1. Introduction

In rare cases, civilian or military trauma to the neck may lead to acute pharyngeal and laryngeal injuries which are likely to put the patient’s life at risk. Due to the low incidence of this type of injury, few authors have published data from large patient cohorts, and the exact incidence of such injuries still remains poorly documented. In North American series, the rate of external laryngeal trauma has been reported as between 1 in 30,000 and 1 in 137,000 patients admitted into emergency departments. As a result, currently available evidence arises from small case series and expert opinions, as reported by Schaefer et al. The important analysis carried out by these authors reviewed literature from the last 90 years, and also took into account recent trauma databases. The low incidence of neck trauma and the socio-demographic characteristics of patients need to be considered from a historical perspective, especially with regard to international conflicts and terrorism. For example, in the decades immediately following World War II, the incidence of blunt trauma outnumbered penetrating laryngeal injuries due to road traffic accidents (RTA) and poor automobile design. However, the frequency of blunt neck injuries gradually decreased as improvements were made to the safety of motor vehicles and to the protection of their drivers.

Currently, aero-digestive tract injuries to the neck are reported in about 7% of penetrating neck injuries. A prospective study of 223 patients with penetrating neck injuries identified only 14 patients (6.3%) with pharyngo-oesophageal or laryngo-tracheal injuries. The incidence was higher in gunshot wounds (7.2%) than in stab wounds (3.1%).

In terms of blunt trauma to the neck, the incidence of injuries to the aero-digestive tract is very low nowadays. In a survey of 11,663 blunt trauma patients, only 40 cases (0.34%) had laryngo-tracheal injuries, and 9 cases (0.08%) suffered oesophageal injuries. Laryngo-tracheal injury is less common in children than adults since the paediatric larynx and trachea are more deformable and therefore more resistant to fracture. On the other hand, the paediatric larynx is more prone to oedema following trauma.

When considering neck injuries, vulnerability should be considered in view of the complex anatomy and compact anatomic content of this region. Immediately life-threatening situations mainly occur when neck injuries create difficult conditions for airway management, creating a
stressful situation for pre-hospital intervention teams and in-department A&E teams. Due to its essential role in phonation, breathing and feeding, and the presence of major vascular, endocrine and nervous systems, injuries to the throat also lead to impaired function and serious loss of quality of life. The precise knowledge of the mechanisms of injury, as well as the recognition of clinical signs allowing early injury diagnosis, is of paramount importance in order to avoid delays in giving appropriate care to these patients. This type of rapid diagnosis will in turn make the identification of patients requiring surgical management easier.

2. Anatomy of laryngeal trauma

2.1. Classical description

The larynx is situated along the midline of the neck. It is suspended from the skull via the hyoid bone anterior to cervical vertebrae C4-C6. It is composed of cartilaginous pieces joined together by a fibrous membrane.

Its skeleton is formed by:
- Two immobile cartilages, the thyroid and cricoid, which keep the larynx open. The former is V shaped and open at the posterior; the latter is circular and closed (representing the narrowest section of the respiratory tract)
- Two mobile cartilages, the arytenoids, each of which represents a fragile articulation with the cricoid. Their mobility allows abduction and adduction of the vocal cords and therefore plays an essential role in the three functions of the larynx: breathing, phonation and deglutition.

The mucosa covering these structures is characterized by its low adherence to the underlying tissue and therefore may cause devolvement and the development of sub-mucosal haematomas.

A number of anatomic factors may partly account for the low frequency of injury to the larynx:
- Its composition of cartilages and membrane forms an elastic structure which is less fragile than other more rigid structures.
- Its anatomical position in the neck offers protection to the larynx via the mandible, the sternum and the cervical vertebrae. Laterally, the larynx is protected by the SCM muscle, which offers a muscular mattress for the larynx.

In case of an accident, the head tends towards excessive spontaneous flexion of the neck. With this reflex movement, the mandible comes into contact with the sternum, thus providing further protection for the larynx. This is especially the case in the paediatric population, as the head is comparatively larger, the neck shorter and the larynx situated higher. On the other hand, the larynx is narrower and the mucosa less adherent than in adults. A minor injury may therefore cause respiratory difficulties in children.

