Chapter

16 AIRWAY MANAGEMENT

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ANATOMY AND PHYSIOLOGY OF THE UPPER AIRWAY

1. How does resistance to airflow through the nasal passages compare to that through the mouth?
2. What nerves provide sensory innervation to the nasal cavity?
3. What nerves provide sensory innervation to the hard and soft palate?
4. What nerve provides sensory innervation to the anterior two thirds of the tongue?
5. What nerve innervates the posterior third of the tongue, the soft palate, and the oropharynx?
6. What are the three components of the pharynx?
7. What nerves innervate the pharynx?
8. What are the three unpaired cartilages that are located in the larynx?
9. What are the three paired cartilages that are located in the larynx?
10. What is different about the cricoid cartilage compared with the other tracheal cartilages?
11. Where is the narrowest part of the adult airway?
12. What two nerves provide the motor innervation to the larynx?
13. Damage to what nerve would cause paralysis to the principal abductors of the vocal cords, the posterior cricoarytenoid muscles?
14. Which nerve provides motor function to one of the tensors of the vocal cords, the cricothyroid muscle?

AIRWAY ASSESSMENT

15. How should the patient's airway be assessed prior to airway management for a procedure?
16. What is the purpose of the Mallampati classification system?
17. Describe the observer/patient position during Mallampati classification.
18. Describe the Mallampati classes.
19. Why are decreased submandibular space and compliance associated with difficult intubation?
20. What are some clinical conditions associated with decreased submandibular compliance?
21. What is the purpose of the upper lip bite test (ULBT)?
22. Describe the ULBT classes.
23. What is the concern with a patient with a short thyromental distance?
24. What three axes must be aligned to obtain a line of vision during direct laryngoscopy? How is this accomplished? What is this final position called?
25. What position is associated with improved alignment of the three axes to obtain a line of vision during laryngoscopy in obese patients?
26. What maneuver facilitates identification of the cricoid cartilage in patients who do not have a prominent thyroid cartilage?

AIRWAY MANAGEMENT TECHNIQUES

27. List variables associated with difficult face mask ventilation.
28. What are the causes of difficult or inadequate mask ventilation?
29. Describe preoxygenation prior to the induction of anesthesia. What is its value?
30. How is preoxygenation accomplished?
31. What are the two factors that influence the duration of apnea without desaturation?
32. Why is it important to limit ventilation pressure to less than 20 cm H_2O during face mask ventilation?
33. What is an advantage of nasal airways over oral airways in a lightly anesthetized patient? What are some contraindications to nasal airway placement?

SUPRAGLOTTIC AIRWAY DEVICES

34. What are the advantages of supraglottic airway devices over endotracheal intubation in elective airway management?
35. List variables associated with difficult supraglottic airway placement.
36. What are some potential contraindications to supraglottic airway placement?
37. What are some reported complications of laryngeal mask airway use in difficult airway patients?
38. Describe features of the second generation supraglottic airways, such as LMA Fastrach, LMA ProSeal or Supreme, Air-Q Masked Laryngeal Airways, and I-gel, that make them different from LMA Classic.
39. Describe advantages of the esophageal tracheal Combitube (ETC) and King Laryngeal Tube (King LT).

ENDOTRACHEAL INTUBATION

40. What is the best way to position the patient for direct laryngoscopy and endotracheal intubation?
41. What are some indications for intubation?
42. What is the purpose of the Cormack and Lehane score?
43. Describe the Cormack and Lehane grades.
44. What are four management principles to consider for intubation of a patient with a history of or an examination concerning for a difficult airway?
45. How can thyroid cartilage maneuvers facilitate visualization of the glottic opening during direct laryngoscopy?
46. What are the advantages of curved (Macintosh) laryngoscope blades and the straight (Miller) laryngoscope blades?
47. Describe the proper placement of the tip of a curved (Macintosh) laryngoscope blade versus that of a straight (Miller) laryngoscope blade for exposure of the glottic opening during direct laryngoscopy.
48. What is the main advantage of video laryngoscopes over direct laryngoscopy?
49. Describe why an angulated video laryngoscope blade is advantageous when intubating a patient with a suspected or known difficult airway and the technique for insertion.
50. Describe how a channeled differs from a nonchanneled video laryngoscope and how a channeled video laryngoscope blade is used.
51. Explain the difference between endotracheal tube stylets, introducers, and airway exchange catheters.
52. Name some uses of endotracheal tube stylets, introducers, and airway exchange catheters.
53. What are some complications of endotracheal tube stylets, introducers, and airway exchange catheters?
54. Explain how to exchange a supraglottic airway for an endotracheal tube using an Aintree intubation catheter.

FLEXIBLE FIBEROPTIC ENDOTRACHEAL INTUBATION

55. What are some indications for fiberoptic endotracheal intubation?
56. What are disadvantages to fiberoptic endotracheal intubations?
57. Why is fiberoptic endotracheal intubation recommended for patients with unstable cervical spines?

58. Why is fiberoptic endotracheal intubation recommended for patients who have sustained an injury to the upper airway from either blunt or penetrating trauma?
59. When is an awake fiberoptic endotracheal intubation indicated?
60. What are some advantages and disadvantages of nasal fiberoptic endotracheal intubation?
61. Why should an antisialagogue be given before fiberoptic endotracheal intubation?
62. What are the advantages of topical anesthesia over nerve blocks for airway anesthesia?
63. Why is lidocaine the preferred topical local anesthetic for the airway?
64. Describe preparation of the tongue and oropharynx for nasal or oral fiberoptic endotracheal intubation.
65. Describe preparation of the nose and nasopharynx for nasal fiberoptic endotracheal intubation.
66. Why is nebulization of local anesthetic more effective at providing topical anesthesia to the trachea than spraying?
67. Name two blocks that can be performed to provide topical anesthesia for the larynx and trachea.
68. How can the risks of mucosal trauma/bleeding or submucosal tunneling with nasal endotracheal intubation be minimized?
69. What is the utility of oral intubating airways during oral fiberoptic endotracheal tracheal intubation?
70. What are the advantages of inflating the endotracheal tube cuff during fiberoptic intubation?
71. How is endotracheal tube depth verified during fiberoptic intubation?
72. What are possible causes of resistance when advancing the fiberoptic bronchoscope?
73. What are possible causes of resistance when removing the fiberoptic bronchoscope?
74. Why is visualization more difficult during fiberoptic endotracheal intubation in an asleep patient?

BLIND NASOTRACHEAL INTUBATION

75. Describe the blind nasal endotracheal intubation technique.

ENDOTRACHEAL TUBE SIZES

76. How are endotracheal tubes sized?
77. Why are endotracheal tubes radiopaque and transparent?
78. Why are low-pressure, high-volume cuffs on endotracheal tubes preferred?
79. What are some serious complications attributable to excessive endotracheal cuff pressures?

CONFIRMATION OF ENDOTRACHEAL TUBE PLACEMENT

80. What are some methods to confirm the correct placement of an endotracheal tube?
81. Describe endotracheal tube movement during head flexion and extension.

SPECIAL SITUATIONS

82. What is the purpose of cricoid pressure and when should it be used?
83. How is cricoid pressure performed?
84. What are some possible complications of cricoid pressure?

