Acute external laryngotracheal trauma: Diagnosis and management

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Abstract
Laryngotracheal trauma may result in lifelong complications or even death if diagnosis or treatment is delayed. Emergency room physicians, trauma surgeons, anesthesiologists, and especially otolaryngologists should maintain a high level of awareness of and suspicion for laryngotracheal trauma whenever a patient presents with multiple trauma in general or with cervical trauma in particular. Although there is some controversy regarding care, treatment in experienced hands will usually result in a favorable outcome. In this article, we review and update the diagnosis and management of acute external laryngotracheal trauma.

Introduction
Laryngotracheal trauma has been reported to account for 1 in every 5,000 to 30,000 emergency room visits in the United States. Its rarity notwithstanding, it is second to only intracranial injury as the most common cause of death among patients with head and neck trauma. A blunt or penetrating laryngotracheal injury can result in acute airway obstruction and death at the scene of an accident or crime. In recent years, advances in emergency services, including better evacuation procedures and heightened training, have improved survival rates.

The scarcity of laryngeal trauma is primarily attributable to the protected position of the larynx. It is shielded inferiorly by the sternum, superiorly by the mandible, posteriorly by the cervical spine, and laterally by the sternocleidomastoid muscles. The laryngeal complex is also supported by muscular and tendinous attachments, which can deflect trauma in all directions except posteriorly. The muscular attachments disperse perimeral forces during impact. However, an anterior force may traumatize the larynx against the cervical spine.

Because of the infrequency of laryngeal injuries among surviving trauma patients, laryngeal and tracheal trauma may too often be ignored or overlooked. Performing an initial intubation or tracheostomy in a patient with respiratory compromise may pose a risk of injury or may contribute to a more protracted course. In fact, trauma is the most common cause of laryngeal stenosis.

Otolaryngologists are the guardians of the upper aerodigestive tract in general and of the larynx and trachea in particular. As such, we are responsible for the thorough evaluation, prompt treatment, and adequate follow-up of patients with laryngotracheal trauma. In addition, we must develop a strong and ongoing working relationship with anesthesiologists in order to plan and manage a laryngeal injury. In this article, we review and update the management of acute external laryngotracheal trauma.

Diagnosis and classification of injuries
Successful treatment of laryngotracheal trauma requires the incorporation of a spectrum of clinical, physical, and radiographic data. Classification and grading systems proposed by the senior author (I.E.) years ago provide an organizational framework as well as a wide spectrum of management options for physicians. These guidelines are general; evaluation and treatment must be individualized. Also, there is no substitute for good clinical judgment.

Management begins with an assessment of the mechanism of injury, the level of injury, and the severity of injury:

Mechanism of injury. The two main classifications of trauma are blunt and penetrating:

Blunt trauma. The most common cause of blunt laryngotracheal trauma is motor vehicle accidents. In most accidents, the driver is thrust against the steering wheel or windscreen with the neck extended. This can result in thyroid cartilage fracture, mucosal disruption, edema, arytenoid dislocation, and/or torn laryngeal ligaments. Fortunately, the incidence of blunt laryngotracheal injuries associated with automobile accidents is declining as a result of improved dashboard designs, passenger restraints, air bags, and other safety devices. Other etiologic considerations in blunt trauma are sports injuries and acts of violence.
Presenting symptoms include dyspnea, dysphonia, neck pain, dysphagia, odynophagia, and hemoptysis. The two most common are respiratory distress and dysphonia. Physical findings may include subcutaneous emphysema, tenderness, edema, hematoma, ecchymosis, and distortion or loss of laryngeal landmarks. Laryngotracheal injury is sometimes overlooked because the severity of the symptoms does not always correspond with the extent of injury. Coincidental involvement of adjacent anatomic structures may go unrecognized as a result of the delayed clinical manifestations.

