Chapter 101: Laryngeal and Esopheageal Trauma

Phillip M. Brown, Steven D. Schaefer

Within the neck are contained all elements necessary to connect and coordinate the function of the head with the rest of the body. Injury to the neck may disrupt any of these vital functions and may involve bony, soft tissue, vascular, and central nervous system elements. Although other associated injuries may appear more impressive, correct treatment of the neck injury with securing of the airway should always remain a first priority. A multidisciplinary approach is very useful, because each member of the team contributes expertise in a particular area.

This chapter addresses the management of nonvascular soft tissue injuries of the neck, primarily laryngeal trauma. Experience in managing laryngeal trauma is limited because of the rarity of this injury. External laryngeal trauma accounts for only 1 in 30.000 emergency room visits (Schaefer and Close, 1989). Iatrogenic laryngeal injury conversely is becoming more frequent with the increased incidence of long-term endotracheal intubation. Although these injuries are rare, their initial management has a tremendous impact on both the immediate probability of survival of the patient and the long-term quality of life of the patient.

Mechanisms of Injury

Injury to the larynx is uncommon for several reasons. The inferior projection of the mandible affors protection to a large degree from anterior blows. Posteriorly, the larynx is protected by the rigid cervical spine. Nonetheless, injuries do occur and the resultant damage to the larynx is usually characteristic of the 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 ingestion.

Anterior blunt injuries are most commonly the result of motor vehicle accidents (Fig. 101-1; Nahum and Siegel, 1967; Pennington, 1972). The incidence of this type of injury is declining, presumably because of mandatory seat belt laws, lower speed limits, and better education regarding drunken driving. The use of front seat air bags may reduce the incidence even further. If no seat belt is worn, or if a lap belt only is used without shoulder restraint, during rapid deceleration the driver is thrust forward with the neck in a hyperextended fashion. This position removes the bony protection afforded by the mandible, exposing the larynx to anterior crushing forces. If the larynx then strikes the steering wheel or dashboard, it may be compressed between these objects and the cervical spine (Nahum and Siegel, 1967).

Clothesline injuries occur when the rider of an unprotected vehicle such as a motorcycle or snowmobile encounters a fixed horizontal object, such as a clothesline, at neck level. This type of injury imparts a very large amount of energy over a relatively small area, resulting in massive trauma (Close, 1981). Many of these injuries lead to death at the accident scene from crushing the larynx or separation of the cricoid from the larynx or trachea.

Strangulation injuries occur from manual compression, from assaults with strangulation by a soft object, or from attempted suicide by hanging. Typically the initial findings may only be a hoarse voice and abrasions on the skin of the overlying neck. However, these injuries may later be associated with marked edema of the larynx and resultant loss of airway 12 to 24 hours after injury (Stanley and Hanson, 1983).

Penetrating trauma, in contrast to trauma from motor vehicle accidents, is increasing because of the rise in personal assaults (Fig. 101-2). For example, in a review of 148 cases of penetrating neck trauma, injury to the larynx or trachea was noted in 12 cases (Saletta et al, 1976). The injury from gunshot wounds depends on the type of weapon used and the range from which it was fired. Shotgun injuries at close range impart intense energy to the soft tissues and are usually fatal. From a long range the damage may be minimal. Low-velocity handguns, as are commonly used in domestic assaults, generally have only a moderate blast effect on surrounding tissue, and these injuries may be misleading on initial examination because of the bullet's erratic course in soft tissues. High-velocity weapons, such as hunting rifles and military assault weapons, impart a significant amount of kinetic energy to the tissues (Lemay, 1971). In these injuries a wide debridement of surrounding tissue is advisable at the time of repair, because the injured area may necrose well beyond the limit of the immediately evident nonviable tissue. Knife injuries carry no ability to destroy tissue distant to the path of injury, and their course may be accurately estimated from the entrance and exit wounds.

