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Neck Trauma: Don't Put Your Neck On The Line

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CME Objectives

Upon completing this article, you should be able to:
1. describe the importance of early and appropriate airway management;
2. describe the diagnostic approach to vascular injuries by zone of injury in neck trauma;
3. identify and provide initial management for laryngeal injury; and
4. discuss the importance of early recognition of esophageal trauma and the accuracy of available diagnostic modalities.

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See "Physician CME Information" on back page.

At 3:00 a.m. on a humid August morning, the telemetry nurse informs you that an ambulance is bringing in a 27-year-old male shot in the neck. Paramedics reported minimal blood at the scene. In the field, the paramedics applied a bandage and initiated 0.9 normal saline. Just as you step into the resuscitation room, a second call comes over the radio. Another ambulance is bringing in a 19-year-old unrestrained front seat passenger complaining of hoarseness and trouble breathing after striking her neck on the dash.

WHETHER at a busy Level I trauma center or a small rural hospital, emergency physicians must be familiar with the complex anatomy, pathophysiology, evaluation, and management of patients with penetrating and blunt neck trauma. Injuries range from obvious to subtle and can result in both immediate and delayed complications. Presentation can be dramatic in cases of penetrating airway and vascular injury, or insidious as with blunt vascular dissection or missed esophageal disruption.

This issue of *Emergency Medicine Practice* provides a comprehensive review of penetrating and blunt neck trauma with a focus on the evaluation and management of injuries to the airway, vascular, and digestive systems. (Please also see the October 2001 issue of *Emergency Medicine Practice*, "Cervical Spine Injury: A State-Of-The-Art Approach To Assessment And Management," which is available online for subscribers at http://www.empractice.net.)

Critical Appraisal Of The Literature

The emergency medicine, trauma, anesthesia, radiology, and otolaryngology literature on penetrating and blunt neck trauma is enormous, often contradictory, and concentrates more on specific diagnostic modalities and surgical treatment than initial management. (See **Table 1** on page 2.) The majority of studies are retrospective reviews of various diagnostic modalities. In comparison to cervical spine injury, relatively few prospective

studies address the ED management of blunt and penetrating neck trauma. Specific practice guidelines for these injuries are not adequately covered in the ATLS course, ACEP clinical policies, or practice guideline Web sites. The institutional capabilities and current opinions of the radiologist and trauma surgeon on call dictate imaging studies and treatment.

Epidemiology

Penetrating neck trauma tends to cluster in specific urban areas and is often cared for at Level I trauma centers. At other hospitals, this lack of familiarity and the complexity of the problem make this a "high-risk" situation for both the patient and the physician. Penetrating neck injuries account for 5%-10% of all traumatic injuries and have an overall mortality of up to 10%.[1] Most injuries to the neck are in Zone II (between the cricoid and angle of the jaw).[2]

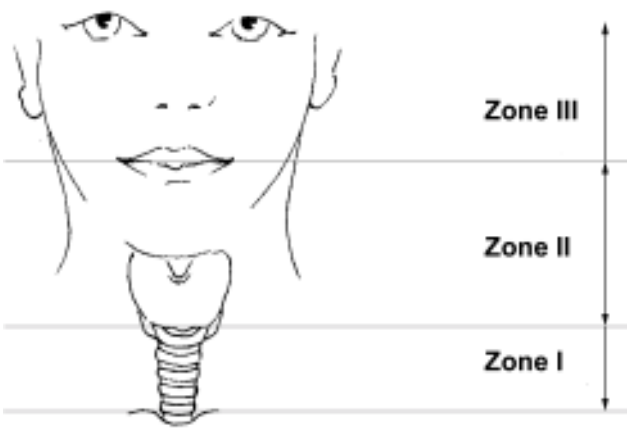
Blunt neck trauma is less frequent and dramatic, yet it is equally life-threatening. While vascular injuries predominate in penetrating trauma, airway injuries prevail in blunt trauma. Blunt neck injuries are often initially overlooked in the setting of multisystem trauma.[3] The neck's complex framework of supporting fascial planes, musculature, and cartilage result in minimal physical findings and delayed complications.[4] A high index of suspicion is essential in order to avoid significant morbidity and mortality from delayed infection, airway obstruction, or cerebrovascular events.

The incidence of blunt carotid injury varies widely between studies. In one series, there were only 49 patients with blunt carotid injury identified at 11 trauma centers over a six-year period.[5] Other reviews place the incidence between 0.1% and 0.33%.[6,7]

Table 1. Recent controversies in penetrating and blunt neck trauma.

- Method of airway management and role of paralytics
- Mandatory vs. selective exploration of penetrating neck injuries
- Diagnostic testing in the asymptomatic patient with penetrating neck trauma
- Flexible vs. rigid fiberoptic endoscopy in penetrating neck trauma
- Indications for vascular imaging in blunt neck trauma

Figure 1. Injury zones.



Anatomy

Complexity and proximity define the challenging anatomy of the neck. The respiratory, vascular, nervous, gastrointestinal, skeletal, endocrine, and lymphatic systems all traverse the narrow confines of this space. The structures of the anterior neck are especially vulnerable.

To simplify the approach to injuries, current trauma literature divides the neck anatomically into zones. (See **Figure 1**.) Zone I, between the sternal notch and the cricoid cartilage, contains the proximal subclavian, vertebral, and carotid arteries, apices of the lung and trachea, esophagus, thoracic duct, and thyroid and parathyroid glands. Zone II, between the cricoid cartilage and angle of the mandible, contains the carotid and vertebral arteries, trachea, larynx, esophagus, spinal cord, and vagus and recurrent laryngeal nerves. Zone III, above the angle of the mandible, contains the pharynx, salivary glands, distal carotid and vertebral arteries, and several cranial nerves.

Zone II injuries are the most common and have the best prognosis. The anatomy allows for relatively simple surgical exposure, application of direct pressure, and control of vessels.[8] Exposure and control of injury is much more difficult with Zone I and III injuries. Zone I injuries have the highest mortality secondary to involvement of intrathoracic structures; hemothorax, pneumothorax, and great vessel injury are common.

The neck is also divided into triangles. The anterior triangle is bordered laterally by the anterior border of the sternocleidomastoid, superiorly by the inferior mandible, and medially by the anterior midline of the neck. Injuries to the anterior triangle permit easy access for initial evaluation and surgical management. The posterior triangle is bordered posteriorly by the anterior surface of the trapezius, anteriorly by the posterior surface of the sternocleidomastoid, and inferiorly by the middle third of the clavicle. Injuries to the posterior triangle defy simple evaluation or control.

The neck is further divided into fascial planes. The platysma, a broad thin sheet of muscle extending from the facial muscles to the thorax, is a traditional surgical landmark for penetrating trauma. *Wounds that penetrate the platysma require surgical consultation.* The platysma is covered by superficial fascia anteriorly and the deep fascia posteriorly. The deep fascial layers of the neck include the investing, pretracheal, and prevertebral fascia. These three fascial layers help support the neck and may contain hemorrhage within a single compartment. The pretracheal fascia is continuous with the anterior pericardium, providing a route for infection to spread to the mediastinum in cases of aerodigestive tract injury. (See **Figure 2** on page 3.)

Pathophysiology

For the purpose of this article, neck trauma is divided into penetrating, blunt, and strangulation injury.

The pathophysiology of penetrating injury varies with mechanism. Gunshot wounds may be divided into low- and high-energy wounds. A high-velocity military assault rifle fired into the neck at 50 feet will produce more extensive tissue damage than a low-velocity handgun fired from the same distance. In addition to energy, multiple other factors determine the extent of injury, including mass, shape, fragmentation of the missile, and the tissue penetrated.[9] Low-energy shotgun pellets follow erratic trajectories along the tissue pathway of least resistance and may result in pellet emboli to the heart or other organs.[10] Stab wounds may leave a seemingly innocent wound, but the depth and path of penetration is difficult to predict. Descriptions regarding blade size, depth of penetration, and body position at impact may be misleading.

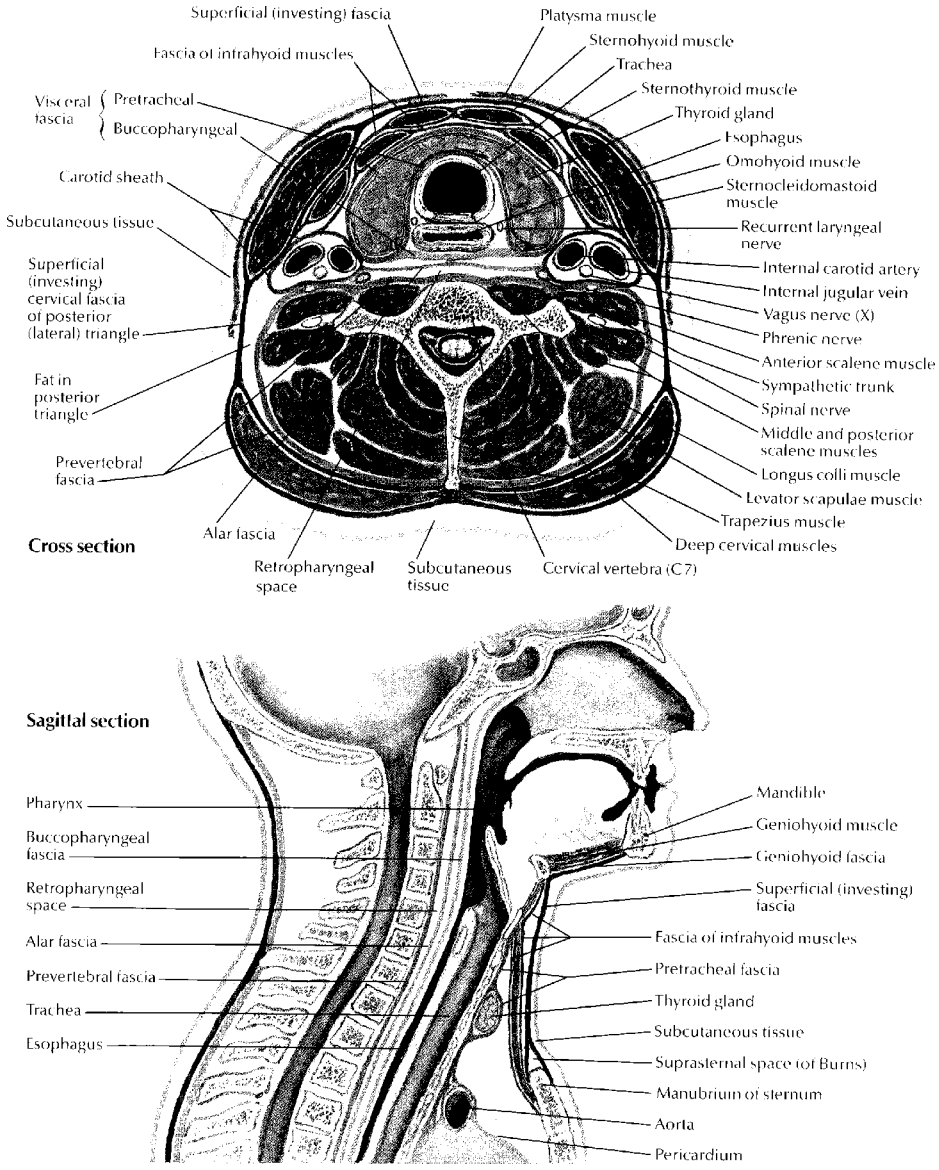
Penetrating vascular injuries can be rapidly fatal from a variety of mechanisms. While any large vessel injury can lead to hemorrhagic shock, carotid injuries can also produce a rapidly expanding hematoma that may distort or occlude the airway. Large lacerations of the jugular venous system can generate an air embolism, causing hypotension and respiratory distress.[11]

Blunt neck trauma may initially go unrecognized due to more noticeable damage to the chest, abdomen, or head. Common mechanisms include a motor vehicle collision involving an unrestrained passenger decelerating against the dash ("the padded dash syndrome"), a shoulder harness creating shearing injury to the neck, and blunt neck trauma secondary to airbag deployment, clothesline, and bicycle handlebar injuries.[12-15] Laryngeal trauma may result from a sharp blow to the anterior neck that compresses the thyroid and cricoid cartilages against the cervical spine.

