15 Emergent Management of Neck Trauma

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Key Points

- Vertebral artery injuries are commonly associated with cervical spine fractures. Have a low threshold to do vascular studies in patients with c-spine fractures.
- CT angiography is the study of choice to rule out vascular traumatic injury.
- CT is the study of choice to rule out c-spine fractures. Plain films are not sensitive enough.
- CTA is a sensitive test for disruption of the airway in penetrating trauma. A negative test with high clinical suspicion requires bronchoscopy.
- CT is sensitive for penetrating esophageal injuries. A negative test with high clinical suspicion requires a gastrografin swallow study and/or esophagoscopy.
- CTA is the diagnostic test of choice in the stable penetrating neck-injured patient. Zone 2 injuries no longer require immediate surgical exploration.
- The cervical collar may be removed to manage trauma to the neck in gunshot wounds to the neck without neurological signs. Follow-up c-spine CT is recommended, as stable c-spine fractures may be present.
- Strangulation can cause tracheal and vascular injuries even without a fall. Keep a low threshold for CTA in these cases.

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15.1 Introduction

Members of the trauma team must be prepared to recognize and evaluate traumatic injuries to the neck during the initial evaluation of a trauma patient and intervene to decisively manage these potentially life-threatening injuries. Often, the approach begins with consideration of the mechanism involved in the traumatic event, and injuries associated with the mechanism are anticipated. The same approach will be followed in this chapter, and each injury mechanism section will then consider injuries grouped by the three main components of the neck: aerodigestive, vascular, and spinal. Airway injuries require a high index of suspicion and prompt management in all trauma patients. However, the anatomic distortions that accompany severe neck trauma require providers to proceed in an organized and stepwise process potentially through the entire range of airway adjuncts to ensure the ultimate goal of oxygenation and ventilation. Esophageal injuries are not easily evaluated during the initial trauma survey but must be identified early, as delays beyond 24 h are associated with significant increase in mortality [1]. Arterial and venous injuries have both immediate and long-term associated morbidity and mortality and may require advanced imaging to evaluate, prognose, and plan interventions. Active hemorrhage from the neck must be managed in the initial trauma resuscitation as patients are bridged to definitive surgical or interventional radiology approaches to achieving hemostasis. High spinal cord injuries remain devastating

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injuries. Patients with an unstable cervical spine must be identified and efforts undertaken to prevent additional spinal cord injury.

15.2 Blunt Injuries

15.2.1 Blunt Aerodigestive Injuries

15.2.1.1 Epidemiology

Blunt aerodigestive trauma remains rare. A large review of 11,663 blunt trauma patients only identified 40 (0.34%) cases of laryngotracheal trauma and 9 (0.08%) cases of esophageal injury [2]. Other large reviews have found incidences closer to 1% [3]. As a result, providers must remain vigilant as many injuries present subtly without evidence of overt injury.

Motor vehicle collisions are thought to be one of the more common blunt mechanisms of aerodigestive injury. Padded dash syndrome has previously been described prior to the widespread use of seatbelts [4]. In these cases, unrestrained patients involved in a collision would continue forward with their neck hyperextended, striking it on the steering wheel or dashboard. This results in fracture of tracheal rings. The esophagus may also be injured as the hyperextended neck stretches the esophagus and upon collision compresses it between the cervical vertebrae and the trachea, resulting in tears in the muscular wall. Blunt chest trauma in a patient who fully inhales prior to the traumatic event may significantly raise his or her intrathoracic pressure and when this force is transmitted to a closed glottis, resulting in trachea rupture. Other common mechanisms include direct blows during athletic events such as hockey pucks or balls propelled at high velocities. Assaults with fists, feet, or objects may also focus kinetic energy on the trachea.

Clothesline injuries are a unique group of injuries that often have devastating consequences. Force is applied as a partially circumferential band that may crush the trachea and cause fractures of the tracheal rings. As the patient continues moving through the wire, often while riding a motorized vehicle, the wire will be dragged up the neck and over the head. This may result in distraction injury particularly when it reaches the mandible and hyperextends the neck [5].

15.2.1.2 Clinical Presentation

Establishing the mechanism of injury through a thorough history, either from the patient or emergency medical services providers, is paramount to the initial evaluation of a patient with neck trauma. Blunt traumatic injuries to the aerodigestive tract range from benign injuries requiring brief observation to significant distortion of the trachea with airway compromise. Esophageal injuries often present subtly and may be easily missed. Delay in recognition of these injuries results significantly in increased mortality [1].

Prompt evaluation of the airway following blunt neck trauma is paramount. Signs and symptoms vary greatly and relate to the degree of injury and the location. Partial transection of the trachea creates a one-way valve during spontaneous respirations and allows air to exit through the defect into the surrounding subcutaneous tissue. If the defect is small enough or the surrounding tissue adherent, there may be limited difficulty for the patient to spontaneously breathe. Patients who have been intubated in the prehospital environment prior to imaging must be met with particular caution as case reports have identified endotracheal tubes in the mediastinum, soft tissue of the neck, and the esophagus. Post-intubation, providers may miss injuries because the endotracheal tube has crossed the defect, and the patient ventilates easily without significant leak. Greene and Stark evaluated cervical tracheal injuries and identified a relationship between the injury being above or below the glottis and the associated signs of injury. Those injured above the glottis had changes in voice, difficulty swallowing, subcutaneous air, and progressive obstruction of the airway. In contrast, injuries below the glottis had signs of more lower airway injury including persistent air leak from chest tubes or endotracheal tubes and hemoptysis [6]. The increasing use of anticoagulants in the outpatient setting has led to rare cases of delayed airway compromise due to expanding neck hematomas after minor neck injury [7].