The pediatric larynx is injured less often than that of the adult. Situated higher in the neck than the adult larynx, it is afforded greater protection from the caudal projection of the mandible. However, when injured, increased soft tissue damage and decreased cartilaginous fractures are likely because of the loose attachment of the overlying mucous membrane, lack of fibrous support, and increased elasticity of the cartilaginous framework. Also, the relative cross-sectional area of the larynx compared to that of the adult is decreased. This combination of increased soft tissue injury and decreased cross-sectional area makes the pediatric airway especially vulnerable to embarrassment, particularly since the attending medical personnel may be unimpressed with the severity of the injury because of the lack of associated cartilage fractures.

Inhalation injuries occur from inhalation of superheated air, especially steam, with its increased capacity to carry thermal energy. On inhalation of heated air the glottis reflexively closes. This limits the amount of thermal injury by stopping respiration, thus decreasing the amount of air inhaled, and limits the injury to the supraglottic larynx. This injury is usually associated with burns to other parts of the body and is more common in burn injuries sustained in closed areas. The initial presentation may be unremarkable except for erythema of the upper airway and occasionally carbon-stained sputum. An airway must be secured early in these injuries before fluid resuscitation of the associated burn injury begins, since this will lead to marked edema of the injured mucosa with loss of airway and inability to endotracheally intubate the patient.

Injuries from caustic ingestion typically occur in the pediatric population and may result from a variety of household products. In the adult these are usually the result of a suicide attempt and are characteristically from ingestion of lye or hydrocarbons. Besides the usual oral, pharyngeal, and esophageal injuries, the larynx may be injured by direct contact

during ingestion or regurgitation of the ingested substance. Reflux glottic closure limits these injuries to the supraglottic larynx.

External Laryngeal Trauma

Diagnostic assessment

The signs and symptoms of external laryngeal trauma vary from obvious open fractures to subtle aberrations of normal laryngeal function. External examination of the neck may reveal an open fracture or laryngocutaneous fistula. The larynx should be palpated for any crepitance. Tenderness to palpation, although not specific, is often present in significant injury. The skin of the neck may reveal contusions or abrasions from blunt trauma or indicate a line pattern indicative of a strangulation injury (Olson, 1971; Stanley and Hanson, 1983). Any penetrating injury is examined for an entrance and an exit wound, and the most likely path of travel of the projective is determined. Open wounds are not explored with instruments nor are they probed for fear of dislodging a hematoma and initiating further bleeding. The cervical spine should be palpated for any bony step-offs or tenderness. Hemoptysis may reveal an injury to the upper aerodigestive system, but it is often difficult to differentiate from bleeding from associated facial trauma.

External laryngeal trauma is often associated with a change in voice (Stanley et al, 1987). In severe trauma the patient may be entirely aphonic. More commonly the voice is present but is altered because of the change in architecture of the larynx. Hematomas of the true vocal folds add mass to this vibratory unit and lower the fundamental frequency of vibration. Paresis of the vocal fold, either from damage to the recurrent laryngeal nerve or from mechanical dislocation of the cricoarytenoid joint, may cause a weak, breathy voice. Finally, any alteration in the larynx that changes the airflow patterns has the potential to alter the voice.

One of the most serious alterations of laryngeal function is the abnormal flow of air through the upper airway. In instances of cricotracheal separation the airway may be maintained via a cutaneous laceration that connects with the trachea. In gunshot wounds a similar situation may exist where the path of the missile serves as a laryngocutaneous fistula and allows respiration despite obstruction at the glottic or supraglottic level (Fig. 101-3; Harrison, 1984). In this instance an obvious airflow will be noted from the wound, and no attempt should be made to cover, compress, or otherwise manipulate such a wound until the surgeon is ready to surgically secure the airway. Stridor may occur from bilateral vocal fold paresis or disruption or may result from any combination of unilateral immobility and subglottic, glottic, or supraglottic edema. If severe enough, edema alone with normal vocal fold function may cause stridor.

