Premiere Publications from The Triological Society

Read all three of our prestigious publications, each offering high-quality content to keep you informed with the latest developments in the field.

**Laryngoscope**

*FOUNDED IN 1896*

Editor-in-Chief: Michael G. Stewart, MD, MPH

The leading source for information in head and neck disorders.

[Laryngoscope.com](http://Laryngoscope.com)

**Laryngoscope Investigative Otolaryngology**

*Open Access*

Editor-in-Chief: D. Bradley Welling, MD, PhD, FACS

Rapid dissemination of the science and practice of otolaryngology-head and neck surgery.

[InvestigativeOto.com](http://InvestigativeOto.com)

**ENTtoday**

*A publication of the Triological Society*

Editor-in-Chief: Alexander Chiu, MD

Must-have timely information that Otolaryngologist-head and neck surgeons can use in daily practice.

[Enttoday.org](http://Enttoday.org)

*WILEY*
Laryngeal Fracture Presentation and Management in United States Emergency Rooms

Rosh K. V. Sethi, MD, MPH; Dara Khatib, BS; Maxwell Kligerman, MD, MPH; Elliott D. Kozin, MD; Stacey T. Gray, MD; Matthew R. Naunheim, MD, MBA

Objectives/Hypothesis: There are limited data on laryngeal fracture presentation and management in US emergency departments (EDs). We aimed to characterize patients who are diagnosed with laryngeal fractures in the ED and identify management patterns.

Study Design: Retrospective review of the Nationwide Emergency Department Sample (NEDS) from 2009 to 2011.

Methods: The NEDS was queried for patient visits with a primary diagnosis of open or closed laryngeal fracture (International Classification of Diseases, Ninth Revision codes 807.5 and 807.6). Patient demographics, comorbidities, ED management, and hospital characteristics were extracted.

Results: There were 3,102 ED visits with a diagnosis of laryngeal fracture during the study period. Mean patient age was 40.9 years (range, 3–93 years). The majority of patients were male (85.5%) and sustained a closed (vs. open) fracture (91.4%), with an overall mortality rate of 3.8%. The majority of patients were treated for more than one injury during the same visit (76.2%). Most patients were evaluated at a trauma hospital (53.9%), and most patients were admitted to the hospital (71.9%). Emergent intubation or tracheostomy was rarely reported (2.6% and 0.1% of all cases), and a minority of patients underwent fiberoptic flexible laryngoscopy in the ED (1.9%). Laryngeal fractures occurred more frequently during summer months (28.2%). Mean charge for the entirety of the ED stay was $4,957.34.

Conclusions: Laryngeal fracture is rare and frequently associated with other injuries. The frequency of emergent airway procedure, imaging, and flexible fiberoptic laryngoscopy is lower than expected, raising concerns about appropriate workup and management or recognition of injury in the ED setting.

Key Words: Larynx, laryngeal cartilage, cartilage fracture, fracture, larynx fracture, laryngeal trauma, larynx trauma, airway trauma, airway, larynx, laryngeal.

Level of Evidence: NA

INTRODUCTION

Laryngeal trauma is a rare but potentially life-threatening injury that results from either blunt or penetrating wounds to the neck. Blunt trauma is more common than penetrating injury, with motor vehicle collisions responsible for the majority of cases.5 Damage to the larynx can be mild or severe, ranging from edema and mucosal tears to cartilage fracture and airway collapse.2 Presenting symptoms commonly include dyspnea, dysphonia, anterior neck pain, and hemoptysis, as well as physical exam findings such as flattening of the thyroid cartilage protuberance, neck crepitus, and diminished breath sounds; conversely, some patients may exhibit no symptoms.3 Displaced laryngeal fractures can have particularly devastating outcomes, leading to significant problems with airway patency and protection, swallowing, and phonation.3