TRANSTRACHEAL TECHNIQUES

85. In what situations are transtracheal techniques most commonly used? What are different transtracheal techniques that can be used?
86. What are predictors of difficult access through the cricothyroid membrane?
87. What is a cricothyrotomy, and when is it usually performed?
88. Describe a percutaneous cricothyroidotomy.
89. Describe a surgical cricothyroidotomy.
90. What are the possible complications of cricothyroidotomy?
91. Describe how access for transtracheal jet ventilation is obtained.
92. What are the possible complications of transtracheal jet ventilation?
93. Describe how a retrograde endotracheal intubation is performed.

ENDOTRACHEAL EXTUBATION

94. What are the steps of tracheal extubation?
95. Why is tracheal extubation during a light level of anesthesia dangerous?
96. What is laryngospasm? When is it most likely to occur?
97. What are the benefits, indications, and contraindications to extubation before the return of protective airway reflexes (deep extubation)?

COMPLICATIONS OF TRACHEAL INTUBATION

98. What are some possible complications of endotracheal intubation?
99. What are the causes of major airway-related adverse events after tracheal extubation?
100. How should laryngospasm be treated?
101. What is the major complication of prolonged tracheal intubation, and how can it be potentially prevented?

AIRWAY MANAGEMENT IN INFANTS AND CHILDREN

102. What are some differences between the infant and the adult airway? At what age does the pediatric upper airway take on more adult-like characteristics?
103. At what level in the neck is the larynx located in infants as compared to adults? What effect does this have on the tongue?
104. Is the infant's tongue, in proportion to the size of the mouth, larger or smaller than an adult's tongue? What are the consequences of this?
105. How does an infant's epiglottis differ from an adult's epiglottis?
106. What is the narrowest portion of an infant's airway?
107. Describe the best head and neck positioning of an infant during direct laryngoscopy.
108. What is different about an infant's nares compared to an adult's? Why is this important?
109. How does oxygen consumption per kilogram compare between infants and adults? Why is this important?
110. What are some questions for the parents regarding the pediatric patient's history that are important for airway management?
111. Why is premedication useful in pediatric anesthesia?
112. What is the premedication dose of oral midazolam for infants or children?
113. If a child is uncooperative with taking oral midazolam as a premedication, what other options are available?
114. Describe an inhaled induction in a child. When should nitrous oxide be discontinued?
115. Describe maneuvers to overcome airway obstruction during mask induction in infants and children.
116. What determines the appropriate size of an laryngeal mask airway (LMA) for use in infants and children?
117. Describe the difference between the cuff pressure and the leak pressure in a supraglottic airway device.
118. What advantage does the Air-Q intubating laryngeal airway (ILA) have over an LMA in pediatric patients?
119. What formula is often used to estimate the appropriate size of an endotracheal tube for infants and children? Is this formula for cuffed or uncuffed endotracheal tubes?
120. How is the formula used to estimate the appropriate size of an endotracheal tube for infants and children adapted for cuffed endotracheal tubes?
121. What are the advantages of cuffed versus uncuffed endotracheal tubes in infants and children? What are the disadvantages?
122. What are the potential complications of using too large an uncuffed endotracheal tube or an overinflated cuffed endotracheal tube?
123. Are cuffed endotracheal tubes associated with a higher incidence of postextubation croup than uncuffed endotracheal tubes?
124. What is the appropriate leak pressure when using uncuffed endotracheal tubes in infants and children?

125. What is the appropriate cuff pressure for endotracheal tubes in infants and children? What is the best way to measure the cuff pressure?
126. What three advantages do Microcuff endotracheal tubes have over conventional pediatric cuffed endotracheal tubes?
127. What are the advantages and disadvantages of straight laryngoscope blades over curved laryngoscope blades when intubating infants or small children?
128. Describe the most useful sizes of laryngoscope blades according to age.
129. What are the advantages of video laryngoscopes over direct laryngoscopy in infants and children? What are the disadvantages?
130. Describe the different GlideScope sizes and models according to age and weight.
131. Describe the limitations of flexible fiberoptic bronchoscopes used in infants and children.
132. Is an awake fiberoptic endotracheal intubation usually an option in managing an expected difficult airway in infants and children?
133. What is the safest vasoconstrictor to apply to the nasal mucosa when performing a nasal fiberoptic endotracheal intubation in infants or children?
134. What is the most important first step when an unexpected difficult airway occurs in pediatric patients?
135. In a difficult pediatric intubation situation, why should repeated attempts at direct laryngoscopy be avoided? What should be done instead?
136. What personnel and equipment should be in the operating room before induction of anesthesia in a pediatric patient with an expected difficult airway?
137. Why is tracheal extubation in infants and children riskier than in that of adults?
138. What is the most common reason for postextubation croup in infants and children? What are other risk factors for postextubation croup in infants and children?
139. What are the clinical manifestations of postextubation croup?
140. How is postextubation croup treated in infants and children?
141. What are pediatric patients with obstructive sleep apnea at risk for in the postoperative period?
142. Describe tracheal extubation and postoperative monitoring for infants and children with obstructive sleep apnea.
143. When does laryngospasm typically occur in infants and children?
144. How should laryngospasm be treated in infants and children?
145. How should extubation after a difficult intubation be handled in infants and children?

ANSWERS*

ANATOMY AND PHYSIOLOGY OF THE UPPER AIRWAY

1. Resistance to airflow through the nasal passages is twice that through the mouth and accounts for approximately 50% to 75% of total airway resistance. (241)
2. The majority of the sensory innervation of the nasal cavity is derived from the ethmoidal branch of the ophthalmic nerve and branches of the maxillary division of the trigeminal nerve from the sphenopalatine ganglion. (241)
3. The greater and lesser palatine nerves branch from the sphenopalatine ganglion to innervate the hard and soft palate. (241)
4. The mandibular division (V_3) of the trigeminal nerve (cranial nerve V) forms the lingual nerve, which provides sensation to the anterior two-thirds of the tongue. (241)
5. The posterior third of the tongue, the soft palate, and the oropharynx are innervated by the glossopharyngeal nerve (cranial nerve IX). (241)

*Numbers in parentheses refer to pages, figures, boxes, or tables in Pardo MC, Miller RD, eds. *Basics of Anesthesia*. 7th ed. Philadelphia: Elsevier; 2018.

6. The three components of the pharynx are the nasopharynx, the oropharynx, and the hypopharynx. (241)
7. The pharynx is innervated by cranial nerves IX (glossopharyngeal) and X (vagus). (241)
8. The three unpaired cartilages located in the larynx are the epiglottis, thyroid, and cricoid cartilages. (242)
9. The three paired cartilages located in the larynx are the arytenoids, corniculates, and cuneiform cartilages. (242)
10. The cricoid cartilage is the most cephalad tracheal cartilage and is the only one that has a full ring structure. It is shaped like a signet ring, wider in the cephalocaudal dimension posteriorly. (242)
11. The vocal cords are the narrowest portion of the adult airway. (242)
12. The superior laryngeal nerve, external division, and the recurrent laryngeal nerve provide motor innervation to the larynx. (242)
13. Damage to the recurrent laryngeal nerve would cause paralysis of the cricoarytenoid muscles. These muscles are the principal abductors of the vocal cords. (242)
14. The superior laryngeal nerve, external division, innervates the cricothyroid muscle. This is the only laryngeal muscle innervated by the superior laryngeal nerve, external branch. (242)