A third, more subtle form of laryngeal dysfunction is aspiration. This is usually due to immobility of one or both vocal folds. Although not clinically apparent in the immediate postinjury period, this may become evident at a later time.

After the initial examination and securing of the airway, an examination of the endolaryngeal anatomy is attempted. In the past this was only possible in the awake patient using the indirect mirror examination, and therefore it was not very useful in the severely

injured patient. Today the widespread use of direct fiberoptic examination has allowed for much improved nonoperative evaluation of the injured larynx (Schaefer, 1982; Schaefer and Close, 1989). Care must be taken in the examination of the nonintubated patient, because the minor trauma associated with insertion of the fiberoptic laryngoscope may precipitate an airway emergency. After insertion of this instrument through the nares, the oropharynx and hypopharynx are examined for injury. The larynx is then examined for hematomas and their size and location noted. The arytenoids are evaluated for full range of motion with phonation and respiration. Partial limitation of range of motion indicates a structural deformity or dislocation of the arytenoid, whereas complete immobility is more suggestive of recurrent nerve injury. Failure of the true vocal folds to meet in the same horizontal plane may also be present, indicating a structural change in the laryngeal framework or superior laryngeal nerve injury. Finally, any exposed cartilage is noted along with the integrity of the surrounding mucosa.

Computed tomography

The role of preoperative radiographic evaluation of the injured larynx has changed dramatically with the widespread availability of computed tomography (CT) (Friedman et al, 1981; Mancuso and Hanafee, 1979; Maceri et al, 1982; Schaefer and Brown, 1983). Before the use of CT, plain soft tissue neck film, contrast laryngography, and tomograms were available to assess the soft tissues of the larynx. Frequently these studies added little information about the integrity of the larynx not already known by physical examination of the patient with direct fiberoptic laryngoscopy. Plain films may identify fractures but reveal the anatomy in only two dimensions and add little information about the soft tissue status of the larynx. Laryngography is often impossible in the acutely injured patient because of the patient's inability to cooperate. Plain tomograms lack the three-dimensional analysis and clarity of CT. CT scanning allows evaluation of the laryngeal cartilaginous framework in a noninvasive manner, thus possibly avoiding unnecessary operative explorations by selecting out those patients who should do well without surgical intervention (Fig. 101-4). In patients with injuries obviously in need of open surgical repair, such as exposed cartilage or displaced fractures with overlying mucosal lacerations, CT adds little to the preoperative and surgical examination of the larynx (Schaefer and Brown, 1983). Rather, CT should be reserved for those patients in whom laryngeal injury is suspected by history and physical examination without obvious surgical indications. This may include patients who have only a single sign or symptom of laryngeal injury, such as hoarseness, and minimal findings suggestive of laryngeal injury. In this instance CT scanning may allow the surgeon to confirm the lack of injury in a noninvasive manner without direct laryngoscopy and the concomitant need for general anesthesia. CT may also be used to identify the patient with minimally displaced midline and lateral thyroid cartilage fractures that are otherwise unremarkable and minimally symptomatic and that, if left unrepaired, would lead to long-term phonatory disturbances because of disruption of the normal laryngeal valving mechanisms (Stanley et al, 1987). When massive edema or hematomas are present, direct laryngoscopy may not be useful in determining the integrity of the laryngeal framework. In this instance, if CT scanning demonstrates no evidence of laryngeal fractures the patient may be treated with a tracheotomy and observation, thus avoiding open exploration.

Initial management

On the patient's arrival in the emergency room the first priority is to establish an airway. This may be very difficult in the neck injury patient and often requires emergent tracheotomy or cricothyroidotomy. Care must be taken to avoid manipulation of the neck. Until a cervical spine injury has been excluded no extension of the neck should be allowed during either orotracheal intubation or tracheotomy. After securing the airway, venous access should be obtained with a minimum of two large-bore cannulas. Isotonic fluids are administered as needed to maintain circulation. The patient is then completely disrobed and examined for other injuries. If the patient is unstable after these immediate measures, then he or she is taken directly to the operating room. If, on the other hand, the patient is relatively stable after these measures, the diagnostic assessment may proceed in a more orderly manner. The minimum radiographic evaluation consists of cervical spine series and a chest radiograph. Subplatysmal penetrating injuries in the area of the carotid arteries should be evaluated with arteriography. After full assessment of all injuries the various physicians involved should determine the order of treatment and proceed accordingly.

