Penetrating and blunt trauma to the neck: clinical presentation, assessment and emergency management

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Abstract. Penetrating and blunt trauma to the neck: clinical presentation, assessment and emergency management. In Belgium, and even in Western Europe, penetrating and blunt injury to the neck is relatively uncommon in both the civilian and military populations. Pre-hospital and emergency assessment and management will therefore always prove challenging, as individual exposure to this specific type of injury remains low. Historically, the neck has been divided into three anatomical zones with specific landmarks to guide the diagnostic and therapeutic approach to penetrating neck injuries. Most penetrating injuries need to be explored surgically, although with the advent of multi-detector computed tomographic angiography (MDCTA), which yields high diagnostic sensitivity, this inflexible approach has recently changed to a more targeted management, based on clinical, radiographic and, if deemed necessary, endoscopic findings. However, some authors have addressed their concern about this novel, ‘no-zone’ approach, since the risk of missing less apparent aerodigestive tract injuries may increase. It is recommended, therefore, that all patients with penetrating neck injuries be closely observed, irrespective of the initial findings. The incidence of blunt neck injury is much lower, and this makes risk assessment and management even more difficult in comparison with penetrating injuries. Again, MDCTA is most often the first diagnostic tool if a blunt neck injury is suspected, due to its good sensitivity for blunt cerebrovascular injuries (BCVI) as well as for aerodigestive tract injuries. Specific patterns of injury and unexpected neurological and neuro-radiological findings in trauma patients should always warrant further investigation. Despite ongoing debate, systemic anticoagulation is recommended for most BCVI, sometimes combined with endovascular treatment. Aerodigestive tract injuries may present dramatically, but are often more subtle, making the diagnosis more difficult than other types of neck injuries. Treatment may be conservative if damage is minimal, but surgery is warranted in all other cases.

1. Introduction

Pre-hospital and emergency management of patients with neck injuries can be challenging. Even seemingly minor injuries may rapidly become life-threatening emergencies, requiring multidisciplinary specialist care involving emergency physicians, vascular surgeons, ear, nose and throat (ENT) and head and neck (HN) surgeons, anaesthesiologists and (interventional) radiologists. Blunt trauma to the neck, excluding cervical spine injuries, represents only 5% of all neck trauma, but can be very challenging to assess since its presentation is often delayed.1 Penetrating injuries, on the other hand, are more common, and even when they seem to be only superficial and minor, always need thorough investigation and observation.1 ENT and HN surgeons are very familiar with neck exploration and with establishing a surgical airway, but this is very rarely needed in traumatic, acute circumstances. Emergency physicians, on the other hand, are used to managing major trauma in a structured way; however, the presence of neck injuries may complicate this management and may require the prioritization of interventions.

In this review, we aim to summarize the current knowledge of blunt and penetrating injuries to the neck. We will focus on the differences
between historical mandatory neck exploration for penetrating injuries, and the more targeted approach that is now somewhat more widely used. This review underlines the importance of recognizing the risk factors for blunt cerebrovascular injuries, since these are reported more frequently and are more important than once thought.

2. Anatomy

Trauma to the neck can give rise to devastating injuries, as the area of the neck is a relatively unprotected anatomical region and contains a high concentration of vital structures. The neck contains several major vessels that lie relatively superficially and are protected only by their fascia and the overlying soft tissues. The same holds for the aerodigestive tract, which is even less protected by surrounding layers. The apical pleura, the brachial plexus, the thoracic lymphatic duct and the major intrathoracic vessels appear to be well protected by the clavicles, the sternum and the rib cage, but are much more vulnerable to penetrating lower neck injuries through the upper thoracic aperture and the supraclavicular fossa. The spinal cord, on the other hand, is well protected by the bony cervical spine, making penetrating injuries less harmful than sometimes anticipated.2,3

Less vital, but nevertheless important, are the thyroid gland, the parathyroid glands and the lower cranial nerves. Anatomical location can make a major difference in presentation, diagnostic and therapeutic approach, mainly in penetrating injuries. Historically, an anatomical division into anterior and posterior triangles, divided by the sternocleidomastoid muscle, was used to define this difference. The boundaries of the anterior triangle are the midline of the anterior neck, the lower border of the mandible and the anterior border of the sternocleidomastoid muscle. This triangle contains all vital vascular and aerodigestive structures.

The posterior triangle, however, is delineated by the posterior border of the sternocleidomastoid muscle, the middle third of the clavicle and the anterior border of the trapezius muscle and contains only the following vital structures at the base of the triangle: the apical lung, the brachial plexus and the subclavian artery and vein.

An alternative approach to anatomical division was presented by Roon and Christensen, who divided the anterior neck into three zones (Figure 1, Table 1), guiding diagnostic and therapeutic management for penetrating injuries.4,5 This artificial anatomical separation can indeed help to guide management. In penetrating injuries, however, the definition of which injuries

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| **Table 1**

Landmarks and features of the anatomical zones of the neck. 5

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<tr>
<th>Anatomical zone</th>
<th>Features</th>
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| Zone I | - From clavicles to cricoid cartilage  
- Defines area containing major vital structures  
- Is considered to be well protected  
Contains:  
intrathoracic major vessels  
subclavian veins and arteries, the proximal vertebral and carotid arteries  
oesophagus, proximal trachea, larynx  
brachial plexus, spinal cord  
superior mediastinum, pleura |
| Zone II | - From cricoid cartilage to the angle of the mandible  
- Defines area containing all vital structures  
- Is considered to be least protected, very superficial  
Contains:  
Carotid arteries, jugular veins, vertebral arteries  
Trachea, larynx, oesophagus  
Spinal cord |
| Zone III | - From the angle of the mandible to the base of the skull  
- Very confined, protected area  
- Difficult to assess and explore  
Contains:  
Distal vertebral and carotid arteries  
Pharynx  
Spinal cord |
Trauma to the neck

The prevertebral fascia covers the prevertebral muscles and blends with the axillary sheath to cover the subclavian vessels.