Esophageal injuries are easily missed as the focus is on the airway during the initial evaluation. Gastric tubes are often blindly placed in the emergency department prior to imaging, and later finding the tube outside of the gastrointestinal tract may be the first evidence of an injury. Therefore, a high index of suspicion based on the mechanism and associated injuries including complete transection of the trachea or posterior wall disruption of the trachea should raise suspicion for an esophageal injury. Blood return from the gastric tube is neither sensitive nor specific but should raise concern in the right clinical context. Pain with swallowing and chest pain are also early symptoms. The eponym Hamman's sign refers to the auscultation of crepitus or a popping sound that changes throughout the cardiac cycle classically as a result of mediastinal emphysema [8].

15.2.1.3 Diagnostic Evaluation

High-resolution computed tomography (CT) imaging has radically changed the approach to the evaluation of blunt neck trauma and is now the standard in the initial evaluation of blunt neck trauma. Figure 15.1 outlines the diagnostic pathway for these patients. CT imaging has largely supplanted the use of plain films, though significant aerodigestive injuries can be diagnosed with lateral soft tissue neck X-rays [9]. Chest X-ray during the initial trauma room evaluation may raise suspicion for an aerodigestive injury when there is evidence of pneumomediastinum or pneumothorax

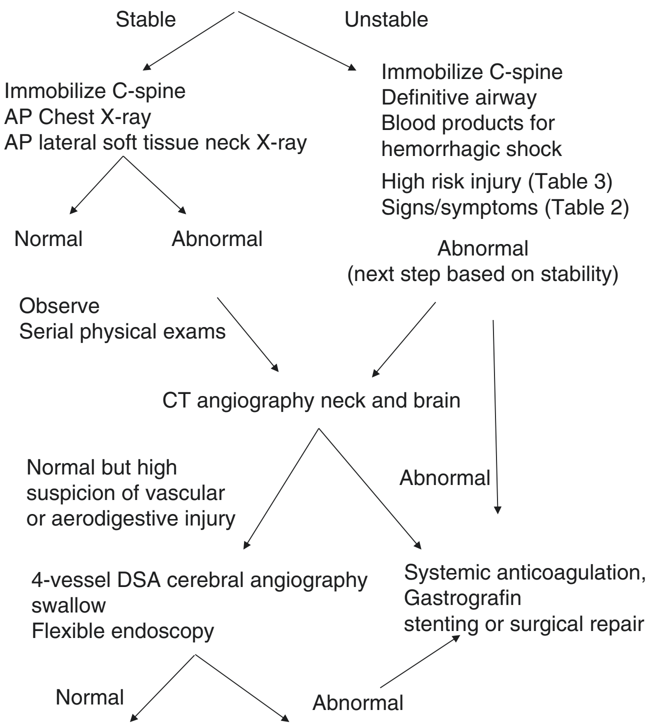

Fig. 15.1 Diagnostic evaluation of blunt neck trauma

without overlying chest injury. However, for hemodynamically stable patients, CT imaging remains paramount and guides decisions about operative repair.

Chen and colleagues investigated the accuracy of CT in the evaluation of tracheal rupture utilizing a cadaver model and trauma room patient controls. With a sensitivity of 85% for the detection of tracheal injury, including directly visualizing the tracheal injury in 71% of cases, the authors concluded that CT was a useful modality for screening trauma patients with pneumomediastinum and selecting those patients who should undergo early bronchoscopy [10]. Moriwaki et al. found that adding three-dimensional reconstruction to the CT evaluation of tracheal injuries was useful and accurately identified the location of injuries seen on bronchoscopy [11]. Airway patency and the need for emergent intubation often dictate the ability to adequately perform direct evaluation of the upper airway. In patients who do not require urgent intubation, fiber-optic nasopharyngoscopy remains useful for evaluating vocal cord function and the extent of injury to the upper airway. In conjunction with the upper airway evaluation, bronchoscopy should be considered to evaluate the subglottic larynx. Table 15.1 reviews a proposed management strategy system for laryngeal injuries which Schaefer and Brown developed based on CT imaging and endoscopy [12].

Imaging modalities to evaluate the esophagus include direct visualization with esophagoscopy and indirect methods that utilize an ionizing imaging study with a contrast agent, generally gastrografin. Computed tomography remains a valuable tool in the initial evaluation of these patients and aids in the detection of associated injuries including disruption of the posterior trachea. Such injuries should significantly raise the concern for esophageal injury and additional studies should be performed even when screening studies are negative.

15.2.2 Blunt Vascular Injuries

15.2.2.1 Epidemiology

Blunt vascular injuries (BVI) of the neck are identified in 0.24–1% of all major blunt trauma patients [13–17]. Motor vehicle collisions and motorcycle crashes are noted to be particularly common mechanisms of injury for BVI. Falls, pedestrians struck by a vehicle, and assaults are also commonly identified mechanisms [17–19]. These injuries remain devastating with a reported 28–40% mortality in some studies and 80% morbidity in those patients identified after neurologic symptoms develop [20, 21].

Blunt vascular injuries result from stretching of the vessel and disruption of the vessel wall. These tears are thought to occur after the vessel is stretched beyond its elastic capacity, through either a hyperflexion, hyperextension, or rotational force. Direct blows may result in vessel disruption, but the mechanism is again likely related to local stretching of the vessel beyond its capacity to deform. Partial tears of the intima expose the thrombogenic subendothelium and promote the formation of a thrombus [22]. Complete disruption of the vessel is possible and, in the case of carotid artery injury, rapidly fatal. In less severe injuries, thrombus formation that completely occludes a vessel is often not clinically evident due to collateral flow; however, partial thrombus that embolizes will produce a diffuse ischemic stroke. BVI may also lead to pseudoaneurysms, arteriovenous fistula formation, and dissections. Identifying these injuries early remains paramount to reducing morbidity and mortality [21].