Management

The management of injuries to the larynx and esophagus is based on the mechanism of injury and extent of injury found during the initial assessment. In all instances the first priority is securing the airway (Krekorian, 1975). If the patient is breathing well and without injury requiring surgical care, then observation may be indicated without tracheotomy or endotracheal intubation. However, all injuries to this region carry a propensity for airway embarrassment. A good rule of thumb, especially in the case of persons with a large experience in trauma to this area, is to err on the side of caution when determining the need for airway intervention.

Nonsurgical versus surgical management

The purpose of the extensive physical and radiologic evaluation is not only to identify the patients with injury but also to select those patients who are likely to do well without surgical intervention (Olson and Miles, 1971; Schaefer, 1982; Schaefer and Brown, 1983; Schaefer and Close, 1989; Trone et al, 1980). Medical management assumes the patient does not require a tracheotomy and has an otherwise stable airway. If the patient has only minor laryngeal mucosal lacerations not involving the anterior commissure or single nondisplaced fractures of the thyroid cartilage without overlying mucosal lacerations or exposed cartilage, then treatment can be confined to close observation and head of bed elevation. Steroids may be useful if given early after the time of injury. Minor hematomas noted to be stable in size and not causing respiratory embarrassment may be treated in a like manner. All injuries involving the anterior commissure, having exposed cartilage, involving multiple fractures of the cricoid cartilage, causing vocal fold paralysis, having multiple or displaced fractures of the thyroid cartilage, causing sufficient airway compromise to require intubation or tracheotomy, or associated with an injury to another area of the neck requiring surgical intervention are treated in the operating room with open surgical exploration and repair (Schaefer and Close, 1989).

Surgical management

The surgical repair of the larynx should be coordinated with all surgical teams involved as well as with the anesthesiologist. The person responsible for the airway at each stage of the procedure should be designated before bringing the patient to the operating room. Plans for emergently obtaining an airway as well as the instruments required should also be arranged before surgery.

The most conservative, reliable method of securing an airway in the patient with laryngeal injuries is local, awake tracheotomy. Endotracheal intubation may cause further damage to the larynx, be exceedingly difficult, interfere with subsequent examination and repair of the larynx, and convert an urgent procedure to an emergent one (Fig. 101-5).

After local, awake tracheotomy, general anesthesia is induced. Following this, direct laryngoscopy is performed. The larynx is examined for exposed cartilage, hematomas, lacerations, and range of motion of the true vocal folds. The subglottis is evaluated for injury to the cricoid and trachea. Rigid esophagoscopy is then performed to rule out injury to the esophagus (Krekorian, 1975).

The pediatric patient is a special consideration when obtaining a surgical airway. Endotracheal intubation in the injured pediatric larynx carries all of the same risks as in an adult. The option of awake, local tracheotomy is not feasible in a frightened, injured child. The time margin of error is also less, since 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 may then be performed over the bronchoscope.

Following direct laryngoscopy and examination with the patient under anesthesia and after review of the CT findings, the need for open exploration and repair is reevaluated. In those patients with only edema, hematomas, nondisplaced fractures of the thyroid cartilage, normal true vocal fold motion, and no injury to the anterior commissure, no further surgery is usually indicated (Miller, 1970; Schaefer and Close, 1989; Trone et al, 1980). Anesthesia is discontinued, and the patient is observed carefully with head of bed elevation. Serial flexible fiberoptic laryngoscopic examinations are performed to ensure proper healing, and the tracheotomy tube is removed as soon as tolerated.

