Chapter 15

Airway Management and Ventilation

Unit Summary

Establishing and maintaining a patent (open) airway and ensuring effective oxygenation and ventilation are vital aspects of effective patient care. Attempting to stabilize the condition of a patient whose airway is compromised is futile. The human body needs a constant supply of oxygen to carry out the physiologic processes necessary to sustain life; the airway is where it all begins. Few situations will cause such acute deterioration and death more rapidly than airway or ventilation compromise.To preserve life, the airway must remain patent at all times—regardless of the situation. This chapter provides complex knowledge of airway management and ventilation methods, as well as reviewing anatomical and physiologic considerations.

National EMS Education Standard Competencies

**Airway Management, Respiration, and Artificial Ventilation**

Integrates complex knowledge of anatomy, physiology, and pathophysiology into the assessment to develop and implement a treatment plan with the goal of ensuring a patent airway, adequate mechanical ventilation, and respiration for patients of all ages.

***Airway Management***

• Airway anatomy (pp 712-717)

• Airway assessment (pp 728-732)

• Techniques of ensuring a patent airway (pp 736-737)

***Respiration***

• Anatomy of the respiratory system (pp 712-717)

• Physiology and pathophysiology of respiration (pp 717-728)

* Pulmonary ventilation (p 717)
* Oxygenation (pp 722-723)
* Respiration (p 723)
* External (p 723)
* Internal (p 724)
* Cellular (p 724)

• Assessment and management of adequate and inadequate respiration (pp 725-732)

• Supplemental oxygen therapy (pp 750-756)

***Artificial Ventilation***

Assessment and management of adequate and inadequate ventilation

• Artificial ventilation (pp 758-761)

• Minute ventilation (pp 720, 726)

• Alveolar ventilation (p 720)

• Effect of artificial ventilation on cardiac output (p 728)

Knowledge Objectives

1. Describe the major structures of the respiratory system, including the upper and lower airway. (pp 712-717)
2. Discuss the physiology of breathing, including ventilation, oxygenation, and respiration. (p 717)
3. Discuss important concepts related to ventilation, including partial pressure, volumes, and neural and chemical control of ventilation. (pp 717-725)
4. Explain positive-pressure ventilation versus negative-pressure ventilation. (pp 756-757)
5. Discuss respiratory drive versus hypoxic drive. (pp 721-722)
6. Describe factors related to pathophysiology of respiration, including ventilation/perfusion ratio mismatch, hypoventilation, hyperventilation, and circulatory compromise. (pp 726-727)
7. Discuss acid/base imbalance, specifically respiratory acidosis and respiratory alkalosis. (p 728)
8. List the signs of adequate breathing. (p 729)
9. List the signs of inadequate breathing. (pp 729-730)
10. List abnormal breathing patterns to recognize when assessing a patient is breathing. (p 731)
11. Discuss how to assess a patient’s breath sounds. (pp 730-732)
12. List methods for end-tidal carbon dioxide assessment, and discuss its importance. (pp 735-736)
13. Describe the assessment and care of a patient with apnea. (pp 758-761)
14. Understand how to assess for adequate and inadequate respiration, including the use of pulse oximetry. (pp 729-730, 733-734)
15. Understand how to assess for a patent airway. (pp 728-732)
16. Describe how to perform the head tilt-chin lift maneuver. (p 738)
17. Describe how to perform the jaw-thrust maneuver. (p 738)
18. Describe how to perform the tongue-jaw lift. (p 738)
19. Understand the importance and techniques of suctioning. (pp 739-742)
20. Explain how to measure and insert an oropharyngeal (oral) airway. (p 744)
21. Describe how to measure and insert a nasopharyngeal (nasal) airway. (p 746)
22. Explain the use of the recovery position to maintain a clear airway. (p 737)
23. Describe the importance of giving supplemental oxygen to patients who are hypoxic. (p 750)
24. Understand the basics of how oxygen is stored and the various hazards associated with its use. (pp 750-752)
25. Describe the use of a nonrebreathing mask, and state the oxygen flow requirements for its use. (p 754)
26. Understand the indications for using a nasal cannula rather than a nonrebreathing face mask. (pp 754-755)
27. Describe the indications for use of a humidifier during supplemental oxygen therapy. (pp 754, 756)
28. Explain the steps to take to perform mouth-to-mouth, mouth-to-nose, and mouth-to-mask ventilation. (p 758)
29. Describe the use of a one-, two-, or three-person bag-mask device and a manually triggered ventilation (MTV) device. (pp 758-762)
30. Discuss automatic transport ventilators and how to use them. (p 762)
31. Describe the signs associated with adequate and inadequate artificial ventilation. (p 761)
32. Describe the indications, contraindications, and complications of use of continuous positive airway pressure (CPAP). (pp 763-764)
33. Explain considerations surrounding gastric distention and how to perform nasogastric and orogastric decompression. (pp 765-766)
34. Discuss airway management considerations for patients with a laryngectomy, tracheostomy, or stoma. (pp 769-772)
35. List the advanced airway devices and techniques available to the paramedic. (pp 774-775)
36. Discuss methods used to predict the difficult airway. (pp 775-776)
37. Describe the advantages, disadvantages, and equipment used when performing endotracheal intubation. (pp 776-780)
38. Explain how to determine correct endotracheal tube size. (pp 776-777)
39. List factors to consider when determining correct laryngoscope blade size. (pp 777-778)
40. Discuss the indications, contraindications, advantages, disadvantages, and complications of orotracheal intubation. (pp 778-786)
41. List the methods available for confirming correct endotracheal tube placement and the advantages and disadvantages of each method. (pp 784-785)
42. Describe how to secure an endotracheal tube. (p 786)
43. Discuss the indications, contraindications, advantages, disadvantages, and complications of nasotracheal intubation. (pp 786-790)
44. Discuss the indications, contraindications, advantages, disadvantages, and complications of digital intubation. (pp 790-794)
45. Discuss the indications, contraindications, advantages, disadvantages, and complications of transillumination intubation. (pp 794-798)
46. Discuss the indications, contraindications, advantages, disadvantages, and complications of retrograde intubation. (pp 798-802)
47. Explain what to do when intubation fails. (pp 802-803)
48. Explain how to perform tracheobronchial suctioning. (p 803)
49. Discuss considerations related to field extubation. (pp 803-804)
50. Discuss the indications, contraindications, advantages, disadvantages, and complications of endotracheal intubation in the pediatric patient. (pp 805-810)
51. Explain how to determine correct endotracheal tube size for a pediatric patient. (pp 805-806)
52. List factors to consider when determining correct laryngoscope blade size for a pediatric patient. (p 805)
53. List possible pharmacologic adjuncts to airway management and ventilation, including both sedatives and neuromuscular blocking agents used for emergency intubation. (pp 810-812)
54. Discuss the procedure for performing rapid-sequence intubation (RSI). (pp 812-813)
55. Discuss the esophageal tracheal Combitube (ETC), including how it works, its indications, contraindications, and complications, and the procedure for inserting it. (pp 814-815)
56. Discuss the laryngeal mask airway (LMA), including how it works, its indications, contraindications, and complications, and the procedure for inserting it. (pp 815, 817-819)
57. Discuss King LT airway devices, including how they work, their indications, contraindications, and complications, and the procedure for inserting them. (pp 818, 820-821)
58. Discuss the Cobra perilaryngeal airway (CobraPLA), including how it works, its indications, contraindications, and complications, and the procedure for inserting it. (pp 821-823)
59. Discuss the indications, contraindications, advantages, disadvantages, and complications of performing open cricothyrotomy. (pp 824-827)
60. Discuss the indications, contraindications, advantages, disadvantages, and complications of performing needle cricothyrotomy. (pp 828-831)
61. Understand the causes of foreign body airway obstruction. (pp 746-748)
62. Describe the management of mild and severe foreign body airway obstruction in an adult, a child, and an infant. (pp 749-750)

Skills Objectives

1. Demonstrate use of pulse oximetry. (pp 733-734)
2. Demonstrate how to position the unresponsive patient. (p 737)
3. Demonstrate the steps in performing the head tilt-chin lift maneuver. (p 738, Skill Drill 1)
4. Demonstrate the steps in performing the jaw-thrust maneuver. (p 738, Skill Drill 2)
5. Demonstrate the steps in performing the tongue-jaw lift maneuver. (p 738, Skill Drill 3)
6. Demonstrate how to place a patient in the recovery position. (p 737)
7. Demonstrate how to operate a suction unit. (pp 739-742)
8. Demonstrate how to suction a patient’s airway. (pp 741-742, Skill Drill 4)
9. Demonstrate the insertion of an oral airway. (p 744, Skill Drill 5)
10. Demonstrate the insertion of an oral airway with a 90° rotation. (p 744, Skill Drill 6)
11. Demonstrate the insertion of a nasal airway. (p 746, Skill Drill 7)
12. Demonstrate how to use Magill forceps to remove an object that is in the airway. (p 750, Skill Drill 8)
13. Demonstrate how to place an oxygen cylinder into service. (pp 753-754, Skill Drill 9)
14. Demonstrate the use of a partial rebreathing mask in providing supplemental oxygen therapy to patients. (p 755)
15. Demonstrate the use of a Venturi mask in providing supplemental oxygen therapy to patients. (p 755)
16. Demonstrate the use of a humidifier in providing supplemental oxygen therapy to patients. (p 756)
17. Demonstrate how to assist a patient with ventilations using the bag-mask device for one and two rescuers. (pp 760-761)
18. Demonstrate mouth-to-mask ventilation. (p 758, Skill Drill 10)
19. Demonstrate the use of a manually triggered ventilation device to assist in delivering artificial ventilation to the patient. (pp 761-762)
20. Demonstrate the use of an automatic transport ventilator to assist in delivering artificial ventilation to the patient. (p 762)
21. Demonstrate the use of CPAP. (p 764, Skill Drill 11)
22. Demonstrate insertion of a nasogastric tube. (pp 766-768, Skill Drill 12)
23. Demonstrate insertion of an orogastric tube. (pp 768-769, Skill Drill 13)
24. Demonstrate how to suction a stoma. (p 770, Skill Drill 14)
25. Demonstrate mouth-to-stoma ventilation using a resuscitation mask. (p 770, Skill Drill 15)
26. Demonstrate bag-mask device-to-stoma ventilation. (p 770, Skill Drill 16)
27. Demonstrate how to replace a dislodged tracheostomy tube. (pp 771-772, Skill Drill 17)
28. Demonstrate how to secure an endotracheal tube. (p 786)
29. Demonstrate the entire procedure for orotracheal intubation using direct laryngoscopy. (p 786, Skill Drill 18)
30. Demonstrate how to perform blind nasotracheal intubation. (p 790, Skill Drill 19)
31. Demonstrate how to perform digital intubation. (p 794, Skill Drill 20)
32. Demonstrate how to perform transillumination intubation. (p 798, Skill Drill 21)
33. Demonstrate how to perform retrograde intubation. (pp 800-802, Skill Drill 22)
34. Discuss how to perform face-to-face intubation. (pp 801-802)
35. Demonstrate how to perform tracheobronchial suctioning. (p 803, Skill Drill 23)
36. Demonstrate how to perform endotracheal intubation in the pediatric patient. (p 807, Skill Drill 24)
37. Demonstrate how to perform rapid-sequence intubation (RSI). (pp 812-813)
38. Demonstrate insertion of the Combitube. (p 815, Skill Drill 25)
39. Demonstrate insertion of the laryngeal mask airway. (pp 818-819, Skill Drill 26)
40. Demonstrate insertion of the King LT airway. (p 821, Skill Drill 27)
41. Demonstrate insertion of the Cobra perilaryngeal airway. (pp 822-823, Skill Drill 28)
42. Demonstrate how to perform open cricothyrotomy. (pp 826-828, Skill Drill 29)
43. Demonstrate how to perform needle cricothyrotomy and translaryngeal catheter ventilation. (pp 830-831, Skill Drill 30)

Readings and Preparation

Review all instructional materials including Chapter 15 of *Nancy Caroline’s Emergency Care in the Streets*, seventh edition, and all related presentation support materials.

Review all instructional materials including Chapter 7 of *Nancy Caroline’s Emergency Care in the Streets*, seventh edition, and all related presentation support materials.

Support Materials

• Lecture PowerPoint presentation

• Case Study PowerPoint presentation

• Skill Drill PowerPoint presentations

- Skill Drill 15-1, Head Tilt-Chin Lift Maneuver

- Skill Drill 15-2, Jaw-Thrust Maneuver

- Skill Drill 15-3, Tongue-Jaw Lift Maneuver

- Skill Drill 15-4, Suctioning a Patient’s Airway

- Skill Drill 15-5, Inserting an Oral Airway

- Skill Drill 15-6, Inserting an Oral Airway With a 90° Rotation

- Skill Drill 15-7, Inserting a Nasal Airway

- Skill Drill 15-8, Removal of an Upper Airway Obstruction With Magill Forceps

- Skill Drill 15-9, Placing an Oxygen Cylinder Into Service

- Skill Drill 15-10, Mouth-to-Mask Ventilation

- Skill Drill 15-11, Using CPAP

- Skill Drill 15-12, Nasogastric Tube Insertion in a Responsive Patient

- Skill Drill 15-13, Orogastric Tube Insertion

- Skill Drill 15-14, Suctioning of a Stoma

- Skill Drill 15-15, Mouth-to-Stoma Ventilation Using a Resuscitation Mask

- Skill Drill 15-16, Bag-Mask Device-to-Stoma Ventilation

- Skill Drill 15-17, Replacing a Dislodged Tracheostomy Tube With a Temporary Endotracheal Tube

- Skill Drill 15-18, Intubation of the Trachea Using Direct Laryngoscopy

- Skill Drill 15-19, Performing Blind Nasotracheal Intubation

- Skill Drill 15-20, Performing Digital Intubation

- Skill Drill 15-21, Performing Transillumination Intubation

- Skill Drill 15-22, Performing Retrograde Intubation

- Skill Drill 15-23, Performing Tracheobronchial Suctioning

- Skill Drill 15-24, Performing Pediatric Endotracheal Intubation

- Skill Drill 15-25, Inserting a Combitube

- Skill Drill 15-26, LMA Insertion

- Skill Drill 15-27, Inserting a King LT Airway

- Skill Drill 15-28, Inserting a Cobra Perilaryngeal Airway (CobraPLA)

- Skill Drill 15-29, Performing an Open Cricothyrotomy

- Skill Drill 15-30, Performing Needle Cricothyrotomy and Translarygneal Catheter Ventilation

• Provide handouts with a graphic of the respiratory system and human anatomy to all students for use in assignments.

• Skill Evaluation Sheets

- Skill Drill 15-1, Head Tilt-Chin Lift Maneuver

- Skill Drill 15-2, Jaw-Thrust Maneuver

- Skill Drill 15-3, Tongue-Jaw Lift Maneuver

- Skill Drill 15-4, Suctioning a Patient’s Airway

- Skill Drill 15-5, Inserting an Oral Airway

- Skill Drill 15-6, Inserting an Oral Airway With a 90° Rotation

- Skill Drill 15-7, Inserting a Nasal Airway

- Skill Drill 15-8, Removal of an Upper Airway Obstruction With Magill Forceps

- Skill Drill 15-9, Placing an Oxygen Cylinder Into Service

- Skill Drill 15-10, Mouth-to-Mask Ventilation

- Skill Drill 15-11, Using CPAP

- Skill Drill 15-12, Nasogastric Tube Insertion in a Responsive Patient

- Skill Drill 15-13, Orogastric Tube Insertion

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- Skill Drill 15-15, Mouth-to-Stoma Ventilation Using a Resuscitation Mask

- Skill Drill 15-16, Bag-Mask Device-to-Stoma Ventilation

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- Skill Drill 15-29, Performing an Open Cricothyrotomy

- Skill Drill 15-30, Performing Needle Cricothyrotomy and Translarygneal Catheter Ventilation

Enhancements

• Direct students to visit the companion website to *Nancy Caroline’s Emergency Care in the Streets*, Seventh Edition, at http://www.paramedic.emszone.com for online activities.

• Local resources may be available through pulmonary physicians or respiratory therapy providers to provide an indepth point of view.

• **Content connections:** Chapters 15 and 16 provide enhancement to each other. Emphasis on airway and oxygenation management is a key component to all care-related chapters in the text.

Teaching Tips

In this chapter, there is ample opportunity for visual learning as most of the topics have an associated skill set. This is extremely beneficial to all visually based learners.

Unit Activities

**Writing activities:** Have students select a recently published study concerning prehospital use of endotrachael intubation (alternatively this can be assigned). Students will present and defend their opinion of the findings in relation to their local EMS system.

**Student presentations:** Students may present their written assignment to the class. Students may also be assigned a(n) airway control or monitoring device to present to the class. The presentation should include a thorough discussion of indications, contraindications, and use.

**Group activities:** Have students design and demonstrate an airway management scenario. The group must select a respiratory chief complaint type, and demonstrate proper assessment techniques and patient care.

**Visual thinking:** Provide students with a blank human anatomy diagram. Direct students to trace a droplet of O2 through the respiratory system, through the alveolar respiration process, and the removal of CO2 from blood stream through exhalation.

Pre-Lecture

### You are the Medic

“You are the Medic” is a progressive case study that encourages critical-thinking skills.

### Instructor Directions

Direct students to read the “You are the Medic” scenario found throughout Chapter 15.

• You may wish to assign students to a partner or a group. Direct them to review the discussion questions at the end of the scenario and prepare a response to each question. Facilitate a class dialogue centered on the discussion questions and the Patient Care Report.

• You may also use this as an individual activity and ask students to turn in their comments on a separate piece of paper.

Lecture

I. Introduction

A. Establishing and maintaining a patent (open) airway and ensuring effective oxygenation and ventilation are vital to patient care.

1. It is futile to try to stabilize a patient whose airway is compromised.

2. The human body needs a constant supply of oxygen.

a. Begins with the airway

b. Airway or ventilation compromise will rapidly lead to acute deterioration and death.

3. Respiratory system

a. Brings in oxygen

b. Eliminates carbon dioxide

i. Primary waste product of oxygen metabolism

c. Vital organs will not function properly if process is interrupted.

i. Permanent death of brain cells occurs after approximately 6 minutes without oxygen.

4. Failure to manage the airway or inappropriate management of the airway is a major cause of preventable death in the prehospital setting.

a. Basic airway management techniques are crucial skills.

b. Mortality and morbidity increase due to:

i. Failure to use basic airway techniques

ii. Improper performance of the techniques

iii. Rush to use advanced interventions

iv. Failure to reassess the patient’s condition

5. Paramedics must understand the importance of:

a. Early detection of airway problems

b. Rapid and effective intervention

c. Continual reassessment

6. Appropriate airway management

a. Open and maintain a patent airway.

b. Recognize and treat airway obstructions.

c. Assess ventilation and oxygenation status.

d. Administer supplemental oxygen.

e. Provide ventilatory assistance.

7. Steps must be performed in order.

a. Bypass steps that do not apply.

II. Anatomy of the Respiratory System

A. Respiratory system

1. All structures that make up the airway and help us breathe (ventilate)

2. Upper and lower airways

3. Structures include:

a. Diaphragm

b. Intercostal muscles

c. Accessory muscles of breathing

d. Nerves from the brain and spinal cord to those muscles

4. Ventilation: Movement of air into and out of the lungs

5. Diaphragm and intercostal muscles make the chest rise and fall during normal breathing.

B. Anatomy of the upper airway

1. Upper airway consists of all anatomic airway structures above the level of the vocal chords:

a. Nose

b. Mouth

c. Jaw

d. Oral cavity

e. Pharynx (throat)

2. Larynx: Divides upper and lower airways

3. Major functions of the upper airway are:

a. Warm, filter, and humidify incoming air

i. Warming helps protect against hypothermia.

ii. Soft tissues of the airway moisturize air.

4. Pharynx

a. Muscular tube that extends from the nose and mouth to the esophagus and trachea

b. Composed of:

i. Nasopharynx

ii. Oropharynx

iii. Laryngopharynx (hypopharynx)

(a) Lowest portion of the pharynx

(b) Opens into the larynx anteriorly and the esophagus posteriorly

5. Nasopharynx

a. Air enters through the nose and passes into the nasopharynx.

b. Nasopharynx is formed by the union of the facial bones.

c. Nasal cavity is lined with a ciliated mucous membrane.

i. Keeps contaminants out of the respiratory tract

ii. Produces additional mucus during illness to trap potentially infectious agents

iii. Extremely delicate, has a rich blood supply

d. Trauma to the nasal passages

i. May result in profuse bleeding from the posterior nasal cavity

(a) Cannot be controlled by direct pressure

e. Nasal passages and septum can also be damaged by extrinsic factors.

i. Example: Cocaine use

ii. Septum separates the nares

f. Turbinates

i. Three bony shelves

ii. Protrude from the lateral walls of the nasal cavity

iii. Extend into the nasal passageway, parallel to the nasal floor

iv. Increase surface area of the nasal mucosa

(a) Improves the warming, filtering, and humidification of inhaled air

g. Nasal septum

i. Rigid partition composed of the ethmoid and vomer bones and cartilage

ii. Divides the nasopharynx into two passages

iii. Normally in the midline of the nose

iv. May be deviated

(a) Important when considering a nasal airway device

h. Frontal and maxillary sinuses

i. Numerous openings along the lateral walls of the nasal passageway extend into these sinuses.

ii. Referred to as the paranasal sinuses because of proximity to and direct communication with the nasal passage

iii. Prevent contaminants from entering the respiratory tract

iv. Act as tributaries for fluid to and from the eustachian tubes and tear ducts

v. Fractures of the bones that comprise the sinuses may cause cerebrospinal fluid (CSF) to:

(a) Leak from the nose (cerebrospinal rhinorrhea)

(b) Leak from the ears (cerebrospinal otorrhea)

(c) Drain from the posterior nasopharynx down the throat, causing a salty taste

6. Oropharynx

a. Forms the posterior of the oral cavity, which is bordered:

i. Superiorly by the hard and soft palates

ii. Laterally by the cheeks

iii. Inferiorly by the tongue

b. Adult teeth are embedded in the gums.

i. Significant force is required to dislodge them.

ii. Lesser trauma may result in fracture or avulsion of teeth.

(a) Can obstruct the upper airway

(b) Can cause aspiration of tooth fragments into the lungs

c. Tongue

i. Large muscle attached to the mandible and hyoid bone

(a) Hyoid bone: Small, horseshoe-shaped bone to which the jaw, epiglottis, and thyroid cartilage attach

ii. Tendency to fall back and occlude the posterior pharynx when the mandible relaxes

iii. Most common cause of anatomic upper airway obstruction

d. Palate

i. Forms the roof of the mouth

ii. Separates the oropharynx and nasopharynx

iii. Hard palate: anterior portion

(a) Formed by the maxilla and palatine bones

iv. Soft palate: Posterior to the hard palate

e. Palatoglossal arch

i. Posterior border of the oral cavity

ii. Extension of the soft palate

f. Uvula

i. Soft-tissue structure

ii. Resembles a punching bag

iii. Extends into the palatoglossal arch at the base of the tongue in the posterior aspect of the oral cavity

g. Palatopharyngeal arch: Entrance to the throat (pharynx)

h. Tonsils

i. Composed of lymphatic tissue

ii. Trap bacteria

iii. Help fight infection

i. Palatine tonsils

i. Paired structures

ii. Lie just behind the walls of the palatoglossal arch

iii. Anterior to the palatopharyngeal arch

j. Pharyngeal tonsil (adenoid): Located on the posterior nasopharyngeal wall

k. Lingual tonsils: At the base of the tongue

l. Adenoids and tonsils often become swollen and infected.

i. Can potentially obstruct the upper airway

C. Anatomy of the lower airway

1. Lower airway exchanges oxygen and carbon dioxide.

a. Externally: Extends from the fourth cervical vertebra to the xiphoid process

b. Internally: Spans the glottis to the pulmonary capillary membrane

2. Larynx

a. Complex structure formed by many independent cartilaginous structures

b. Marks where the upper airway ends and lower airway begins

c. Thyroid cartilage

i. Shield-shaped structure

ii. Formed by two plates that join in a “V” shape anteriorly to form the laryngeal prominence

(a) Known as the Adam’s apple

(b) More pronounced in men

(c) Can be difficult to locate in obese or short-necked patients

iii. Suspended from the hyoid bone by the thyroid ligament

iv. Directly anterior to the glottic opening

d. Cricoid cartilage (cricoid ring)

i. Lies inferiorly to the thyroid cartilage

ii. Forms the lowest portion of the larynx

iii. First ring of the trachea

iv. Only upper airway structure that forms a complete ring

e. Cricothyroid membrane: Ligament between the thyroid and cricoid cartilage

i. Site for emergency surgical and nonsurgical access to the airway (cricothyrotomy)

ii. Bordered laterally and inferiorly by the highly vascular thyroid gland

iii. Because of this location, paramedics must locate anatomic landmarks carefully when accessing the airway via this site.

3. Glottis (glottic opening)

a. Space between the vocal cords

b. Narrowest portion of the adult airway

c. Airway patency in this area depends heavily on adequate muscle tone.

d. Lateral borders are the vocal cords.

i. White bands of tough tissue

ii. Partially separated at rest (glottis is partially open)

iii. During forceful inhalation, they open widely to provide minimum resistance to air flow.

e. Superior border is the epiglottis.

i. Leaf-shaped cartilaginous flap

ii. Prevents food and liquid from entering the glottis during swallowing

iii. Attached to the:

(a) Thyroid cartilage by the thyroepiglottic ligament

(b) Base of the tongue by the glossoepiglottic ligament

(c) Hyoid bone by the hyoepiglottic ligament

f. The positions of the tongue and epiglottis change as the hyoid bone is moved.

i. Occurs:

(a) During the head tilt-chin lift maneuver

(b) By direct forward displacement of the base of the tongue (often done during intubation)

g. Vallecula

i. Anatomic space (“pocket”) between the base of the tongue and the epiglottis

ii. Important landmark for endotracheal (ET) intubation

h. Corniculate and cuneiform cartilages

i. At the inferior border of the glottic opening

ii. Appear as bumps just below the glottis

i. Arytenoid cartilages

i. Pyramid-like cartilaginous structures

ii. Form the posterior attachment of the vocal cords

iii. Valuable guides for ET intubation

iv. As arytenoid cartilages pivot, vocal chords open and close.

(a) Regulates the passage of air through the larynx

(b) Controls the production of sound

(c) Larynx sometimes called the “voice box”

j. Piriform fossae

i. Two pockets of tissue

ii. On the lateral borders of the larynx

iii. Airway devices are occasionally inadvertently inserted into these pockets, resulting in a tenting of the skin under the jaw.

k. When the airway is stimulated, defensive reflexes cause a laryngospasm—spasmodic closure of the vocal cords

i. Seals off the airway

ii. Normally lasts a few seconds

iii. Persistent laryngospasm can threaten airway patency by preventing ventilation altogether.

4. Trachea (windpipe)

a. Conduit for air entry into the lungs

b. Tubular structure approximately 10 to 12 cm long

c. Consists of a series of C-shaped cartilaginous rings

d. Begins immediately below the cricoid cartilage

e. Descends anteriorly down the midline of the neck and chest to the level of the fifth or sixth thoracic vertebra in the mediastinum

i. Mediastinum: The space between the lungs

(a) Contains the trachea, heart, great vessels, and a portion of the esophagus

f. The shape of the tracheal rings enables food to pass down the esophagus easily during swallowing.

g. Anatomically, the esophagus lies posterior to the trachea.

h. Divides into the right and left mainstem bronchi at the level of the carina

i. Right bronchus

(a) Shorter and straighter than the left bronchus

(b) ET tube that is inserted too far will often come to lie in the right mainstem bronchus.

i. Trachea and mainstem bronchi are lined with:

i. Mucous-producing cells (goblet cells)

(a) Secrete a sticky lining that traps potential contaminants

ii. Cilia

(a) Sweep foreign material out of the airway

iii. Beta-2 adrenergic receptors

(a) Bronchodilation when stimulated

5. Lungs

a. All of the blood vessels and bronchi enter each lung at the hilum.

b. Consist of the entire mass of tissue (parenchyma) that includes:

i. Smaller bronchi

ii. Bronchioles

iii. Alveoli

c. Can hold approximately 6 L of air

d. Right lung has three lobes; left has two.

i. Covered with a thin, slippery outer membrane (visceral pleura)

e. The parietal pleura lines the inside of the thoracic cavity.

i. A small amount of fluid is found between the pleurae.

