Chapter 2: Airway and Ventilatory Management

Objectives:

Upon completion of this chapter, the physician will be able to identify actual or impending airway obstruction, explain the techniques of establishing and maintaining a patent airway, and confirm the adequacy of ventilation.

Specifically, the physician will be able to:

A. Recognize the signs and symptoms of acute airway obstruction.
B. Identify the clinical setting in which airway compromise is likely to occur.
C. Explain the techniques to establish and maintain a patent airway and confirm the adequacy of ventilation and oxygenation.
   1. Pulse oximetry
   2. End-tidal carbon dioxide measurement
D. Define what is meant by the term definitive airway and the steps needed to maintain oxygenation before, during, and after establishing a definitive airway.
E. Perform definitive airway placement with maintenance of cervical spine alignment during the skill station, and perform percutaneous transtracheal jet insufflation and cricothyroidotomy during the surgical practicum.
F. Demonstrate ventilatory techniques for one and two rescuers.
I. Introduction

The inability to provide oxygenated blood to the brain and other vital structures is the quickest killer of the injured. Prevention of hypoxemia requires a protected, unobstructed airway and adequate ventilation that must take priority over all other conditions. An airway must be secured, oxygen delivered, and ventilatory support provided. **Supplemental oxygen must be administered to all trauma patients.**

Early preventable deaths from airway problems after trauma include:

1. Failure to recognize the partially obstructed airway and/or patient limitations in providing adequate ventilatory volumes. The combination of partial airway obstruction and impaired ventilatory mechanics can result in life-threatening hypoxemia. This combination can easily be overlooked if more obvious injuries attract the physician's attention. **Remember:** Airway and ventilation are the first priorities.

2. Delay in providing an airway when it is needed.

3. Delay in providing assisted ventilation when it is needed.

4. Technical difficulties in securing a definitive airway and/or providing assisted ventilation. Unintentional intubation of the esophagus can further compromise ventilation and may be rapidly fatal if not recognized promptly and corrected.

5. Aspiration of gastric contents.

II. Airway

A. Problem Recognition

Airway compromise may be sudden and complete, insidious and partial, and progressive and/or recurrent. Although often related to pain and/or anxiety, tachypnea may be a subtle but early sign of airway or ventilatory compromise. Therefore, assessment and frequent reassessment of airway patency and adequacy of ventilation are important. The patient with an altered level of consciousness is at particular risk for airway compromise and often requires provision of a definitive airway. The unconscious head-injured patient, the patient obtunded from alcohol and/or other drugs, and the patient with thoracic injuries may have compromised ventilatory effort. In these patients, endotracheal intubation is intended to: (1) provide an airway, (2) deliver supplementary oxygen, (3) support ventilation, and (4) prevent aspiration. **Maintaining oxygenation and preventing hypercarbia are critical in managing the trauma patient, especially if the patient has sustained a head injury.** The physician should anticipate vomiting in all injured patients and be prepared. The presence of gastric contents in the oropharynx confirms a significant risk of aspiration with the patient's very next breath. Immediate suctioning and rotation of the entire patient to the lateral position are indicated.

Trauma to the face is another setting that may demand aggressive airway management. The mechanisms for this injury is exemplified by the unbelted passenger/driver who is thrown...
into the windshield and dashboard. Trauma to the midface may produce fracture-dislocations
with compromise to the nasopharynx and oropharynx. Facial fractures may be associated with
hemorrhage, increased secretions, and dislodged teeth, causing additional problems in
maintaining a patent airway. Fractures of the mandible, especially bilateral body fractures,
may cause loss of normal muscle support and inability to protrude the tongue. Airway
obstruction will result if the patient is in a supine position.

Patients who refuse to lie down may be indicating difficulty in maintaining their
airway or handling secretions. Neck injuries may cause airway obstruction by disruption of
the larynx and trachea or by compression of the airway from hemorrhage into the soft tissues
of the neck.

During initial assessment of the airway, the "talking patient" provides reassurance (at
least for the moment) that the airway is patent and not compromised. Therefore, the most
important early measure is to talk to the patient and stimulate a verbal response. A positive,
appropriate verbal response indicates that the airway is patent, ventilation intact, and brain
perfusion adequate. Failure to respond or an inappropriate response suggests an altered level
of consciousness or airway/ventilatory compromise.

B. Objective Signs - Airway Obstruction

1. Look to see if the patient is agitated or obtunded. Agitation suggests hypoxia, and
obtundation suggests hypercarbia. Cyanosis indicates hypoxemia due to inadequate
oxygenation and should be sought by inspection of the nail beds and circumoral skin. Look
for retractions and the use of accessory muscles of ventilation which, when present, provide
additional evidence of airway compromise.

2. Listen for abnormal sounds. Noisy breathing is obstructed breathing. Snoring,
gurgling, and crowing sounds (stridor) may be associated with partial occlusion of the
pharynx or larynx. Hoarseness (dysphonia) implies functional, laryngeal obstruction. The
abusive or belligerent patient may be hypoxic and should not be presumed intoxicated.