In patients with more severe injuries, surgical exploration is performed. Controversy exists as to the optimal time for repair (Leopodl, 1983; Miles et al, 1971; Olson, 1978). Some authors advocate delay of repair for 3 to 5 days to allow for edema to subside and for easier identification of mucosal lacerations. However, excellent results have been obtained with early repair, avoiding the morbidity of leaving open wounds in a contaminated field, and we recommend early surgical management (Schaefer and Close, 1989). In either case surgical exploration begins with a subplatysmal apron flap that is elevated to the level of the hyoid bone. The strap muscles are divide in the midline and retracted laterally. A midline thyrotomy is then used to enter the larynx. Laryngeal skeletal fractures are repaired using wire or nonabsorbable suture. To avoid further damage to the laryngeal mucosa, no fracture site sutures are tightened until all fractures have been reduced. Simple nondisplaced fractures may be repaired by suturing the outer perichondrium with nonabsorbable sutures. All mucosal lacerations are meticulously repaired using fine absorbable sutures. If the arytenoid is

dislocated it is reduced. In nearly all civilian injuries, wounds can be closed using adjacent mucosa. In cases involving military weapons or other instances where a large loss of tissue is encountered, regional mucosal flaps or skin grafts may be used to complete the lining of the larynx.

The indications for stenting in these injuries are controversial (Leopold, 1983; Miles et al, 1971; Thomas and Stevens, 1975; Trone et al, 1980). When deciding on the use of a stent the advantages must be weighed against the additional damage to the mucosa caused by the stent. Stents are recommended for injuries involving the anterior commissure, in comminuted fractures of the thyroid cartilage, and in cases where the architecture of the larynx is not maintained by open fixation of the fractures. The advantages of stenting in these instances are decreased web formation at the anterior commissure and better support of the laryngeal architecture during the healing process. This additional support may be useful in light of the movement of the larynx with phonation and swallowing during the healing process. Stenting alone without open reduction and fixation of fractures and closure of lacerations is unsatisfactory.

The choice of type of stent ranges from finger cots filled with foam rubber to commercially manufactures Silastic stents. All should be roughly in the shape of the larynx and made of soft material to avoid further mucosal damage. The stent should extend from the false vocal fold to the first tracheal ring in order to add stability and prevent endolaryngeal adhesions. Ideally the stent should be secured in such a manner as to be easily removed using endoscopic techniques.

An easily available stent can be created using a 3.5 cm length of Portex endotracheal tubing (Figs. 101-6 to 101-8; Schaefer and Carder, 1980). The superior end of the tube is sewn tightly closed to prevent aspiration and smooth clamps are placed to approximate the true and false vocal folds. The stent is then autoclaved to 82°C, thereby reforming the tube to the desired shape. The stent is secured by two separate monofilament sutures through the laryngeal ventricles and cricothyroid membrane and tied to skin buttons. All stents should be removed as soon as possible to minimize the damage to the mucosa. A period of 10 to 14 days is usually adequate even in severe injuries.

Following repair of the injured larynx and placement of a stent if indicated, the anterior commissure is reconstituted by suturing the true vocal fold to the outer perichondrium. Regardless of the need for stenting, reconstructing the anterior commissure is essential to maintain the scaphoid shape of this site and to preserve a normal voice. The thyrotomy is closed using permanent sutures or wire. The strap muscles are reapproximated and the wound closed over a drain.

Various other injuries may also be encountered during surgery. As much as one third of the anterior cricoid or trachea can be repaired using the sternohyoid muscle and its overlying fascia. Loss of the anterior one third of the thyroid cartilage or hemiglottis can be repaired by closure of mucosal lacerations over a stent. The recurrent laryngeal nerve may be severed by the injury. If this is found, a neurorrhaphy of the severed ends should be performed. Although the intricate abductor-adductor function of the larynx will not likely return, the reinnervation may help maintain muscle tone and therefore voice quality. If open reduction and internal fixation with stenting are unsuccessful in restoring the laryngeal

architecture because of massive trauma and tissue loss, partial or total laryngectomy may be necessary. The decision for partial or total laryngectomy should be based on the same guidelines used in oncologic reconstruction based on the defect. However, total laryngectomy has not been necesssary in large series of laryngeal trauma in civilian populations and is more likely to be considered acceptable treatment with military wounds (Schaefer and Close, 1989).

