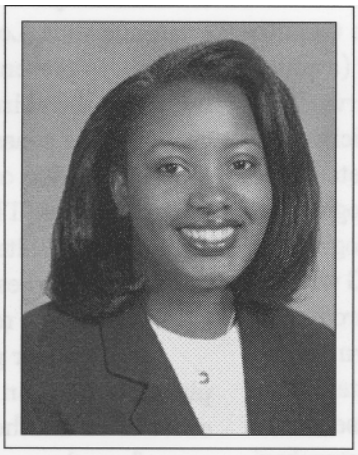
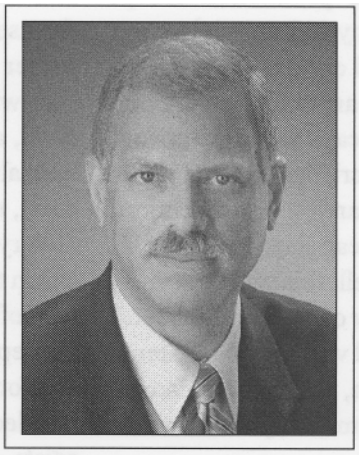
Blunt Trauma to the Larynx and Trachea: Considerations for the Professional Voice User

Yolanda D. Heman-Ackah, MD and Robert T. Sataloff, MD, DMA



Yolanda D. Heman-Ackah, M.D.



Robert T. Sataloff, M.D., D.M.A.

INTRODUCTION

Blunt injury to the larynx (the voice box) and trachea (the windpipe) is the most common cause of laryngotracheal injury in the United States today, accounting for sixty percent of all injuries to the laryngotracheal complex.[1,2] These injuries result from motor vehicle collisions, accidents involving all-terrain vehicles, bicycle accidents, stage injuries, contact sports, strangulation, and hanging-type injuries. The complications associated with such injuries range from airway obstruction and difficulty breathing to voice compromise and permanent hoarseness, with complication rates as high as fifteen to twenty-five percent.[2-4] Because of the potential for untreated laryngeal and tracheal injuries to cause permanent voice, swallowing, and breathing disabilities, early evaluation and treatment by an otolaryngologist or laryngologist (an otolaryngologist who specializes in the treatment of laryngeal and voice disorders) is imperative. It is essential for singing teachers to be familiar with these problems and their proper management. Symptoms and signs of voice-threatening, and even life-threatening, injuries maybe subtle and dismissed even by some physicians as insignificant. Even an injury caused by something as innocent as an arm or elbow striking the neck of a fellow actor, dancer, or singer during a theatrical performance can be disastrous unless recognized and treated promptly. Singing teachers are often the first professionals in a position to recognize the potential importance of such an apparently "minor" event.

Journal of Singing, September/October 2002
Volume 59, No. 1, pp. 41-47

LARYNGOTRACHEAL ANATOMY

The larynx is relatively protected from trauma by the overhang of the mandible (the jaw) above, the bony prominence of the clavicles (the collarbone) and sternal manubrium (the breast bone) below, and by the mass of the neck muscles on the sides. The framework (structure) of the larynx consists primarily of four cartilages, the thyroid, the cricoid, and the paired arytenoid cartilages. The thyroid cartilage is shaped like a shield and forms the protective casing for the vocal folds. The prominence of the thyroid

cartilage in the necks of men is often referred to as the "Adam's apple." The arytenoid cartilages sit on top of the cricoid cartilage in the back of the larynx and serve as points of attachment for the vocal folds. In the front of the larynx, the vocal folds attach to the inner aspect of the thyroid cartilage, and thus span the distance between the arytenoid and thyroid cartilages. The cricoid cartilage sits below the vocal folds and is shaped like a signet ring. The ring-like structure of the cricoid serves as a stent to help hold open the airway below the vocal folds. The trachea connects to the bottom portion of the cricoid cartilage and serves as the conduit for air to pass through the larynx to the lungs. The muscles of the vocal folds and the other muscles of voice production attach to the thyroid, cricoid, and arytenoid cartilages. If a normal voice is to be produced, each of these cartilages and muscles must function properly and lie in its correct anatomical location. Displaced fractures of the cartilages, tears in the vocal fold and/or laryngeal muscles, or dislocations of the arytenoids from their normal positions on the cricoid cartilage (cricoarytenoid dislocation) often result in hoarse or breathy voices and, occasionally, airway obstruction and breathing difficulties. Dislocation of a cricothyroid joint (the joint that connects the cricoid and thyroid cartilage) may result in loss of the ability to change pitch.'