Prior studies from the 1990s have estimated the incidence of laryngeal trauma to be between one per 5,000 to one per 140,000 emergency room visits,4–7 with a mortality rate between 1% and 13%.6,8 These data may be disparate because of differences in sample size, varying geographic locations, and rarity of the diagnosis, which makes it difficult to study. Laryngeal fracture is a relatively rare outcome that can present with late-onset symptoms, and as such its diagnosis requires a high degree of clinical suspicion.9 Prompt diagnosis and management of laryngeal fracture has been shown to reduce mortality and significantly improve long-term complications with breathing, swallowing, and phonation.7 However, the symptomatology and treatment of laryngeal trauma depend largely on the mechanism and anatomical location of injury.4 Accordingly, there are limited clinical data available to guide optimal management in an emergent setting.4–8

Although several recent studies have assessed the subject of laryngeal trauma, most have relied on retrospective data from single institutions.5,7–11 Only two studies to date...
have analyzed national databases to study laryngeal injury patterns. In 2011, Sidell et al. assessed pediatric laryngeal trauma using the National Trauma Data Bank. In 1999, Jewett et al. studied 399 patients with external laryngeal trauma managed in an inpatient setting. However, a substantial gap in the literature still remains with regard to understanding national emergency room patterns and outcomes for laryngeal trauma. Few studies have specifically assessed laryngeal fractures, which occur in upward of 1% of all cases of laryngeal trauma.

Herein, we present the first nationwide emergency department (ED) analysis of laryngeal fractures by analyzing the National Emergency Department Sample (NEDS). We provide a detailed overview of patient demographics, the nature of their injuries, and the course of management in the ED.

MATERIALS AND METHODS

Data Source

A retrospective analysis was conducted using the 2009 to 2011 NEDS, published by the Healthcare Cost and Utilization Project and sponsored by the Agency for Healthcare Research and Quality. The NEDS is the largest publically available, all-payer ED database in the United States. It contains discharge abstracts from approximately 135 million ED visits at 945 hospitals across 33 states and the District of Columbia, approximating a 20% stratified sample of hospital-based EDs in the United States. It includes demographic data, the nature of ED visits, discharge data, and charge information.

Diagnosis and Procedural Codes

In the NEDS, all ED visits were queried for International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes consistent with a diagnosis of open or closed laryngeal fracture (ICD-9-CM codes 807.5 and 807.6). Patient demographics (age, gender, patient residence, median household income quartile by zip code, insurance payer), hospital characteristics (trauma designation and teaching status), and patient disposition were obtained. The NEDS classifies mechanism of injury based on ICD-9-CM external causes of injury codes (E-codes) according to established methods. There are 11, non-mutually exclusive categories including injury from blunt trauma, cutting/piercing, drowning/submersion, fall, fire, firearm, machinery, motor vehicle traffic, natural/environmental causes (e.g., stings and bites), poisoning, and suffocation that were queried. The Injury Severity Score (ISS), an established medical score used to determine trauma severity (major trauma defined as ISS > 15), was averaged for laryngeal fracture patients. Presence or absence of concurrent injuries was also characterized.

Procedures performed in the ED were queried, including bedside flexible fiberoptic laryngoscopy (Current Procedural Terminology [CPT] codes 92511, 31575), emergency intubation (CPT code 31500), and emergency tracheostomy or cricothyroidotomy (CPT codes 31603, 31605). Diagnostic workup, including computed tomography (CT) imaging of the neck (CPT codes 70490, 70491, 70498) and chest (CPT codes 71250, 71260, 71270, 71275) were queried. Finally, presence or absence of physical exam findings including dysphonia (ICD-9-CM code 784.42), stridor (ICD-9-CM code 786.1) or open wound of the neck (ICD-9-CM code 874) was determined.

Statistical Analysis

Descriptive analysis was performed to characterize patient demographics (age, gender, residence, national quartile for median household income of patient’s zip code and insurance), visit characteristics (year, season, day of week), payment information (primary payer), mean ED charges (representative only of charges incurred in the ED setting and not during subsequent hospitalization, if applicable), hospital characteristics (trauma designation, teaching status, geographic region), injury information (mechanism of injury, characteristics, severity score), and management information (emergency intubation, emergent tracheostomy/cricothyroidotomy and fiberoptic scope exam). The NEDS is a stratified two-stage cluster sample; discharge weights and standard formulas for a two-stage cluster sample were used to generate national estimates and calculate standard errors.

