Introduction

External laryngeal trauma is a relatively uncommon injury estimated at approximately 1 in every 30,000 emergency room visits. This is fortunate because injury to the larynx can result in serious airway problems and impaired voice production if not diagnosed promptly. The initial concern with acute laryngeal trauma is securing the airway. Vocal function, while certainly of secondary importance in terms of preservation of life, is often determined by the effectiveness of the initial management. Therefore, it is imperative that the otolaryngologist be familiar with the diagnosis and treatment of this rare, but very serious type of injury.

Anatomy and Physiology

Fortunately the larynx is well protected by the mandible, the sternum and the flexion mechanism of the neck. The primary functions of the larynx are to provide an airway, protect the lower respiratory tract, and produce the voice. The larynx can be divided into three areas: supraglottis, glottis and subglottis. Support is maintained by the hyoid bone, thyroid cartilage and cricoid cartilage. The supraglottis is less dependent on external support and contains abundant soft tissue and redundant mucosa. The glottis relies heavily on external support and the coordination of cricoarytenoid mobility and neuromuscular activity to support the airway and provide phonation. In the adult, the airway is narrowest at the glottis. Therefore, injury at this level may seriously compromise airway support. The subglottis is supported by the only circular cartilage in the larynx, the cricoid, which is the narrowest point of the neonatal and infant airways.

Mechanism of Injury

The type of injury can be classified as either blunt or penetrating. Blunt injuries are commonly the result of motor vehicle crashes. The laryngeal skeleton is compressed between a foreign object (i.e., steering wheel or dashboard) and the anterior aspect of the cervical spine. This splays the alae of the thyroid cartilage and with enough force, may fracture the cartilage.
often in a vertical median or paramedian nature. Other types of blunt trauma include sports related injury, strangulation, assaults or the clothesline injury associated with snowmobiles or all terrain vehicles. The force of the injury can cause significant soft tissue and/or cartilage disruption with minimal external signs of trauma. Blunt trauma may also cause dislocation of the cricoarytenoid joint or damage to the recurrent laryngeal nerves with resultant impaired vocal cord mobility.

Penetrating trauma to the larynx may occur secondary to knife or bullet wounds. The extent of injury varies with the type of assault weapon, and it is important to realize that other associated injuries, such as neurological, vascular, or esophageal, are more common in these situations.

**Initial Evaluation**

Initial management should follow ATLS principles. Securing an airway takes precedence over other problems. Injury to the cervical spine should be suspected in these patients until proven otherwise. There is some controversy over airway management in these patients, but most authors recommend tracheotomy under local anesthesia for patients exhibiting respiratory distress. Attempts at oral or nasotracheal intubations in these patients may result in further damage to an already tenuous airway. Cricothyroidotomies should be avoided in the setting of laryngeal trauma as this may contribute to further injury. Special considerations exist in the pediatric patient population. Due to the smaller dimensions of the pediatric airway and potential for soft swelling edema with laryngeal trauma, it is recommended that they undergo tracheotomy over a ventilating bronchoscope in the operating room. In patients with no acute breathing difficulties, a detailed history and careful physical examination can be obtained.

Presenting symptoms of laryngeal trauma may include a change in the quality of voice, pain, dysphagia, odynophagia, hemoptysis and/or stridor. Inability to tolerate the supine position is a concerning symptom with regard to airway stability. Schaefer reports that the symptom correlating with the most severe injury is impaired respiration. Fuhrman, et al., reports the most reliable symptom as hoarseness, subcutaneous emphysema and hemoptysis. The most reliable symptoms reported by Fuhrman were tenderness and subcutaneous emphysema. Other physical exam findings, such as anterior neck contusion and tracheal deviation may also occur. Associated injuries including cervical spine, esophageal and vascular injuries must be considered and evaluated.