2.2. Alternative anatomical classification

In the classical approach, two triangular zones are recognized anterior and posterior to the sternocleido-mastoid muscle. The anterior zone contains the most important vascular and aero-digestive structures, while the posterior region contains the less vital structures. In 1969, Cook County investigators divided the neck into three zones, and in 1979, Roon and Christensen revised this classification with the aim of standardizing attitudes to therapy and treatment. Their classification has become the most widely used, and defines Zone I from the clavicles to the cricoid cartilage, Zone II from the cricoid cartilage to the angles of the mandible and Zone III from the angle of the mandible to the base of the skull.

This classification enables diagnosis modalities and management strategies arising from the evaluation of all structures at risk of injury, based on the content of all three zones.

3. Etiopathogeny

The mechanisms of injury will differ according to the open or closed nature of the lesions under consideration.

3.1. Blunt trauma

Whatever the origin of these lesions, the principle remains the same: anterior compression of the larynx, which is forced against the rigid posterior wall formed by the cervical column. Since the larynx is an elastic structure, low-velocity trauma causes contusions to the soft tissue or fractures of the hyoid bone. In contrast, high velocity trauma not only causes laceration of the soft tissue but also fractures the thyroid and/or cricoid cartilage. Another type of injury, known as a "clothes-line" injury, may also be encountered. These types of injuries, in contrast to the minimal skin lesions...
Direct and indirect injuries of the pharynx and larynx

shown, may sometimes lead to life-threatening situations such as crico-tracheal dislocation.3

Closed injuries stem chiefly from road traffic accidents (RTA), and are caused by the throat directly hitting the dashboard, the steering wheel, or the handlebars of a motorcycle. The incidence of these types of injuries has diminished with the increased use of seatbelts and the implementation of airbags. Physical aggression forms the second most common cause of blunt trauma, and displays a similar injury mechanism by anterior compression. Sports trauma also accounts for a few cases of laryngeal lesions due to a direct blow to the structure (football, rugby, hockey, high-speed sports). These types of lesions may also be caused voluntarily by acts of violence such as strangulation. In these cases, the main risk of injury is related to the oedema caused by compression to the vascular structures of the neck. These lesions may not be apparent until 12-24 hours after the initial injury.11

Deceleration injuries following a high-velocity RTA may also lead to this type of closed lesion. Here, the causes of injury are mainly oedema to the soft tissue or lesions to the cricoid or carena.

3.2. Penetrating trauma

3.2.1. Stab wounds

The severity of the injury and its mechanisms will vary depending on the type of weapon used. In the case of a blade, the most common lesions affect the soft tissues: the pre-laryngeal muscles, the laryngeal membrane and the trachea. The vascular structures of the neck are well protected by the sterno-cleido-mastoid muscle and are therefore only injured in very deep and lacerating wounds. The hypopharynx and oesophagus are well protected by their anatomical position and are only rarely injured. If a sharp instrument such as a screwdriver causes an injury, the entry wound will be small but the underlying injuries may, in contrast, be severe. In such cases, an exploration is necessary in order to exclude haematomas or lesions to the mucosa that may, if ignored, lead to a rapid aggravation of dyspnoea.12

3.2.2. Gunshot wounds

These lesions are much more complex injuries, since injuries are caused not only to the structures in the path of the projectile, but to also the surrounding structures. The kinetic energy of the projectile dissipates in all three planes and thus causes dilacerations of soft tissue, fracture of cartilage and vascular and neurological lesions. In these cases, post-traumatic necrosis is frequent. Although the entry and exit wounds are small, careful exploration is therefore necessary to assess the extent of the damage to the tissues.12,13

3.2.3. Other types

Other open lesions are caused by work-related accidents and form a very heterogeneous group that is outside the scope of this work. These types of injury are often seen in agriculture and forestry work. (Figure 1)

![Figure 1](image.png)

Penetrating neck injury: industrial accident involving a chainsaw. The patient was admitted for severe dyspnoea requiring urgent tracheostomy. Cervical dilaceration with associated left anterior thyroid cartilage fracture and laryngeal wound penetrating the crico-thyroidian membrane

4. Clinical presentation and physical evaluation

Whenever possible, information concerning the entire history, circumstances and mechanism of injury together with pre-hospital data and reports of respiratory and circulatory status should be carefully recorded. If the patient’s level of consciousness permits, their complaints should be recorded during careful clinical examination. This clinical assessment should focus on any respiratory, vascular or neurological damage.
In practice, there are two possible scenarios depending upon the patient’s level of consciousness: awake and alert, or not. Unconscious patients or patients with endotracheal intubation prove a greater diagnostic challenge to the clinician.