Patient demographics, emergency procedures, and injury/visit/payment/hospital characteristics were compared by fracture type (open vs. closed) in bivariable analysis. Differences in proportions and means were assessed using sample design-adjusted statistical tests including the Wald χ² test (for proportions) and two-sided unpaired t tests (for means). Statistical significance was determined using a type I error threshold of 0.05. Data linkages and statistical analysis were performed using SAS version 9.4 (SAS Institute, Cary, NC).

RESULTS

Patient Demographics and Geographic Distribution

A total of 3,102 ED visits from 2009 to 2011 were associated with a diagnosis of open or closed laryngeal fracture and were included in our analysis; complete patient characteristics are presented in Table I. There was a total of 388,904,009 ED visits during this time frame, and the incidence of laryngeal fracture was approximately one per 125,000 ED visits. Mean patient age was 40.9 years (standard error of the mean [SEM] = 0.65 years; range, 3–93 years), and the majority of patients were male (85.5%). The greatest number of laryngeal fractures occurred in the geographic south of the United States (36.0%), whereas the fewest occurred in the geographic northeast (19.6%) (Fig. 1).

Income, Insurance, and ED Charges

The majority of patients came from households in the lowest quartile for median household income by zip code (31.4%) as compared to patients from households in the highest quartile of median income (18.7%). Most patients had private insurance (32.3%), whereas Medicare (9.5%) made up the smallest proportion of primary payers. The mean ED charge per visit was $4,957.34 (SEM = $471.35).

Symptomatology and Mechanism of Laryngeal Fracture

Injury characteristics are presented in Table II. All diagnoses were related to an injury, and the most common mechanisms of injury were blunt trauma (28.8%), motor vehicle trauma (16.2%), and fall (10.6%). Injuries were described as unintentional (76.2%), assaults (31.6%), or intentional self-harm (5.5%). A
large proportion of patients were treated for more than one injury during the same visit (66.9%). Laryngeal fractures occurred more frequently during the summer months (28.2%). The most commonly documented symptoms were open wound of neck (10.9%), dysphonia (3.6%), and stridor (0.6%).

**ED Management and Outcomes**

The majority of patients sustained a closed (versus open) fracture (91.4%), and the mean ISS was low (10.0). Emergent intubation was rarely reported (2.6% of all cases), and only a very small minority of patients underwent flexible fiberoptic laryngoscopy in the ED (1.9%) or required emergency tracheostomy or cricothyroidotomy (0.1%). A minority of patients underwent CT with or without angiography of the neck (11.5%) or of the chest (2.0%). Most patients were evaluated at a trauma hospital (53.9%) and were subsequently admitted (71.9%). The overall mortality rate of laryngeal fractures was 3.8%, and includes patients who either died in the ED (1.8%) or during their subsequent hospitalization (2.0%). The cause of death could not be determined in the NEDS.

**Workup, Management, and Outcome Differences Between Open and Closed Fractures**

A comparison of injury and management characteristics between closed and open laryngeal fractures is presented in Table III. Patients presenting with open laryngeal fractures were younger than those presenting with closed fractures (32.9 years vs. 41.7 years, $P < .0001$). CT/computed tomography angiography (CTA) of the neck was performed more frequently in patients with closed fractures (352 times vs. six times, $P = .0009$). ISS was greater in open fractures than in closed fractures (30.3 vs. 8.1, $P < .0001$). Patients with open laryngeal fractures were more likely to present with an open wound of the neck (45.4% vs. 7.6%, $P < .0001$). The etiology of injury was more likely to be blunt trauma for patients with closed fractures (31.3% vs. 1.7%, $P < .0001$), whereas a cut or piercing was the most likely etiology for patients with open fractures (19.8% vs. 1.2%, $P = .0029$). There was no statistically significant difference in mortality (3.8% vs. 3.2%, $P = .7935$) between closed and open fractures. All patients who underwent emergency tracheostomy or cricothyroidotomy had closed laryngeal fractures (0.1% of all patients).