ADULT LARYNGOTRACHEAL INJURIES FROM BLUNT TRAUMA

Laryngotracheal injuries are relatively rare in adults, except when there is a direct blow to the neck. In motor vehicle collisions, the typical victim of laryngotracheal trauma is an unbelted, front seat passenger or driver in a vehicle without protective air bags. Upon collision, the front seat passenger or driver is propelled forward with the neck in extension, eliminating the jaw as a protective shield. As the front of the neck hits the dashboard or steering wheel, the cartilages of the larynx are crushed against the spine of the neck.'" Lower impact, direct blows to the larynx can occur during athletic competition (such as playing basketball, hockey, or football); during dances, stage fights or other performance activities; while falling forward onto a blunt object such as the handle bars of a bicycle; with strangulation; or with hanging of the neck from a suspended rope or wire. Such forces also compress the larynx and trachea against the spine, resulting in injury.

The thyroid and cricoid cartilages interact dynamically to protect the airway from blunt injury' Forces to the front part of the larynx often are encountered first by the thyroid cartilage, which bends against the cervical (neck) spine on impact. The thyroid cartilage eventually reaches a point of maximal flexibility, and a fracture occurs often at or near the midline of the cartilage.

Vocal fold injuries result from vertical fractures of the thyroid cartilage. As the thyroid cartilage snaps back from its compression against the cervical spine, the thyroarytenoid muscle and ligament (which together comprise the vocal fold) may tear, resulting in a separation at any point along its length. This may be evident as lacerations or hemorrhage (bleeding) of one or both vocal folds. The mucosa (the lining tissue) on the arytenoids may be denuded or avulsed. Because of the traction on the arytenoids from the spring-like motion of the thyroid cartilage as it snaps back from the spine, the arytenoids may also become displaced from their joint space, resulting in cricoarytenoid dislocation. If one segment of the thyroid cartilage fails to return to its normal position, an overlapping fracture may occur, resulting in malposition of the vocal fold. All of these injuries will result in hoarseness that may not resolve unless the injured tissues and cartilages are repaired; and even then, some permanent voice deficit is common.

After the thyroid cartilage fractures, the force then impacts the cricoid ring, which was previously shielded by the thyroid cartilage. In a patient with a marked laryngeal prominence, multiple fractures of the thyroid cartilage may occur prior to the distribution of force onto the cricoid cartilage.' The cricoid has a relatively thin front arch that blends on the sides into a thicker, more sturdy cartilage. The thicker regions on the sides of the cricoid cartilage provide most of the support for this portion of the airway. Lower level impacts, such as elbow injuries to the neck, may result in cricothyroid joint injuries or in midline fractures of the cricoid. The airway is maintained by the thicker cartilage on the sides of the cricoid cartilage. With higher impact forces, secondary fractures can occur on the sides of the cricoid cartilage, resulting in airway collapse and possible injury to the recurrent laryngeal nerve (the nerve that supplies motor function to the vocal folds) due to impingement of the nerve by segments of fractured cartilage.

If the force is severe and/or low in the neck, complete separation of the larynx and trachea may occur.' This situation is potentially life-threatening and requires emergent medical care. Separation usually occurs below the cricoid cartilage, resulting in displacement of the trachea into the chest

and collapse of neck tissues into the airway, with consequent airway obstruction and difficulty breathing.[8]-[11] The neck muscles may serve as a temporary opening for air until edema (swelling) and hematoma formation (bleeding into the tissues) result in obstruction of this temporary airway.

PEDIATRIC LARYNGOTRACHEAL INJURIES FROM BLUNT TRAUMA

Fractures of the thyroid and cricoid cartilage from blunt trauma are uncommon in children. The greater elasticity of a child's cartilages makes them more resilient to external stresses. The child's larynx also sits higher in the neck than in the adult, and the jaw serves more effectively as a protective shield in the child than it does in the adult.[12] Children are more likely to sustain injuries that result in edema and hematoma formation in the larynx and trachea.[11"2] This is of particular concern in the child because the smaller diameter of the airway makes it more susceptible to breathing problems.

