the rise and fall of the chest provides some indication of tube placement. If the chest moves symmetrically during each ventilation, this suggests proper tube placement. Placing your hands on the thoracic cage provides additional tactile information: both sides of the patient's chest should expand equally with ventilation. You should palpate the thoracic cage to feel the separation of the ribs with chest expansion.

Chest wall movement can be very difficult to detect in obese patients, women with large breasts, patients with rigid chest walls, and patients with poorly compliant lungs. Endotracheal tubes that have been placed in the esophagus can result in the inflation and deflation of the stomach and/or esophagus, which can cause the chest wall to move in a way that mimics the movements associated with lung ventilation.

End-Tidal Carbon Dioxide

The continual presence of carbon dioxide in the patient's exhaled breath is the established standard for confirming endotracheal tube placement.

End-tidal carbon dioxide (CO₂) has become the standard for determining placement in the operating room (▼ Figure 11-5). Because no respiration occurs in



Figure 11-5 End-tidal CO₂.

Case Study

Case Study, Part 2

You place the patient on a non-rebreathing mask set at 15 L/min. As your partner is applying a cardiac monitor, you complete a focused history, physical examination, and baseline vital signs. Your findings are recorded as follows:

Physical Examination

Recording time

2 minutes after patient contact

Level of orientation

Alert

Head

Cyanosis around the lips, coughing up blood-tinged sputum

Neck

Accessory muscle use

Chest

Unremarkable

Lung sounds

Coarse rhonchi in both bases with scattered rales and rhonchi to both apices

Abdomen

Soft and nontender

Pelvis

Unremarkable

Extremities

Moves all extremities

Back

Unremarkable

History

Age, sex, weight

50-year-old man, 75 kg

Signs and symptoms

Patient complains of acute onset of shortness of breath that woke him from sleep.

Allergies to medications

Codeine, aspirin

Medications taken

Vasotec (Enalapril maleate)
Digoxin (Lanoxin)
Furosemide (Lasix)

Past pertinent medical history

Hypertension, acute myocardial infarction, congestive heart failure

Last food/fluid intake

Ate supper approximately 8 hours earlier

Events prior to onset

No sentinel events reported

Onset of symptoms

Sudden, while sleeping

Provoking/palliative factors

The patient reports a 2-day history of exertional intolerance and generalized weakness.

Quality of discomfort

The patient is clearly in distress. He denies having pain.

Radiating/related signs/symptoms

Patient is coughing up secretions that are tinged with blood.

Severity of complaint

The respiratory distress is worse, even more so than when he called EMS.

Time

The episode began 20 minutes ago.

Vital Signs

Skin signs

Pale, cool, dry

Pulse rate/quality

120 beats/min, regular

Blood pressure

160/94 mm Hg

Respiratory rate/depth

28 breaths/min, significantly labored

Pupils

Equal, reactive

SpO₂

83% (100% oxygen)

Electrocardiogram

Sinus tachycardia

Question 2: Is the management that you are providing for this patient producing a noted improvement in his condition?

Question 3: Should you consider a more aggressive management approach? Why?

Skill Drill

11-2 Performing End-Tidal CO_2 Detection



1 Detach ventilation device from the endotracheal tube.



2 Attach in-line capnograph or capnometer to proximal adaptor of the endotracheal tube.



3 Reattach the ventilation device to the endotracheal tube and resume ventilations.



4 Monitor the capnograph or capnometer for appropriate reading (appropriate color change or digital reading).

the stomach, the presence of carbon dioxide indicates that the tube is in the trachea. The continual presence of more than 2% carbon dioxide (corresponding to approximately 15 mm Hg) in the exhaled breath is considered a positive finding.

In theory, carbonated beverages or antacids in the stomach could produce false-positive results. Although this does occur, the carbon dioxide from these sources is quickly vented from the stomach and is not replaced. Therefore, it is generally considered that carbon dioxide in exhaled breath after six breaths strongly suggests tracheal tube placement. The most likely cause of a false-positive result is from the tube not being inserted far enough into

the trachea. In the case of a supraglottic placement of the tube, there will still be carbon dioxide in the exhaled breath yet positive control of the airway does not exist. The risk of tube dislodgement is great, and the risk of aspiration remains.