There is still debate over the diagnostic role of symptoms and physical evaluation in the accurate diagnosis of injuries associated with neck trauma. Several studies emphasise the futility of further investigation in clinically evaluable asymptomatic patients.\(^4,14,15\) However, missed vascular and oesophageal injury have been reported in asymptomatic patients.\(^6\) Indeed, clinical signs and symptoms have low sensitivity, specificity and predictive value.\(^11\) Some authors have warned of the inconsistent relationship between severity of the injury and clinical symptoms.

In line with this finding, the practice guidelines for the Association for Surgery Trauma consider that physical examination alone is inadequate to rule out aero-digestive injuries.

The clinical presentation varies from a hoarse voice to major respiratory distress, while symptoms range from dyspnoea, dysphonia, odynophagia and coughing to haemoptysis. An air leak during coughing and the appearance of subcutaneous emphysema in the neck are key elements in the evaluation of laryngo-tracheal injury. Data from a retrospective study of patients with penetrating laryngo-tracheal injuries indicated that the most frequent clinical finding was the presence of subcutaneous emphysema (39%), followed by respiratory distress (33%), haemoptysis (5%) and hoarseness (4%).\(^19\) Symptoms following blunt trauma are often minimal and delayed. In such cases, the initial assessment may be hindered by the presence of associated injuries to the face, head or cervical spine.

Skin inspection should search for any excoriation, ecchymosis or wound as well as for an eventual air leak through the wound during coughing. In stable patients who have undergone penetrating trauma, identification of the wound’s location in Zones I, II or III should be noted. This information, together with the patient’s symptoms, plays an important role in therapeutic decision making. Potential compromise of the airway is further determined by the trajectory of a projectile or knife and the energy dissipated in the injury. The extent of injury following blunt trauma may be more difficult to define, and the injury may progress in the hours following the lesion; this emphasizes the importance of laryngoscopic examination. Palpation, to search for loss of normal anatomical relief or subcutaneous emphysema, should be carried out cautiously in order to avoid dislocating an undiagnosed unstable fracture.

Clinical evaluation should include observation and repeated re-evaluation of the patient due to the possible risk of oedema, haematoma, or fracture instability of the larynx.

### Table 1

<table>
<thead>
<tr>
<th>Grade</th>
<th>Lesions</th>
<th>Respiratory risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Normal larynx</td>
<td>None</td>
</tr>
<tr>
<td>1</td>
<td>No fracture</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Discreet haematoma</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Low injury to mucosa</td>
<td>None</td>
</tr>
<tr>
<td>2</td>
<td>Undisplaced fracture</td>
<td>Present, severity depends on the lesions</td>
</tr>
<tr>
<td></td>
<td>Low oedema</td>
<td>Present, severity depends on the lesions</td>
</tr>
<tr>
<td></td>
<td>Moderate haematoma</td>
<td>Present, severity depends on the lesions</td>
</tr>
<tr>
<td></td>
<td>Low mucosal tear</td>
<td>Present, severity depends on the lesions</td>
</tr>
<tr>
<td>3</td>
<td>Displaced fracture</td>
<td>Major</td>
</tr>
<tr>
<td></td>
<td>Major oedema</td>
<td>Tracheotomy necessary</td>
</tr>
<tr>
<td></td>
<td>Important haematoma</td>
<td>Major</td>
</tr>
<tr>
<td></td>
<td>Important mucosal tear</td>
<td>Tracheotomy necessary</td>
</tr>
<tr>
<td></td>
<td>Cartilage uncovered</td>
<td>Major</td>
</tr>
<tr>
<td></td>
<td>Vocal cord damage</td>
<td>Tracheotomy necessary</td>
</tr>
<tr>
<td>4</td>
<td>Grade 3+</td>
<td>Major</td>
</tr>
<tr>
<td></td>
<td>Unstable fracture or multiple fracture</td>
<td>Tracheotomy necessary</td>
</tr>
<tr>
<td></td>
<td>Stabilization necessary</td>
<td>Major</td>
</tr>
<tr>
<td></td>
<td>Major mucosal disruption</td>
<td>Tracheotomy necessary</td>
</tr>
<tr>
<td></td>
<td>Anterior laryngeal destabilization</td>
<td>Major</td>
</tr>
<tr>
<td>5</td>
<td>Complete laryngo-tracheal separation</td>
<td>Major</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tracheotomy necessary</td>
</tr>
</tbody>
</table>
Direct and indirect injuries of the pharynx and larynx