(a) Decreases friction during breathing

f. In the lungs, each bronchus divides into increasingly smaller bronchi.

g. Bronchi subdivide into bronchioles.

i. Made of smooth muscle

ii. Lined with beta-2 adrenergic receptors

iii. Can dilate or constrict in response to various stimuli

iv. Smaller bronchioles branch into alveolar ducts that end at the alveolar sacs.

h. Alveoli

i. Balloonlike clusters of single-layer air sacs

ii. Functional site for the exchange of oxygen and carbon dioxide

(a) Occurs by simple diffusion between the alveoli and the pulmonary capillaries

iii. Increase surface area of the lungs

(a) Expand during deep inhalation

(b) Become even thinner, making diffusion easier

iv. Lined with a phospholipid compound (surfactant)

(a) Decreases surface tension on the alveolar walls and keeps them expanded

(b) Decreased pulmonary surfactant leads to collapse of the alveoli (atelectasis).

6. Familiarity with these physical landmarks will help you assess and manage the airway:

a. Jugular notch

b. Angle of Louis

c. Sternum

i. Manubrium

ii. Body

iii. Xiphoid process

d. Costal angle

III. Physiology of Breathing

A. Respiratory and cardiovascular systems

1. Work together to ensure that:

a. A constant supply of oxygen and nutrients is delivered to every cell

b. Waste products are removed from every cell

2. If either system is compromised:

a. Oxygen delivery is not effective.

b. Cell death may occur.

IV. Ventilation

A. Pulmonary ventilation

1. Process of moving air into and out of the lungs

2. Necessary for oxygenation and respiration

3. Two phases:

a. Inhalation (inspiration)

b. Exhalation (expiration)

4. Adequate, continuous ventilation is essential for life.

a. If a patient is not breathing or is breathing inadequately, you must immediately intervene.

B. Inhalation

1. The role of muscles

a. Inhalation is the active, muscular part of breathing.

b. Governed by Boyle’s law

i. The pressure of a gas is inversely proportional to its volume.

c. Air enters the body through the mouth and nose, moves to the trachea.

i. Travels to and from the lungs

ii. Fills and empties the alveoli

d. Diaphragm and intercostal muscles contract.

i. Diaphragm descends, enlarges the thoracic cage

ii. Intercostal muscles lift ribs up and out

iii. Combined actions enlarge the thorax

e. Maximum inhalation occurs when the diaphragm and intercostal muscles are contracted and the lungs fill with air.

f. Diaphragm

i. Specialized skeletal muscle

ii. Innervated by the phrenic nerve

iii. Voluntary and an involuntary muscle

(a) Voluntary (somatic) control: Deep breath, coughing

(b) Involuntary muscle whenever voluntary function ceases

g. Lungs

i. Have no muscle tissue; cannot move on their own

ii. Lung function depends on the movement of the chest and supporting structures.

iii. Supporting structures include:

(a) Thorax

(b) Thoracic cage (chest cage)

(c) Diaphragm

(d) Intercostal muscles

(e) Accessory muscles

(1) Secondary muscles of breathing

h. Air pressure: Normally higher outside the body (atmospheric pressure) than within the thorax

i. Thoracic cage expands during inhalation, and air pressure within the thorax decreases.

i. Creates a slight vacuum

ii. Air is pulled in through the trachea.

iii. Lungs fill.

iv. Process is called negative-pressure ventilation

j. When air pressure inside the thorax equals air pressure outside the body, air stops moving.

i. Gases move from area of higher pressure to area of lower pressure (diffusion) until the pressures are equal.

ii. Inhalation stops when pressure is equalized.

k. Thoracic cage: Like a bell jar in which balloons are suspended.

i. Balloons are the lungs.

ii. Base of the jar is the diaphragm—moves up and down slightly with each breath

iii. Ribs (sides of the jar) maintain the shape of the chest.

iv. Only opening into the jar is a small tube at the top (trachea).

v. During inhalation, the bottom of the jar moves down slightly.

(a) Causes a decrease in pressure in the jar

(b) Creates a slight vacuum

vi. Balloons fill with air.

2. The role of diffusion

a. Oxygen transfer from air into the capillaries in the alveoli involves diffusion.

b. Partial pressure

i. Amount of gas in air or dissolved in liquid (e.g., the blood)

ii. Governed by Henry’s law

(a) The amount of a gas in a solution varies directly with the partial pressure of a gas over a solution.

(b) As the pressure of a gas over a liquid decreases, the amount of gas dissolved in the liquid will also decrease.

(c) As more pressure is applied over the liquid, more gas can be dissolved in the liquid.

(d) Molecules of a gas can be dissolved in a liquid and remain in the liquid as long as the liquid is in a pressurized, closed container (e.g., circulatory system).

iii. Measured in millimeters of mercury (mm Hg), or torr.

(a) Partial pressure of oxygen in air residing in the alveoli is 104 mm Hg.

(b) Carbon dioxide enters the alveoli from the blood and causes a partial pressure of 40 mm Hg.

iv. Deoxygenated arterial blood from the heart has a partial pressure of oxygen (Pao2) that is lower than the partial pressure of oxygen in the alveoli.

v. The body attempts to equalize the partial pressure.

(a) Oxygen diffuses across the alveolar-capillary membrane into the blood.

(b) Carbon dioxide diffuses into the alveoli and is eliminated during exhalation.

(c) Oxygen and carbon dioxide both diffuse until the partial pressure is equal.

vi. Process occurs in reverse when arterial blood reaches the tissues.

(a) Oxygen diffuses into the tissue fluid and then into the cells.

(b) Carbon dioxide diffuses out of the cells and into the fluid and blood.

3. Lung volumes

a. Inhalation is focused on delivering oxygen to the alveoli.

b. Breathing becomes deeper as the tidal volume responds to the increased metabolic demand for oxygen.

c. Not all inhaled air reaches the alveoli.

d. Alveolar volume (alveolar ventilation): Volume of air that reaches the alveoli

i. Subtract dead space volume from tidal volume.

e. Tidal volume (VT): Amount of air (in milliliters [mL]) that is moved into or out of the respiratory tract during one breath.

i. Measure of the depth of breathing

f. Normal tidal volume

i. Adult: 5 to 7 mL/kg (about 500 mL)

ii. Infants and children: Approximately 6 to 8 mL/kg

g. Dead space volume (VD): Portion of tidal volume that does not reach the alveoli and, therefore, does not participate in gas exchange

i. Can add up to approximately 150 mL in a healthy man

ii. Certain respiratory diseases increase dead space volume by creating intrapulmonary obstructions or atelectasis (alveolar collapse).

(a) These areas are called physiologic dead space.

h. Minute ventilation, or minute volume (VM), is the amount of air moved through the respiratory tract in 1 minute.

i. Includes anatomic dead space

ii. Multiply tidal volume and respiratory rate

i. Alveolar minute volume (VA), or minute alveolar ventilation, is the actual volume of air that reaches the alveoli and participates in pulmonary gas exchange each minute

i. Subtract dead space volume from tidal volume, then multiply that number by the respiratory rate (number of times a person breathes in 1 minute).

ii. Affected by:

(a) Variations in tidal volume

(b) Variations in respiratory rate

iii. As respirations become faster, they often become more shallow (reduced tidal volume).

iv. When respirations are too rapid and too shallow, much inhaled air may reach only the anatomic dead space before it is exhaled.

(a) Smaller volumes of air reach the alveoli.

(b) Alveolar minute volume would decrease.

j. Inspiratory reserve volume: Amount of air that can be inhaled in addition to the normal tidal volume

i. About 3,000 mL in a healthy adult

k. Functional reserve capacity: Amount of air that can be forced from the lungs in one exhalation following an optimal inspiration

l. Expiratory reserve volume: Amount of air that can be exhaled following normal (relaxed) exhalation

i. About 1,200 mL

ii. Even forceful exhalation cannot completely empty the lungs of air.

m. Residual volume: Air that remains in the lungs after maximal exhalation

i. About 1,200 mL in a healthy man

n. Vital capacity: Amount of air that can be forcefully exhaled after a full inhalation

i. About 4,800 mL in a healthy man

o. Total lung capacity (maximum amount of air the lungs can hold): Vital capacity plus residual volume

i. About 6,000 mL (6 L) in a healthy man

p. Respiratory and cardiac diseases affect lung volumes.

C. Exhalation

1. Does not normally require muscular effort; passive process

2. Chest expands; mechanical receptors (stretch receptors) in the chest wall and bronchioles send a signal to the apneustic center via the vagus nerve to inhibit the respiratory center; exhalation occurs.

a. Feedback loop is called the Hering-Breuer reflex

b. Combination of mechanical and neural control

c. Terminates inhalation to prevent overexpansion of the lungs

3. Diaphragm and intercostal muscles relax.

a. Increases intrapulmonary pressure

4. Natural elasticity (recoil) of the lungs passively removes air

a. When the size of the thoracic cage decreases, air in the lungs is compressed into a smaller space.

b. Air pressure within the thorax becomes higher than the outside pressure; air is pushed out through the trachea.

D. Regulation of ventilation

1. The body’s need for oxygen changes constantly.

2. Respiratory system responds by altering the rate and depth of ventilation

a. Regulated primarily by the pH of CSF

i. Directly related to the amount of carbon dioxide dissolved in the plasma portion of the blood (Paco2)

3. Complex series of receptors and feedback loops:

a. Sense gas concentrations in body fluids

b. Send messages to the respiratory center in the brain

i. Adjusts rate and depth of ventilation

4. For most people, the drive to breathe is based on pH changes in the blood and CSF.

a. When oxygen level rises, the respiratory center suspends breathing.

b. Rising carbon dioxide level stimulates the respiratory center to begin breathing again.

5. Neural control of ventilation

a. Involuntary function of the nervous system

b. Originates in the medulla oblongata and the pons (parts of the brainstem)

c. Medulla: Primary involuntary (autonomic) respiratory center

i. Controls the rate, depth, and rhythm (regularity) of breathing in a negative feedback interaction with the pons

d. Apneustic center of the pons

i. Secondary control center if the medulla fails to initiate breathing

ii. Influences the respiratory rate by increasing the number of inspirations per minute

iii. Balanced by the pneumotaxic center, which has an inhibitory response on inspiration

6. Chemical control of ventilation

a. Goal of the respiratory system: Keep blood concentrations of oxygen and carbon dioxide and its acid-base balance within very narrow ranges.

b. Chemoreceptors

i. Provide feedback to the respiratory centers to adjust the rate and depth of respiration based on the body’s needs.

ii. Constantly monitor the chemical composition of body fluids.

iii. Provide feedback on many metabolic processes.

iv. Three sets affect respiratory function.

(a) Those located in the carotid bodies

(b) Those in the aortic arch

(c) Central chemoreceptors

c. Chemoreceptors in the carotid bodies and the aortic arch

i. Measure carbon dioxide in arterial blood

ii. Send signals to the respiratory center via:

(a) Glossopharyngeal nerve (9th cranial nerve)

(b) Vagus nerve (10th cranial nerve)

d. Central chemoreceptors

i. Adjacent to the respiratory centers in the medulla

ii. Monitor the pH of the CSF

(a) Acidity of CSF is an indirect measure of the amount of carbon dioxide in arterial blood.

iii. An increase in the acidity of CSF triggers central chemoreceptors to increase the rate and depth of breathing.

e. Chemoreceptors in the aortic arch and carotid bodies send messages to the respiratory centers to increase breathing when blood plasma (Pao2) decreases.

i. Normally a backup to the primary control of ventilation

ii. When serum carbon dioxide or hydrogen ion levels increase because of a medical condition or traumatic injury involving the respiratory system, chemoreceptors stimulate the medulla to increase the respiratory rate.

(a) Removes more carbon dioxide or acid from the body

(b) Dorsal respiratory group: Initiates inspiration based on information received from chemoreceptors

(c) Ventral respiratory group: Primarily responsible for motor control of inspiratory and expiratory muscles

f. Hypoxic drive

i. Patients with chronic obstructive pulmonary disease (COPD) have difficulty eliminating carbon dioxide through exhalation.

(a) Always have higher blood levels of carbon dioxide

(1) Can alter primary respiratory drive (which is based on increased arterial CO2 levels and the pH of CSF)

(2) Theory: Respiratory centers in the brain gradually accommodate elevated carbon dioxide levels.

ii. In patients with end-stage COPD, “backup system” controls breathing

iii. Hypoxic drive: Secondary control

(a) Stimulates breathing when arterial oxygen level falls

(b) Much less sensitive and less powerful than the carbon dioxide sensors in the brainstem.

(c) Typically found in end-stage COPD, not with a recent diagnosis of COPD

iv. Providing high concentrations of oxygen over time will increase Pao2.

(a) Many physicians believe this could negatively affect the drive to breathe.

(b) Exercise caution when administering high concentrations of oxygen to patients with end-stage COPD.

(c) Never withhold a high concentration of oxygen from a patient who needs it.

(d) Be prepared to assist ventilations if:

(1) Patient becomes sleepy

(2) Respiratory depression develops

7. Control of ventilation by other factors

a. Numerous factors other than changes in pH, Paco2, and Pao2 can influence ventilation.

i. Fever: Respirations increase in response to increased metabolic activity.

ii. Certain medications cause respirations to increase or decrease.

iii. Pain and strong emotions can increase respirations.

iv. Excessive amounts of narcotic analgesics and benzodiazepines decrease respirations.

b. Hypoxia increases respirations.

i. Goal: To bring more oxygen into the body

c. Acidosis increases respirations.

i. Compensatory response

ii. Promotes elimination of excess acids

d. Metabolic rate influences rate of breathing.

i. High metabolic rate: Respirations increase

ii. Low metabolic rate: Respirations slow

E. Oxygenation

1. Process of loading oxygen molecules onto hemoglobin molecules in the bloodstream

2. Air must contain an adequate percentage of oxygen.

a. Oxygenation cannot occur without ventilation.

b. Ventilation is possible without oxygenation and may occur:

i. In places where the oxygen level has been depleted

(a) Example: Confined places

ii. When other gases prevent oxygen from binding to hemoglobin

(a) Example: Carbon monoxide (CO)

iii. In climbers who ascend too quickly to an altitude with inadequate atmospheric pressure

3. Fraction of inspired oxygen (FIo2): The percentage of oxygen in inhaled air

a. Increases when supplemental oxygen is given

b. Commonly documented as a decimal number

i. A person breathing room air, which contains about 21% oxygen, would be documented as having an FIo2 of 0.21.

4. The oxyhemoglobin dissociation curve

a. Hemoglobin

i. Protein necessary for life

ii. Iron-containing molecule

iii. Has a great affinity for oxygen molecules

iv. Approximately 95% of the protein in a red blood cell is hemoglobin.

b. Hemoglobin and hematocrit measurements

i. Common lab tests that determine the hemoglobin level and ratio of red blood cells to plasma

c. Hemoglobin levels

i. Reported in grams per deciliter (dL)

ii. Normal values

(a) Men: 14 to 16 g/dL

(b) Women: 12 to 14 g/dL

d. Hematocrit values

i. Indicate the percentage of red blood cells in whole blood

ii. Normal values

(a) Men: 45% to 52%

(b) Women: 37% to 48%

e. One hemoglobin molecule reversibly binds with four oxygen molecules.

f. Oxygen saturation

i. Expressed as Spo2 if measured by pulse oximetry

ii. Expressed as Sao2 if measured in the arterial blood gases (ABGs)

iii. Proportional to the amount of oxygen dissolved in the plasma component of blood (PaO2)

(a) Relationship is represented by the oxyhemoglobin dissociation curve

iv. Under normal conditions (PaO2 105 mm Hg), the Spo2/Sao2 is approximately 98%.

g. Deoxygenated blood is not completely devoid of oxygen.

i. Some oxygen is still bound to the hemoglobin.

(a) Respiratory system’s ability to supply oxygen to the rest of the body exceeds demand in normal resting conditions

ii. When metabolism increases, demand for oxygen increases and venous blood contains less oxygen.

h. As blood is circulated to the tissue level:

i. PaO2 begins to drop.

ii. Hemoglobin releases its oxygen molecules to make them available for cellular respiration.

i. Various other conditions can also shift the entire curve:

i. Acidosis (decreased pH) and increased carbon dioxide levels

(a) Curve shifts to the right

(b) Hemoglobin gives up its oxygen faster and earlier.

ii. Alkalosis (increased pH) and a decrease in carbon dioxide levels

(a) Curve shifts to the left

(b) Hemoglobin holds on to more oxygen.

F. Respiration

1. Cells take energy from nutrients through a series of chemical processes called metabolism.

a. During metabolism each cell:

i. Combines nutrients and oxygen

ii. Produces energy (adenosine triphosphate [ATP]) and waste products

2. Respiration: Process of exchanging oxygen and carbon dioxide

a. Provides cells with oxygen

b. Disposes of waste (carbon dioxide)

c. Involves:

i. Ventilation

ii. Diffusion of oxygen and carbon dioxide between the blood and pulmonary alveoli

iii. Transport of oxygen and carbon dioxide throughout the body

3. External respiration

a. Also called pulmonary respiration

b. Process of exchanging oxygen and carbon dioxide between the alveoli and blood in pulmonary capillaries

c. Air reaches the alveoli and comes into contact with a combination of phospholipids (surfactant).

i. Facilitates the exchange of oxygen and carbon dioxide

d. Adequate ventilation is necessary for external respiration but does not guarantee it.

e. Once oxygen crosses the alveolar membrane, it is bound to hemoglobin.

i. Transports the oxygen back to the left side of the heart, where it is pumped out to the rest of the body

4. Internal respiration

a. Exchange of oxygen and carbon dioxide between the systemic circulation and the body’s cells

i. Also called cellular respiration

b. Aerobic metabolism (aerobic respiration): In the presence of oxygen, the mitochondria of the cells convert glucose into energy.

c. Kreb cycle and oxidative phosphorylation: Series of processes in which energy is produced in the form of ATP.

d. Without adequate oxygen, cells do not completely convert glucose into energy.

i. Lactic acid and other toxins accumulate in the cell.

ii. This process, anaerobic metabolism (anaerobic respiration), cannot meet the cell’s metabolic demands.

e. If anaerobic metabolism is not corrected, cells will eventually die.

i. Adequate perfusion and ventilation are required for aerobic internal respiration.

(a) Perfusion and ventilation do not guarantee aerobic internal respiration.

f. When mitochondria use oxygen to convert glucose to energy, carbon dioxide accumulates in the cell.

i. Transported through the circulatory system and back to the lungs for exhalation

g. Without oxygen, anaerobic metabolism eventually leads to cell death.

i. Initially, cells become hypoxic.

ii. As stores of glucose are depleted, lactic acid remains, destroying cellular proteins.

(a) Leads to cell death and infarction of tissue

h. Knowing barriers to proper ventilation, oxygenation, and respiration will help you:

i. Recognize the signs and symptoms of inadequate tissue perfusion and oxygenation.

ii. Immediately intervene.

iii. Correct a potentially life-threatening condition.

V. Pathophysiology of Respiration

A. Multiple conditions can inhibit the body’s ability to effectively provide oxygen to cells.

1. Disruption of pulmonary ventilation, oxygenation, and respiration will cause immediate effects on the body.

a. Must be recognized and corrected immediately

b. Important to distinguish a primary ventilation problem from a primary oxygenation or respiration problem

2. Every cell needs a constant supply of oxygen to survive.

a. Some tissues are more resilient than others.

b. Sufficient levels of external respiration and perfusion are required.

i. Perfusion: Circulation of blood within an organ or tissue in adequate amounts to meet cells’ current needs

B. Hypoxia

1. Dangerous condition in which tissues and cells do not receive enough oxygen

a. Death may occur quickly if not corrected.

2. Varying signs and symptoms

a. Onset and degree of tissue damage often depend on the quality of ventilations.

b. Early signs include restlessness, irritability, apprehension, tachycardia, and anxiety.

c. Late signs include mental status changes, a weak (thready) pulse, and cyanosis.

d. Responsive patients often report shortness of breath (dyspnea) and may not be able to speak in complete sentences.

3. Best to administer oxygen before signs and symptoms appear

C. Ventilation-perfusion ratio and mismatch

1. The lungs have a role in placing ambient air in proximity to circulating blood to permit gas exchange.

a. Air and blood flow must be directed to the same place at the same time (ventilation and perfusion must be matched).

i. Failure to match ventilation and perfusion (V/Q mismatch) lies behind most abnormalities in oxygen and carbon dioxide exchange.

2. In most people, normal resting minute ventilation is approximately 6 L/min.

a. Resting alveolar volume: Approximately 4 L/min.

b. Pulmonary artery blood flow: Approximately 5 L/min

c. Overall ratio of ventilation to perfusion: 4:5 L/min, or 0.8 L/min.

3. Because neither ventilation nor perfusion is distributed equally, both are distributed to dependent regions of the lungs at rest.

a. However, an increase in gravity-dependent flow is more marked with perfusion than with ventilation.

i. Ratio of ventilation to perfusion is highest at the apex of the lung and lowest at the base.

4. When ventilation is compromised but perfusion continues:

a. Blood passes over alveolar membranes without gas exchange.

i. Lack of oxygen diffusing into the circulatory system

b. Carbon dioxide is recirculated into the bloodstream.

i. Results in V/Q mismatch

ii. Could lead to severe hypoxemia if not recognized and treated

5. Similar problems can occur when perfusion across the alveolar membrane is disrupted.

a. Less oxygen is absorbed into the bloodstream; less carbon dioxide is removed (V/Q mismatch)

b. Can lead to hypoxemia

i. Immediate intervention is needed to prevent further damage or death.

D. Factors affecting ventilation

1. Maintaining a patent airway is critical for the provision of oxygen to tissues.

2. Intrinsic (internal) and extrinsic (external) factors can cause airway obstruction.

3. Intrinsic factors include infection, allergic reactions, and unresponsiveness.

a. The tongue is the most common obstruction in an unresponsive patient.

i. Easily corrected

ii. Can result in hypoxia and hinder tissue perfusion

iii. Indicators: Snoring respirations, improper position of head/neck

iv. Prompt correction is necessary.

b. Some factors are not necessarily directly part of the respiratory system.

i. Interruptions in the central and peripheral systems can drastically affect breathing.

ii. Medications that depress the central nervous system, if taken in excess, lower the respiratory rate and reduce tidal volume.

(a) Carbon dioxide in the respiratory and circulatory systems is increased.

(1) Increases carbon dioxide in the blood

iii. Trauma to the head and spinal cord can interrupt nervous control of ventilation.

iv. Neuromuscular disorders can affect the nervous system’s control of breathing.

(a) Examples: Muscular dystrophy and poliomyelitis

v. Neuromuscular blocking agents (paralytics) paralyze a patient and induce apnea.

c. Allergic reactions

i. Swelling (angioedema) can obstruct the airway.

ii. Bronchoconstriction can decrease pulmonary ventilation.

(a) Also associated with conditions such as COPD and asthma

4. Extrinsic factors can include trauma and foreign body airway obstruction.

a. Trauma to the airway or chest

i. Requires immediate evaluation and intervention

b. Blunt or penetrating trauma and burns

i. Can disrupt airflow through the trachea and into the lungs

ii. Quickly results in oxygenation deficiencies

c. Trauma to the chest wall

i. Can result in structural damage to the thorax, leading to inadequate pulmonary ventilation

ii. Example: A patient with numerous rib fractures or a flail chest may purposely breathe shallowly in an attempt to alleviate pain from the injury.

(a) Called respiratory splinting

(b) Can result in decreased pulmonary ventilation

iii. Proper ventilatory support is crucial.

5. Hypoventilation occurs when carbon dioxide production exceeds carbon dioxide elimination.

a. Carbon dioxide production can exceed the body’s ability to eliminate it.

b. Carbon dioxide elimination can be depressed to the extent that it no longer keeps up with normal metabolism.

6. Hyperventilation occurs when carbon dioxide elimination exceeds carbon dioxide production.

7. Decrease in minute volume decreases carbon dioxide elimination.

a. Results in buildup of carbon dioxide in the blood (hypercarbia)

8. Increase in minute volume increases carbon dioxide elimination.

a. Lowers carbon dioxide in the blood (hypocarbia)

E. Factors affecting oxygenation and respiration

1. External factors

a. Adequate respiration requires proper ventilation and oxygenation.

b. External factors in ambient air have a key role in the overall process of respiration.

i. Examples: Atmospheric pressure, partial pressure of oxygen

ii. At high altitudes, the percentage of oxygen remains the same, but partial pressure decreases because total atmospheric pressure decreases.

iii. Closed environments may also have decreases in ambient oxygen.

(a) Examples: Mines and trenches

c. Toxic gases displace oxygen in the environment.

i. Make proper oxygenation and respiration difficult

ii. In particular, CO has a much greater affinity for hemoglobin than does oxygen (250 times more).

(a) Inhibits the proper transport of oxygen to tissues

2. Internal factors

a. Conditions that reduce the surface area for gas exchange also decrease the body’s oxygen supply.

b. Medical conditions may also decrease surface area of the alveoli by damaging them or by leading to an accumulation of fluid in the lungs.

c. Nonfunctional alveoli inhibit the diffusion of oxygen and carbon dioxide.

i. Blood entering the lungs from the right side of the heart bypasses the alveoli.

ii. Returns to the left side of the heart in an unoxygenated state

iii. Called intrapulmonary shunting

d. Submersion victims and patients with pulmonary edema have fluid in the alveoli.

i. Inhibits adequate gas exchange at the alveolar membrane

ii. Results in decreased oxygenation and respiration

iii. Exposure to certain environmental conditions or occupational hazards can also result in fluid accumulation in the alveoli over time.

(a) Examples: High altitudes, epoxy resins

iv. These conditions can result in anaerobic respiration and an increase in lactic acid accumulation.

(a) Can result in life-threatening conditions

e. Other conditions that affect cells include:

i. Hypoglycemia

(a) Oxygen and glucose levels decrease; body is unable to meet metabolic needs and maintain homeostasis.

(b) Cell death is likely.

ii. Infection

(a) Increases metabolic needs, disrupts homeostasis

(b) Will lead to cell death if not corrected

iii. Hormonal imbalances

(a) If insulin levels decrease, cellular uptake of glucose will decrease.

(b) Cells will metabolize fatty acids.

(c) Result is ketoacidosis—a form of metabolic acidosis

3. Circulatory compromise

a. Circulatory system must function efficiently for respiration to occur.

i. Compromise leads to inadequate perfusion; oxygen demands will not be met.

b. Obstruction of blood flow to cells and tissues is typically related to trauma emergencies, including:

i. Simple or tension pneumothorax

ii. Open pneumothorax (sucking chest wound)

iii. Hemothorax

iv. Hemopneumothorax

v. Pulmonary embolism

c. These conditions inhibit gas exchange at the tissue level.

d. Conditions such as heart failure and cardiac tamponade inhibit the heart’s ability to effectively pump oxygenated blood to the tissues.

e. Blood loss and anemia reduce the oxygen-carrying ability of the blood.

i. Not enough hemoglobin molecules available to bind with oxygen

f. When the body is in shock, oxygen is not delivered to cells efficiently.

i. Hemorrhagic shock

(a) Form of hypovolemic shock

(b) Abnormal decrease in blood volume due to bleeding

(c) Causes inadequate oxygen delivery to the body

ii. Vasodilatory shock

(a) Caused by an increase in the size of the blood vessels

(b) Diameter of the blood vessels increases.

(c) Blood pressure decreases and blood flow diminishes.

(d) Oxygen is not delivered effectively to tissues.

iii. Both forms of shock result in poor tissue perfusion that leads to anaerobic metabolism.

iv. If shock is suspected, treat aggressively.

F. Acid-base balance

1. Hypoventilation, hyperventilation, and hypoxia can disrupt the acid-base balance.

a. May lead to rapid deterioration and death

2. Respiratory and renal systems help maintain homeostasis.

a. Homeostasis

i. Tendency toward stability in the body’s internal environment

ii. Requires a balance between acids and bases

iii. Fastest way to eliminate excess acid is through the respiratory system

(a) Can be expelled as carbon dioxide from the lungs

(b) Slowing respirations will increase the level of carbon dioxide.

b. The renal system regulates pH by filtering out more hydrogen and retaining bicarbonate when needed, or doing the reverse.

i. Fastest way to eliminate excess H+ ions is to create water and carbon dioxide.

ii. Can be expelled as gases from the lungs

3. Anything that inhibits respiratory function can lead to acid retention and acidosis.

a. Alkalosis can develop if the respiratory rate is too high (or the volume too much).