The three fascial layers blend together to form the carotid sheath, creating a tight vascular compartment that gives a protecting tamponade effect in haemorrhage, but also creates the risk of external airway compression in the case of expanding haematoma. Additionally, it may guide infections to the neck, spreading to the mediastinum.

Finally, although anatomical division into triangles or zones can be very helpful in the first assessment, injury patterns rarely respect these boundaries. Additionally, surgical emphysema, expanding haematomas or extensive lacerations can cloud anatomical judgement and make landmark-based decision impossible.

3. Prehospital and immediate emergency management

All trauma patients should be managed using the same structured approach, whether they suffer from blunt or penetrating trauma. The safety of healthcare professionals is the first priority, irrespective of the patient’s condition. In the case of a penetrating neck injury, this can be challenging; however, safety must be guaranteed at all times before a patient can be approached.

Pre-hospital management differs from management in the emergency department, as there is less time, fewer staff and fewer resources for evaluation and treatment. A primary survey should be carried out to look for life-threatening injuries to be treated immediately if needed. When the patient’s condition is sufficiently stable, a secondary survey should be carried out for every trauma patient. However, depending on associated injuries and the severity of these injuries, further diagnostics and secondary survey may be deferred, although these should never be forgotten.

As neck injuries need a high level of kinetic energy, have a high risk of other associated major injuries, and often need specialized diagnostic and surgical care, these patients need to be transferred primarily to a tertiary care centre with trauma capacity, an experienced Head and Neck Team and an intensive care unit. It is clear from recent literature that mortality decreases if trauma care is centralized in dedicated trauma centres.
unprotected difficult airway or uncontrollable major haemorrhage are exceptions and should always be transported to the nearest emergency department, with secondary transfer as soon as possible.

The initial approach is performed according current Advanced Trauma Life Support (ATLS) or European Trauma Course (ETC) protocols, which both use the structured ‘ABCD’ approach. In the in-hospital setting, a trauma team leader should take charge of his team members, all assigned to one specific task during the primary survey.

3.1. Five-second round

On arrival of the trauma patient in the emergency department, and obviously also when assessing a patient in the pre-hospital environment, the trauma team leader should make sure the patient has a patent airway, has no cardiorespiratory arrest and has no ongoing major haemorrhage. This short evaluation can be life-saving, as it may prompt immediate intervention. Complete handover then will be deferred until a basic airway is established, chest compressions are started or local pressure is applied in order to stop the bleeding.

3.2. Airway

Establishing a definitive airway in patients with neck injuries is always challenging, and when preparing a patient with neck injury, a difficult airway should be anticipated. In the hospital setting, calling for an anaesthesiologist should be considered.

Of highest importance is the recognition of clinical factors (Table 2) that indicate which patients need prompt and advanced airway management. In these patients, the main issue is to ensure that the definitive securing of the airway is not delayed, since distortion of anatomy and external compression by haematoma, oedema or surgical emphysema of the neck can make conventional techniques difficult, if not impossible. In the aforementioned indications, the decision is easily taken; however, the difficulty lies in those patients in which the symptoms are less pronounced. In these patients, a decision should be made based on a risk-benefit analysis, taking into account the site of injury, the own experience, additional injuries and travel time. The mechanism of injury should also be considered and will be evaluated and reported using the MIST acronym by most pre-hospital and military medical teams (M: Mechanism of injury, I: Injuries sustained, S: Signs, T: Treatment and trends in the vital signs).

Pre-hospital intubation by emergency physicians is associated with an increased complication ratio and even mortality, and complications and failure rates are higher for less skilled and less experienced professionals, with higher failure rates and a higher incidence of surgical airways observed in non-anaesthetic pre-hospital teams. Since patients with injuries which are apparently only minor may rapidly deteriorate and lose their airway, it may be prudent to secure the airway early, even if patients are found to have no major or compromising injuries after a complete diagnostic work-up. The optimal sedation and airway management for these patients is difficult to define, since many approaches are available and have been proven to be successful. These patients always need adequate sedation in the pre-hospital setting before advanced airway management is started, as this will increase the chances of successful intubation.