**DISCUSSION**

This epidemiological study is the first nationwide, hospital-based ED analysis of laryngeal fractures in the United States. These findings suggest that laryngeal fractures are rare; however, there is a possibility of underdiagnosis in the ED setting given the relatively low incidence compared to prior single-institution reports. Although our calculated incidence of laryngeal fracture was approximately one per 125,000 ED visits, single-institution reports have found an incidence of approximately 1 in 30,000 patients who present to the ED. Our results also highlight significant differences in the mechanism of injury, severity, presentation, and management of closed versus open fractures. Finally, the frequency of intubation, emergent tracheostomy/cricothyroidotomy, imaging, and flexible fiberoptic laryngoscopy is lower than expected given current management algorithms cited in the literature, raising concerns about appropriate recognition, workup, and management in the ED setting.

Laryngoscope 129: October 2019

Sethi et al.: Laryngeal Fractures in the ED
As expected, laryngeal fractures occurred more frequently in the summer months, when individuals may be more likely to engage in recreational activities or experience injuries. The temporal nature of increased vehicular travel could also contribute to these results, as previous research has demonstrated that summer and fall months experience more motor vehicle accidents than winter and spring. Airbag deployment may also result in blunt neck trauma and may account for this observed injury pattern. Although laryngeal fractures occurred disproportionately across geographic regions in the United States, these statistics are consistent with 2009 to 2011 census data documenting disproportionate population sizes across these regions. As of 2011, 37.2% of the population lived in the South, where 36% of laryngeal fractures occurred; similarly, the Northeast held the lowest percentage of the population in 2011 (17.9%) and had the lowest proportion of laryngeal fractures (19.6%).

The vast majority of laryngeal fractures occurred in adult males. Given that the most common mechanisms of injury were blunt trauma and motor vehicle collisions, with a large number of injuries related to assault, this finding is likely related to the tendency for males to engage in riskier behavior than females. Disproportionate fracture burden among men may also be associated with the larger size of the larynx, greater projection of the thyroid cartilage, and increased rigidity. Lower socioeconomic status was found to be associated with increased likelihood of laryngeal fracture. This is consistent with previously published reports that socioeconomic status may be inversely associated with risk-prone behavior.

Our analysis identified several significant differences between open and closed laryngeal fractures. Blunt, non-penetrating trauma would be expected to result in a greater frequency of closed fractures, whereas a cut or piercing injury would be expected to result in a greater frequency of open fractures; both of these assumptions are corroborated by our findings. Similarly, given that injuries tend to be more severe in open fractures, the higher ISS for open fractures is expected. A higher ISS in this population is likely indicative of more significant trauma burden in general due to the mechanism of injury. Mean age differences between open and closed fractures are analogously explained by the greater likelihood of risk prone behavior among younger men.

Notably, CT/CTA of the neck was performed infrequently in the ED, and the majority of times only utilized among patients with closed rather than open fractures. These patients were more likely to have sustained blunt trauma; therefore, imaging may have been employed primarily to rule out vascular injury or to assess the cervical spine. It is possible that in many of these cases, laryngeal fracture was an incidental finding, as few patients had any significant airway symptoms. Patients with open fractures were likely unstable for imaging due to concurrent injuries and higher ISS. Overall, the frequency of imaging was low, raising the possibility of inaccurate reporting or coding; it is unclear how a diagnosis of laryngeal fracture could be made without a neck CT or laryngoscopy. It is also possible that patients may have been diagnosed in the inpatient setting on tertiary survey rather than in the ED setting. These data were not available in the NEDS. Generally, the value of imaging is controversial, though CT exhibits reliability for diagnosing the presence of a fracture and defining the extent of soft tissue trauma in a stable patient. Imaging should only be obtained if a patient is deemed safe and absent of any concerning symptoms such as stridor, crepitus, or decreased oxygen saturation that may warrant urgent intervention first.

