Laryngeal Trauma
Epidemiology

- Incidence: 1 in every 30,000 ER visits
  - 8/100,000/year

- Laryngeal injuries in 30 to 70% in penetrating neck trauma (especially zone II)

Figure 3: Zones of penetrating injury in the neck. Zone I, sternum and clavicles to cricoid cartilage; zone II, cricoid cartilage to angle of mandible; zone III, angle of mandible to skull base. The inferior limit of zone II has been described as either the cricoid cartilage or the clavicles (see shaded area). Reprinted with permission from BC Decker [10]. Copyright 1990, BC Decker.
Anatomy

- Support: hyoid, thyroid, cricoid
  - the only complete ring around the airway and loss of this ring almost invariably leads to stenosis

- Protection of the larynx
  - Superiorly by the mandible
  - Inferiorly by the sternum
  - Laterally by the SCM muscle
  - Posteriorly by the cervical spine
Laryngeal fracture is an uncommon injury presenting acutely to the otolaryngologist.

- 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 SCM muscle
- frequently associated with multiple other life-threatening injuries, associated loss of airway and immediate death at the accident scene may ensue
- when such patients arrive in casualty they are often acutely managed by a trauma team.
Blunt Injury

- Most Common Cause
- Direct blows/rupture/shear force
  - MVA
    - Declining with seat belts, airbags
    - Steering wheel (Dashboard)
  - Sports
    - Cycling, motorcycle racing, ice hockey, martial arts
  - Assault
  - Suicide
Blunt Injury

**Classification**

- **Clothesline**
  - All-terrain vehicle/Snow Mobile vs Tree Branch
  - Large energy to small area
  - Massive trauma, frequently instant death/ asphyxiation
    - Crushed Larynx
    - Tracheal Separation
    - Bilateral RLN injury

- **Strangulation**
  - Low velocity
  - Initial hoarseness and skin abrasion
  - Hyoid fracture = classic injury
  - Subsequent edema/loss of airway
Penetrating Injury

Classification

- **Gunshot Wound**
  - range and velocity

- **Knife/slash Wound**
  - Cleaner, less peripheral damage

- Be vigilant for injuries away from obvious effected area

FIG. 76-1: Cavitation effects of a bullet wound in soft tissue.
Inhalation/ Ingestion

Inhalation
- Hot air/Smoke/Steam
- Initial erythema and carbon sputum
- Followed by marked edema
- Early airway control prior to fluid resuscitation

Ingestion
- Mucosal Burns
- Pediatric: household items
- Adult: lye or hydrocarbons
- Direct damage while ingesting or regurgitation
- Alkali generally worse than acid

Glottic reflex limits injury to supraglottis
Iatrogenic

- Intubation
  - Larynx/Pharynx laceration or abrasion
  - Arytenoid dislocation
  - Neuropraxia of lingual, hypoglossal, SLN or RLN
- Prolonged Intubation
  - Generally change to tracheotomy in 7-10 days (earlier with inhalation injury)
- Tracheotomy
  - Cricoid/RLN injury
Contemporary assessment of laryngotracheal trauma

Rehal A. Bhojani, BS, David H. Rosenbaum, MD, Erkan Dikmen, MD, Michelle Paul, BS, B. Zane Atkins, MD, David Zories, MD, Aaron S. Estrera, MD, Michael A. Wait, MD, Dan M. Meyer, MD, Michael E. Jessen, MD, and J. Michael DiMaio, MD

![Pie chart]

**Figure 1.** Mechanism of injury for blunt and penetrating LTT.

![Bar chart]

**Figure 2.** Signs and symptoms of patients with LTT with respect to blunt trauma and penetrating trauma groups. White columns: Blunt (n = 19); black columns: penetrating (n = 52).
Traumatic Emergencies Involving the Pediatric Airway

David L. Mandell, MD

Classification

Table 1  Etiologies of neck and airway injuries in children [2,7].

<table>
<thead>
<tr>
<th>External Trauma</th>
<th>Penetrating</th>
<th>Internal Trauma</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blunt</td>
<td>Bicycle crashes</td>
<td>Gunshot wounds</td>
</tr>
<tr>
<td>Blunt</td>
<td>Motor vehicle crashes</td>
<td>Stab injuries</td>
</tr>
<tr>
<td>Seat belts</td>
<td>Airbags</td>
<td>Penetrating glass</td>
</tr>
<tr>
<td>“Clothesline” injury</td>
<td>Child abuse</td>
<td>Intubation injury</td>
</tr>
<tr>
<td>(strangulation)</td>
<td>Suicide attempts (hanging)</td>
<td>Foreign body aspiration</td>
</tr>
<tr>
<td>Athletic injuries</td>
<td></td>
<td>Caustic ingestion</td>
</tr>
</tbody>
</table>