Multiple mechanisms of vascular injury occur in blunt neck trauma. Direct blows to the anterior neck can compress the carotid, while blows to the head that cause rotation and hyperextension stretch the carotid artery across the cervical spine. Abrupt full flexion of the neck may crush the internal carotid artery between the angle of the mandible and upper cervical vertebrae, allowing for delayed dissection.[12,16] Carotid artery injury also occurs in the setting of blunt oral trauma and basilar skull fracture. Blunt carotid injury may occur in 0.7% of patients; patterns of injury include dissection, pseudoaneurysm formation, and thrombosis.[17]

Because the sympathetic fibers from the thoracic chain wind around the carotid artery, injury to the artery that disrupts these fibers will

Figure 2. Neck anatomy.



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produce Horner's syndrome (small pupil, droopy lid, and inability to sweat on the side of the face ipsilateral to the carotid injury). Since carotid disruption can produce ischemia to the ipsilateral cerebral cortex, patients may present with paralysis contralateral to the injured carotid. Blunt carotid injuries can also cause a rapidly expanding hematoma that can distort or occlude the airway.

Patients with vertebral artery trauma may present with a puzzling clinical picture. Some have vague complaints of visual changes, nausea, and vertigo. Notably, neurologic deficits do not relate to the particular vertebral artery involved. Because a clot in a vertebral artery will pass through the basilar artery and then into the posterior circulation, emboli from the right vertebral artery can travel to either the right or left posterior brain, resulting in a hodgepodge of cranial nerve deficits or alterations in mental status.[18-20] Esophageal injury due to blunt trauma is extremely rare and should only be investigated when there are clinical findings suggestive of injury, such as significant pain on swallowing or the presence of unexplained subcutaneous air.[21]

"Having the critics praise you is like having the hangman say you've got a pretty neck."—Eli Wallach

Differential Diagnosis

Isolated injuries to the neck are the exception—multiple system injury and unexpected injury are the rule. The true path of a bullet may or may not follow a straight line between the entrance and exit wound (or from entrance wound to the final location of the bullet within the neck). Likewise, the depth and path of stab wounds are difficult to evaluate from external inspection. Strangulation victims (especially those who have attempted to hang themselves) may appear stable on arrival only to decompensate dramatically hours after presentation.

During the secondary survey, the emergency physician must methodically search for signs and symptoms of injury, system by system, as described in the following physical examination section. Even in the absence of hard findings, clinical suspicion combined with an organized diagnostic approach will provide the best and most cost-effective patient care.

Esophageal injuries are the least common but are *the most frequently missed injuries in penetrating neck trauma*.[22] A low incidence and a lack of sensitive and specific clinical signs make the diagnosis of esophageal injury difficult. Furthermore, esophageal injuries may be masked by other injuries. One study of penetrating

Cost- And Time-Effective Strategies For Neck Trauma

1. Quickly check to see if the wound penetrates the platysma. If it does, call a surgeon—right then. Wounds that violate the platysma require surgical consultation.

Caveat: Carefully lift the wound edges enough to determine platysmal violation; anything beyond that is unnecessary and risky. Avoid blind probing, which could dislodge a clot.

2. Employ simple, quick, and low-cost diagnostic maneuvers.

Have stable patients speak, cough, and swallow to determine whether they have an abnormal voice, hemoptysis, or dysphagia. Auscultate their carotid arteries for bruits. Use the physical examination and clinical maneuvers to determine the need for further testing (selective testing).

Caveat: Any patient who cannot cooperate with a clinical examination, such as those who are intoxicated or comatose, needs either surgery or an objective test. Local practice will often determine whether testing strategies are selective (based on the clinical picture) or mandatory (all patients undergo a battery of diagnostic tests).

3. Employ selective vs. mandatory exploration and testing.

Limited data exist on the analysis of cost-effective strategies for blunt and strangulation neck injury. An algorithm validated by Demetriades et al for penetrating neck trauma reduced emergent operative procedures and significantly decreased costs without missing significant injury.[53] Similar protocols have been published in multiple other studies.

Caveat: Selective operation and selective testing require strict adherence to established protocols and may be very labor-intensive. Whether this strategy can be extended to all institutions (especially those without in-hospital surgical support) remains unclear. Surgical consultation is essential in determining diagnostic evaluation.

4. Consider alternatives to angiography.

Helical CT angiography (HCTA) may soon replace screening angiography in the evaluation of neck injury. The use of color-flow carotid Doppler is already well-established. In a study by Fry et al, color-flow Doppler cost $1200 less than angiography and resulted in no false-negative or false-positive injuries.[68] Demetriades et al showed that the combination of physical examination and color-flow Doppler resulted in no significant missed injuries in cases of penetrating wounds to the neck.[122]

Caveat: While color-flow Doppler is well-studied in penetrating trauma of the neck, it is less well-studied in blunt injuries. HCTA has great potential, and early prospective studies are encouraging; however, larger studies are needed before it becomes the standard of care. ▲

laryngotracheal injuries found esophageal injuries in 11 of 57 patients.[23] In another study of esophageal injury, 35 of 48 patients had at least one other injury, with nine patients having at least three other injuries.[24] Delayed operative repair of esophageal injuries results in high morbidity and mortality due to early contamination of the paraesophageal space.[25] Rapid diagnosis of occult esophageal injury must be a high priority in penetrating neck trauma.

Prehospital Care

Information obtained by the paramedics may help determine the type of weapon used, range, position of the victim at the time of penetration, and trajectory. Within many urban settings, field triage criteria mandate transport of all penetrating neck trauma to the closest regional trauma center. On the other hand, patients with isolated blunt neck trauma may be taken to non-Level I trauma centers, especially when there is no evidence of multisystem injury.

Airway management in the field by emergency medical technicians is fraught with unforeseen hazards. Hematomas and laryngotracheal injuries both necessitate and complicate initial airway management. Even common bag-valve-mask techniques may worsen injuries and distort anatomy by dissection of air into the surrounding tissues.

Indications for airway management in the field include long transport times with an unstable or potentially unstable patient, stridor or severe respiratory distress, apnea, and impending cardiopulmonary arrest. Orotracheal intubation allows for direct assessment of the airway and placement of the airway with the fewest complications. Prehospital cricothyrotomy is indicated only with failed orotracheal intubation, entrapment at scene with the need for a secure airway, or significant maxillofacial trauma in patients requiring airway management.[26] If the cervical spine is at risk from either blunt or penetrating trauma, medics should immobilize the neck prior to transport.

Prehospital providers must perform a rapid assessment for tension pneumothorax and other immediate life threats. Intravenous lines should be inserted en route. In the presence of air sucking or bubbling neck wounds, apply Vaseline gauze to occlude the wound. Some authorities suggest placing the patient in the Trendelenburg position to decrease the chance of fatal air embolism,[22,27,28] although this recommendation has not been studied in a prospective fashion. Apply direct pressure to control active bleeding.

Emergency Department Management

Initial Management

As with any trauma patient, simultaneous evaluation and management begins with the ABCs of the primary trauma survey. Treatment occurs simultaneously with evaluation. Airway intervention may be necessary even before a patient is completely undressed and log rolled. Nurses should provide supplemental oxygen and establish vascular access shortly after patient arrival. Throughout the ED evaluation and management of trauma, any deterioration should trigger reassessment and stabilization of the ABCs.

Airway Management

If consciousness is impaired, open the airway with a jaw thrust in the setting of suspected cervical trauma, or with a head tilt and chin lift in the absence of such injury.[29,30] The timing of more definitive airway management is controversial. The fundamental principle, however, is that *earlier intubation leads to easier intubation*. Earlier intubation allows less time for anatomical distortion and patient deterioration. "Playing it safe" by intubating early decreases the need for later crash intubation away from the "friendly confines" of the ED.[31] In a large retrospective study, Eggen and Jorden defined the following criteria for emergent intubation: acute respiratory distress, airway compromise from blood or secretions, extensive subcutaneous emphysema, tracheal shift, or alteration in mental status.[32] They recommend elective prophylactic intubation for minimally symptomatic patients in case of suspected progressive airway compromise or if such a patient is likely to be out of the ED for a prolonged time for diagnostic studies.[32] Walls et al suggest intubation for all gunshot wounds to the neck regardless of evidence of vascular or direct airway injury.[31]

Radiographic clearance of the cervical spine is not necessary before airway manipulation when an experienced member of the team provides cervical spine immobilization. Rapid sequence intubation (RSI) may be performed with in-line cervical spine immobilization prior to formal radiographic clearance of the cervical spine.[33-36] Unstable cervical injuries are rare with penetrating neck trauma in the presence of a normal neurologic examination.

Multiple retrospective studies demonstrate the potential difficulty of securing an airway in penetrating neck trauma.[23,31,32,37] In a recent large retrospective review, Mandavia et al reported on 748 consecutive patients with penetrating neck trauma. Eighty-two (11%) required intubation; six out of the 39 patients who underwent RSI required multiple attempts, and three of 12 patients who initially underwent fiberoptic intubation required rescue RSI.[37] In a retrospective analysis of 114 patients with penetrating neck trauma, Eggen and Jorden reported that 26 of 69 intubation attempts were initially unsuccessful, with six requiring an alternative to endotracheal intubation.[32]

The ideal method of airway management is also controversial. Management options for the patient with neck trauma in the ED include RSI, oral intubation with sedation or local airway anesthesia, blind nasotracheal intubation, direct fiberoptic nasotracheal or orotracheal intubation, retrograde guidewire orotracheal intubation, cricothyrotomy, tracheostomy, and placement of the

endotracheal tube through an open wound or into a visible distal segment of the trachea.[33]

Orotracheal Intubation

Several retrospective reviews support orotracheal intubation as the initial modality of choice.[23,31,32,37] Orotracheal intubation provides direct visualization of the vocal cords, the fewest complications, and the highest success rate. The familiarity of ED physicians with RSI makes this a preferred technique in the majority of cases of penetrating neck trauma. Mandavia et al reported that two-thirds of all critical airways were managed with RSI, with a 100% success rate, including two rescue cases of failed fiberoptic intubations.[37] Likewise, in the anesthesia literature, Shearer and Giesecke had a 98% success rate using RSI in patients with penetrating neck trauma.[33]

To prevent the "can't intubate/can't ventilate" nightmare, avoid paralyzing patients who cannot easily be bagged. A morbidly obese male with a thick beard covering a small mouth should raise this concern. In addition, significant distortion of the airway due to expanding hematomas or direct airway trauma may render the bag-valve-mask impossible.