4. Four main clinical presentations of acid-base disorders:

a. Respiratory acidosis

b. Respiratory alkalosis

c. Metabolic acidosis

d. Metabolic alkalosis

5. Fluctuations in pH due to available bicarbonate result in metabolic acidosis or alkalosis.

6. Fluctuations in pH due to respiratory disorders result in respiratory acidosis or alkalosis.

7. Acid-base disorders that are not immediately correctable by the body’s buffering systems cause the body to initiate compensatory mechanisms to help return levels to normal.

a. Patient management often involves treating more than one form of acid-base imbalance.

VI. Patient Assessment: Airway Evaluation

A. The importance of carefully assessing a patient’s airway and ventilatory status cannot be overemphasized.

1. The quality of your assessment determines the quality of care.

B. Recognizing adequate breathing

1. An adult who is responsive, alert, and able to speak has no immediate airway or breathing problems.

a. Normal breathing in an adult at rest is characterized by

i. Rate between 12 and 20 breaths/min

ii. Adequate depth (tidal volume)

iii. Regular pattern of inhalation and exhalation

iv. Clear and equal breath sounds bilaterally

b. Changes in rate and regularity should be subtle.

C. Recognizing inadequate breathing.

1. Any patient should be assessed for breathing adequacy.

a. Breathing does not necessarily mean *adequate* breathing.

b. General rule: if you can see or hear a patient breathe, there is a problem.

2. An adult who is breathing at a rate of less than 12 breaths/min or more than 20 breaths/min must be evaluated for other signs of inadequate ventilation, such as:

a. Shallow breathing (reduced tidal volume)

b. Irregular pattern of breathing

c. Altered mentation

d. Adventitious (abnormal) airway sounds

3. Cyanosis (blue or purple skin color) is a clear indicator of low blood oxygen.

4. Patients with respiratory distress often compensate with preferential positioning, such as:

a. Upright sniffing (tripod) position

b. Semi-Fowler (semisitting) position

5. Potential causes of respiratory distress and inadequate ventilation include:

a. Severe infection (sepsis)

b. Trauma

c. Brainstem insult

d. Noxious or oxygen-poor environment

e. Renal failure

f. Upper and/or lower airway obstruction

g. Respiratory muscle impairment (e.g., spinal cord injury)

h. Central nervous system impairment (e.g., head injury or drug overdose)

6. To properly manage an airway, perform the following steps in order:

a. Open the airway.

b. Clear the airway.

c. Assess breathing.

d. Provide appropriate intervention(s).

7. Evaluation of a patient with a respiratory complaint includes visual observations, palpation, and auscultation.

8. Visual techniques: Use at first sight of the patient

a. How is the patient positioned? Tripod position (elbows out)?

b. Experiencing orthopnea (positional dyspnea)?

c. Adequate rise and fall of the chest (adequate tidal volume)?

d. Patient gasping for air (air hunger)?

e. Skin: Color? Moist or clammy (diaphoretic)?

f. Nostrils flaring?

g. Breathing through pursed lips?

h. Any retractions (skin pulling between and around the ribs during inhalation)?

i. Intercostal?

ii. At the suprasternal notch?

iii. At the supraclavicular fossa?

iv. Subcostal?

i. Patient using accessory muscles to breathe?

j. Chest wall moving symmetrically? (Asymmetric indicates that airflow into one lung is decreased.)

k. Patient taking a series of quick breaths, followed by prolonged exhalation?

9. A patient with inadequate ventilation may appear to be working hard to breathe (labored breathing).

a. May involve the use of accessory muscles

i. Sternocleidomastoid (neck muscles)

ii. Chest pectoralis major

iii. Abdominal

10. Signs of inadequate ventilation in adults include the following:

a. Respiratory rate of fewer than 12 breaths/min or more than 20 breaths/min in the presence of dyspnea

b. Irregular rhythm (e.g., series of deep breaths followed by periods of apnea)

c. Diminished, absent, or noisy auscultated breath sounds

d. Abdominal breathing

e. Reduced flow of exhaled air at the nose and mouth

f. Unequal or inadequate chest expansion, resulting in reduced tidal volume

g. Increased effort of breathing—use of accessory muscles

h. Shallow depth of breathing (reduced tidal volume)

i. Skin that is pale, cyanotic, cool, moist (clammy), or mottled

j. Retractions

k. Staccato speech patterns (one- or two-word dyspnea)

11. When assessing a patient with respiratory distress, consider possible reduced oxygen levels in the external environment.

12. Feel for air movement at the nose and mouth.

13. Observe the chest for symmetry; note any paradoxical motion (opposite normal chest movement).

14. Assess for pulsus paradoxus.

a. Clinical finding in which systolic blood pressure drops more than 10 mm Hg during inhalation

b. May detect a change in pulse quality or even the disappearance of a pulse during inhalation

c. Generally seen in patients with conditions that cause an increase in intrathoracic pressure

i. Decompensating COPD

ii. Severe pericardial tamponade

iii. Tension pneumothorax

iv. Severe asthma attack

15. Ask questions to determine the evolution of the current problem:

a. Onset sudden or gradual?

b. Known cause or “trigger”?

c. Duration: Constant or recurrent?

d. Does anything alleviate or exacerbate the problem?

e. Other symptoms, such as a productive cough (if yes, what color is the sputum?), chest pain or pressure, or fever?

f. Any interventions attempted before EMS arrival?

g. Has the patient been evaluated by a physician or admitted to the hospital for this condition in the past?

i. Was the patient hospitalized or seen in the emergency department and released?

ii. If hospitalized, admitted to intensive care (clinically significant) or a regular, unmonitored floor?

h. Is the patient currently taking any medications? If so, determine *overall* compliance by asking:

i. “Have you been able to take all of your pills as directed?”

ii. “Is there anything that has stopped you from taking your pills as directed?”

iii. “Is there something that bothers you about taking a certain pill?”

iv. Look at the prescription date and directions to verify information.

v. Any changes in the current prescription, such as a new medication or changes in the prescribing directions of an existing medication?

i. Any risk factors that could cause or exacerbate the condition, such as alcohol or illicit drug use, cigarette smoking, or an inadequate diet?

16. Evaluate protective reflexes of the airway.

a. Coughing, sneezing, and gagging

i. A patient whose cough mechanism is suppressed is at serious risk of aspirating foreign material.

ii. Gag reflex: A spastic pharyngeal and esophageal reflex caused by stimulation of the posterior pharynx to prevent foreign bodies from entering the trachea

(a) Eyelash reflex is a fairly reliable indicator in an unresponsive patient.

(1) If the lower eyelid contracts when you gently stroke the upper eyelashes, the gag reflex is probably intact.

17. Sighing: A slow, deep inhalation followed by a prolonged exhalation

a. Periodically hyperinflates the lungs, thereby reexpanding atelectatic (collapsed) alveoli.

b. Average person sighs about once per minute

18. Hiccuping: A sudden inhalation, due to spasmodic contraction of the diaphragm, cut short by closure of the glottis

a. Serves no physiologic purpose

b. Persistent hiccups may be clinically significant.

19. Patients with serious injuries or illness may present with changes in respiratory pattern.

D. Assessment of breath sounds

1. Auscultate breath sounds with a stethoscope.

a. Should be clear and equal on both sides of the chest (bilaterally), anteriorly, and posteriorly

b. Compare each apex (top) of the lung with the opposite apex and each base (bottom) of the lung with the opposite base.

2. Breath sounds are created as air moves through the tracheobronchial tree.

a. Size of the airway determines the type of sound.

b. Breath sounds: Heard over the majority of the chest, represent airflow into alveoli.

i. Tracheal breath sounds (bronchial breath sounds): Heard by placing the stethoscope diaphragm over the trachea or sternum.

(a) Assess for duration, pitch, and intensity.

ii. Vesicular breath sounds: Softer, muffled sounds

(a) Expiratory phase: Barely audible

iii. Bronchovesicular sounds

(a) Combination of the two

(b) Heard in places where airways and alveoli are found

(c) Should be assessed for duration, pitch, and intensity

3. Duration: Length of time for the inspiratory and expiratory phase of the breath

a. Normally, expiration is at least twice as long as inspiration.

b. Relationship expressed by I/E ratio (inspiratory/expiratory ratio)

i. Normal I/E ratio is 1:2.

ii. When the lower airway is obstructed, expiratory phase may be four to five times as long as inspiration.

(a) I/E ratio 1:4 or 1:5

iii. In patients who are tachypneic, the expiratory phase is short and approaches that of inspiration.

(a) I/E ratio may be 1:1

4. Pitch is described as higher or lower than normal (stridor or wheezing).

a. Intensity of sound depends on:

i. Airflow rate

ii. Constancy of flow throughout inspiration

iii. Patient position

iv. Site selected for auscultation

b. Less intense sounds are said to be diminished.

5. Always auscultate directly on skin.

6. Sounds that are present in an unexpected area can indicate an abnormal condition.

7. Adventitious (abnormal) breath sounds: Usually classified as continuous or discontinuous.

a. Wheezing

i. Continuous sound as air flows through a constricted lower airway

ii. High-pitched sound that may be heard on inspiration, expiration, or both

b. Rhonchi

i. Continuous, low-pitched sounds

ii. Indicate mucus or fluid in larger lower airways

c. Crackles (formerly known as rales)

i. Occur when airflow causes mucus or fluid in the airways to move in the smaller lower airways

ii. Tend to clear with coughing

iii. May also be heard when collapsed airways or alveoli pop open

iv. Classified as discontinuous sounds

v. May occur early or late in the inspiratory cycle

vi. Early inspiratory crackles:

(a) Usually occur when larger, proximal bronchi open

(b) Common in patients with COPD

(c) Tend not to clear with coughing

vii. Late inspiratory crackles

(a) Occur when peripheral alveoli and airways pop open

(b) More common in dependent lung regions

8. Stridor

a. Results from foreign body aspiration, infection, swelling, disease, or trauma within or immediately above the glottic opening

b. Produces a loud, high-pitched sound typically heard during inspiration

9. A pleural friction rub results from inflammation that causes the pleura to thicken.

a. Surfaces of the visceral and parietal pleura rub together.

b. Often creates stabbing pain with breathing or any movement of the thorax.

E. Quantifying ventilation and oxygenation

1. Pulse oximetry

a. Simple, rapid, safe, and noninvasive method of measuring how well a person’s hemoglobin is saturated.

b. Pulse oximeter: Measures the percentage of hemoglobin (Hb) in arterial blood that is saturated with oxygen.

i. A sensor probe transmits light through the vascular bed to a light-sensing detector.

(a) Amount of light depends on the proportion of hemoglobin that is saturated with oxygen.

ii. To ensure that the instrument is measuring arterial and not venous oxygen saturation, pulse oximeters assess only pulsating blood vessels.

iii. Also measure pulse

(a) Can check device functioning by comparing its pulse reading with your measurement of the patient’s pulse by palpation

c. A normally oxygenated, normally perfused person should have an Spo2 of greater than 95% while breathing room air.

i. Less than 95% in a nonsmoker suggests hypoxemia.

ii. Less than 90% signals a need for aggressive oxygen therapy.

d. Pulse oximeters may be useful in the following prehospital situations:

i. Monitoring the oxygenation status of a patient during an intubation attempt or during suctioning

(a) Low-saturation alarm signals that intubation should be aborted and patient should be ventilated.

ii. Identifying deterioration in the condition of a trauma victim

(a) Declining Spo2 level can prompt a search for the cause.

iii. Identifying deterioration in the condition of a patient with cardiac disease

(a) May enable early identification of congestive heart failure following a myocardial infarction

iv. Identifying high-risk patients with respiratory problems

v. Assessing vascular status in orthopedic trauma

(a) Use with a fractured extremity to evaluate the pulse distal to the fracture.

(b) Loss of a pulse means that the limb may require urgent action in the field.

(c) A pulse oximeter clipped to a finger or toe on a broken limb might provide information about circulation to the limb.

e. Circumstances that might produce erroneous readings:

i. Bright ambient light

(a) May enter the spectrophotometer and create an incorrect reading

(b) Cover the sensor clip with a towel or aluminum foil to protect it.

ii. Patient motion

(a) May mistake motion for arterial pulsation and read oxygen saturation from a vein rather than an artery.

iii. Poor perfusion

(a) Makes it difficult to sense a pulse and therefore to generate a reading

(b) If the vessels in a patient’s limbs are constricted and the limbs are cold, you may need to place the clip on the earlobe or nose.

iv. Nail polish

(a) Carry disposable acetone swabs to remove nail polish quickly.

v. Venous pulsations occurring with right-sided heart failure

(a) If a vein is pulsating, the oximeter may regard it as an artery.

vi. Abnormal hemoglobin

f. Two types of hemoglobin normally found:

i. Oxyhemoglobin (Hbo2): Hemoglobin that is occupied by oxygen

ii. Reduced hemoglobin: Hemoglobin after oxygen has been released to cells

g. Normal Spo2 values may be observed in the presence of methemoglobin and carboxyhemoglobin even though the body is not receiving sufficient oxygen.

i. Methemoglobin (metHb): Compound formed by oxidation of the iron on hemoglobin

ii. Carboxyhemoglobin (COHb): Hemoglobin loaded with CO

h. Carbon monoxide binds to hemoglobin 250 times more readily than oxygen.

i. A CO-oximeter, or CO monitor:

i. Measures absorption at several wavelengths to distinguish Hbo2 from COHb

ii. Determines Hbo2 saturation (percentage of oxygenated Hb compared with the total amount of hemoglobin) including COHb, metHb, Hbo2, and reduced Hb

2. Peak expiratory flow measurement

a. Bronchoconstriction can be evaluated by measuring the peak rate of a forceful exhalation with a peak expiratory flowmeter.

i. Increasing peak expiratory flow: Suggests patient is responding to treatment

ii. Decreasing peak expiratory flow: Suggests patient’s condition is deteriorating

b. Varies based on gender, height, and age.

i. Healthy adults have a peak expiratory flow rate of 350 to 750 mL.

c. To assess peak expiratory flow:

i. Place the patient in a seated position with legs dangling.

ii. Assemble the flowmeter.

iii. Ensure that it reads zero.

iv. Ask the patient to take a deep breath, place the mouthpiece in his or her mouth, and exhale as forcefully as possible (make sure there are no air leaks).

v. Perform the test three times.

vi. Take the best peak flow rate of the three readings.

3. Arterial blood gas analysis

a. Provides the most comprehensive quantitative information about the respiratory system.

b. Blood is obtained from a superficial artery.

c. Blood is analyzed for pH, Paco2, PaO2, Hco3− (concentration of bicarbonate ions), base excess (indicating acidosis or alkalosis), and Sao2.

i. pH and Hco3− are used to evaluate a patient’s acid-base status.

ii. Paco2 indicates the effectiveness of ventilation.

iii. PaO2 and Sao2 are indicators of oxygenation.

d. To maintain normal ABG values, a balance between alveolar volume and perfusion of the alveolar capillaries must be maintained.

4. End-tidal carbon dioxide (etco2) assessment

a. etco2 monitors detect carbon dioxide in exhaled air.

i. Important adjuncts for determining ventilation adequacy

ii. Analyze air samples through a special etco2 nasal cannula in a spontaneously breathing patient with an adequate airway.

iii. Can also assess ventilation adequacy in patients in whom an advanced airway has been inserted

b. Carbon dioxide concentration in exhaled gases closely approximate arterial Paco2 levels (normally range between 35 and 45 mm Hg).

i. Typically, etco2 is approximately 2 to 5 mm Hg lower than arterial Paco2.

c. etco2 detector is a reliable method for confirming and monitoring advanced airway placement.

d. etco2 detector types:

i. Digital

ii. Waveform

iii. Digital/ waveform

iv. Colorimetric

e. Capnometer displays a numeric reading of exhaled carbon dioxide

f. Capnographer performs the same function but provides a graphic representation of exhaled carbon dioxide

i. Three types:

(a) Waveform

(b) Digital/waveform

(c) Colorimetric

g. Waveform capnography provides information regarding exhaled carbon dioxide level.

i. Displays a graphic waveform on the portable cardiac monitor/defibrillator

ii. Many portable cardiac monitor/defibrillators provide a numeric reading and a waveform (digital/waveform capnography).

h. Capnographic waveform features include contour, baseline level, rate and rise of carbon dioxide level.

i. Phase A-B: Initial stage of exhalation

(a) Respiratory baseline

(b) Gas sample is dead space gas, free of carbon dioxide

(c) Point B: Mixture of alveolar gas with dead space gas, resulting in an abrupt rise in carbon dioxide levels

ii. Phase B-C: Expiratory upslope

iii. Phase C-D: Expiratory or alveolar plateau

(a) Gas sampled is essentially alveolar

(b) Point D: Maximal etco2 level—the best reflection of alveolar carbon dioxide level

iv. Phase D-E: Inspiratory down stroke

(a) Fresh gas is introduced.

(b) Waveform returns to the baseline level of carbon dioxide—approximately 0.

i. Colorimetric capnographer provides qualitative (does not assign a numeric value) information regarding the presence of carbon dioxide in exhaled breath.

i. After 6 to 8 positive-pressure breaths paper inside the detector should turn from purple to yellow during exhalation.

(a) Indicates the presence of exhaled carbon dioxide

ii. Should be used during initial confirmation of ET tube placement and replaced as soon as possible with a quantitative device.

iii. Sensitive to temperature extremes and humidity

(a) May be less reliable if vomitus or other secretions get into it

(b) Paper inside degrades over time

j. Capnography can indicate chest compression effectiveness and detect return of spontaneous circulation.

i. Possible because blood must circulate through the lungs for carbon dioxide to be exhaled and measured

k. etco2 monitoring is limited with cardiac arrest.

i. In a patient with a short arrest interval, exhaled carbon dioxide may be detected despite a lack of perfusion.

ii. Patients with prolonged cardiac arrest will have minimal to no exhaled carbon dioxide because of severe acidosis and minimal or no carbon dioxide return to the lungs.

VII. Airway Management

A. Air reaches the lungs only through the trachea, so a patent airway is essential.

1. Patency is obvious if the patient is responsive and can talk.

2. Manual maneuvers may be required to open airway.

a. Artificial airway adjuncts may be needed.

3. In a compromised airway, clearing the airway and maintaining patency are vital.

a. Clearing the airway means removing obstructing material, tissue, or fluids from the nose, mouth, and throat.

b. Maintaining the airway means keeping the airway patent.

B. Positioning the patient

1. Unresponsive patients found in a prone position must be positioned in a supine position.

a. Log roll the person as a unit.

b. Once the patient is supine, quickly assess for breathing by visualizing the chest for visible movement.

c. If the patient is breathing adequately and is not injured, move to recovery position.

i. Left lateral recumbent position

ii. Use in all nontrauma patients with decreased LOC who can maintain their airway spontaneously and are breathing adequately

C. Manual airway maneuvers

1. If an unresponsive patient has a pulse but is not breathing, you must open the airway manually.

2. The most common cause of airway obstruction in an unresponsive patient is the tongue.

a. Manually maneuver the patient’s head to propel the tongue forward and open the airway using either:

i. Head tilt-chin lift maneuver *or*

ii. Jaw-thrust maneuver (with or without head tilt)

3. Head tilt-chin lift maneuver

a. Preferred technique with a patient who has not sustained trauma

b. Occasionally, the patient will resume breathing with this technique alone.

c. Considerations:

i. Indications

(a) Unresponsive patient

(b) No mechanism for cervical spine injury

(c) Patient is unable to protect his or her own airway.

ii. Contraindications

(a) Responsive patient

(b) Possible cervical spine injury

iii. Advantages

(a) No equipment required

(b) Simple, safe, and noninvasive

iv. Disadvantages

(a) May be hazardous to patients with spinal injury

(b) No protection from aspiration

d. Refer to ***Skill Drill 15-1***.

4. Jaw-thrust maneuver

a. Use if you suspect a cervical spine injury

b. Place your fingers behind the angle of the jaw and lift the jaw forward.

c. Jaw is displaced forward at the mandibular angle.

d. Considerations:

i. Indications

(a) Unresponsive patient

(b) Possible cervical spine injury

(c) Patient is unable to protect his or her own airway.

ii. Contraindications

(a) Responsive patient with resistance to opening the mouth

(b) May be needed in a responsive patient who has sustained a jaw fracture to keep the tongue away from the back of the throat

iii. Advantages

(a) May be used in patients with cervical spine injury

(b) May use with cervical collar in place

(c) No special equipment required

iv. Disadvantages

(a) Cannot maintain if patient becomes responsive or combative

(b) Difficult to maintain for an extended time

(c) Very difficult to use in conjunction with bag-mask ventilation

(d) Thumb must remain in place to maintain jaw displacement

(e) Requires second rescuer for bag-mask ventilation

(f) No protection against aspiration

e. Refer to ***Skill Drill 15-2***.

5. Tongue-jaw lift maneuver

a. Used more commonly to open a patient’s airway for the purpose of suctioning or inserting an oropharyngeal airway.

b. Cannot be used to ventilate a patient because it will not allow for an adequate mask seal on the patient’s face.

c. Refer to ***Skill Drill 15-3***.

VIII. Suctioning

A. When the mouth or throat becomes filled with vomitus, blood, or secretions, a suction apparatus enables you to remove material quickly and efficiently.

1. Ventilating a patient with secretions in his or her mouth will force material into the lungs.

2. Clearing the airway with suction (indicated if you hear gurgling) is your next priority after opening the airway with manual maneuvers.

B. Suctioning equipment

1. Ambulances should carry:

a. Fixed suction unit

b. Portable suction unit

2. Regardless of your location, you must have quick access to suction.

3. Hand-operated suctioning units with disposable canisters

a. Reliable, effective, relatively inexpensive

b. Can easily fit into your first in bag

4. Mechanical or vacuum-powered suction units

a. Should be capable of generating a vacuum of 300 mm Hg within 4 seconds of clamping off the tubing

b. Amount of suction should be adjustable

c. Check the vacuum on the mechanical suction unit at the beginning of every shift.

i. Turn on the device.

ii. Clamp the tubing.

iii. Make sure the pressure gauge registers 300 mm Hg.

d. Ensure that all battery-charged units have fully charged batteries.

5. The following supplies should be readily accessible at the patient’s head:

a. Wide-bore, thick-walled, nonkinking tubing

b. Soft and rigid suction catheters

c. Nonbreakable, disposable collection bottle

d. Supply of water for rinsing the catheters

6. Suction catheter

a. Hollow, cylindrical device

b. Used to remove fluids and secretions from the patient’s airway

7. Yankauer catheter (tonsil-tip catheter)

a. Good option for suctioning the pharynx in adults

b. Preferred device for infants and children

c. Plastic-tip catheters with a large diameter

d. Rigid so they do not collapse

i. Capable of suctioning large volumes of fluid rapidly

e. Tips with a curved contour

i. Allow for easy, rapid placement in the oropharynx

8. Soft plastic, nonrigid catheters

a. Sometimes called French or whistle-tip catheters

b. Can be placed in the oropharynx or nasopharynx or down an ET tube

c. Come in various sizes

d. Have a smaller diameter than rigid catheters

e. Used:

i. To suction the nose

ii. To suction liquid secretions in the back of the mouth

iii. In situations in which a rigid catheter cannot be used

9. Suction tubing without the attached catheter facilitates suctioning of large debris in the oropharynx and allows access to the back of the pharynx.

C. Suctioning techniques

1. Suctioning removes oxygen from the airway.

a. Adequate preoxygenation is required before suctioning.

b. Each suctioning attempt must be limited to a maximum of:

i. 15 seconds in an adult

ii. 10 seconds in children

iii. 5 seconds in infants

c. Do not stimulate the back of the throat because the vagal stimulus can cause the pulse rate to drop.

d. After suctioning, continue ventilation and oxygenation.

2. Soft-tip catheters

a. Must be lubricated when suctioning the nasopharynx

b. Best used when passed through an ET tube

c. Suction is applied during extraction of the catheter to clear the airway.

d. After suctioning, reevaluate the patency of the airway.

e. Continue to ventilate and oxygenate as needed.

3. Before inserting any suction catheter, measure for the proper size.

a. From the corner of the mouth to the earlobe

b. Never insert a catheter past the base of the tongue.

4. To properly suction a patient’s airway, refer to ***Skill Drill 15-4***.

IX. Airway Adjuncts

A. An artificial airway adjunct may be needed to help maintain airway patency in an unresponsive patient after manually opening the airway and suctioning.

1. *Not a substitute for proper head positioning*

2. Even after an airway adjunct has been inserted, the appropriate manual position of the head must be maintained.

B. Oropharyngeal (oral) airway

1. Curved, hard plastic device that fits over the back of the tongue

a. Makes it much easier to ventilate patients with a bag-mask device

b. Can also serve as an effective bite-block

2. Should be inserted promptly in unresponsive patients who have no gag reflex

a. Will stimulate gagging and retching in a responsive patient

b. To assess gag reflex, use the eyelash reflex.

c. If the patient gags during insertion, remove the device immediately and be prepared to suction.

3. Considerations:

a. Indications: Unresponsive patients who have no gag reflex

b. Contraindications

i. Responsive patients

ii. Patients with a gag reflex

c. Advantages

i. Noninvasive

ii. Easily placed

iii. Prevents blockage of the glottis by the tongue

d. Disadvantages: No prevention of aspiration

e. Complications

i. Unexpected gag may cause vomiting.

ii. Improper technique may cause pharyngeal or dental trauma.

4. If the oral airway is improperly sized or is inserted incorrectly, it could push the tongue back into the pharynx, creating an airway obstruction.

5. Rough insertion can injure the hard palate.

6. Before insertion, suction the oropharynx as needed.

7. To properly insert an oral airway, refer to ***Skill Drill 15-5*** and ***Skill Drill 15-6***.

C. Nasopharyngeal (nasal) airway

1. Soft, rubber tube inserted through the nose into the posterior pharynx

2. Allows passage of air from the nose to the lower airway

3. Range in size from 12 French to 32 French; length depends on size

4. Much better tolerated than an oral airway in patients with an intact gag reflex but an altered LOC

5. Do not use with trauma to the nose or if you suspect a skull fracture.

a. May cause the device to enter the brain through the hole caused by the fracture

6. Must be inserted gently to avoid precipitating epistaxis (nosebleed)

7. Lubricate the airway generously with a water-soluble gel, preferably one that contains a local anesthetic.

8. Slide it gently, tip downward, into one nostril.

9. If you meet resistance, try the other nostril.

10. Considerations:

a. Indications

i. Unresponsive patients

ii. Patients with an altered mental status who have an intact gag reflex

b. Contraindications

i. Patient intolerance

ii. Presence of facial (specifically, the nose) fracture or skull fracture

c. Advantages

i. Can be suctioned through

ii. Provides a patent airway

iii. Can be tolerated by responsive patients

iv. Can be safely placed “blindly”

v. No requirement for the mouth to be open

d. Disadvantages

i. Improper technique may result in severe bleeding.

(a) Resulting epistaxis may be extremely difficult to control.

ii. Does not protect from aspiration

11. To properly insert a nasal airway, refer to ***Skill Drill 15-7***.

X. Airway Obstructions

A. The airway connects the body to the life-giving oxygen.

1. Paramedics must recognize the signs of an obstructed airway and immediately take corrective action.

B. Causes of airway obstruction

1. Sudden foreign body airway obstruction usually occurs:

a. Adult: During a meal

b. Children: While eating or playing with small toys

2. Multitude of other causes, including:

a. Tongue

b. Laryngeal edema

c. Laryngeal spasm (laryngospasm)

d. Trauma

e. Aspiration

3. When obstruction is due to infection or a severe allergic reaction, repeated attempts to clear the airway will be unsuccessful and potentially harmful.

a. Requires specific management and prompt transport to an appropriate medical facility

4. Tongue

a. With altered LOC, the tongue tends to fall back against the posterior wall of the pharynx, closing off the airway.

b. With partial tongue obstruction, patient will have snoring respirations.

c. With complete obstruction, no respirations

d. Simple to correct using a manual maneuver (e.g., head tilt-chin lift, jaw-thrust)

5. Foreign body

a. Causes many deaths, often from choking on food

b. Typical victim

i. Middle-aged or older

ii. Wears dentures

iii. Has consumed alcohol

(a) Depresses protective reflexes

(b) Adversely affects judgment about size of pieces of food

c. Increased risk with conditions that decrease airway reflexes (such as stroke)

d. Obstruction may be mild or severe depending on the object’s size and location

e. Signs may include:

i. Choking

ii. Gagging

iii. Stridor

iv. Dyspnea

v. Aphonia (inability to speak)

vi. Dysphonia (difficulty speaking)

f. Treatment depends on whether the patient is effectively moving air.