Figure 1  Pediatric and adult airways. E indicates epiglottis; H, hyoid; T, thyroid cartilage; C, cricoid cartilage. Reprinted with permission from WB Saunders [17]. Copyright 2003, WB Saunders.
Pediatric Patient

Pediatric Considerations

- Larynx more superior (C4 vs C7) = more mandible protection
- Generally more soft tissue and less cartilage damage
  - Looser soft tissue
  - Less fibrous support
  - More elastic cartilage
- Tend to underestimate severity b/c lack of fxs
- Circumferential area less = vulnerable to submucosal changes = More often life-threatening

- Rigid bronchoscopy followed by tracheotomy over the bronchoscope
Symptom & Sign

- Hemoptysis
- Voice changes, hoarseness
- Difficulty in swallowing
- Neck pain
- Air-bubble from neck wound
- Deformity of thyroid cartilage

Investigation

- Hematoma
- Subcutaneous emphysema

Bruising, Abrasion

Hematoma Subcutaneous emphysema
Stable Condition

- Cervical CT (with a CT angiography protocol)
- Laryngoscopy
- Flexible bronchoscopy
- Esophagoscopy
Fig. 10. (A, B) Axial CT through the larynx in 25-year-old man following a motor vehicle accident shows disruption of the posterior aspect of the non-ossified cricoid ring (arrow) with a deformed airway and misalignment of the arytenoid cartilages. (C) Sagittal reformat shows the airway deformation and soft tissue swelling.
Investigation

Dilemmas

### TABLE II
**Usage of Pre-operative CT Scans**

<table>
<thead>
<tr>
<th></th>
<th>Selective use</th>
<th>Routine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gussack(^6,7)</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Schafer and Close(^9)</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Schild and Denny(^36)</td>
<td></td>
<td>+</td>
</tr>
<tr>
<td>Fuhrman et al.(^8)</td>
<td></td>
<td>+</td>
</tr>
<tr>
<td>Bent and Porubsky(^37)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yen et al.(^18)</td>
<td>+</td>
<td></td>
</tr>
</tbody>
</table>

### TABLE III
**Usage of Oesophagoscopy**

<table>
<thead>
<tr>
<th></th>
<th>Oesophagoscopy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gussack(^6)</td>
<td>Routine with neck exploration</td>
</tr>
<tr>
<td>Schafer and Close(^9)</td>
<td>Useful</td>
</tr>
<tr>
<td>Fuhrman(^8)</td>
<td>Routine except in minor haematoma/ laceration without detectable fracture</td>
</tr>
<tr>
<td>Yen(^18)</td>
<td>If oesophageal injury suspected</td>
</tr>
</tbody>
</table>

management dilemmas in laryngeal trauma
## Table 4  Laryngotracheal injury classification.

<table>
<thead>
<tr>
<th>Group</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Minor endolaryngeal hematoma</td>
</tr>
<tr>
<td>II</td>
<td>Minor mucosal disruption or nondisplaced fracture on CT</td>
</tr>
<tr>
<td>III</td>
<td>Massive edema, large tears, or exposed cartilage</td>
</tr>
<tr>
<td>IV</td>
<td>Massive trauma with multiple fractures</td>
</tr>
<tr>
<td>V</td>
<td>Complete laryngotracheal separation</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Degree</th>
<th>Symptoms</th>
<th>Signs</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Mild Voice change, dyspnea, cough</td>
<td>Minor hematoma, small laceration, no fracture, minimal to no airway compromise</td>
</tr>
<tr>
<td>II</td>
<td>Compromised airway, hemoptysis</td>
<td>Obstructing hematoma, edema, minor mucosal laceration, nondisplaced fracture</td>
</tr>
<tr>
<td>III</td>
<td>Severe airway compromise, stridor</td>
<td>Massive edema, hematoma, deep mucosal tears, exposed cartilage, displaced fractures, unilateral TVC immobility</td>
</tr>
<tr>
<td>IV</td>
<td>Impending airway obstruction</td>
<td>Same as III with arytenoid dislocation, comminuted fractures, bilateral TVC immobility</td>
</tr>
<tr>
<td>V</td>
<td>Complete airway obstruction</td>
<td>Laryngotracheal separation, skeletal collapse</td>
</tr>
</tbody>
</table>

Data from references [25, 26].