In stable patients, flexible fiberoptic laryngoscopy in the emergency room should be performed. CT scan, direct laryngoscopy, bronchoscopy and esophagoscopy are used selectively based on initial fiberoptic exam findings. It has become increasingly important to categorize patients by the severity of trauma according to fiberoptic exam and CT findings in order to aid with the management of their injuries. Suggested protocols for treatment are offered by categorization into four groups established by Schaefer and Close with the addition of a fifth group for cricotracheal separation by Fuhrman et al.
Laryngotracheal Injury Classification

Group I injuries include minor endolaryngeal hematoma, edema or laceration without detectable fracture. Group II injuries have edema, hematoma, minor mucosal disruption without exposed cartilage, and nondisplaced fractures noted on CT scan. Massive edema, mucosal disruption, displaced fractures, exposed cartilage and/or cord immobility qualify as Group III injuries. Group IV injury is the same as group III with the addition of two or more fracture lines, skeletal instability or significant anterior commissure trauma. The group V category includes complete laryngotracheal separation.

Radiologic evaluation

In the stable patient, after the airway has been evaluated, a CT scan of the larynx can be obtained. A CT scan is not necessary in a patient presenting with clear indications for surgery, such as active bleeding, hemoptysis, need for emergent surgical airway, exposed cartilage and significant lacerations on laryngoscopy, or air escaping through the neck wound. Conversely, patients with minimal trauma and a normal exam will not likely benefit from a CT scan of the larynx. In patients with significant laryngeal trauma and intermediate exam findings, CT scanning should be performed to determine the integrity of the laryngeal framework. It should be noted that some authors routinely obtain CT scans even for severe trauma before proceeding to the operating room as a “roadmap” of the patient’s injuries. The entire cervical spine should be evaluated radiographically. Angiography and Gastrografin esophagrams may be indicated in selected cases, especially in the event of significant penetrating trauma to the area.

Nonsurgical Management

Laryngeal injuries may be treated medically or surgically depending on initial fiberoptic laryngoscopic and CT scan findings. A patient can be treated medically with close observation if the injury will resolve without surgical intervention and the airway is stable. Group I injuries can be safely managed with a minimum of 24 hours of close observation, head of bed elevation, voice rest and humidification of inspired air. Antibiotics are recommended with disruption of the laryngeal mucosa. Treatment with anti-reflux medication is also initiated. Although not proven, systemic steroids are often given to reduce laryngeal edema. Nasogastric tube feedings should be considered if significant mucosal lacerations are present. Serial flexible fiberoptic examinations should be performed to evaluate the airway and healing prior to discharge.

Surgical Management

The indications for surgical management may range from the need to establish an airway to open reduction and internal fixation of laryngoskeletal fractures. Penetrating traumas are more likely to require open exploration than blunt traumas. Group II through group V patients will usually require some form of surgical intervention. Surgical options fall into one of three categories: endoscopy alone, endoscopy with exploration, and endoscopy with exploration and stenting. If there is any doubt about the extent of injury endoscopy should be performed. Indications for surgical exploration include: large mucosal lacerations, exposed cartilage, multiple or displaced cartilaginous fractures, vocal cord immobility, fractured cricoid, disruption of the cricoarytenoid joint, and lacerations involving the free margin of the vocal cord or anterior...
commisure. A vertically oriented fracture of the median or paramedian thyroid ala may significantly alter the stability of the laryngeal skeleton and usually necessitates ORIF. Tracheotomy should be performed in patients with injuries of this extent and should be lower than usual (fourth to fifth ring) via a vertical incision (better exposure in the case of laryngotracheal separation).

When laryngeal exploration is indicated, it should be performed within 24 hours of the injury in order to maximize airway and phonation results. A horizontal skin incision is made at the level of the cricothyroid membrane and subplatysmal flaps are elevated. The strap muscles are then divided in the midline and the laryngeal skeleton is exposed. The larynx can then be explored via a midline thyrotomy or via a vertical fracture within 2 to 3 mm of the midline. The thyroid laminae are retracted laterally to visualize the endolarynx. All exposed cartilaginous and submucosal tissues are then covered with mucosa working posteriorly to anteriorly. Primary closure is almost always possible and debridement should be minimized. Closure is performed with absorbable suture with knots outside the laryngeal lumen to prevent granulation. Displaced arytenoid cartilages should be reduced. The anterior commissure should be reconstituted by using 4.0 sutures to suspend the anterior true vocal cords to the outer perichondrium of the thyroid cartilage. The thyrotomy can then be reapproximated with nonabsorbable suture, wire or rigid miniplates.