AIRWAY ASSESSMENT

15. Assessment of the patient's airway prior to airway management includes history gathering and a physical examination. Aspects of the history may include a history of the patient's airway experiences, review of previous anesthetic and medical records, and the gathering of information that may be pertinent such as congenital defects, disease states, and gastrointestinal disorders. The physical examination should evaluate for features to predict the potential for difficult airway management. (242)
16. Mallampati proposed a classification system (Mallampati score) to correlate the oropharyngeal space with the predicted ease of direct laryngoscopy and tracheal intubation. (243)
17. With the observer at eye level, the patient holds the head in a neutral position, opens the mouth maximally, and protrudes the tongue without phonating. (243)
18. The Mallampati classes are as follows:
    Class I: The soft palate, fauces, uvula, and tonsillar pillars are visible.
    Class II: The soft palate, fauces, and uvula are visible.
    Class III: The soft palate and base of the uvula are visible.
    Class IV: The soft palate is not visible. (243)
19. Decreased submandibular space and compliance correlate with poor laryngoscopic view. The submandibular space is the area into which the soft tissues of the pharynx must be displaced to obtain a line of vision during direct laryngoscopy. Anything that limits the size of this space or compliance of the tissue will decrease the amount of anterior displacement that can be achieved. (243)
20. Ludwig angina, tumors or masses, radiation scarring, burns, and previous neck surgery are conditions that can decrease submandibular compliance. (243)
21. The upper lip bite test (ULBT) assesses the ability to prognath the mandible, which correlates with visualization of glottic structures on direct laryngoscopy. (243)
22. The classes of the ULBT are as follows:
    Class I: Lower incisors can bite above the vermilion border of the upper lip.
    Class II: Lower incisors cannot reach vermilion border.
    Class III: Lower incisors cannot bite upper lip. (243)
23. A thyromental distance (mentum to thyroid cartilage) less than 6 to 7 cm correlates with a poor laryngoscopic view. This is typically seen in patients with a receding mandible or short neck. Three ordinary fingerbreadths approximate this distance. (243)

24. The laryngeal, pharyngeal, and oral axes must be aligned to obtain a line of vision during direct laryngoscopy. Flexion of the neck, by elevating the head approximately 10 cm, aligns the laryngeal and pharyngeal axes. Extension of the head on the atlanto-occipital joint aligns the oral and pharyngeal axes. These maneuvers place the head in the "sniffing" position and bring the three axes into optimal alignment. (245)
25. Obesity is associated with difficulty in airway management. To increase the likelihood of successful endotracheal intubation, a wedge-shaped bolster placed behind the obese patient's shoulders and back results in a more optimal sniffing position. (245)
26. In patients who do not have a prominent thyroid cartilage, identification of the cricoid cartilage can be achieved by palpating the neck at the sternal notch and sliding the fingers up the neck until a tracheal cartilage that is wider and higher (cricoid cartilage) than those below is felt. (246)

AIRWAY MANAGEMENT TECHNIQUES

27. Independent variables associated with difficult face mask ventilation are (1) age older than 55 years, (2) increased body mass index (BMI), (3) a beard, (4) lack of teeth, (5) a history of snoring or obstructive sleep apnea, (6) Mallampati class III to IV, (7) history of neck radiation, (8) male gender, (9) limited ability to protrude the mandible, and (10) history of an airway mass or tumor. Difficult face mask ventilation can also develop after multiple laryngoscopy attempts. (246)
28. Inadequate face mask ventilation may be due to one or more of the following problems: inadequate mask or supraglottic airway seal, excessive gas leak, or excessive resistance to the ingress or egress of gas. (246)
29. "Preoxygenation" describes the administration of oxygen to patients prior to the induction of anesthesia resulting in apnea. The goal is to achieve an end-tidal oxygen level of about 90%. Preoxygenation increases the duration of apnea without oxygen desaturation by filling the functional residual capacity with oxygen, thus increasing the patient's reserve of oxygen while apneic. (247)
30. Methods by which to preoxygenate a patient prior to the induction of anesthesia include having the patient breathe 100% oxygen for 3 minutes or take eight deep breaths in 60 seconds. Although it was previously believed that having a patient take four deep breaths was sufficient for preoxygenation, this has been since proved not to be as effective as the other two methods. In obese patients, adequate preoxygenation may take longer. Having the obese patient sit in an upright position and applying continuous positive airway pressure may facilitate preoxygenation in this population. (247)
31. The two factors that influence the duration of apnea without desaturation are oxygen consumption and the volume of the functional residual capacity. (247)
32. Ventilating pressure during face mask ventilation should be less than 20 cm H_2O to avoid insufflation of the stomach. (248)
33. Nasal airways are advantageous over oral airways in that they are tolerated at lower levels of anesthesia. Oral airways are more likely to generate a gag reflex or cause laryngospasm in a lightly anesthetized patient. Nasal airways are relatively contraindicated in patients who have coagulation or platelet abnormalities, are pregnant, or have basilar skull fractures. (248)

SUPRAGLOTTIC AIRWAY DEVICES

34. For elective airway management, advantages of supraglottic airway devices over endotracheal intubation include placement quickly and without the use of laryngoscope, less hemodynamic changes with insertion and removal, less coughing and bucking with removal, no need for muscle relaxants, preserved laryngeal competence and mucociliary function, and less laryngeal trauma. (248)
35. Difficult supraglottic airway placement or failure has been associated with small mouth opening, supra- or extraglottic pathology, fixed cervical spine deformity, use of cricoid pressure, poor dentition or large incisors, male sex, surgical table rotation, and increased BMI. (248)

36. Some potential contraindications for using supraglottic airway devices are patients at risk for regurgitation of gastric contents, nonsupine position, obesity, pregnant patients, long surgical time, and intra-abdominal or airway procedures. There are clinical situations when supraglottic airway placement may be acceptable despite a relative contraindication, but one must consider the risk versus benefit in these situations. (248)
37. Reported complications of laryngeal mask airway use in difficult airway patients include bronchospasm, postoperative swallowing difficulties, respiratory obstruction, laryngeal nerve injury, edema, and hypoglossal nerve paralysis. (248)
38. The second generation supraglottic airways such as the LMA Fastrach, LMA ProSeal or Supreme, Air-Q, and I-gel supraglottic airways have one or more of the following features: (1) improved airway seal to allow for ventilation with higher airway pressures, (2) a second lumen that acts as an esophageal vent to keep gases and fluid separate from the airway and facilitate placement of an orogastric tube, (3) an airway channel that can be used as a conduit for intubation, and (4) a bite block that is present in the airway shaft. (249)
39. The esophageal tracheal Combitube (ETC) and King Laryngeal Tube (King LT) devices are inserted blindly, require minimal training, and need no movement of the head or neck. These airway devices are primarily used in prehospital settings for emergency airway control when esophageal intubation cannot be achieved. (250)