15.2.2.2 Clinical Presentation

Trauma team members must identify significant vascular injury early in a patient's hospitalization to avoid serious adverse events. While some patients may present with frank uncontrollable hemorrhage and hemodynamic instability, often there are only subtle clues on the history and physical exam to alert providers to impending instability. So-called hard (Table 15.2) and soft (Table 15.3) signs have been described to both raise clinical suspicion for injury and aid in the decision to take a patient immediately to the operating room. Hard signs describe physical exam findings that indicate a high likelihood of the need for early surgical intervention. Providers should examine a patient for evidence of severe hemorrhage such as pulsatile bleeding or an expanding

Table 15.1 Classification system for laryngeal injuries based on a combination of CT scanning and endoscopy [62]

Group	Symptoms	Signs	Management
1.	Minor airway symptoms	Minor laryngeal hematoma or laceration	Steroids, antibiotics, voice rest, humidification, anti-reflux meds, observation
2.	Compromised airway	Worse edema, hematoma mucosal disruption, non-displaced fractures	Intubation/tracheotomy steroids, antibiotics, pan endoscopy
3.	Compromised airway	Massive edema, large mucosal lacerations	Panendoscopy, open repair with stenting, ±tracheotomy
4.	Compromised airway	More severe than group 3 disruption anterior larynx unstable fracture, 2 or more fracture lines, severe mucosal injury	Panendoscopy, open repair with stenting, tracheotomy
5.	Compromised airway	Complete laryngotracheal separation	Intubation/tracheotomy, pan endoscopy, reconstruction, restoration, or resection with end-to-end anastomosis ±stenting

Shaeffer's approach to management of laryngeal trauma

Table 15.2 Hard signs

Expanding hematoma
Active uncontrollable hemorrhage
Pulsatile hematoma
Airway compromise
Hemorrhagic shock
Neurologic deficit
Massive subcutaneous air

Table 15.3 Soft signs

Hemoptysis
Dyspnea
Voice change
Non-expanding hematoma

hematoma. Pulse deficit, while not sensitive, should be noted if present. Injuries that create flaps of the intimal layer, dissections, or pseudoaneurysms are nonocclusive, and a pulse deficit will not be present. A bruit or thrill raises the concern that a traumatic arteriovenous fistula has developed.

Soft signs are not as predictive of vascular injury as these signs, such as hypotension, shock, non-pulsatile hematoma, are present in many patients without significant vascular injury. Neurologic deficit is also considered a soft sign, and traumatic brain injury must be distinguished from neurologic insult as a result of decreased flow or thromboembolic event due to a vascular injury. When considering neurologic deficits, providers should consider the time course. In the case of thromboembolic events, patients may have no symptoms until minutes to hours after the event and then develop stroke-like symptoms such as aphasia or loss of motor function. Similar delays occur when there is a non-functioning circle of Willis, and a vascular insult results in a low-flow state to a portion of the brain. If this occurs after frank vessel transection, these symptoms will occur early post-injury; however, if it results from expanding thrombus formation, a longer delay to symptom onset can be expected.

History and physical exam alone, prior to the onset of neurologic deficits, are insufficient to definitively rule out blunt cerebrovascular injury [23]. McKevitt et al. found that only 40% of blunt vascular neck injuries were suspected during the initial evaluation [21]. Unfortunately, patients are typically diagnosed with a vascular injury after the onset of neurologic deficits or a stroke [13]. Part of this challenge comes from these patients often not having isolated neck trauma. These concurrent injuries draw the traumatologist's attention away from the neck, and providers attribute the patient's hemodynamic and neurologic state to an injury outside the neck. Further clouding the evaluation, head and major thoracic injuries, both common entities in blunt trauma patients, are associated with a significantly increased risk of blunt cerebrovascular injury [21]. Both the Eastern and Western Trauma Associations of the United States endorse definitive diagnostic testing, even in asymptomatic patients, with any of the high-risk characteristics listed in Table 15.4 [24–27]. With this aggressive approach, Miller and colleagues diagnosed 79% of carotid artery and all vertebral artery injuries prior to the onset of ischemic neurologic deficits [17].

The vast majority of patients with blunt vertebral artery injury have concurrent cervical spine injury. Associated carotid injuries are also common [19]. Miller et al. found that 33% of patients with cervical spine fracture screened for vascular injury had a vertebral artery injury [17]. Transverse foramen fractures may have up to an 88% rate of vertebral artery injury [28]. Unfortunately, many of these studies have slim enrollment due to the overall uncommon nature of these injuries. As a result, rates of injury may be misleading, but overall trends likely hold.

15.2.2.3 Diagnostic Evaluation

The gold standard remains four-vessel biplanar cerebral angiography (FVCA) [20]. It allows providers to detect dissection and pseudoaneurysm formation. Occlusive thrombus and transection are also clearly demonstrated. Prior evaluations of FVCA have found that injuries missed on angiography do not generally require repair, and mortality is exceedingly low in this population [29, 30]. Unfortunately,

Table 15.4 High-risk criteria for blunt cerebrovascular injury (endorsed by both the Eastern and Western Trauma Associations of the United States)