5. Classification of injuries

The different types of laryngeal lesions are listed in Table 1. It should be noted that a direct blow to the larynx can cause any of these types of lesions, but may also lead to a spasm or cardiac arrest. This is explained by the rich innervation of the larynx which, when injured, may lead to a nociceptive reflex. This is also known as “laryngeal commotion”.

6. Associated injuries

In addition to laryngeal and tracheal injuries, patients suffering from penetrating or blunt trauma to the neck may suffer from associated injuries, due to the anatomical characteristics of the neck area. Associated injuries occur in up to 50% of penetrating trauma cases. Associated vascular injuries have been reported in 25%–31% of cervical wounds, increasing patient mortality to 50% versus the 10% seen in blunt trauma. Any active bleeding, expanding haematoma, vascular thrill or the presence of neurological defect is indicative of vascular injury in almost 90% of cases, versus 1% with these elements absent at clinical examination.

Pharyngeal and oesophageal injuries are more common in penetrating trauma (33%–50%) and are often asymptomatic. Unfortunately, the complications of undiagnosed perforation lead to local abscess formation and may sometimes develop into mediastinitis.

Before any manipulation of the cervical spine is allowed, spinal cord injury must be excluded. Other nervous structures are also potentially at risk, including the cranial and phrenic nerves, the cervical sympathetic system and the brachial plexus.

7. Complementary examinations

No laryngeal examination should be conducted unless the airway is stabilized. It must be noted that any fibroscopic examination can destabilize the patient and lead to dyspnoea, and must therefore be performed in a delicate and careful manner.

7.1. Flexible naso-fibroscopy (Figure 2)

Local anaesthesia is to be avoided, as it may lead to respiratory failure. Likewise, any examination of the sub-glottic region should be conducted with the utmost care, when necessary. This fibroscopic examination enables an evaluation of the extent of the lesions to the mucosa, laryngeal oedema, the diameter of the respiratory tract and thus an assessment of the risk of further complications. Careful examination should also evaluate damaged or uncovered cartilage. This examination will also enable the diagnosis of any possible crico-arythenoid dislocation. In addition, this will facilitate the search for lesions to the cavum, oropharynx and hypopharynx.

7.2. Rigid endoscopy under general anaesthesia

This examination should take place once a tracheotomy has been carried out and after cervical column fracture has been ruled out. Classic rigid laryngoscopes are used together with the usual optics of 0°, 30° and 70°. These enlarging optics enable the examination of lesions at different angles. The examination should focus on mucosal lesions, haematomas and oedema. Any dislocation of the crico-arythenoids should also be noted. In order to rule out laryngo-tracheal deinsertion, the sub-glottic and crico-tracheal regions should not be overlooked. As lesions to the cervical oesophagus may also exist, a careful examination of this region should be performed at the same time.

Surgical exploration may sometimes be necessary. This approach will be discussed later.
7.3. Imagery

Once the patient is stabilized, a CT scan should be carried out. This is the imaging technique of choice for trauma to the neck region. It should be performed using an injection of contrast in order to enable the study of lesions to the soft tissues. The CT-scan should use thin 1-2 mm slices in order to be accurate in detecting small fractures.4,19 (Figures 3-8)

8. Management

8.1. From the emergency physician’s point of view

Emergency doctors should be aware that, from the onset, haemodynamically unstable patients or patients with evident aero-digestive injury are likely to benefit from prompt surgical management. Apart from these critical situations, management is usually based on the symptoms displayed by the patient and on the location of the injury. The general ABCDE (Airway, Breathing, Circulation, Disability, External examination) approach, based on the Advanced Trauma Life Support, Pre-Hospital Trauma Life Support and European Resuscitation Council guidelines, remains perfectly relevant and allows for adequate prioritization of initial care.