The most common cause of a false-negative result is a significant disruption in pulmonary blood flow. It takes a severe interruption in pulmonary blood flow to drop the concentration of carbon dioxide in the exhaled breath below 2%, but the concentration in many emergency patients falls into this category. The most common situation occurs in cardiac arrest. In this state of very low blood flow, pulmonary perfusion is often insufficient to increase carbon dioxide levels

above 2%. In fact, it has been suggested that end-tidal CO₂ indicates the amount of cardiac output generated by compressions during cardiopulmonary resuscitation. The amount of end-tidal CO₂ has even been correlated with the likelihood of successful resuscitation.

Other causes of interrupted pulmonary blood flow that are sufficient enough to cause false-negative results are low cardiac output, hypotension, pulmonary embolism, and severe bronchospasm. Therefore, the continual presence of end-tidal CO₂ (greater than 15 mm Hg, or 2%) almost guarantees that the tube is not in the esophagus, but the absence of end-tidal CO₂, however, does not mean that the tube is in the esophagus. The patient may not be generating enough carbon dioxide to register a positive result, as is often the case during cardiac arrest. Two devices are generally used to measure end-tidal CO₂—the capnometer and the capnographer.

Capnometer

A **capnometer** simply measures the amount of carbon dioxide in expired gas. Capnometers are either colorimetric or electronic.

Colorimetric Capnometers

The colorimetric capnometer, also known as an end-tidal CO₂ detector, is a simple and ingenious device that uses a chemical reaction of carbon dioxide to detect its presence in the exhaled gas. In the presence of carbon dioxide, metacresol purple changes color to yellow. If a piece of filter paper containing metacresol purple is placed in-between the endotracheal tube and the ventilation device, the paper will turn from purple to yellow if the carbon dioxide concentration is greater than 2% in the exhaled breath (◀ **Skill Drill 11-2**). This chemical reaction is very rapid and should occur with each breath.

Unfortunately, colorimetric capnometers do not make quantitative measurements. With more than 2% carbon dioxide in the gas sample, the color change is dramatic and usually obvious in well-lit environments (some adjustment may be needed for incandescent lights by using an alternative color chart). The filter will not change at all when exposed to a concentration of carbon dioxide of less than 0.05%. In carbon dioxide concentrations between 0.05% and 2%, the chemical reaction is incomplete and may indicate poor pulmonary perfusion or improper tube placement. It is generally recommended that such an intermediate color change after 6 breaths requires confirmation of tube placement using other techniques.

The colorimetric capnometer has some limitations. The end-tidal CO₂ detector is not affected by temperature but is affected by humidity. The device becomes ineffective when exposed to room air for more than a few hours and after about 15 minutes of

Case Study

Case Study, Part 3

Noting that oxygen by nonbreathing mask is not producing a notable improvement in the patient's condition, you begin assisting ventilations with a BVM device attached to 100% oxygen. The patient does not resist. Your partner and a first responder load the patient into the ambulance and begin transport to the hospital, which is approximately 20 minutes away. You request that the first responder accompany and assist you in the back of the ambulance. You reassess the patient's condition and vital signs:

Ongoing Assessment

Recording time

7 minutes after patient contact

Initial assessment

You note decreased compliance with bag-valve-mask ventilations. The patient continues to produce blood-tinged secretions.

Intervention reassessment

Diffuse coarse rhonchi are now audible in all lung fields.

Any other changes

The patient's level of conscious has markedly decreased.

Vital Signs

Skin signs

Remains pale, cool, and dry

Pulse rate/quality

132 beats/min, regular

Blood pressure

156/88 mm Hg

Respiratory rate/depth

30 breaths/min, assisted with BVM device

Pupils

Dilated, but reactive

SpO₂

86% (with BVM ventilation and 100% oxygen)

Electrocardiogram

Sinus tachycardia

Question 4: On the basis of your ongoing assessment findings, what intervention should you consider at this point?

Question 5: Are there additional interventions that might improve this patient's condition?

continual ventilation. It should not be used with humidified breathing gas. The color change is apparent in fluorescent light but has to be adjusted for incandescent light. The color change can be difficult for colorblind individuals to detect.

Electronic Capnometers

Electronic capnometers detect and calculate the amount of carbon dioxide in the exhaled breath. These devices calculate this information very quickly and accurately, providing a real-time indication of the patient's carbon dioxide levels. With modern electronics these devices are now smaller,

more reliable, cheaper, and lighter than they have been in the past.