An individual who falls onto the handlebar of the bicycle may suffer an injury in which the cricoid cartilage is dislocated and pushed underneath the thyroid cartilage.[11-14] These "telescoping" injuries are more common in children. With more forceful blows, complete separation of the larynx and trachea may occur. The adolescent and young adult riding a snowmobile or an all-terrain vehicle may sustain a "clothes-line" type injury to the neck. Upon collision with a cable or wire, the cable presses the larynx and trachea against the cervical spine and can sever them.[14] These can be fatal injuries, especially when neck tissue collapse into the space between the severed segments of the airway. In addition, there may be an associated injury, and possibly transection, of both recurrent laryngeal nerves that are also compressed against the cervical spine during the injury.[11,14] This paralyzes both vocal folds so they cannot open to breathe; the resultant immobility of the vocal folds can also be devastating to the voice.

ASSESSMENT OF BLUNT INJURIES

Initial evaluation and assessment of the blunt trauma patient is similar for adults and children. It is important for the physician to understand the mechanism of injury. A high index of suspicion for blunt neck injury should be maintained in motor vehicle collisions, even without obvious external signs. Knowledge of the speed of the vehicle at the time of collision, the use of seat belts by the trauma victim, and the presence and deployment of air bags can also be helpful in estimating the amount of force involved. In the patient with short stature, the force of deceleration against a locking shoulder strap that is draped over the neck may also produce significant injury.

Medical assessment of the patient begins with evaluation and stabilization of the airway in those who are having or have the potential to develop difficulty breathing. In patients who have experienced lower impact blows to the neck and larynx, immediate evaluation and treatment are also necessary to assess for reparable injuries and to prevent late complications. Any patient with symptoms after blunt laryngeal trauma, regardless of how "minor" they may seem, should be evaluated within twenty-four hours of injury by an otolaryngologist or laryngologist. These physicians are specialty trained in the diagnosis and treatment of laryngeal injuries. The professional voice user with symptoms after laryngeal trauma should be particularly vigilant about seeking care from these specialists, as an injury that may not be recognized by other physicians can cause significant long-term voice disability.

Evaluation and Treatment of the Blunt Trauma Patient without Airway Distress

In the patient without immediate signs of upper airway compromise, evaluation proceeds with a complete evaluation, including examination of the neck, assessment of voice quality, and flexible fiberoptic evaluation of the larynx and upper airway. Fiberoptic laryngoscopy is a procedure that involves the placement of a thin, lighted, flexible telescope into the nose, from which the larynx can be evaluated. Fiberoptic laryngoscopy allows assessment of the mobility of the vocal folds, patency of the upper airway, and integrity of the laryngeal mucosa. If there is an adequate airway for breathing, intubation (placement of a breathing tube) is not necessary. Because of the potential for the development of worsening laryngeal edema and airway compromise, serial examinations of the airway should be performed during the first twenty-four to forty-eight hours after injury if intubation is initially deemed unnecessary; hospital admission is recommended in some cases.

Management is determined by the severity of the initial signs and symptoms." Patients with any sign of laryngeal injury (Table 1) should have a computed tomography (CT) scan of the larynx to evaluate for possible laryngeal framework injury.[13, 15, 16] CT of other head, neck, chest, and abdominal structures maybe appropriate as

Table 1. Signs and Symptoms of Laryngeal Injury

Hoarseness	Shortness of breath
Stridor (noisy breathing)	Laryngeal edema
Laryngeal hematoma	Air pockets underneath the neck skin
Laryngeal laceration	Neck pain/point laryngeal tenderness
Difficulty swallowing	Loss of laryngeal landmarks
Pain with swallowing or talking	Impaired vocal fold mobility
Cough productive of blood	Cricoarytenoid dislocation
Bruising of the neck	Exposed laryngeal cartilage

well, depending on the suspicion for or presence of other injuries. Fractures of the thyroid cartilage can be present with very mild laryngeal signs and should be evaluated. Often, hoarseness is the only sign of laryngeal fracture, especially with low-impact forces such as elbow injuries to the neck while playing basketball or blows to the neck from an overly playful toddler or dog. If left untreated, the hoarseness may become permanent; and the fractured larynx will heal, fusing the fractured segments into their new, malpositioned locations. Attempts at restoring the voice to normal after the fracture segments are healed are difficult and often less successful than repairs that are performed within one to two days of injury.