Oral intubation with sedation alone (awake intubation) is indicated when bag-mask ventilation may be difficult. Sedation is best performed with ketamine (1-2 mg/kg slow IV push) or rapid-acting reversible agents (such as midazolam 0.05 mg/kg or fentanyl 1-2 mcg/kg). Preservation of respiratory drive is the biggest advantage of ketamine. If time permits, have the patient breathe nebulized 4% lidocaine to anesthetize the airway and facilitate cooperation. Direct local airway anesthesia is another option; however, it may be difficult to perform on a moving target unless combined with adequate patient sedation.

Special caution is indicated in the patient with significant blunt or penetrating laryngeal injury. With blunt trauma, closed laryngeal injury may make orotracheal intubation impossible. With massive blunt laryngeal trauma in the patient maintaining an airway, avoid paralysis and prepare for an immediate surgical airway and neck exploration in the operating room. Awake intubation with local anesthesia and endotracheal intubation over a fiberoptic bronchoscope are other alternatives to consider in the difficult (and fortunately rare) case of blunt neck trauma with significant laryngeal injury.[4,38]

With penetrating trauma, open injuries to the larynx may facilitate direct intubation of distal segments.[38] Grasp the distal segment with a towel clip to stabilize the trachea and directly intubate through the neck wound. (See **Figure 3**.)

Beware the clothesline injury; this particularly lethal mechanism occurs when the rider of a motorcycle, snowmobile, or bicycle runs into an unseen wire or tree limb. In such a case, the trachea may be transsected, making RSI a dangerous procedure. Pharmacologic paralysis may result in loss of supporting muscle tone and misalignment of the discontinuous tracheal segments, which makes it impossible to ventilate or intubate—leaving the only therapeutic alternative an ED median sternotomy to look for the missing proximal trachea.

Alternative Approaches To The Airway

Use alternative airway approaches when orotracheal intubation is unsuccessful or contraindicated. Blind nasotracheal intubation is not generally recommended in patients with neck trauma; it can be especially dangerous when there is a possibility of dislodging a clot. In addition, the distorted anatomy leads to a higher failure rate for blind nasotracheal intubation. Intubation over a fiberoptic bronchoscope is time-consuming, and a bloody airway makes it a challenging procedure even in experienced hands.[33] Retrograde intubation using a guide wire inserted in the cricothyroid membrane and brought out through the mouth is often slow and requires experience and skill.

Cricothyrotomy

Surgical airways are often the rescue method of choice. Cricothyrotomy is a quick and easy procedure in the absence of anatomic distortion. Some believe that a horizontal incision directly through the skin into the cricothyroid membrane is preferred when landmarks are easily palpable, while an initial vertical incision may allow for better identification of the cricothyroid membrane when there is swelling or anatomic distortion. Cricothyrotomy is contraindicated (or *relatively* contraindicated) in the presence of an expanding hematoma over the cricothyroid membrane. In patients with laryngeal trauma, tracheostomy is preferred over cricothyrotomy *if time permits*. However, if the patient with laryngeal trauma is dying from asphyxiation, perform an emergent cricothyrotomy (or needle cricothyrotomy).[33]

Percutaneous Transtracheal Ventilation

Percutaneous transtracheal jet ventilation (needle

Figure 3. Direct intubation of trachea.

In cases of open tracheal wounds, the best (and sometimes only) airway strategy may be direct intubation through the defect.

cricothyrotomy) is a valuable airway rescue technique for patients with distorted anatomy who cannot be intubated orally.[39] It is an alternative airway of choice in children under 8 years in whom cricothyrotomy is contraindicated. A large-bore catheter placed through the cricothyroid membrane provides up to an hour of ventilation until a formal tracheotomy can be performed by a surgeon.[40]

Insert a 10- or 12-gauge needle through the cricothyroid membrane (directed toward the feet) while aspirating with a syringe. Once air is aspirated, advance the catheter, withdraw the needle, and secure the catheter. Attach the catheter to high-pressured ventilation tubing connected to the standard wall oxygen outlet at 55 pounds per square inch. A finger control valve can be used to achieve an inspiratory-to-expiratory ratio of at least 1:3, to avoid barotrauma. Percutaneous transtracheal ventilation devices are available commercially or can be constructed from parts available to any respiratory therapist.[41,42] Assemble this kit before you need it, as the arrival of a patient with a compromised airway is no time to start searching for parts.

Tracheostomy

Although more difficult to perform, tracheostomy may be required when other techniques have failed and cricothyrotomy is contraindicated.[37] Formal tracheostomy is usually left to the surgical consultant but may be accomplished by emergency physicians experienced in the procedure. Airway approach recommendations by clinical presentation are reviewed the Clinical Pathways on pages 12-17.

Breathing

Patients with Zone I injuries are especially prone to pneumothorax and hemothorax. The combination of hypotension, respiratory distress, and unilateral decreased breath sounds should prompt immediate needle thoracentesis followed by tube thoracostomy.

Circulation

Control Bleeding

Use direct pressure to control bleeding. *Clamping of vessels—blind or otherwise—should never be done in the ED.* Only the trauma surgeon should clamp vessels, and then only in the operating room with appropriate exposure, as inappropriate use of a clamp could lead to ischemic cerebrovascular accident or iatrogenic nerve injury.

If the hemorrhage cannot be staunched with pressure because the wound is particularly large and deep, consider the placement of a Foley catheter. Insert the Foley as far as possible and inflate the balloon with water until the bleeding stops or resistance is felt.[43] This technique is especially valuable in penetrating wounds to Zone I. Because of involvement of the subclavian vessels, such bleeding is notoriously difficult to manage in the ED. Uncontrolled intrathoracic hemorrhage from a Zone I injury may require an emergent thoracotomy.[2] Ligation of simple venous injuries is acceptable in the setting of hemodynamic instability.[44]

Vascular Access

Establish vascular access. Some authorities suggest placing the IV in the extremity opposite the injury under the assumption that fluid or blood administered on the side of the injury is more likely to leak out any venous wound in the neck.[45] However, this assertion is not well-studied.

At least two large-bore IVs of crystalloid solution given "wide-open" is a traditional standard in the hypotensive patient. However, the amount of fluid that should be given remains controversial. Despite the "common wisdom" of providing large-volume crystalloid resuscitation for traumatic shock, no controlled clinical trials demonstrate a benefit to early aggressive resuscitation (especially prior to control of bleeding). Animal data suggest that aggressive fluid resuscitation may actually increase bleeding in uncontrolled hemorrhage.[46] One prehospital study examined this issue in a series of nearly 600 hypotensive patients with *penetrating* torso injuries.[47] In this trial, strictly limiting prehospital fluids improved outcomes, and patients in this group demonstrated both lower mortality and fewer complications. However, the role of hypotensive resuscitation requires further study.

Cardiac Arrest

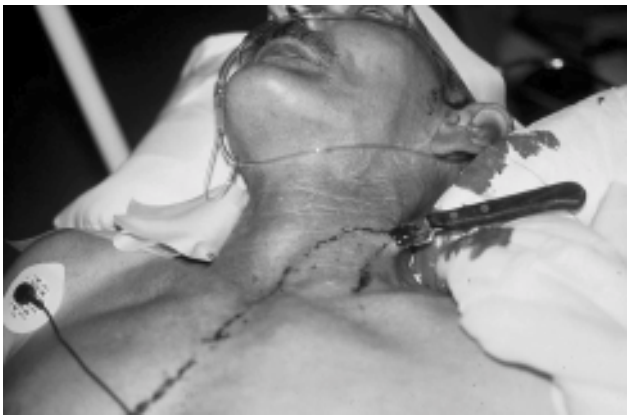
It comes as no surprise that cardiac arrest in the setting of penetrating neck trauma is a poor prognostic sign. Heroic interventions may include ED thoracotomy to cross-clamp the aorta and perform open cardiac massage, obtain control of bleeding vessels, and possibly to aspirate the right ventricle to treat air embolism.

Standard Trauma Interventions

If an impaled object is in place (knife, stick, etc.), *leave it alone.* (See **Figure 4**.) Impaled objects may tamponade lacerated vessels; ED removal could precipitate life-threatening hemorrhage. Such objects should be removed

Figure 4. Knife in neck.

In cases of impalement, leave the implement alone! This knife should be removed in the operating room.



in the operating room.

Most of the standard trauma interventions such as monitoring of vital signs and ECG, Foley catheterization, etc., remain unchanged in the patient with neck trauma, with one exception. The placement of a nasogastric tube is controversial, as some theorize that the tube could dislodge a clot and worsen the hemorrhage.[22,48] Consult the treating surgeon in regards to this decision.

"To repeat what others have said, requires education; to challenge it, requires brains."
—Mary Pettibone Poole, "A Glass Eye at a Keyhole," 1938

History

Asking the patient his or her name provides immediate useful information regarding mental status and airway. No answer or a harsh or muffled voice should prompt immediate intervention.

Determine the mechanism of injury, weapons involved, number of shots fired (if it is a gunshot wound), and other details from the scene. When evaluating neck trauma, it may be helpful to divide the questions into organ-specific clusters. "Airway questions" would include any shortness of breath, difficulty speaking, pain with inspiration, and hemoptysis. Inquire whether the patient has pain with swallowing (an important clue to esophageal disruption). "Neurologic questions" would address numbness or weakness with special attention to whether the deficit is on the right vs. left side (associated with carotid injury or stroke) as opposed to arms vs. legs (more often linked with spinal injury). Ask whether the patient had associated head trauma or loss of consciousness. "Vascular questions" focus on blood loss, swelling of the neck, or the sound of "whooshing" in the ears (pulsatile tinnitus), which is associated with carotid dissection.

In assessing the past medical history, determine whether the patient had any prior neck or chest surgeries and assess whether the patient is on warfarin or other medications that could affect hemostasis.

Physical Examination

Attention to the "ABCs," vital signs, and mental status provides important clues regarding clinical stability. Inspect the airway for signs of injury, bleeding, and the patient's ability to protect his or her airway. Assess breathing by looking for symmetrical chest rise and fall, auscultating the neck and chest for stridor or other abnormal sounds, and palpating the neck and chest for obvious injury, subcutaneous emphysema, and hematomas. Circulation can be evaluated by palpating the arterial pulses in the neck, face, and extremities and assessing mental status, blood pressure, and heart rate. Check disability via the AVPU scale (Alert, responds to Verbal stimuli, responds to Painful stimuli, or is Unresponsive) or the Glasgow Coma Scale. Exposure is essential in all trauma patients, given the likelihood of multiple injuries, often-incomplete histories, and delayed development of injury.

The secondary survey begins with a head-to-toe physical examination of the patient. Location of wounds and number of missiles may help direct the necessary work-up.[49] The secondary survey in neck trauma must focus on airway, digestive tract, vascular, and nervous system injury.

Neck Examination

Signs of laryngeal injury include pain or tenderness, hoarseness or voice alteration, stridor, subcutaneous emphysema, dysphagia, hemoptysis, bubbling wounds, and deformity of external landmarks. Pay particular attention to the character of the patient's voice. Any intrinsic laryngeal injuries can lead to hoarseness. Extrinsic laryngeal injuries resulting in voice changes include recurrent laryngeal nerve injury and extralaryngeal hematoma. Minimal initial voice changes and physical examination findings may progress into life-threatening injuries. Increasing intralaryngeal hematoma and edema may not reach the maximum until several hours post-injury, necessitating repeat examinations and close attention to respiratory status.[3]

The clinical findings associated with penetrating vascular injury to the neck may be obvious (e.g., brisk bleeding accompanied by shock), or subtle and detectable only through careful physical examination. Signs of vascular injury (see **Table 2** on page 9) include expanding hematomas, carotid bruits / thrills, hemothorax, and cerebrovascular accident from air embolism.