A balanced anaesthesia with titrated opioids, sedatives and muscle relaxants, followed by orotracheal intubation, is the most widely used and safest approach. It is prudent to use short-acting drugs, as these will allow patients who are found to be difficult to intubate and ventilate potentially to return to spontaneous ventilation. However, complete and irreversible airway collapse after induction and relaxation should be anticipated in all patients with neck injuries, due to the loss of pharyngeal and laryngeal muscle tone. In these patients, spontaneous ventilation will be impossible and rapid desaturation will occur, which needs to be solved either by rapid intubation or by establishing

| Signs and symptoms indicating urgent need for definitive airway securement |
|-----------------------------------------------|-----------------|
| Stridor                                      | Stridor         |
| Acute respiratory distress                   | Acute respiratory distress |
| Severe hypoxia                               | Severe hypoxia   |
| Airway obstruction from blood or secretions  | Airway obstruction from blood or secretions |
| Massive subcutaneous emphysema of the neck   | Massive subcutaneous emphysema of the neck |
| Tracheal shift (due to neck injury)          | Tracheal shift (due to neck injury) |
| Alteration in mental status                 | Alteration in mental status     |
| Profound shock                              | Profound shock |
| Expanding neck haematoma                    | Expanding neck haematoma |
| Voice changes                                | Voice changes |
| Symptomatic patients with prolonged travel times | Symptomatic patients with prolonged travel times |
Pre-hospital use of video-laryngoscopy is not widespread, but if available may be used as a first-attempt laryngoscopy. Success rates for this technique are higher, even in inexperienced users, but that benefit is lost if used in trauma, since the airway may be obstructed by blood and secretions.

Fibre-optic intubation may be an alternative for patients managed in the emergency department or in the operating room, but can be challenging in the injured airway, as blood and secretions, as well as loss of anatomical landmarks, may obscure the view. Moreover, fibre-optic intubation is recognized as an advanced skill, needing practice and expertise.

In the case of failed intubation, a stepwise approach for the unanticipated difficult airway is proposed (Figure 3), although the suggested alternatives may prove less useful in the pre-hospital environment than in elective or in-hospital conditions.

Management of unanticipated difficult tracheal intubation in adults

- **Plan A:** Facemask ventilation and tracheal intubation
  - Optimise head and neck position
  - Preoxygenate
  - Adequate neuromuscular blockade
  - Direct / Video Laryngoscopy (maximum 3+1 attempts)
  - External laryngeal manipulation
  - Bougie
  - Remove cricoid pressure
  - Maintain oxygenation and anaesthesia

- **Plan B:** Maintaining oxygenation: SAD insertion
  - 2nd generation device recommended
  - Change device or size (maximum 3 attempts)
  - Oxygenate and ventilate

- **Plan C:** Facemask ventilation
  - If facemask ventilation impossible, paralyse
  - Final attempt at facemask ventilation
  - Use 2 person technique and adjutants

- **Plan D:** Emergency front of neck access
  - Scalpel cricothyroidotomy

**STOP AND THINK**
- Options (consider risks and benefits):
  1. Wake the patient up
  2. Intubate trachea via the SAD
  3. Proceed without intubating the trachea
  4. Tracheostomy or cricothyroidotomy

**Post-operative care and follow up**
- Formulate immediate airway management plan
- Monitor for complications
- Complete airway alert form
- Explain to the patient in person and in writing
- Send written report to GP and local database

**Figure 3**
Management of unanticipated difficult tracheal intubation in adults.
In patients with a compromised airway due to neck injury, however, little time is left for alternative methods. Reverting relaxation and waiting for sedation to wear off takes several minutes and step-down to bag-mask ventilation should be the first logical, but sometimes impossible, step. In some patients, a supraglottic airway (such as a laryngeal mask or I-gel) may be used, but this should only be considered as a temporary measure and again will prove difficult in severe airway distortion, with obstructing blood and secretions and laryngeal or tracheal injury.

Due to the aforementioned reasons, achieving a surgical airway is often the next step in the case of failed intubation and ventilation. If a “cannot intubate, cannot ventilate” scenario is highly suspected, a surgical airway should be the first option in order to decrease the risk of severe hypoxia, airway oedema and additional injury.

As mentioned earlier, the identification of cricothyroidotomy landmarks before sedation is prudent. Several techniques are available, along with pre-made cricothyroidotomy kits. Percutaneous needle cricothyroidotomy is an easy way to gain access, but carries the risk of malposition, causing emphysema or dislodgement. Oxygen can be delivered through the needle, but caution must be taken not to hyperinflate the lungs and to allow air to exit again. This is primarily considered as a rescue technique if nothing else is available. The Seldinger technique is safer, although more complicated, and this combines needle cricothyroidotomy with the use of a guidewire and dilator, involving the insertion of a tracheal cannula, most often with a ‘ready-to-use’ kit.

Since the incidence of acute surgical airway procedures is low, it may be difficult for an emergency physician to gain much experience and even a single surgical kit may be difficult to become familiar with. The use of a surgical blade, forceps for dilation and a small-bore endotracheal tube is therefore an easy and effective alternative. A recent porcine model showed higher success rates and more confident use of the surgical versus the percutaneous technique; the Difficult Airway Society has also changed its algorithm to a surgical cricothyroidotomy rather than a percutaneous technique. If the injury itself has created a transection of the larynx or the trachea, using the same trajectory can be the most rapid pathway for establishing an airway. An endotracheal tube can be directed through the laceration, aided by a bougie if needed, although care should be taken not to create a false route. Once the airway is secured, the correct position of the endotracheal tube needs to be confirmed using end-tidal CO\textsubscript{2}-monitoring, auscultation, visual symmetrical expansion of the chest and conventional radiography of the chest, once the patient is stabilized and admitted in the emergency department.