3. Feel for movement of air with the expiratory effort and quickly determine if the
trachea is midline.

III. Ventilation

A. Problem Recognition

Assuring a patent airway is an important first step in providing oxygen to the patient -
but it is only a first step. An unobstructed airway is not likely to benefit the patient unless
the patient also is ventilating adequately. Ventilation may be compromised by airway
obstruction but also by altered ventilatory mechanics or central nervous system (CNS)
depression. If breathing is not improved by clearing the airway, other etiologies must be
sought. Direct trauma to the chest, especially with rib fractures, causes pain with breathing
and leads to rapid, shallow ventilation and hypoxemia. Intracranial injury may cause abnormal
patterns of breathing and compromise adequacy of ventilation. Cervical spinal cord injury may
result in diaphragmatic breathing and interfere with the ability to meet increased oxygen
demands. Complete cervical cord transection, which spares the phrenic nerves (C-3,4), results in abdominal breathing and paralysis of the intercostal muscles. Assisted ventilation may be required.

**B. Objective Signs**

1. **Look** for symmetrical rise and fall of the chest. Asymmetry suggests splinting or a flail chest and any labored breathing should be regarded as an imminent threat to the patient's oxygenation.

2. **Listen** for movement of air on both sides of the chest. Decreased or absent breath sounds over one or both hemithoraces should alert the examiner to the presence of thoracic injury. (See Chapter 4, Thoracic Trauma.) Beware of a rapid respiratory rate - tachypnea may indicate air hunger.

**IV. Management**

The assessment of airway patency and adequacy of ventilation must be done quickly and accurately. If problems are identified or **suspected**, measures should be instituted immediately to improve oxygenation and reduce the risk of further ventilatory compromise. These include airway maintenance techniques, definitive airway measures (including surgical airway), and methods to provide supplemental ventilation. Because all of these may require some neck motion, protection of the cervical spine must be provided in all patients, especially if the patient has a known, unstable cervical spine injury or is incompletely evaluated and at risk. The neck must be securely immobilized until the possibility of a spinal injury has been excluded with roentgenographic studies or the injury has been recognized and appropriately managed.

Patients wearing a motorcycle or sports helmet who require airway management should have their head and neck held in a neutral position while the helmet is removed. This is a two-person procedure. One person provides in-line manual immobilization from below while the second person expands the helmet laterally and removes it from above. In-line manual immobilization is re-established from above and the patient's head and neck are secured during airway management. Removal of the helmet using a cast cutter while stabilizing the head and neck minimizes cervical spine motion in the patient with a known cervical spine injury.

Supplemental oxygen should be provided before and immediately after airway management measures are instituted. Suction is essential and should be readily available and be of the rigid-type (tonsil suction tip). Patients with facial injuries may have associated cribriform plate fractures and the use of soft suction catheters (or nasogastric tube) inserted through the nose may be complicated by passage of the tube into the cranial vault.

**A. Airway Maintenance Techniques**

For the patient with an altered sensorium, the tongue prolapses backward and obstructs the hypopharynx. This form of obstruction can be corrected readily by the chin-lift or jaw-thrust maneuver. The airway can then be maintained with an oropharyngeal or nasopharyngeal
1. Chin lift

The fingers of one hand are placed under the mandible, which is gently lifted upward to bring the chin anterior. The thumb of the same hand lightly depresses the lower lip to open the mouth. The thumb may also be placed behind the lower incisors and, simultaneously, the chin gently lifted. The chin-lift maneuver should not hyperextend the neck. This maneuver is useful for the trauma victim because it does not risk compromising a possible cervical spine fracture or converting a fracture without cord injury into one with cord injury.

2. Jaw thrust

The jaw-thrust maneuver is performed by grasping the angles of the lower jaw, one hand on each side, and displacing the mandible forward. When this method is used with the mouth-to-face mask, a good seal and adequate ventilation are achieved.

3. Oropharyngeal airway

The oral airway is inserted into the mouth behind the tongue. The preferred technique is to use a tongue blade to depress the tongue and then insert the airway posteriorly. The airway must not push the tongue backward and block, rather than clear, the airway. This device must not be used in the conscious patient because it may induce gagging, vomiting, and aspiration.

An alternative technique is to insert the oral airway upside-down, so its concavity is directed upward, until the soft palate is encountered. At this point, the airway is rotated 180 degrees, the concavity is directed caudad, and the airway is slipped into place over the tongue. This method should not be used for children, because the rotation of the airway may damage the teeth.

4. Nasopharyngeal airway

The nasopharyngeal airway is inserted in one nostril and passed gently into the posterior oropharynx. The nasopharyngeal airway is preferred to the oropharyngeal airway in the responsive patient because it is better tolerated and less likely to induce vomiting. It should be well lubricated, then inserted into the nostril that appears to be unobstructed. If obstruction is encountered during introduction of the airway, stop and try the other nostril. If the tip of the nasopharyngeal tube is visible in the posterior oropharynx, it may provide safe passage of a nasogastric tube in the patient with facial fractures.

B. Definitive Airway

A definitive airway requires a tube present in the trachea with the cuff inflated, the tube connected to some form of oxygen-enriched assisted ventilation, and the airway secured in place with tape. Definitive airways are of three varieties: orotracheal tube, nasotracheal tube, and surgical airway (cricothyroidotomy or tracheostomy). The decision to provide a definitive airway is based on clinical findings and includes:
a. Apnea

b. Inability to maintain a patent airway by other means

c. Protection of the lower airway from aspiration of blood or vomitus

d. Impending or potential compromise of the airway, eg, following inhalation injury, facial fractures, or sustained seizure activity.

e. Closed head injury requiring hyperventilation

f. Failure to maintain adequate oxygenation by face mask oxygen supplementation.