Listen over the carotids for bruits (put the diaphragm inside a glove to avoid getting blood on your stethoscope in case of penetrating trauma). A bruit may provide an important clue to carotid dissection or injury.[7]

Inspect the wounds by gently separating wound edges to determine if the wound has penetrated the platysma; if so, a surgical consult is needed. Avoid probing past the platysma to prevent clot disruption, false passages, and otherwise aggravating the injury.

The clinical signs of esophageal injuries include neck pain and tenderness, resistance to passive motion of the neck, subcutaneous emphysema, dyspnea, dysphagia, and bleeding from mouth or nasogastric tube.

Chest Examination

Palpation of the anterior chest may reveal subcutaneous air associated with pneumothorax. Listen for asymmetry of breath sounds, another important clue to air in the pleural space. Cardiac auscultation can demonstrate a crunching sound with each beat of the heart, a finding known as "Hamman's crunch." This sound can occur with any condition that leads pneumomediastinum; esophageal perforation is a rare but important cause.

Vascular Examination

In addition to evaluation of the carotids (e.g., assess pulses, bleeding, hematomas, and bruits) carefully examine the peripheral pulses—most importantly the radial or brachial pulses. A deficit in an upper-extremity pulse may signal a subclavian injury.

Neurologic Examination

Motor deficits may be secondary to stroke related to carotid artery injury, spinal cord damage, or injury to the peripheral nerves (in particular, the brachial plexus). In Zone II injuries, carefully examine the cranial nerves; damage to the facial nerve produces a traumatic Bell's palsy, while hypoglossal nerve injury will deviate the tongue.

Table 2. Clinical findings by system.

Airway injury
- Voice changes
- Respiratory compromise / stridor
- Airway compromise
- Subcutaneous emphysema
- Hemoptysis
- Bubbling wound

Penetrating vascular injury
- Shock with or without active bleeding
- Expanding or pulsatile hematoma
- Brisk bleeding from wound site
- Airway compromise
- Decreased pulse (radial, ulnar, carotid, temporal, facial arteries)
- Carotid bruit / thrill
- Hemothorax
- Air embolism
- Cerebrovascular accident
- Neurologic findings incongruent with head CT
- Asymptomatic interval between trauma and symptoms with negative head CT
- Ipsilateral headache
- Ipsilateral Horner's syndrome
- Facial or neck pain

Blunt vascular injury

Carotid artery injury
- Hematoma lateral neck
- Bruit over carotid
- Horner's syndrome
- Transient ischemic attack
- Aphasia
- Contralateral hemiparesis

Vertebral artery injury
- Ataxia
- Vertigo
- Nystagmus
- Hemiparesis
- Dysarthria
- Diplopia

Digestive tract injury
- Pain on swallowing
- Neck pain or tenderness
- Resistance of neck to passive motion
- Subcutaneous emphysema
- Dyspnea
- Bleeding from mouth or nasogastric tube
- *Clinical signs often non-diagnostic*

Clinical findings in blunt vascular injury depend on whether the carotid or vertebral artery is involved. Classic features include neurologic abnormalities incongruent with head CT (including stroke-like symptoms), a lucid interval between trauma and symptoms, ipsilateral headache, and facial or neck pain.[50]

Skin Examination

In cases of strangulation injury, the skin examination is revealing. Patients may present with petechiae in the face and neck and often demonstrate subconjunctival hemorrhage.

Diagnostic Maneuvers

There are several important diagnostic maneuvers that can greatly augment the physical examination. First, have the patient cough to determine if he or she has hemoptysis; then, have the patient swallow to check for dysphagia; and finally, listen to the patient speak to assess laryngeal function. A positive finding resulting from these challenges will prompt further evaluation of the airway, esophagus, and larynx, respectively.

Diagnostic Studies

An important early decision involves the decision "to test or to treat." In a practical sense, this amounts to mandatory operation vs. a strategy of selective operation combined with a targeted diagnostic evaluation. An even more controversial issue is selective *testing*, where testing is based on clinical findings and not the mere fact of neck injury.

Mandatory vs. Selective Operative Intervention

Mandatory neck exploration has mostly been supplanted by selective neck exploration of wounds that penetrate the platysma. During World War II, all wounds penetrating the platysma were surgically explored.[1] There are several advantages of emergent operating room exploration. A negative neck exploration involves only a short, simple procedure, fewer additional diagnostic tests, and a shorter length of stay in the hospital compared to other management strategies.[51] Patients with negative neck explorations require only a short period of observation and can avoid the disastrous complications of an occult vascular injury. However, mandatory exploration results in a high negative exploration rate with the resultant morbidity of needless explorations (although the morbidity of a negative exploration is usually low).

During the 1990s, selective neck exploration of stable patients with penetrating injuries became the standard of care. Many surgeons questioned the need to apply lessons from high-velocity military weapons to civilian injuries.[8,22,51-53] Asensio et al reviewed and combined data from 26 studies of mandatory and selective exploration that included over 4000 patients.[1] The percentage of negative explorations decreased from 46% in the mandatory group to 30% utilizing a selective approach, with no change in the mortality rate. Many of these studies

showed that selective neck exploration with selective ancillary diagnostic testing safely excludes injury while decreasing the negative exploration rate.

Indications for immediate operative intervention without further diagnostic evaluation are presented in **Table 3**. If immediate surgical exploration is not indicated, then further evaluation is required to exclude occult injuries.

Transcervical gunshot wounds remain an area of controversy. In a retrospective review by Hirshberg et al, of 41 patients with a transcervical gunshot wound, 83% had positive neck explorations.[54] However, in a more recent prospective study utilizing a selective approach, only 21% of transcervical gunshot wounds had a therapeutic operation.[52] The difference between these numbers may relate to a baseline difference in acuity. In the study by Hirshberg et al, nearly 40% of the patients had evidence of life-threatening injuries on ED presentation.

Table 3. Indications for immediate operative repair by system.

System	Finding
Vascular	Shock Pulse deficit (absent radial pulse)* Uncontrolled bleeding Rapidly expanding hematoma
Respiratory	Stridor* Hemoptysis* Dysphonia*
Digestive	Hematemesis* Dysphagia*
Neurologic	Neurologic deficits*

* In conjunction with other clinical findings

Figure 5. X-ray of Zone I injury.

Zone I injuries are often associated with severe trauma to intrathoracic structures. Always obtain a chest x-ray in patients with these injuries.

Laboratory Investigation

Laboratory investigation of significant blunt and penetrating neck trauma includes some initial (and often serial) measurements of hemoglobin or hematocrit. Patients who are hemodynamically unstable, significantly anemic, or show evidence of ongoing blood loss should receive a type and crossmatch or type and screen, depending on the clinical circumstances. Injury victims with known or suspected liver disease, patients on warfarin, or those with persistent bleeding are candidates for coagulation studies.

Early measurement of systemic acidosis (base deficit, lactate, or pH) can provide important clues to occult shock.[55] It may also be helpful to follow the trend of acidosis over time to determine the success of the resuscitation.[56]

Radiology

Chest and neck radiographs are an important part of the initial work-up of blunt and penetrating neck trauma. (See **Figure 5**.) The initial x-rays should always be done in the resuscitation room of the ED and not in the radiology suite. Positive findings on soft-tissue neck radiographs (see **Table 4**) include subcutaneous emphysema, prevertebral emphysema, and the location of any missile or fragment. Chest x-ray may reveal pneumothorax, hemothorax, mediastinal air, widened mediastinal structures, and the location of missile fragments. In a retrospective study of 110 bullet wounds to the neck, 48 patients had positive chest x-ray findings, including six hemothoraces, nine pneumothoraces, and four hemopneumothoraces.[57]

Targeted Diagnostic Strategies

All of the following diagnostic algorithms depend on a central premise—that the patient is clinically stable. Most unstable patients, as well as patients who become unstable, need to go to the operating room without diagnostic delay. An exception would include those in whom interventional angiography may be life-saving.

Table 4. Important neck and chest radiograph findings in neck trauma.

Neck
- Subcutaneous emphysema
- Prevertebral emphysema
- Missile fragments
- Fractured calcified larynx

Chest
- Pneumothorax
- Hemothorax
- Mediastinal air
- Pleural effusion
- Widened mediastinum
- Missile fragments

Airway Injuries

Airway evaluation is essential for patients with a change in voice, subcutaneous air, hemoptysis, or respiratory difficulties. Conversely, the absence of clinical findings reliably excludes laryngeal trauma in both blunt and penetrating laryngeal injuries.[22,58]

The diagnostic evaluation of penetrating and blunt airway injury begins with visualization of the endolarynx via a fiberoptic scope or indirect or direct laryngoscopy.[3,11,59-61] Laryngoscopy is indicated with positive clinical findings or a significant mechanism to evaluate the extent of intraluminal injury.[4] Conventional radiographic evaluation serves an important adjunctive role. Findings on soft-tissue cervical radiographs include subcutaneous or prevertebral air or a fractured calcified larynx.

CT scanning plays a central role in the evaluation of suspected airway injury, especially in the case of suspected laryngeal involvement. It accurately identifies the location and extent of laryngeal fractures.[62-65] Perform CT when the diagnosis of laryngeal fracture is suspected, even in the presence of a negative endolarynx examination or when the endolarynx cannot be visualized (intubated patients). CT findings determine the need for operative intervention and guide preoperative planning in displaced fractures.[22,66] Laryngeal injuries are classified into four groups depending on the degree of injury. (See **Table 5**.)

Vascular Injuries

Angiography

Angiography has been the traditional gold standard in the diagnosis of vascular injuries. However, the best method of vascular imaging in penetrating injuries continues to evolve as newer and less invasive imaging techniques become more widely available. In Zone III injuries, angiography may play both a therapeutic and diagnostic role.

Table 5. Laryngeal injury classification by Schaefer.

Group	Findings
1	Minor endolaryngeal hematoma or lacerations, absence of detectable laryngeal fractures, and minimal airway compromise
2	Edema, hematoma or minor mucosal disruption without exposed cartilage, varying degrees of airway compromise
3	Massive edema, large mucosal lacerations, exposed cartilage, displaced fractures, vocal-cord immobility, varying degrees of airway compromise
4	As in group 3 with disruption of the anterior larynx or unstable laryngeal cartilaginous skeleton

Source: Schaefer SD. Primary management of laryngeal trauma. *Ann Otol Rhinol Laryngol* 1982 Jul-Aug;91(4 Pt 1):399-402.

Carotid Duplex Scanning

Proponents of carotid duplex scanning point to the invasive nature and high cost of routine angiography. Multiple studies comparing angiography and carotid duplex scanning have found the sensitivity of carotid duplex scanning in excluding vascular injury ranges from 90% to 100%.[67-69] These studies recommend carotid duplex scanning to exclude injury in asymptomatic Zone II and III penetrating injuries. Because of occasional false-positive studies, positive carotid duplex scanning should be followed by angiography to confirm the injury.