Age is a factor in the pattern of laryngeal fractures. The thyroid and cricoid cartilages ossify during early adulthood. In adults, a calcified laryngeal complex tends to fracture in more than one place, whereas a cartilaginous larynx tends to fracture at a single site. The more elastic properties of a nonossified larynx afford some protection against avulsion and rupture. The pediatric anatomy also confers protection. In a child younger than 3 years, the cricoid cartilage is at the level of C4; in adults, it is at the level of C7. The higher position affords children more laryngeal protection, although it leaves the trachea more exposed.

Penetrating trauma. It is imperative to identify the source of a penetrating injury, assess the entry and exit wounds, and search for displaced skin, broken bone, and cartilage fragments. A failure to remove foreign bodies may lead to complications. Moreover, penetrating objects are likely to cause injuries to adjacent structures. When the trachea is involved, the clinical picture may be dominated by subcutaneous emphysema, simple or tension pneumothorax, or pneumomediastinum, which might delay detection of the laryngeal injury. A thorough discussion of the characteristics of different penetrating objects (e.g., bullets and knives) is beyond the scope of this overview.

Level of injury. For classification purposes, the head and neck is divided into three trauma zones: zone 1 includes the area below the sternal notch, zone 2 extends between the sternal notch and the mandibular angle, and zone 3 includes the area above the mandibular angle. Radiography, endoscopy, angiography, and surgical exploration may be indicated, depending on the nature of the clinical signs and symptoms. Injury to the throat can also be classified according to the anatomic level as either hypopharyngeal, supraglottic, glottic, subglottic, and tracheal. Multiple anatomic levels may be involved in laryngotracheal trauma.

Severity of injury. Injuries can be clinically classified into five types according to the degree and extent of the patient’s presenting symptoms and signs (Table 1). The type of injury determines the management strategy (Table 2). Continual reassessment is essential at every stage of hospital care, beginning in the emergency department, until the patient’s safety is assured.

Table 1. Classification of laryngotracheal trauma according to the degree of the injury

<table>
<thead>
<tr>
<th>Type</th>
<th>Degree</th>
<th>Symptoms</th>
<th>Signs (in order of their incidence)</th>
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<tbody>
<tr>
<td>1</td>
<td>Mild</td>
<td>Mild voice change, mild dyspnea, cough</td>
<td>Minor hematomas, small lacerations, no fractures or dislocations</td>
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<tr>
<td>2</td>
<td>Moderate</td>
<td>Compromised airway, hemoptysis</td>
<td>Obstructing hematoma, edema, minor mucosal disruption, nondisplaced fractures</td>
</tr>
<tr>
<td>3</td>
<td>Severe</td>
<td>Severe airway compromise, stridor</td>
<td>Massive edema and hematoma, deep mucosal tears, exposed cartilage, aspiration, displaced fractures, unilateral vocal fold immobility</td>
</tr>
<tr>
<td>4</td>
<td>Profound</td>
<td>Impending airway obstruction</td>
<td>Massive edema, mucosal avulsion, fragmented cartilage, aspiration, displaced arytenoids, bilateral vocal fold immobility</td>
</tr>
<tr>
<td>5</td>
<td>Critical</td>
<td>Complete airway obstruction</td>
<td>Skeletal collapse, structural disruption and breakdown, complete laryngotracheal separation</td>
</tr>
</tbody>
</table>

Source: Modified from data included in references 1 and 2.
be postponed while injuries to other organ systems are treated immediately.

Cricothyroidotomy and tracheotomy. Emergency cricothyroidotomy and tracheotomy with local anesthesia are the two most commonly used procedures for cases of severe trauma. Cricothyroidotomy is the more direct, simple, and safe way of bypassing upper airway obstruction, but it carries potential risks to the vocal folds, even in experienced hands. Most cricothyroidotomies should be converted to conventional tracheotomies in order to reduce potential complications.