### 3.3. Breathing

The incidence of haemothorax and (tension) pneumothorax is higher in penetrating Zone I injuries but also occurs in blunt neck trauma, since the kinetic energy needed to cause blunt injury to the neck is generally high. During the primary survey, the position of the trachea and the presence or absence of breath sounds and surgical emphysema should be assessed. As the auscultation can be challenging during trauma management and the evaluation of breath sounds is not always unequivocal, thoracic ultrasound may be useful as part of a Focused Assessment with Sonography in Trauma (FAST). FAST includes a bedside, focused ultrasound examination of the trauma patient, performed by an emergency physician, radiologist or surgeon, looking in particular for absence of pleural sliding or presence of intrathoracic, intra-abdominal or pericardial fluid. FAST has a high sensitivity and specificity for the detection of haemothorax and pneumothorax. Aided by ultrasound, the clinical diagnosis for tension pneumothorax (Table 3) or massive haemothorax

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<th><strong>Clinical</strong></th>
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<tr>
<td>Unilateral or bilateral reduced breath sounds</td>
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<tr>
<td>Tympanic chest percussion</td>
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<tr>
<td>Tracheal deviation</td>
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<td>Distended jugular veins</td>
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<td>Hypotension</td>
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<tr>
<td>Tachycardia/bradycardia</td>
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<tr>
<td>Traumatic (peri)arrest</td>
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<tr>
<th><strong>Ultrasound</strong></th>
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<tr>
<td>Absence of lung sliding</td>
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<tr>
<td>Presence of lung point</td>
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*Table 3* Clinical and ultrasonographic signs of tension pneumothorax.
should prompt finger thoracostomy for urgent decompression, followed by chest drain insertion. Needle thoracostomy has a relatively high failure rate, due to variations in chest wall thickness and kinking and obstruction of the needle or cannula, and it is therefore no longer recommended for the treatment of tension pneumothorax.

If tracheal deviation is present in these patients, with or without clinical suggestion of tension pneumothorax or haemothorax, expanding neck haematoma should always be considered since this will change treatment dramatically.

High-flow oxygen and pulse oximetry should be applied at all times, as well as end-tidal CO₂ monitoring in all ventilated patients or patients with reduced consciousness.

3.4. Circulation

Massive haemorrhage leading to exsanguination is the most frequent cause of death in penetrating neck injuries. As already mentioned, it is important to address and treat massive haemorrhage immediately upon the patient’s arrival. Direct manual local pressure should be applied, taking care not to occlude both the carotid artery and the jugular vein and not to compromise the airway. The use of local haemostatic agents and dressings may be considered, as these have proven to be more effective than a simple pressure bandage in controlling penetrating injury. The use of clamping vessels in the emergency department is never recommended, since more damage can be done and ischaemic events may be precipitated. On the other hand, the use of a Foley catheter as a tamponade tool has proven to be successful. Two large-bore intravenous or intrasosseous cannulas should be inserted, preferably at the contralateral side of the injury. Although rare, venous air embolism has been reported in penetrating neck and chest injuries. If possible, the patient should be positioned with a head-down tilt as a precautionary measure.

As massive haemorrhage is common in penetrating neck injuries and concomitant intrathoracic injuries always should be considered, the early preparation and activation of a massive transfusion procedure should be anticipated. Massive transfusion should be initiated with a standard and predefined transfusion ratio of red packed cells, fresh-frozen plasma and thrombocytes (e.g., 1:1:1), although this represents a goal-directed therapy, guided by further clinical judgement and (bedside) coagulation tests. Administration of calcium chloride, desmopressin or factor concentrate should be considered, as suggested by the European guidelines for management of major haemorrhage. If your centre is accepting major trauma, a massive transfusion procedure should be present, using standard activation criteria and transfusion goals.

Early administration of tranexamic acid (1 gram in bolus, followed by 1 gram over 8 hours as infusion) has become the standard of care, since this significantly decreases mortality in all bleeding trauma patients. It should be given within 3 hours after injury and even pre-hospital administration of the first dose is advocated.

The availability of cardiothoracic surgeons and a rapid decision on emergency sternotomy should be kept in mind when managing patients with penetrating Zone I neck injuries. In patients with uncontrollable haemorrhage and haemodynamic instability, emergency surgical exploration is sometimes their only chance of survival. Access to experienced interventional radiology on a 24/7 basis is another service that needs to be available, since this can be life-saving in less accessible vascular injuries (e.g., Zone III injuries).

3.5. Disability

Reduced consciousness may have different causes in patients with blunt and penetrating neck injuries. Concomitant intoxication, associated severe traumatic brain injury, haemorrhagic shock and hypoxia are well-known causes in patients with a Glasgow Coma Scale of less than nine. Patients who are combative may need sedation and intubation for their own safety, as otherwise they may be unmanageable.

Focal neurological deficit or coma may be present in patients with penetrating as well as blunt neck injuries. The causes for neurological deficit may include obstruction of cerebral blood flow due to vascular embolization, dissection or transection, as will be discussed in the relevant chapters.