---

well validated prospectively with regard to outcome?
Airway Control

- **the choice of airway control should be based on the patient’s presentation.**
  - Nondisplaced laryngeal injury → only close monitoring,
  - A destroyed larynx → immediate tracheostomy.
- **Intubation**
  - Consider if mucosa intact or minimal displaced fx
  - O/W risk of more injury, and tube in the way
- **Cricothyrotomy**
  - Associated facial injuries, signs of substantial neck trauma, or a destroyed larynx,
- **Tracheostomy**
  - For children or adults endotracheal intubation is not an option
  - Awake in OR
- **Pediatric**
  - Consider bronchoscope intubation then tracheotomy

Upper Airway Injury and Its Management
Airway Control

- LMA should not be used
  - effectiveness is decreased when the anatomy is distorted, and they may worsen the injury.
- Neuromuscular blockade should be avoided until the airway is secure.
  - If the patient is awake and ventilating (even with a compromised airway),
Airway Control

The disadvantages of orotracheal intubation
- the need for extension of the neck
- for advanced airway management skills in the use of a flexible bronchoscope or fiberoptic wand.

If the use of neuromuscular blockers is deemed necessary, a surgical airway may be preferable.


**TABLE I**

**METHOD OF INITIAL AIRWAY CONTROL**

<table>
<thead>
<tr>
<th></th>
<th>Intubation</th>
<th>Tracheostomy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harris and Ainsworth*</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Fitz-Hugh and Powell*</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Olson and Miles*</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Sheely*</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Lambert and McMurray*</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Yarington*</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Trone*</td>
<td></td>
<td>+</td>
</tr>
<tr>
<td>Gussack*</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Schafer and Close*</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Fuhrman <em>et al.</em></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Yen*</td>
<td>+</td>
<td></td>
</tr>
</tbody>
</table>

Surgical Exploration/Repair

- **Aim**
  - Airway patency
  - External anatomy restoration
  - Internal functional anatomy

- **Neck exploration**
  - Midline thyrotomy for endolaryngeal injury

- **Hemostasis, remove clot or debridement**

- **Meticulous repair of lacerations**
  - Cover cartilage

- **Reduce fxs – wire or plate**

- **Relocate arytenoids**

- **Flaps for tissue loss**
Reduction of Fractures

Management

- Wire/Suture
- Plating
  - Miniplates vs. absorbable
  - Offers immediate rigid fixation
  - Well tolerated in situ
  - Better strength in animal studies
Review Article

Management dilemmas in laryngeal trauma

Soft Tissue Repair

- Repair mucosa/vocal cords with absorbable 5.0/6.0
- Resuspend vocal cords with 4.0 absorbable to external perichondrium of thyroid cartilage
- Cover cartilage
  - Grafts if needed (mucosa, STSG)
  - Disrupt mucosa and expose cartilage lead to granulation tissue
**Stents**

- Denuded ant commissure, poor architecture
- Prevents webbing, supports framework
- Soft, shape of larynx
- Secured by skin button
- Removed 10-14 days
  - O/W granulation

**Management**

*Fig. 69-6.* Fixation of Portex endolaryngeal stent using non-absorbable sutures.
Stents

Types of stents
- Endotracheal tube *(COVER THE TOP END TO PREVENT ASPIRATION)*
- Finger cots filled with gauze or foam
- Polymeric silicone stents

Secure the stents
- Heavy, nonabsorbable suture
  - Larynx at the ventricle
  - Cricothyroid membrane
  - Tied outside the skin
  - Endoscopically removed
Pediatric Management

Table 2  Conservative management of the acutely injured pediatric airway without abnormalities detected by endoscopy or CT.

<table>
<thead>
<tr>
<th>Standard recommendations [17,20]</th>
<th>Other considerations [20]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observation in monitored setting</td>
<td>Antireflux medical therapy</td>
</tr>
<tr>
<td>Humidification of inspired air</td>
<td>Intravenous corticosteroids</td>
</tr>
<tr>
<td>Elevation of head of bed</td>
<td>Broad-spectrum antibiotics</td>
</tr>
<tr>
<td>Reevaluation of the larynx in 7 to 14 days</td>
<td></td>
</tr>
</tbody>
</table>

Table 3  Indications for CT of the injured pediatric neck.

<table>
<thead>
<tr>
<th>Indications</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stable airway</td>
<td>If CT shows intact laryngeal cartilage structures, typically no need for open laryngeal surgery. CT can grossly assess soft tissue symmetry and airway patency and demonstrate occult laryngeal injuries [22].</td>
</tr>
<tr>
<td>Significant airway edema or laryngeal hematoma on flexible fiberoptic nasolaryngoscopy</td>
<td></td>
</tr>
<tr>
<td>Flexible fiberoptic laryngoscope and/or trained personnel not available</td>
<td></td>
</tr>
<tr>
<td>Patient too young or uncooperative for safe performance of flexible nasolaryngoscopy</td>
<td></td>
</tr>
<tr>
<td>Unstable airway</td>
<td>Airway should be secured before CT scan. CT may help in operative planning for those cases with severe trauma [22].</td>
</tr>
<tr>
<td>Exposed laryngeal cartilage</td>
<td></td>
</tr>
<tr>
<td>Laryngotracheal separation</td>
<td></td>
</tr>
<tr>
<td>Tracheobronchial rupture</td>
<td></td>
</tr>
<tr>
<td>Laryngeal crush injury</td>
<td></td>
</tr>
</tbody>
</table>
Post operation