Tracheotomy, even when expertly performed and managed, is the primary cause of long-term laryngotracheal complications. Therefore, tracheotomy should be performed and maintained only when medically indicated. The tracheotomy incision should be made as low in the neck as possible to avoid further injury to the laryngotracheal complex. The cervical incision should be vertical, which allows for inferior extension if it becomes necessary to achieve better anatomic exposure. In some cases of open soft-tissue injuries, tracheotomy can be performed through the existing wounds in the neck. When an open surgical laryngotracheal reconstruction is considered (i.e., in a patient with a type 3, 4, or 5 injury), it may be wise to establish a long-term, self-sustaining, tube-free tracheostoma and to include it in the reconstructive procedure. This will create a circumferential mucocutaneous junction that may prevent further laryngotracheal damage caused by infection, granulation tissue, or a prolonged foreign-body effect.

Endotracheal intubation. Intubation may be difficult in the presence of spinal, facial, or cervical trauma. Even in cases of only limited intraluminal injury, intubation may exacerbate the situation, so tracheotomy is preferred (figure 1). Tracheotomy is generally preferred for patients with a severe laryngeal injury. Finally, some concomitant injuries—such as those to the tongue, jaw, or spine—may preclude safe intubation. In these cases, a controlled tracheotomy over a laryngeal mask airway or over a rigid ventilating bronchoscope can be performed.

Intubation is best performed in the context of a panendoscopy so that the injury is evaluated under direct vision. A smaller tube with a high-volume, low-pressure cuff is recommended. Fiberoptic or rigidendoscopy may be used to both plan and perform intubation. Consideration may be given to fiberoptically guided intubation rather than flexible bronchoscopy if the intubation can be carried out promptly and safely.

Examination by an otolaryngologist during the course of an intubation and panendoscopy and prior to the placement of the tube is essential because once the patient is intubated, it is difficult to examine and monitor the larynx and trachea. These structures may become affected by secondary inflammation, infection, and further damage secondary to the superimposed presence of the tube. Prolonged intubation poses a significant risk of complications that must not be overlooked or underestimated.

Fiberoptic and direct endoscopy. The best method of examining the larynx during all stages of the workup is to use a flexible fiberoptic nasopharyngoscope with suction capability. However, this instrument may not be useful in a patient with a severely traumatized upper aerodigestive

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**Table 2. Suggested management for each type of injury**

<table>
<thead>
<tr>
<th>Type</th>
<th>Management</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Observation, humidification, antibiotics, steroids, respiratory therapy</td>
</tr>
<tr>
<td>2</td>
<td>Tracheotomy/intubation, panendoscopy, antibiotics, steroids</td>
</tr>
<tr>
<td>3</td>
<td>Panendoscopy, open surgical repair with or without stenting and with or without tracheotomy or tracheostomy</td>
</tr>
<tr>
<td>4</td>
<td>Panendoscopy, open surgical repair with stenting, with or without tracheotomy or tracheostomy</td>
</tr>
<tr>
<td>5</td>
<td>Tracheotomy/intubation, panendoscopy, reconstruction, restoration, or resection with end-to-end anastomosis with or without stenting (a long-term tube may serve as a stent)</td>
</tr>
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</table>

Source: Modified from data included in references 1, 2, and 3.
tract that is restricted by edema or tissue hemorrhage and flooded with blood or secretions. In such instances, rigid endoscopy, preferably with a rigid Hopkins rod telescope, has no substitute. Endoscopic photographs may be useful for documentation and follow-up.

Imaging studies. Computed tomography (CT) is the imaging procedure of choice for the initial evaluation. Other authors routinely obtain CT once the patient is stabilized and able to leave the emergency room or operating room. Obtaining a CT generally causes no significant delay in the management of stable patients. A thin-slice axial CT may be useful not only for demonstrating the extent of cartilaginous and soft-tissue injuries, but for defining the anatomic limits of the injury and the degree of airway obstruction, as well. Axial CT also allows the physician to assess any concomitant injuries involving adjacent structures in the neck, skull, spine, and chest. A sagittal projection may further enhance the three-dimensional perception of the trauma. A spiral (helical) CT with “virtual bronchoscopy” capability may provide additional valuable information.