ENDOTRACHEAL INTUBATION

40. The best way to position the patient for direct laryngoscopy and endotracheal intubation is to elevate the patient's head 8 to 10 cm with pads under the occiput (shoulders remaining on the table) and to extend the head at the atlanto-occipital joint. This maximally aligns the oral, pharyngeal, and laryngeal axes to create a line of vision from the lips to the glottic opening. The height of the operating table should be adjusted such that the patient's face is near the level of the standing anesthesia provider's xiphoid cartilage. (250)
41. Indications for endotracheal intubation include (1) the need to provide a patent airway, (2) prevention of inhalation (aspiration) of gastric contents, (3) need for frequent suctioning, (4) facilitating positive-pressure ventilation of the lungs, (5) operative position other than supine, (6) operative site near or involving the upper airway, (7) operative conditions requiring neuromuscular blockade, and (8) difficult airway maintenance by mask. (250)
42. The Cormack and Lehane score grades the glottic view that is obtained with direct laryngoscopy and can be a predictor of a difficult airway. (251)
43. The Cormack and Lehane score grades the direct laryngoscopic view as follows:
    Grade I: Most of the glottis is visible.
    Grade II: Only the posterior portion of the glottis is visible.
    Grade III: The epiglottis, but no part of the glottis, can be seen.
    Grade IV: No airway structures are visualized. (251)
44. In patients with anticipated or history of a difficult airway, the following management principles should be considered: (1) awake intubation versus intubation after the induction of general anesthesia, (2) initial intubation method via noninvasive versus invasive techniques, (3) video laryngoscopy as an initial approach to intubation, and (4) maintaining versus ablating spontaneous ventilation. (251)
45. Backward upward rightward pressure (BURP) on the thyroid cartilage with the laryngoscopist's right hand may facilitate visualization of the glottic opening during direct laryngoscopy. (251)
46. The advantages of the curved (Macintosh) blade include less trauma to teeth, more room for passage of the endotracheal tube, larger flange size improves the ability to sweep the tongue, and less bruising of the epiglottis because the tip of the blade does not directly lift this structure. The advantages of the straight (Miller) blade are better exposure of the glottic opening and a smaller profile, which can be beneficial in patients with smaller mouth opening. (252)

47. During laryngoscopy with a Macintosh blade, the distal end of the curved blade is advanced into the space between the base of the tongue and the pharyngeal surface of the epiglottis. During laryngoscopy with a Miller blade, the distal end of the straight blade is advanced beneath the laryngeal surface of the epiglottis. The epiglottis is then elevated by the blade to expose the glottic opening. (252)
48. Video laryngoscopes can help obtain a view of the larynx by providing indirect visualization of the glottic opening without alignment of the oral, pharyngeal, and tracheal axes, and enable tracheal intubation in patients who have conditions (limited mouth opening, inability to flex the neck) that can make traditional laryngoscopy difficult or impossible. There is also a slightly improved view of the larynx because the camera is located more distally on the blade, providing for a wider visual field. (252)
49. Angulated video laryngoscope blades allow for a more anteriorly oriented view that can be obtained with minimal flexion or extension of the patient's head and neck. They are usually inserted midline in the mouth, and the tip of the video laryngoscope blade may be placed in the vallecula or be used to lift the epiglottis directly. A preshaped stylet that matches the curvature of the blade is usually required. (253)
50. Channeled video laryngoscope blades (Airtraq and King Vision) have a guide channel that directs an endotracheal tube toward the glottic opening via blades that are more angulated than traditional Macintosh blades. The endotracheal tube is preloaded into the guide channel, and the video laryngoscope is inserted midline in the mouth until the epiglottis is visualized. Nonchanneled video laryngoscopes (GlideScope, C-MAC, McGrath) require that an endotracheal tube (usually with a preshaped stylet) is advanced into the mouth under direct visualization until it can be viewed on the monitor and advanced into the trachea. When using nonchanneled video laryngoscopes advancement of the endotracheal tube blindly without direct visualization can result in tonsillar and pharyngeal injuries. (253)
51. Malleable metal stylets are used to stiffen and provide curvature to an endotracheal tube to help facilitate laryngoscopy and tracheal intubation. A bougie or an introducer is used when there is a poor laryngoscopic view and difficulty passing an endotracheal tube. They are shaped with a curve near the distal tip, which facilitates placement into the airway. An endotracheal tube can be advanced over the bougie or introducer into the airway. Airway exchange catheters are designed for exchange of endotracheal tubes. When placed prior to extubation, they can also be left in the airway as a conduit for reintubation in the case of failed extubation. (255)
52. Endotracheal tube stylets, introducers, and airway exchange catheters can be used to facilitate difficult endotracheal intubation, endotracheal tube exchange, and supraglottic airway exchange for an endotracheal tube. (255)
53. Complications of intubating endotracheal tube stylets include bleeding, sore throat, and tracheal trauma. Complications of endotracheal tube exchangers include tracheal/bronchial laceration and gastric perforation. If placed deeper there is a risk of bronchial perforation and pneumothorax. The use of high-pressure jet ventilation through the endotracheal tube exchanger can lead to other serious complications. (255)
54. To exchange a supraglottic airway for an endotracheal tube, the airway exchange catheter (AIC) is threaded onto a fiberoptic bronchoscope. The distal end of the fiberoptic bronchoscope is not covered by the AIC to allow for manipulation. The AIC and fiberoptic bronchoscope are then placed in the lumen of the supraglottic airway and advanced as a unit through the vocal cords into the trachea. The fiberoptic bronchoscope is then removed while the AIC remains in the trachea. The supraglottic airway is removed over the AIC, and an endotracheal tube is then placed over the AIC into the trachea. Finally, the AIC is removed. (255)

FLEXIBLE FIBEROPTIC ENDOTRACHEAL INTUBATION

55. Indications for fiberoptic endotracheal intubation include patients with predicted difficult airway, patients with unstable cervical spines, and patients who have sustained an injury to the upper airway from either blunt or penetrating trauma. (256)
56. Disadvantages of fiberoptic endotracheal intubation are that it requires time to set up and prepare the patient's airway. Therefore, if immediate airway management is required, another technique should be used. Also, the fiberoptic bronchoscope needs space to pass through. Anything that impinges on upper airway size (edema of the pharynx or tongue, infection, hematoma, infiltrating masses) will make fiberoptic intubation more difficult. Blood and secretions in the upper airway can obscure optics of the fiberoptic bronchoscope, making visualization difficult. A relative contraindication to fiberoptic intubation is the presence of a pharyngeal abscess, which could be disrupted as the endotracheal tube is advanced and result in aspiration of purulent material. (256)
57. Fiberoptic endotracheal intubation does not require movement of the patient's neck and can be performed awake, before induction of general anesthesia, thereby allowing for evaluation of the patient's neurologic function after tracheal intubation and surgical positioning. (256)
58. Patients who have sustained an injury to the upper airway from either blunt or penetrating trauma are at risk for the endotracheal tube creating a false passage by exiting the airway through the disrupted tissue during direct laryngoscopy. By performing a fiberoptic intubation, not only can the injury be assessed, but also the tracheal tube can be placed beyond the level of the injury. This eliminates the risk of causing subcutaneous emphysema, which could compress and further compromise the airway. (256)
59. Awake fiberoptic endotracheal intubation is most frequently chosen when a difficult tracheal intubation by direct laryngoscopy is anticipated in a patient who is able to cooperate with the procedure. By intubating before induction of general anesthesia, the patient maintains upper airway patency and spontaneous respirations and can eliminate the risk of failed ventilation and failed tracheal intubation. The technique also does not require movement of the patient's neck, thereby maintaining cervical spine immobility in patients with unstable cervical spines, and allows for evaluation of the patient's neurologic function after tracheal intubation or surgical positioning. (256)
60. In general, the nasal route is easier than the oral route for fiberoptic endotracheal intubation because the angle of curvature of the endotracheal tube naturally approximates that of the patient's upper airway. Additionally, nasal fiberoptic endotracheal intubation tends to be less of a stimulus for the gag reflex. A disadvantage of nasal fiberoptic endotracheal intubation is that the risk of inducing bleeding is higher when the nasal route is used. Therefore, the nasal route is relatively contraindicated in patients with platelet abnormalities or coagulation disorders. (257)
61. An antisialagogue (glycopyrrolate, 0.2 mg IV) should be administered before fiberoptic endotracheal intubation to inhibit the formation of secretions that can obscure fiberoptic visualization. (257)
62. Topical anesthesia for airway anesthesia is less invasive and better tolerated in awake patients than nerve blocks. Topical anesthesia can be as effective as nerve blocks for airway anesthesia but has a higher risk of local anesthetic toxicity. (257)
63. Lidocaine is the preferred topical local anesthetic for the airway because of its broad therapeutic window. Benzocaine can cause methemoglobinemia even in therapeutic doses. Tetracaine has a very narrow therapeutic window, and the maximum allowable dose can easily be exceeded. Cetacaine is a mixture of benzocaine and tetracaine and has the disadvantages of each local anesthetic. Cocaine can cause sympathomimetic effects, such as tachycardia and hypertension, and central nervous system stimulation, and it can have abuse potential. (257)