- Antibiotics
- Anti-reflux
- Elevate Head
- Tracheotomy Care
- Stent removal
- Decannulate
Complication

- Aspiration/Dysphagia/Odynophagia
- Dysphonia, Vocal Fold immobility
  - Wait 6-12 months before intervention if RLN
- Fistula
- Unable to decannulate
- Granulation Tissue/Obstruction
  - Pre-op delayed diagnosis
  - Post-op
- Subglottic stenosis
  - Dilation, Excision
  - Cricoid split, Resection
Management

- RLN Injury
  - Attempt primary repair, but only expect tone
- Tracheal separation
  - Reapproximate cartilages
- Severe trauma
  - Consider partial/total laryngectomy
Prognosis

- Mortality 10-30%
- Higher Risk in
  - Blunt Trauma (63%)
  - Need for emergency airway
- Higher risk of poor voice/airway from blunt trauma
Figure 5 Diagnostic and therapeutic approach to the injured neck with a stable airway. Data from references [13,18,19].
Figure 6 Diagnostic and therapeutic approach to the injured neck and an unstable airway. Data from references [13,17,21].
Management

- History of Neck Trauma, Examine for Physical Signs of Injury
  - Impending Airway Obstruction
    - Tracheotomy
      - Direct Laryngoscopy and Esophagoscopy
        - Hematoma, Small Laceration, but Endolarynx Intact
          - Observation
          - Open Exploration of Neck With Open Reduction and Internal Fixation of Fracture Without Thyrotomy
            - ORIF Fractures, Repair Mucosal Lacerations + Endolaryngeal Stent
        - Isolated Fracture, Displaced or Angulated Thyroid Cartilage but Endolarynx Intact
          - Observation
          - Tracheotomy or Intubation
            - Direct Laryngoscopy and Esophagoscopy
              - Laryngeal Thyrotomy
                - Laryngeal Cartilage Unstable, Anterior Commissure Disrupted, Massive Mucosal Injuries
                  - ORIF Fractures, Repair Mucosal Lacerations
        - Mucosa and Cartilage Disrupted
          - Observation
          - Tracheotomy or Intubation
            - Direct Laryngoscopy and Esophagoscopy
              - Laryngeal Thyrotomy
                - Laryngeal Cartilage Stable, Anterior Commissure Intact
                  - ORIF Fractures, Repair Mucosal Lacerations
  - Nondisplaced, Nonangulated Thyroid Cartilage Fracture
    - Mucosa and Cartilage Disrupted
      - Mild Abnormality
        - Normal Endolarynx
          - Observation
        - Abnormal
          - CT Scan
            - Tracheotomy or Intubation
              - Direct Laryngoscopy and Esophagoscopy
                - Laryngeal Thyrotomy
                  - Laryngeal Cartilage Unstable, Anterior Commissure Disrupted, Massive Mucosal Injuries
                    - ORIF Fractures, Repair Mucosal Lacerations
    - Airway Stable
      - Flexible Fiberoptic Laryngoscopy
        - Observation
          - Tracheotomy or Intubation
            - Direct Laryngoscopy and Esophagoscopy
              - Laryngeal Thyrotomy
                - Laryngeal Cartilage Unstable, Anterior Commissure Disrupted, Massive Mucosal Injuries
                  - ORIF Fractures, Repair Mucosal Lacerations
Pediatric Patient

Classification

Figure 2 Crush injury of the larynx with multiple laryngeal fractures. Top arrow, Thyroid cartilage fragment. Middle arrow, Ruptured cricothyroid membrane. Bottom arrow, Cricoid cartilage fracture.
Penetrating Injuries of the Visceral Compartment of the Neck

Jeffrey M. Bumpous, MD, Paul D. Whitt, MD, Toni M. Ganzel, MD, and Stacie D. McClane, MD
Classification

- ATLS principles
- Intubation hazardous
  - Schaefer in 1991 - worsen preexisting injury
  - Further tears or cricotracheal separation
- Respiratory distress
  - Tracheotomy under local anesthesia
- Avoid cricothyroidotomies
  - Worsen injury
- If no acute breathing difficulties
  - Detailed history and careful physical examination
Reference