The urgency of the situation and circumstances surrounding the need for airway intervention dictate the specific route and method to be used. Continued assisted ventilation is aided by supplemental sedation, analgesics, or muscle relaxants, as indicated. The use of an oximeter may be helpful in determining the need for a definitive airway, the urgency of the need, and, by inference, effectiveness of airway placement. Orotracheal and nasotracheal intubation are the methods used most frequently. The potential for concomitant cervical spine injury is of major concern in the patient requiring an airway. The algorithm appearing at the conclusion of surgical airway in this chapter offers a scheme by which decisions for the appropriate route of airway management can be made.

1. Orotracheal intubation

For the unconscious patient who has sustained blunt trauma and the need for definitive airway is anticipated, determine the urgency for establishing an airway. If there is no immediate need, then, a roentgenogram of the cervical spine should be obtained. A normal lateral cervical spine roentgenogram is reassuring and allows for safe orotracheal intubation with midline immobilization of the head and neck. **However, a normal lateral cervical spine film does not exclude a cervical spine injury.** Spinal immobilization should be maintained. If no cervical spine fractures are noted, orotracheal intubation should be performed. If the patient is apneic, the two-person technique for orotracheal intubation with inline manual cervical immobilization should be attempted.

Following insertion of the orotracheal tube, the cuff should be inflated and assisted ventilation should be instituted. Proper placement of the tube is suggested but not confirmed by hearing equal breath sounds bilaterally and detecting no borborygmi in the epigastrium. The presence of gurgling noises in the epigastrium with inspiration suggests esophageal intubation and warrants repositioning of the tube. If tube position is still in doubt, end-tidal carbon dioxide measurement is a reliable guide to the adequacy of ventilation. Tube position is determined by the colorimetric technique and used primarily to confirm position of the endotracheal tube. It is not used for physiologic monitoring. Absent end-tidal carbon dioxide tension confirms esophageal intubation. When the proper position of the tube is determined, it should be secured in place. If the patient is moved, tube placement should be reassessed.
2. Nasopharyngeal intubation

Nasopharyngeal intubation is a useful technique when a cervical spine fracture is confirmed or suspected, or when urgency of airway management precludes a cervical spine roentgenogram. Nasotracheal intubation is contraindicated in the apneic patient and whenever severe midface fractures or suspicion of a basilar skull fracture exist. Precautions regarding cervical spine immobilization should be followed as with orotracheal intubation.

Note: The most important determinant of whether to proceed with orotracheal or nasotracheal intubation is the experience of the physician. Both techniques are safe and effective when performed properly. Esophageal occlusion by cricoid pressure is useful in preventing aspiration and providing better visualization of the airway.

Malpositioning of the endotracheal tube must be considered in all patients who arrive at the hospital with an endotracheal tube in place. This is important because the tube may have been inserted into a mainstem bronchus or dislodged during patient transport from the field or another hospital. Epigastric fullness in a patient already intubated should alert the physician to the possibility of esophageal intubation. Placement must be checked carefully. A chest roentgenogram may be helpful to assess the position of the tube, but it cannot exclude esophageal intubation.

If the patient's condition permits, fiberoptic endoscopy may facilitate difficult orotracheal or nasotracheal intubation. The endoscopic techniques may be used for selected cases of maxillofacial and cervical spine injury and for stocky patients with short necks. If these injuries or conditions preclude orotracheal or nasotracheal intubation, the physician may proceed directly to surgical techniques: needle or surgical cricothyroidotomy.

3. Surgical airway

Inability to intubate the trachea is a clear indication for creating a surgical airway.

When edema of the glottis, fracture of the larynx, or severe oropharyngeal hemorrhage obstructs the airway and an endotracheal tube cannot be placed through the cords, a surgical cricothyroidotomy may be performed to allow air passage. Insertion of a needle through the cricothyroid membrane or into the trachea is a useful technique in emergency situations to provide oxygen on a short-term basis until a definitive airway can be placed. A tracheostomy, done under emergency conditions, is difficult to perform, is often associated with profuse bleeding, and is too time-consuming.

a. Jet insufflation of the airway

Jet insufflation can provide up to 45 minutes of extra time so that intubation can be accomplished on an urgent rather than an emergent basis. The jet insufflation technique is performed by placing a large-caliber plastic cannula, #12- to #14-gauge (#16- to #18-gauge in children), through the cricothyroid membrane into the trachea below the level of the obstruction. The cannula is then connected to wall oxygen at 15 liters/minute (40 to 50 psi) with either a Y-connector or a side hole cut in the tubing attached between the oxygen source
and the plastic cannula. Intermittent insufflation, one second on and four seconds off, can then be achieved by placing the thumb over the open end of the Y-connector or the side hole. The patient can be adequately oxygenated for only 30 to 45 minutes using this technique. During the four seconds that the oxygen is not being delivered under pressure, some exhalation occurs. Because of the inadequate exhalation, carbon dioxide slowly accumulates and limits the use of this technique, especially in head-injured patients.