Notably, few patients required emergent intubation or cricothyroidotomy, and a minority underwent flexible fiberoptic laryngoscopy. Emergent intubation, tracheostomy, or cricothyroidotomy are rare in general; however, regarding the latter, these findings are inconsistent with recommended management of patients with suspected

Fig. 1. Geographic variation in prevalence of laryngeal trauma across the United States, 2009 to 2011. [Color figure can be viewed in the online issue, which is available at www.laryngoscope.com.]
Injury Characteristics, Emergency Department Procedures and Management, Patient Symptoms, and Disposition.

<table>
<thead>
<tr>
<th>Injury Characteristics</th>
<th>Weighted Frequency (Mean ± Standard Error of Percent), N = 3,102</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fracture type</td>
<td></td>
</tr>
<tr>
<td>Open</td>
<td>266 (8.6 ± 1.4)</td>
</tr>
<tr>
<td>Closed</td>
<td>2,836 (91.4 ± 1.4)</td>
</tr>
<tr>
<td>Injury mechanism*</td>
<td></td>
</tr>
<tr>
<td>Fall</td>
<td>329 (10.6 ± 1.3)</td>
</tr>
<tr>
<td>Blunt trauma</td>
<td>892 (28.8 ± 1.9)</td>
</tr>
<tr>
<td>Motor vehicle traffic</td>
<td>502 (16.2 ± 1.4)</td>
</tr>
<tr>
<td>Nature</td>
<td>59 (1.9 ± 0.6)</td>
</tr>
<tr>
<td>Age, yr, mean</td>
<td>41.7 (0.7)</td>
</tr>
<tr>
<td>Emergency intubation</td>
<td>79 (2.8 ± 0.5)</td>
</tr>
<tr>
<td>Emergency tracheostomy</td>
<td>4 (0.1 ± 0.1)</td>
</tr>
<tr>
<td>Injury Severity Score</td>
<td>329 (12.4 ± 1.4)</td>
</tr>
<tr>
<td>Death</td>
<td>108 (3.8 ± 0.7)</td>
</tr>
<tr>
<td>Injury type*</td>
<td></td>
</tr>
<tr>
<td>Unintentional</td>
<td>2,365 (76.2 ± 2.2)</td>
</tr>
<tr>
<td>Assault</td>
<td>981 (31.6 ± 1.9)</td>
</tr>
<tr>
<td>Intended self-harm</td>
<td>172 (5.5 ± 1.0)</td>
</tr>
<tr>
<td>Injury Severity Score</td>
<td>8.1 (0.2)</td>
</tr>
<tr>
<td>Multiple injuries</td>
<td>2,075 (66.9 ± 1.9)</td>
</tr>
<tr>
<td>Emergency intubation</td>
<td>79 (2.6 ± 0.4)</td>
</tr>
<tr>
<td>Emergency tracheostomy</td>
<td>4 (0.1 ± 0.1)</td>
</tr>
<tr>
<td>Fiberoptic laryngoscopy</td>
<td>60 (2.1 ± 0.6)</td>
</tr>
<tr>
<td>CT/CTA neck</td>
<td>352 (12.4 ± 1.4)</td>
</tr>
<tr>
<td>CT/CTA chest</td>
<td>61 (2.0 ± 0.6)</td>
</tr>
<tr>
<td>Stridor</td>
<td>19 (0.7 ± 0.3)</td>
</tr>
<tr>
<td>Dysphonia</td>
<td>111 (3.9 ± 0.8)</td>
</tr>
<tr>
<td>Open wound of neck</td>
<td>217 (7.6 ± 1.1)</td>
</tr>
<tr>
<td>Death</td>
<td>55 (1.8 ± 0.4)</td>
</tr>
<tr>
<td>Emergency tracheostomy</td>
<td>79 (2.6 ± 0.4)</td>
</tr>
<tr>
<td>Fiberoptic laryngoscopy</td>
<td>60 (2.1 ± 0.6)</td>
</tr>
<tr>
<td>CT/CTA neck</td>
<td>352 (12.4 ± 1.4)</td>
</tr>
<tr>
<td>CT/CTA chest</td>
<td>61 (2.0 ± 0.6)</td>
</tr>
<tr>
<td>Stridor</td>
<td>19 (0.7 ± 0.3)</td>
</tr>
<tr>
<td>Dysphonia</td>
<td>111 (3.9 ± 0.8)</td>
</tr>
<tr>
<td>Open wound of neck</td>
<td>217 (7.6 ± 1.1)</td>
</tr>
<tr>
<td>Death</td>
<td>55 (1.8 ± 0.4)</td>
</tr>
<tr>
<td>In hospital</td>
<td>62 (2.0 ± 0.5)</td>
</tr>
</tbody>
</table>

*Non–mutually exclusive categories.