Fractures that appear unstable often will be evaluated further with direct laryngoscopy and surgical repair. Patients with minimally displaced fractures that are associated with significant laryngeal injuries also require direct laryngoscopy and repair. Direct laryngoscopy is a procedure performed in the operating room usually under general anesthesia during which a telescope that allows better examination of the larynx is placed through the mouth. Because of the high potential for concomitant cervical spine injuries, assessment of the cervical spine is always performed prior to operative intervention for the laryngeal injuries. The presence of a cervical spine injury may preclude the ability to perform a direct laryngoscopy. In these instances, surgical repair of the laryngeal injuries is begun based on findings on CT scan and fiberoptic laryngoscopy.

Patients without fractures on CT scanning and those with minimally displaced, stable fractures can be observed closely. Injuries that consist of isolated mucosal lacerations of the supraglottic larynx (the part of the larynx above the vocal folds), superficial lacerations that do not involve the vibrating edge of the true vocal fold, small hematomas of the true vocal fold, and/or mild mucosal edema may also be observed. Management of these patients includes the use of antibiotics, antireflux medications, antireflux behavioral modifications, voice rest, humidity, and frequent reexamination. Antireflux behavioral modifications include elevation of the head of the bed; avoidance of caffeine, tobacco products, dairy products, and citrus produce; and the avoidance of late meals and exercising too soon after meals. The use of antireflux medications and antireflux behavioral modifications help to limit additional inflammation and delays in wound healing caused by laryngopharyngeal reflux. Humidity helps to keep the vocal folds lubricated, which aids in the healing process. The benefit of steroids is controversial. The disadvantage of steroids is that they may interfere with and prolong the natural process of wound healing. The advantage of using steroids is that they may minimize the formation of scar tissue and decrease laryngeal swelling.[1,5,15,17,18] In the patient with mild to moderate mucosal edema, high-dose steroids are given during the first twenty-four to forty-eight hours to minimize acute mucosal swelling.

Evaluation and Treatment of the Blunt Trauma Patient with Airway Distress

Signs of upper airway distress include stridor (noisy breathing), shortness of breath, and labored breathing. These patients maybe very anxious, because the inability to breathe normally reduces the oxygen supply to the body and can sometimes produce a fear of suffocation. The patient should be examined for signs of injury. In the presence of immediate, post-traumatic airway distress, significant laryngotracheal injury is likely. The neck is stabilized to prevent worsening of unrecognized cervical spine injuries, and the airway is secured with a tracheotomy.[1,6,11,15-25] A tracheotomy is an operation that allows a breathing tube to be placed through the neck into the trachea. It allows unobstructed breathing in patients who have significant swelling in the parts of the airway above it. Orotracheal and/or nasotracheal intubation (placement of a breathing tube through the mouth or nose) in the presence of severe laryngotracheal trauma can lead to further laryngeal injury and airway compromise. These forms of intubation are avoided in favor of tracheotomy when intubation is needed. In addition, because the tracheotomy is placed below the vocal folds (instead of between them as is done with orotracheal and naso-

tracheal intubation), the risk of damage to the vocal folds from the tube is reduced.

Operative evaluation of the larynx with direct laryngoscopy is performed after securing the airway. If direct laryngoscopy reveals significant laryngeal injuries, surgical repair is performed. The presence of obvious laryngeal fractures is also an indication for surgical repair. If direct laryngoscopy does not reveal a need for surgery, then a postoperative CT scan of the larynx is obtained to complete the evaluation.

Intraoperative Evaluation

Intraoperative evaluation begins with direct laryngoscopy to assess the extent of endolaryngeal injury, esophagoscopy (examination of the esophagus through a telescope) to assess for esophageal lacerations, and bronchoscopy (examination of the trachea and bronchi of the lungs through a telescope) to assess for subglottic and tracheobronchial injuries. The arytenoid cartilages are palpated (felt) for possible dislocation. In the patient with isolated cricoarytenoid joint dislocation, reduction can usually be accomplished endoscopically (by operating through the laryngoscope), especially if the dislocation is noted early. With delays in diagnosis, scarring and stiffening of the joint can begin, making reduction more difficult and increasing the likelihood of a permanently hoarse voice. If no other injuries that require repair are noted on CT scan or on direct laryngoscopy, then open exploration is not necessary.