Jet insufflation must be used with caution when complete foreign body obstruction of the glottic area is suspected. Although high pressure may expel the impacted material into the hypopharynx where it can be readily removed, significant barotrauma may occur including pulmonary rupture with tension pneumothorax. Low flow rates (5 to 7 liters per minute) should be used when glottic obstruction is present.

b. Surgical cricothyroidotomy

Surgical cricothyroidotomy is performed by making a skin incision that extends through the cricothyroid membrane. A curved hemostat may be inserted to dilate the opening and a small endotracheal tube or tracheostomy tube (preferably 5 to 7 mm) can be inserted. When the endotracheal tube is used, the cervical collar can be reapplied. One must be alerted to the possibility that the endotracheal tube can become malpositioned. Care must be taken, especially with children, to avoid damage to the cricoid cartilage, which is the only circumferential support to the upper trachea. Therefore, surgical cricothyroidotomy is not recommended for children under 12 years of age. (See Chapter 10, Pediatric Trauma.)

4. Airway decision scheme

The airway decision scheme (Figure 1, Airway Algorithm) applies only to the unconscious patient who is in acute respiratory distress (or apneic) and in need of an immediate airway, and in whom a cervical spine injury is suspected by mechanism of injury or physical examination. The first priority is to assure continued oxygenation with maintenance of cervical spine immobilization. This is accomplished initially by position (ie, chin lift or jaw thrust) and preliminary airway techniques (ie, oropharyngeal airway or nasopharyngeal airway) already discussed.

In the patient who is still showing some respiratory effort, a nasotracheal tube may be passed if the rescuer is skilled in this technique. Otherwise, an orotracheal tube should be passed while the second rescuer provides in-line immobilization. If neither a nasotracheal or orotracheal tube can be inserted and the patient's respiratory status is in jeopardy, a cricothyroidotomy should be performed.

In the apneic patient, in-line immobilization should be maintained by one rescuer and orotracheal intubation should be performed. If severe maxillofacial injury precludes nasotracheal intubation and orotracheal intubation cannot be achieved for any reason, a cricothyroidotomy is indicated.

It is important that the rescuer maintain oxygenation and ventilation before, during, and immediately upon completion of insertion of the definitive airway. Prolonged periods of inadequate or absent ventilation and oxygenation should be avoided.
C. Ventilation and Oxygenation

The primary goal of ventilation is to achieve maximum cellular oxygenation which is promoted in the trauma patient by providing an environment rich in oxygen and sustained gas exchange at the alveolar capillary membrane through improved ventilatory efforts.

1. Oxygenation

Oxygenated inspired air is best provided via a tight-fitted oxygen reservoir mask with a flow rate of 10 to 12 liters/minute. Other methods, ie, nasal catheter, nasal cannula, nonrebreather mask, etc, can improve inspired oxygen concentration.

Since changes in oxygenation occur rapidly and are impossible to detect clinically, pulse oximetry should be considered when difficulties are anticipated in intubation or ventilation. This includes the transport of the critically injured patient. Pulse oximetry is a noninvasive method to continuously measure oxygen saturation (O₂ sat) of arterial blood. It does not measure the partial pressure of oxygen (PaO₂) and depending on the position of the oxyhemoglobin dissociation curve, the PaO₂ may vary widely. (See Table 1, PaO₂ Levels versus O₂ Saturation Levels.) However, a measured saturation of 95% or greater by pulse oximetry is strong corroborating evidence of adequate, peripheral arterial oxygenation (PaO₂ > 70 mm Hg). Pulse oximetry requires intact peripheral perfusion and cannot distinguish oxyhemoglobin from carboxyhemoglobin or methemoglobin, which limits its usefulness in the severely vasoconstricted patient and in the patient with carbon monoxide poisoning. Profound anemia (hemoglobin < 5 gms) and hypothermia (< 30 degree centigrade) impede the reliability of the technique. However, in most trauma patients pulse oximetry is not only useful, but continuous monitoring of oxygen saturation provides an immediate assessment of therapeutic interventions. (See Skill Station IV, Vascular Access and Monitoring in Chapter 3, Shock.)

2. Ventilation

Effective ventilation can be achieved by mouth-to-face mask or bag-valve-face mask techniques. Frequently, only one person is present to provide ventilation; under these circumstances, mouth-to-face mask ventilation is preferred method. Studies suggest that one-person ventilation techniques, using a bag-valve mask, are less effective than two-person techniques in which both hands can be used to assure a good seal. Bag-valve-mask ventilation should be considered a two-rescuer technique.

Intubation of the hypoventilated and/or apneic patient may not be successful initially and may require multiple attempts. The patient must be ventilated periodically during prolonged efforts to intubate. The physician should practice taking a deep breath when intubation is first attempted. When the physician must breathe, the attempted intubation should be aborted, and the patient should be ventilated.
Table 1. Approximate PaO$_2$ versus O$_2$ Saturation Levels at Sea Level

<table>
<thead>
<tr>
<th>PaO$_2$ Levels</th>
<th>O$_2$ Saturation Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>27 mm Hg</td>
<td>50 mm Hg</td>
</tr>
<tr>
<td>30 mm Hg</td>
<td>60 mm Hg</td>
</tr>
<tr>
<td>60 mm Hg</td>
<td>90 mm Hg</td>
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<tr>
<td>90 mm Hg</td>
<td>100 mm Hg</td>
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Figure 1. Airway Algorithm

**Immediate Need For Definitive Airway**
Unconscious Patient With Blunt Trauma
Suspect Cervical Spine Injury
**Oxygenate / Ventilate**

1. **Apneic** --> Orotracheal intubation with in-line manual cervical immobilization --> Unable --> Surgical Airway.