6. Laryngeal spasm and edema

a. Laryngeal spasm (laryngospasm) results in spasmodic closure of the vocal cords, completely occluding the airway.

b. Often caused by trauma during an overly aggressive intubation attempt *or*

c. Occurs immediately on extubation

d. Laryngeal edema causes the glottic opening to become extremely narrow or totally closed.

i. Common causes include:

(a) Epiglottitis

(b) Anaphylaxis

(c) Inhalation injury

e. May be relieved by aggressive ventilation or a forceful upward pull of the jaw.

f. Muscle relaxant medications may be effective in relieving laryngeal spasm.

g. Resolution does not mean that laryngospasm will not recur.

h. Transport patient to the hospital for evaluation.

7. Laryngeal injury

a. Fracture of the larynx increases airway resistance by decreasing airway size due to:

i. Decreased muscle tone

ii. Laryngeal edema

iii. Ventilatory effort

b. Penetrating and crush injuries to the larynx can compromise the airway secondary to swelling and bleeding.

c. Advanced airway management may be required.

8. Aspiration

a. Increases mortality.

i. Potentially obstructs the airway

ii. Destroys delicate bronchiolar tissue

iii. Introduces pathogens into the lungs

iv. Decreases the patient’s ability to ventilate (or be ventilated)

b. Suction should be readily available for any patient who is unable to maintain his or her own airway.

i. Always assume patient has a full stomach.

C. Recognition of an airway obstruction

1. Differences in managing mild versus severe airway obstruction are significant.

2. Mild obstruction

a. Patient is responsive.

b. Able to exchange air but may show varying degrees of respiratory distress

c. Will usually have noisy respirations and may be coughing

d. Should be left alone

i. Forceful cough is the most effective means of dislodging the obstruction.

ii. Attempts to manually remove the object could force it farther down into the airway.

e. Closely monitor the patient’s condition.

f. Be prepared to intervene if you see signs of severe airway obstruction.

3. Severe obstruction

a. Patient typically experiences a sudden inability to breathe, talk, or cough.

b. May grasp at his or her throat (universal sign of choking)

c. May begin to turn cyanotic

d. May make frantic, exaggerated attempts to move air

e. Has a weak, ineffective, or absent cough

f. Is in marked respiratory distress

g. Weak inspiratory stridor and cyanosis often present

D. Emergency medical care for foreign body airway obstruction

1. If patient is responsive, ask, “Are you choking?”

a. If the patient nods “yes” and cannot speak, begin treatment immediately.

b. If the obstruction is not promptly cleared, blood oxygen will decrease dramatically.

2. If, after opening the airway, you are unable to ventilate the patient or you feel resistance when ventilating, reopen the airway and again attempt to ventilate the patient.

3. Lung compliance is the ability of the alveoli to expand when air is:

a. Drawn into the lungs during negative-pressure ventilation

b. Pushed into the lungs during positive-pressure ventilation

4. If large pieces of foreign body are found in the airway, sweep them forward and out of the mouth with your gloved index finger.

a. Attempt to remove only foreign bodies that you can see and easily retrieve.

5. Once airway is open, insert your index finger along the inside of the cheek and into the throat at the base of the tongue.

a. Try to hook the foreign body to dislodge it and maneuver it into the mouth.

b. Do not force the foreign body deeper into the airway.

c. Do not blindly insert any object other than your finger to remove a foreign body.

i. An instrument can damage the pharynx and cause hemorrhaging.

6. Clear the airway of secretions with suctioning as needed.

7. Abdominal thrust maneuver (Heimlich maneuver) is the most effective way to dislodge and force an object out of the airway of a responsive patient.

a. Aims to create an artificial cough, thereby expelling the object.

b. Perform until the object is expelled or until the patient becomes unresponsive.

c. If patient is in the advanced stages of pregnancy or is morbidly obese, perform chest thrusts instead.

8. If patient becomes unresponsive, position him or her supine on the ground and begin chest compressions.

a. 30 chest compressions

b. 15 if two rescuers are present and the patient is an infant or a child

9. Then open the airway and look in the mouth.

10. Attempt to remove the foreign body only if you can see it.

11. Attempt a rescue breath.

a. If the first breath does not produce visible chest rise, reopen the airway and reattempt to ventilate.

b. If both breaths fail to produce visible chest rise, continue chest compressions.

c. If these techniques do not work, proceed with direct laryngoscopy.

i. Insert the laryngoscope blade into the patient’s mouth.

ii. If you see the foreign body, remove it with Magill forceps.

(a) Refer to ***Skill Drill 15-8***.

XI. Supplemental Oxygen Therapy

A. Supplemental oxygen should be administered to any patient with potential hypoxia.

1. In some conditions, a body part does not receive enough oxygen, *even though overall oxygen supply is adequate*.

2. Increasing available oxygen enhances compensatory mechanisms during shock and other distressed states.

3. Oxygen-delivery method

a. Must be appropriate for the patient’s ventilatory status

b. Reassess frequently.

c. Adjust based on clinical condition and breathing adequacy.

B. Oxygen sources

1. Oxygen cylinders

a. Pure (100%) oxygen is stored in seamless steel or aluminum cylinders.

b. Cylinder color may vary: silver, chrome, green, or a combination.

c. Make sure that the cylinder is labeled “medical oxygen.”

d. Look for letters and numbers stamped on the cylinder’s collar.

i. Especially month and year (indicate last test date)

e. Various cylinder sizes

i. You will most often use D (350 L of oxygen, typically carried from ambulance to patient) and M (3,000 L of oxygen, stays in the ambulance, main supply tank).

f. Oxygen delivery is measured in liters per minute (L/min).

g. Replace an oxygen cylinder with a full one when the pressure falls to 200 psi or lower.

i. That level is called the safe residual pressure.

ii. In some EMS systems, the safe residual pressure is 500 psi.

iii. Using the pressure in the cylinder and the flow rate, you can calculate how long the supply of oxygen will last.

2. Liquid oxygen

a. Oxygen that is cooled to its aqueous state

b. Converts to a gaseous state when warmed

c. Units generally require upright storage.

d. Special requirements for large-volume storage and cylinder transfer

C. Safety reminders

1. Any cylinder containing compressed gas under high pressure has the potential to assume the properties of a rocket.

2. Oxygen presents a fire hazard because it supports the combustion process.

3. Safety precautions are necessary when handling oxygen cylinders:

a. Keep combustible materials away from the cylinder, regulators, fittings, valves, and tubing.

b. No smoking near cylinders.

c. Store in a cool, well-ventilated area with temperature below 125°F (approximately 50°C)

d. Use only with a safe, properly fitting regulator valve.

e. Close all valves when the cylinder is not in use, even if the tank is empty.

f. Secure cylinders so they will not topple over.

g. When working with an oxygen cylinder, always position yourself to its side.

i. Never place any part of your body over the cylinder valve.

h. Have the cylinder hydrostat tested every 10 years to make sure it can sustain the high pressures required.

D. Oxygen regulators and flowmeters

1. High-pressure regulators are attached to the cylinder stem to deliver gas under high pressure.

a. Used to transfer gas from tank to tank

2. Pressure in a full cylinder is approximately 2,000 psi.

3. Gas flow from cylinder to patient is controlled by a therapy regulator.

a. Reduces the high pressure of gas to a safe range (about 50 psi)

4. Flowmeters allow oxygen delivered to the patient to be adjusted from 1 to 25 L/min.

a. Two most common types:

i. Pressure-compensated flowmeter

(a) Float ball rises or falls based on gas flow in the tube

(b) Gas flow is controlled by a needle valve.

(c) Affected by gravity; must remain upright for accurate flow reading

ii. Bourdon-gauge flowmeter

(a) Can be placed in any position

(b) Pressure gauge is calibrated to record the flow rate.

(c) Major disadvantage: Does not compensate for backpressure

(1) Usually records a higher flow rate when there is any obstruction to gas flow downstream.

E. Preparing an oxygen cylinder for use

1. Before administering supplemental oxygen, you must prepare the oxygen cylinder and therapy regulator.

2. Refer to ***Skill Drill 15-9***.

XII. Supplemental Oxygen-Delivery Devices

A. Nonrebreathing mask

1. Preferred device in the prehospital setting

2. Can provide between 90% and 100% inspired oxygen (Fio2)

a. Good mask-to-face seal

b. Flow rate of 15 L/min

3. Combination mask and reservoir bag system

a. Oxygen fills a reservoir bag that is attached to the mask by a one-way valve.

b. Permits the patient to inhale from the reservoir bag but not to exhale back into it

4. Before administering, ensure that the reservoir bag is completely filled.

a. Oxygen flow rate is adjusted from 12 to 15 L/min to prevent collapse of the bag during inhalation.

5. Use a pediatric nonrebreathing mask for infants and small children.

6. Indications: Spontaneously breathing patients who require high-flow oxygen concentrations and are breathing adequately

7. Contraindications: Apnea and poor respiratory effort

a. Device delivers oxygen passively, so the patient’s respirations must be of adequate depth to draw in air.

B. Nasal cannula

1. Delivers oxygen via two small prongs that fit into the nostrils

2. Oxygen flow rate: 1 to 6 L/min,

3. Oxygen concentration: 24% to 44%

4. Higher flow rates will irritate the nasal mucosa.

5. An oxygen humidifier should be used when giving oxygen via nasal cannula for a prolonged period.

6. Provides low to moderate oxygen enrichment

7. Most beneficial for patients who require long-term oxygen therapy

8. Ineffective if the patient:

a. Is apneic

b. Has poor respiratory effort

c. Is severely hypoxic

d. Is a mouth-breather

9. In the prehospital setting, primarily used when patients:

a. Cannot tolerate a nonrebreathing mask *or*

b. Require low concentrations of oxygen to maintain an oxygen saturation greater than 94%

10. Generally well tolerated

11. Does not provide high volumes or concentrations of oxygen

C. Partial rebreathing mask

1. Similar to the nonrebreathing mask but lacks a one-way valve between the mask and the reservoir

2. Residual exhaled air is mixed in the mask and rebreathed.

3. Contraindications: Same as nonrebreathing mask

a. Apnea

b. Inadequate tidal volume

4. Higher oxygen concentrations are attainable.

a. Flow rates of 6 to 10 L/min

b. Oxygen concentration of 35% to 60%

5. Increasing the oxygen flow rate beyond 10 L/min will not enhance the oxygen concentration.

6. Leakage from the mask decreases the amount of oxygen inhaled by the patient.

D. Venturi mask

1. Draws room air into the mask along with oxygen

2. Can deliver 24%, 28%, 35%, or 40% oxygen depending on the adapter

3. Especially useful in the hospital management of patients with chronic respiratory diseases

4. Little advantage in prehospital care, except for long-range transport of patients with such conditions

E. Tracheostomy masks

1. Cover the tracheostomy hole (stoma) and have a strap that goes around the neck

a. Usually available in intensive care units

b. May not be available in the emergency setting

c. Improvise by placing a face mask over the stoma and adjusting the strap.

F. Oxygen humidifier

1. Oxygen stored in cylinders has zero humidity.

2. Dry gases will rapidly dry the mucous membranes.

3. An oxygen humidifier consists of a small bottle of sterile water.

a. Moisturizes oxygen before it reaches the patient

b. Must be kept upright; practical only for the fixed oxygen unit in the ambulance

4. Can be a source of infection

a. Either fill nondisposable bottle halfway with sterile water and clean the bottle in between patients, *or*

b. Use a disposable bottle.

XIII. Ventilatory Support

A. A patient who is not breathing needs artificial ventilation and 100% supplemental oxygen.

1. Artificial ventilation is the skill of providing ventilation to a patient who is breathing spontaneously or not breathing at all

a. Techniques are extremely effective when performed properly.

2. Patients who are breathing inadequately are typically unable to speak in complete sentences.

a. Examples: Breathing too fast or too slowly with reduced tidal volume (shallow breathing)

b. May require artificial ventilation to help maintain minute volume

3. Fast, shallow breathing

a. Does not allow for adequate exchange of oxygen and carbon dioxide in the alveoli

4. Indications for assisted ventilation include signs of:

a. Altered mental status

b. Inadequate minute volume

5. Signs of potential respiratory failure include:

a. Excessive accessory muscle use

b. Fatigue from labored breathing

6. Patients with these signs need immediate treatment.

7. Two treatment options:

a. Assisted ventilation with a bag-mask device

b. Continuous positive airway pressure (CPAP)

B. Normal ventilation vs. positive-pressure ventilation

1. Normal ventilation

a. Diaphragm contracts

b. Negative pressure is generated in the chest cavity.

i. Draws air into the chest through the trachea

ii. Attempt to equalize the pressure in the chest with the pressure of the external atmosphere (negative-pressure ventilation)

2. Positive-pressure ventilation

a. Generated by a device, such as a bag-mask device

b. Forces air into the chest cavity from the external environment

3. The physical act of the chest wall expanding and recoiling during breathing aids the circulatory system in returning blood to the heart.

a. Chest wall movement works similar to a pump.

b. Pressure changes in the thoracic cavity help draw venous blood back to the heart; improves preload.

4. With positive-pressure ventilation, more air is needed to achieve the same oxygenation and ventilatory effects of normal breathing.

a. Increase in airway wall pressure causes the walls of the chest cavity to push out of their normal anatomic shape.

b. Increases overall intrathoracic pressure within the chest cavity

c. Blood flow is decreased due to the increased pressure in the chest.

i. Results in insufficient venous return to the heart

ii. Amount of blood pumped out of the heart is reduced

iii. Imperative that paramedics regulate the rate and volume of artificial ventilations

5. Cardiac output is a function of stroke volume multiplied by the pulse rate.

a. Stroke volume: Amount of blood ejected by the ventricle in one cardiac cycle

b. Pulse rate: Assessed by palpating the pulse for 1 minute

c. Cardiac output: Amount of blood ejected by the left ventricle in 1 minute

6. Normally, when a person breathes, air enters the trachea.

a. Force generated from positive-pressure ventilation allows air to enter the trachea and the esophagus.

b. Ventilations that are too forceful can open the esophagus and instill air in the stomach.

i. Complication called gastric distention

C. Assisted ventilation

1. To assist ventilations using a bag-mask device:

a. Explain the procedure to the patient.

b. Place the mask over the patient’s nose and mouth.

c. Squeeze the bag each time the patient inhales, maintaining the same rate as the patient.

d. After the initial 5 to 10 breaths, slowly adjust the rate and deliver the appropriate tidal volume.

e. Adjust the rate and tidal volume to maintain adequate minute volume.

D. Artificial ventilation

1. Without immediate treatment, patients who are in respiratory arrest will die.

a. Once you determine that a patient is not breathing, you must begin artificial ventilation immediately.

2. Methods include:

a. Mouth-to-mask technique

b. One-, two-, or three-person bag-mask device technique

c. Manually triggered ventilation device

3. Mouth-to-mouth, mouth-to-nose, and mouth-to-mask ventilation

a. Mouth-to-mouth ventilation

i. Routinely performed with a barrier device

(a) Protective item that features a plastic barrier placed on a patient’s face with a one-way valve to prevent the backflow of secretions, vomitus, and gases

(b) Provides adequate protection for paramedics

ii. Most basic form of ventilation

b. Mouth-to-nose

i. Ventilating through the nose rather than the mouth

ii. Indications include apnea and the lack of availability of other ventilation devices

c. Mouth-to-mouth and mouth-to-nose ventilation

i. Require no special equipment

ii. Can provide adequate tidal volume

iii. Carry risk of unknown communicable diseases and psychological barriers

d. Mouth-to-mask ventilation

i. Preferred over mouth-to-mouth and mouth-to-nose

ii. Places a physical barrier between your mouth and the patient’s mouth

(a) One-way valve (on most masks) prevents exposure to body fluids

iii. Easier to secure an effective seal because you can use both hands

(a) Enables provision of adequate tidal volume

iv. Mask with an oxygen inlet provides oxygen during mouth-to-mask ventilation to supplement the air from your own lungs.

v. Mask may be shaped like a triangle or a doughnut

(a) Apex (top) placed across the bridge of the nose

(b) Base (bottom) placed in the groove between the lower lip and the chin.

(c) In the center is a chimney with a 15-mm connector.

vi. To properly perform mouth-to-mask ventilation, refer to ***Skill Drill 15-10***.

e. Ventilation effectiveness is best determined by:

i. Watching the patient’s chest rise and fall *and*

ii. Feeling for resistance of the lungs as they expand

f. You should also hear and feel air escape as the patient passively exhales.

g. Provide the correct number of breaths per minute for the patient’s age.

E. The bag-mask device

1. Can deliver nearly 100% oxygen with an oxygen flow rate of 15 L/min and an adequate seal.

a. Can deliver only as much volume as can be squeezed out of the bag by hand

2. Provides less tidal volume than mouth-to-mask ventilation but delivers a higher oxygen concentration

3. Most common device used to ventilate patients in the prehospital setting

4. Can provide adequate tidal volume when used by an experienced paramedic, but mastery is difficult

a. Mask seal on a medical patient may be difficult to maintain with only one rescuer.

i. Tidal volume and oxygen concentration depend on mask seal integrity.

5. Bag-mask device components and characteristics

a. Disposable, self-inflating bag

b. No pop-off valve or, if one is present, the capability of disabling it

c. True nonrebreathing outlet valve

d. Oxygen reservoir that permits delivery of a high concentration of oxygen

e. One-way, no-jam inlet valve system that provides:

i. Oxygen inlet flow at a maximum of 15 L/min

ii. Standard 15/22-mm fitting for a face mask and an advanced airway (ET tube, LMA, King LT, Combitube)

f. Transparent face mask

g. Ability to perform under extreme environmental conditions

h. Total amount of gas in the reservoir bag of an adult bag-mask device is usually 1,200 to 1,600 mL.

i. Pediatric bag: 500 to 700 mL

ii. Infant bag: 150 to 240 mL

i. Volume of oxygen to deliver to the patient is based on visible chest rise.

i. Delivered tidal volume of 500 to 600 mL (6-7 mL/kg) per breath will produce visible chest rise in most adults.

ii. Deliver each breath over a period of 1 second at the appropriate rate.

(a) Breaths given too forcefully or too fast can result in two negative effects:

(1) Gastric distention (associated risks: vomiting and aspiration)

(2) Decreased venous return to the heart (preload) due to increased intrathoracic pressure

iii. Inadequate tidal volume and oxygen may be delivered because of:

(a) Improper technique

(b) Ineffective mask-to-face seal

(c) Presence of gastric distention

6. Bag-mask device technique

a. Work with a partner whenever possible.

i. One secures the mask to the patient’s face with two hands to maintain good seal.

ii. Other squeezes the bag

b. Difficult for one person to maintain a proper seal while squeezing the bag

c. Steps for two-person bag-mask device technique:

i. Kneel above patient’s head; partner should be at the side of the head if possible.

(a) Select the proper size mask.

ii. Maintain neck in a hyperextended position unless you suspect a cervical spine injury.

(a) If you suspect a cervical spine injury, stabilize head and neck in a neutral position and use the jaw-thrust maneuver.

(b) Open the mouth, suction as needed.

(c) Insert an oral or nasal airway to help maintain airway patency.

iii. Place the mask on the patient’s face.

(a) Top goes over the bridge of the nose and bottom goes in the groove between lower lip and chin

(b) If the mask has a ventilation port, center the port over the mouth.

(c) Inflate the collar for a better fit and seal if necessary.

iv. Bring the lower jaw up to the mask with your last three fingers to help maintain an open airway.

(a) Do not grab the fleshy part of the neck.

(b) If you suspect a spinal injury, make sure your partner manually stabilizes the cervical spine as you move the lower jaw.

v. Connect the bag to the mask.

vi. Hold the mask in place while your partner squeezes the bag until the patient’s chest visibly rises.

(a) If you suspect spinal injury, stabilize the head and neck while maintaining an adequate mask-to-face seal.

(b) Squeeze the bag once every 5 to 6 seconds for adults, every 3 to 5 seconds for infants and children.

vii. If you are alone, hold your index finger over the lower part of the mask and your thumb over the upper part of the mask.

(a) Use remaining fingers to pull the lower jaw into the mask (EC-clamp method)

(b) Use the head tilt-chin lift maneuver to make sure the neck is extended.

(c) Squeeze the bag with your other hand once every 5 to 6 seconds for adults, every 3 to 5 seconds for infants and children.

viii. Observe for gastric distention, changes in compliance of the bag with ventilations, and improvement or deterioration of the patient’s status.

d. When assisting ventilation, squeeze bag as patient inhales.

i. For the next 5 to 10 breaths, adjust rate and tidal volume until an adequate minute volume is achieved.

e. If patient is breathing too fast (hyperventilation) with reduced tidal volume:

i. Explain the procedure.

ii. First, assist ventilations at the rate at which the patient has been breathing.

iii. For the next 5 to 10 breaths, slowly adjust the rate and tidal volume until an adequate minute volume is achieved.

f. Evaluate the effectiveness of your ventilations.

i. Not adequate if:

(a) Chest does not rise and fall with each ventilation

(b) Rate of ventilation is too slow or too fast for the patient’s age

(c) Pulse rate does not improve

g. If the chest does not rise and fall:

i. You may need to reposition the head or insert an oral or nasal airway.

ii. If the stomach seems to be rising and falling, reposition the head.

(a) With suspected spinal injury, reposition jaw not head.

iii. If too much air is escaping from the mask, reposition the mask for a better seal.

h. If chest still does not rise and fall, check for an airway obstruction.

i. If none is found, attempt ventilation with another device.

F. Manually triggered ventilation devices

1. Also known as the flow-restricted, oxygen-powered ventilation device

a. Mainly used to ventilate apneic or hypoventilating patients

b. Can also be used to provide supplemental oxygen to breathing patients

2. Have a “demand valve” that delivers 100% oxygen as the patient begins to inhale

a. Stops the flow of gas at the end of the inhalation phase

3. Makes an airtight seal with the patient’s face, so inspired gas is nearly 100% oxygen

a. Major advantage: Allows one rescuer to use both hands to maintain a mask-to-face seal while providing positive-pressure ventilation.

b. Associated with difficulty in maintaining adequate ventilation without assistance

i. Do not use routinely.

(a) High incidence of gastric distention

(b) Possible damage to structures within the chest cavity due to excessive pressure (barotrauma)

ii. Do not use with infants, children, COPD, possible cervical spine, or chest injury.

4. Virtually impossible to assess for lung compliance when using

a. Be especially cautious when ventilating.

5. Generally, patients find it most comfortable if they hold the mask themselves.

6. Device delivers only the volume of oxygen needed by the patient during inhalation

7. Relatively expensive and typically not disposable

a. Must disinfect entire unit after each use

8. Includes an adapter designed to fit into standard ventilation masks

a. When the button on the top of the regulator is pressed, oxygen flows at a constant rate.

b. One hand is still needed to press the button, leaving only one hand to maintain seal.

9. Components and characteristics of manually triggered ventilation devices

a. Peak flow rate of 100% oxygen of up to 40 L/min

b. Inspiratory pressure safety release valve

i. Opens at approximately 30 cm of water

ii. Vents any remaining volume or stops the flow of oxygen

c. Audible alarm sounds whenever relief valve pressure is exceeded

d. Can operate satisfactorily under varying environmental conditions

e. Trigger (or lever) is positioned so both of the rescuer’s hands can remain on the mask while supporting the patient’s head

10. Requires proper training and practice

11. Must make sure there is an airtight fit between the mask and the patient’s face

12. Amount of pressure needed for adequate ventilation varies according to:

a. Size of patient

b. Lung volume

c. Condition of the lungs

13. Keep your eyes on the chest at all times to avoid hyperinflation of the lungs.

14. Always follow local protocol.

G. Automatic transport ventilators

1. Steps for using ATV:

a. Attach to wall-mounted oxygen source.

b. Set tidal volume and ventilatory rate per patient’s age and condition.

c. Connect to the 15/22-mm fitting on the ET tube or other advanced airway device.

d. Auscultate the patient’s breath sounds; observe for equal chest rise.

2. Manually triggered device attached to a control box

a. Allows rate and tidal volume to be set

b. Frees hands to perform non-airway-related tasks

3. Bag-mask device should always be readily available in case of malfunction.

4. Most models have adjustments for:

a. Respiratory rate

i. In most cases, set at the midpoint or average for the patient’s age.

b. Tidal volume

i. Estimate using a formula based on 6 to 7 mL/kg

5. Deliver a preset volume at a preset ventilatory rate.

a. Does not guarantee that all of the volume is delivered to the lungs, unless the patient is intubated.

6. Generally oxygen powered.

a. Some models may require an external power source.

7. Generally consumes 5 L/min of oxygen; bag-mask device uses 15 to 25 L/min

8. Pressure-relief valve can lead to:

a. Hypoventilation in patients with inadequate lung compliance

b. Increased airway resistance

c. Airway obstruction

9. Possibility of barotrauma if relief valve fails or ventilation is overzealous

XIV. Continuous Positive Airway Pressure

**A. Continuous positive airway pressure (CPAP) is a noninvasive means of providing ventilatory support for patients experiencing respiratory distress.**

1. Excellent adjunct in the treatment of respiratory distress caused by the following conditions:

a. Acute pulmonary edema

b. Obstructive lung disease

c. Acute bronchospasm (as in asthma)

2. Typically, many patients with these conditions would be managed with advanced airway techniques (e.g., ET intubation).

a. Early intervention with CPAP is an alternative and can prevent the need for intubation.

3. Functions of CPAP:

a. Increases pressure in the lungs

b. Opens collapsed alveoli and prevents further alveolar collapse (atelectasis)

c. Pushes more oxygen across the alveolar membrane

d. Forces interstitial fluid back into the pulmonary circulation

4. Desired effect: Improve pulmonary compliance; make spontaneous ventilation easier

5. Typically delivered through a face mask secured with a strapping system

a. Face mask is fitted with a pressure relief valve that determines the amount of pressure delivered to the patient

i. Pressure results in a high inspiratory flow and the need to push a pressure valve open with exhalation.

**B. Indications for CPAP**

1. Indicated for patients in respiratory distress whose compensatory mechanisms cannot keep up with oxygen demand.

a. Treats the symptoms, not necessarily the underlying pathology

2. General guidelines for using CPAP include:

a. Patient is alert and able to follow commands.

b. Obvious signs of moderate to severe respiratory distress from an underlying disease

c. Respiratory distress after submersion

d. Rapid breathing (more than 26 breaths/min) that affects overall minute volume

e. Pulse oximetry reading less than 90%

3. Always follow local guidelines and protocols.

**C. Contraindications to CPAP**

1. General contraindications:

a. Respiratory arrest

b. Hypoventilation (slow respiratory rate and/or reduced tidal volume)

c. Signs and symptoms of a pneumothorax or chest trauma

d. Tracheostomy

e. Active gastrointestinal bleeding or vomiting

f. Patient unable to follow verbal commands

g. Inability to properly fit the CPAP system mask and strap

h. Inability to tolerate the mask

2. Always reassess the patient for signs of clinical deterioration and/or respiratory failure.

a. Not all patients will improve with CPAP.

b. Once signs of respiratory failure become apparent or the patient can no longer follow commands, remove CPAP, and initiate ventilation with a bag-mask device attached to high-flow oxygen.

**D. Application of CPAP**

1. Generally composed of a generator, mask, and circuit that contains corrugated tubing, bacteria filter, and a one-way valve.

2. During the expiratory phase, the patient exhales against a resistance (positive end-expiratory pressure [PEEP]).

a. Depending on the device, the PEEP is:

i. Controlled by manually adjusting it using a manometer *or*

ii. Predetermined by a fixed setting on the PEEP valve

b. A PEEP of 5 to 10 cm H2O is generally an acceptable therapeutic range.