Surgical Repair

Surgery is performed to repair mucosal lacerations involving the anterior commissure (the junction of the vocal folds in the front of the larynx) and/or the vibratory edge of the vocal fold; to repair deep lacerations of the vocal fold muscle; to restore the mucosal cover over exposed cartilage; to reposition the vocal fold; to reposition herniated tissue above the vocal folds; to reconnect separated segments of the vocal folds; to reconnect separated segments of larynx and trachea; and to repair displaced and/or unstable fractures. If not previously done, tracheotomy is performed to allow intraoperative access to the larynx and postoperative airway management.

Principles of Repair

The basic principles of repair follow the primary principles of wound healing elsewhere in the body. Repair within the first twenty-four hours after injury is most desirable to pre-vent scar tissue formation from occur-ring prior to closure."' An attempt is made to repair all mucosal lacerations and defects to prevent scar formation. The formation of scar tissue may result in vibratory dysfunction of the vocal folds, stenosis, or webbing (scar tissue that forms bands connecting the vocal folds).

Endolaryngeal Stenting

After all mucosal injuries are repaired, a decision is made regarding the necessity for an endolaryngeal stent, a spacer placed within the larynx to hold the vocal folds in position and keep them from scarring to each other. Endolaryngeal stents were developed originally to help keep the airway open. However, these have fallen out of favor for routine use in the last twenty-five years because of their propensity to move within the larynx. This movement may cause friction on the repaired mucosa, which promotes scar tissue formation.[26] Endolaryngeal stents are reserved for patients with severely comminuted fractures (crushing injuries) that are not amenable to routine external fixation, extensive lacerations of mucosa within the larynx that are not amenable to repair of at least one side, and/or mucosal injury in the region of the anterior commissure. In these situations, stenting is helpful in providing internal fixation and in minimizing webbing, especially at the anterior commissure.[15,17] Stents are removed in seven to fourteen days.

Laryngeal Fixation

Reduction and fixation of the cartilaginous framework is performed after all mucosal injuries have been addressed. If a stent is deemed necessary, it is placed prior to repair of the framework injuries. The fractures are reduced (placed back to their normal positions) and fixated (secured) to ensure a stable reduction. Tradition-ally, stabilization has been achieved using stainless steel wire or nonabsorbable suture. However, because these provide only two-dimensional fixation, there can be some movement of the laryngeal fragments with head turning, neck flexion, and swallowing. Movement of the fracture segments can delay the healing process and sometimes can result in malposition of the healing segments. The recent availability of titanium and absorbable miniplates, which are tiny plates and screws similar to the ones that are used to repair broken bones elsewhere in the body, has allowed more rigid fixation of the laryngeal framework in three-dimensional planes. This has the advantage over wire or suture fixation in that it allows for immediate immobilization of the fracture segments, can be used effectively in most comminuted (splintered) fractures, and can decrease the need for endolaryngeal stenting.[27,28] The miniplates can be bent to con-

form to the geometry of the laryngeal framework, thus preserving the shape of the larynx. Usually, low-profile (thin) plates provide adequate fixation of the laryngeal framework and are not noticeable under the skin.

Recurrent Laryngeal Nerve Repair

Laryngotracheal separation injuries maybe accompanied by unilateral or bilateral recurrent laryngeal nerve injuries. The superior laryngeal nerves also can be injured. An attempt should be made to locate the nerves if the vocal folds exhibit evidence of immobility preoperatively. Crushed or otherwise damaged but intact nerves should be left alone to regenerate on their own. If a severed nerve is found, the severed ends are reconnected either to each other or to undamaged nerves nearby. If no repair is per-formed, the vocal folds will be paralyzed and unable to move, and usually the voice will be permanently breathy and hoarse. Although recurrent laryngeal nerve repair is unlikely to restore full function to the vocal fold, it should provide enough tone to the vocal fold muscle for long-term vocalization purposes.[29,30] Surgery to "fine-tune" the voice can be performed one year later, after the nerve has had a chance to regenerate.

POSTOPERATIVE MANAGEMENT

The goal of postoperative management is to promote wound healing and to limit scar tissue formation. Patients who undergo mucosal repair of the vocal folds should exercise strict voice rest for the first few days to a week after surgery to allow the initial phases of wound healing to occur. Occasionally, a small flexible feeding tube is placed through the nose and into the stomach to allow tube feedings in the early postoperative period. All patients with mucosal injuries are placed on an aggressive antireflux protocol, even in the absence of a history of gastro-esophageal reflux, to minimize delays in wound healing associated with reflux induced laryngeal injury.[31] Antibiotics are given to patients with open cartilage wounds to minimize the risk of laryngeal cartilage infection.