Historically, much attention has been paid to the strict immobilization of the cervical spine. In blunt trauma, the incidence of cervical spine injury and vertebral fractures is relatively high, and the cervical spine has traditionally been immobilized
using a semi-rigid cervical collar. This dogma has recently been questioned, and concerns have been raised about the efficacy of immobilization, its safety and the complications caused by inappropriate use.\textsuperscript{6,37} Some authors suggest that cervical collars should no longer be used routinely.\textsuperscript{18} It seems to be more important to try clearing the cervical spine, using widespread clinical score systems.\textsuperscript{39} Once spinal immobilization is indicated, local practice guidelines should be followed, as there is no generally accepted consensus on this issue. 

Unstable cervical spine fractures are rarely seen in penetrating neck injuries in awake, cooperative patients without focal neurological deficit, especially in stab wounds.\textsuperscript{3,40} Gunshots and shrapnel wounds have a slightly higher incidence of cervical spine fractures, but these never present asymptptomatically. It is of utmost importance that the application of a cervical collar, and spinal immobilization in general, never interfere with airway management. If the cervical spine can be secured without the use of a cervical collar, this approach should probably be preferred.\textsuperscript{2,3}

3.6. Exposure

Standard trauma care should include early recognition and treatment of hypothermia, as accidental hypothermia will increase coagulopathy and mortality.\textsuperscript{41} This will require active management and external heating, as patients need to be fully exposed for the primary as well as for the secondary survey. Every trauma patient eventually needs a log roll, to look for less obvious injuries to the back or buttocks. In blunt trauma, this log roll is usually carried out during the secondary survey; however, in penetrating trauma it should be carried out earlier, as it may reveal the real cause for instability, thus mandating immediate surgical management.

4. Assessment and management at the hospital

4.1. Penetrating neck injury

Penetrating neck injuries are caused by gunshots, stabbing or penetrating debris after an explosion or high-speed collision. Gunshots cause devastating injuries, leaving a permanent cavity due to direct impact and tissue destruction and a temporary cavity caused by transfer of the kinetic energy into the surrounding structures, which can extend way beyond the original missile trajectory.\textsuperscript{42} Compared to gunshot wounds, stab wounds generally cause less extensive damage, since damage is only found in the original injury trajectory. By definition, the platysma muscle is violated in a penetrating neck injury; if it has not been breached, the wound can be closed and the patient discharged.

When assessing a patient, it is important to define whether the injury is found in the anterior or posterior triangle and to identify in which of the three anatomical zones the entry point is found, since this will have influence on patient management. However, it is even more important to recognize that penetrating neck injury trajectories seldom adhere to predefined anatomical borders.

4.1.1. Assessment

Signs and symptoms may range from minimal skin breach to exsanguination. Most authors define ‘hard signs’ as an indication for immediate and mandatory exploration (Table 4).\textsuperscript{43} In the classical approach, all penetrating neck injuries needed further diagnostic workup with angiography and endoscopy.\textsuperscript{44}

In this approach, Zone II injuries were always explored, whereas injuries in Zones I and III could be managed conservatively, depending on the injuries, since these zones are more difficult to access.\textsuperscript{45} Indeed, surgical exploration of injuries in Zones I and III was only performed if these injuries were suspected on initial work-up. Historically, this mandatory diagnostic work-up and low threshold for surgical exploration led to a high rate of negative findings. Consequently, some authors suggest that a more selective approach can be used. Although some authors rely solely on physical examination,
Trauma to the neck

In patients with negative CT angiography but highly suspected vascular injury, classical four-vessel angiography should be carried out. Putting together the results of these diagnostic tests will support either admission and thorough observation or surgical exploration.

The assessment and management of penetrating injuries is now based much more extensively on clinical and imaging findings, with a progressive and significantly reduced need for invasive procedures; the mortality, however, remains the same. The classical and the selective approach are both summarized in Figure 4, as published by Shiroff et al.

4.1.2. Spinal injury

Penetrating injuries behave completely differently from blunt neck injury in terms of causing cervical spine injuries. Stab injuries never cause
unstable spinal fractures, whereas highly energetic penetrating trauma (e.g., gunshot, shrapnel, debris after explosion) have a much higher potential for causing unstable fractures; due to their devastating nature, however, they always will present with overt neurological signs.\(^2\)\(^,\)\(^3\)

As mentioned above, the efficacy of a cervical collar for spinal immobilization has been questioned recently, and this practice can probably be abandoned for all asymptomatic penetrating neck injuries. Other tools (e.g., manual in-line stabilization) should be used for all other patients if spinal immobilization is indicated, in order to keep the anterior access of the neck available.

### 4.2. Blunt neck injury

Only 5% of all neck injuries are caused by blunt trauma, and the presentation can range from immediate death and life-threatening airway obstruction to more subtle and insidious signs, making the diagnosis less evident.

A motor vehicle accident (MVA) remains the most common cause of blunt neck injury, causing direct pressure to the anterior neck from the dashboard, steering wheel or airbag deployment.\(^1\)\(^,\)\(^5\)\(^1\) Direct pressure to the neck is transduced to the trachea and causes compression of the oesophagus against the cervical spine. Falls, direct blows to the anterior neck during sport or fights, impact from a bicycle handlebar or clothesline injuries are all well described causes of blunt neck trauma. Strangulation by hanging, manual choking or ligature suffocation can cause venous jugular obstruction, intracranial hypertension and unconsciousness, and consequently direct pressure on the trachea and obstruction of the airflow, leading to asphyxiation.\(^5\)\(^2\)

Specific injuries are discussed below in detail.