Electronic capnometers usually have an adapter that fits between the endotracheal tube and the ventilation device. The amount of carbon dioxide is displayed quantitatively or with a bar graph of LED lights.

The major advantage of electric capnometers is that they quantify the carbon dioxide. This is not only valuable for the verification of endotracheal tube placement but also provides an approximation of PaCO₂. In most cases, end-tidal CO₂ is about 5 to 6 mm Hg below PaCO₂. This information makes it possible and practical to adjust minute volume (by altering ventilatory rate and/or volume) to maintain normal PaCO₂ during ventilation. End-tidal CO₂ becomes an unreliable approximation of PaCO₂ in cases of significant ventilation-perfusion mismatch (V-Q mismatch).

Capnograph

A **capnograph** instantly plots the level of carbon dioxide in a gas sample on a printout known as a capnogram. The information from the capnogram allows you to track trends in the end-tidal CO₂ and quickly identify problems that would not be obvious in a simple quantitative reading. Any pattern on the capnogram that is irregular and oscillating, always returning to baseline between breaths, should alert you to a potential problem.

Some capnographs are bulky, requiring calibration, a warm-up period, paper, and AC power. These types are obviously not practical for prehospital use. Newer models are now small, light, and battery operated. Some manufacturers are even incorporating capnography into other monitors (such as an electrocardiogram monitor). The capnograph has great potential for use not only in verifying tube placement, but in guiding ventilation rate and depth.

The Esophageal Detection Device

The trachea is a rigid structure that is essentially noncollapsible. In contrast, the esophagus is a flaccid tube that expands only when something is placed into it. Because of this anatomic distinction, you cannot draw air when negative pressure is applied to the tip of an endotracheal tube placed in the esophagus because the walls of the esophagus will occlude the tip of the tube. In contrast, the trachea, being rigid, will not form an airtight seal with the tip of an endotracheal tube subjected to negative pressure. You can draw air from the lungs by applying negative pressure.

The simple anatomic distinction is the basis for the **esophageal detection device (EDD)**. The EDD is a bulb or syringe with a 15/22-mm adapter. The syringe is attached to the end of the endotracheal tube. The plunger is withdrawn, creating negative pressure. If the tube is in the trachea, air is easily drawn into the syringe and the plunger does not move when released. If the tube is in the esophagus, a vacuum is created as you withdraw the plunger, and the plunger moves back toward zero when released.

With the bulb model, the bulb is collapsed and then attached to the end of the endotracheal tube. If it remains collapsed, the tube is in the esophagus. If the bulb briskly expands, the tube is properly positioned in the trachea.

The main limitation of the EDD is that gastric or esophageal air may fill the bulb or syringe. It is important therefore to apply the device before ventilation has begun. The bulb must be collapsed before being connected to the tube as well, because squeezing it while it is attached to the tube would instill a small amount of air that could theoretically cause a false-positive result. There is a low incidence of false-negative results in very obese patients. The EDD cannot detect mainstem intubation or oropharyngeal placement.

Transillumination

In most patients the tissue overlying the trachea is relatively thin. If a bright bulb is positioned at the tip of a properly placed endotracheal tube, a point of light should be visible in the midline of the neck, at the level of the sternal notch. A number of commercially available devices use **transillumination** for confirmation of tube placement and for intubating. When used as a tube confirmation technique, a bright light is positioned at the tip of the inserted endotracheal tube. A tightly circumscribed light visible through the tissue of the neck at the midline strongly suggests proper tube placement.

A main advantage of transillumination is the ability to judge the depth of insertion. The proper location for the tip of the tube is halfway between the glottic opening and the carina. The sternal notch is the external landmark for this location. When you are placing an endotracheal tube under direct visualization, the proper depth of insertion is estimated by advancing the proximal end of the cuff 1 to 2 cm beyond the glottic opening, typically to a depth of 21 to 23 cm in an adult of average height. With transillumination, you can adjust the depth of the endotracheal tube until the light is right at the sternal notch. The main disadvantage of transillumination

is the fact that it can be difficult to see the light in obese, bullnecked patients or in situations where ambient light is particularly bright.

Miscellaneous Techniques for Determining Tube Placement

The best assurance that a patient is properly intubated is to use a combination of verification techniques. Although the following techniques are generally not reliable enough to be used individually, they provide important confirmatory information. When those techniques are combined with other verification techniques, the confidence that you have in the interpretation of the results will be increased.