Symptomatic patients
Arterial hemorrhage from the neck, mouth, nose, or ear
Cervical hematoma
Cervical bruit <50 years of age
Focal or lateralizing neurologic deficit (e.g., hemiparesis, transient ischemic attack, Horner's syndrome, vertebrobasilar insufficiency)
Major thoracic trauma
Asymptomatic patients
Severe cervical hyperextension/rotation or hyperflexion
Severe facial trauma including bilateral facial, complex midface LeFort and subcondylar fractures
Basilar skull fracture involving the carotid canal
Blunt head injury with diffuse axonal injury and Glasgow Coma Score <6
Cervical vertebral body or transverse foramen fracture, any fracture at C1–C3 level, subluxation, or ligamentous injury
Near-hanging with cerebral anoxia
Clothesline-type injury or seat belt abrasion with significant cervical pain, swelling, or altered mental status

Table 15.5 Classification system for blunt carotid artery injuries based on the angiographic findings [22]

Injury grade	Findings on imaging
1	Dissection or luminal irregularity with <25% narrowing of lumen
2	Raised intimal flap, intraluminal thrombus, dissection, or intraluminal hematoma with ≥25% narrowing of lumen
3	Pseudoaneurysm
4	Occlusion
5	Transection with active extravasation

Developed by and Biffl and colleagues 1999
Biffl WL, Moore EE, Offner PJ, Brega KE, Franciose RJ, Burch JM. Blunt carotid arterial injuries: implications of a new grading scale. J Trauma. 1999;47(5):845–53

FVCA is not rapidly available, requires special resources and providers, and has associated complications. Table 15.5 outlines a system Biffl and colleagues developed to classify angiographic findings in blunt carotid artery injury [22]. The broad categories remain useful in both predicting outcome and guiding therapy.

Multi-detector CT angiography (CTA) has gained widespread availability and likely performs comparably with FVCA. Eight or greater multi-slice (multi-detector) CTA should be considered the minimum for acceptable images. CTA with four or fewer slice capabilities lacks the required sensitivity and specificity for providers to make sound decisions of its results [20]. Direct comparison of newer CT scanners supports this recommendation with reported sensitivity of 97.7% and specificity of 100% [31]. Other studies have not found such impressive results, but the missed injuries were patients in the low-risk Biffl classification grade 1 [32]. Patients stable enough to undergo initial imaging should have a CTA performed if risk factors and clinical suspicion raise the concern for vascular injury. This approach decreases the time to diagnosis and the rate of stroke compared to the historic approach of screening with FVCA [33]. Limitations with CTA remain and, in some cases, make the images suboptimal or unusable. As expected, this impacts the sensitivity of this screening modality [34]. The limitations of metal fragment artifact are less common than in patients with ballistic injuries, and despite its limitations, this technology remains appealing for the blunt trauma population.

Magnetic resonance angiography (MRA) lacks appreciable added benefit to the screening of blunt neck trauma. Prior studies have found that it lacks sufficient sensitivity and specificity [35]. Given the ever-improving image quality and availability of CTA, the added cost, time, and limited availability of MRA make it a poor study for the evaluation of blunt vascular injuries. Duplex ultrasound is also a poor study for screening and is not recommended [20]. It is limited to evaluating the common and external carotid arteries only. It is highly operator dependent, and injuries with uninterrupted flow (dissection, pseudoaneurysm formation) may be missed. In the era of ever-improving CTA, FVCA, MRA, and duplex ultrasound should be considered secondary modalities.

15.2.3 Blunt Cervical Spine Injuries

The possibility of cervical spine injury must be considered in any multiple trauma patient. Hyperflexion/extension and rotation of the cervical spine precipitate many cord injuries by creating unstable bony and ligamentous injuries. This occurs when the head moves rapidly in a particular direction causing extra stress on the spine. Cervical spine injury should be considered in any blunt injury mechanism, particularly those with concurrent head injuries. Hanging and strangulation will be considered in a separate section.

Plain radiographs lack the sensitivity and specificity necessary to confidently diagnose injuries to the cervical spine. Two primary decision rules, National Emergency X-Radiography Utilization Study (NEXUS) criteria for cervical spine imaging and the Canadian C-Spine Rule, were created to determine which patients are sufficiently low risk for injury that they can be safely evaluated without cervical spine imaging. NEXUS criteria require providers to answer negatively to five questions, listed in Table 15.6 [36]. The Canadian C-Spine Rule was derived as a series of three questions, outlined in Table 15.7 [37]. Both rules have high sensitivities at the expense of limited specificity. Unlike NEXUS, the Canadian C-Spine Rule includes an age cutoff of 65, above which it is not validated. More recent evidence has

Table 15.6 NEXUS criteria [36]

NEXUS (National Emergency X-ray Utilization Study) criteria for clearing the cervical spine without imaging. If none of the findings below are present, a patient may be safely evaluated without cervical spine imaging
1. Midline spinal tenderness
2. Focal neurological deficit
3. Intoxication
4. Distracting injury
5. Focal neurological deficit

Table 15.7 Canadian C-Spine Rule [37]

Exclusion criteria:
1. Age 65 years or older
2. Paresthesias
3. Dangerous mechanism (fall from greater than 3 ft (1 m)/5 stairs, axial load, high-speed motor vehicle collision/rollover/ejection, bicycle collision, motorized recreational vehicle)
Low-risk criteria:
1. Sitting position in the ED
2. Ambulatory at any time
3. Delayed (not immediate onset) neck pain
4. No midline tenderness
5. Simple rear-end motor vehicle collision (MVC), not simple if pushed into traffic, hit by bus/large truck, rollover, hit by high-speed vehicle
At least one low-risk criteria present:
1. Patient is able to rotate head 45° to the left and right
Patients do not require c-spine imaging if they fulfill any one of the low-risk criteria and are able to perform head rotation of 45° to the left and right

questioned the validity of NEXUS application to those over 65 years of age as well, and NEXUS may lack the sensitivity to safely exclude these patients [38]. A more prudent approach given the decreased risk of radiation exposure and resulting malignancy with age is a more liberal approach to imaging in those patients over the age of 65.