#### 4.2.1. Spinal injuries

Full coverage of blunt cervical spine trauma is beyond the scope of this article. Current emphasis is placed on the use of clinical decision rules (e.g., Canadian C-spine, NEXUS) to determine whether spinal immobilization and/or imaging is recommended.\(^3\)\(^9\) If the cervical spine cannot be cleared at the scene, the patient should be offered the possibility of self-extrication if cooperative and alert, without obvious focal neurological signs or distracting injuries.\(^8\) If the patient needs to be extricated, a long spinal board or other extrication device should be used; however, these tools are not designed for transportation, and a vacuum mattress or a scoop with the use of head blocks alongside the head should be used for this purpose.\(^6\)\(^,\)\(^3\)\(^8\) The use of

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**Table 5**

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<th>Signs and symptoms for penetrating oesophageal injury.(^1)</th>
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<tr>
<td>Airway compromise</td>
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<tr>
<td>Respiratory distress</td>
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<tr>
<td>Hoarseness</td>
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<tr>
<td>Subcutaneous emphysema</td>
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<tr>
<td>Stridor</td>
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<td>Leakage of saliva</td>
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#### 4.1.3. Injury to the aerodigestive tract

Penetrating injuries to the aerodigestive tract should be identified and surgically repaired within 12-24 hours, as morbidity and mortality increase rapidly after this timeframe, mainly in oesophageal injuries. In symptomatic patients (Table 5) there is no doubt that surgical exploration is mandatory, but in asymptomatic patients, a more selective approach is currently used. This is in contrast with the more classical approach, where every penetrating injury breaching the platysma had to be explored. If the risk of aerodigestive injury is considered to be low, based on CT angiography and clinical factors, careful observation may be advised. Panendoscopy should be carried out if doubt exists. Depending on the findings, surgical repair or watchful conservative management with antibiotic coverage should be carried out.\(^3\)\(^9\)

#### 4.1.4. Penetrating vascular injury

Penetrating neck traumas have a high incidence of vascular injury, with associated high mortality. A high percentage of patients with obvious vascular `hard signs’ will need surgical or endovascular treatment. The gold standard still is classical angiography, although the increased availability, sensitivity and specificity of MDCTA favour this technique in contemporary management. Classical angiography is still useful in patients with indeterminate CTA but high clinical suspicion. Depending on the injuries found, surgical exploration and repair or endovascular treatment is recommended in arterial lesions, whereas most venous lacerations can be managed conservatively.

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a rigid cervical collar is questionable, and depends more on local practice and habit than on hard evidence. Alert, cooperative patients are able to maintain their own cervical spine, even without the use of a collar. Uncooperative or combative adults and most children do not tolerate the application of a collar very well, and benefit more from manual in-line stabilization; sedated, intubated patients remain still and need only minimal additional cervical spine protection except during transport and transfer. Cervical immobilization should never interfere with airway evaluation or management, as this may restrict access to the neck.

If imaging is needed, CT scan of the cervical spine is indicated in major trauma, as sensitivity of plan radiographs is relatively low and most patients suffering from multiple trauma receive a full trauma CT scan initially.4,5,34

4.2.2. Strangulation
Strangulation due to manual, ligature or posture strangulation or hanging is a very specific form of blunt neck trauma; it was once thought to be due purely to airway compromise, but is in fact mainly caused by vascular venous obstruction.1,52 Venous outflow obstruction causes intracranial hypertension, unconsciousness and consequently arterial and laryngeal compression. Death from direct laryngeal or carotid-body-mediated dysrhythmia is rare. Additionally, strangulation will cause direct laryngotracheal fracture, spinal fracture, carotid artery injury and pharyngeal injuries. Hyoid fractures are classically reported in strangulation injuries, but seem to be rare.55 In young patients presenting with unexplained lateralized neurological signs, bruising over the anterior neck or spontaneous carotid dissection, accidental, criminal or deliberate strangulation should be considered.

In all strangulation victims, MDCTA should be considered, and observation is absolutely necessary.26 Depending on the findings of the clinical examination, further endoscopic investigation is needed, as pointed out below. Obviously, psychological follow-up should be offered to all patients.

4.2.3. Injury to the aerodigestive tract
Blunt tracheobronchial and oesophageal injuries are relatively uncommon in the general trauma population.1

4.2.3.1. Assessment
Blunt trauma to the oesophagus has a good outcome if the diagnosis is established early, although mortality increases rapidly after 24 hours. Symptoms can be very clear (odynophagia, dysphagia, drooling, haematemesis/blood in the gastric tube, subcutaneous emphysema) or very subtle to asymptomatic. Unrevealed oesophageal rupture, however, can lead to a delayed presentation with airway compromise due to haematoma or with mediastinitis, which both carry a poor prognosis.

Blunt trauma to the glottis presents more clearly in most patients. Supraglottic injuries mainly will present with cervical surgical emphysema, palpable cricoid cartilage disruption, hoarseness, dysphagia and/or evolving airway obstruction. Subglottic injuries present more subtly with haemoptysis (or blood in the endotracheal tube) and a persistent air leak after endotracheal intubation.

The primary investigation will rely on the mechanism of injury, but will include a full primary and secondary survey. A chest radiograph or FAST showing pneumothorax, pneumomediastinum or haemothorax will guide the management in the acute phase.