8.1.1. Airway

Penetrating or blunt injuries to the neck may lead to immediate or delayed life-threatening compromise of the airway.

Figure 3 and 4
Physical aggression: direct blow to the larynx. Severe dysphonia without dyspnoea
Fracture of the posterior part of the cricoid cartilage with shift of the arythenoid due to crico-arythenoid dislocation. Haematoma on the right of the larynx

Figure 5
Fall in a bathtub. Dysphonia and severe dyspnoea. Urgent tracheostomy
Left paramedian fracture of the thyroid cartilage with posterior fracture of the cricoïd causing narrowing of the respiratory tract
Direct and indirect injuries of the pharynx and larynx

While most high-velocity weapons and severe blunt trauma are generally associated with urgent airway control. A review of 59 patients with penetrating laryngo-tracheal trauma showed that endotracheal intubation or cricothyroidotomy was rarely required in A&E. Another series including 40 patients with blunt laryngo-tracheal trauma also showed very similar results.

Clinical factors found to indicate the need for aggressive airway management include acute respiratory distress, obstructed airway, massive subcutaneous emphysema (of the neck), tracheal shift, severe alteration in mental status and expanding neck haematoma. However, stab wounds and low-velocity gunshot wounds seldom require pre-hospital or emergency room intubation,

---

**Figure 6**

Open trauma: industrial accident involving a chainsaw. Anterior cervical wound (dilaceration) with open injury to the larynx at the level of the crico-thyroid membrane and associated fracture of the lower left thyroid. Dyspnoea at admission, urgent tracheotomy.

**Figure 7**

**Figure 8**

**Figure 6, 7 and 8**

Open trauma: industrial accident involving a chainsaw. Anterior cervical wound (dilaceration) with open injury to the larynx at the level of the crico-thyroid membrane and associated fracture of the lower left thyroid. Dyspnoea at admission, urgent tracheotomy.
There is still debate over the ideal airway management for patients with significant injury mechanisms but no obvious signs of respiratory distress or vascular injury. Indeed, the advantage of an early “securing” intubation is based on the assumption that in case of delay, the potential dissection of fascia compartments by the air or blood could compromise any later attempt. This alternative, however, comes at the cost of performing intubations that would ultimately prove to be unnecessary and, sometimes, harmful. In these situations, several works have highlighted the importance of highly experienced physicians. The integrity of the larynx and trachea must therefore be definitively evaluated before intubation and any partial separation or avulsions considered. Similarly, the airway should be visible to direct endoscopy. Intubation of a patient with a fractured larynx could lead to a complete trans-section or create a false passage.

In most cases, classical oro-tracheal intubation is the easiest and most appropriate approach, but this may be rendered difficult in the presence of a large haematoma or oedema.

In case of doubt over the integrity of the larynx, tracheostomy is regarded as the best choice for securing the airway. The emergency team must be prepared for this possibility and must anticipate the need for specific technical and human resources for performing an appropriate procedure under adequate conditions and with suitable timing.

8.1.2. Breathing

An important factor to be considered by the emergency doctor is the proximity of the neck to the thorax, with possible combined injury to both areas. This is especially the case when hypoxaemia or ventilation difficulties occur. Asymmetric ventilation should always evoke the possibility of a co-existing haemo- or pneumothorax.

8.1.3. Circulation

Additionally, any critical external bleeding from the neck must be adequately identified and managed.

---

**Figure 9**

Zones of the neck:
- **Zone I** is the most caudal zone. Its lower boundary is formed by the clavicle/sternal notch. Its upper boundary is defined by the horizontal plane passing through the cricoid cartilage.
- **Zone II**, or the middle zone, is located between the horizontal plane passing through the cricoid cartilage and the horizontal plane passing through the angle of the mandible.
- **Zone III** is located between the horizontal plane passing through the angle of the mandible and the base of the skull.
In order to avoid extravasations, it is important to place the intravenous line access at a site where the administered fluid will not flow towards the injury site. Finally, proper protection of the cervical spine should always be assured when injury to the cervical spine is suspected.