3. Always consult the manual for assembly instructions.

4. Most units are powered by oxygen, so it is important to have a full cylinder of oxygen and a backup cylinder.

5. Some units use a continuous flow of oxygen; others use oxygen on a demand basis.

a. Continuously monitor the amount of available oxygen in the cylinder.

6. Some of the newer devices allow you to adjust the Fio2.

a. Most are set to deliver a fixed Fio2 of 30% to 35%.

b. Some can deliver as high as 80%.

7. To properly use CPAP, refer to ***Skill Drill*** ***15-11***.

**E. Complications of CPAP**

1. Some patients may find CPAP claustrophobic and will resist it.

a. Important to explain the process and coach patients

b. Do not force the mask on any patient.

i. Will create a higher level of anxiety and increase oxygen demand

2. High volume of pressure generated by CPAP can cause a pneumothorax due to barotrauma.

a. Be aware of this risk, and continually assess your patient for signs and symptoms.

3. Increased pressure in the chest cavity can result in hypotension.

a. As intrathoracic pressure increases, venous blood returning to the heart (preload) meets resistance, which can result in a sudden drop in blood pressure.

b. Not common with lower levels of CPAP, but continuous monitoring of blood pressure is essential.

4. Air may enter the stomach, which increases risk of aspiration if vomiting occurs.

XV. Gastric Distention

**A. Any form of artificial ventilation that blows air into the patient’s mouth may lead to inflation of the patient’s stomach with air.**

1. Gastric distention is especially likely to occur when:

a. Excessive pressure is used to inflate the lungs.

b. Ventilations are performed too fast or too forcefully.

c. Airway is partially obstructed during ventilation attempts.

2. Pressure in the airway forces open the esophagus, and air flows into the stomach.

3. Occurs most often in children but is common in adults as well

4. A distended stomach is harmful for at least two reasons.

a. Promotes regurgitation of stomach contents

i. Can lead to aspiration

b. Pushes the diaphragm upward into the chest

i. Reduces space in which lungs can expand

5. Signs include:

a. Increase in the diameter of the stomach

b. Increasingly distended abdomen

c. Increased resistance to bag-mask ventilations

6. If these signs are noted

a. Reassess and reposition the airway as needed.

b. Observe the chest for adequate rise and fall as you continue ventilating.

c. Limit ventilation times to 1 second or the time needed to produce adequate chest rise.

**B. Invasive gastric decompression**

1. Involves inserting a gastric tube into the stomach and removing the contents with suction

a. Decreases pressure on the diaphragm

b. Virtually eliminates the risks of regurgitation and aspiration

2. In certain cases of poisoning, activated charcoal can be instilled via a gastric tube.

3. Tube can be inserted into the stomach via:

a. Mouth (orogastric [OG] tube)

b. Nose (nasogastric [NG] tube)

4. Should be considered:

a. For any patient who will need positive-pressure ventilation for an extended period

b. When gastric distention interferes with ventilations

5. Must be used with extreme caution in any patient with known esophageal disease

6. Never use in a patient whose esophagus is not patent.

7. After insertion, make sure tube has been placed into the stomach.

8. Nasogastric tube

a. Inserted through the nose, into the nasopharynx, through the esophagus, and into the stomach

b. In airway management and ventilation, it decompresses the stomach.

i. Decreases pressure on the diaphragm

ii. Limits risk of regurgitation

c. Also used to perform gastric lavage—a procedure in which the stomach is decontaminated following a toxic ingestion

d. Relatively well tolerated, even by responsive patients

e. During insertion, most responsive patients will gag and may vomit, even if gag reflex is suppressed.

i. With decreased LOC, vomiting can seriously threaten the airway.

f. Contraindicated in patients with severe facial injuries, particularly midface fractures and skull fractures

i. Tube may be inadvertently inserted through the fracture, into the cranial vault

ii. Use OG route of insertion instead.

g. Improper technique can cause trauma to the nasal passageways, esophagus, or gastric lining.

h. May interfere with the mask seal of the bag-mask device in patients who are not intubated

i. To properly insert a nasogastric tube in a responsive patient, refer to ***Skill Drill 15-12***.

9. Orogastric tube

a. Serves the same purpose as an NG tube but is inserted through the mouth instead of the nose

b. Advantages and disadvantages are essentially the same as they are for the NG tube.

c. Major differences:

i. No risk of nasal bleeding

ii. Safer in patients with severe facial trauma

iii. Can use larger tubes

d. Less comfortable for responsive patients

i. Causes gagging much more often

ii. Increases the possibility of vomiting

iii. Responsive patients tend to bite the tube as it is passed orally.

e. Generally preferred for patients who are unresponsive without a gag reflex

i. Almost always inserted after the airway is protected with an ET tube.

ii. Insertion before intubating may obscure your view of the vocal cords.

f. To properly insert an orogastric tube, refer to ***Skill Drill 15-13***.

XVI. Special Patient Considerations

**A. Laryngectomy, tracheostomy, stoma, and tracheostomy tubes**

1. A laryngectomy is a surgical procedure in which the larynx is removed.

a. Performed by making a tracheostomy (surgical opening into the trachea)

b. Creates a stoma (orifice that connects the trachea to the outside air)

c. Surgical removal of the entire larynx is called total laryngectomy

i. People who have had this procedure breathe through a stoma.

ii. Can no longer ventilate by mouth-to-mask technique

(a) Air blown into the mouth or nose goes into the stomach and will not reach the lower airway.

d. A partial laryngectomy entails surgical removal of a portion of the larynx.

i. People who have had this procedure breathe through the stoma and the nose or mouth.

2. Suctioning of a stoma

a. Failure to recognize and identify the need could result in hypoxia.

b. Not uncommon for a stoma to become occluded with mucous plugs

c. Suctioning must be performed with extreme care.

i. Even the slightest irritation of the tracheal wall can result in a violent laryngospasm and complete airway closure.

ii. Limit suctioning to 10 seconds.

d. To properly suction a stoma, refer to ***Skill Drill 15-14***.

3. Ventilation of stoma patients

a. Neither the head tilt–chin lift nor the jaw-thrust maneuver is required.

b. Ventilations with a stoma and no tracheostomy tube can be performed with either:

i. Mouth-to-stoma technique (with a resuscitation mask) *or*

ii. Bag-mask device

c. Regardless of the technique, use an infant- or child-sized mask to make an adequate seal over the stoma.

i. Seal the nose and mouth with one hand to prevent air leaking up the trachea.

(a) Release following each ventilation.

d. Two rescuers are needed with a bag-mask device:

i. One to seal the nose and mouth

ii. One to squeeze the bag-mask device

e. If you are unable to ventilate, try suctioning the stoma and mouth with a French or soft-tip catheter before providing artificial ventilation through the nose and mouth.

i. Would only work with a partial laryngectomy, not a total laryngectomy.

f. To properly perform mouth-to-stoma ventilation with a resuscitation mask, refer to ***Skill Drill 15-15***.

g. To properly perform bag-mask device-to-stoma ventilation, refer to ***Skill Drill 15-16***.

4. Tracheostomy tubes

a. Plastic tube placed within the tracheostomy site (stoma)

b. Requires a 15/22-mm adapter to be compatible with ventilatory devices

c. Patients may receive supplemental oxygen via:

i. Tubing designed to fit over the tube

ii. Placing an oxygen mask over the tube

d. To ventilate, attach the bag-mask device to the tracheostomy tube.

e. Patients who experience sudden dyspnea often have thick secretions in the tube.

i. Perform suctioning through the tracheostomy tube as you would through a stoma.

f. When a tracheostomy tube becomes dislodged, stenosis (narrowing) of the stoma may occur.

i. Potentially life-threatening; impairs the patient’s ventilatory ability

ii. May have to insert an ET tube into the stoma before it becomes totally occluded.

g. Patients may be less tolerant of even brief periods of hypoxia.

h. To properly replace a dislodged tracheostomy tube, refer to ***Skill Drill 15-17***.

**B. Dental appliances**

1. Can take many different forms:

a. Dentures (upper, lower, or both)

b. Bridges

c. Individual teeth

d. Braces (in the younger population)

2. Must determine whether an appliance is loose or fitting well when assessing the airway

a. Especially important if patient is unresponsive

b. Leave in place if it fits well.

c. Remove appliance if loose.

3. If an unresponsive patient has an airway obstruction caused by a dental appliance, perform the usual steps in clearing an obstruction:

a. Chest compressions

b. Direct laryngoscopy

c. Magill forceps

4. Take great care if the obstruction is caused by a bridge; they often have sharp metal ends that can easily lacerate the posterior pharynx or larynx.

5. Generally best to remove dental appliances before intubating.

**C. Facial trauma**

1. Facial trauma can result in severe tissue swelling and bleeding into the airway.

a. Control bleeding with direct pressure.

b. Suction the airway as needed.

2. You may encounter a patient with severe facial trauma who is breathing inadequately and has severe oropharyngeal bleeding.

a. Suction airway for 15 seconds (less in infants and children).

b. Provide positive-pressure ventilation for 2 minutes.

c. Alternate suction and ventilation until oral secretions have been cleared or the airway has been secured with an ET tube.

3. Facial injuries should increase suspicion of cervical spine injury.

a. Use the jaw-thrust maneuver.

b. Keep the head in a neutral in-line position.

4. Endotracheal intubation of a trauma patient is most effectively performed by two paramedics.

a. One maintains neutral in-line stabilization of the head; the other intubates.

5. Alternative technique: Stabilize the head with your thighs and then perform the intubation.

6. Stay alert for changes in ventilation compliance or sounds that may indicate laryngeal edema (such as stridor).

7. If you are unable to effectively ventilate or orally intubate, perform a cricothyrotomy (surgical or needle).

XVII. Advanced Airway Management

**A. One of the most common mistakes with respiratory or cardiac arrest is to proceed with advanced airway management too early, forsaking the basic techniques of establishing and maintaining a patent airway in a hypoxic patient.**

1. Establish and maintain a patent airway with basic techniques and maneuvers; then consider advanced airway management.

2. Patients primarily require advanced airway management for two reasons:

a. Failure to maintain a patent airway *and/or*

b. Failure to adequately oxygenate and ventilate

3. Advanced airway management involves the insertion of a number of advanced airway devices, including:

a. ET tube

i. Orotracheal intubation

ii. Blind nasotracheal intubation

iii. Digital intubation

iv. Intubation via transillumination

v. Face-to-face intubation

vi. Retrograde intubation

b. King LT airway

c. Laryngeal mask airway (LMA)

d. Cobra perilaryngeal airway (CobraPLA)

e. Esophageal tracheal Combitube (ETC)

f. Surgical and needle cricothyrotomy

**B. Predicting the difficult airway**

1. Anatomic findings suggestive of a difficult airway may include:

a. Congenital abnormalities (i.e., dysmorphic face)

b. Recent surgery

c. Trauma

d. Infection

e. Neoplastic diseases (such as cancer)

2. LEMON: Mnemonic to guide assessment of the difficult airway; stands for:

a. Look externally.

i. The following can make intubation more difficult:

(a) Short, thick necks

(b) Morbid obesity

(c) Dental conditions, such as an overbite or “buck” teeth

b. Evaluate 3-3-2.

i. First “3” refers to mouth opening.

(a) A width of less than three fingers indicates a potentially difficult airway.

ii. Second “3” refers to mandible length.

(a) At least three fingerwidths is optimal.

(b) Measure from the tip of the chin to the hyoid bone.

(c) Smaller mandibles

(1) Have less room for displacement of the tongue and epiglottis

(2) Can make airway management more difficult

iii. “2” refers to the distance from the hyoid bone to the thyroid notch; should be at least two fingers wide.

c. Mallampati

i. Mallampati classification predicts the relative difficulty of intubation.

(a) Notes the oropharyngeal structures visible in an upright, seated patient who is fully able to open his or her mouth

(b) Limited value in patients who are unresponsive

d. Obstruction.

i. Note anything that might interfere with visualization or ET tube placement.

(a) Foreign body

(b) Obesity

(c) Hematoma

(d) Masses

e. Neck mobility.

i. “Sniffing position” is ideal for visualization and intubation; adult head slightly elevated and extended.

ii. Neck mobility problems are most common with:

(a) Trauma patients (due to cervical collars or injury)

(b) Elderly patients (due to osteoporosis or arthritis)

**C. Endotracheal intubation**

1. Endotracheal intubation: Passing an ET tube through the glottic opening and sealing the tube with a cuff inflated against the tracheal wall

2. Orotracheal intubation: Tube is passed into the trachea through the mouth

3. Nasotracheal intubation: Tube is passed into the trachea through the nose

4. Intubation of the trachea is the best means of achieving complete control of the airway.

a. Advantages

i. Provision of a secure airway

ii. Protection against aspiration

iii. Provision of an alternative route to the IV or intraosseous (IO) route for certain medications (as a last resort)

b. Disadvantages

i. Special equipment required

ii. Physiologic functions of the upper airway (warming, filtering, humidifying) bypassed

c. Complications

i. Bleeding

ii. Hypoxia

iii. Laryngeal swelling

iv. Laryngospasm

v. Vocal cord damage

vi. Mucosal necrosis

vii. Barotrauma

5. Endotracheal tubes (ET)

a. Basic structure includes:

i. Proximal end

ii. Tube

iii. Cuff and pilot balloon

iv. Distal tip

b. Proximal end

i. Equipped with an adapter that allows it to be attached to any ventilation device

ii. Includes an inflation port with a pilot balloon

c. Distal cuff is inflated with a syringe

d. Pilot balloon indicates whether the distal cuff is inflated or deflated once the tube has been inserted into the mouth

e. Centimeter markings along the length of the ET tube provide a measurement of its depth.

f. Distal end of the tube has:

i. Beveled tip to facilitate insertion

ii. Opening on the side called Murphy’s eye

(a) Enables ventilation to occur even if the tip becomes occluded

g. Tubes range in size.

i. 2.5 to 9.0 mm in inside diameter

ii. 12 to 32 cm in length

iii. A tube that is too small will lead to increased resistance to airflow and difficulty in ventilating.

iv. A tube that is too large can be difficult to insert and may cause trauma.

h. Pediatric patients

i. Tube ranges from 2.5 to 4.5 mm.

ii. Funnel-shaped cricoid ring forms an anatomic seal with the ET tube, eliminating the need for a distal cuff in most cases.

iii. Lacks a balloon cuff, so no pilot balloon

i. Anatomic clues can help determine the proper tube size.

i. Internal diameter of the nostril is a good approximation of the diameter of the glottic opening.

ii. Diameter of the little finger or the size of the thumbnail is a good approximation of airway size.

iii. Predictions of size are just estimates

(a) Always have *three* ET tubes ready

(1) One you think will be appropriate

(2) One a size larger

(3) One a size smaller.

6. Laryngoscopes and blades

a. A laryngoscope is required to perform orotracheal intubation by direct laryngoscopy.

b. Laryngoscope consists of a handle and interchangeable blades

i. Handle contains the power source for the light on the blade

ii. When the blade is perpendicular, the light shines near the blade’s tip

c. Two most common types of blades:

i. Straight (Miller and Wisconsin)

ii. Curved (Macintosh)

d. Straight laryngoscope blade

i. Tip will extend beneath the epiglottis and lift it up

(a) Useful with infants and small children, who often have a long, floppy epiglottis.

ii. In an adult, use of a straight blade is more likely to damage teeth if used improperly.

e. Curved laryngoscope blade

i. Less likely to be levered against the teeth by an inexperienced paramedic

ii. Direction of the curve conforms to that of the tongue and pharynx

iii. Tip is placed in the vallecula (space between the epiglottis and the base of the tongue)

(a) Indirectly lifts the epiglottis to expose the vocal cords

f. Have curved and straight blades available.

g. Blade size

i. Ranges from 0 to 4

ii. 0, 1, and 2 are appropriate for infants and children.

iii. 3 and 4 considered adult sizes

iv. For pediatric patients, blade size is often based on the child’s age or height.

v. For adults, usually based on paramedic experience and the size of the patient

h. Stylet

i. Semirigid wire that is inserted into the ET tube

ii. Molds and maintains the shape of the tube

iii. Lets you guide the tip of the tube over the arytenoid cartilage, even if you cannot see the entire glottic opening

iv. Should be lubricated with a water-soluble gel to facilitate its removal

v. End should be bent to form a gentle curve

vi. End should rest at least 1⁄2" back from the end of the ET tube

(a) If it protrudes beyond the end of the tube, it may damage the vocal cords.

vii. Bend the other end over the proximal tube connector, so that it cannot slip farther into the tube.

i. Magill forceps have two uses in the emergency setting.

i. Remove airway obstructions under direct visualization.

ii. Guide the tip of the ET tube through the glottic opening if the proper angle cannot be achieved with manipulation of the tube.

**D. Orotracheal intubation by direct laryngoscopy**

1. Involves inserting an ET tube through the mouth and into the trachea while visualizing the glottic opening with a laryngoscope

a. Indications

i. Airway control needed as a result of coma, respiratory arrest, and/or cardiac arrest

ii. Ventilatory support before impending respiratory failure

iii. Prolonged ventilatory support required

iv. Absence of a gag reflex

v. Traumatic brain injury

vi. Unresponsiveness

vii. Impending airway compromise (burns or trauma)

viii. Medication administration (last resort)

b. Contraindications

i. Intact gag reflex

ii. Inability to open the patient’s mouth because of trauma, dislocation of the jaw, or a pathologic condition

iii. Inability to see the glottic opening

iv. Copious secretions, vomitus, or blood in the airway

2. Standard precautions

a. Intubation may expose you to blood or other body fluids, so take proper precautions.

i. Gloves

ii. Mask that covers your entire face

3. Preoxygenation

a. Adequate preoxygenation with a bag-mask device and 100% oxygen is critical before intubation.

b. Preoxygenate an apneic or hypoventilating patient for 2 to 3 minutes.

i. During the intubation attempt, the patient will undergo a period of “forced apnea.”

ii. Goal of preoxygenation is to prevent hypoxia from occurring during this time.

iii. Monitor Spo2 and achieve as close to 100% saturation as possible during the 2- to 3-minute period.

iv. During the intubation attempt, continually monitor Spo2 and maintain it at greater than 95%.

c. Consequences of even brief periods of hypoxia can be disastrous.

i. Do not rely solely on pulse oximetry to quantify oxygenation status.

4. Positioning the patient

a. Airway has three axes: mouth, pharynx, larynx

i. At acute angles when the head is in a neutral position

(a) Makes laryngoscopy difficult

ii. Must be aligned to the greatest extent possible to facilitate visualization of the airway

(a) Place the patient in the “sniffing” position.

b. Sniffing position

i. Involves the following:

(a) Approximately a 20° extension of the atlanto-occipital joint

(b) 30° flexion of the neck at C6 and C7 for a patient with a short neck and/or “no chin”

ii. Can be achieved in most supine patients by extending the head and elevating the occiput 2.5 to 5 cm

iii. Elevate the head and/or neck with folded towels until the ear is at the level of the sternum.

5. Blade insertion

a. After you have positioned the patient’s head and provided preoxygenation, direct your partner to stop ventilating.

b. Position yourself at the top of the patient’s head.

c. Grasp the laryngoscope with your left hand, as far down on the handle as possible.

d. If the mouth is not open:

i. Place the side of your right-hand thumb just below the bottom lip and push the mouth open, *or*

ii. “Scissor” your thumb and index finger between the molars, *or*

iii. Open the mouth with the tongue-jaw lift maneuver.

e. Insert the blade into the *right* side of the mouth.

f. Use the blade flange to sweep the tongue gently to the left while moving the blade into the midline.

g. Slowly advance the blade while sweeping the tongue to the left.

i. Curved blade into the vallecula

ii. Straight blade beneath the epiglottis

h. Exert *gentle* traction at a 45° angle to the floor as you lift the patient’s jaw.

i. Do not “pry” back on the laryngoscope.

ii. Keep your back and your left arm straight as you pull upward.

6. Visualization of the glottic opening

a. Continue *lifting* the laryngoscope as you look down the blade.

i. Identifying the epiglottis or the arytenoid cartilage enables to you make small adjustments in the position of the blade.

b. With the curved blade, “walk” the blade down the tongue.

c. With the straight blade, insert the blade straight back until the tip touches the posterior pharyngeal wall.

d. As you work the tip of the blade into position, the glottic opening should come into full view.

e. The vocal cords are the white fibrous bands that lie vertically within the glottic opening; they should be slightly open.

f. Gum elastic bougie

i. Flexible device that is approximately 1 cm in diameter and 60 cm long

ii. Used in epiglottis-only views to facilitate intubation

iii. Inserted through the glottic opening under direct laryngoscopy

iv. Once it is placed deeply into the trachea, it becomes a guide for the ET tube.

(a) Slide the tube over the gum bougie and into the trachea.

v. Remove the gum bougie, ventilate, and confirm proper ET tube placement.

7. Tube insertion

a. Pick up the ET tube in your right hand, holding it near the connector as you would hold a pencil.

b. Insert the tube from the right corner of the mouth through the vocal cords.

c. Continue to insert the tube until the proximal end of the cuff is 1 to 2 cm past the vocal cords.

i. *If you cannot see the vocal cords, do not insert the tube.*

d. A major mistake of beginners is to try to pass the tube down the barrel of the laryngoscope blade.

i. Blade is designed to visualize the glottic opening, not as a guide for the tube.

ii. Will obscure your view of the glottic opening and should be avoided

8. Ventilation

a. After you have seen the ET tube cuff pass roughly 1⁄2′′ beyond the vocal cords:

i. Gently remove the blade.

ii. Hold the tube securely with your right hand.

iii. Remove the stylet from the tube.

b. Inflate distal cuff with 5 to 10 mL of air, then detach syringe from the inflation port.

i. If the syringe is not removed *immediately*, air from the cuff may leak back into the syringe.

ii. Inflating the distal cuff with excess pressure may cause tissue necrosis of the tracheal wall.

c. Have your assistant attach the bag-mask device to the ET tube and continue ventilation.

d. In-line T-piece capnography monitor should be placed between the bag-mask device and ET tube.

e. As the first ventilations are delivered, look at the patient’s chest to ensure that it rises with each ventilation.

f. At the same time, listen with a stethoscope to both lungs and to the stomach.

i. If the tube is properly positioned, you will hear equal breath sounds bilaterally and a quiet epigastrium.

ii. Epigastric sounds may be transmitted to the lungs in obese patients or patients with significant gastric distention.

g. Ventilation should continue as dictated by the patient’s age.

i. Apneic adult with a pulse: 10 to 12 breaths/min (one breath every 5 to 6 seconds)

ii. Apneic infant/child with a pulse: 12 to 20 breaths/min (one breath every 3 to 5 seconds)

iii. Patient (any age) in cardiac arrest: 8 to 10 breaths/min (one breath every 6 to 8 seconds)

(a) Do not stop chest compressions to deliver ventilations (asynchronous CPR).

9. Confirmation of tube placement

a. Visualizing the ET tube passing between the vocal cords is the first (and most reliable) way to confirm that the tube has entered the trachea.

b. Auscultation is the next step.

i. Unequal or absent breath sounds suggest:

(a) Esophageal placement

(b) Right mainstem bronchus placement

(c) Pneumothorax

(d) Bronchial obstruction

ii. Bilaterally absent breath sounds or gurgling over the epigastrium indicates that you have intubated the esophagus not the trachea.

(a) *Immediately* remove ET tube.

(b) Be prepared to vigorously suction the airway.

(c) After clearing the airway, ventilate with a bag-mask device and 100% oxygen for 30 seconds to 1 minute before you reattempt intubation.

iii. If breath sounds are heard only on the right side of the chest, the tube has likely been advanced too far.

(a) Loosen or remove the tube-securing device.

(b) Deflate the distal cuff.

(c) Place your stethoscope over the left side of the chest.

(d) While ventilation continues, slowly retract the tube while simultaneously listening for breath sounds over the left side of the chest.

(e) Stop as soon as bilaterally equal breath sounds are heard.

(f) Note the depth of the tube (in cm) at the patient’s teeth.

(g) Reinflate the distal cuff.

(h) Secure the tube.

(i) Resume ventilations.

c. If the ET tube has been properly positioned in the trachea:

i. Bag-mask device should be easy to compress

ii. You should see corresponding chest expansion.

iii. Increased resistance during ventilations may indicate:

(a) Gastric distention

(b) Esophageal intubation *or*

(c) Tension pneumothorax

d. Continuous waveform capnography, in addition to a clinical assessment, is the most reliable method of confirming and monitoring correct placement.

i. Ideal time to attach the capnography T-piece is when the bag-mask device is attached to the ET tube.

ii. If waveform capnography is not available, a colorimetric ETco2 detector or an esophageal detector device can be used.

e. Esophageal detector device: A bulb or syringe with a 15/22-mm adapter

i. Syringe model

(a) Syringe is attached to the end of the ET tube and the plunger is withdrawn

(b) If the tube is in the trachea, the plunger does not move when released.

(c) If the tube is in the esophagus, the plunger moves back toward zero when released.

ii. Bulb model

(a) Bulb is squeezed and then attached to the end of the ET tube

(b) If it remains collapsed or inflates slowly, esophageal intubation has likely occurred.

(c) If the bulb briskly expands, the tube is properly positioned in the trachea.

f. After confirming proper tube placement, note and mark the ET tube where it emerges from the mouth.

i. Enables health care personnel to determine whether the tube has slipped in or out

10. Securing the tube

a. Never take your hand off the ET tube before it has been secured with an appropriate device.

i. Support the secured tube manually while you ventilate the patient to avoid a sudden jolt from the bag-mask device.

b. Many commercial tube-securing devices are available.

c. Steps for securing an ET tube:

i. Note the centimeter marking on the ET tube at the level of the patient’s teeth.

ii. Remove the bag-mask device from the ET tube.

iii. Position the ET tube in the center of the mouth.

iv. Place the securing device over the ET tube.

(a) Tighten the screw to secure it in place.

(b) Fasten the strap.

v. Reattach the bag-mask device, auscultate again over the lungs and over the epigastrium, and note the capnography reading and waveform.

d. Many commercially manufactured ET tube-securing devices feature a built-in bite block.

e. If you do not have a commercially manufactured device, you can secure the tube in place with tape and insert a bite block or oral airway.

f. It is important to minimize head movement in an intubated patient.

i. Apply a cervical collar.

ii. Place the patient on a long backboard.

iii. Stabilize the patient’s head with lateral immobilization blocks.

g. To properly intubate the trachea using direct laryngoscopy, refer to ***Skill Drill 15-18***.

**E. Nasotracheal intubation**

1. Insertion of a tube into the trachea through the nose

a. Usually performed without directly visualizing the vocal cords in the prehospital setting

2. Excellent technique for establishing control over the airway in situations when it is difficult or hazardous to perform laryngoscopy

3. Indications and contraindications

a. Indicated for patients who are breathing spontaneously but require definitive airway management

i. Responsive patients

ii. Patients with altered mental status and intact gag reflex who are in respiratory failure because of conditions such as:

(a) COPD

(b) Asthma

(c) Pulmonary edema

b. Contraindicated for:

i. Apneic patients (in respiratory or cardiac arrest)

(a) Should be orotracheally intubated

ii. Patients with head trauma and possible midface fractures

iii. Patients with anatomic abnormalities or frequent cocaine use

c. Avoid in patients with blood-clotting abnormalities and in patients who take anticoagulation medications.

4. Advantages and disadvantages

a. Advantages

i. Can be performed on patients who are responsive and breathing

ii. No need for a laryngoscope; eliminates the risk of trauma to teeth or soft tissues of the mouth.

iii. Mouth does not need to be opened—better suited to patients with limited temporomandibular joint mobility

iv. Does not require sniffing position; ideal with a possible spinal injury.

v. Tube is inserted through the nose, so patient cannot bite the tube.

vi. Can be secured more easily than an orally inserted tube.

b. Disadvantage

i. Blind technique, so major tube confirmation methods cannot be used.