In those who fail the decision rule or have concerning high-risk features, the initial imaging modality of choice is CT scan. Unfortunately, concern remains that CT may not effectively rule out patients, and those with persistent pain on palpation or range of motion of the neck must have an MRI to evaluate for ligamentous injury and a potentially unstable cervical spine. Inaba et al. recently challenged this belief with an assessment of patients who failed the NEXUS decision rule and underwent CT scanning. The three patients with clinically important c-spine injuries who were missed on CT scan all had a focal neurologic deficit and may be sensitive enough to rule out injury without the need for further imaging [39]. The Eastern Association for the Surgery of Trauma (EAST) has also recently released a conditional recommendation for the removal of cervical collars after a negative high-quality CT scan in obtunded patients [40]. The data pool for the meta-analysis was low, yet there are no documented negative outcomes in any obtunded trauma patients whose collars were removed after a normal CT. While it may be premature for institutions to change their imaging policy, it would appear that CT of the cervical spine may ultimately be sufficient to clear both trauma patients with persistent pain and no neurological symptoms, as well as obtunded patients with normal scans.

15.3 Penetrating Injuries

15.3.1 Penetrating Aerodigestive Injuries

15.3.1.1 Epidemiology

Penetrating aerodigestive injuries are most commonly the result of gunshot or stab wounds, likely due to gunshot and stab wounds being the most common forms of penetrating trauma. Overall, these wounds remain extremely rare with one large center identifying only 10 cases out of 12,789 consecutive blunt and penetrating trauma patients presenting over 8 years. Most of these patients required emergent operative management [41].

15.3.1.2 Clinical Presentation

Presenting symptoms vary depending on the structures damaged. In patients with disruption of the trachea, change in voice, dyspnea, and progressive deterioration of the airway may occur. Penetrating wounds also result in injury to surrounding vascular structures, and patients with known vascular injury must be carefully observed for expanding hematomas that may progress to airway obstruction. Concurrent vascular and airway injuries may allow communication between the two structures, and patients who survive to the emergency department will have significant hemorrhage into the trachea that is difficult to control prior to the operating room, and these are often nonsurvivable injuries. Hemoptysis was seen rarely in a large review, but its presence in isolated neck injury should raise serious concerns [42].

It is anatomically challenging for patients to have an isolated penetrating injury to the esophagus; however, given its relatively central location, it must be considered in any patient in whom the likely trajectory of the penetrating object crosses the central plane. As with blunt trauma, these injuries must be detected early as delays result in mediastinal infections and significant mortality [43]. Patients going directly to the operating room for exploration may have less morbidity compared with those who undergo exhaustive preoperative evaluation [44]. Greene et al. found odynophagia, severe chest pain, hematemesis, and dysphagia to be sensitive for esophageal injury [6]. The neck should be palpated for crepitance, and plain X-rays of the chest that include the neck should be reviewed for subcutaneous emphysema or evidence of mediastinal free air.

15.3.1.3 Diagnostic Evaluation

Figure 15.2 outlines a diagnostic approach to penetrating neck injuries. Initial evaluation should include a chest X-ray as part of routine imaging during the initial evaluation and resuscitation of a trauma patient. Evidence of subcutaneous free air should alert providers to an aerodigestive injury. While trajectories of penetrating objects are difficult to predict, any patient with an isolated neck injury who is found to have a pneumothorax on screening X-ray should raise significant concern for an aerodigestive injury. Stable patients should undergo further imaging to define injuries and plan operative management. Unstable patients should have their airway secured and aerodigestive injuries evaluated further in the operating room.

The ever-improving image quality and accessibility of CTA make this the preferred initial imaging study. CTA accurately evaluates for disruption of the tracheal wall and allows for surgical planning [10]. The addition of three-dimensional reconstructions further improves visualization of complex injuries. Despite the advancements in CT, bronchoscopy remains the gold standard, and institutional policies should be followed regarding the decision to routinely screen with bronchoscopy. If suspicion remains high after a negative CT, bronchoscopy should be pursued.

Extrapulmonary air is easily identified on CT and is useful in raising suspicion for an esophageal injury, especially

