TITLE: Laryngeal Trauma
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Introduction

Blunt and penetrating injury to the anterior neck may produce life-threatening injuries involving airway, major vascular structures, the cervical esophagus and the cervical spine. Along with cervical spine immobilization, airway injuries take paramount in the assessment and management of the acute trauma patient. Although many associated injuries may appear more impressive, correct management of the neck injury with immediate attention to securing the airway is always the first priority. Acute laryngotracheal trauma is uncommon presenting acutely to the otolaryngologist. This is because (1) the injury is uncommon due to protection of the larynx superiorly by the mandible (particularly when the head is flexed), inferiorly by the sternum and laterally by the sternomastoid muscle; (2) when such an injury occurs, it is not infrequently associated with multiple other life-threatening injuries, associated loss of airway and immediate death at the accident scene may ensue; (3) when such patients arrive in casualty they are often acutely managed by a Trauma team.

Although these injuries are rare, occurring in one percent of patients sustaining blunt neck trauma and account for approximately 1 in every 30,000 emergency room visits, their initial management has a tremendous impact on the immediate probability of survival of the patient and the patient's long-term quality of life.. In penetrating trauma to the neck, especially zone II, laryngotracheal injuries are seen in 31 to 69 percent of patients. Although these injuries are rare, their initial management has a tremendous impact on the immediate probability of survival of the patient and the patient's long-term quality of life. Vocal dysfunction, while certainly of secondary importance in terms of preservation of life, could be a consequence of ineffective of the initial management of laryngotracheal injuries.

Laryngeal embryology

The larynx develops from the fourth and fifth branchial arches. At the third week of gestation, the respiratory primordium is derived from the primitive foregut to later form the lung

bud and later the bronchial bud which will eventually develop into the tracheobronchial tree. At the fourth and fifth week of gestation the tracheoesophageal folds fuse to form the tracheoesophageal septum leading to the separation of the tracheal airway lumen from the esophageal digestive tract.

The laryngotracheal groove is the primitive opening of the larynx during development. This structure will develop into the primitive laryngeal aditus which is formed by three eminences. The hypobranchial eminence is the most cephalad of these structures and will later develop into the epiglottis. The other two eminences will form the arythenoid cartilages. The laryngeal lumen obliterates and later recanalyzes by the tenth week of gestation.

There are certain difference between the adult and the newborn larynx. The diameter of the subglottic and glottis are narrower which leads to increased propensity for airway obstruction and compromise. In the infant the narrowest portion of the airway is the subglottis in contrast to the glottis in the child and adult. The subglottic region is about 4 to 5 millimeters in diameter. The epiglottis is also narrower in infants and is tubular and omega in shape. The larynx lies at the level of the fourth cervical vertebrae at birth. By fifteen years of age it descends to the level of the six to seventh vertebrae. Blunt laryngotracheal injury is uncommon in the pediatric population because the mandible, the elasticity of the cartilaginous support of the airway, and the mobility of the supporting tissues collectively act to protect the laryngotrachea.

Laryngeal Anatomy

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.

The anatomy of the larynx and the relation to adjacent structures are key to the rarity of injury. The inferior projection of the mandible affords significant protection from anterior blows. Inferiorly the larynx is protected by the sternum and laterally by the sternomastoid muscle. Posteriorly, the larynx is protected by the cervical spine.

Laryngeal Function

The larynx has an array of functions including breathing passage, airway protection, clearance of secretions, and vocalization. To maintain these functions, the skeletal framework and its underlying soft tissue must be intact. The framework includes the thyroid cartilage, cricoid cartilage and the tracheal rings. In laryngeal injuries, symptoms are commonly direct manifestation of the malfunction of the coordinated activities within the larynx. Reduction in the size of the laryngeal airway can produce symptoms of airway obstruction ranging from mild stridor, to increased work of breathing associated to retractions, nasal flaring and tachypnea, apnea, cyanosis and even sudden death.

Damage to the cricoarytenoid joint or damage to the recurrent laryngeal nerves with resultant impaired vocal cord mobility may lead to aspiration and dysphonia. These symptoms persist after resolution of acute life threatening period affecting the patient's long-term quality of life.

Mechanism of Injury

The mechanisms of laryngeal injury can be divided into blunt trauma, including clothesline, crushing, and strangulation injuries; penetrating trauma; inhalation injuries; and injuries caused by caustic ingestions.

Anterior blunt injuries are most commonly the result of motor vehicle accidents. This can be a car driver, which on forward thrust during rapid deceleration the neck is extended impacting against the steering wheel. The laryngeal skeleton is compressed between a foreign object (i.e., steering wheel or dashboard) and the anterior aspect of the cervical spine. Hyperextension of the neck removes the mandibular barrier, exposing the larynx to anterior crushing forces. With the increasing use of seatbelts and airbags, the number of laryngeal fractures arising from motor vehicle accidents is likely to decrease, although seat belt harness and air bags injuries of the larynx have been described. Blunt pediatric neck injuries are more often life-threatening, because relatively minor direct trauma to the larynx or trachea may result in significant injury, including laryngotracheal disruption. . Also, the relative smaller cross-sectional area of the pediatric population predisposed them to higher risk of airway compromised.

Other less common blunt injuries can be caused by the motorcyclist or snowmobile who suddenly encounters a fixed horizontal barrier at the level of the neck suffering a clothes-line type injury. This type of injury imparts a large amount of energy over a relatively small area, resulting in massive trauma and a high probability of sudden death by crushing the larynx or separating the cricoid from the larynx or trachea. Assault accounts for a small proportion of cases. Strangulation by assault or during a suicidal attempt may lead to immediate airway obstruction or delayed laryngeal with airway compromised.