CONCLUSION

Blunt injury to the laryngotracheal complex can result from motor vehicle accidents, bicycle accidents, all-terrain vehicle accidents, contact sports, stage performance, strangulation, and hanging injuries. The primary concern in the initial management of these injuries is the establishment and maintenance of an adequate airway for breathing; however, even the patient with "minor" symptoms, such as hoarseness, should be evaluated, as these patients may also have laryngeal fractures or soft tissue injuries of the larynx that require repair. If injuries are found, repair should be completed as soon as possible to limit permanent disabilities related to the voice, swallowing, and breathing. Usually, injuries to the larynx and trachea are best evaluated and treated by otolaryngologists or laryngologists, as other physicians are not as familiar with the intricacies involved in the assessment, diagnosis, and treatment of such injuries. Reconstruction of the normal anatomical relationships of the larynx and trachea is performed, as needed, in an attempt to restore the normal phonatory, respiratory, and protective functions of the larynx. Singing teachers should be familiar with these principles and problems since even good doctors sometimes regard post-traumatic hoarseness as "minor." Recognizing the need for prompt, expert evaluation and referring a vocalist appropriately may save a voice and a life.

Notes

1. S. D. Schaefer, "The Treatment of Acute External Laryngeal Injuries,"*Archives of Otolaryngology Head and Neck Surgery* 117 (1991): *35-39.*

2. G. D. Gussack, G. J. Jurkovich, and A. Luterman, Laryngotracheal Trauma: A Protocol Approach to a Rare Injury," *Laryngoscope 96* (1986): *660-665.*

3. B. *S.* Jewett, *W. W.* Shockley, and R. Rutledge, "External Laryngeal Trauma Analysis of *392* Patients," *Archives of Otolaryngology Head and Neck Surgery* 125 *(1999): 877-880.*

4. G. Minard, K. A. Kudsk, M. A. Croce, J. A. Butts, R. S. Cicala, and T. C. Fabian, "Laryngotracheal Trauma," *American Surgeon 58* (1992): 181-187.

5. R. T. Sataloff, "Structural Abnormalities of the Larynx," in R. T. Sataloff, ed., *Professional Voice: The Science and Art of Clinical Care,* second edition (San Diego: Singular Publishing Group, Inc., 1997), *537.*

6. *C.* L. Pennington, "External Trauma of the Larynx and Trachea: Immediate Treatment and Management," *Annals-of Otolaryngology, Rhinology, and Laryngology* 81 (1972): 546-554.

7. L. *W.* Travis, N. R. Olson, J. *W.* Melvin, and J. G. Snyder, "Static and Dynamic Impact Trauma of the Human Larynx," *American Academy of Ophthomology and Otolaryngology 80 (1975): 382-390.*

8. D. G. Ashbaugh, and J. H. Gordon, "Traumatic Avulsion of the Trachea Associated with Cricoid Fracture,"*Journal of Thoracic and Cardiovascular Surgery 69* (1975): *800-803.*

9. S. M. Gold, M. E. Gerber, S. R. Shott, and C. M. Meyer III, "Blunt Laryngotracheal Trauma in Children," *Archives of Otolaryngology Head and Neck Surgery* 123 (1997): 83-87.

10. D. P. Bryce, "Current Management of Laryngotracheal Injury," *Advances in Otology, Rhinoscopy, Laryngology* 29 (1983): 27-38.

11. H. R. Ford, M. J. Gardner, and J. M. Lynch, "Laryngotracheal Disruption from Blunt Pediatric Neck Injuries: Impact of Early Recognition and Intervention on Outcome," *Journal of Pediatric Surgery* 30 (1995): 331-334.

12. C. M. Meyer III, P. Orobello, R. T. Cotton, and G. O. Bratcher, "Blunt Laryngeal Trauma in Children," *Laryngoscope 97* (1987): 1043-1048.

13. C. J. Offia, and D. Endres, "Isolated Laryngotracheal Separation Following Blunt Trauma to the Neck,"Journal *of Laryngology and Otolaryngology* 111 (1997): 1079-1081.

14. W. A. Alonso, V. G. Caruso, and E. A. Roncace, "Minibikes, a New Factor in Laryngotracheal Trauma," *Annals of Otolaryngology, Rhinology, and Laryngology* 81 (1973): 800-804.