(a) Confirming proper tube position requires even more diligence

5. Complications

a. Bleeding is the most common.

i. Especially with rough technique

ii. Poses an additional threat to an already compromised airway

iii. Incidence of bleeding can be reduced by gentle insertion of the tube and lubrication of the tip with a water-soluble gel

(a) Anesthetic lubricant containing a vasoconstrictive agent will reduce patient discomfort and the likelihood and severity of nasal bleeding

6. Equipment

a. Same equipment used for orotracheal intubation (minus laryngoscope and stylet)

i. Select a tube that is slightly smaller than the nostril.

b. Some ET tubes have been designed specifically for blind nasotracheal intubation.

i. Endotrol tube

(a) Slightly more flexible than a standard ET tube

(b) Equipped with a “trigger” that moves the tip of the tube anteriorly and increases the tube’s overall curvature

c. Movement of air through the ET tube helps determine proper tube placement

i. A number of devices allow a paramedic to confirm successful intubation without placing his or her face next to the tube.

**F. Technique for nasotracheal intubation**

1. Use the patient’s spontaneous respirations to guide a nasotracheal tube into the trachea and confirm proper placement.

a. Tube is advanced as the patient inhales

2. After preparing your equipment and preoxygenating the patient, insert the tube into the nostril with the bevel facing toward the nasal septum.

a. Right nostril is typically used

b. If the right nostril is obstructed, insert the tube into the left nostril, but rotate the tube 180° as its tip enters the nasopharynx.

3. Aim the tip of the tube straight back toward the ear.

a. Do *not* insert the tube with the tip aimed upward toward the eye.

4. Position the tube just above the glottic opening so that the patient will draw the tube into the trachea when he or she inhales deeply.

5. Manipulate the patient’s head to control the position of the tip of the tube.

a. Cup your left hand (if tube is in the right nostril) under the patient’s occiput.

b. Move the head to achieve maximum air flow through the tube.

6. Instruct the patient to take a deep breath, and *gently* advance the tube with the inhalation.

a. Placement in the trachea will be evidenced by an increase in air movement through the tube.

7. If you see a soft-tissue bulge on either side of the airway, the tube may be inserted into the piriform fossa.

a. Hold the patient’s head still and slightly withdraw the tube.

b. Once maximum airflow is detected, advance the tube on inhalation.

c. If you do not see a soft-tissue bulge, the tube has entered the esophagus.

i. Withdraw the tube until you detect airflow, and then extend the head.

8. Once the tube has been properly positioned:

a. Inflate the distal cuff with the minimum amount of air necessary.

b. Attach a bag-mask device to the tube, and ventilate.

c. Confirmation and monitoring are extremely important.

9. Clean up any secretions or excess lubricant, and secure the tube with tape.

10. Document depth of insertion at the nostril.

11. To properly perform blind nasotracheal intubation, refer to ***Skill Drill 15-19***.

**G. Digital intubation**

1. Involves directly palpating the glottic structures and elevating the epiglottis with your middle finger while guiding the ET tube into the trachea by feel

a. Gives you an option in some extreme circumstances

2. Indications and contraindications

a. Digital intubation may be used in the following exceptional circumstances:

i. Laryngoscope is not available or has malfunctioned

ii. Other intubation techniques have failed.

iii. Patient is in a confined space.

iv. Patient is extremely obese or has a short neck.

v. Copious secretions obscure the airway.

vi. Head cannot be moved due to trauma, or immobilization equipment interferes with direct laryngoscopy

vii. Massive airway trauma has made visualization of the intubation landmarks impossible.

b. Can be performed in pediatric patients, but the size of an adult’s fingers relative to the size of the child’s mouth usually makes the technique impossible.

c. Absolutely contraindicated if the patient is:

i. Breathing

ii. Not deeply unresponsive

iii. Has an intact gag reflex

3. Advantages and disadvantages

a. Does not require a laryngoscope, so most advantageous in case of equipment failure

b. Ideal if the vocal cords are obscured by copious, uncontrollable oral secretions

c. Does not require the sniffing position, so it can be performed on trauma patients and patients whose heads cannot be placed in a sniffing position

d. The major disadvantage is risk of being bitten.

i. Only perform in patients who are deeply unresponsive *and* apneic

e. Risk of exposure to infectious disease if teeth tear through gloves

4. Complications

a. Major complication: Misplacement of the ET tube

b. Insertion of a bite block or dental prod can cause lip trauma and tooth damage.

c. Vigorous attempts at insertion or improper technique can cause airway trauma or swelling.

d. Any intubation attempt can result in hypoxia.

i. Carefully monitor clinical condition.

ii. Limit intubation attempts to 30 seconds.

iii. Ventilate appropriately between attempts.

5. Equipment

a. Same equipment as required for orotracheal intubation (minus laryngoscope), plus your fingers

i. Stylet

ii. ETco2 detector or esophageal detector device

iii. Appropriate device to secure the tube

6. Technique for digital intubation

a. Prepare equipment as your assistant ventilates the patient with a bag-mask device and 100% oxygen.

b. Select an ET tube that is one half to a full size smaller than that used for intubation with direct laryngoscopy.

c. Tip of the tube is guided into the trachea; index finger is a leverage point.

d. Two configurations are recommended.

i. “Open J” configuration: Stylet is inserted; large J shape is made in the distal end of the tube.

ii. “U-handle” configuration: Tube is bent into a U shape; proximal half of the tube is bent into a 90° handle toward your dominant hand.

e. Sniffing position is not required.

f. Insert a bite block or the flange of an oral airway between the patient’s molars.

g. Insert the index and middle fingers of your left hand into the right side of the mouth.

i. Press down against the tongue as you slide your fingers until you can feel the epiglottis.

ii. Pull the epiglottis forward with your middle finger.

h. Hold the ET tube in your right hand like a pencil, and insert it into the left side of the patient’s mouth.

i. Advance the tube and guide its tip toward the glottis.

j. Once you feel the cuff of the tube pass about 2" beyond your fingertip, stabilize the tube while you gently withdraw your fingers from the patient’s mouth.

k. Carefully remove the stylet, and inflate the distal cuff with 5 to 10 mL of air.

l. Attach the bag-mask device to the ET tube, and ventilate while observing for visible chest rise.

m. Rigorous protocol for confirmation of tube placement must be followed.

i. Auscultate both lungs and over the epigastrium

ii. Monitor ETco2

iii. Properly secure the tube in place.

n. Continue ventilations according to the patient’s clinical condition.

o. To properly perform digital intubation, refer to ***Skill Drill 15-20***.

**H. Transillumination techniques for intubation**

1. Tissue that overlies the trachea is relatively thin.

a. Bright light source placed in the trachea emits a bright, well-circumscribed light

b. A number of devices can be used to intubate the trachea with transillumination.

i. “Lighted stylet” describes any malleable stylet with a bright light source at its distal end.

2. Indications and contraindications

a. Can be used whenever a patient needs to be intubated, but usually performed after other techniques have failed

b. Absolutely contraindicated in patients with:

i. Intact gag reflex

ii. Airway obstruction

c. May be difficult in obese patients and patients with short, muscular necks

d. Theoretically possible with pediatric patients; however, the stylet *must* fit inside the ET tube.

3. Advantages and disadvantages

a. No laryngoscope used, so problems associated with laryngoscopy are largely avoided.

b. Visual parameter—a light at the midline of the neck—increases chance for successful tube placement.

c. Does not require visualization of the glottic opening

d. Sniffing position is not required; safe with possible spinal injuries.

e. Major disadvantages:

i. Requirements for special equipment

ii. Proficiency with equipment

iii. Can be difficult or impossible in brightly lit areas.

4. Complications

a. Misplacement of the tube in the esophagus because intubator cannot directly visualize the tube passing between the vocal cords

i. Requires strict attention to tube confirmation techniques.

5. Equipment

a. Device with a rigid stylet and a bright light source at the end

i. Light should shine laterally and forward.

ii. Stylet must be long enough to accommodate a standard-length ET tube.

iii. Need a method of securing the stylet within the tube

6. Technique for transillumination-guided intubation

a. Patient must be preoxygenated for at least 2 to 3 minutes with a bag-mask device and 100% oxygen.

b. Select the appropriately sized ET tube, and check the cuff to ensure that it holds air.

c. Lubricate and insert the lighted stylet so the light is positioned at the tip of the tube.

d. Ensure the stylet is firmly seated into the tube.

e. Prepare the tube by bending it into the proper shape.

i. Stylet should be straight, with a sharp 90° angle in the tube-stylet assembly just proximal to the cuff.

f. Place the head in a neutral or slightly extended position

g. Intubator is typically at the patient’s head.

h. While holding the stylet in your dominant hand, displace the jaw forwardly by grasping it with your thumb and forefinger

i. Turn on the lighted stylet, and insert it in the midline of the mouth, with the tip toward the laryngeal prominence.

j. As you continue to insert the assembly, draw your wrist toward you.

i. Tightly circumscribed light slightly below the thyroid cartilage: Tip of the tube has entered the trachea.

ii. Faintly glowing light and bulging of the soft tissue above the thyroid cartilage: Tip of the tube is in the vallecular space.

(a) Withdraw tube slightly, displace jaw forward, and readvance the tube-stylet assembly.

iii. Dim, diffuse light at the anterior part of the neck: Esophageal placement.

(a) Slightly withdraw tube-stylet assembly and extend the head.

(b) Consider increasing the angle of the bend in the tube.

(c) If you continue to encounter difficulty, abort the procedure and ventilate the patient before reattempting insertion.

k. Once light is visible at the midline, hold the stylet in place and advance the tube approximately 2 to 4 cm into the trachea.

l. When the tube is securely in the trachea, manually stabilize it and carefully withdraw the stylet.

m. Inflate the distal cuff of the ET tube with 5 to 10 mL of air, detach the syringe from the inflation port, and attach the bag-mask device to the ET tube.

n. Ventilate the patient while auscultating both lungs and the epigastrium.

o. Following confirmation of tube placement, secure tube with the appropriate device and continue ventilations.

p. To properly perform transillumination intubation, refer to ***Skill Drill 15-21***.

**I. Retrograde intubation**

1. Rarely performed in the prehospital environment

a. Only relevant in EMS systems where local protocols indicate

2. A needle is placed percutaneously within the trachea via the cricothyroid membrane.

a. A wire is placed toward the head through the needle upward through the trachea and into the mouth.

b. The wire is then visualized and secured, and the ET tube is placed over the wire and guided into the trachea.

c. The wire is subsequently removed, and the ET tube is advanced and secured.

3. Indications include:

a. Upper airway obstruction

b. Copious secretions in the airway

c. Failure to intubate the trachea by less invasive methods

4. Contraindications include:

a. Lack of familiarity with the procedure

b. Laryngeal trauma

c. Unrecognizable or distorted landmarks

d. Coagulopathy (relative contraindication)

e. Severe hypoxia (due to inability to ventilate during the procedure and time to perform the procedure)

5. Complications include:

a. Hypoxia

b. Cardiac dysrhythmias

c. Mechanical trauma

d. Infection

e. Increased intracranial pressure

6. Assessment findings and transport complications are the same as with standard intubation.

7. To properly perform retrograde intubation, refer to ***Skill Drill 15-22***.

**J. Face-to-face intubation**

1. Intubation may be performed with the paramedic’s face at the same level as the patient’s face when other positions are not possible.

a. Essentially the same as orotracheal intubation using direct laryngoscopy, with the following exceptions:

i. Head is manually stabilized by a second paramedic during the entire procedure, not in sniffing position.

ii. Laryngoscope (with a curved blade) is held in the right hand with the blade facing downward; ET tube is held in the left hand.

(a) Blade is inserted into the right side of the mouth, tongue is swept to the left, and vocal cords are visualized.

iii. Once the blade has been placed, the intubator may slightly adjust the head for better visualization by pulling the mandible forward while pressing down.

**K. Failed intubation**

1. A failed airway attempt is defined as:

a. The failure to maintain acceptable oxygen saturation during or after one or more failed intubation attempts, *or*

b. A total of three failed intubation attempts, even when the oxygen saturation can be maintained.

2. Rescue airway techniques are available.

a. Perform simple BLS airway maneuvers with an oral airway and/or a nasal airway and a bag-mask device.

i. Objective is to ventilate and oxygenate—not intubate.

b. Consider using a rescue airway device, (e.g., King LT, LMA, or Combitube).

**L. Tracheobronchial suctioning**

1. Involves passing a suction catheter into the ET tube to remove pulmonary secretions

a. Do not do it if you do not have to!

i. Requires strict attention to sterile technique

ii. Can cause cardiac dysrhythmias and cardiac arrest

b. Avoid unless secretions are so massive that they interfere with ventilation.

c. If it must be performed:

i. Use sterile technique.

ii. Monitor cardiac rhythm and oxygen saturation.

2. Preoxygenate for at least 2 to 3 minutes.

a. May be necessary to inject 3 to 5 mL of sterile water down the ET tube to loosen thick secretions.

3. Gently insert the suction catheter down the ET tube until resistance is felt.

4. Apply suction as the catheter is extracted (do not exceed 10 seconds in an adult).

5. When complete, reattach the bag-mask device, continue ventilations, and reassess the patient.

6. To properly perform tracheobronchial suctioning, refer to ***Skill Drill 15-23***.

**M. Field extubation**

1. Extubation: Process of removing the tube from an intubated patient—rarely done in the prehospital setting.

a. Generally, only consider for a patient who is *unreasonably* intolerant of the ET tube

b. Better to sedate the patient

c. Before performing, contact medical control or follow local protocols.

2. Obvious risk is overestimation of the patient’s ability to protect his or her own airway

3. High risk of laryngospasm when performed on responsive patients

4. Most patients experience upper airway swelling.

5. Do not remove the ET tube unless you are *absolutely* sure you can reintubate.

a. Instead, sedate the patient with a benzodiazepine.

b. If a paralytic drug was used to facilitate intubation, consider administering additional doses.

6. Absolutely contraindicated if there is any risk of recurrent respiratory failure or uncertainty about a patient’s ability to maintain his or her own airway.

7. If indicated, first ensure adequate oxygenation.

8. Discuss and explain the procedure with the patient.

9. If possible, have the patient sit up or lean slightly forward.

10. Assemble and have available all equipment to suction, ventilate, and reintubate.

11. After confirming that the patient can protect his or her own airway, suction the oropharynx.

12. Deflate the distal cuff on the ET tube as the patient begins to exhale so any accumulated secretions are not aspirated into the lungs.

13. On the next exhalation, *remove the tube in one steady motion*.

14. Place a towel or emesis basin in front of the patient’s mouth in case of vomiting.

**N. Pediatric endotracheal intubation**

1. Studies suggest that bag-mask ventilations in pediatric patients can be as effective as intubation when transport times are short.

a. If bag-mask ventilations are not producing adequate ventilation, the patient should be intubated.

2. Indications in pediatric patients are the same as those in adults:

a. Cardiopulmonary arrest

b. Respiratory failure or arrest

c. Traumatic brain injury

d. Unresponsiveness

e. Inability to maintain a patent airway

f. Need for prolonged ventilation

g. Need for ET administration of resuscitative medications (if no IV or IO access available)

3. Proper airway positioning is critical; anatomic differences between children and adults are key to success.

4. Laryngoscope and blades

a. Thinner pediatric handles are preferred.

b. Straight blades facilitate lifting of the floppy epiglottis.

c. Blade should extend from the mouth to the tragus of the ear

i. Can be measured with a length-based resuscitation tape measure or using the following guidelines:

(a) Premature newborn: size 0 straight blade

(b) Full-term newborn to 1 year: size 1 straight blade

(c) 2 years to adolescent: size 2 straight blade

(d) Adolescent and older: size 3 straight or curved blade

5. Endotracheal tubes

a. To estimate the appropriate size ET tube, use a length-based resuscitation tape measure.

i. Tape measure also provides information about the proper size of basic airway adjuncts, drug doses, defibrillation and cardioversion settings, and other care.

ii. If one is not available, use either of the following formulas for children older than 1 year.

(a) [Age (in years) + 16] ÷ 4

(b) [Age (in years) ÷ 4] + 4

iii. Certain anatomic clues can be used to estimate tube size.

iv. Or general guidelines based on the child’s age group can be followed.

b. Cuffed ET tubes are generally not used in the field until the child is 8 to 10 years old.

i. Can cause ischemia and damage the tracheal mucosa at the level of the cricoid ring

ii. Tubes smaller than 5.0 mm generally do not have a cuff.

c. Have tubes one size smaller and one size larger than expected

d. Appropriate depth of tube insertion is 2 to 3 cm beyond the vocal cords.

e. Record and monitor the depth at the corner of the mouth after insertion.

f. For uncuffed tubes, a black band often encircles the tube at the distal end.

i. When you see this band at the level of the vocal cords, stop.

g. Cuffed tubes should be inserted until the cuff is just below the level of the vocal cords.

i. Another guideline is to insert the tube to a depth equal to three times the inside diameter (mm) of the ET tube.

6. Pediatric stylet

a. If used, insert it into the ET tube, stopping at least 1 cm from the end of the tube.

b. Will fit into tube sizes 3.0 to 6.0 mm

c. After inserting the stylet into the tube, bend the tube into a gentle upward curve or, in some cases, the shape of a hockey stick.

7. Preoxygenation

a. Adequate preoxygenation for at least 2 to 3 minutes before attempting intubation cannot be overemphasized.

b. While preoxygenating, ensure that the child’s head is in the sniffing position or the neutral position with suspected trauma.

c. If needed, insert an airway adjunct.

8. Additional preparation

a. Stimulation of the parasympathetic nervous system with resultant bradycardia can occur during intubation, so monitor cardiac rhythm.

b. Use a pulse oximeter throughout the intubation attempt to monitor pulse rate and oxygen saturation.

c. Have suction readily available.

d. Atropine sulfate may be administered to prevent vagal nerve-induced bradycardia.

9. Intubation technique

a. With the head in sniffing position, open the mouth by applying thumb pressure on the chin.

i. Some children may require the cross-finger technique: use your thumb and index finger or thumb and middle finger to push the upper and lower teeth apart.

b. If an oral airway has been inserted, remove it.

c. Suction if needed

d. Hold the laryngoscope handle in your left hand, using your thumb, index finger, and middle finger to hold the handle (“trigger finger” position).

e. Insert the blade in the right side of the mouth, sweeping the tongue to the left side and keeping it under the blade.

f. Advance the blade straight along the tongue, while applying gentle traction upward at a 45° angle.

g. Never use the teeth or gums as a fulcrum for the blade; teeth can easily be loosened or cracked.

h. When the blade passes the epiglottis, gently lift the epiglottis if you are using a straight blade.

i. Curved blade: Place the tip of the blade in the vallecula; lift jaw, tongue, and blade gently at a 45° angle.

i. Identify the vocal cords and other normal anatomic landmarks.

j. Additional gentle suctioning may be needed to facilitate your view of the vocal cords.

k. Hold the ET tube in your right hand, and insert the tube from the right-side corner of the mouth.

i. Do not pass the tube through the channel of the laryngoscope blade.

l. Guide tube through the vocal cords, advancing it until the glottic or vocal cord mark (black band) is positioned just beyond the vocal cords

m. Record the depth of the tube, and remove the blade.

n. Carefully remove the stylet while holding the tube securely in place.

o. Recheck tube depth to ensure that it did not become displaced during removal.

p. If you are using a cuffed ET tube, inflate the cuff enough to form a seal between the tube and tracheal wall.

q. Attach the tube to a bag-mask device and 100% oxygen, with an ETco2 detector between the bag and tube.

r. Confirm proper ET tube placement with several techniques.

i. Look for bilateral chest rise during ventilation.

ii. Auscultate the lungs bilaterally, listening for two breaths in each location.

iii. If breath sounds are decreased on the left side, the tube may be positioned too deep.

iv. To correct this, listen to the left side of the chest while ventilating and carefully withdrawing the tube, until breath sounds are equal.

v. Rerecord tube depth.

s. Auscultate over the epigastrium to ensure that no bubbling or gurgling sounds are present.

i. These sounds indicate esophageal intubation.

ii. Mandates immediate removal of the tube, suctioning as needed, and ventilation before reattempting intubation.

t. Additional clinical methods to confirm proper ET tube placement include:

i. Improvement in the child’s skin color, pulse rate, and oxygen saturation

ii. Waveform capnography

u. If you must use the colorimetric ETco2 detector or EDD, remember two important points:

i. Adult colorimetric ETco2 detector cannot be used in children weighing less than 15 kg.

ii. Esophageal bulb or syringe cannot be used in children weighing less than 20 kg

v. After you confirm proper tube placement, hold the tube firmly in place and secure it.

i. One person should always hold the tube in place while another secures it.

w. Reconfirm tube placement following any patient movement.

i. Auscultate for bilateral breath sounds and epigastric sounds.

ii. Once position has been confirmed, resume ventilations.

x. If tube is too large or you cannot identify the vocal cords and glottic landmarks:

i. Abort the intubation attempt and ventilate.

ii. Modify your equipment selection accordingly, and start from the beginning.

iii. If intubation cannot be accomplished after two attempts, discontinue attempts, and resume ventilation for the remainder of the transport.

y. To properly perform pediatric endotracheal intubation, refer to ***Skill Drill 15-24***.

z. If an intubated child’s condition deteriorates, the DOPE mnemonic can be used to recall common causes.

i. Displacement

ii. Obstruction

iii. Pneumothorax

iv. Equipment failure

10. Complications of endotracheal intubation

a. Essentially the same in pediatric patients as in adults:

i. Unrecognized esophageal intubation

(a) Frequently monitor the position of the tube.

(b) Use continuous waveform capnography.

ii. Induction of emesis and possible aspiration

(a) Always have a suctioning device immediately available.

iii. Hypoxia resulting from prolonged intubation attempts

(a) Limit pediatric intubation attempts to 20 seconds.

(b) Monitor the child’s cardiac rhythm and oxygen saturation.

iv. Damage to teeth, soft tissues, and intraoral structures

XVIII. Pharmacologic Adjuncts to Airway Management and Ventilation

**A. Pharmacologic agents are used to:**

1. Decrease the discomfort of intubation

2. Decrease the incidence of complications

3. Make aggressive airway management possible for patients who are unable to cooperate

**B. Sedation in emergency intubation**

1. Reduces a patient’s anxiety, induce amnesia, and decrease gag reflex

2. Complications are related primarily to undersedation and oversedation.

a. Undersedation can result in:

i. Inadequate patient cooperation

ii. Complications of gagging

iii. Incomplete amnesia of the event

b. Oversedation can result in:

i. Uncontrolled general anesthesia

ii. Loss of protective airway reflexes

iii. Respiratory depression

iv. Complete airway collapse

v. Hypotension

3. Level of sedation desired dictates the amount of medication administered

a. Follow local protocol or contact medical control regarding the appropriate dose.

4. Two major classes of sedatives are commonly used:

a. Analgesics decrease the perception of pain.

b. Sedative-hypnotics induce sleep and decrease anxiety; they do not reduce pain.

5. Butyrophenones

a. Potent, effective sedatives

b. Haloperidol (Haldol) and droperidol (Inapsine) are frequently used in emergency situations for anxiolysis, the relief of anxiety.

i. Effective for:

(a) Calming agitated patients

(b) Trauma patients who are combative

(c) Patients experiencing alcohol withdrawal

(d) Patients with acute psychoses

c. Do not produce apnea and have little effect on the cardiovascular system.

d. Droperidol is faster acting than haloperidol.

e. Not recommended for induction of anesthesia

6. Benzodiazepines

a. Sedative-hypnotic drugs

b. Diazepam (Valium) and midazolam (Versed)

i. Provide muscle relaxation and mild sedation.

ii. Used extensively as anxiolytic and antiseizure medications

iii. Also provide anterograde amnesia.

c. Midazolam

i. Two to four times as potent as diazepam

ii. Faster acting

iii. Shorter duration of action

iv. Large doses are necessary, so it should not be used as an induction agent.

v. Likelihood of complications increases because of the large dose required

d. Use of neuromuscular blockers (paralytics) to achieve muscle relaxation is preferred because they require smaller doses.

e. Potential side effects: Respiratory depression and slight hypotension

f. Flumazenil (Romazicon) is a benzodiazepine antagonist.

7. Barbiturates

a. Sedative-hypnotic medications

b. Thiopental (Pentothal, Trapanal)

i. Short acting, causes rapid onset of profound sedation

ii. Pentothal no longer available in the United States.

c. Methohexital (Brevital)

i. Ultra-short acting

ii. Twice as potent as thiopental

d. Can cause significant respiratory depression and a drop in blood pressure

i. Drop in blood pressure can be profound and potentially irreversible in hypovolemic patients.

8. Opioids/narcotics

a. Potent analgesics with sedative properties

b. Used as a premedication, during induction, and in maintenance of sedation or amnesia

c. Fentanyl (Sublimaze) and alfentanil (Alfenta)

i. Fentanyl

(a) 70 to 150 times more potent than morphine

(b) Rapid onset of action

(c) Relatively short duration of action

ii. Alfentanil

(a) Less potent than fentanyl

(b) Faster onset of action and a shorter duration of action

(c) Eliminated from the body faster

d. Can cause profound respiratory and central nervous system depression

e. Naloxone (Narcan) is a narcotic antagonist.

9. Nonnarcotic/nonbarbiturate

a. Etomidate (Amidate)

i. Hypnotic-sedative drug often used in the induction of general anesthesia

ii. Fast-acting, short duration

iii. Little effect on pulse rate, blood pressure, and intracranial pressure (ICP)

iv. Does not cause the histamine release and bronchoconstriction that may occur with other agents

v. High incidence of uncomfortable myoclonic muscle movement

vi. Useful induction agent in patients with:

(a) Coronary artery disease

(b) Increased ICP

(c) Borderline hypotension/hypovolemia

**C. Neuromuscular blockade in emergency intubation**

1. Cerebral hypoxia can make a docile person combative, aggressive, belligerent, and uncooperative.

a. Must be treated with aggressive oxygenation and ventilation

b. Physical restraint used to be common.

c. “Chemical paralysis” with neuromuscular blocking agents (paralytics) is safer.

i. Protective airway reflexes are lost.

2. Neuromuscular blocking agents

a. Sedatives alone can facilitate intubation, but it is more effective to use a drug designed to induce paralysis.

i. Affects every skeletal muscle

ii. Within about 1 minute of receiving, patient becomes totally paralyzed.

(a) Stops breathing

(b) Jaw muscles go slack

(c) Base of the tongue falls back against the posterior pharynx, obstructs the airway.

b. You must be absolutely sure that you can secure the airway.

i. Paralytic agents do not affect cardiac or smooth muscle.

c. Paralytic agents have no effect on LOC.

i. Patient can hear, feel, and think.

**D. Pharmacology of neuromuscular blocking agents**

1. Skeletal (striated) muscles are voluntary and require input from the somatic nervous system to initiate contraction.

a. Impulse to contract reaches the terminal end of a motor nerve; acetylcholine (ACh) is released into the synaptic cleft (junction between nerve cell and muscle cell).

b. Acetylcholine diffuses and occupies receptor sites, triggering changes in electrical properties of the muscle fiber.

i. Process is called depolarization

c. When enough motor end plates have been depolarized, the muscle fiber contracts.

d. Depolarization lasts for a few milliseconds because of the presence of acetylcholinesterase

i. Enzyme that quickly removes ACh

2. Paralytic medications

a. Function at the neuromuscular junction

b. Relax the muscle by impeding the action of ACh

c. Classified into two categories: depolarizing and nondepolarizing agents

3. Depolarizing neuromuscular blocking agent

a. Competitively binds with the ACh receptor sites but is not affected as quickly by acetylcholinesterase.

b. Succinylcholine chloride (Anectine) is the only depolarizing neuromuscular blocking agent.

i. Fasciculations can be observed during its administration.

(a) Characterized by brief, uncoordinated twitching of small muscle groups

(b) Tend to cause generalized muscle pain when it wears off

c. Characterized by very rapid onset (60-90 seconds) and short duration of action (5-10 minutes)

i. Often used as an initial paralytic

d. Should be used with caution in patients with burns, crush injuries, and blunt trauma

i. Can result in hyperkalemia

e. Can cause bradycardia, especially in pediatric patients

i. Administration of atropine sulfate should precede the administration of succinylcholine in pediatric patients.

4. Nondepolarizing neuromuscular blocking agents

a. Also bind to ACh receptor sites but do not cause depolarization of the muscle fiber

b. In sufficient quantity, the amount of medication exceeds the amount of ACh in the synaptic cleft.

c. Prevent fasciculations when administered in small quantities before a depolarizing paralytic.

d. Most commonly used: Vecuronium bromide (Norcuron), pancuronium bromide (Pavulon), and rocuronium bromide (Zemuron).

i. All three: Duration of action longer than that of succinylcholine

ii. Vecuronium: Rapid onset of action (2 minutes); duration of action of about 45 minutes

iii. Rocuronium: Rapid onset of action (< 2 minutes); duration of action of 45 to 60 minutes

iv. Pancuronium: Rapid onset of action (3–5 minutes); duration of action of 1 hour

e. Ideal when a patient requires extended periods of paralysis

f. Do not give before the patient’s airway has been secured.