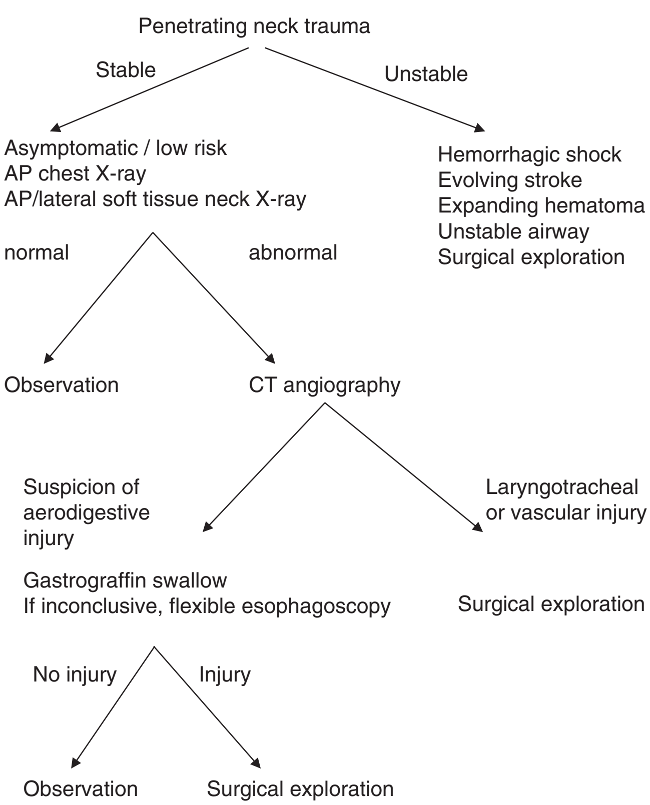

Fig. 15.2 Diagnostic evaluation for penetrating neck trauma

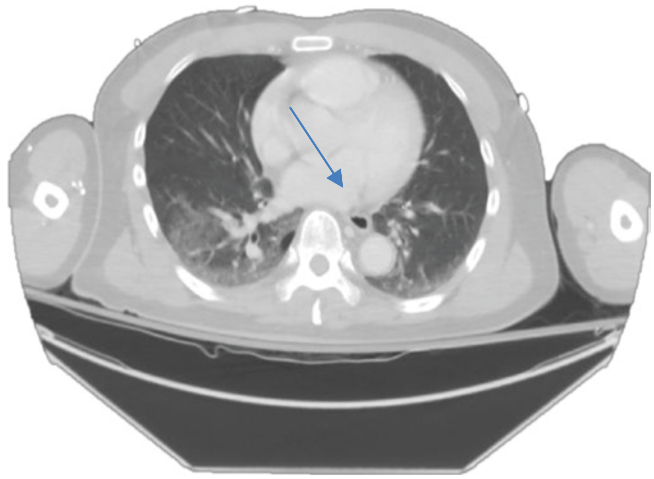

Fig. 15.3 CT image with free air. CT thorax reveals free air in the mediastinum (arrow). Also noted are pulmonary contusions bilaterally posteriorly

when it is found within the mediastinum (Fig. 15.3). Weigelt et al. evaluated the utility of barium swallow and endoscopy in a series of stable patients with penetrating neck trauma and found all cases of esophageal injury were identified when a combination of both modalities was employed [45]. Recently, CT esophagography has emerged as a sensitive and specific screening test that will likely replace barium swallow studies and may significantly reduce the need for flexible or rigid endoscopy. Conradie and Gebremariam reported 95% sensitivity and 85.4 and 91.5% specificity for two independent and blinded radiologists reviewing the studies. False positives were noted when the study was performed concurrently with CTA [46]. While this imaging modality is exciting, enough literature evaluating its sensitivity and specificity is lacking; therefore, providers should obtain a combination of gastrografin swallow and endoscopy if suspicion remains high for esophageal injury despite a negative CT [47].

15.3.2 Penetrating Vascular Injuries

15.3.2.1 Epidemiology

As with other types of penetrating neck trauma, penetrating vascular injuries are most commonly the result of gunshot and stab wounds. In the civilian environment, these are commonly the result of interpersonal violence and involve handguns in comparison with the military experience involving higher-energy rifles. Mortality has been estimated at 3–6% [48].

15.3.2.2 Clinical Presentation

Vascular injuries resulting from penetrating trauma may be rapidly fatal and must be identified early in a patient's hospital course. The "hard" and "soft" signs discussed in the blunt vascular injury section should be reviewed in all cases of penetrating neck trauma and may assist the clinician in identifying those patients who should undergo additional investigation for a vascular injury (see Tables 15.2 and 15.3). Penetrating injuries vary greatly and may range from injury to the adventitia alone to frank transection with exsanguination. Given the tight confines of the neck, vascular injuries may result in expanding hematomas with compression effects on surrounding structures producing respiratory symptoms (change in voice, tracheal deviation) or neurologic symptoms (cervical plexopathy). Isolated injuries to the neck that produce hemodynamic instability without neurologic symptoms (indicating a high spinal cord injury) should initially be assumed to result from significant injury to the vascular bed. Of special note, isolated jugular injuries often tamponade prior to intervention, and these injuries may not be recognized on initial exam [49].

15.3.2.3 Diagnostic Evaluation

The principles reviewed above in the blunt vascular section generally apply to the approach for the diagnostic evaluation of penetrating injuries. Hemodynamically unstable patients should be taken urgently to the operating theater for neck exploration. Historically, surgical exploration was conducted for all penetrating wounds that violated the platysma in zone 2. As a result of improved imaging modalities and additional techniques for more conservative management of vascular neck injuries, this dogmatic approach is no longer practiced when a selective approach is feasible. While unstable patients still require operative evaluation for a vascular injury, stable patients should first undergo imaging to identify injuries that are amenable to both surgical and nonsurgical techniques.

The widespread availability of CT has allowed clinicians to rapidly image patients. In series of penetrating neck injuries, the sensitivity of CT angiography is 90–100% compared with conventional angiography and surgical exploration [50, 51]. Others have observed that multi-slice helical computed tomography angiography (MCTA) may provide 100% sensitivity for the detection of all vascular and aerodigestive injuries making this an excellent screening test [52]. CT angiography (CTA) evaluates the vessels and provides information about the wound trajectory; the study may raise suspicion for vascular injury when ballistic fragments or the trajectory are within 5 mm of a major vessel [53]. CTA may show frank extravasation of contrast material, pseudoaneurysm formation with evidence of an irregular vessel wall, or occlusion with a lack of contrast visualized distal to the injury.

15.3.3 Penetrating Cervical Spine Injuries

Cervical injuries as a result of penetrating trauma with a normal neurologic exam are unlikely to be unstable. Published reports of patients with an unstable cervical spine due to stab wounds have not been identified, and it remains unlikely that an attacker would have the physical strength necessary to fracture the cervical spine in such a way as to create an unstable injury. Gunshot wounds that create an unstable cervical spine require disruption of the column in two places and must traverse or injure the spinal cord. Medzon and colleagues reviewed 14 years of patient records and found no gunshot wounds to the face or neck that created an unstable cervical spine without neurologic signs on presentation. There were three neurologically intact patients identified who did have stable cervical spine fractures after gunshot wounds to the face [54]. Additionally, a large review of gunshot wounds to the head found no cases of cervical spine injury [55]. Despite these findings, CT scan of the neck remains important during the evaluation of the traumatically injured patient. However, it appears that cervical injuries are rare, and any injury without neurologic deficit is likely stable. Therefore, providers should treat the patient's airway compromise or vascular injury as needed and remove the cervical collar if necessary. Once stabilized or access is no longer needed, the collar should be replaced until CT evaluation of the spine is obtained to ensure no occult fractures exist.