2. **Severe, maxillofacial injury** --> Inability to intubate --> Surgical Airway.

3. **Breathing** --> Nasotracheal or orotracheal intubation with in-line manual cervical immobilization* --> Unable --> Surgical Airway.

* Proceed according to clinical judgment and skill/experience level.

With intubation of the trachea accomplished, assisted ventilation should follow, using positive-pressure breathing techniques. A volume- or pressure-regulated respirator can be employed, depending on availability of the equipment. The physician should be alert for the complications secondary to changes in intrathoracic pressure, which can convert a simple pneumothorax to a tension pneumothorax, or even create a pneumothorax secondary to barotrauma.
V. Summary

A. Actual or impending airway obstruction should be suspected in all injured patients.

B. With all airway maneuvers, the cervical spine must be protected by in-line immobilization.

C. Clinical signs suggesting airway compromise should be managed by securing a patent airway and providing adequate oxygen-enriched ventilation.

D. A definitive airway should be inserted if there is any doubt on the part of the physician as to the integrity of the patient's airway.

E. A definitive airway should be placed early after the patient has been ventilated with oxygen-enriched air and prolonged periods of apnea must be avoided.

F. Airway management requires assessment and reassessment of airway patency, tube position, and ventilatory effectiveness.

G. The selection of orotracheal or nasotracheal routes for intubation is based on the experience and skill level of the physician.

H. Surgical airway is indicated whenever an airway is needed and intubation is unsuccessful.
Skill Station II: Airway and Ventilatory Management

Resources and Equipment

This list is the recommended equipment to conduct this skill session in accordance with the stated objectives for and intent of the procedures outlined. Additional equipment may be used providing it does not detract from the stated objectives and intent of this skill, or from performing the procedure in a safe method as described and recommended by the ACS Committee on Trauma.

1. Adult intubation manikin - two or three.
2. Infant intubation manikin - one or two.
3. Adult orotracheal tubes - one of each size.
4. Adult nasotracheal tube - two.
5. Infant endotracheal tubes - one of each size, uncuffed.
6. Laryngoscope handles - one for each manikin.
7. Laryngoscope blades - infant and adult sizes, straight and curved.
8. Extra batteries for laryngoscope handles.
10. Stethoscopes - two.
11. Soapy water to lubricate endotracheal tubes.
12. Nasal anesthetic spray (simulation purposes only) (optional).
13. Semirigid cervical collar, applied to one adult intubation manikin.
15. Malleable endotracheal tube stylet - one or two.
16. Oropharyngeal airway - assorted sizes.
17. Nasopharyngeal airway - assorted sizes.
18. Bag-valve-mask device - one or two. (Note: Type that includes a one-way valve preventing the back flow of air and secretions).
19. Pocket face mask - one or two.
20. Rigid suction device - one (tonsil suction device).
21. End-tidal CO₂ colorimetric device (optional).
22. Tongue blades - several.

Objectives

Performance at this station will allow the participant to practice and demonstrate the following skills on adult and infant intubation manikins.

1. Ventilate the patient, comparing ventilatory volumes delivered via the rescuer's lungs and a face mask versus the bag-valve-mask device.
2. Insert oral and nasal pharyngeal airways.
3. Using both oral and nasal routes, intubate the trachea of an adult intubation manikin, within the guidelines listed, and provide effective ventilation.
4. Intubate the trachea of an infant intubation manikin with an endotracheal tube
within the guidelines listed, and provide effective ventilation.

5. Relate the indications and complications of trauma to airway management when performing oral endotracheal intubation and nasotracheal intubation.

**Procedures**

Six procedures for acute airway management are outlined in Skill Station II:

1. Oropharyngeal airway insertion.
2. Nasopharyngeal airway insertion.
3. Ventilation without intubation.
4. Orotracheal intubation.
5. Nasotracheal intubation.
6. Infant endotracheal intubation.
Skill Procedures: Airway and Ventilatory Management

Note: Universal precautions are required whenever caring for the trauma patient.

I. Oropharyngeal Airway Insertion

A. Select the proper-sized airway. (Place the airway against the patient's face. The correctly sized airway will extend from the center of the patient's mouth to the angle of the jaw.)

B. Open the patient's mouth with either the chin lift maneuver or the crossed-finger technique (scissors technique).

C. Insert a tongue blade on top of the patient's tongue far enough back to depress the tongue adequately, being careful not to gag the patient.

D. Insert the airway posteriorly, gently sliding the airway over the curvature of the tongue until the device's flange rests on top of the patient's lips. The airway must not push the tongue backward and block the airway.