As a patient passively exhales, the gas from the lungs is warm and moist. If the tube is properly positioned in the trachea, mist will form on the inside of the tube. Unfortunately, misting can also sometimes occur in a patient who has a significant amount of gastric air who has been esophageally intubated. Even when the tube is correctly positioned, mist may not form in a hot, humid environment.

When the tube is in the trachea, there will be a small “puff” of exhaled air as the patient’s sternum is depressed. This can be heard or felt at the proximal end of the tube during external chest compressions.

If the tube is properly placed, a pressure wave in the pilot balloon can be felt when a gentle force is applied to the trachea just above the sternal notch. An assistant who is providing the Sellick maneuver often can feel the tube pass through the cricoid ring into the trachea. Because of the ridges in the wall of the trachea, this sensation has been described as “washboardlike.”

If the patient’s SpO₂ improves, the tube is likely in the trachea. The SpO₂ can improve, however, in a spontaneously breathing patient who is esophageally intubated. Furthermore, it is hard to obtain saturation in pulseless patients, and readings below 80% can be inaccurate.

Regurgitation of stomach contents through the endotracheal tube indicates that the tube is in the esophagus. Some patients have copious tracheal secretions, but these should be easily distinguished from vomitus.

If the patient is able to make any noise (such as talk, grunt, or moan) by moving air past the vocal cords, the tube is in the wrong place and should be immediately removed. This rule does not apply to pediatric patients intubated with uncuffed tubes.

▼ **Table 11-1** summarizes these techniques and their false-positive and false-negative findings.

Table 11-1
Errors of Tests Used to Determine Endotracheal Tube Placement

	False-Positive Findings	False-Negative Findings
Visualization	<p>Tube may slip out after visualization</p> <p>Poor visualization</p> <p>Misinterpretation of anatomic landmarks</p>	<p>Misinterpretation of anatomic landmarks</p>
Observation/palpation of the chest	<p>Gastric ventilation causing chest wall movement</p>	<p>Limited chest wall mobility in poorly compliant lungs</p> <p>Difficult to detect chest wall movement in obese, barrel-chested, or large-breasted patients</p>
Breath sounds	<p>Gastric sounds can mimic breath sounds</p> <p>Transmitted breath sounds</p> <p>Transmitted bronchial sounds</p>	<p>Difficult to hear in obese patients, traumatic injuries, pneumothorax, obstructions, COPD, bronchospasm, pulmonary edema, pneumonectomy</p>

Ventilating the Intubated Patient

Effective ventilation is a real art. It requires experience, attention to detail, and a certain touch. Once a patient is intubated, ventilation becomes much easier. In fact, increased efficiency of ventilation is one of the main reasons to intubate. Nonetheless, ventilation technique is still important after the patient has been intubated.

When the patient has been endotracheally intubated, none of the air forced into the mouth goes to the stomach, but it is still necessary to deliver the ventilatory volume slowly, over 1 to 2 seconds. A slow inspiratory time reduces the airflow and hemodynamic complications of positive pressure ventilation and keeps intrapulmonary pressure low, reducing the chances of barotrauma.

Another advantage of ventilating the intubated patient is that you no longer have to worry about the mask seal. The cuff on the endotracheal tube provides a virtually airtight seal. With an intubated patient the dead space of the mask is eliminated, and you can usually decrease the ventilation volume to 5 to 7 cc/kg.

The 15/22-mm adapter on the end of the endotracheal tube is a universal connector to all ventilation equipment. In emergency medicine, there are a number of options for ventilating the intubated patient, as described in the following sections.

Bag-Valve-Mask Device

Bag-valve-mask ventilation is the most common method of ventilating intubated patients in emergency care. You will often use the **bag-valve-mask (BVM) device** while moving patients and while awaiting a ventilator. In addition to being fast, ventilation with a BVM device provides a “feel” for the breathing. You can judge the **compliance** of the lungs, possibly becoming alert to significant bronchospasm or an evolving pneumothorax. You can feel the rattling and gurgling of fluid or mucous obstructions and the need for tracheobronchial suctioning.

One of the biggest advantages of the BVM device lies in the ventilation of breathing patients. You can time your ventilations to the patient’s own breathing pattern. If the minute volume is inadequate, you can increase the patient’s tidal volume by gently squeezing the bag during inhalation and/or interspersing breaths between the patient’s own breaths, thereby increasing the respiratory rate.