Postoperative care

All patients with laryngeal trauma should continue to receive postoperative antibiotics for 5 to 7 days in an effort to reduce infection and granulation tissue. As tolerated with other injuries that might be present, the patient should have the head of the bed elevated to minimize edema. The patient should be encouraged to ambulate as soon as tolerated. If a tracheostomy is present, routine care is provided. Stents placed at the time of surgery should be removed as soon as possible to prevent further mucosal damage, usually 10 to 14 days after surgery. Decannulation may be performed as tolerated as soon as the stent is removed. Follow-up examinations should be for at least 1 year to assess true vocal fold function return and to monitor the development of any subglottic stenosis present. Antacids and H2 blockers should be routinely employed to prevent reflux, because this may cause increased scarring of laryngeal tissues. Nasogastric tubes are avoided where possible to reduce reflux and prevent erosion of the posterior cricoid mucosa associated with their use.

Complications

The complications following repair of external laryngeal trauma are the result of the larynx's inability to function in phonation, respiration, and deglutition (Fig. 101-9). Postoperative granulation tissue may be seen after removal of the stent. This is best treated with prevention by meticulous closure of all mucosal lacerations at the time of surgery. Postoperative antibiotics may reduce the amount of granulation, as will early removal of the stent. Profuse granulations that persist may be debulked using endoscopic technique.

Vocal fold paralysis may cause a weak voice if it is unilateral or aphonia and respiratory compromise if bilateral. Unless the recurrent laryngeal nerve was shown to be severed at the time of surgery, no procedures should be performed to compensate for the paralysis for at least 6 months, since delayed recovery may occur. If after 6 months to 1 year no return is noted, a medialization procedure may be performed to strengthen the voice in the case of a unilateral paralysis. A medialization procedure may also be useful in the instance of aspiration in the presence of a unilateral paralysis. If a bilateral paralysis is present and the patient desires an attempt at decannulation, an arytenoidectomy may be done. Subglottic stenosis may also be present and cause a failure to decannulate. Again, no repair should be undertaken for 6 to 12 months to allow for scar maturation. After this time the patient should have direct laryngoscopy and bronchoscopy to examine the lesion and plan the repair. If a short segment of tracheal stenosis is found with normal airway below, then an excision of the stenotic segment and primary reanastomosis may be performed, using a release of the suprahyoid suspensory system to gain further mobilization (Williams, 1974). Additionally, mediastinal tracheal dissection and incision of the annular ligaments of the trachea may be used in combination with suprahyoid release to allow for excision and primary reanastomosis of lesions up to 12.5 cm in the adult (Grillo, 1965). Longer stenotic segments can be repaired with anterior and, if needed, posterior cricotracheal cartilage grafts as popularized in the repair

of subglottic stenosis in children (Whited, 1984). In the very rare case of massive trauma with inability to decannulate the patient postoperatively and repeated problems with aspiration despite medialization procedures, a total laryngectomy may be necessary to prevent further aspiration. In this situation the indications are the same as would be used for aspiration after partial laryngectomy.

Outcome

The eventual outcome of patients after laryngeal trauma depends on the extent of the original injury and the quality of subsequent repairs. In those patients who do not require operative intervention the prognosis for full return of function is excellent (Leopold, 1983; Schaefer and Close, 1989; Schaefer, 1982). Patients requiring surgical intervention still have an excellent chance of eventual decannulation with an adequate to good voice (Hirano et al, 1985; Krekorian, 1975; Pennington, 1972; Schaefer and Close, 1989; Stanley and Hanson, 1987). Long-term complications after repair are uncommon.