Helical CT Angiography

Helical CT angiography (HCTA) is an alternative to both carotid duplex scanning and angiography in the evaluation of penetrating vascular injury. Several prospective studies have examined the role of CT in penetrating neck trauma. In a recent small study of 14 patients, Mazolewski et al demonstrated that dynamic CT was 100% sensitive in excluding vascular injury.[70] In another study, Munera et al found that HCTA was 90% sensitive and 100% specific compared to angiography.[71] Using direct and indirect signs of injury on HCTA, LeBlang et al reported a sensitivity of 100% and a specificity of 97%.[72] Other centers have not had such compelling results; the Memphis center found CTA to be less than 50% sensitive in detecting blunt carotid injuries.[73]

Direct signs of vascular injury include wall irregularity, contrast extravasation, lack of vascular enhancement, and caliber changes. Indirect signs included bone or bullet fragments less than 5 mm from a major vessel, path of injury through a major vessel, and a hematoma in the carotid sheath.[72] Artifact and scatter associated with metallic fragments can complicate interpretation. However, with more and larger studies, HCTA may become an appropriate screening tool for vascular injury in neck trauma.

Magnetic Resonance Imaging

Case reports demonstrate that magnetic resonance imaging (MRI) can reveal a variety of vascular lesions. However, MRI has not been used specifically in patients with neck trauma and is limited by cost and logistical constraints.[74]

Special Considerations In Penetrating Trauma

Indications for immediate exploration of vascular injuries include shock, pulse deficit, and a rapidly expanding hematoma. In stable patients with penetrating neck injuries, diagnostic evaluation varies by neck zone injured. For Zone I injuries, perform angiography in all patients to exclude injury to intrathoracic vessels. In stable patients with indications for operative repair, angiography determines the need for thoracotomy prior

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Clinical Pathway: Initial Approach To The Airway In Patients With Neck Trauma

Immediate indications for airway management

- Stridor
- Respiratory distress
- Profound shock
- Rapidly expanding hematoma

YES →

NO ↓

Urgent or prophylactic indications for airway management

- Progressive neck swelling
- Need to transfer symptomatic patient
- Voice changes
- Progressive symptoms
- Extensive subcutaneous emphysema, edema, or tracheal shift
- Alteration in mental status
- Prolonged time away from the ED for diagnostic study is anticipated and patient symptomatic

YES →

NO ↓

Continue to re-evaluate airway status

Intubate
(Class I)

Options:

- RSI—if not difficult to bag and no anatomical disruption (airway of choice) **(Class I)**
- Awake intubation—if anticipated to be difficult to bag or suspected tracheal disruption **(Class II)**
- Fiberoptic intubation—if skilled operator and no significant blood in airway **(Class II-III)**
- Cricothyrotomy—can't RSI and no hematoma over cricothyroid membrane or laryngeal fracture **(Class I-II)**
- Needle cricothyrotomy—if child or other relative contraindication to cricothyrotomy **(Class II)**
- Tracheostomy—can't RSI and contraindications to cricothyrotomy **(Class I-II)**
- Direct tracheal intubation—open trachea **(Class II)**

The **evidence for recommendations** is graded using the following scale. For complete definitions, see back page. **Class I:** Definitely recommended. Definitive, excellent evidence provides support. **Class II:** Acceptable and useful. Good evidence provides support. **Class III:** May be acceptable, possibly useful. Fair-to-good evidence provides support. **Indeterminate:** Continuing area of research.

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Clinical Pathway: Management Of Penetrating Neck Trauma

Platysma intact?

YES → Local wound repair and discharge

NO ↓

Patient unstable?

YES →
- Consult surgeon
- Resuscitate
- Manage airway
- Type and cross-match
- Direct pressure on bleeding sites
- Facilitate transfer to operating room or trauma center

NO ↓

- Consult surgeon **(Class I)**
- Chest x-ray **(Class I)**
- Neck films **(Class II-III)**
- Hemoglobin/hematocrit **(Class I-II)**
- Lactate or base deficit **(Class II-III)**

↓

Zone III
(Above the angle of the jaw)

YES →
- Color-flow Doppler or CT angiography **(Class II-III)**
- Angiography **(Class I-II)**
- CT of head if suspected intracranial penetration or neurologic findings **(Class I)**
- Evaluate for esophageal injury if pain on swallowing or subcutaneous air **(Class I)**
  - Esophagoscopy **(Class I-II)**
  - Esophagography **(Class I-II)**
- Laryngoscopy or CT of neck (if clinical findings of airway injury) **(Class II)**
- Bronchoscopy (if clinical findings) **(Class II-III)**

NO ↓

Zone I
(Below the cricoid cartilage)

YES →
- Angiography **(Class I-II)**
- Color-flow Doppler or CT angiography **(Class II-III)**
- Evaluate for esophageal injury if pain on swallowing or subcutaneous air **(Class I)**
  - Esophagoscopy **(Class I-II)**
  - Esophagography **(Class I-II)**
- Laryngoscopy or CT of neck (if clinical findings of airway injury) **(Class II)**
- Bronchoscopy (if clinical findings) **(Class II-III)**

NO ↓

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Clinical Pathway: Management Of Penetrating Neck Trauma (continued)

Zone II
(Between the cricoid cartilage and angle of the jaw)

Indications for immediate operation? → YES

- Shock
- Uncontrolled bleeding
- Rapidly expanding hematoma
- Pulse deficit (absent radial pulse)*
- Stridor*
- Hemoptysis*
- Dysphonia*
- Hematemesis*
- Dysphagia*
- Neurologic deficits*

* In conjunction with other clincial findings

- Facilitate transfer to operating room or to trauma center
- Resuscitate as possible

NO

- Abnormal voice
- Subcutaneous air
- Respiratory signs or symptoms
- Blood in airway

→ YES

- Laryngoscopy (fiberoptic or direct) **(Class I-II)**
- CT scan of larynx **(Class I-II)**
- Bronchoscopy **(Class II-III)**

NO

- Pain on swallowing
- Abnormal air on neck or chest x-ray
- Altered mental status

→ YES

Contrast study of esophagus with Gastrografin. If negative, then contrast study with barium; if negative, then esophagoscopy.

NO

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Clinical Pathway: Management Of Penetrating Neck Trauma (continued)

- Slowly expanding hematoma
- Carotid bruit or thrill
- Neurologic deficit unexplained by head CT or peripheral nerve injury
- Horner's syndrome

YES →

- Angiography **(Class I)**
- Color-flow Doppler **(Class II-III)**
- Helical CT angiogram **(Class II-III)**

NO ↓

Stable, asymptomatic patient with Zone II injury*

Option 1: Selective diagnostic testing ↓

Admit for observation and serial examinations
(Class I-II)

Option 2: Mandatory diagnostic testing ↓

Vascular evaluation
- Angiography **(Class II)** ***OR***
- Helical CT angiography **(Class II-III)** ***OR***
- Color-flow Doppler **(Class II-III)**

Esophageal evaluation
- Contrast studies and endoscopy **(Class II)**

Airway evaluation
- Laryngoscopy and CT **(Class II)**

* Management of stable asymptomatic Zone II injuries is very institution- and surgeon-dependent

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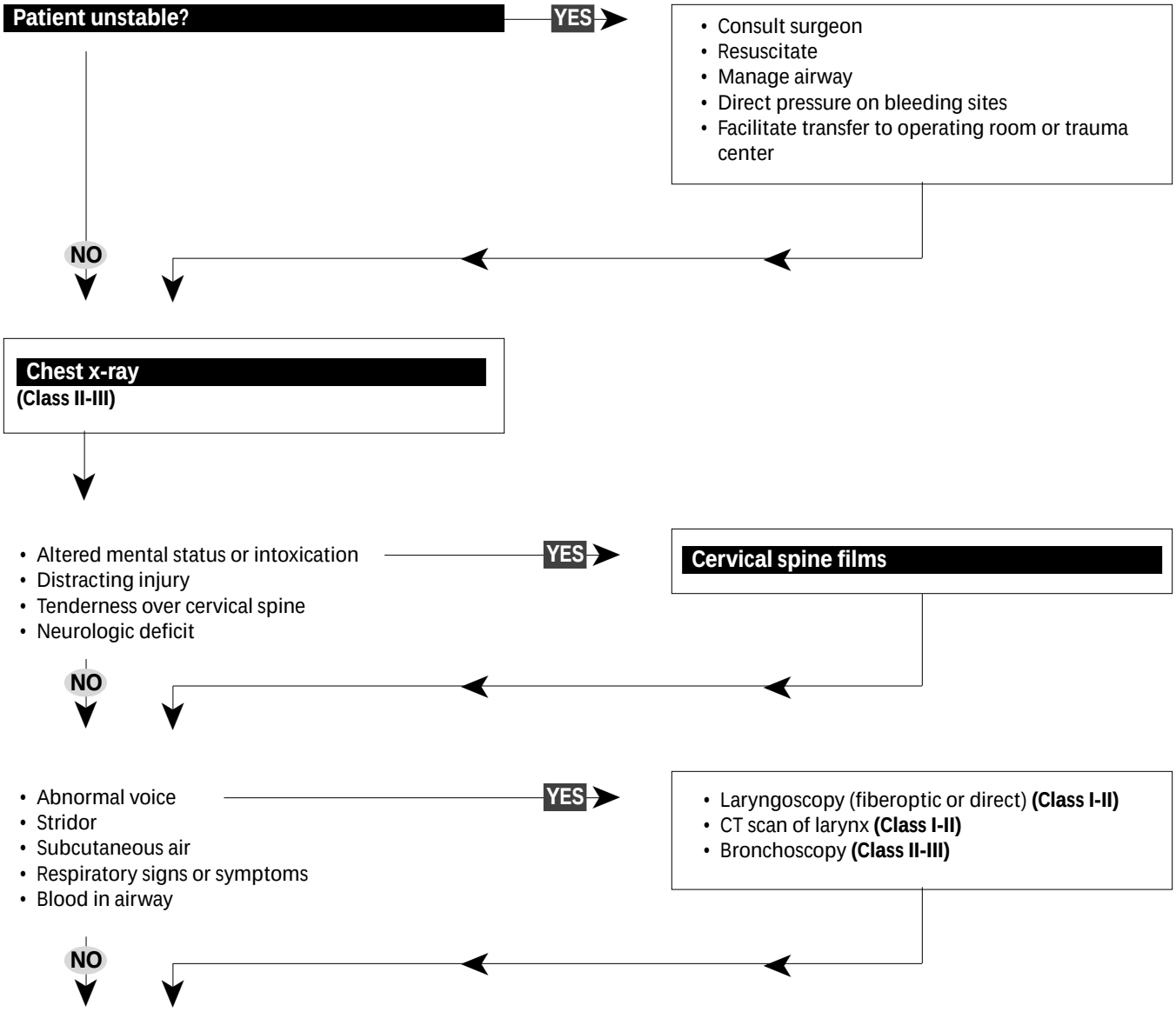
Clinical Pathway: Management Of Blunt Neck Trauma