8.1.4. Disability
Early neurological evaluation is paramount in the identification of direct nerve or spinal cord injury. Physicians should also consider cerebral ischaemia as a consequence of carotid injury.

8.1.5. Specific management of neck injury according to Roon and Christensen’s Zones (Figure 9)
In 2008, the Eastern Association for the Surgery of Trauma published their clinical practice guidelines for penetrating neck trauma. According to these guidelines, the management of injuries to the neck that penetrate the platysma depends on the anatomic level of injury. Lesions in Zone I should be managed and treated as upper thoracic injury. This zone covers the area from the thoracic inlet to the cricothyroid membrane. Zone III is situated above the angle of the mandible, and trauma to this area should be considered as a head injury. Zone II, situated as it is between the other two, remains an area of controversy. Indeed, selective operative management and mandatory exploration of penetrating injuries in this zone are considered to be equally justified and safe options.

8.2. From the head and neck surgeon’s point of view
There are two possible therapeutic solutions: observation or surgical management. The latter aims to re-establish anatomy, provide the patient with adequate laryngeal stability and reconstitute a functional respiratory tract.

8.2.1. Observation
In Type 0-2 lesions, if respiratory risk is absent then surveillance in a hospital setting should be carried out. The patient should remain in observation for 24 hours so that the development of compromising haematoma and/or oedema may be excluded. A cortisone-based drug therapy may be initiated if necessary in addition to painkillers when needed.

In the case of open wounds, antibiotic therapy should be started. In both cases, antacid therapy may be used to decrease local inflammation.

8.2.2. Surgical treatment
Surgical treatment is necessary in Grade 3-5 lesions, and should be carried out within the 24 hours following injury. This surgery is recommended under cover of tracheotomy. The aim of surgical treatment is to re-establish the most anatomic respiratory tract possible, to restore phonation and assure a sufficient mucosal lining. In addition, surgery will stabilize the fractured laryngeal cartilage. The incision should preferably be horizontal and situated away from the tracheotomy. The horizontal incision offers two advantages: a large view of the larynx and an acceptable wound healing.

The most common approach to the larynx uses a vertical medial or para-medial thyrotomy. This approach gives the surgeon a large view of the endolarynx and allows the necessary surgical repairs to be carried out without causing any functional damage. If there is a vertical fracture to the thyroid cartilage (and if medial or para-medial), this should be used in order to avoid increasing damage to the larynx.

Once the mucosae have been assessed they should be sutured using absorbable 4.0 or 5.0 monofilaments. The suture should be without tension and should use inverted sutures so as not to cause granulous healing.

If stenosis is present a calibration should be performed. The most frequently used types are the Montgomery tubes or Montgomery calibrating prosthesis. The latter should be fixed trans-cutaneously in order to avoid migration or inhalation. These calibrating devices should be left in place for as short a period as possible (less than 3 weeks) and the removal should be carried out under general anaesthesia and fibroscopic control of the respiratory tract.

Any fractured cartilage (if unstable or and moved) is stabilized and repaired in order to re-establish an anatomically acceptable architecture. The fractured cartilage is repaired using non-absorbable suture, K-wire or plating. After careful and hermetic closure of the thyrotomy, the pre-laryngeal muscles are sutured to further increase sealing. In the case of open trauma, a surgical exploration is required to search for vascular, nervous or pharyngo-oesophageal lesions. These injuries must also be repaired in a meticulous manner in addition to the above-mentioned repair.
8.2.3. Follow-up
The respiratory tract and laryngeal mobility are easily evaluated at distance from the initial trauma. It should be noted that, in addition to respiratory problems, persistent dysphonia is frequent. This may be explained by ankylosis of the crico-arythenoid, fibrosis of the vocal cords or nerve injury with laryngeal paralysis. When dysphonia persists, the patient should be referred to a speech therapist; if speech therapy approaches prove insufficient, more invasive techniques such as injection (fat or other) into the vocal cords may be proposed.

References