The main disadvantage of BVM ventilation is that it requires one person to be constantly vigilant about ventilation. The ventilator cannot be distracted by other tasks and interrupt ventilations.

The BVM device is also a bit awkward. If the ventilator is not paying close attention, the tube can inadvertently be moved.

The Flow-Restricted, Oxygen-Powered Ventilation Device

The **flow-restricted, oxygen-powered ventilation device (FROPVD)**, also referred to as a **manually triggered automatic ventilator (MTV)**, can be used to ventilate an intubated patient. The FROPVD is a valve that attaches to an oxygen regulator and provides 100% oxygen at constant flow rate of 60 L/min when a button is depressed. The constant flow keeps intrapulmonary pressure reasonably constant throughout the ventilation. The FROPVD has a pressure valve that prevents ventilation pressures in excess of 40 cm of water, which may decrease the incidence of **barotrauma**. The controlled flow rate and pressure relief are particularly important in cases of chest trauma. Any form of positive pressure ventilation will likely increase the size of a preexisting pneumothorax, but the flow restriction afforded by the FROPVD may keep the increase in intrapleural air minimal.

The FROPVD can be triggered in two ways. For nonbreathing patients, a button on the device is depressed, opening the valve, and starting the flow of oxygen. For breathing patients, the device is triggered by intrinsically generated negative pressure. It can therefore be attached to the endotracheal tube of a breathing patient to provide 100% oxygen. As with the BVM device, the minute volume can be increased if the patient is hypoventilating by increasing the rate and/or volume of the breaths.

One disadvantage of ventilating intubated patients with the FROPVD is the loss of the “feel” for the ventilations. The FROPVD also requires one person to be dedicated to ventilating the patient. Finally, the flow restriction and pressure pop-off may make it impossible to ventilate a patient with poor lung compliance, increased airway resistance, or a heavy chest wall. The FROPVD is not recommended for the ventilation of children.

Automatic Transport Ventilator

The **automatic transport ventilator (ATV)** has a number of advantages over the FROPVD and the BVM device. After you set the tidal volume and respiratory rate of the ATV, it will ventilate the patient automatically. With the ATV, one person need not be dedicated to ventilation. Most ATVs do not allow patients to control their own breathing, however, which can be very upsetting to conscious patients able to breathe on their own.

Paramedic Safety

Accidental extubation can occur if the BVM device pulls on the tube. It is strongly recommended that the BVM device be disconnected when it is not being used (such as during patient movement or defibrillation).

Ventilator

A ventilator is frequently used to ventilate patients after the emergency phase of care. Ventilators allow precise control of all the variables of ventilation. Ventilators are used on both breathing and apneic patients. Some ventilator settings require that the patient do some of the work of breathing. These settings can be used to help “wean” patients off ventilatory dependence. The proper setup and use of ventilators is beyond the scope of this book, but you should know the basic functions of ventilators used in your facility.

Extubation in Emergency Medicine

Extubation is the process of removing the tube from an intubated patient (► [Skill Drill 11-3](#)). In the critical care environment, the decision to extubate a patient is very complicated and depends on many factors. It may take days or weeks to wean a patient off of a ventilator and be confident that the person will be able to ventilate and maintain his or her own airway. The decision to extubate the critical care patient is beyond the scope of this book.

In emergency medicine we rarely extubate patients. The major indication for extubation is when the patient’s level of consciousness improves and he or she begins gagging on the tube. In general,

Teamwork

It takes considerable effort to coordinate the efforts of the rescuers managing an advanced airway such as an endotracheal intubation. Determining roles of various team members prior to the actual call is useful in minimizing confusion at the scene.

Case Study

Case Study, Part 4

You perform endotracheal intubation on this patient as his condition is clearly not improving with basic airway management. The ambulance is briefly stopped and your partner assists you in the back. After sedating the patient, you successfully place the endotracheal tube. Correct placement is confirmed by auscultation of the lungs and an end-tidal CO₂ detector. Because of the obvious fluid in the lungs and the secretions evident in the endotracheal tube, you decide to perform tracheobronchial suctioning. The patient’s condition is improved following intubation and suctioning. You arrive at the hospital approximately 5 minutes later and give your report to the charge nurse. His last set of vital signs are noted below:

Vital Signs

Recording time
35 minutes after patient contact

Skin signs

Pink, cool, and dry

Pulse rate/quality

94 beats/min, regular

Blood pressure

128/66 mm Hg

Respiratory rate/depth

24 breaths/min, intubated

Pupils

Equal and reactive

SpO₂

94% (intubated with ventilatory assistance)

Electrocardiogram

Normal sinus rhythm

The patient is later admitted to the hospital, with a diagnosis of acute exacerbation of his congestive heart failure.