64. Topical anesthesia of the tongue and oropharynx may be achieved by spraying or direct application or by bilateral blocks of the glossopharyngeal nerve. For a glossopharyngeal nerve block, approximately 2 mL of 2% lidocaine is injected at a depth of 0.5 cm (after first confirming negative aspiration) at the base of each anterior tonsillar pillar. (257)
65. Anesthetizing the nasal mucosa can be achieved by spraying (atomizing or nebulizing) or direct application (ointment, gels, or gargling solutions) of local anesthetics onto the nasal mucosa. Local anesthetic solutions can also be applied by placing soaked cotton-tipped swabs or pledgets into the nares. When a nasal intubation is performed, vasoconstriction is also necessary. Vasoconstriction with 0.05% oxymetazoline HCL spray is recommended. (257)
66. Nebulization of local anesthetic is more effective at providing topical anesthesia to ("topicalizing") the trachea than spraying because the small particle size of local anesthetic created by a nebulizer is carried more effectively into the trachea. It does, however, also travel into the smaller airways, where the anesthetic is not needed, and undergoes more rapid systemic absorption. The larger local anesthetic particle size of a spray causes it to be deposited in the pharynx, with only a small proportion reaching the trachea. (257)
67. Two blocks that can be performed for topical anesthesia of the larynx and trachea include the superior laryngeal nerve block and the transtracheal block. The transtracheal block is designed to block the sensory distribution of the recurrent laryngeal nerve. (257)
68. Softening the endotracheal tube in warm water and lubricating it before use make it less likely to cause mucosal trauma/bleeding or submucosal tunneling during nasal endotracheal intubation. (257)
69. Use of an oral intubating airway facilitates directing the bronchoscope in midline and creating space during oral fiberoptic endotracheal intubation. (257)
70. Inflation of the endotracheal tube cuff during advancement with the fiberoptic bronchoscope in the pharynx serves to create an enlarged pharyngeal space. Because secretions tend to adhere to the pharyngeal walls, endotracheal tube cuff inflation also helps keep the optics of the fiberoptic bronchoscope from being obscured. The inflated cuff further aims the tip of the endotracheal tube anteriorly. (257)
71. The appropriate depth of endotracheal tube placement can be verified by observing the distance between the carina and the tip of the endotracheal tube as the fiberoptic bronchoscope is withdrawn. (257)
72. Resistance to advancement of the endotracheal tube often means the endotracheal tube is impacted on an arytenoid. If this occurs, rotation of the endotracheal tube may be helpful. Forcing advancement of the endotracheal tube may result in kinking of the endotracheal tube, advancement into the esophagus, and damage to the fiberoptic bronchoscope. (258)
73. If there is any resistance when removing the fiberoptic bronchoscope, the scope is either through the Murphy eye or kinked in the pharynx. In both instances, the endotracheal tube and the scope must be withdrawn together to prevent damaging the fiberoptic bronchoscope. (258)
74. An important difference in performing fiberoptic laryngoscopy in an anesthetized patient is that the soft tissues of the pharynx, in contrast to the awake state, tend to relax and limit space for visualization with the fiberoptic bronchoscope. Using jaw thrust, using specialized oral airways, expanding the endotracheal tube cuff in the pharynx, or applying traction on the tongue may overcome this problem. It is advisable to have a second person trained in anesthesia delivery assisting when a fiberoptic endotracheal intubation is performed under general anesthesia because it is difficult to maintain the patient's airway, be attentive to the monitors, and perform the fiberoptic intubation alone. (258)

BLIND NASOTRACHEAL INTUBATION

75. Blind nasotracheal intubation involves advancing an endotracheal tube blindly from the nose into the trachea while listening to breath sounds or attaching the endotracheal tube to an anesthesia circuit and observing end-tidal CO_2. However, this technique is rarely used for difficult airway management, as there are now numerous other devices available for management of the difficult airway. (258)

ENDOTRACHEAL TUBE SIZES

76. Endotracheal tubes are sized according to their internal diameter (ID), which is marked on each tube. They are available in 0.5 mm ID increments. (258)
77. Endotracheal tubes are radiopaque to ascertain radiographically the position of the distal tip relative to the carina. They are transparent to permit visualization of secretions or airflow as evidenced by condensation of water vapor in the lumen of the tube ("breath fogging") during exhalation. (258)
78. Pressure on the tracheal wall is minimized through the use of a low-pressure, high-volume endotracheal tube cuff. The cuff needs to be inflated to facilitate positive-pressure ventilation of the lungs and to decrease the risk of the aspiration of gastric contents. Using the minimum volume of air in the cuff that prevents air leaks during positive ventilation pressure (20 to 30 cm H_2O) also minimizes the likelihood of mucosal ischemia resulting from prolonged pressure on the tracheal wall. (258)
79. Serious complications attributable to excessive endotracheal tube cuff pressures include tracheal stenosis, tracheal rupture, tracheoesophageal fistula, tracheocarotid fistula, and tracheoinnominate artery fistula. (258)

CONFIRMATION OF ENDOTRACHEAL TUBE PLACEMENT

80. Confirmation of placement of the endotracheal tube in the trachea is verified by identification of carbon dioxide in the patient's exhaled tidal volume and by physical examination. The presence of carbon dioxide in the exhaled gases from the endotracheal tube as detected by capnography (end-tidal P_{CO_2} >30 mm Hg for three to five consecutive breaths) should be immediate and sustained. Symmetric chest rise with manual ventilation, bilateral breath sounds, and absence of breath sounds over the epigastrium are confirmed after tracheal intubation. Palpation or balloting of the endotracheal tube cuff in the suprasternal notch can help determine endotracheal versus endobronchial intubation. (258)
81. Flexion of the patient's head may advance and convert tracheal placement of an endotracheal tube into an endobronchial intubation, especially in children. Conversely, extension of the head can withdraw the tube and result in pharyngeal placement and extubation from the trachea. (259)