Magnetic resonance imaging (MRI) allows for multiple-axis imaging of the larynx and trachea, thereby providing valuable information regarding extent and configuration of soft-tissue trauma. MRI is also useful for evaluating the long-term complications of laryngotracheal trauma, such as tracheal stenosis. For best results, an MRI should be T1-weighted, and the echo and repetition time should be short. High-resolution images should be obtained in the direct sagittal plane, and the oblique axial and coronal planes should be oriented both perpendicular to and parallel to the longitudinal axis of the laryngotracheal airway. One advantage that CT has over MRI is that CT requires less time to complete.

If a patient cannot be transferred from the emergency room or the operating room because his or her condition is unstable, routine x-ray studies of the cervical spine and cervical soft tissues and plain films of the chest and skull may be the only practically available options. 

In penetrating injuries, there is always a possibility of a pharyngoesophageal perforation and a laryngeal or tracheoesophageal fistula. A meglumine diatrizoate (Gastrografin) contrast study should be performed whenever a perforation cannot be completely confirmed or ruled out by endoscopic examination.

Panendoscopy. Direct rigid laryngoscopy, bronchoscopy, and esophagoscopy are essential to assessing the traumatized aerodigestive tract and the larynx. These procedures should be performed only after the cervical spine has been thoroughly examined for fractures. Once cervical spine integrity has been confirmed, panendoscopy should be performed on any patient with a type 2, 3, 4, or 5 injury. Panendoscopy should precede surgical exploration and repair. At the completion of the procedure, the patient may be carefully intubated and undergo tracheotomy performed over a ventilating bronchoscope. The rigid Hopkins rod telescope provides magnification, straight and angulated exposures, and assistance in obtaining photographic and video documentation.

Follow-up management

The ultimate goals of long-term treatment are to maintain an adequate airway, to prevent aspiration, and to restore ventilation, deglutition, and phonation to pretrauma quality. Restoration or reconstructive management can be undertaken conservatively (patients with type 1 trauma) or invasively (all others). Patients with a type 1 injury usually recover completely with minimal sequelae.

Surgical intervention can be performed as either an open surgical procedure or as an open surgical exploration and repair. Again, the decision rests on the severity of the injury (table 2). A temporary tracheotomy with the smallest and effective tube placed for the shortest possible amount of time is recommended for patients with moderate injuries in order to secure and maintain the airway while hematoma and edema subside. A long-term, tube-free, flap tracheotomy in conjunction with laryngotracheal reconstruction is recommended for more severe cases in order to avoid a tube’s adverse effects on the healing processes. Surgical intervention should be carried out as a direct continuation of panendoscopy of the pharynx, esophagus, larynx, and trachea.

When irreparable segmental damage of the upper trachea or cricoid arch is encountered, primary resection followed by cricotracheal or tracheothyroidal anastomosis may be the treatment of choice. This approach may also be used to manage concomitant esophageal tears or fistulae.

Closed operative interventions. Closed reductions of arytenoid dislocations or minimally displaced fractures of the laryngeal skeleton, occasionally followed by endoscopically introduced stents, have been suggested as alternatives to open reductions. However, experience is limited and the success rate is low. Therefore, most surgical interventions are open procedures.

Open surgical techniques. Jewett et al reviewed a trauma database of 392 patients in 11 states and found that open surgical intervention was required in 32% of patients with external laryngeal trauma. The purpose of an open intervention is to stabilize significant skeletal fractures and to repair any associated soft-tissue injuries (figure 2, table 3). Special attention should be given to covering all exposed cartilage with mucosa to prevent the formation of granulation tissue and the development of chondritis. This can be accomplished with grafting and rotation flaps.
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A review of the details of each open surgical procedure is beyond the scope of this article. Instead, the following four principles may be helpful:

• The treating otolaryngologist should be well trained, experienced, and versatile.
• Each case must be approached individually. A dogmatic approach should be avoided, and experimentation should be condemned. Prioritize every step of the treatment. Attention should be directed not only to securing the airway but to preventing aspiration and preserving voice quality, as well.
• The operation should be kept as simple as possible, and every step must be planned.