15.4 Strangulation

Strangulation represents a broad range of mechanisms that ultimately result in the application of force around the neck. The injuries that result from strangulation are related to the manner in which the force is applied and the rate of application, the duration of application, and the vector of the force. Commonly encountered strangulation categories include hangings, strangulation with a ligature device, manual choking with hands, and excessive manipulation of the neck as may occur during chiropractor manipulation. Four primary mechanisms of death have been described: carotid body compression with resulting dysrhythmia; obstruction of blood flow into the brain through carotid artery compression; obstruction of blood flow out of the brain resulting in cerebral congestion, loss of consciousness, and either increased pressure against the ligature device obstructing respirations and resulting in asphyxia or prolonged cerebral congestion from continued vascular outflow obstruction and decreased ability to allow blood into the brain resulting in a fatal prolonged fall in the cerebral perfusion pressure; and asphyxiation due to tracheal compression. Jugular venous obstruction takes the least amount of force and is likely the most common. Asphyxiation through tracheal compression requires sufficient force to fracture the trachea. Carotid compression takes more force than jugular compression and is difficult to produce without associated jugular obstruction. Carotid body reflex stimulation rates are difficult to determine [56].

Hangings in which a person falls from a significant distance may cause cervical fractures with spinal cord injuries resulting in apnea, but these are less frequently encountered.

15.4.1 Aerodigestive Injuries

15.4.1.1 Special Considerations in Strangulation

Suspension hangings without an associated fall may result in injury to the pharynx with fractures of the thyroid cartilage being most frequently observed. This risk may increase as the patient ages, likely related to ossification of the thyroid cartilage [57]. A large series failed to find any injury to the cricoid cartilage, and again the injuries were isolated to the thyroid cartilage and hyoid bone [58]. Unlike clothesline injuries that may cause a shearing injury to the trachea, suspension strangulation appears to apply forceful pressure that fractures higher airway structures. This has important clinical implications for those patients who require a surgical airway approach as it makes these patients more amenable to a cricothyroidotomy compared with clothesline injuries in which transection and distraction may result in a complete separation of the upper pharynx from the lower trachea [5].

15.4.2 Vascular Injuries

15.4.2.1 Special Considerations in Strangulation

Patients who present after a suspension hanging may sustain vascular injuries. One series of 175 patients noted 32 (18.3%) with a vascular injury. Injuries were more common on the ipsilateral side of the ligature knot, and the proposed mechanism of injury is traction on the vessel resulting in intimal tears or perivascular hematomas and not a result of direct pressure on the vessel [57]. An additional large review of suspension hangings found tearing of the carotid adventitia in 21.7% of cases, and providers must remain vigilant for these injuries. This review found a low incidence of jugular injuries (2.2%), and it has been hypothesized that this is due to the venous vascular bed having more elastic fibers that allow for greater traction without injury [58].

15.4.3 Cervical Spine Injuries

15.4.3.1 Special Considerations in Strangulation

Cervical spine injuries in strangulation depend greatly on the associated fall. For those patients strangulated without a fall, either in a choke hold or hanged in a standing or seated position, there is decreased risk of cervical spine injury. However, one review of hangings did find three patients with anterior subluxation of C6–C7, but all were over the age of 60, and all had the ligature knot under the mandible in an anterior position, indicating a hyperextension stretching mechanism [57]. Others have noted a low incidence of C2 fractures [58]. Regardless of the cervical level involved, these injuries are relatively infrequent in suspension hangings. In contrast, patients who have fallen from any distance into the ligature may sustain significant spinal injuries.

15.5 Management

15.5.1 Aerodigestive Injuries

Airway injuries necessitate early definitive control of the injured airway with endotracheal intubation being the preferred method. Isolated airway injuries that have been secured can then be taken to the operating room for planned repair. If a cervical collar is in place, particularly in blunt trauma, a second provider should perform in-line cervical stabilization to minimize movement of the cervical spine during laryngoscopy. However, the decision to intubate remains one of clinical judgment. Clear indications include severely altered mental status, inability to protect the upper airway, or expectation that the clinical course likely involves deterioration with failure of the patient's ability to control his or her airway. Patients with severe vascular injury and expanding or large hematoma should raise concern for eventual airway impingement and be managed definitively during the initial resuscitation.

Rapid sequence intubation (RSI) with the use of a sedative and paralytic remains the standard approach. Succinylcholine was studied in patients with a penetrating neck injury and found to be safe and allow a high degree of success. Of the 39 patients who underwent RSI, clinicians had a 100% success rate. Three out of 12 had failure of fiberoptic intubation by otolaryngology but were successfully intubated with RSI [59]. Other paralytic agents including rocuronium and vecuronium are safe and effective agents with the caveat of prolonged duration of action. Sedatives should be selected and dosage given to maintain hemodynamic stability. Etomidate provides rapid onset of sedation and minimal hemodynamic impact.