Table 101-1 gives results of airway and voice evaluations following laryngeal trauma (Schaefer and Close, 1989). Group 1 consisted of patients with minor injuries treated without operative intervention. Group 2 consisted of patients treated with tracheostomy and endoscopy but whose injuries were not felt to require open exploration and repair. Groups 3 and 4 sustained massive injury requiring open exploration and repair. A good voice was one that was close to normal or comparable to the patient's voice before injury. Moderate to marked hoarseness was described as a fair voice, and a voice just above a whisper was classified as poor. Airway quality was judged as good if the patient denied restriction, fair if some restriction persisted, and poor if permanent tracheostomy was required.

Iatrogenic Trauma

Intubation injuries

Most endolaryngeal injuries result as a complication of intubation. This may occur as a result of intubation technique or from trauma to the glottis or subglottis from the endotracheal tube. Other injuries to the larynx may result from surgical intervention including tracheotomy or excision of laryngeal masses such as papillomas or granulomas or as a result of surgery to improve an already injured larynx, such as Teflon injection of a true vocal fold.

The best treatment for intubation trauma is prevention. This is best accomplished by the proper instruction of all personnel performing intubations as to the correct techniques of intubation, choosing the correct-size endotracheal tube for the patient, and performing all intubations in a controlled manner. Possible complications of intubation include injury to the lingual, hypoglossal, superior laryngeal, or recurrent laryngeal nerves; pharyngeal lacerations; cricoarytenoid dislocation; and injury to the vocal folds from forceful manipulation and insertion of the tube or inserting a tube too large for the patient. Nerve injuries usually represent a neurapraxia and, unless an obvious or likely severing of the nerve has occurred, are best treated expectantly. Pharyngeal lacerations are treated with a short course of antibiotics unless a severe injury has occurred, such as perforation of the piriform sinus, in which case the injury should be repaired surgically, drained, and the patient fed by a nasogastric tube for 5 to 7 days. Cricoarytenoid dislocation results from traumatic intubation

and is usually first noticed as a postintubation vocal fold paralysis. If diagnosed early, cricoarytenoid dislocation may be treated with endoscopic reduction of the dislocated joint (Close, 1987). Abrasions to the larynx from intubation are usually mild and may be treated in most instances with head of bed elevation, cool mist humidification, and observation. The indications for operative intervention are the same as those for other forms of laryngeal trauma.

Another major source of iatrogenic laryngeal injury is from prolonged intubation. Since the advent of low-pressure cuffed endotracheal tubes, long-term intubation is less hazardous than before. However, as the widespread use of advanced ICU care for critically ill patients increases, the incidence of long-term intubation and its subsequent complications have also increased. The decision to convert endotracheal intubation to a tracheostomy must be based on several factors, including the risk of surgery in a critically ill patient and the likely need for further ventilatory support. In general, the risks of prolonged endotracheal intubation outweigh the risk of tracheotomy between 7 and 10 days after intubation (Whited, 1984). Certain instances should have earlier conversion to tracheostomy. These include preexisting circumferential subglottic mucosal injuries, as occur with inhalation of supraheated air, and patients with excessive movement and result increased trauma to the larynx from the endotracheal tube. Another complication of endotracheal intubation is accidental extubation. In those situations where, after accidental extubation, reintubation may be difficult or impossible because of edema of the airway or other reasons, early tracheotomy should be strongly considered to prevent a possibly fatal catastrophe.