**E. Rapid-sequence intubation**

1. Includes safe, smooth, and rapid induction of sedation and paralysis followed immediately by intubation

a. Generally used for patients who need to be intubated but are unable to cooperate

2. Preparation of the patient and equipment

a. Explain the procedure and reassure the patient.

b. Apply a cardiac monitor and pulse oximeter.

c. Check, prepare, and assemble your equipment.

i. Have suction immediately available.

3. Preoxygenation

a. Adequately preoxygenate all patients before you begin.

b. Apply high-flow oxygen via nonrebreathing mask if the patient is breathing spontaneously and has adequate tidal volume.

c. If patient is hypoventilating, assisted ventilations with a bag-mask device and high-flow oxygen may be necessary.

i. Avoid bag-mask ventilation before RSI whenever possible.

4. Premedication

a. Stimulation of the glottis associated with intubation can cause dysrhythmias and a substantial increase in ICP.

i. If you are performing RSI on a patient with closed head trauma, protocol may call for 1 to 1.5 mg/kg of lidocaine.

(a) Blunts the increase in ICP

b. If your initial paralytic of choice is succinylcholine, administer a defasciculating dose of a nondepolarizing paralytic if time permits.

i. Typically 10% of the normal dose

c. Atropine sulfate should also be administered to decrease potential for bradycardia.

i. Usual adult dose is 0.5 mg; infants and children 0.02 mg/kg.

5. Sedation and paralysis

a. As long as the patient is hemodynamically stable (systolic blood pressure of > 90 mm Hg), administer a sedative.

b. As soon as the patient is adequately sedated, administer the paralytic agent.

c. Onset of paralysis should be complete within 2 minutes.

d. Signs of adequate paralysis include:

i. Apnea

ii. Laxity of the mandible

iii. Loss of the eyelash reflex

6. Intubation

a. Intubate the trachea as carefully as possible.

b. If you cannot accomplish the intubation within 30 seconds, stop and ventilate the patient for 30 to 60 seconds before trying again.

c. If you must ventilate the patient with a bag-mask device, do so slowly.

i. 1 second per breath

ii. Enough to produce visible chest rise

d. Once the tube is in the trachea:

i. Inflate the cuff.

ii. Remove the stylet.

iii. Verify correct position of the ET tube.

iv. Secure the tube.

v. Continue ventilations at the appropriate rate.

7. Maintenance of paralysis and sedation

a. When you are absolutely sure that you have successfully intubated the trachea, additional paralytic administration may be necessary.

b. If you administered succinylcholine initially, administer a nondepolarizing agent to maintain long-term paralysis.

c. If you administered a long-acting paralytic initially, additional dosing is usually not necessary.

d. General steps of RSI may need to be modified for patients in unstable condition.

i. If oxygen saturation drops, you must ventilate (*slowly*).

ii. If patient is hemodynamically unstable, judge whether sedation is appropriate or whether risk of profound hypotension is too great.

XIX. Alternative Advanced Airway Devices

**A. Multilumen airways**

1. Multilumen airway devices are inserted blindly.

2. Clinically proven to secure the airway and allow for better ventilation than a bag-mask device and simple airway adjunct in most cases

3. Two such devices:

a. Pharyngotracheal lumen airway (predecessor to Combitube and rarely used)

b. Combitube

i. Has a long tube, blindly inserted into the airway

ii. Can be used for ventilation whether inserted into the esophagus or trachea

iii. Almost always comes to rest in the esophagus but can function as an ET tube if inserted into the trachea.

4. Contain two lumens

a. Each lumen has a standard adapter, which accommodates any ventilation device.

5. Also contain an oropharyngeal balloon, which eliminates the need for a mask seal.

6. Indications and contraindications

a. Indicated for airway management of deeply unresponsive, apneic patients with no gag reflex in whom ET intubation is not possible or has failed

i. If the patient regains consciousness, the device must be removed.

b. Cannot be used in children younger than 16 years

i. Should be used only for patients between 5' and 7' tall.

ii. Smaller version (Combitube SA) is available for patients more than 4' tall.

c. Contraindicated with:

i. Esophageal trauma

ii. Known pathologic condition of the esophagus

iii. Patients who have ingested a caustic substance

iv. History of alcoholism

7. Advantages and disadvantages

a. Ventilation is possible whether tube enters esophagus or trachea.

b. Insertion is technically easier than ET intubation.

c. Head is in the neutral position, so cervical spine movement is minimal.

d. No mask seal required.

e. Provides some airway patency.

i. If the tube is placed in the trachea, it functions like an ET tube.

ii. If the tube is placed in the esophagus, the pharyngeal balloon creates an airtight seal in the oropharynx.

iii. Jaw-thrust maneuver should easily alleviate any ventilatory difficulty.

f. Ventilation in the wrong port results in no pulmonary ventilation.

g. Usually considered temporary and should be replaced as soon as possible.

h. Pharyngeal balloon reduces but does not eliminate risk of aspiration.

i. Intubating the trachea via direct laryngoscopy with a multilumen airway in place is extremely challenging.

8. Complications of multilumen airways

a. Most significant complication is *unrecognized* displacement into the esophagus

i. Use multiple confirmation techniques.

b. Laryngospasm, vomiting, and possible hypoventilation may occur during insertion.

c. Pharyngeal or esophageal trauma may result from improper technique.

d. Ventilation may be difficult if the pharyngeal balloon pushes the epiglottis over the glottic opening.

9. Insertion techniques

a. Combitube consists of:

i. Single tube with two lumens

ii. Two balloons

iii. Two ventilation attachments

b. Before insertion, check and prepare equipment:

i. Check both cuffs; ensure that they hold air.

ii. Preoxygenate before insertion.

iii. Do not interrupt ventilation for longer than 30 seconds to insert the airway.

c. For insertion, head should be in a neutral position.

i. Forwardly displace the jaw.

(a) With head in a neutral position, insert the thumb of your nondominant hand into the mouth and lift the jaw.

ii. Insert the device.

(a) Insert the device blindly into the posterior pharynx until the incisors are between the two black lines printed on the tube.

(b) Be gentle; stop advancing the tube if you meet resistance.

iii. Two independent inflation valves must be inflated sequentially.

(a) First inflates the balloon on the pharyngeal tube (blue, No. 1) and is filled with 100 mL of air.

(b) Second inflates the distal balloon of the tracheal tube (clear, No. 2) and is filled with 15 mL of air.

d. Confirmation of ventilation is critical.

e. To properly insert a Combitube, refer to ***Skill Drill 15-25***.

f. Following inflation of the balloons, begin to ventilate through the longer (blue) tube first.

g. Observe for chest rise, and auscultate breath and epigastric sounds.

i. If there are no breath sounds and the chest does not rise and fall, switch to the shorter (clear) tube.

h. Continuously monitor ventilation.

i. Secure the device once ventilations are confirmed.

ii. Use continuous waveform capnography to confirm the presence of exhaled carbon dioxide.

**B. Supraglottic airway devices**

1. Laryngeal mask airway (LMA)

a. Viable option for patients who require more airway and ventilatory support than bag-mask ventilation can provide but do not require ET intubation

b. Provides a conduit from the glottic opening to the ventilation device

c. Surrounds the opening of the larynx with an inflatable silicone cuff positioned in the hypopharynx

d. When properly inserted, the opening is positioned at the glottic opening, and the tip is inserted into the proximal esophagus.

e. Inflatable cuff conforms to airway contours, forms a relatively airtight seal

f. Indications and contraindications

i. One alternative to bag-mask ventilation when patient cannot be intubated

ii. Less effective in obese patients

iii. Pregnant patients and patients with a hiatal hernia are at an increased risk for regurgitation.

iv. Ineffective with patients requiring high pulmonary pressures

g. Advantages and disadvantages

i. Better ventilation than a bag-mask device and an oral and/or nasal airway

ii. Does not require continual maintenance of a mask seal

iii. Does not require laryngoscopy

iv. Significantly less risk of soft-tissue, vocal cord, tracheal wall, and dental trauma than with ET and other forms of intubation

v. Provides protection from upper airway secretions

vi. Main disadvantage: Does not protect against aspiration

vii. During prolonged LMA ventilation, some air may be insufflated into the stomach.

viii. Not a primary airway in emergency situations

h. Complications of using the LMA

i. Most significant complications involve regurgitation and subsequent aspiration

ii. Should be used only in patients who are fasting

iii. Weigh risks of aspiration vs. hypoventilation with bag-mask ventilation.

iv. Look for clinical indications of adequate ventilation.

v. Hypoventilation of patients who require high ventilatory pressures can occur.

vi. A few cases of upper airway swelling have been reported.

i. Equipment for the LMA

i. Comes in seven sizes based on patient’s weight

ii. Consists of a tube and an inflatable mask cuff

iii. Two vertical bars at tube opening prevent occlusion.

iv. Proximal end of the tube is fitted with a standard adapter.

(a) Compatible with any ventilation device

v. Cuff has a one-way valve assembly.

(a) Inflate with predetermined volume of air

vi. A 6.0-mm ET tube can be passed through a size 3 or 4 LMA.

vii. Fasttrach LMA guides an ET tube into the trachea

j. Insertion technique

i. Before insertion, check and prepare all equipment.

ii. To properly insert an LMA, refer to ***Skill Drill 15-26***.

2. King LT airway

a. Latex-free, single-use, single-lumen airway

b. Blindly inserted into the esophagus

c. Can be used to:

i. Provide positive-pressure ventilation to apneic patients

ii. Maintain a patent airway in spontaneously breathing patients who require advanced airway management

d. Adult and pediatric sizes

e. Curved tube with ventilation ports located between two inflatable cuffs

i. Distal cuff seals esophagus; proximal cuff seals oropharynx.

f. Can be inserted more easily and quickly than the Combitube

g. Two types: LT-D and LTS-D

i. King LT-D can be used in adults and children.

ii. King LTS-D is used only in adults.

h. Five sizes of each type, based on patient height and or weight

i. Each size has a different color of proximal connector and requires different cuff inflation pressures.

i. King LT-D and LTS-D share most of the same features.

i. Both have:

(a) Proximal pharyngeal cuff

(b) Distal cuff

(c) Several ventilation outlets

ii. In both, an ET tube introducer (a gum elastic bougie) can be inserted through the tube, where it exits between the pharyngeal and distal cuffs.

iii. Distal end: closed in LT-D; open in LTS-D

(a) Opening in LTS-D permits insertion of a suction catheter for gastric decompression.

j. Indications

i. Alternative to bag-mask ventilation for a failed intubation attempt

ii. Has the same advantages, disadvantages, complications, and special considerations as the Combitube

k. Contraindications

i. Does not eliminate the risk of vomiting and aspiration

ii. High airway pressures can cause air to leak into the stomach or out of the mouth.

iii. Should not be used in patients:

(a) With an intact gag reflex

(b) With known esophageal disease

(c) Who have ingested a caustic substance

iv. Proper placement is confirmed by:

(a) Observing chest rise

(b) Auscultating lungs and epigastrium

(c) Waveform capnography

l. Complications of the King LT airway

i. Laryngospasm, vomiting, and hypoventilation may occur.

ii. Trauma may result from improper insertion technique.

iii. Ventilation may be difficult if the pharyngeal balloon pushes the epiglottis over the glottic opening.

(a) If this occurs, gently withdraw the device until ventilation becomes easier.

m. Insertion technique

i. Patient’s height and weight determine size you should use.

ii. To properly insert a King LT airway, refer to ***Skill Drill 15-27***.

3. Cobra perilaryngeal airway (CobraPLA)

a. Named because of the “cobra” shape of the distal part of the airway

i. Allows device to slide easily along the hard palate and to hold the soft tissue of the airway away from the laryngeal inlet

b. Supraglottic device with a tube for ventilation and a circumferential cuff proximal to the distal end, which is the ventilation outlet

c. Has a standard adapter

d. Distal tip is proximal to the esophagus and seals the hypopharynx.

e. When cuff is inflated, it raises the tongue and creates an airway seal allowing for ventilation.

f. Available in eight sizes

g. Indications

i. Usage is similar to other supraglottic airway devices.

ii. Can be used in pediatric patients

iii. Does not protect against aspiration

h. Contraindications

i. Risk for aspiration and massive trauma to the oral cavity

i. Complications

i. Laryngospasm may occur with intact gag reflex.

ii. If not inserted far enough, inflation of the cuff may cause tongue to disrupt an adequate seal.

iii. Patient cannot be ventilated if the device is too small.

j. Insertion technique

i. Refer to ***Skill Drill 15-28***.

XX. Surgical and Nonsurgical Cricothyrotomy

**A. Two methods of securing a patent airway can be used when conventional techniques fail.**

1. Open (surgical) cricothyrotomy and translaryngeal catheter ventilation (nonsurgical or needle cricothyrotomy)

2. To perform them, you must be familiar with:

a. Key anatomic landmarks in the anterior aspect of the neck

b. Important blood vessels in this area

i. Superior cricothyroid vessels run at a transverse angle across the upper third of the cricothyroid membrane.

ii. External jugular veins run vertically and are located lateral to the cricothyroid membrane.

3. When performing cricothyrotomy, expect minor bleeding from subcutaneous and small skin vessels as you incise the cricothyroid membrane.

a. Should be easily controlled with light pressure after the tube has been inserted.

**B. Open cricothyrotomy**

1. Also called surgical cricothyrotomy

2. Involves:

a. Incising the cricothyroid membrane with a scalpel

b. Inserting an ET or tracheostomy tube directly into the subglottic area of the trachea

3. Cricothyroid membrane is the ideal site for a surgical opening into the trachea.

a. No important structures lie between the skin and the airway.

b. Airway at this level is relatively close to the skin

c. Posterior airway wall at this level is formed by tough cricoid cartilage

i. Helps prevent accidental perforation into the esophagus

4. Several types

a. Open (surgical) cricothyrotomy

i. Involves incising the skin and cricothyroid membrane and inserting an ET or tracheostomy tube

b. Modified cricothyrotomy

i. Many use a modification of the Seldinger technique to enable placement of the airway.

(a) Uses a needle and guide wire or guide catheter for tube placement in blood vessels or other hollow organs

c. Commercially manufactured airway placement devices use a device that functions as an introducer and an airway.

5. Indications and contraindications

a. Indicated when a patent airway cannot be secured with more conventional means

b. Situations that may preclude conventional airway management include:

i. Severe foreign body obstructions that cannot be extracted with Magill forceps and direct laryngoscopy

ii. Airway obstructions from swelling

iii. Massive maxillofacial trauma

iv. Inability to open the patient’s mouth

c. Main contraindication is the ability to secure a patent airway by less invasive means.

d. Other contraindications include:

i. Inability to identify the correct anatomic landmarks (cricothyroid membrane)

ii. Crushing injuries to the larynx and tracheal transection

iii. Underlying anatomic abnormalities

iv. Age younger than 8 years

(a) Larynx of a small child is generally unable to support a tube large enough to produce effective ventilation without causing damage to the larynx.

e. In situations in which cricothyrotomy is contraindicated, the patient must be rapidly transported to the closest appropriate facility.

6. Advantages and disadvantages

a. Can be performed quickly and without manipulating the cervical spine

b. Difficult to perform in children and patients with short, muscular, or fat necks

c. More difficult than needle cricothyrotomy

d. Inserting a large-bore tube permits greater tidal volume, which facilitates more effective oxygenation and ventilation.

7. Complications

a. Expect minor bleeding.

b. More severe bleeding is usually the result of laceration of the external jugular vein.

i. Incising cricothyroid membrane vertically minimizes this risk.

c. Inserting the tube gently minimizes risks of perforating the esophagus and damaging the laryngeal nerves.

d. Must be performed quickly

i. Taking too long will result in unnecessary hypoxia.

e. Tube misplacement should be suspected when subcutaneous emphysema is encountered after the procedure.

f. Maintain aseptic technique to the extent possible.

8. Equipment

a. If a commercial kit is not available, prepare the following equipment and supplies:

i. Scalpel

ii. ET or tracheostomy tube (6.0 mm minimum)

iii. Commercial device (or tape) for securing the tube

iv. Curved hemostats

v. Suction apparatus

vi. Sterile gauze pads for bleeding control

vii. Bag-mask device attached to 100% oxygen

9. Technique for performing open cricothyrotomy

a. Must proceed rapidly, yet cautiously

b. Identify the cricothyroid membrane by palpating for the “V” notch of the thyroid cartilage (high, sharp bump).

c. When you have located the “V” notch, slide your index finger down into the depression between the thyroid and cricoid cartilage (cricothyroid membrane).

d. Your partner should prepare equipment and ensure that the cardiac monitor and pulse oximeter are attached to the patient.

e. Maintain aseptic technique as you cleanse the area with iodine.

f. While stabilizing the larynx, make a 1- to 2-cm vertical incision over the cricothyroid membrane.

g. Insert the curved hemostats into the opening and spread it apart.

h. Gently insert a 6.0-mm cuffed ET tube or a 6.0 tracheostomy (Shiley) tube and direct it into the trachea.

i. Inflate the distal cuff with the appropriate volume of air.

j. Attach the bag-mask device to the standard adapter, and ventilate the patient while your partner auscultates.

i. If epigastric sounds are heard, you have likely inserted the tube into the esophagus.

ii. Additional confirmation of correct tube placement can be accomplished by attaching an ETco2 detector between the tube and bag-mask device.

k. After confirming proper tube placement, ensure that any minor bleeding has been controlled, properly secure the tube, and continue to ventilate at the appropriate rate.

l. To properly perform an open cricothyrotomy, refer to ***Skill Drill 15-29***.

**C. Needle cricothyrotomy**

1. A 14- to 16-gauge over-the-needle IV catheter is inserted through the cricothyroid membrane and into the trachea.

2. Adequate oxygenation and ventilation are achieved by attaching a high-pressure jet ventilator to the hub of the catheter.

a. Known as translaryngeal catheter ventilation

b. Commonly used as a temporary measure until a more definitive airway can be obtained

3. Indications and contraindications

a. Indications are essentially the same as for the open cricothyrotomy:

i. Inability to ventilate by less invasive techniques

ii. Massive maxillofacial trauma

iii. Inability to open patient’s mouth

iv. Uncontrolled oropharyngeal bleeding

b. Contraindicated with severe airway obstruction above the site of catheter insertion.

i. Exhalation is not as effective with a small-bore catheter as with a large-bore tube.

ii. Exhalation via the glottic opening is not possible.

iii. Hypercarbia and hypoxia may occur.

c. High-pressure ventilator would cause an increase in intrathoracic pressure, resulting in barotrauma and a potential pneumothorax.

d. Barotrauma can also be caused by overinflation of the lungs with the jet ventilator.

e. If the equipment necessary is not immediately available, perform an open cricothyrotomy.

4. Advantages and disadvantages

a. Needle cricothyrotomy is faster and easier to perform than open cricothyrotomy.

b. Lower risk of damaging adjacent structures because you are not incising it with a scalpel

c. Allows for subsequent intubation attempts because it uses a small-bore catheter

d. Does not require manipulation of the patient’s cervical spine

e. Using a smaller-bore tube does not provide protection from aspiration.

f. Technique requires a specialized, high-pressure jet ventilator.

5. Complications

a. Improper catheter placement can result in severe bleeding.

b. Excessive air leakage around the insertion site can cause subcutaneous emphysema.

c. If too much air infiltrates into the subcutaneous space, compression of the trachea and subsequent obstruction may occur.

d. Extreme care must be exercised when ventilating with a jet ventilator.

i. Release valve should be opened just long enough for adequate chest rise to occur.

ii. Overinflation of the lungs can result in barotrauma.

iii. Underinflation of the lungs can result in hypoventilation.

6. Equipment

a. Needed to perform needle cricothyrotomy and translaryngeal catheter ventilation:

i. Large-bore IV catheter (14-16 gauge)

ii. 10-mL syringe

iii. 3 mL of sterile water or saline

iv. Oxygen source (50 psi)

v. High-pressure jet ventilator device and oxygen tubing

7. Technique for performing needle cricothyrotomy

a. Draw up approximately 3 mL of sterile water or saline into a 10-mL syringe and attach the syringe to the IV catheter.

b. Place the head in a neutral position, and locate the cricothyroid membrane.

c. If time permits, cleanse the area with an iodine-containing solution.

d. Stabilize the larynx, and insert the needle into the midline of the cricothyroid membrane at a 45° angle toward the feet.

e. After a pop is felt, insert the needle approximately 1 cm farther, and then aspirate with the syringe.

i. If the catheter has been correctly placed, you should be able to easily aspirate air and see the saline or water bubbling.

ii. If blood is aspirated or if you meet resistance, you should reevaluate catheter placement.

f. Advance the catheter over the needle until the catheter hub is flush with the skin, then withdraw the needle and place it in a puncture-proof biohazard container.

g. Attach one end of the oxygen tubing to the catheter and the other to the jet ventilator.

h. Begin ventilations by opening the release valve and observing for adequate chest rise.

i. Auscultation of breath and epigastric sounds will further confirm placement.

i. Turn the release valve off as soon as you see the chest rise.

j. Exhalation will occur passively via the glottis.

k. Ventilate as dictated by clinical condition.

l. Secure the catheter by placing a folded 4" × 4" gauze pad under the catheter and taping it in place.

m. Continue ventilations while frequently reassessing the patient.

n. To properly perform needle cricothyrotomy and translaryngeal catheter ventilation, refer to ***Skill Drill 15-30***.

XXI. Summary

**A. The upper airway consists of all structures above the vocal cords—larynx, oropharynx, nasopharynx, tongue. Its functions include warming, filtering, and humidifying inhaled air.**

**B. The lower airway consists of all structures below the vocal cords—trachea, mainstem bronchi, bronchioles, pulmonary capillaries, and alveoli. Pulmonary gas exchange takes place at the alveolar level in the lungs.**

**C. The diaphragm is the major muscle of breathing, innervated by the phrenic nerves. The intercostal muscles, between the ribs, are innervated by the intercostal nerves. Accessory muscles (used during respiratory distress) include the sternocleidomastoid muscles of the neck.**

**D. The respiratory and cardiovascular systems ensure that oxygen and nutrients are constantly delivered to every cell and that carbon dioxide and other waste products are removed.**

**E. Ventilation, oxygenation, and respiration are crucial for tissues to receive nutrients.**

**F. Ventilation is the act of moving air into and out of the lungs and requires proper functioning of the diaphragm and intercostal muscles. Diffusion allows oxygen to transfer from the air into the capillaries.**

**G. Changes in oxygen demand are regulated primarily by the pH of the cerebrospinal fluid (CSF), which is directly related to the amount of carbon dioxide dissolved in the plasma portion of the blood (Paco2). The medullary respiratory centers in the brainstem control the rate, depth, and rhythm of breathing. Chemoreceptors monitor the chemical composition of the blood and provide feedback to the respiratory centers.**

**H. Negative-pressure ventilation is the drawing of air into the lungs due to changes in intrathoracic pressure. Positive-pressure ventilation is the forcing of air into the lungs and is provided to patients who are not breathing (apneic) or are breathing inadequately.**

**I. Oxygenation is the process of loading oxygen molecules onto hemoglobin in the bloodstream. Oxygenation may not occur if the environment is depleted of oxygen or if the environment contains carbon monoxide.**

**J. Respiration is the exchange of oxygen and carbon dioxide in the alveoli and tissues. Cells normally perform aerobic respiration, converting glucose into energy. Without oxygen, cells perform anaerobic metabolism, which cannot meet the cell’s metabolic demands and will lead to cell death.**

**K. The primary breathing stimulus in a healthy person is based on increasing arterial carbon dioxide levels. The hypoxic drive—a backup system to breathe—is based on decreasing arterial oxygen levels.**

**L. Many conditions can inhibit the body’s ability to deliver oxygen to cells. With ventilation/perfusion ratio mismatch, ventilation may be compromised but perfusion continues, leading to a lack of oxygen diffusing into the bloodstream, which can lead to severe hypoxemia.**

**M. Other factors that impede oxygen delivery include airway swelling and obstruction, medications that depress the central nervous system, neuromuscular disorders, respiratory and cardiac diseases, hypoglycemia, circulatory compromise, submersion, and trauma to the head, neck, spine, or chest.**

**N. Hypoventilation, hyperventilation, and hypoxia can disrupt the acid-base balance, which may lead to rapid deterioration and death. The fastest way to eliminate excess acid is to expel it as carbon dioxide from the lungs. Slowing respirations increase the level of carbon dioxide and thus acid. Respiratory acidosis and respiratory alkalosis can result from a number of conditions and can be life threatening.**

**O. Adequate adult breathing features a respiratory rate between 12 and 20 breaths/min, adequate depth (tidal volume), a regular pattern of inhalation and exhalation, symmetric chest rise, and bilaterally clear and equal breath sounds.**

**P. Inadequate breathing features a rate that is too slow (< 12 breaths/min) or too fast (> 20 breaths/min), shallow depth of breathing (reduced tidal volume), irregular inhalation and exhalation, asymmetric chest movement, adventitious airway sounds, cyanosis, and altered mental status.**

**Q. Abnormal breathing patterns include Cheyne-Stokes respirations, Kussmaul respirations, Biot (ataxic) respirations, apneustic respirations, and agonal gasps.**

**R. While assessing breathing, auscultate breath sounds with a stethoscope. Breath sounds represent airflow into the alveoli. They should be clear and equal on both sides of the chest (bilaterally), anteriorly, and posteriorly. Abnormal breath sounds include wheezing, rhonchi, crackles, stridor, and pleural friction rub.**

**S. The pulse oximeter measures the percentage of blood oxygen saturation (Spo2). The measurement depends on adequate perfusion to the capillary beds and can be inaccurate when the patient is cold, is in shock, or has been exposed to carbon monoxide.**

**T. Peak expiratory flow assesses bronchoconstriction and is used to gauge the effectiveness of treatment, such as inhaled beta-2 agonists.**

**U. End-tidal CO2 (ETco2) monitors detect carbon dioxide in exhaled air and help determine ventilation adequacy. They can be used with a spontaneously breathing patient or when an advanced airway has been inserted. Quantitative waveform capnography is the most accurate method for monitoring ETco2.**

**V. Patients with inadequate breathing require positive-pressure ventilation; patients with adequate breathing who are suspected of being hypoxemic require 100% supplemental oxygen via a nonrebreathing mask. Never withhold oxygen from any patient suspected of being hypoxemic.**

**W. Unrecognized inadequate breathing will lead to hypoxia, a dangerous condition in which cells and tissues do not receive adequate oxygen.**

**X. The airway must remain patent at all times. First, position the patient in the recovery (left lateral recumbent) position, the preferred position for unresponsive patients without traumatic injuries who are breathing adequately.**

**Y. Properly position the head. Manual airway maneuvers include the head tilt-chin lift, jaw-thrust (with and without head tilt), and tongue-jaw lift.**

**Z. Clearing the airway means removing obstructing material; maintaining the airway means keeping it open, manually or with adjunctive devices.**

**AA. Oropharyngeal suctioning may be required after opening an airway. Rigid (tonsil-tip) catheters are preferred when suctioning the pharynx. Soft, plastic (whistle-tip) catheters are used to suction the nose and can be passed down an endotracheal tube to suction pulmonary secretions.**

**BB. Limit oropharyngeal suction to 15 seconds in an adult, 10 seconds in a child, and 5 seconds in an infant.**

**CC. Airway obstruction can be caused by choking on food (or, in children, on toys), epiglottitis, inhalation injuries, airway trauma with swelling, and anaphylaxis. It is critical to differentiate between a mild (partial) airway obstruction and a severe (complete) airway obstruction.**

**DD. Chest compressions, finger sweeps (only if the object can be seen and easily retrieved), manual removal of the object, and attempts to ventilate is the recommended sequence in attempting to remove a foreign body airway obstruction in an unresponsive adult. Perform abdominal thrusts continuously in a responsive adult or child with an airway obstruction until the obstruction is relieved or he or she becomes unresponsive.**