E. Remove the tongue blade.

F. Ventilate the patient with a pocket face mask or bag-valve-mask device.

II. Nasopharyngeal Airway Insertion

A. Assess the nasal passages for any apparent obstruction (polyps, fractures, hemorrhage, etc).

B. Select the appropriately sized airway.

C. Lubricate the nasal pharyngeal airway with a water-soluble lubricant or tap water.

D. Insert the tip of the airway into the nostril and direct it posteriorly and toward the ear.

E. Gently pass the nasal pharyngeal airway through the nostril into the hypopharynx with a slight rotating motion, until the flange rests against the nostril.

F. Ventilate the patient with a pocket face mask or bag-valve-mask device.
III. Ventilation Without Intubation

A. Mouth-to-Pocket Face Mask (One-person Technique)

Remember: In accordance with universal precautions, only use the type of pocket face mask that includes a one-way valve to prevent back flow of air and secretions.

1. Attach oxygen tubing to the face mask. Oxygen flow rate should be 12 L/min.
2. Apply the face mask to the patient, using both hands.
3. Assure an adequate seal of the mask to the face.
4. Secure an open airway by using the jaw-thrust or chin-life maneuver.
5. Taking a deep breath, place your mouth over the mouth port and blow.
6. Assess the ventilatory efforts by observing the patient's chest movement.
7. Ventilate the patient in this manner every five seconds.

B. Bag-Valve-Mask Ventilation (Two-person Technique)

1. Select the appropriately sized mask to fit the patient's face.
2. Connect the oxygen tubing to the bag-valve device, and adjust the flow of oxygen to 12 L/minute.
3. Assure that the patient's airway is patent and secured by previously described techniques.
4. The first person applies the mask to the patient's face, ascertaining a tight seal with both hands.
5. The second person ventilates the patient by squeezing the bag with both hands.
6. The adequacy of ventilation is assessed by observing the patient's chest movement.
7. The patient should be ventilated in this manner every five seconds.
IV. Adult Orotracheal Intubation

A. Assure that adequate ventilation and oxygenation are in progress, and that suctioning equipment is immediately available in the event the patient vomits.

B. Inflate the cuff of the endotracheal tube to ascertain that the balloon does not leak, then deflate the cuff.

C. Connect the laryngoscope blade to the handle, and check the bulb for brightness.

D. Have an assistant manually immobilize the head and neck. The patient's neck must not be hyperextended or hyperflexed during this procedure.

E. Hold the laryngoscope in the left hand.

F. Insert the laryngoscope into the right side of the patient's mouth, displacing the tongue to the left.

G. Visually examine the epiglottis and then the vocal cords.

H. Gently insert the endotracheal tube into the trachea without applying pressure on the teeth or oral tissues.

I. Inflate the cuff with enough air to provide an adequate seal. **Do not overinflate the cuff.**

J. Check the placement of the endotracheal tube by bag-valve-to-tube ventilation.

K. Visually observe lung expansion with ventilation.

L. Auscultate the chest and abdomen with a stethoscope to ascertain tube position.

M. Secure the tube. If the patient is moved, the tube placement should be reassessed.

N. If endotracheal intubation is not accomplished within seconds or in the same time required to hold your breath before exhaling, discontinue attempts, ventilate the patient with a bag-valve-mask device, and try again.

O. Placement of the tube must be checked carefully. A chest roentgenogram may be helpful to assess the position of the tube, but it cannot exclude esophageal intubation.

P. **Optional procedure:** Attach an end-tidal CO₂ colorimetric device (if available) to the endotracheal tube, between the adapter and the ventilating device. Use of the colorimetric device provides a reliable means of confirming the position of the endotracheal tube in the trachea.

Q. **Optional procedure:** Attach a pulse oximeter device to one of the patient's fingers (intact peripheral perfusion must exist) to measure and monitor the patient's oxygen saturation.
levels. Pulse oximetry is useful to monitor oxygen saturation levels continuously, and provides an immediate assessment of therapeutic interventions.
V. Adult Nasotracheal Intubation

**Remember:** Blind nasotracheal intubation is contraindicated in the apneic patient and whenever severe midface fractures or suspicion of basilar skull fracture exist.

A. If a cervical spine fracture is suspected, leave the cervical collar in place to assist in maintaining immobilization of the neck.

B. Assure that adequate ventilation and oxygenation are in progress.

C. Inflate the cuff of the endotracheal tube to ascertain that the balloon does not leak, then deflate the cuff.

D. If the patient is **conscious**, spray the nasal passage with an anesthetic and vasoconstrictor to anesthetize and constrict the mucosa. If the patient is **unconscious**, it is adequate to spray the nasal passage only with a vasoconstrictor.

E. Have an assistant maintain manual immobilization of the head and neck.

F. Lubricate the nasotracheal tube with a local anesthetic jelly and insert the tube (with or without a stylet) into the nostril.

G. Guide the tube slowly but firmly into the nasal passage, going up from the nostril (to avoid the large inferior turbinate) and then backward and down into the nasopharynx. The curve of the tube should be aligned to facilitate passage along this curved course.