SPECIAL SITUATIONS

82. Cricoid pressure (Sellick maneuver) is thought to prevent spillage of gastric contents into the pharynx during the period from induction of anesthesia (unconsciousness) to successful placement of a cuffed endotracheal tube. The use of cricoid pressure remains controversial. It should probably be considered in selected patients at high risk for regurgitation during induction but should be released if it impedes oxygenation, ventilation, or view of glottic structures. (259)
83. An assistant should exert downward external pressure with the thumb and index finger on the cricoid cartilage to displace the cartilaginous cricothyroid ring posteriorly and thus compress the underlying upper esophagus against the cervical vertebrae. The recommended magnitude of downward external pressure is 30 newtons, but this pressure is difficult to judge. (259)
84. Possible complications of cricoid pressure include increasing the difficulty of mask ventilation or worsening laryngoscopic view, nausea, vomiting, and esophageal rupture. (259)

85. In situations when ventilation and intubation are unsuccessful despite use of a supraglottic airway, emergency invasive access should be used. Invasive emergency access consists of percutaneous or surgical airway, jet ventilation, and retrograde intubation. (259)
86. Predictors of difficult access through the cricothyroid membrane include increased neck circumference, overlying neck pathology, and a fixed cervical spine flexion deformity. (259)
87. A cricothyrotomy involves the placement of an endotracheal tube through the cricothyroid membrane. It can be done using a percutaneous or surgical technique. Cricothyrotomy can be a lifesaving procedure in a “cannot intubate, cannot ventilate” situation or can be used as a first-line technique to secure an airway when using a less invasive technique is not possible owing to factors such as facial trauma, upper airway bleeding, or upper airway obstruction. (259)
88. The percutaneous cricothyrotomy uses a Seldinger technique in which a needle is advanced at a 90-degree angle through the cricothyroid membrane while aspirating with an attached syringe. A change in resistance is felt as a pop when the needle enters the trachea and air is aspirated. The needle should be then angled at a 30- to 45-degree angle and directed caudally. A guidewire is then advanced through the needle, followed by removal of the needle and placement of a combined dilator and airway of adequate caliber (>4 mm). Finally, the wire and dilator are removed, leaving the airway in place. (260)
89. The surgical cricothyrotomy technique involves a vertical or horizontal skin incision, followed by a horizontal incision through the cricothyroid membrane through which a standard endotracheal tube or tracheostomy tube is placed. A tracheal hook, dilator, airway exchange catheter, or bougie can assist in placement of the airway. (260)
90. Possible complications of a cricothyrotomy include bleeding, laryngeal or tracheal injury, infection, and subglottic stenosis. (260)
91. Transtracheal jet ventilation is achieved by placement of an over-the-needle catheter in the trachea through the cricothyroid membrane. The cricothyroid membrane should be identified, and a catheter over a needle connected to a syringe should puncture the membrane at a 90-degree angle until air is aspirated. The catheter should be advanced off the needle into the trachea at a 30- to 45-degree angle caudally. After reconfirming correct placement by aspiration of air, the catheter should be connected to a high-pressure oxygen source. (260)
92. Possible complications of transtracheal jet ventilation include pneumothorax, pneumomediastinum, bleeding, infection, and subcutaneous emphysema. Transtracheal jet ventilation should not be performed when there is upper airway obstruction or any disruption of the airway. (260)
93. Retrograde endotracheal intubation allows intubation without identification of the glottic inlet. The cricothyroid membrane is punctured with a needle at a 90-degree angle while aspirating with an attached syringe. Once in the trachea, the syringe is detached and a guide (usually a wire or catheter) is threaded through the needle in a cephalad direction. It is then retrieved from the mouth or nose. An endotracheal tube, with or without a fiberoptic laryngoscope, is threaded over the wire until it stops on impact with the anterior wall of the trachea. Tension on the guide can be relaxed to allow the endotracheal tube to pass farther into the trachea before removing the wire. Retrograde endotracheal intubation should not be performed in patients with anterior neck pathology (tumors, infection) or coagulopathy. (260)

ENDOTRACHEAL EXTUBATION

94. Before extubation, patients should be placed on 100% oxygen and any residual neuromuscular blockade should be reversed. Routine extubation criteria such as spontaneous respirations with adequate minute ventilation, satisfactory oxygenation and acid-base status, and hemodynamic stability should be met. The oropharynx is suctioned, and a bite block should be placed to prevent

occlusion of the endotracheal tube, if not already present. For deep extubation, adequate anesthesia should be confirmed, and awake patients should be able to follow commands. Then the endotracheal tube can removed by deflating the endotracheal tube cuff and rapidly removing the endotracheal tube from the patient's trachea and upper airway while a positive-pressure breath is delivered to help expel any secretions. After tracheal extubation, 100% oxygen is delivered by face mask. Adequate airway patency, ventilation, and oxygenation are then confirmed. (260)

95. Tracheal extubation after general anesthesia must be performed when the patient is either deeply anesthetized or fully awake. Tracheal extubation during a light level of anesthesia (disconjugate gaze, breath holding or coughing, and not responsive to command) increases the risk for laryngospasm. (260)
96. Laryngospasm is an involuntary spasm/closure of the vocal cords that may present as stridor or attempts to breathe without air exchange. Laryngospasm is likely to occur during tracheal extubation, particularly under a light level of anesthesia when the vocal cords are stimulated by mucus, blood, or other substances. (260)
97. Tracheal extubation before the return of protective airway reflexes (deep tracheal extubation) is generally associated with less coughing and attenuated hemodynamic effects on emergence. This may be preferred in patients at risk from adverse effects of increased intracranial or intraocular pressure, bleeding into the surgical wound, or wound dehiscence. Previous difficult face mask ventilation or difficult endotracheal intubation, high risk of aspiration, restricted access to the airway, obstructive sleep apnea or obesity, and a surgical procedure that may have resulted in airway edema, bleeding or increased irritability are relative contraindications to deep tracheal extubation. (260)

COMPLICATIONS OF TRACHEAL INTUBATION

98. Possible complications of endotracheal intubation can be divided into those incurred during laryngoscopy and tracheal intubation, those that occur while the tracheal tube is in place, and those that can occur after extubation of the trachea. Risks of direct laryngoscopy and endotracheal intubation include dental damage, oral or pharyngeal injury, lip lacerations and bruises, and laryngeal, arytenoid, esophageal, or tracheal damage. Systemic hypertension, tachycardia, increases in intracranial pressure, and aspiration of gastric contents may also occur during this time. During tracheal intubation possible complications include obstruction, accidental endobronchial intubation, accidental extubation, and tracheal tube cuff leak. Complications that can occur after extubation of the trachea include edema, laryngospasm, bronchospasm, aspiration of gastric contents, pharyngitis, laryngitis, tracheal stenosis, vocal cord paralysis, and arytenoid cartilage dislocation. (261)
99. After tracheal extubation, major airway-related adverse events are often due to airway obstruction from laryngeal edema, laryngospasm, or bronchospasm. (261)
100. If laryngospasm occurs, oxygen delivered with positive pressure through a face mask and jaw thrust may be sufficient treatment. Administration of succinylcholine or an anesthetic drug, such as propofol, is indicated if laryngospasm persists. (261–262)
101. The major complication of prolonged tracheal intubation (>48 hours) is damage to the tracheal mucosa, which may progress to destruction of cartilaginous rings and subsequent fibrous scar formation and tracheal stenosis. Using high-volume, low-pressure cuffs and keeping cuff pressures less than 25 cm H_2O can help prevent this complication. (262)

AIRWAY MANAGEMENT IN INFANTS AND CHILDREN

102. Differences between the infant and adult airway include positioning of the larynx in the neck, tongue size, epiglottis size, size of the head relative to the body, neck length, nares size, and location of the narrowest point. Usually by the time the child is about 10 years old the upper airway has taken on more adult-like characteristics. (262)