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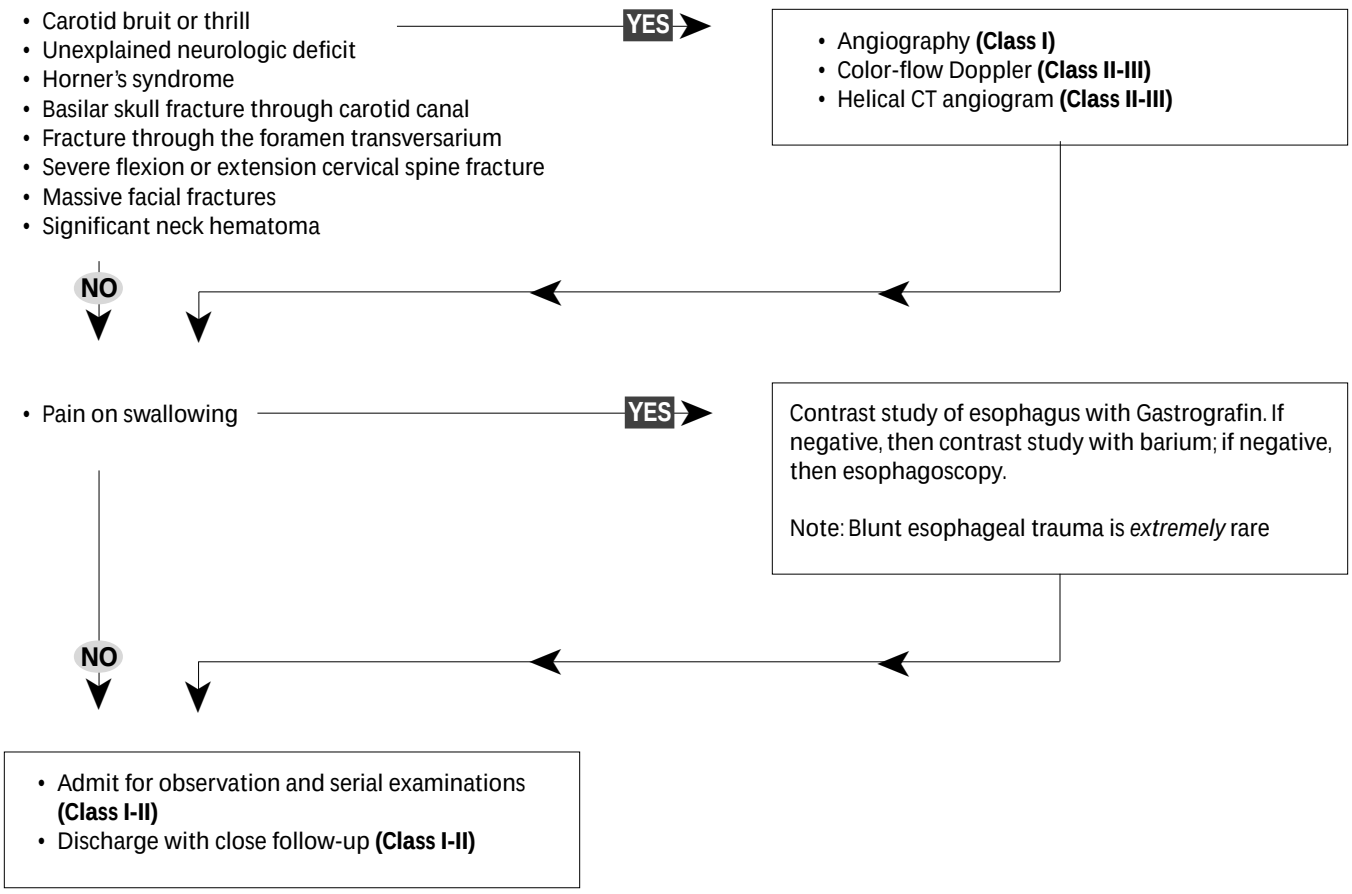
Clinical Pathway: Management Of Blunt Neck Trauma (continued)



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to neck exploration to repair thoracic outlet vessels.[51,75-78] For stable patients without indications for operative therapy, a small recent retrospective study has challenged the need for routine angiography. Of 138 Zone I injuries from five Level I trauma centers over a 10-year period, none of the 36 patients with a normal physical examination and chest x-ray had an arterial injury. The authors concluded that patients with a normal physical examination and chest x-ray might not require routine angiography.

Zone II injuries in patients with indications for surgery do not require diagnostic investigations prior to surgery since the anatomy allows for easy exploration and repair of injuries. The diagnostic approach to patients without indications for surgery is controversial due to the debate of the reliability of physical examinations to exclude serious vascular injuries in penetrating Zone II neck injuries. *Some centers rely on the physical examination to determine which patients require vascular imaging; other centers perform these studies routinely.* It becomes a matter of local practice because the literature

Ten Pitfalls To Avoid

1. "He was still breathing on his own! Airway management wasn't indicated."

In the setting of neck trauma, early intubation leads to easier intubation. Waiting to see if that pulsatile mass will continue to expand is never recommended. Elective or prophylactic intubation should be considered even for the mildly symptomatic—especially if swelling is progressive.

2. "But the cric is the rescue procedure of choice!"

Cricothyrotomy is relatively contraindicated when an expanding hematoma is present over the cricothyroid membrane or the patient has a suspected laryngeal fracture. In such circumstances, tracheostomy is indicated if RSI should fail. In certain situations, fiberoptics may be the modality of choice. Awake oral intubation with local airway anesthesia is also useful.

3. "I had to explore to the full depths of the wound!"

With adequate lighting and good retraction, the superficial tissues can be spread in order to see if the platysma has been violated. Further exploration in the ED is not warranted. Aggressive deep probing to explore the depths of the wound is best left to the surgeon in the operating room.

4. "It was a tiny neck wound! How was I supposed to know the path of the ice pick?"

You can't, and so you must suspect the worst. Any wound that penetrates the platysma (or cannot be proven *not* to penetrate the platysma) should be aggressively treated as a penetrating neck injury.

5. "The patient had no evidence of vascular injury on exam and his head CT was normal! I thought he was being dramatic."

About 25%-50% of patients with vascular injury after blunt neck trauma have no external evidence of injury. Neurologic deficits not explained by head CT imaging are the hallmark of vascular injury in blunt neck trauma. Image the great vessels of the neck in such cases.

6. "There was no evidence of a fractured larynx on the x-ray!"

Clearly visualizing a fractured larynx may not be possible unless the patient's cartilage is calcified. Physical examination findings include voice changes, respiratory compromise, tenderness, deformity, subcutaneous emphysema, and abrasions. Carefully palpate the neck for subcutaneous air. CT scan and a thorough endolaryngeal examination are the diagnostic modalities of choice.

7. "I had to assess for laryngeal injury before intubating!"

Save the patient—then get the study. CT scan can be used to assess the larynx, while providing information on the vascular and gastrointestinal tract in the intubated patient.

8. "I ran his work-up by the book. I managed the airway, ordered vascular studies, and evaluated the larynx and esophagus."

Why didn't you call the surgeon the instant you saw the knife went through the platysma? Early surgical consultation is one of the cornerstones in the management of penetrating neck trauma.

9. "His exam was negative, but I still did an x-ray and an upper GI with barium!"

The lack of sensitive and specific clinical signs makes the diagnosis of esophageal injury difficult. Physical examination, neck and chest radiographs, contrast studies, *and* endoscopy should be utilized to exclude esophageal injury.

10. "There was a fountain of blood. I had to start clamping and tying."

Direct pressure is the best method to control bleeding. Clamping and blindly "tying off all the big bleeders" is best avoided in the ED. ▲

is so conflicted.

Some studies show that physical examination is a reliable determinant of who needs vascular imaging (angiography or color-flow Doppler). The authors reviewed eight studies with a total of 1216 patients. Of the 837 patients observed without hard signs of injury, five patients (0.6%) had injuries that required intervention. Three prospective studies involving 688 patients with Zone II injuries report a missed injury rate of less than 1% using physical examination alone in select patients.[79-81] Because transcervical and gunshot wounds are considered "high-risk," many centers perform routine angiography on such patients despite a negative physical examination.

Other studies have found a higher incidence of missed injuries when physical examination alone is used to detect vascular trauma. In a retrospective review, Meyer et al studied 113 asymptomatic Zone II injured patients who underwent arteriography, laryngotracheoscopy, esophageal contrast studies, and esophagoscopy followed by neck exploration. In these 113 patients, clinical assessment alone had only a 68% accuracy in detecting injuries (although most missed injuries were non-operative in nature).[82] In a study from South Africa of 393 consecutive stab wounds to the neck, clinical signs were absent in 30% of positive neck explorations (defined as an injury to the pharynx, esophagus, trachea, or vascular structure).[83] These studies and others support the authors' recommendation that both physical examination and ancillary diagnostic testing are required to rule out vascular injury.

For Zone III penetrating injuries, physical examination is not reliable in excluding vascular injuries. Angiography is recommended since high internal carotid injuries may be difficult to visualize at operation and embolization may provide the most effective care.[76,84,85]

Blunt Trauma

The incidence of vascular injury in the setting of closed head injury is 0.08-1.00%.[86,87] A recent two-year prospective study of the trauma registry at the University of Tennessee reported an incidence of blunt cerebrovascular injury in 1% of all blunt trauma victims.[88] Ninety-three percent of lesions occur at the bifurcation of carotids or higher. Multiple vessel injuries are found in 40%-80%.[7,86] In one study of 66 patients with blunt carotid injury, angiographic findings included 54 intimal dissections, 11 pseudoaneurysms, 17 thromboses, four carotid cavernous fistulas, and one transsected internal carotid artery.

The diagnosis of vascular injury in blunt trauma is difficult. Co-existing injuries mask the clinical signs of carotid or vertebral injury, and 25%-50% of patients have no external signs of neck trauma.[89] Delayed neurologic deficits are the rule rather than the exception. More than 90% of patients are asymptomatic from hours to weeks after the injury; however, 10% of patients experience a transient ischemic attack or cerebrovascular accident within one hour, and 17% develop symptoms days to weeks post-injury.

Indications for diagnostic investigation of suspected blunt vascular injury include positive screening criteria (as described later in this section), neurologic findings incongruent with head CT, and monoparesis or hemiparesis with normal mental status. In patients with neurologic deficits unexplained by CT findings, spinal cord injury, or peripheral nerve injury, the incidence of vascular injury is 21%. In a series of 66 cases of blunt carotid artery injury, 34% of patients were diagnosed by incompatible neurologic and CT findings, 43% by new-onset neurologic deficits, and 23% by physical examination (neck injury, Horner's syndrome).[7]

Patients with altered mental status who have either significant external cervical trauma or basilar skull fracture should also be studied. In patients with a high-risk mechanism of injury (cervical hyperextension or hyperflexion, direct cervical blow, near hanging) and injury pattern (carotid canal, mid-face, and cervical spine fracture), 27% suffered vascular injuries.[90]

Using screening criteria, the detection rate for injury is much higher. Rozycki et al performed HCTA or conventional angiography on 131 patients with a cervicothoracic seat belt sign. They found a 3% incidence of occult vascular injury, a number significantly higher than that found in other studies (0.24%-0.86%).[91] The presence of these vascular injuries was strongly associated with a Glasgow Coma Scale score of less than 14, severe associated injuries (an Injury Severity Score > 16), and a clavicle and/or first rib fracture. However, one patient with blunt carotid injury presented with a Glasgow Coma Scale score of 15, a normal neurologic examination, and an ecchymosis (but no hematoma) over her right clavicle. Over an 18-month period, Kerwin et al used the following criteria to screen 1935 patients for possible blunt vascular injury: anisocoria, unexplained hemiparesis or other neurologic deficit, basilar skull fracture through or near the carotid canal, fracture through the foramen transversarium, cerebrovascular accident / transient ischemic attack, massive epistaxis, severe flexion or extension cervical spine fracture, massive facial fractures, and neck hematoma. Forty-eight patients had a positive screen and underwent angiography. Injuries were identified in 21 patients (44%). The overall incidence of blunt carotid / vertebral injury was 2.5% of patients admitted.[92] No patient screened for a neck hematoma alone had a carotid injury.