H. As the tube passes through the nose and into the nasopharynx, it must turn downward to pass through the pharynx.

I. Once the tube has entered the pharynx, listen to the airflow emanating from the endotracheal tube. Advance the tube until the sound of the moving air is maximal, suggesting location of the tip at the opening of the trachea. While listening to air movement, determine the point of inhalation and advance the tube quickly. If tube placement is unsuccessful, repeat the procedure by applying gentle pressure on the thyroid cartilage. **Remember, intermittently ventilate and oxygenate the patient.**

J. **Optional method:** If an endotracheal stylet is utilized, bend the lower end of the tube and stylet (approximately the last one-fourth) to a near 90-degree angle. As the tube is inserted, the end of the tube should point to the ipsilateral ear. Be sure that the stylet is recessed approximately one-half inch from the end of the tube to prevent trauma during insertion. Gently, yet firmly, guide the tube into the pharynx, and through the glottis and vocal cords. Continue to advance the tube with gentle pressure as you withdraw the stylet.

K. Inflate the cuff with enough air to provide an adequate seal. Avoid overinflation.

L. Check the placement of the endotracheal tube by bag-valve-to-tube ventilation.

M. Visually observe lung expansion with ventilation.
N. Auscultate the chest and abdomen with a stethoscope to ascertain tube position.

O. Secure the tube. If the patient is moved, the tube placement should be reassessed.

P. If endotracheal intubation is not accomplished within 30 seconds or in the same time required to hold your breath before exhaling, discontinue attempts, ventilate the patient with a bag-valve-mask device, and try again.

Q. Placement of the tube must be checked carefully. A chest roentgenogram may be helpful to assess the position of the tube, but it cannot exclude esophageal intubation.

R. **Optional procedure:** Attach an end-tidal CO₂ colorimetric device (if available) to the endotracheal tube, between the adapter and the ventilating device. The use of this device provides a reliable means of confirming the position of the endotracheal tube in the trachea.

S. **Optional procedure:** Attach a pulse oximeter device to one of the patient's fingers (intact peripheral perfusion must exist) to measure and monitor the patient's oxygen saturation levels. Pulse oximetry is useful to monitor oxygen saturation levels continuously, and provides an immediate assessment of therapeutic interventions.

**Complications of Orotracheal and Nasotracheal Intubation**

1. Esophageal intubation, leading to hypoxia and death.
2. Right mainstem bronchus intubation, resulting in ventilation of the right lung only, collapse of the left lung, and pneumothorax.
3. Inability to intubate, leading to hypoxia and death.
4. Induction of vomiting, leading to aspiration, hypoxia, and death.
5. Dislocation of the mandible.
6. Laceration of the soft tissues of the airway, posterior pharynx, epiglottis, and/or larynx.
7. Trauma to the airway resulting in hemorrhage and potential aspiration.
8. Chipping or loosening of the teeth (caused by levering of the laryngoscope blade against the teeth).
9. Rupture/leak of the endotracheal tube cuff, resulting in loss of seal during ventilation, and necessitating reintubation.
11. Conversion of a cervical vertebral injury without neurologic deficit to a cervical cord injury with neurologic deficit.
VI. Infant Orotracheal Intubation

A. Ensure that adequate ventilation and oxygenation are in progress.

B. Connect the laryngoscope blade and handle; check the light bulb for brilliance.

C. Hold the laryngoscope in the left hand.

D. Insert the laryngoscope blade in the right side of the mouth, moving the tongue to the left.

E. Observe the epiglottis, then the vocal cords.

F. Insert the endotracheal tube.

G. Check the placement of the tube by bag-valve-to-tube ventilation.

H. Check the placement of the endotracheal tube by observing lung inflations and auscultating the chest and abdomen with a stethoscope.

I. Secure the tube. If the patient is moved, the tube placement should be reassessed.

J. If endotracheal intubation is not accomplished within 30 seconds or in the same time required to hold your breath before exhaling, discontinue attempts, ventilate the patient with a bag-valve-mask device, and try again.

K. Placement of the tube must be checked carefully. A chest roentgenogram may be helpful to assess the position of the tube, but it cannot exclude esophageal intubation.

L. Optional procedure: Attach an end-tidal CO₂ colorimetric device to the endotracheal tube, between the adapter and the ventilating device. The use of this device provides a reliable means of confirming the position of the endotracheal tube in the trachea.

M. Optional procedure: Attach a pulse oximeter device to one of the patient's fingers (intact peripheral perfusion must exist) to measure and monitor the patient's oxygen saturation levels. Pulse oximetry is useful to monitor oxygen saturation levels continuously, and provides an immediate assessment of therapeutic interventions.
Skill Station III: Cricothyroidotomy

This surgical procedure, if performed on a live, anesthetized animal, must be conducted in a USDA-Registered Animal Laboratory Facility. (See ATLS Instructor Manual, Section II, Chapter 9 - Policies, Procedures, and Protocols for Surgical Skills Practicum.)

Resources and Equipment

This list is the recommended equipment to conduct this skill session in accordance with the stated objectives for and intent of the procedures outlined. Additional equipment may be used providing it does not detract from the stated objectives and intent of this skill, or from performing the procedure in a safe method as described and recommended by the ACS Committee on Trauma.