103. The infant larynx is located higher in the neck at the level of C3-C4. In adults the larynx is at the level of C4-C5. In infants the larynx at this level causes the tongue to shift more superiorly, closer to the palate. The tongue more easily opposes the palate, which can cause airway obstruction in situations such as during the inhalation induction of anesthesia. (263)
104. An infant's tongue is larger in proportion to the size of the mouth than an adult's. The relatively large size of the tongue makes direct laryngoscopy more difficult and can contribute to obstruction of the upper airway during sedation, inhalation induction of anesthesia, or emergence from anesthesia. (263)
105. The epiglottis in an infant's airway is often described as relatively larger, stiffer, and more omega-shaped than an adult epiglottis. More important, an infant's epiglottis is typically angled in a more posterior position, thereby blocking visualization of the vocal cords during direct laryngoscopy. During direct laryngoscopy in infants and small children it may be necessary to lift the epiglottis with the tip of the laryngoscope blade to visualize the vocal cords. (263)
106. The narrowest portion of an infant's airway is at the cricoid cartilage, whereas the narrowest portion of an adult's airway is at the vocal cords. (263)
107. An infant's head and occiput are relatively larger than an adult's. The proper position for direct laryngoscopy and tracheal intubation in an adult is often described as the sniffing position with the head elevated and the neck flexed at C6-C7 and extended at C1-C2. An infant, on the other hand, requires a shoulder roll or neck roll to establish an optimal position for face mask ventilation and direct laryngoscopy. (263)
108. An infant's nares are relatively smaller than an adult's. This can offer significant resistance to airflow and increase the work of breathing, especially when secretions, edema, or bleeding narrow them. (263)
109. Oxygen consumption per kilogram is much higher in infants than in adults. The clinical importance of this is that even after preoxygenation there is less allowable time for endotracheal intubation before the infant desaturates. (263)
110. Questions for the parents regarding the pediatric patient's history that are important for airway management include asking about history of previous airway issues and if there are any syndromes associated with difficult airway management. The parents should be asked if there is a history of snoring. Snoring in infants or children should prompt additional questioning about whether the child has obstructive sleep apnea and should alert the anesthesia provider that respiratory obstruction may develop during the induction and emergence phases of anesthesia, as well as in the postoperative period. This is of particular concern if opioids are given for pain management. The parents should also be asked whether the child has any loose teeth. It may be beneficial to remove very loose teeth prior to proceeding with airway management to prevent the possibility of dislodgement and aspiration. (263)
111. Preanesthetic medication can facilitate separation of the infant or child from the parents before the induction of anesthesia. Preanesthetic medication can also facilitate the inhalational induction of anesthesia in infants and children. Preanesthetic medication is often not necessary in infants younger than 6 months because stranger anxiety does not usually develop until 6 to 9 months of age. (263)
112. For infants or children premedication with midazolam syrup (2 mg/mL) can be given orally in a dose of 0.5 mg/kg up to a maximum dose of about 20 mg. (264)
113. If the child is uncooperative with taking oral midazolam and preanesthetic medication is essential, midazolam can also be given intranasally, intramuscularly, or rectally. If necessary, ketamine can be given intramuscularly in a dose of about 3 mg/kg. (264)
114. In a child without an intravenous catheter in place, the induction of anesthesia with the odorless mixture of nitrous oxide and oxygen through a face mask and then slowly increasing the concentration of sevoflurane is the best approach in a cooperative child. When the infant or child becomes unconscious, the nitrous oxide should be turned off to administer 100% oxygen. (264)

115. There are several maneuvers to relieve airway obstruction during mask induction in infants and children. The first step is to open the mouth, extend the neck, and provide anterior pressure to the angle of the mandible. An oral airway or a nasal airway may need to be inserted. Occasionally, a supraglottic airway may need to be inserted. (264)
116. The weight of the infant or child determines the appropriate size of the laryngeal mask airway (LMA). (265)
117. The cuff pressure is the actual pressure of the cuff of the supraglottic airway and is measured with a manometer in cm H_2O. The leak pressure is measured by slowly closing the APL valve to slowly increase the level of positive pressure that is delivered via the anesthesia circuit. The leak pressure is the pressure at which one first hears air leakage around the cuff of the supraglottic airway device. With supraglottic airway devices it is common for the cuff pressures to be higher than the leak pressures. (265)
118. The major advantage of the Air-Q ILA over an LMA is a design that facilitates endotracheal intubation with standard oral endotracheal tubes. The airway tube has a larger diameter than the LMA, allowing for intubation with a larger endotracheal tube than the correspondingly sized LMA. In addition, the Air-Q ILA can be used with a specially designed ILA removal stylet that stabilizes the endotracheal tube and allows controlled removal of the ILA without dislodging the tube from the trachea. (265)
119. The appropriately sized endotracheal tube for infants and children can be estimated by using the following formula: (age + 16)/4 = endotracheal tube size. This formula is for uncuffed endotracheal tubes. (265)
120. When using a cuffed endotracheal tube in infants and children, the formula used to estimate the appropriately sized uncuffed endotracheal tube must be adapted. To adapt the formula it is necessary to subtract half a size from the calculated size to estimate the appropriate size of a cuffed endotracheal tube. (266)
121. The advantages of cuffed endotracheal tubes in infants and children are that they (1) minimize the need for repeated laryngoscopy, (2) allow for lower fresh gas flows, (3) decrease the amount of inhalational agent used, and (4) decrease the concentrations of anesthetic gases detectable in operating rooms. The disadvantage of a cuffed endotracheal tube as compared to an uncuffed endotracheal tube is that a smaller cuffed than uncuffed tube is required and can increase resistance through the endotracheal tube and the work of breathing. (266)
122. If too large an uncuffed endotracheal tube or an overinflated cuffed endotracheal tube is utilized, the tracheal mucosa will be compressed causing subglottic edema either at the level of the cricoid cartilage or below. This complication can result in postextubation croup in mild cases and tracheal stenosis in more severe cases involving prolonged tracheal intubation. (266)
123. Using cuffed endotracheal tubes does not increase the incidence of postextubation croup as compared to using uncuffed endotracheal tubes. (266)
124. The leak pressure when using uncuffed endotracheal tubes in infants and children should be 20 to 25 cm H_2O. If the leak pressure is too high, a smaller endotracheal tube should be used, and if the leak pressure is too low, a larger endotracheal tube should be used. (266)
125. The cuff pressure should be 20 to 25 cm H_2O when using cuffed endotracheal tubes in infants and children and should be measured with a manometer. (266)
126. The new Microcuff pediatric endotracheal tubes appear to offer several distinct advantages over conventional cuffed pediatric endotracheal tubes. The Microcuff endotracheal tubes have a cuff that is made from a microthin polyurethane membrane that is stronger than conventional cuffs and seals the airway at lower cuff pressures than conventional endotracheal tubes. This reduces the potential for mucosal edema and postextubation croup. The cuff on the Microcuff endotracheal tube is also shorter and placed closer to the tip

of the endotracheal tube, increasing the chances that the endotracheal tube is correctly placed. The Microcuff endotracheal tube also has an intubation depth mark, which indicates the correct depth for insertion and also increases the ability for correct placement. (267)