15. S. D. Schaefer, and L. G. Close, "Acute Management of Laryngeal Trauma. Update," *Annals of Otolaryngology, Rhinology, and Laryngology* 98 (1989): 98-104.

16. J. A. Schild, and E. C. Denneny, "Evaluation and Treatment of Acute Laryngeal Fractures," *Head and Neck* 11 (1989): 491-496.

17. N. R. Olson, "Surgical Treatment of Acute Blunt Laryngeal Injuries," *Annals of Otolaryngology, Rhinology, and Laryngology* ***87*** **(1978):** 716-721.

18. E. Lucente, M. Mitrani, S. H. Sacks, and H. F. Biller, "Penetrating Injuries of the Larynx," *Ear Nose Throat* ***Journal 64*** **(1985): 406-415.**

19. J. B. Bent, J. R. Silver, and E. S. Proubsky, "Acute Laryngeal Trauma: A Review of 77 Patients," *Archives of Otolaryngology Head and Neck Surgery* 109 (1993): 441-449.

20. C. P. Reece, and C. H. Shatney, "Blunt Injuries to the Cervical Trachea: Review of 51 Patients," *Southern Medical Journal* 81 (1988): 1542-1547.

21. P. L. Chodosh, "Cricoid Fracture with Tracheal Avulsion," *Archives of Otolaryngology Head and Neck Surgery 87* (1968): 461-467.

22. H. H. Harris, "Management of Injuries to the Larynx and Trachea," *Laryngoscope 82* (1972): 1924-1929.

23. J. Ogura, "Management of Traumatic Injuries of the Larynx and Trachea Including *Stenosis,"Journal ofLaryngology and Otolaryngology* 85 (1971): 1259-1261.

24. T. H. Trone, S. D. Schaefer, and H. M. Carder, "Blunt and Penetrating Laryngeal Trauma: A 13 Year Review," *Archives of Otolaryngology Head and Neck Surgery* 88 (1980): 257-261.

25. G. M. Fuhrman, F. H. Stieg, and C. A. Buerk, "Blunt Laryngeal Trauma: Classification and Management Protocol," *Journal of Trauma* 30 (1990): 87-92.

26. G. D. Thomas, and M. H. Stevens, "Stenting in Experimental Laryngeal Injuries," *Archives of Otolaryngology Head and Neck Surgery* 101 (1975): 217-221.

27. P. Woo, and R. Kellman, "Laryngeal Framework Reconstruction with Miniplates: Indications and Extended Indications in 27 Cases," *Operative Techniques Otolaryngological Head Neck Surgery 3* (1972): 159-164.

28. P. Woo, "Laryngeal Framework Reconstruction with Miniplates," *Annals of Otolaryngology, Rhinology, and Laryngology* 99 (1990): 772-777.

29. R. L Crumley, "Teflon Versus Thyroplasty Versus Nerve Transfer: A Comparison," *Annals of Otolaryngology, Rhinology, and Laryngology* 99 (1990): 759-763.

30. R. L. Crumley, "Update: Ansa Cervicalis to Recurrent Laryngeal Nerve Anastomosis for Unilateral Laryngeal Paralysis," *Laryngoscope* 101 (1991): 384-388.

31. F. B. Little, J. A. Kaufman, R I. Kohut, and R. B. Marshall, "Effects of Gastric Acid on the Pathogenesis of Sublottic Stenosis," *Annals of Otolaryngology, Rhinology, and Laryngology* 94 (1985): 516-519.

Yolanda D. Heman-Ackah, MD, is Assistant Professor of Laryngology and Professional Voice Care in the Department of Otolaryngology—Head and Neck Surgery at the University of Illinois at Chicago. She is the director and founder of the Voice Center at the University of Illinois at Chicago. She has authored and coauthored numerous publications in the fields of laryngology and professional voice care, including award-winning scientific journal articles, book chapters, and a book.

Robert Thayer Sataloff, MD, DMA, is professor of Otolaryngology—Head and Neck Surgery, Thomas Jefferson University; Chairman, Department of Otolaryngology —Head and Neck Surgery, Graduate Hospital; Adjunct Professor, Department of Otorhinolaryngology, University of Pennsylvania; Adjunct Professor, Department of Otolaryngology—Head and Neck Surgery, Georgetown University School of Medicine; Chairman, The Voice Foundation; Chairman, The American Institute for Voice and Ear Research. He has authored more than 500 publications, including twenty books.