Fractures of the cartilages are reduced and can be stabilized using a variety of materials, including stainless steel wires, nonabsorbable suture, and miniplates. If the fracture is comminuted, small fragments of cartilage with no intact perichondrium are removed to prevent chondritis. Adaptation miniplates have the theoretical advantage of immediate stability of the larynx (less need for endolaryngeal stenting), ability to bridge large gaps (comminuted fractures), and easier restoration of the preinjury geometry of the laryngeal framework.

Endolaryngeal stenting is reserved for wounds involving disruption of the anterior commissure, massive mucosal injuries and comminuted fractures of the laryngeal skeleton. Stenting reestablishes the normal scaphoid shape of the anterior commissure, stabilizes severely comminuted fractures and prevents web formation and stenosis. A variety of stents can be used including a shortened Portex endotracheal tube, manufactured silastic stents, or a finger cot filled with sponge rubber. Stents should reach from the false cords to the first tracheal ring and conform to the shape of the endolarynx. The stent should be stabilized within the larynx and allow movement with the larynx during swallowing. A heavy, nonabsorbable suture is passed through the stent and larynx at the ventricle and another at the cricothyroid membrane and tied over buttons outside the skin. The stent should not be left longer than 2 to 3 weeks. Removal is performed under general anesthesia with endoscopy and additional procedures for removal of granulation tissue as necessary.

The unique injury of laryngotracheal separation usually results in immediate death. Occasionally the airway may maintain patency with an intact mucosal layer. Although successful intubation attempts with bronchoscopy have been reported, it is usually more safely managed by emergent tracheotomy. Bilateral recurrent laryngeal nerve injury and subglottic stenosis are common with this injury. Surgical repair requires permanent sutures between the cricoid and second tracheal ring for airway support. This may be difficult with concomitant cricoid fracture after internal fixation.
Severe wounds involving extensive tissue and framework loss of the supraglottic or hemilarynx can be managed using various partial laryngectomy procedures to restore function. Total laryngectomy is a last resort and is reserved for situations where the basic elements of the laryngeal skeleton and investing soft tissue are not usable for repair.

Outcomes

The ultimate quality of airway, voice and swallowing are important considerations following repair of external laryngeal trauma. Airway status is poor if the patient remains cannulated, fair with mild aspiration or exercise intolerance and good if it resembles preinjury status. Voice can be considered poor if it represents aphonia or whisper, fair if it is functional but changed (hoarse), and good if normal. Swallowing function is either normal or abnormal from the subjective reports of the patient. Generally, conservatively managed injuries fare better than surgical ones in large part due to the differences in severity of the initial insult. The use of endolaryngeal stents tends to decrease the quality of voice without affecting the overall airway status. Also, the less time the stent is left in place, the more favorable the result. Vocal cord paralysis adversely affects outcomes with regard to both airway and voice. Improved results are also shown with the earlier the timing of the repair (less than 48 hours from injury being significant).

Conclusion

External laryngeal trauma is a rare injury that can be managed in a systematic fashion. Early recognition is important for both initial preservation of life as well as long-term airway and vocal function. The signs and symptoms hoarseness, subcutaneous emphysema, and pain with a history of laryngeal trauma should prompt a timely evaluation of the larynx and airway support. Flexible fiberoptic laryngoscopy followed by CT scans and surgical procedures as deemed necessary are standard in the initial evaluation. Associated cervical spine, vascular and esophageal injuries should be excluded. Treatment, either medical or surgical (with/without stenting) is based on the site and extent of injury.

Bibliography