127. The advantages of straight laryngoscope blades when intubating infants and small children are as follows: (1) they have a smaller profile that fits more easily into the smaller mouths of infants and children, and (2) they have a smaller tip that more effectively lifts the epiglottis to provide a better view of the vocal cords. The disadvantage of a straight blade is that it does not retract the tongue as well to the left side of the mouth. A curved blade has a larger flange that retracts the tongue to the left more effectively and may be useful in certain patient populations in which the tongue is larger than normal. (267)
128. In infants younger than 1 year, a Miller 1 straight laryngoscope blade is most useful. In children between 1 and 3 years of age, a 1½ straight laryngoscope blade, such as a Wis-Hipple, is often useful. A longer straight laryngoscope blade such as a Miller 2 is appropriate for most children between 3 and 10 years of age. The tracheas of children older than 11 years are often more easily intubated with a curved laryngoscope blade such as a Macintosh 3. Both straight and curved laryngoscope blades of various sizes should always be available. (267)
129. The advantages of video laryngoscopes over direct laryngoscopy in infants and children include (1) the ability to see the glottis opening and vocal cords without aligning the oral, pharyngeal, and laryngeal axes; (2) improved ability to visualize the glottis opening and vocal cords in patients with limited neck extension, hypoplastic mandibles, or anterior airways; and (3) the ability to teach as both the student and teacher can view the monitor at the same time. Disadvantages include the requirement of adequate mouth opening and the potential need for increased time to intubate. (267)
130. The different GlideScope sizes and models according to the patient's age and weight are as follows: GVL 0 is designed for infants weighing less than 2.5 kg, the GVL 1 for infants from 2.5 to 5.0 kg, the GVL 2 for infants from 5 to 15 kg, and the GVL 2.5 for children from 15 to 30 kg. The Glidescope Titanium S3 or T3 is recommended for children and teenagers from 30 to 70 kg, and the Titanium S4 or T4 for teenagers more than 70 kg. (268)
131. The limitations of the smaller flexible fiberoptic bronchoscopes used in infants and small children include (1) limited field of vision, (2) view that is easily obscured by secretions or bleeding, (3) inferior optics compared to larger adult bronchoscopes because of fewer fiberoptic bundles, and (4) no suction channel. (268)
132. It is unlikely that infants and children will cooperate with procedures such as an awake fiberoptic endotracheal intubation, so it is usually necessary to induce anesthesia and manage the difficult airway in these patients while they are asleep. (268)
133. The safest vasoconstrictor to apply to the nasal mucosa when performing a nasal fiberoptic endotracheal intubation in infants or children is oxymetazoline HCl 0.05% nasal spray. Phenylephrine applied to the nasal mucosa in infants and children has been associated with cases of phenylephrine toxicity. (268-269)
134. When an unexpected difficult airway appears in pediatric patients, the most important first step is to call for an additional anesthesia colleague to help. (269)
135. In a difficult pediatric intubation situation, it is critical to not persist with repeated attempts at direct laryngoscopy, which can result in trauma to the upper airway, edema, and bleeding. In most situations, a supraglottic airway should be inserted to provide an airway to oxygenate and ventilate the patient and allow time to obtain additional personnel and airway equipment. A supraglottic airway may be the only way to maintain an airway until the patient wakes up or a surgical airway is established. A supraglottic airway is also an excellent conduit for fiberoptic intubation. (269)

136. For expected difficult airway in the pediatric patient, an additional anesthesia colleague should be available for help during the induction of anesthesia, inserting an intravenous line, and securing the airway. A surgeon capable of establishing a surgical airway and emergency airway equipment should be in the operating room before beginning the induction of anesthesia. (269)
137. Infants and small children are at a higher risk than adults for croup, stridor, and laryngospasm after tracheal extubation. (270)
138. Croup occurs most commonly when either an uncuffed endotracheal tube that is too large or an overinflated cuffed endotracheal tube is used. The resulting mechanical pressure on the tracheal mucosa causes venous congestion and edema, and in severe cases can even compromise the arterial blood supply, causing mucosal ischemia. The resulting edema can narrow the tracheal lumen, especially in infants and small children. Because resistance to flow in an endotracheal tube is inversely proportional to the radius of the lumen to the fourth power, 1 mm of edema in an infant airway is much more significant than 1 mm of edema in an adult airway. Other risk factors for postextubation croup include multiple tracheal intubation attempts, unusual positioning of the head during surgery, increased duration of surgery, and procedures involving the upper airway, such as rigid bronchoscopy. (270)
139. An infant or child with postextubation croup usually has respiratory distress in the postanesthesia care unit. Nasal flaring, retractions, an increased respiratory rate, audible stridor, and decreased oxygen saturation are common clinical findings. (270)
140. Treatment of postextubation croup or stridor in infants and children depends on the degree of respiratory distress. Mild symptoms can be managed with humidified oxygen and prolonged observation in the postanesthesia care unit. More severe cases may require aerosolized racemic epinephrine and postoperative observation in an intensive care unit. Patients whose respiratory distress is severe and not relieved with these measures may need to be reintubated with an endotracheal tube smaller than the one previously used. Steroids administered intravenously for preventing upper airway edema are more beneficial when given before the airway is instrumented and should be administered before procedures such as rigid bronchoscopy. (270)
141. Infants and children with obstructive sleep apnea are at significant risk for airway obstruction, respiratory distress, and the potential for apnea in the postoperative period. At baseline these infants and children hypoventilate, which results in hypercapnia and often arterial hypoxemia while asleep. Residual inhaled anesthetics or residual neuromuscular blockade can depress airway reflexes, skeletal muscle tone and strength, and respiratory drive and result in significant airway compromise in infants and children with obstructive sleep apnea. (270)
142. Tracheal extubation in patients with obstructive sleep apnea should be considered only when these infants and children are fully awake. All infants and children with obstructive sleep apnea should be monitored postoperatively with pulse oximetry and apnea monitoring. High-risk patients should be monitored postoperatively in an intensive care unit setting. Opioids must be very carefully titrated both intraoperatively and postoperatively because they can depress the ventilatory drive and contribute to significant hypercapnia and arterial hypoxemia in these infants and children. (270)
143. Laryngospasm most commonly occurs in infants and children during either inhalational induction of anesthesia or the emergence from anesthesia often after extubation or removal of a supraglottic airway device. (270)
144. The majority of laryngospasm episodes in pediatric patients can be treated successfully with continuous positive-pressure ventilation via face mask with 100% oxygen, while applying a chin lift and jaw thrust. The positive pressure may have to be as high as 50 cm H_2O to successfully break the laryngospasm. If positive pressure is not successful and the infant or child is desaturating or

bradycardic, further intervention is necessary. If there is intravenous access, laryngospasm should be treated with approximately 0.6 to 1.0 mg/kg of intravenous propofol and, if necessary, 0.2 to 0.3 mg/kg of intravenous rocuronium. If there is no intravenous access, laryngospasm should be treated with 0.6 to 1.0 mg/kg of intramuscular rocuronium or 1.5 to 2.0 mg/kg of intramuscular succinylcholine. (270)

145. Tracheal extubation of an infant or child after a difficult intubation is considered carefully because reintubation can be more difficult than the initial intubation. The tracheas of infants and children with difficult airways should be extubated only when they are fully awake and there is no residual neuromuscular blockade. An infant or child with a difficult airway should be extubated only when appropriate equipment and personnel are available for urgent reintubation. (270)