Diagnostic imaging for blunt trauma with suspected vascular injury is institution-specific and depends on equipment availability and the skill of the radiology investigators. Angiography is recommended in the acutely injured and symptomatic patient.[7]

Color-flow Doppler ultrasound may be used to screen lower-risk patients.[7] Color-flow Doppler provides rapid identification and quantification of arterial dissection but is operator-dependent and unable to assess the upper extracranial and intracranial internal carotid arteries.

Helical CT angiography has been used as a screening modality for patients at risk for blunt carotid injury.[74]

However, the diagnostic accuracy has not been well-established in blunt trauma. The use of HCTA did significantly decrease the time to diagnosis from 156 hours to 5.9 hours and demonstrated an increased detection rate of cervical arterial injuries.[87]

MR angiography accurately detects carotid and vertebral artery injuries.[93-95] Reported sensitivity and specificity are greater than 95% for carotid artery dissection. MR is currently recommended as a follow-up test for stable patients since it is difficult to perform in acutely injured or unstable patients.[7,94,95] Perform MR as a screening tool in stable patients to assess for occult carotid injury in patients who have sustained blunt trauma with severe closed head injury.

Digestive Tract Injuries

Penetrating Trauma

The indications for diagnostic testing for esophageal injury in penetrating neck injury include any positive clinical findings (especially pain on swallowing), a projectile in proximity to or trajectory crossing the midline, a projectile beyond the limits of surgical exploration, and the presence of subcutaneous air on cervical or chest radiographs.[24,53,96] In one prospective study, Demetriades et al found pain on swallowing water or saliva to be a sensitive sign.[53] Their data indicated that a normal physical examination (no dysphagia, no hemoptysis on coughing, and no subcutaneous air) had a 100% negative predictive value for esophageal injury in awake patients. However, in a review by Weigelt et al, the authors found that physical examination was only 80% sensitive for esophageal injury.[97]

The exclusion of penetrating esophageal injury must include some combination of physical examination, plain radiographs, contrast radiographs, endoscopy, and surgical exploration. A patient suspected of esophageal injury may undergo several sequential tests (assuming that each study is negative), usually starting with Gastrografin, followed by barium swallow, and finally endoscopy. The importance of early detection and treatment of these injuries, with operative repair and antibiotics for the prevention of serious complications and death, cannot be overemphasized.

Plain radiographs, esophageal contrast studies, and esophagoscopy are frequently used together to assess for esophageal injuries; however, none of the tests in isolation has the sensitivity to reliably exclude these injuries. Plain radiographs of the neck may reveal subcutaneous emphysema or an increased prevertebral shadow. Chest x-ray findings suggestive of esophageal injury include pleural effusions, pneumothorax, mediastinal air, and widening of the superior mediastinum. Normal radiographs do not reliably exclude injury. In one study, six of 17 patients with penetrating esophageal trauma had normal cervical and chest radiographs.[96]

Multiple studies show that esophageal contrast studies have a sensitivity of only 50%-90%.[24,96] Many centers begin with Gastrografin (since it causes less pleural irritation than barium should the contrast leak from a perforation) followed by the more sensitive barium study if the Gastrografin swallow is negative. If both swallowing studies are negative, perform esophagoscopy. Three small studies suggest flexible endoscopy alone may be adequate, each reporting a sensitivity of 100% and specificities of 83%-93%.[98-100] In another trial, rigid esophagoscopy demonstrated a higher diagnostic yield than flexible esophagoscopy.[101] However, flexible endoscopy is easier to perform, is less likely to cause injury, allows for evaluation of the stomach and duodenum, and does not require general anesthesia when compared to rigid endoscopy.[99,100] In a study by Horwitz et al (illustrated in **Table 6**), the combination of physical examination, barium swallow, and endoscopy missed no injuries.[100]

Two groups report surgical exploration of all patients with abnormal soft-tissue air without employing contrast studies or esophagoscopy, claiming low sensitivity of these tests.[75,76] They recommend esophageal contrast studies and endoscopy only in Zone I penetrating injuries if the wound approaches the mediastinum but not in Zone II and Zone III injuries due to overlying bony shadows and contractions of the pharyngeal muscles, which often make the studies technically inadequate. Others disagree with this aggressive operative strategy, pointing out that only 36% of patients with penetrating neck trauma and subcutaneous emphysema require an operation.[81]

Blunt Injury

Esophageal injury is exceedingly rare in patients with blunt neck trauma. In the world's literature, there are only 10 reported cases of esophageal injury due to blunt trauma.[21] Diagnostic investigation for these injuries is unnecessary unless clinical findings are present. The classic clinical findings include subcutaneous air and pain on swallowing; however, these presentations are not unique to blunt esophageal injury and are found more commonly with laryngotracheal injuries.

Strangulation Injury

Up to 10% of all violent deaths each year are due to strangulation. In many cases, physical findings are absent in non-fatal strangulation.[102] Strangulation injury may be defined as any mechanism that produces compression of

Table 6. Accuracy of independent diagnostic tests in esophageal injuries.

	Sensitivity*	Specificity	Accuracy
Physical examination	80%	64%	72%
Contrast study	89%	100%	94%
Endoscopy	89%	95%	94%

*Combination of all modalities missed no injuries

Source: Horwitz B, Krevsky B, Buckman RF Jr, et al. Endoscopic evaluation of penetrating esophageal injuries. *Am J Gastroenterol* 1993 Aug;88(8):1249-1253.

the neck. Proposed mechanisms include hanging, postural strangulation, ligature strangulation, and manual strangulation.[103] With hanging, the victim's body is either totally or partially suspended by a ligature. Transverse intimal tears at the bifurcation of common carotid artery are common in judicial hangings. Postural strangulation occurs when the victim's neck is stretched over an object and then compressed by the pressure of his own body. Ligature strangulation results when a ligature is pulled around the neck. Half of all victims of ligature strangulation have hyoid and laryngeal injuries. Manual strangulation is often associated with fracture of the larynx, hyoid bone, and thyroid cartilage. Autoerotic self-strangulation occurs when the victim (almost always a male) ties a ligature around his neck, masturbates, and then tightens the ligature to induce hypoxia near the moment of orgasm (presumably to increase sexual pleasure).[104] This technique is sometimes employed in conjunction with inhaled nitrates.

The supposed mechanism of death in strangulation victims is progressive cerebral ischemia and hypoxia caused by compression of blood vessels in the neck. Pressure on the neck obstructs venous circulation, causing stagnant hypoxia. The resulting loss of consciousness and decreased muscle tone in the neck allows for occlusion of the arterial circulation. Total blockage of the airway occurs later, when the full weight of the body creates enough pressure to occlude the trachea. Cervical spine injury is rare in patients who sustain near-strangulation or non-judicial hangings; in-hospital death or complications are usually due to non-cardiogenic pulmonary edema.[105,106]

As in the case of blunt neck trauma, strangulation patients are often "under-evaluated." The patient may be intoxicated or appear hysterical. Abused women may minimize events and symptoms to avoid police involvement that they fear could worsen the cycle of domestic violence. History provided by witnesses may be purposely inaccurate. Clinical findings such as hoarseness and conjunctival hemorrhage may be misinterpreted as benign illness.[102] Because hyperventilation may result from airway edema and aspiration pneumonia, anxiety must always be a diagnosis of exclusion in the ED.

Few formal algorithms exist for the evaluation of strangulation injury. A high index of suspicion is essential to avoid delayed morbidity and mortality. Clinical evaluation may include pulse oximetry, chest and neck radiographs, angiography, HCTA, MR, carotid Doppler ultrasound, pharyngoscopy, and fiberoptic laryngobronchoscopy as described for blunt neck injuries.[102] Admission or observation is prudent in survivors of hangings to monitor the development of non-cardiogenic pulmonary edema.

Pediatric Neck Trauma

Several anatomical differences between children and adults impact ED management. In children, the larynx is higher and better protected,[107] rendering it less susceptible to injury. Several studies suggest that the incidence of pediatric penetrating neck trauma is increasing, with mortality rates of up to 40%.[108-110] Gunshot wounds, glass and other types of stab wounds are responsible for the majority of penetrating injuries.

The evaluation and management of pediatric penetrating neck trauma parallels that of adults, with many of the same controversies. Indications for immediate operative intervention are identical to adults.[108] The debate over diagnostic testing in the asymptomatic patient takes on added importance. Some authors argue that the work-up itself may be dangerous in children because of the need for general anesthesia for endoscopy and the higher risk of iatrogenic injury with angiography.[108] They argue that in stable, asymptomatic pediatric patients, observation without invasive diagnostic testing is a reasonable course of action. After stabilization, transport pediatric victims of penetrating neck trauma to a Level I trauma center, preferably one with pediatric surgeons on call.

Although less common, significant blunt pediatric injuries are reported to be more devastating, have a longer hospital course, and more often require surgery than penetrating neck injuries.[15] Typical mechanisms in children include mini-bike clothesline injuries and bicycle handlebar injuries. Blunt neck injuries more commonly present with respiratory distress. If endotracheal intubation appears difficult or impossible, intubation over a fiberoptic bronchoscope or formal tracheostomy are the preferred methods of airway management.[15] Cricothyrotomy is contraindicated in patients less than 5-10 years old because of the potential for developing subglottic stenosis, although needle cricothyrotomy may be life-saving. Adverse outcomes are often related to delays in diagnosis.[15]

Pediatric strangulation injuries are likewise ruinous. Accidents involving car windows, window covering cords, cribs, high chairs, furniture, and clothing are common mechanisms in children under 5 years of age.[111,112] Accidental strangulation with rope and cords predominate in younger children, while teens may be at risk for autoerotic asphyxia or suicide, with an increasing male-to-female predominance with age.[112,113] The initial airway, pulmonary, and nervous system injury are often obvious, but delayed rises in intracranial pressure with "late herniations" have also been described.[114] The extent of initial injury and the effectiveness of ED resuscitation were the main factors of successful outcomes.[112]

"We rationalize, we dissimilate, we pretend:
we pretend that modern medicine is a rational science,
all facts, no nonsense, and just what it seems.
But we have only to tap its glossy veneer for it
to split wide open, and reveal to us its roots
and foundations, its old dark heart of metaphysics,
mysticism, magic, and myth."
—Oliver Sacks, in Awakenings,1987

Treatment

The definitive treatment of serious neck injuries is generally beyond the scope of this article and rests in the hands of surgical consultants. However, a brief discussion of management principles may be helpful to the emergency physician.

Airway Injuries

Treatment begins with early aggressive airway management. Perform oral endotracheal intubation for patients with suspected group 1 and 2 injuries as described in **Table 5** on page 11.[12] Cricothyrotomy is relatively contraindicated with significant laryngeal disruption. The utility of endotracheal intubation over a fiberoptic bronchoscope depends on availability, secretions and bleeding, and physician experience.[4] In severe injuries, perform tracheostomy under local anesthesia with the patient awake and breathing spontaneously (such a procedure is traditionally left to an experienced surgeon).[61] With tracheal transsection and other severe injuries, RSI may convert a partial airway obstruction to a complete airway obstruction if supporting muscle tone is lost with paralysis.