MDCTA has now become the imaging modality of choice in all haemodynamically stable patients.6 In patients with radiological injuries or high clinical suspicion of aerodigestive injuries, panendoscopy is recommended to increase diagnostic accuracy. Fibre-optic flexible endoscopy is used for upper airway evaluation, including visualization of the glottis and vocal cords, and may aid if a difficult airway is anticipated. Direct laryngoscopy under anaesthesia can be used for evaluation of the larynx, and bronchoscopy will be used to search for subglottic injuries. Oesophagoscopy combined with a radio-contrast swallow series will reliably detect all oesophageal injuries.

4.2.3.2. Treatment
Immediate airway protection is needed if any airway compromise is suspected.

Subsequent management of blunt aerodigestive injuries depends on the severity of the injury and concomitant injuries. Expanding haematomas, airway disruption or oesophageal rupture all need to be explored; only rarely are minor, minimally symptomatic injuries managed conservatively.

All injuries, even those with negative imaging or panendoscopy, need observation for at least 24 hours, as presentation can be delayed.
4.2.4. Blunt cerebrovascular injury

Blunt cerebrovascular injury (BCVI) is defined as the presence of damage to the carotid or the vertebral arteries. This is a rare but important finding in blunt trauma patients, with a reported prevalence as high as 2.7% and a reported mortality of up to 40% if symptoms are present. Diagnosis of BCVI will complicate management in trauma patients, as systemic anticoagulation is the mainstay of treatment, while leaving these injuries untreated will result in a dramatic increase in neurologic ischaemic events, even in asymptomatic patients.

BCVI involves multiple vessels (isolated or combined) in up to 32% of all patients and consists of various types of injuries (including intimal flaps, dissection, embolization and thrombosis, pseudoaneurysm, carotid-cavernous fistula or transection). The pathophysiology of these injuries is less clear, but several suggestions have been made, including the rupture of a plaque resulting in thrombosis or embolization, stretching or rotation of the carotid artery over the bony cervical spine or direct injury due to basal skull fractures, spinal fracture or introraoral injuries. Injuries may occur to any level of the vessel, but most carotid injuries are found in the internal carotid artery proximal of the base of the skull and the cavernous and petrous segments, whereas vertebral artery injuries are located at the levels of C3 to C6 and the tonsillar level.

4.2.4.1. Assessment

The presentation may vary from death and major ischaemic stroke to asymptomatic patients in which associated injuries suggest the presence of BCVI. The updated Denver Screening Criteria (Table 6) may be used as a guide to further diagnostic assessment.

Table 6
The updated Denver Screening Criteria

<table>
<thead>
<tr>
<th>Signs and symptoms of BCVI:</th>
</tr>
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<tbody>
<tr>
<td>Neurological deficit, unexplained by CT head</td>
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<tr>
<td>Ischaemic stroke on secondary CT head</td>
</tr>
<tr>
<td>Expanding cervical haematoma</td>
</tr>
<tr>
<td>Supraclavicular seatbelt sign</td>
</tr>
<tr>
<td>Cervical bruit or thrill</td>
</tr>
<tr>
<td>Arterial bleed from mouth/nose/neck</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Injuries frequently associated with BCVI:</th>
</tr>
</thead>
<tbody>
<tr>
<td>LeFort II or III fracture</td>
</tr>
<tr>
<td>Mandible fracture</td>
</tr>
<tr>
<td>Complex skull fracture, basilar skull fracture, petrous bone fracture, or occipital condyle fracture</td>
</tr>
<tr>
<td>Traumatic brain injury consistent with diffuse axonal injury and GCS score of less than 9</td>
</tr>
<tr>
<td>Cervical subluxation or ligamentous injury</td>
</tr>
<tr>
<td>Cervical vertebral body fractures, fractures extending into transverse foramina, or fracture involving C1–C3</td>
</tr>
<tr>
<td>Near hanging with anoxic brain injury</td>
</tr>
<tr>
<td>Clothesline-type injury or seatbelt abrasion with significant swelling, pain, or altered mental status</td>
</tr>
<tr>
<td>Traumatic brain injury with thoracic injuries</td>
</tr>
<tr>
<td>Scalp degloving</td>
</tr>
<tr>
<td>Thoracic vascular injuries</td>
</tr>
<tr>
<td>Blunt cardiac rupture</td>
</tr>
</tbody>
</table>

BCVI: Blunt Cerebrovascular injury
CT: Computed Tomography
GCS: Glasgow Coma Scale
C: Cervical vertebra
Trauma to the neck

81

<table>
<thead>
<tr>
<th>Grade</th>
<th>Type of injury</th>
<th>Stroke risk/mortality in carotid injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>mild intimal injuries, &lt; 25% luminal narrowing</td>
<td>8%/11%</td>
</tr>
<tr>
<td>II</td>
<td>intimal injuries &gt; 25% luminal narrowing</td>
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</tr>
<tr>
<td>III</td>
<td>BCVI with pseudoaneurysm formation</td>
<td>26%/11%</td>
</tr>
<tr>
<td>IV</td>
<td>Persistent occlusion in early postinjury period</td>
<td>50%/22%</td>
</tr>
<tr>
<td>V</td>
<td>Transection with free contrast extravasation or arteriovenous fistulas</td>
<td>100%/100%</td>
</tr>
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</table>

BCVI: Blunt Cerebrovascular injury

Systemic anticoagulation and direct endovascular revascularization are considered to be the best clinical practice, where the choice of treatment is guided by the Denver Injury Grading Scale.62 Systemic anticoagulation is the cornerstone of medical treatment, since the pathophysiological process is based on intimal disruption with platelet activation and distal embolization. Whether intravenous heparin (target-activated partial thromboplastin time 50-60 seconds) or antiplatelet therapy is more beneficial remains controversial, but there seem to be no significant differences in neurological outcome between the two approaches.