Injuries during tracheotomy

Tracheotomy may cause injury to the larynx or trachea, and, like endotracheal intubation, the best means of avoiding this is to perform the procedure in a controlled situation under the supervision of experienced personnel. Injury to the larynx or trachea is more likely in an emergent situation where hemostasis and identification of anatomic landmarks are often difficult, and therefore compromise is accepted in an effort to rapidly secure an airway. These procedures may damage the larynx from too high an incision with injury to the cricoid or from injury to the recurrent laryngeal nerve as a result of dissection too lateral on the trachea. Improper choice of tracheotomy cannula size may also cause damage to the trachea from a poor fit and subsequent wear on the tracheal wall, causing erosion of the tracheal epithelium. Before the use of low-pressure endotracheal cuffs, tracheal erosion leading to subclavian artery hemorrhage was common even with relatively short periods of intubation. However, even with low-pressure cuffed endotracheal tubes, overinflation of the tracheal cuff or proloned use may cause a similar type of injury.

Injury to the larynx from surgical excision in benign disease such as papillomas or granulation tissue usually results from overly aggressive removal of tissue or failure to follow standard principles of laryngeal surgery. When removing areas of benign disease it is important to avoid exposing cartilage during the dissection, since this can lead to a chondritis of the larynx, especially in irradiated tissue. It is also important not to denude the anterior commissure bilaterally at one time, because this may lead to anterior webbing. When removing tissue in the subglottic region only one quadrant of the circumference should be addressed at each setting in order to prevent cicatricial scarring and its sequela of subglottic stenosis.

Esophageal Injuries

Esophageal injuries may occur as isolated injuries or in association with other trauma. Blunt trauma to the neck seldom causes esophageal injury but may result from severe laryngeal trauma and perforation of the esophagus by cartilage fragments. A review of 246 penetrating injuries to the neck that violate the platysma revealed 16 injuries to the esophagus (Saletta, 1976). More common are injuries from ingestion of caustic substances. These commonly occur in the pediatric age group as a result of accidental ingestions and usually involve household products or hydrocarbons. In the adult population these injuries are usually the result of attempted suicides.

Diagnostic assessment

Diagnosis of esophageal injuries often relies on the history. The patient, witnesses, and paramedic personnel should be questioned regarding the possible substance ingested. Whenever possible the container should be examined, since the contents may not be accurately labeled. In the case of blunt or penetrating trauma hematemesis may be present if the esophageal mucosa has been violated. A plain-chest radiograph may reveal pneumomediastinum in the presence of esophageal perforation. In all cases pain is usually present to some degree. Physical examination will usually demonstrate oral cavity and oropharyngeal mucosal injury in the case of ingestion. Hoarseness may be present if the substance through direct contact or regurgitation contacted the glottis. There may be edema present, occasionally severe enough to compromise the airway. External trauma to the esophagus is usually diagnosed either radiographically with a barium swallow or with endoscopy. Rigid esophagoscopy is felt to be more sensitive than barium swallow for the diagnosis of esophageal injury but requires swallow for the diagnosis of esophageal injury but requires general anesthesia and personnel skilled in its use (Meyer et al, 1987). The indications for esophagoscopy in the substance ingestion patient are controversial (Meredith et al, 1988). In those cases where the presumed ingested substance is especially tissue damaging, the amount is large, the airway is compromised, or the patient is manifesting signs or symptoms of shock from fluid redistribution, then esophagoscopy is probably warranted (Zargar et al, 1989).

Management

Surgical therapy is indicated for all blunt and penetrating trauma demonstrating injury to the esophagus. This should be undertaken as part of a complete exploration for other associated injuries. Any lacerations to the esophageal mucosa should be closed in several layers and a drain placed. A nasogastric tube should be placed and the patient given nothing by mouth for 7 to 10 days.

Treatment of caustic ingestion depends on the degree of tissue injury. If at the time of endoscopy the larynx is involved tracheotomy is preferred over endotracheal intubation to prevent further laryngeal mucosal damage. Any obviously necrotic tissue seen in the esophagus or stomach is resected and a feeding jejunostomy placed. In less severe esophageal injuries supportive care and fluid resuscitation as needed may be all that are necessary. Steroids may be useful, but their use is controversial. If medical management is employed, repeat endoscopy is useful to reassess tissue viability and dilate any strictures that form.