CASE STUDY

it is better to sedate the patient than to remove the tube, but this may not be an option in some systems or in patients who are hemodynamically unstable.

There are a number of risks in extubating emergency patients. The most obvious is overestimating the ability of the patient to protect his or her own airway. Once you remove the tube, there is no guarantee that you will be able to replace it. Patients who are awake are at a high risk for laryngospasm upon removal of an endotracheal tube, and most patients experience some degree of upper airway swelling because of the trauma of having a tube in their throat. These two facts, complicated by the

Skill Drill

11-3 Performing Extubation



1 Hyperoxygenate the patient.



2 Ensure that ventilation and suction equipment are immediately available.



3 Confirm patient responsiveness.



4 Lean the patient forward.

ever-present possibility of vomiting, make reintubation challenging, and maybe impossible. These risks must be factored against the benefit of removing the tube.

Field extubation is indicated when the patient is able to protect and maintain the airway, the patient is not sedated, and you are confident that you will be able to ventilate and reintubate if necessary. Field extubation should never be performed if there is a risk of continued or recurrent respiratory failure.

Keep in mind that postextubation vomiting and/or laryngospasm is possible.

Field extubation is accomplished by first hyperoxygenating the patient. Discuss the procedure with the patient, and explain what you are going to do. If possible, it is best to have the patient sit up, or lean slightly forward. Be sure to assemble and have available all equipment to suction, ventilate, and reintubate, if necessary. After you have confirmed that the patient remains responsive enough to protect his or



5 Suction the oropharynx.



6 Deflate the distal cuff of the endotracheal tube.



7 Remove the endotracheal tube upon cough or when the patient exhales.

her own airway, suction the oropharynx to remove any debris or secretions that may threaten the airway. Deflate the cuff on the endotracheal tube at the beginning of an exhalation so that any accumulated secretions just above the cuff are not aspirated into the lungs. On the next exhalation, remove the tube in one steady motion, following the curvature of the airway. You may find it useful to hold a towel or emesis basin in front of the patient's mouth, in case the patient gags or vomits.

Paramedic Safety Tip

There are a number of risks in extubating emergency patients. The most obvious is overestimating the ability of the patient to protect his or her own airway.



Chapter Summary

Tracheobronchial suctioning may need to be performed in order to keep the airway clear of secretions and prevent unnecessary hypoxia. Remember to limit suction time to 15 seconds and to monitor the patient's cardiac rhythm, oxygen saturation, or both.

Accurate placement of an endotracheal tube can only be ensured with accurate confirmation techniques. The use of two or more techniques to confirm proper tube placement is highly recommended.

There are a variety of methods and equipment to ventilate a patient who has been intubated. Be very familiar with the equipment that you will be using in your practice in order to be able to manage it effectively and troubleshoot quickly.

In emergency medicine we rarely extubate patients. If you must extubate, be sure that you will be able to ventilate and reintubate if necessary.

Vital Vocabulary

auscultation The technique of listening to certain activities in the body with a stethoscope that would otherwise be inaudible, such as the blood pressure or breath sounds.

automatic transport ventilator (ATV) A special ventilation device that provides automatic positive pressure ventilation, thus freeing up the rescuer. The ATV can be set to deliver a certain rate of ventilations as well as a specific tidal volume.

bag-valve-mask (BVM) device A basic airway device used to provide positive pressure ventilations to apneic or inadequately breathing patients. When used in conjunction with supplemental oxygen, an oxygen reservoir, and an effective mask-to-face seal, approximately 90% to 100% oxygen concentrations can be delivered.

barotrauma Trauma caused by increased pressure, such as when the lungs are overinflated, resulting in damage.

bronchoscope A fiberoptic device typically used to visualize the bronchi. It can be used as a guide for intubation, or as a tube confirmation device.

capnograph An electronic device that plots the level of carbon dioxide in a gas sample on a printout known as a capnogram.