The first-line anticoagulant agent is systemic heparin, mainly due to its reversibility, although antiplatelet therapy should be used if contraindications for heparin are present. Heparin therapy should be transitioned to oral anticoagulants once patients are stable, with prothrombin time/international normalized ratio titrated to 2–3 for 3–6 months.62

Some authors have suggested endovascular stenting as first-line treatment in Grade II–IV injury (as these have been shown to be more resistant to anticoagulation therapy) and in patients where initial medical treatment fails.63-65 Grade V injuries (arteriovenous fistulas) has proven to have nearly equal sensitivity and specificity, and several authors suggest standard whole body MDCTA in severely injured trauma patients, to reduce underdiagnosis and to improve outcomes. In patients where endovascular treatment is planned or with high clinical suspicion but negative MDCTA, classical angiography is still recommended. Due to the operator-dependency of duplex ultrasonography and difficult access of magnetic resonance angiography, and the lower sensitivity and specificity rates of both, these techniques are less useful than MDCTA.52,63,64 Based on digital subtraction angiography findings, injuries can be classified according to the Denver Injury Grading Scale (Table 7).60 In carotid injuries, every grade is directly related to prognosis and to the risk of post-injury stroke. The Denver Injury Grading Scale is currently used to determine the best possible treatment. The same grading system is used for vertebral injuries, despite the less linear prognostic relationship, since the presence of more collateral vessels seems to act as a protective factor.60

4.2.4.2. Treatment

Several studies have investigated the various treatment strategies in BCVI, although the optimal therapeutic management is not yet defined. Several review articles and guidelines address the current agreements and controversies concerning assessment, diagnosis and treatment.57-59 The majority of these studies provide only Level 3 evidence; however, there is agreement that intervention is more effective than conservative treatment, as 75% of all mortality is related directly to the injury or subsequent sequelae, and neurological morbidity is reported to decrease from 60%–87% to as low as 9%–45% if patients are treated.

Table 7
Denver Injury Grading Scale.59,65

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are managed with transarterial or transvenous embolization, but mortality remains dramatically high.59

BCVI can present as a dynamic process, as injuries may evolve over time. There is no standardized follow-up protocol, although MDCTA 7 to 10 days after initial injury is recommended by the Western Trauma Association, as regrading injuries may change management in both directions (a stand-down from anticoagulation or more aggressive endovascular treatment).58,59

5. Neck injuries in children

Differences in the paediatric population are worth mentioning. The reasons for the lower incidence of neck injury in children are numerous. Children are involved less often in blunt accidents as well as in penetrating.68-70 When they are injured, the chances of suffering critical neck injuries are much lower than in the adult population due to more elastic tissue, cartilage instead of bony structures, and mainly because the anterior neck is better protected by the bigger head and chin, and by the shorter neck.

6. Conclusions

Take-home messages for emergency physicians:
1. Early airway management and haemorrhage control are absolute priorities in the emergency management of neck injuries.
2. If patients with neck injury need definitive airway management, a difficult procedure should always be anticipated and the use of a bougie should be considered. In addition, the definition of landmarks for a surgical airway procedure is warranted in the preparation.
3. Surgical cricothyroidotomy is recommended over percutaneous techniques in the event of a “cannot intubate, cannot ventilate” situation.
4. The threshold for CT angiography should be low for all neck injuries.
5. Packing of penetrating neck injuries is mandatory, using a Foley catheter if needed.
- Zone I injuries can potentially require sternotomy: transport the patient to a cardiothoracic surgical centre.
- Zone II injuries can potentially require primary repair, vein or graft repair or ligation: involve the vascular and head and neck surgeons early.
- Zone III injuries may require embolization: consider interventional radiology for diagnostic and therapeutic reasons in the early management of those patients.

Take home messages for ENT/Head and Neck surgeons:
1. Immediate surgical airway procedure can be necessary in less familiar circumstances and environments. If possible, define landmarks before the procedure.
2. Defining anatomical zones is useful in penetrating injuries, although these do not guide diagnostic or therapeutic management completely.
3. In unstable patients, elective surgical exploration is recommended instead of extensive diagnostic work-up. Unstable patients still need immediate exploration, whereas all stable patients will first be assessed with clinical examination and CT angiography.
4. Treatment of BCVI consists of systemic anticoagulation, sometimes followed by endovascular treatment.
5. Although the combination of clinical examination, CT angiography and endoscopic investigations are reliable, all patients with neck injuries should be monitored in the hospital.

References
Trauma to the neck


65. Goodwin RB, Beery PR, Dorbish RJ, Betz JA, Hari JK, Oplek JM, Magee DJ, Hinz SS, Scileppi RM, Franz RW,
Trauma to the neck


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