Sport-related injuries occur most frequently in high velocity sports such as cycling, motorcycle racing and ice hockey or in the martial arts. The incidence is dependent on the popularity of the particular sport.

Penetrating trauma to the larynx most commonly occur secondary to knife or bullet wounds. In gunshot wounds, the extent of injury could be the result of direct penetration or indirectly by the blast effect which varies with the type of assault weapon.

Initial Evaluation

Initial management should follow ATLS principles. Securing an airway takes precedence over other problems and injury to the cervical spine is assumed until proven otherwise. In laryngeal trauma there is controversy about the method of securing the airway. The American College of Surgeons recommends an attempt at intubation, failing which an emergency tracheostomy should be performed. However, Schaefer has stated that intubation following laryngeal trauma is hazardous. Most authors recommend tracheotomy under local anesthesia for

patients exhibiting respiratory distress. Intubation is often impossible to perform in severe trauma, due to swelling and bleeding. It may also worsen a preexisting injury, possibly causing further tears or cricotracheal separation. Even among those who suggest intubation as the initial method of airway control, it is emphasized that it should be done by an experienced physician(Hwang 2004). 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. The option of local tracheotomy is not feasible in a frightened, injured child. The time margin of error is also less because the arterial oxygen saturation drops more quickly than in an adult. In this instance, rigid bronchoscopy is performed to secure the airway under direct visualization. A tracheotomy can then be performed over the bronchoscope.

In patients with no acute breathing difficulties, a detailed history and careful physical examination can be obtained. Observation without tracheotomy or endotracheal intubation may be indicated.

Diagnosis

Presenting symptoms of laryngeal trauma may include a change in the quality of voice, pain, dyspnea, Subcutaneous emphysema, dysphagia, odynophagia, hemoptysis and/or stridor. Inability to tolerate the supine position is a concerning symptom with regard to airway stability. On physical exam the vitals signs including respiratory rate and saturations are closely monitored. The skin of the neck may reveal contusions or abrasions in blunt trauma or a line pattern indicative of a strangulation injury. Some obvious signs of injury are tracheal deviation, open wound with air bubbles or tracheal cartilage. Any penetrating injury is examined for an entrance and exit wound, and the most likely path of travel of the projectile is determined. Open wounds are not explored with instruments, nor are they probed for fear of dislodging a hematoma and initiating further bleeding.

In stable patients, flexible fiberoptic laryngoscopy in the emergency room should be performed. CT scan, direct laryngoscopy, bronchoscopy and esophagosopy 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. CT allows evaluation of the laryngeal skeletal framework in a noninvasive manner, thus avoiding unnecessary operative explorations by selecting patients who should do well without surgical intervention. Optimal imaging is performed using spiral technique and subsecond scan times, particularly when using two-dimensional sections for multiple projections or three-dimensional reconstructions. CT should be reserved for patients in whom laryngeal injury is suspected by history and physical examination without obvious surgical indications.

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.

Medical Management

The purpose of the extensive physical and radiologic evaluation is to identify the patients with injury and to select patients who are likely to do well without surgical intervention. 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. 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. Although not proven, early systemic steroids therapy are often given to reduce laryngeal edema. There was one randomized controlled trial on the use of intravenous dexamethasone in preventing traumatic laryngeal edema in pediatric bronchoscopy. This study showed no reduction in postbronchoscopy laryngeal oedema with the use of intravenous dexamethasone.

Surgical Management

The principles of surgery are hemostasis, evacuation of hematoma, reconstruction of the laryngeal framework and coverage of de-epithelialized surfaces. 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.

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 to the level of the hyoid superiorly and sternal notch inferiorly. The larynx can then be explored via a midline thyrotomy or via a vertical fracture within 2 to 3 mm of the midline. Simple nondisplaced fractures can be repaired by suturing the outer perichondrium with nonabsorbable sutures. Primary closure is almost always possible and debridement should be minimized. All mucosal lacerations are meticulously repaired using fine absorbable sutures. Closure is performed 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. 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. The thyrotomy can then be reapproximated with nonabsorbable suture, wire or rigid miniplates.

There may be a need for endolaryngeal stenting. Stents that have reportedly been used include cut portions of an endotracheal tube as well as finger cots filled with gauze or foam to commercially manufactured polymeric silicone stents. 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. The stent should extend from the false vocal fold to the first tracheal ring to add stability and prevent endolaryngeal adhesions. The stent should be secured in such a manner as to be easily removed using endoscopic techniques. The stents should be removed in a period of 10 to 14 days to prevent mucosal damage, even in the case of severe injury.

In the case of laryngotracheal separation, surgical repair requires permanent sutures between the cricoid and second tracheal ring for airway support. Bilateral recurrent laryngeal nerve injury and subglottic stenosis are common with this injury. If the recurrent laryngeal nerve is severed by the injury, a neurorrhaphy of the severed ends should be performed.

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 outcome after laryngeal trauma depends on the extent of the original injury and the quality of subsequent repairs. 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. 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

Although laryngeal trauma is an uncommon injury, it is life-threatening. Recognizing any airway compromise and need for immediate intervention could prevent immediate death as well as acute and long term morbidity. Initial management should follow ATLS principles. In laryngeal trauma there is controversy about the most appropriate method of securing the airway in certain scenarios, but most authors agree that tracheotomy should be performed on patients exhibiting respiratory distress. In patients with no acute breathing difficulties, a detailed history, careful physical examination and appropriate diagnostic tools should be use to differentiate the need for medical from surgical management.

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