capnometer An electronic or colorimetric device that measures end-tidal CO₂.

compliance From an airway management standpoint, compliance refers to the level of resistance of the lungs during positive pressure ventilation.

direct laryngoscopy The technique of directly viewing the upper airway anatomy (such as the vocal cords) with a laryngoscope. This technique is used to visualize the vocal cords during endotracheal intubation as well as to visualize and remove a foreign body airway obstruction.

end-tidal carbon dioxide (CO₂) The measurement of the amount of carbon dioxide in exhaled breath.

esophageal detection device (EDD) A bulb or plunger device that uses negative pressure to determine whether an endotracheal tube has been inadvertently placed in the esophagus.

extubation Technically, removing any tube in the body. In the context of airway management, it typically refers to the removal of an endotracheal tube.

flow-restricted, oxygen-powered ventilation device (FROPVD) A manually triggered ventilation device that can be used on both apneic patients and breathing patients. The FROPVD delivers a high volume and concentration of oxygen at 60 L/min.

manually triggered automatic ventilator (MTV) A term that is used synonymously with FROPVD.

tracheobronchial suctioning The technique of inserting a flexible suction catheter into the endotracheal tube to remove secretions from the trachea and bronchi.

transillumination Illumination achieved by passing bright light through tissue.

whistle-tip catheter A flexible suction catheter that has molded ends, side holes, and an occlusion port on its proximal end. Used for performing tracheobronchial suctioning.

Case Study Answers

Question 1: On the basis of your initial assessment findings, what is your immediate management for this patient?

Answer: Clearly, this patient's condition (labored breathing, weak and rapid pulse) warrants 100% oxygen, which is initially accomplished with a nonbreathing mask at 15 L/min. Because of the patient's severely labored breathing, you must be prepared to initiate assisted ventilations with a BVM device. The patient is conscious at this point, so he is likely to resist this. However, if his condition does not improve with supplemental oxygen, assisted ventilations will be required. Regardless of his mental status, you will have to instruct the patient that every time he breathes, you will squeeze the BVM device. This procedure is generally not well tolerated in conscious patients, but with coaching and reassurance, patient compliance can be achieved.

Question 2: Is the management that you are providing for this patient producing a noted improvement in his condition?

Answer: No! Despite 100% supplemental oxygen via nonbreathing mask, his oxygen saturation is only 83%. This is likely the result of inadequate tidal volume secondary

to his labored breathing. A weak, rapid pulse and pale, moist skin reinforces that the patient is hypoxic.

Question 3: Should you consider a more aggressive management approach? Why?

Answer: Absolutely! First of all, the patient is coughing up blood-tinged secretions, which must be suctioned from the airway at once. The airway must be kept clear at all times. In addition, his condition is not improving with supplemental oxygen by nonbreathing mask. He is in need of assisted ventilation with a BVM device and 100% oxygen. Increasing this patient's tidal volume will enhance pulmonary gas exchange and perfusion. Tidal volume cannot be provided with a nonbreathing mask. If the patient continues producing oral secretions, you should alternate suctioning for 15 seconds, and then provide assisted ventilations for 2 minutes. This pattern should continue until the airway is clear of secretions.

Question 4: On the basis of your ongoing assessment findings, what intervention should you consider at this point?

Answer: The fluid in this patient's lungs is acting as a pressure gradient when you are attempting ventilations with a BVM device, which is resulting

in decreased ventilatory compliance and ineffective BVM ventilation. This patient's hypoxia is worsening, as evidenced by his decreasing mental status, increasing heart rate, dilated pupils, and low oxygen saturation level despite BVM ventilation. Endotracheal intubation is indicated in order to facilitate the direct instillation of 100% oxygen into the lungs as well as to protect the airway from aspiration.

Question 5: Are there additional interventions that might improve this patient's condition?

Answer: With the blood-tinged secretions that are evident in the endotracheal tube, it is clear that this patient is in fulminate pulmonary edema, which is impeding effective ventilation. Tracheobronchial suctioning via the endotracheal tube is needed to clear the secretions not only from the tube itself, but from the airway as well. In addition, morphine sulfate or nitroglycerin should be considered for this patient, as they both result in systemic venous pooling and decreased preload, both of which will minimize the amount of blood that is backing up into the lungs. You may also elect to give the patient furosemide (Lasix), which will promote excretion of excess fluid from the body.