In patients with significant facial trauma, heavy bleeding into the oropharynx, or distortion of the upper airway anatomy, clinicians should anticipate a difficult airway. It is paramount that clinicians understand and practice alternative methods for securing the airway. In the case of heavy bleeding, the use of constant suction throughout laryngoscopy may improve the view. The head of the bed should remain elevated and not flat as blood will rapidly fill the airway, obscure the view, and fill the lower airway. Clinicians should consider sedative only intubation to allow patients to maintain some protection of their airway. Ketamine provides a dissociative state in which patients continue to breath and is an excellent choice. Fiber-optic intubation and video laryngoscopy are appealing modalities, but blood often obscures the lens and makes visualization impossible. A gum-elastic bougie provides tactile information as it is inserted and should be considered in all patients with airway injury. As it is inserted, it is possible to feel the tracheal rings. When inserted deeply, it will stop at the carina and confirm being in the airway. If it is inadvertently placed in the esophagus, it will continue without interruption, and the tracheal rings will not be felt. The bougie may even allow providers to perform blind intubation through a wound tract when other methods have failed [60].

Tracheal transection presents unique challenges as the endotracheal tube may exist through the defect and enter the surrounding tissue, mediastinum, or in the case of combined tracheal and esophageal injury, it may enter the esophagus distally. These patients are some of the most challenging airway cases, and it is important to emphasize that the goal of airway management during initial resuscitation is to provide oxygenation and ventilation. In cases of failed intubation, the use of supraglottic devices should be considered. While these devices do not provide a secure airway, they may be used to bridge to definitive therapy and provide oxygenation and ventilation as a surgical approach is undertaken.

Ultimately a stepwise approach is necessary, and providers should begin managing each airway with a systematic thoughtful assessment of what backup maneuvers will be utilized if intubation fails. Such a stepwise approach was described in the case of complete tracheal transection and partial esophageal injury that ultimately allowed a child to have an endotracheal tube blindly pass through the proximal esophagus, exit the esophageal defect, and enter the trachea distally through the transection [5]. A surgical airway, either cricothyroidotomy or tracheostomy, is the final approach to airway management. However, in the event of tracheal injury, these techniques may be challenging, and early consultation with otolaryngology should be considered. Concurrent use of methods to maintain oxygenation and ventilation during the surgical procedure will support the best possible neurologic outcome.

15.5.2 Vascular Injuries

Vascular injuries should be managed with the initial goal of achieving hemostasis in any unstable patient. Venous bleeding including the jugular veins may often be managed with ligation. However, if the patient is stable and time allows, primary surgical repair is preferred over graft placement or ligation. Carotid artery injuries should be repaired if possible. In patients with a non-functioning circle of Willis, carotid ligation may result in decreased cerebral blood flow and infarction.

In stable patients who undergo imaging, the degree of injury dictates the approach. Biffl and colleagues described the grading system in Table 15.5 based on angiography findings and proposed treatment strategies [22]. Much of the therapy depends on selective surgical intervention and early anticoagulation. Surgical options include resection, thrombectomy, and vessel ligation. Anticoagulation has reduced both the morbidity and mortality of these injuries [19]. Early detection and anticoagulation of vertebral artery injuries have demonstrated significant improvement in the rate of strokes with Miller et al. finding a 0% incidence of stroke when this approach was taken compared to historic rates of 14% [17]. Endovascular techniques are rapidly advancing and may replace open repair. Continued research and technique mastery are required.

15.5.3 Cervical Spine Injuries

The management of cervical spine injuries depends on prompt recognition and early cervical motion limitation with a rigid cervical collar. While these collars do not prevent movement of the cervical spine, they should be utilized to provide cervical support pending formal surgical means of cervical motion restriction, including placement of a halo vest.

Intubation, both in the emergency department and perioperatively, may require the removal of the cervical collar, but providers should remain vigilant to minimize any extension of the cervical spine and provide in-line traction. Evidence suggests that without manual stabilization, direct laryngoscopy produces 10–11° of head extension during intubation [61]. Patients should be logrolled with a provider manually stabilizing the cervical spine whenever the patient is moved. Alert patients should be engaged throughout their hospitalization as active participants in their care and reminded to limit any movement of their neck.

Case Scenario

A 57-year-old male construction worker falls two floors into the basement of a house onto a concrete surface. It is unclear if he has had loss of consciousness, but on arrival emergency services find him alert and oriented, with an occipital hematoma and stable vital signs. On arrival to the emergency department, he has a cervical collar in place. Vitals are 137/74, heart rate 95, and oxygen saturation of 97% on room air. He is complaining of difficulty breathing. On exam the hematoma is noted as well as a laceration to his chin; breath sounds are symmetric. He has two large-bore IVs placed. Anteroposterior chest X-ray reveals a widened mediastinum. FAST exam is negative.

1. What is the most appropriate next step in the management of this patient?
   A. Intubate prior to further studies to protect his airway.
   B. Cervical spine X-ray in the trauma bay.
   C. CT brain, CT cervical spine, and CT thorax, abdomen, and pelvis.
   D. CT brain, CT cervical spine, CTA neck and thorax, and CT abdomen and pelvis.
2. CT scan reveals free air in the mediastinum. Further evaluation should include:
   A. Esophagoscopy
   B. Bronchoscopy
   C. Immediate intubation
   D. A and B
3. His CT of the cervical spine reveals no fracture of the cervical spine.
   A. If pain persists in the midline, he requires an MRI of the c-spine.
   B. His collar may be removed even if he has midline pain and tenderness.
   C. His collar must remain in place according to EAST guidelines.
   D. Regardless of midline pain, the collar should remain in place and MRI performed.
4. Which of the following physical exam findings, if present, would be considered hard findings concerning for vascular injury?
   A. Hypotension
   B. Pulsatile mass in the neck
   C. Right-sided weakness in the arm and leg
   D. Obvious large hematoma in the anterior neck

Please see Chap. 58 for the correct answer.

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