1. Live, anesthetized animals.
2. Licensed veterinarian (see reference to guidelines above).
3. Animal trough, ropes (sandbags optional).
4. Electric shears with #40 blade.
5. Animal intubation equipment
   a. Endotracheal tubes
   b. Laryngoscope blade and handle
   c. Respirator with 15-mm adapter.
6. Tables or instrument stands.
7. #12- to #14-gauge over-the-needle catheters (8.5 cm in length).
8. Antiseptic swabs.
9. Jet insufflation equipment
   a. Oxygen tubing with a hole cut in one side of the tubing
   b. Unregulated oxygen source of 50 psi or greater (or wall outlet) with oxygen flow meter attached.
10. Pediatric 3.0-mm endotracheal tube adapter.
11. 6- and 12-mL syringes.
12. Strips of 1/2-inch (1.25 cm) tape.
13. Surgical instruments
   a. Scalpel handles with #10 and #11 blades
   b. Hemostats
   c. Tracheal hook (optional)
   d. Tracheal spreader (optional)
   e. Small rake retractors
14. Endotracheal tubes or #5 tracheostomy tubes.
15. Twill-tape.
16. 4x4 sponges.
17. Surgical garb (gloves, shoe covers, and scrub suits or cover gowns).
**Objectives**

1. Performance at this station will allow the participant to practice and demonstrate the technique of needle cricothyroidotomy and surgical cricothyroidotomy on a live, anesthetized animal.

2. Upon completion of this station, the participant will be able to identify the surface markings and structures to be noted while performing a needle cricothyroidotomy and surgical cricothyroidotomy.

3. Upon completion of this station, the participant will be able to discuss the indications of needle cricothyroidotomy and surgical cricothyroidotomy.

4. Upon completion of this station, the participant will be able to discuss complications of these procedures.

**Procedures**

1. Needle cricothyroidotomy.
2. Surgical cricothyroidotomy.
Skills Procedures: Cricothyroidotomy

Note: Universal precautions are required whenever caring for the trauma patient.

I. Needle Cricothyroidotomy

A. Assemble and prepare oxygen tubing by cutting a hole toward one end of the tubing. Connect the other end of the oxygen tubing to an oxygen source, capable of delivering 50 psi or greater at the nipple, and assure free flow of oxygen through the tubing.

B. Place the patient in a supine position.

C. Assemble a #12- or #14-gauge, 8.5 cm, over-the-needle catheter to a 6- to 12-mL syringe.

D. Surgically prepare the neck, using antiseptic swabs.

E. Palpate the cricothyroid membrane, anteriorly, between the thyroid cartilage and cricoid cartilage. Stabilize the trachea with the thumb and forefinger of one hand to prevent lateral movement of the trachea during the procedure.

F. Puncture the skin midline with the needle attached to a syringe, directly over the cricothyroid membrane (ie, midsagittal). A small incision with a #11 blade facilitates passage of the needle through the skin.

G. Direct the needle at a 45-degree angle caudally, while applying negative pressure to the syringe.

H. Carefully insert the needle through the lower half of the cricothyroid membrane, aspirating as the needle is advanced.

I. Aspiration of air signifies entry into the tracheal lumen.

J. Remove the syringe and withdraw the stylet while gently advancing the catheter downward into position, being careful not to perforate the posterior wall of the trachea.

K. Attach the oxygen tubing over the catheter needle hub, and secure the catheter to the patient's neck.

L. Intermittent ventilation can be achieved by occluding the open hole cut into the oxygen tubing with your thumb for one second and releasing it for four seconds. After releasing your thumb from the hole in the tubing, passive exhalation occurs. Note: Adequate PaO₂ can be maintained for only 30 to 45 minutes.

M. Continue to observe lung inflations and auscultate the chest for adequate ventilation.
Complications of Needle Cricothyroidotomy

1. Asphyxia.
2. Aspiration.
3. Cellulitis.
4. Esophageal perforation.
5. Exsanguinating hematoma.
6. Hematoma.
7. Posterior tracheal wall perforation.
8. Subcutaneous and/or mediastinal emphysema.
9. Thyroid perforation.
10. Inadequate ventilation leading to hypoxia and death.
II. Surgical Cricothyroidotomy

A. Place the patient in a supine position with the neck in a neutral position. Palpate the thyroid notch, cricothyroid interval, and the sternal notch for orientation. Assemble the necessary equipment.

B. Surgically prepare and anesthetize the area locally, if the patient is conscious.

C. Stabilize the thyroid cartilage with the left hand.

D. Make a transverse skin incision over the cricothyroid membrane. Carefully incise through the membrane.

E. Insert the scalpel handle into the incision and rotate it 90 degrees to open the airway. (A hemostat or tracheal spreader also may be used instead of the scalpel handle.)

F. Insert an appropriately sized, cuffed endotracheal tube or tracheostomy tube into the cricothyroid membrane incision, directing the tube distally into the trachea.

G. Inflate the cuff and ventilate the patient.

H. Observe lung inflations and auscultate the chest for adequate ventilation.

I. Secure the endotracheal or tracheostomy tube to the patient to prevent dislodging.

J. Caution: Do not cut or remove the cricothyroid cartilage.

Complications of Surgical Cricothyroidotomy

1. Asphyxiation.
2. Aspiration (eg, blood).
3. Cellulitis.
4. Creation of a false passage into the tissues.
5. Subglottic stenosis/edema.
6. Laryngeal stenosis.
7. Hemorrhage or hematoma formation.
8. Laceration of the esophagus.
9. Laceration of the trachea.
10. Mediastinal emphysema.
11. Vocal cord paralysis, hoarseness.