Adherence to the dictate “Primum non nocere” is critical when operating on an injured larynx because mistakes may be very difficult to correct. It is important to realistically and candidly discuss the risks of surgery—as well as the indications, expectations, and benefits—with the patient if possible and with the family prior to surgery.

Stenting. Stents are predominately used to manage severely displaced laryngeal fractures that may cause skeletal instability or breakdown. Besides providing internal support to the cartilage, stents bolster the soft tissues and arytenoids; prevent hematomas, web formation, and aspiration; and promote flap and graft adherence. Many types of stents are available, including molded, tubed, hollow, and balloon-like variations. Yet because no stent is free of limitations or the risk of complications, controversy still surrounds the indications for stenting and the length of time that a stent should remain in place. Many authors believe that stenting should be reserved for severe cases and should not exceed 2 weeks. Any surgeon who expects to become involved in the management of acute laryngotracheal trauma or its long-term consequences must have immediate access to a variety of stent designs and sizes at all times.

Patient care
The essentials of postoperative care are similar to the conservative treatment strategy (table 2). Surgeons should keep in mind a few possible complications:

• Gastroesophageal reflux can undermine even the best of reconstructive techniques. Therefore, it should be controlled by head elevation, antacids, H2 blockers, and proton-pump inhibitors. Nasogastric tubes should be avoided if possible. If feeding by mouth is to be prohibited for a prolonged period of time, a gastrostomy or an enterostomy should be considered.
• Aspiration following laryngotracheal trauma can occur as a result of different mechanisms. A tracheotomy will usually worsen aspiration rather than prevent it, primarily because of the deleterious effect it has on swallowing. Uncontrolled, life-threatening aspirations—as well as infections—may require radical measures such as prolonged stenting, diversion, occlusion, and eventual laryngectomy in severe cases.

Table 3. Ten steps to performing an open reduction

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
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<tbody>
<tr>
<td>1.</td>
<td>Assess the injury.</td>
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<tr>
<td>2.</td>
<td>Secure the airway at all stages.</td>
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<tr>
<td>3.</td>
<td>Prevent and control infection.</td>
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<tr>
<td>4.</td>
<td>Define the injury.</td>
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<tr>
<td>5.</td>
<td>Debride and perform immediate grafting if indicated.</td>
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<tr>
<td>6.</td>
<td>Restore soft tissues and skeletal cartilages by reduction, repositioning, grafting, and/or resecting anastomoses.</td>
</tr>
<tr>
<td>7.</td>
<td>Immobilize and fix fractures with internal support by stenting, wiring, or miniplating.</td>
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<tr>
<td>8.</td>
<td>Close any fistulæ.</td>
</tr>
<tr>
<td>9.</td>
<td>Stent to provide internal support, bolster grafts and flaps, prevent webs, and aspirate.</td>
</tr>
<tr>
<td>10.</td>
<td>Include management of tracheotomy/tracheostomy in the surgical plan.</td>
</tr>
</tbody>
</table>

Source: Modified from data included in reference 1.
• Some extensive reconstructive procedures—for example, laryngofissure, arytenoidectomy, vocal fold resection, and cordotomy—may result in a secure airway and closure of the tracheotomy site at the expense of voice quality. • Long-term treatment and close follow-up are necessary in cases where scarring may progress and persist.24

In conclusion, although there is some controversy regarding the management of acute laryngotracheal trauma, treatment in experienced hands will usually result in a favorable outcome.3,7

References