CT = computed tomography; CTA = computed tomography angiography; ED = emergency department; SEM = standard error of the mean.

The immediate goal of examination of patients with laryngeal trauma is to ascertain injury severity to rapidly identify those who require immediate airway intervention. Guidelines recommend that once the airway is deemed stable, laryngoscopy is a critical step toward evaluating the status of the airway after laryngeal trauma. It is notable that the majority of laryngeal fracture patients were evaluated in nontrauma EDs where access to otolaryngology specialists may have been limited, or there is a lack of adherence to consensus guidelines.

In cases of laryngeal trauma, imaging is also recommended to rule out cervical spine injuries. These findings again raise the possibility that the majority of laryngeal fractures are incidentally discovered, rather than suspected and triaged. There are no published guidelines for how to manage incidentally discovered laryngeal fractures, and so the role of laryngoscopy in this setting remains uncertain. Additionally, it is notable that reported incidences of dysphonia and stridor are low, supporting the possibility that many fractures are incidentally discovered or not appreciated in the emergency setting.

The findings presented here have potential implications for hospital preparedness and education. Because laryngeal fractures vary in their clinical presentation, and often present without any clear symptoms of laryngeal injury, greater awareness of laryngeal fractures by ED physicians and triage nurses may lead to more frequent identification and appropriate consultation or workup. Accurately diagnosing laryngeal fractures may prevent avoidable sequelae, including compromised airway patency, impaired voice production, and dysphagia. Additionally, a number of surgical specialties may be consulted for suspected laryngeal fractures, including general surgery, otolaryngology–head and neck surgery, plastic surgery, and oral and maxillofacial surgery. Because the NEDS does not document consultations, it is unclear whether otolaryngology consultation was associated with likelihood of imaging, intubation, fiberoptic laryngoscopy, diagnosis, or airway outcomes. However, lower threshold for otolaryngology consultation, or transfer to an institution where otolaryngology consultation is available, in the event of neck trauma may improve identification of laryngeal fractures and better guide...
management decisions. Otolaryngologists are particularly important for fiberoptic evaluation of the upper airway, which is strongly recommended in the case of suspected laryngeal trauma.\textsuperscript{23}

There are several limitations to this study. The NEDS is an administrative database and may be subject to coding error. Additionally, detailed data regarding the nature of the injury, timing of injury, symptomatology, consultation, workup, and cause of death were not available. There may be unknown confounders we could not account for given limitation of variables available in the NEDS. The NEDS does not provide data regarding procedures performed in the operating room or inpatient setting. A relatively low number of patients died as a result of their injuries, consistent with prior studies. However, more severe injuries may result in prehospitalization deaths, which we cannot account for in this analysis, and therefore, we may underestimate the true burden of laryngeal fracture trauma. The temporal nature of laryngeal fracture diagnosis in the inpatient versus ED setting is not clear from these data, raising the possibility of delayed diagnosis in the majority of cases. Finally, the NEDS is not a longitudinal database, and subsequent inpatient or outpatient outcomes data cannot be ascertained.

CONCLUSION

This study provides a contemporary analysis of US epidemiological trends of laryngeal fracture, a relatively rare diagnosis commonly associated with other injuries. The frequency of intubation, imaging, emergency airway procedures, and flexible fiberoptic laryngoscopy in the ED setting is lower than expected given current management algorithms cited in the literature, raising concerns about appropriate workup and management in the ED setting versus delayed diagnosis. These findings may improve awareness about laryngeal fractures and optimize diagnostic and management algorithms.

BIBLIOGRAPHY