Nondisplaced fractures are generally treated nonoperatively, while displaced fractures require early surgical intervention. Administer antibiotics in the ED in case of suspected aero-digestive injuries.[115] Initial broad-spectrum antibiotics with anaerobic coverage include clindamycin 900 mg IV or ampicillin/sulbactam 3 g IV.[116]

Vascular Injuries

Penetrating Trauma

Not all carotid injuries require surgical intervention. Non-operative management of carotid injuries is indicated for clinically occult injuries, low-velocity injuries (such as stab wounds), less than 5 mm intimal defects, and less than 5 mm pseudoaneurysms. These patients must have intact distal circulation and be compliant with regular follow-up to detect progression of the injury.

Blunt Trauma

The management of vascular injuries in blunt trauma depends on the size of the lesions and the overall clinical picture. Options include observation, anticoagulation, antiplatelet agents, arterial reconstruction, endovascular stenting, and ligation.[117-119] While some data suggest that heparin improves outcome,[7] none of the treatments are very successful; there is still a high stroke and mortality rate with all of the therapeutic options.

A proposed grading and management scale is presented in **Table 7**.[120]

Digestive Tract Injuries

Penetrating Trauma

Surgical repair and drainage of deep neck spaces are indicated for cervical esophageal and lower hypopharyngeal injuries, and early repair can decrease complications.[25] Non-surgical management is recommended for injuries to the upper portion of the hypopharynx.

Blunt Trauma

Management of blunt esophageal injury is based on the size of the perforation. Antibiotics with anaerobic activity are indicated in all cases of suspected aero-digestive injury. Surgical therapy is recommended for esophageal or large (> 2 cm) pharyngeal perforations and medical therapy for small (< 2 cm) pharyngeal perforations.[121]

Strangulation Injuries

Treatment of these patients begins with aggressive respiratory management for symptomatic patients. These patients are at high risk for progressive edema

Table 7. Blunt carotid arterial injury grading scale with suggested treatment.

Injury grade	Description	Treatment
I	Luminal irregularity or dissection with < 25% luminal narrowing (non clinically significant narrowing)	Anti-platelet therapy vs. anticoagulation
II	Dissection or intramural hematoma with > 25% luminal narrowing, intraluminal thrombus, or raised intimal flap (potentially clinically significant)	Surgical repair if accessible Anticoagulation if surgically inaccessible
III	Pseudoaneurysm	Surgical repair if accessible Stenting if surgically inaccessible
IV	Occlusion	Surgical repair if accessible Anticoagulation if surgically inaccessible
V	Transsection with free extravasation (usually lethal injuries)	Surgical repair if accessible Balloon occlusion or embolization

Source: Biffl WL, Moore EE, Offner PJ et al: Blunt carotid arterial injuries: implications of a new grading scale. *J Trauma* 1999;47:845-853.

of the uvula, epiglottis, larynx, and vocal cords, pulmonary edema, pneumonia, and adult respiratory distress syndrome. Strangulation victims are also at risk for post-traumatic stress disorder and other behavioral and psychiatric problems. Measures to decrease intracranial pressure are indicated in cases of significant neurologic deterioration with impending herniation. Seizure prophylaxis and control may be helpful. Blunt vascular, laryngeal, and esophageal injuries are managed as described.

Disposition

Admission is indicated for all patients with penetrating neck trauma that violate the platysma and for patients with significant blunt trauma. Close observation of initially benign-appearing patients is required to detect delayed presentation of airway, vascular, digestive tract, and nervous system injury. Patients with significant mechanism, physical examination findings, or positive work-up must be followed in an intensive care unit with ready access to the operating room. Patients initially stabilized in hospitals without continuous monitoring and immediate surgical support should be transferred to a Level I trauma center. Focus on the airway of patients who require transfer, as they may lose it during transport. If in doubt, intubate.

If the platysma is intact, patients may be safely discharged in the absence of significant associated injury. Superficial neck injuries can be managed according to standard principles; repair clean wounds less than 12 hours old, but high-risk wounds (old and/or very dirty wounds) should be left open to heal by secondary intention. Administer tetanus toxoid as indicated.

Patients reporting strangulation should be admitted for observation, further evaluation, and coordination of police and social services to secure a safe environment. Victims with historical features or clinical findings of prolonged strangulation (attempted hangings, etc.) should either be admitted or observed for 6-8 hours since minimally symptomatic patients may develop delayed non-cardiogenic pulmonary edema and other sequelae.[102]

Summary

Penetrating and blunt neck injuries continue to challenge physicians caring for trauma victims. Understanding the fundamental principles of neck trauma is vital during the critical first hour. Airway management is crucial; when in doubt, early intubation usually means easier intubation. The specific approach is dictated by clinical presentation, and management often requires skill in multiple airway techniques.

Isolated injury to a single organ system is the exception. Concurrent injuries to the airway, vascular, and gastrointestinal tract demand an organized approach to initial evaluation and management.

The evaluation of injuries to Zone I and III is fairly straightforward and generally require vascular imaging studies. Management of Zone II injuries varies widely depending on the institution; some centers perform mandatory exploration, some mandatory testing, and others rely on selective testing driven by the history, physical, and plain films.

Angiography and carotid duplex scanning may be used together or independently to evaluate for vascular injury. Helical CT angiography may replace angiography as larger prospective studies determine its accuracy. CT scan is especially useful to evaluate laryngeal injury. Contrast studies and endoscopy may be used jointly to prevent the deadly consequences of esophageal perforation. Constant adherence to the ABCs and maintaining a high index of suspicion for airway, vascular, and gastrointestinal injury will help the emergency physician provide effective care for adult and pediatric victims of neck trauma. ▲

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Evidence-based medicine requires a critical appraisal of the literature based upon study methodology and number of subjects. Not all references are equally robust. The findings of a large, prospective, randomized, and blinded trial should carry more weight than a case report.

To help the reader judge the strength of each reference, pertinent information about the study, such as the type of study and the number of patients in the study, will be included in bold type following the reference, where available. In addition, the most informative references cited in the paper, as determined by the authors, will be noted by an asterisk (*) next to the number of the reference.

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Physician CME Questions

1. Most injuries to the neck:
- a. are in Zone I.
- b. are in Zone II.
- c. are in Zone III.
- d. are blunt carotid injuries.

2. Wounds that penetrate the platysma:
- a. always require surgical consultation.
- b. only require surgical consultation in cases of high-velocity injuries.
- c. only require surgical consultation if the emergency physician has trouble probing past the platysma.
- d. only require surgical consultation if the emergency physician is unable to clamp off the bleeding vessels.

3. Horner's syndrome is defined as small pupil, droopy lid, and lack of ability to sweat on the side of the face ipsilateral to the carotid injury.
- a. True
- b. False

4. Esophageal injuries:
- a. are the least common but are the most frequently missed injuries in penetrating neck trauma.
- b. are difficult to diagnose because of their low incidence and lack of sensitive and specific clinical signs.
- c. may often be masked by other injuries.
- d. must be diagnosed early, because delayed operative repair results in high morbidity and mortality due to early contamination of the paraesophageal space.
- e. all of the above.

5. In which of the following circumstances is early intubation of the patient with neck trauma suggested?
- a. Patients with acute respiratory distress or airway compromise from blood or secretions
- b. Patients with gunshot wounds
- c. Symptomatic patients who are likely to be out of the ED for a prolonged time for diagnostic studies
- d. None of the above
- e. All of the above

6. Neck pain and tenderness, resistance to passive motion of the neck, subcutaneous emphysema, dysphagia, and bleeding from mouth or nasogastric tube most likely suggest:
- a. pneumothorax.
- b. blunt vascular injury.
- c. air embolism.
- d. esophageal injuries.

7. To control bleeding in patients with neck trauma, emergency physicians should use direct pressure. Clamping of vessels should only be performed by a trauma surgeon.
- a. True
- b. False

8. Which of the following is *not* a possible sign of airway injury in patients with neck trauma?
- a. Voice changes
- b. Subcutaneous emphysema
- c. Diplopia
- d. Hemoptysis
- e. Bubbling wound

9. The location and extent of laryngeal fractures is most accurately identified by:
- a. clinical examination.
- b. laryngoscopy.
- c. CT scanning.
- d. neck radiographs.

10. In stable patients with penetrating neck injuries in Zone I, the best study to exclude injury to intrathoracic vessels is:
- a. angiography.
- b. MRI.
- c. CT scanning.
- d. carotid duplex scanning.

11. Which of the following most reliably excludes carotid or vertebral artery injury in blunt trauma?
- a. No external signs of neck trauma
- b. Absence of neurologic deficits
- c. Absence of neck hematoma
- d. Angiography

12. Which of the following is least likely to be associated with esophageal injury?
- a. Pain on swallowing
- b. Diplopia
- c. Subcutaneous emphysema
- d. Hemoptysis on coughing

13. Patients with penetrating neck trauma in whom the platysma is intact:
- a. should be admitted to the intensive care unit.
- b. should be admitted for observation.
- c. should be transferred to a Level I trauma center.
- d. may be safely discharged in the absence of significant associated injury.

14. Which of the following is/are indication(s) for immediate exploration of vascular injuries?
- a. Shock
- b. Pulse deficit
- c. A rapidly expanding hematoma
- d. All of the above

15. **Objects that are causing penetrating neck wounds should be removed by the emergency physician in the ED once the airway has been established.**
    a. True
    b. False

16. **Which of the following can cost-effectively help determine the need for further testing in a patient with neck trauma?**
    a. Having the patient cough to determine if he or she has hemoptysis
    b. Having the patient swallow to check for dysphagia
    c. Listening to the patient speak to assess laryngeal function
    d. Auscultating the patient's carotid arteries for bruits
    e. All of the above

Class Of Evidence Definitions

Each action in the clinical pathways section of *Emergency Medicine Practice* receives an alpha-numerical score based on the following definitions.

Class I
- Always acceptable, safe
- Definitely useful
- Proven in both efficacy and effectiveness

Level of Evidence:
- One or more large prospective studies are present (with rare exceptions)
- High-quality meta-analyses
- Study results consistently positive and compelling

Class II
- Safe, acceptable
- Probably useful

Level of Evidence:
- Generally higher levels of evidence
- Non-randomized or retrospective studies: historic, cohort, or case-control studies
- Less robust RCTs
- Results consistently positive

Class III
- May be acceptable
- Possibly useful
- Considered optional or alternative treatments

Level of Evidence:
- Generally lower or intermediate levels of evidence
- Case series, animal studies, consensus panels
- Occasionally positive results

Indeterminate
- Continuing area of research
- No recommendations until further research

Level of Evidence:
- Evidence not available
- Higher studies in progress
- Results inconsistent, contradictory
- Results not compelling

Significantly modified from: The Emergency Cardiovascular Care Committees of the American Heart Association and representatives from the resuscitation councils of ILCOR: How to Develop Evidence-Based Guidelines for Emergency Cardiac Care: Quality of Evidence and Classes of Recommendations; also: Anonymous. Guidelines for cardiopulmonary resuscitation and emergency cardiac care. Emergency Cardiac Care Committee and Subcommittees, American Heart Association. Part IX. Ensuring effectiveness of community-wide emergency cardiac care. *JAMA* 1992;268(16):2289-2295.

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