**EE. Basic airway adjuncts include the oropharyngeal (oral) airway and the nasopharyngeal (nasal) airway. The oral airway keeps the tongue off of the posterior pharynx; it is used only in unresponsive patients without a gag reflex. The nasal airway is better tolerated in patients with altered mental status who have an intact gag reflex.**

**FF. Administer supplemental oxygen to any patient with potential hypoxia, regardless of clinical appearance. Be familiar with oxygen cylinder sizes and their duration of flow, and always use safety precautions with oxygen.**

**GG. The nonrebreathing mask is the preferred device for providing oxygen to adequately breathing patients in the prehospital setting; with a flow rate of 15 L/min, it can deliver up to 90% oxygen. Use the nasal cannula if the patient cannot tolerate the nonrebreathing mask; it can deliver oxygen concentrations of 24% to 44% when the flowmeter is set at 1 to 6 L/min. Other oxygen-delivery devices include the partial rebreathing mask and Venturi mask.**

**HH. The methods of providing artificial ventilation—in order of preference—include the two-person bag-mask technique, mouth-to-mask with one-way valve and supplemental oxygen attached, manually triggered ventilation device, and the one-person bag-mask technique. Use extreme caution with the manually triggered ventilation, and never use it with children or thoracic injuries.**

**II. Continuous positive airway pressure (CPAP) improves breathing by forcing fluid from the alveoli (in pulmonary edema) or dilating the bronchioles (in obstructive lung diseases and asthma). It involves the patient breathing against a certain amount of positive pressure during exhalation. CPAP also reduces the need for intubation.**

**JJ. Remove loose dental appliances before artificial ventilation to prevent them from obstructing the airway; leave tight-fitting ones in place.**

**KK. Remove dental appliances before intubation; removing them afterwards may result in inadvertent extubation.**

**LL. Patients with massive maxillofacial trauma are at high risk for airway compromise due to oral bleeding. Assist ventilations, and provide oral suctioning, as needed.**

**MM. Ventilating too forcefully or too fast can cause gastric distention, which can cause regurgitation and aspiration. Administering ventilations over 1 second—just enough to produce visible chest rise—reduces the incidence of gastric distention and the risks of regurgitation and aspiration.**

**NN. Invasive gastric decompression involves the insertion of a gastric tube into the stomach: either a nasogastric tube via the nose or an orogastric tube via the mouth.**

**OO. Patients with a tracheal stoma or tracheostomy tube may require ventilation, suctioning, or tube replacement. Ventilation through a tracheostomy tube involves attaching the bag-mask device to the tube’s 15/22-mm adapter; ventilation with a stoma and no tracheostomy tube can be performed with a pocket mask or bag-mask device. Use pediatric-size masks when ventilating through a stoma.**

**PP. Patients who are unresponsive or cannot maintain their own airway are candidates for endotracheal (ET) intubation, the insertion of an ET tube into the trachea. In orotracheal intubation, the ET tube is inserted into the trachea via the mouth; in nasotracheal intubation (a blind technique), the ET tube is inserted into the trachea via the nose. Other methods of ET intubation include digital (or tactile) intubation, retrograde intubation, face-to-face intubation, and intubation with the use of a lighted stylet (transillumination).**

**QQ. You must confirm and monitor ET tube placement in intubation. Continuous waveform capnography, in addition to a clinical assessment (such as auscultation of breath sounds and over the epigastrium and assessing for visible chest rise), is the most reliable method.**

**RR. If an attempted intubation does not result in acceptable oxygen saturations, perform simple BLS maneuvers with an oral airway and/or nasal airway and a bag-mask device, and consider using another airway device.**

**SS. Tracheobronchial suctioning is indicated if an intubated patient’s condition deteriorates because of pulmonary secretions in the ET tube.**

**TT. Do not extubate in the prehospital setting unless the patient is unreasonably intolerant of the tube. It is generally best to sedate an intubated patient who is becoming intolerant of the ET tube.**

**UU. Pediatric ET intubation involves the same technique as for adult patients, but with smaller equipment.**

**VV. Rapid-sequence intubation (RSI) involves using pharmacologic agents to sedate and paralyze a patient to facilitate placement of an ET tube. It should be considered when a responsive or combative patient requires intubation but cannot tolerate laryngoscopy.**

**WW. Drugs used for RSI include sedatives and neuromuscular blocking agents (paralytics) to induce complete paralysis. Paralytics are classified as depolarizing and nondepolarizing.**

**XX. Alternative airway devices (may be used if ET intubation is not possible or is unsuccessful) include the Combitube, laryngeal mask airway, King LT airway, and Cobra perilaryngeal airway.**

**YY. Open (surgical) cricothyrotomy involves incising the cricothyroid membrane, inserting a tracheostomy tube or ET tube into the trachea, and ventilating with a bag-mask device. Needle cricothyrotomy involves inserting a 14- to 16-gauge over-the-needle catheter through the cricothyroid membrane and ventilating with a high-pressure jet ventilation device.**

Post-Lecture

This section contains various student-centered end-of-chapter activities designed as enhancements to the instructor’s presentation. As time permits, these activities may be presented in class. They are also designed to be used as homework activities.

***Assessment in Action***

This activity is designed to assist the student in gaining a further understanding of issues surrounding the provision of prehospital care. The activity incorporates both critical thinking and application of paramedic knowledge.

**Instructor Directions**

**1.** Direct students to read the “Assessment in Action” scenario located in the Prep Kit at the end of Chapter 15.

**2.** Direct students to read and individually answer the quiz questions at the end of the scenario. Allow approximately 10 minutes for this part of the activity. Facilitate a class review and dialogue of the answers, allowing students to correct responses as may be needed. Use the quiz question answers noted below to assist in building this review. Allow approximately 10 minutes for this part of the activity.

**3.** You may wish to ask students to complete the activity on their own and turn in their answers on a separate piece of paper.

**Answers to Assessment in Action Questions**

**1.** **Answer:** A. Increased surfactant

**Rationale:** The process of pulmonary respiration occurs when oxygen and carbon dioxide diffuse across the alveolar membrane. Anything that interferes with the ability of these gases to cross the alveolar membrane will impair pulmonary respiration. Surfactant is a proteinaceous substance that lines the alveoli, thus reducing alveolar surface tension and allowing the alveoli to expand. Therefore, surfactant facilitates the process of diffusion, and thus, pulmonary respiration. Widespread atelectasis (alveolar collapse) would impair pulmonary respiration because collapsed alveoli are incapable of exchanging gases. Fluid in the alveoli, such as with pulmonary edema, would also impair pulmonary respiration because it would create a physical barrier to diffusion. A deficiency of surfactant, which would result in an increase in alveolar surface tension, would impair pulmonary respiration because the alveoli would be less able to expand.

**2.** **Answer:** D. Decreased tidal volume and decreased minute volume

**Rationale:** Minute volume (VM) is affected by tidal volume (VT), respiratory rate, or both. If a person’s VT decreased, the respiratory rate would have to increase to maintain adequate VM. Conversely, if the respiratory rate decreased, VT would have to increase to maintain adequate VM. However, when an adult’s respiratory rate becomes extremely fast, VT decreases significantly because most of the inhaled air only makes it to the level of the dead space before it is promptly exhaled. As a result, VM would decrease.

**3.** **Answer:** B. is defined as a deficiency of oxygen at the cellular level.

**Rationale:** Hypoxia is a dangerous condition in which there is a deficiency of oxygen at the cellular level. It requires aggressive oxygenation and, in some cases, ventilatory support. Hypoxemia, a precursor to hypoxia, is defined as a low level of oxygen in arterial blood; it occurs any time there is not enough oxygen to bind to the hemoglobin molecules and is easily treated with supplemental oxygen. Pulse oximetry measures the percentage of hemoglobin that is saturated with oxygen (SpO2); however, a number of factors can produce a false SpO2 reading, such as carbon monoxide poisoning. Therefore, you should not rely on pulse oximetry to rule out hypoxemia. Anoxia is defined as the absence of oxygen to the brain and other vital organs of the body.

**4.** **Answer:** D. mucus or fluid in the smaller lower airways.

**Rationale:** Crackles (formerly known as rales) occur when airflow causes mucus or fluid in the airways to move in the smaller lower airways. They may also be heard when collapsed airways or alveoli pop open. Crackles are often an early indicator of pulmonary edema. Widespread alveolar collapse (atelectasis) would result in bilaterally diminished breath sounds. Air moving through narrowed (constricted) air passages makes a whistling sound called wheezing, which may be heard on exhalation, inhalation, or both. Rhonchi are low-pitched sounds that indicate mucus or fluid accumulation in the larger lower airways; rhonchi are common in patients with severe pulmonary edema or bronchitis.

**5.** **Answer:** C. force fluid from the alveoli.

**Rationale:** CPAP is a noninvasive form of positive pressure ventilation used to treat patients who are in respiratory distress because of pulmonary edema, obstructive lung disease, and asthma. CPAP uses positive end-expiratory pressure (PEEP) to force fluid from the alveoli and open constricted bronchioles. Therefore, patients benefit from CPAP when they breathe against positive pressure, which transmits pressure back to the lungs. CPAP does not increase tidal volume; in fact, it should not be used in patients with reduced tidal volume. Unlike negative pressure ventilation (the drawing of air into the lungs; occurs with normal breathing), which facilitates venous return to the heart (preload), any form of positive pressure ventilation (forcing of air into the lungs) impedes preload, which may cause a decrease in cardiac output. Therefore, you must use caution when administering any form of positive pressure ventilation and closely monitor the patient’s blood pressure and other hemodynamic parameters. Obviously, CPAP would be of no benefit to an apneic patient; ventilation with a bag-mask device or pocket mask is indicated for apneic patients.

**6.** **Answer:** C. Posterior pharynx is partially exposed

**Rationale:** The Mallampati classification can be used to predict the relative difficulty of intubation. This classification notes the oropharyngeal structures visible in an upright, seated patient who is fully able to open his or her mouth. A Mallampati class 1 is assigned if the entire posterior pharynx is fully visible. A Mallampati class 2 is assigned if the posterior pharynx is partially visible. A Mallampati class 3 is assigned if the posterior pharynx cannot be seen, but the base of the uvula is exposed. A Mallampati class 4 is assigned if no posterior pharyngeal structures can be seen.

**7.** **Answer:** A. rocuronium bromide.

**Rationale:** All of the medications listed in this question can be used during rapid-sequence intubation (RSI), also called pharmacologically assisted intubation. However, only neuromuscular blocking agents (such as rocuronium bromide [Zemuron], vecuronium bromide [Norcuron], and pancuronium bromide [Pavulon]) are specifically used to induce paralysis, facilitating placement of an endotracheal tube. While midazolam hydrochloride (Versed) is a commonly used sedative that is given before a neuromuscular blocking agent, it is also used as a sedative before synchronized cardioversion and as an antiseizure medication. Atropine sulfate may be given to children before intubation or to any patient before administering succinylcholine (Anectine); however, it is also used to treat unstable bradycardia and organophosphate poisoning. Lidocaine hydrochloride may be given to patients with a head injury before administering a neuromuscular blocking agent; however, it is also used to treat ventricular dysrhythmias.

**8.** **Answer:** B. have ingested a caustic substance.

**Rationale:** Any airway device that is designed to enter the esophagus, such as the Combitube and King LT airway, is contraindicated in patients with known esophageal disease and in patients who have ingested a caustic (corrosive) substance. Esophageal airways are not intended to provide long-term ventilatory support, and they are not considered definitive airways. Patients who require definitive airway management or long-term ventilatory support should be endotracheally intubated. Provided that an esophageal airway enables adequate ventilation of the patient, it should not be removed in the prehospital setting, although it is usually replaced with an endotracheal tube at the hospital—especially if the patient is in need of prolonged ventilatory support.

**Additional Questions**

**9. Rationale:** It is clear that, despite your efforts to provide 100% oxygen to this patient, she will not tolerate a mask of any type placed on her face. This resistance is common in patients with severe hypoxemia; they feel as though they are being smothered and will fight all of your attempts to administer oxygen. CPAP would be the ideal treatment for her because she is clearly experiencing acute pulmonary edema. However, her inability to tolerate a mask on her face makes this option impossible. Her clinical status continues to decline, and you are still 25 miles away from the closest appropriate medical facility. Immediate, aggressive action must be taken if you are to prevent respiratory arrest, which may lead to cardiopulmonary arrest. In this situation, you should take definitive control over her airway and ventilations; she needs to be sedated, chemically paralyzed, and endotracheally intubated. Rapid-sequence intubation (RSI), also referred to as pharmacologically assisted intubation, is indicated for patients who require aggressive airway management but are too conscious or too combative to be intubated. RSI involves preoxygenating the patient to the best of your ability and then administering—in sequence—a sedative/hypnotic drug, followed by a neuromuscular blocking agent (paralytic). Although this drug will effectively paralyze the patient and induce apnea, it will enable you to intubate the trachea, thus protecting the airway, and facilitate adequate ventilation and oxygenation. The decision to perform such an aggressive intervention should not be taken lightly; however, in this patient, it is your only viable option. If adequate ventilation and oxygenation are not restored, she will no doubt “crash.” Follow your local protocols regarding which induction agents and neuromuscular blocking agents you would use to perform RSI.

**10. Rationale:** Quantitative waveform capnography not only provides real-time, objective data regarding proper advanced airway placement, but also serves as an indicator of perfusion. An abrupt increase in ETco2 during CPR suggests that return of spontaneous circulation (ROSC) has occurred; therefore, you should assess for a carotid pulse. If perfusion is spontaneous, more carbon dioxide will be made and eliminated as the process of cellular anaerobic metabolism is reversed. As cardiac arrest persists, however, you should expect to see a steady decrease in the patient’s ETco2 reading because lesser amounts of carbon dioxide are being made and returned to the lungs due to ongoing anaerobic cellular metabolism, which produces lactic acid, not carbon dioxide.

**11. Rationale:** Respiration is defined as the exchange of gases between the body and its environment. External (pulmonary) respiration is the exchange of oxygen and carbon dioxide in the lungs; it occurs when inhaled oxygen diffuses across the pulmonary capillary membrane and into the alveoli. Oxygen is then released into the circulatory system from the alveoli and returned to the left side of the heart. At the same time, carbon dioxide, which also diffuses across the pulmonary capillary membrane and into the alveoli, is eliminated from the body during exhalation. Internal (cellular) respiration is the exchange of oxygen and carbon dioxide at the tissue and cell level, and occurs when oxygen is delivered to the cells—again, by the process of diffusion—and carbon dioxide is released by the cells and returned to the right side of the heart via the circulatory system.

**12. Rationale:** Negative pressure ventilation is the process of normal breathing. It occurs when the diaphragm and intercostal muscles contract, which increases the size of the thoracic cavity. As a result, pressure in the thorax falls below that of the external atmosphere and air is drawn into the lungs. Negative pressure in the thoracic cavity facilitates venous return to the heart (preload), which maintains cardiac output. Positive-pressure ventilation, which involves the forcing of air into the lungs (as with a bag-mask device), causes pressure in the thoracic cavity to increase. Increased pressure in the thorax impairs preload and, as a result, can cause a decrease in cardiac output and result in hypotension. To minimize this risk, the paramedic should use caution when providing positive pressure ventilation; deliver each breath over a period of 1 second—just enough to produce visible chest rise.

***Assignments***

**A. Review all materials from this lesson and be prepared for a lesson quiz to be administered (date to be determined by instructor).**

**B. Read Chapter 16, *Respiratory Emergencies*, for the next class session.**

***Unit Assessment Keyed for Instructors***

1. Is the diaphragm a voluntary or involuntary muscle?

**Answer:** The diaphragm is a specialized skeletal muscle. Innervated by the phrenic nerve, the diaphragm functions as a voluntary and an involuntary muscle. It acts as a voluntary muscle when a person takes a deep breath, coughs, or holds his or her breath—all actions that are under voluntary (somatic) control. However, unlike other skeletal muscles, the diaphragm functions as an involuntary muscle whenever voluntary function ceases, such as when coughing stops and during sleep. Voluntary use of the diaphragm cannot continue indefinitely. When the concentration of carbon dioxide rises in the blood, the autonomic regulation of breathing resumes under control of the brainstem.

p 717

2. What is negative pressure ventilation, and when does it occur?

**Answer:** The air pressure outside the body—called the atmospheric pressure—is normally higher than the air pressure within the thorax. During inhalation, the thoracic cage expands and the air pressure within the thorax decreases, creating a slight vacuum. This vacuum pulls air in through the trachea, causing the lungs to fill—a process called negative-pressure ventilation. When the air pressure inside the thorax equals the air pressure outside the body, air stops moving. Gases, such as oxygen and carbon dioxide, move from an area of higher pressure to an area of lower pressure (diffusion) until the pressures are equal. At this point, the air stops moving and inhalation stops.

p 719

3. Describe the primary and secondary nervous system control of breathing.

**Answer:** Neural (nervous system) control of breathing, which is an involuntary function, originates in the brainstem—specifically, in the medulla oblongata and the pons. The medulla is the primary involuntary (autonomic) respiratory center. It is connected to the respiratory muscles by the vagus nerve. The medullary respiratory centers control the rate, depth, and rhythm (regularity) of breathing in a negative feedback interaction with the pons. The apneustic center of the pons is the secondary control center if the medulla fails to initiate breathing. The apneustic center influences the respiratory rate by increasing the number of inspirations per minute. This increase is balanced by the pneumotaxic center, which has an inhibitory response on inspiration. The respiratory rate, therefore, results from the interaction between these two centers.

p 720

4. What is the functon of chemoreceptors in respiration?

**Answer:** Chemoreceptors that constantly monitor the chemical composition of body fluids are located throughout the body to provide feedback on many metabolic processes. Three sets of chemoreceptors affect respiratory function: those located in the carotid bodies, those in the aortic arch, and the central chemoreceptors. The chemoreceptors that measure the amount of carbon dioxide in arterial blood are located in the carotid bodies and the aortic arch. These receptors sense tiny changes in the carbon dioxide level and send signals to the respiratory center via the glossopharyngeal nerve (9th cranial nerve) and the vagus nerve (10th cranial nerve).

p 721

5. What is hypoxia, and what are its signs and symptoms?

**Answer:** Failure to meet the body’s needs for oxygen may result in hypoxia. Hypoxia is a dangerous condition in which the tissues and cells do not receive enough oxygen. If hypoxia is uncorrected, death may occur quickly. Patients who are breathing inadequately will show varying signs and symptoms of hypoxia. The onset and degree of tissue damage caused by hypoxia often depend on the quality of ventilations. Early signs of hypoxia include restlessness, irritability, apprehension, tachycardia, and anxiety. Late signs of hypoxia include mental status changes, a weak (thready) pulse, and cyanosis. Responsive patients often report a feeling of shortness of breath (dyspnea ) and may not be able to speak in complete sentences. The best time to give a patient oxygen is before the signs and symptoms of hypoxia appear.

p 725

6. How does V/Q mismatch occur?

**Answer:** The lungs have a functional role in placing ambient (room) air in proximity to circulating blood to permit gas exchange by simple diffusion. To accomplish this, air and blood flow must be directed to the same place at the same time. In other words, ventilation and perfusion must be matched. A failure to match ventilation and perfusion, or V/Q mismatch, lies behind most abnormalities in oxygen and carbon dioxide exchange. When ventilation is compromised but perfusion continues, blood passes over some alveolar membranes without gas exchange taking place; therefore, not all alveoli are enriched with oxygen. Similar problems can occur when perfusion across the alveolar membrane is disrupted. Even though the alveoli are filled with fresh oxygen, disruption in blood flow does not allow for optimal exchange of gases across the membrane. The result of inadequate perfusion is less oxygen absorption in the bloodstream and less carbon dioxide removal.

p 726

7. What are the four clinical presentations of acid-base balance?

**Answer:** There are four main clinical presentations of acid-base disorders:

Respiratory acidosis

Respiratory alkalosis

Metabolic acidosis

Metabolic alkalosis

Fluctuations in pH due to the available bicarbonate in the body result in metabolic acidosis or alkalosis, whereas fluctuations in pH due to respiratory disorders result in respiratory acidosis or alkalosis.

p 729

8. What is the leading cause of death and disability in children and early adults?

**Answer:** Traumatic injuries

p 783

9. Compare hypoxemia and hypoxia.

**Answer:** Hypoxemia is defined as a low level of oxygen in arterial blood. Hypoxia, is a deficiency of oxygen at the tissue and cellular levels. Although these terms are often used interchangeably, they are different processes. Hypoxemia can be reversed by administering supplemental oxygen, whereas hypoxia requires more aggressive oxygenation and, in some cases, ventilatory support.

p 729

10. Discuss adventitious breath sounds.

**Answer:** Adventitious (abnormal) breath sounds are usually classified as continuous or discontinuous. Wheezing is a continuous sound as air flows through a constricted lower airway, as with asthma. Wheezing is a high-pitched sound that may be heard on inspiration, expiration, or both. Rhonchi are also continuous sounds, although they are low-pitched; they indicate mucus or fluid in the larger lower airways (as in pulmonary edema and bronchitis). Crackles (formerly known as rales) occur when airflow causes mucus or fluid in the airways to move in the smaller lower airways. The crackles tend to clear with coughing. Stridor results from foreign body aspiration, infection, swelling, disease, or trauma within or immediately above the glottic opening. Stridor produces a loud, high-pitched sound that is typically heard during the inspiration phase.

p 732

11. What are the normal arterial blood gas values?

**Answer:** Analysis of ABGs provides the most comprehensive quantitative information about the respiratory system. In this procedure, blood is obtained from a superficial artery, such as the radial or femoral artery. The blood is then analyzed for pH, Paco2 , Pao2 , Hco3− (concentration of bicarbonate ions), base excess (indicating acidosis or alkalosis), and Sao2 . Normal values are:

pH 7.35 to 7.45

Pao2 80 to 100 mm Hg

Paco2 35 to 45 mm Hg

Hco3− 22 to 26 mEq/L

Base (excess or deficit) ±2 to ±3 mEq/L

Sao2 > 95%

p 736

12. What are the three types of ETco2 monitors?

**Answer:** The ETco2 detectors may be digital, waveform, digital/ waveform, or colorimetric. A capnometer provides quantitative information, in real time, by displaying a numeric reading of exhaled carbon dioxide. It uses a special adapter, which attaches between the advanced airway device and bag-mask device. Tubing from the adapter then connects to a capnometry machine. Waveform capnography provides quantitative, real-time information regarding the patient’s exhaled carbon dioxide level. Unlike capnometry, however, waveform capnography displays a graphic waveform on the portable cardiac monitor/defibrillator. A colorimetric capnographer provides qualitative (that is, it does not assign a numeric value) information regarding the presence of carbon dioxide in the patient’s exhaled breath. The device is attached between the advanced airway and bag-mask device. After 6 to 8 positive-pressure breaths—the amount of time it takes for carbon dioxide to accumulate in the device— the specially treated paper inside the detector should turn from purple to yellow during exhalation, indicating the presence of exhaled carbon dioxide

p 735-736

13. Describe the process of assisting a patient’s ventilations.

**Answer:** Follow these steps to assist a patient’s ventilations using a bag-mask device. Remember to follow standard precautions as needed when managing the patient’s airway.

1. Explain the procedure to the patient.

2. Place the mask over the patient’s nose and mouth.

3. Squeeze the bag each time the patient inhales, maintaining the same rate as the patient, coaching the patient as needed.

4. After the initial 5 to 10 breaths, slowly adjust the rate and deliver the appropriate tidal volume.

5. Adjust the rate and tidal volume to maintain adequate minute volume.

p 757

14. What are the contraindications to using CPAP?

**Answer:** Continuous positive airway pressure has proven to be immensely beneficial to patients experiencing respiratory distress from acute pulmonary edema, acute bronchospasm, and obstructive lung disease; however, there are times when CPAP is not appropriate.

The following are general contraindications for CPAP use:

Respiratory arrest

Hypoventilation (slow respiratory rate and/or reduced tidal volume)

Signs and symptoms of a pneumothorax or chest trauma

Tracheostomy

Active gastrointestinal bleeding or vomiting

Patient unable to follow verbal commands

Inability to properly fit the CPAP system mask and strap

Excessive facial hair or dysmorphic facial features can impede your ability to ensure a proper-fitting mask

Inability to tolerate the mask

In addition, you should always reassess the patient for signs of clinical deterioration and/or respiratory failure. Although CPAP is an excellent tool to assist with ventilation, not all patients will experience improvement in their condition with this device. Once signs of respiratory failure become apparent or the patient is no longer able to follow commands, CPAP should be removed, and positive-pressure ventilation with a bag-mask device attached to high-flow oxygen should be initiated. In some cases, intubation will be required.

p 763-764

15. How does gastric distention occur, and how can it be relieved in the field?

**Answer:** Any form of artificial ventilation that blows air into the patient’s mouth—as opposed to blowing air directly into the trachea via an ET tube—may lead to inflation of the patient’s stomach with air. Gastric distention —inflation of the patient’s stomach with air—is especially likely to occur when excessive pressure is used to inflate the lungs, when ventilations are performed too fast or too forcefully, or when the airway is partially obstructed during ventilation attempts. The pressure in the airway forces open the esophagus, and air flows into the stomach. Gastric distention occurs most often in children but is common in adults as well. Invasive gastric decompression involves inserting a gastric tube into the stomach and removing the contents with suction. The gastric tube is an effective tool for removing air and liquid from the stomach because removal of the stomach contents decreases the pressure on the diaphragm and virtually eliminates the risks of regurgitation and aspiration.

p 765-766

16. What is the Mallampati classification?

**Answer:** An anesthesiologist, Mallampati, developed the Mallampati classification to predict the relative difficulty of intubation. This classification notes the oropharyngeal structures visible in an upright, seated patient who is fully able to open his or her mouth. Although this is an accurate predictor of intubation difficulty, it is of limited value in unresponsive patients and in patients who cannot follow commands. If a patient is cooperative and able to comply with this evaluation, emergency prehospital intubation is probably not indicated. However, the evaluation is important because it can provide useful information should intubation become necessary.

p 775-776

17. What are some of the anatomic clues that can be used to determine ETT size?

**Answer:** A number of anatomic clues can help determine the proper size of ET tube for adults and children. The internal diameter of the nostril is a good approximation of the diameter of the glottic opening. The diameter of the little finger or the size of the thumbnail is also a good approximation of airway size.

p 777

18. What are the indications for nasotracheal intubation?

**Answer:** Nasotracheal intubation is indicated for patients who are breathing spontaneously but require definitive airway management to prevent further deterioration of their condition. Responsive patients and patients with an altered mental status and an intact gag reflex who are in respiratory failure because of conditions such as COPD, asthma, or pulmonary edema are excellent candidates for nasotracheal intubation.

p 786

19. Why should tracheobronchial suctioning be avoided?

**Answer:** Tracheobronchial suctioning involves passing a suction catheter into the ET tube to remove pulmonary secretions. The first rule to remember about performing tracheobronchial suctioning is this: Do not do it if you do not have to! This kind of suctioning requires strict attention to sterile technique, which is nearly impossible to maintain in the prehospital environment. Suctioning the trachea can also cause cardiac dysrhythmias; cardiac arrest has been reported during tracheobronchial suctioning. For these reasons, you should avoid suctioning through an ET tube unless secretions are so massive that they interfere with ventilation. If tracheobronchial suctioning must be performed, use sterile technique (if possible), and monitor the patient’s cardiac rhythm and oxygen saturation during the procedure.

p 803

***Unit Assessment***

1. Is the diaphragm a voluntary or involuntary muscle?

2. What is negative pressure ventilation, and when does it occur?

3. Describe the primary and secondary nervous system control of breathing.

4. What is the functon of chemoreceptors in respiration?

5. What is hypoxia, and what are its signs and symptoms?

6. How does V/Q mismatch occur?

7. What are the four clinical presentations of acid-base balance?

8. What is the leading cause of death and disability in children and early adults?

9. Compare hypoxemia and hypoxia.

10. Discuss adventitious breath sounds.

11. What are the normal arterial blood gas values?

12. What are the three types of ETco2 monitors?

13. Describe the process of assisting a patient’s ventilations.

14. What are the contraindications to using CPAP?

15. How does gastric distention occur, and how can it be relieved in the field?

16. What is the Mallampati classification?

17. What are some of the anatomic clues that can be used to determine ETT size ?

18. What are the indications for nasotracheal intubation?

19. Why should tracheobronchial suctioning be avoided?