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Acute Neck Trauma in Emergency Medicine: Evidence-Based Assessment, Airway Protection, and Cervical Spine Management

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Abstract

Background: Neck trauma is a high-risk emergency presentation due to the concentration of vital vascular, aerodigestive, and neurologic structures within a confined anatomical space. Even minor external injuries can conceal life-threatening internal damage, making timely diagnosis and intervention critical.

Aim: To review evidence-based strategies for assessment, airway protection, and cervical spine management in acute neck trauma, emphasizing zone-based anatomy and mechanism-specific considerations.

Methods: A comprehensive literature synthesis was conducted, integrating current guidelines, epidemiologic data, and clinical decision frameworks such as ATLS principles and NEXUS criteria. The review addresses diagnostic imaging modalities, physical examination priorities, and multidisciplinary management pathways.

Results: Neck trauma accounts for 5–10% of trauma cases but carries disproportionate morbidity and mortality. Zone I injuries exhibit the highest lethality due to great vessel involvement and limited surgical access, while Zone II injuries are most common and more accessible for operative intervention. Computed tomography angiography (CTA) has emerged as the preferred initial imaging modality for vascular assessment. Airway compromise remains the foremost threat, often evolving rapidly; early airway control and hemorrhage management are essential. Selective rather than mandatory surgical exploration is increasingly favored, guided by hard and soft signs, imaging, and hemodynamic stability.

Conclusion: Optimal outcomes require early airway protection, vigilant reassessment, and multidisciplinary coordination. Advances in imaging and selective intervention strategies have improved safety, but delayed recognition of esophageal or vascular injury remains a major cause of morbidity and mortality.

Keywords: Neck trauma, emergency medicine, airway management, cervical spine, penetrating injury, blunt trauma, CTA, zone classification

Introduction

The evaluation and management of neck trauma in the emergency setting is frequently complex, owing to the high density of critical anatomical structures contained within a relatively small and poorly protected region. The neck functions as a conduit for essential vascular, aerodigestive, and neurologic pathways, and traumatic injury may compromise the airway, precipitate life-threatening hemorrhage, or produce occult neurologic deficits with minimal external signs. Consequently, even seemingly minor injuries can conceal significant underlying damage, creating diagnostic uncertainty and elevating the risk of rapid

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clinical deterioration if key injuries are missed or treatment is delayed. These realities make neck trauma a high-stakes presentation that demands prompt prioritization, structured assessment, and coordinated multidisciplinary response. From an emergency medicine perspective, neck trauma presents a distinctive diagnostic and therapeutic dilemma because injuries may involve multiple systems simultaneously while initial clinical findings remain subtle or misleading. Airway compromise can develop progressively due to hematoma expansion, soft tissue edema, laryngeal disruption, or aspiration of blood, requiring vigilant reassessment and early airway planning. Vascular injuries, including those affecting the carotid and vertebral arteries or major venous structures, may manifest with shock, expanding cervical swelling, or delayed neurologic sequelae such as ischemic stroke, underscoring the need for timely recognition and appropriate imaging strategies. In parallel, aerodigestive tract injuries to the pharynx, larynx, trachea, or esophagus may be difficult to detect on initial examination yet carry substantial morbidity when diagnosis is missed. The proximity of the cervical spine and spinal cord further complicates decision-making, as immobilization, imaging, and airway interventions must be integrated to minimize secondary injury. Collectively, these factors explain why neck trauma is widely regarded as one of the most challenging presentations in the emergency department and why a systematic, evidence-informed approach is essential to optimize outcomes.[1][2][3]

Neck Anatomy

For descriptive clarity and to support decision-making in acute care, the neck is commonly conceptualized using an anatomic “zone” framework, particularly in the context of penetrating trauma. This zonal classification is not merely academic; it has practical diagnostic and management implications because the distribution of vital structures differs by region, the likelihood of particular injuries varies accordingly, and the feasibility of physical examination, imaging, and surgical exposure is not uniform across the neck. For these reasons, when traumatic injuries are described using zone terminology, communication among emergency clinicians, radiologists, anesthesiologists, and surgeons becomes more precise, and management pathways can be more effectively aligned. A detailed understanding of cervical anatomy—especially the location and relationships of vascular, aerodigestive, and neurologic structures—is therefore essential to optimize the evaluation and treatment of neck trauma. Zone I is defined as the region extending from the clavicles to the cricoid cartilage. Clinically, this area is high risk because it contains major vascular conduits and critical thoracic inlet structures, including the innominate vessels, the proximal common carotid artery origins, the subclavian vessels, and the vertebral artery. It also encompasses elements of the brachial plexus, as well as key aerodigestive components such as the trachea and esophagus, and may involve adjacent structures including the lung apex and the thoracic duct. Management of injuries in Zone I is often challenging because surgical access is limited by the clavicles and the bony anatomy of the thoracic inlet; as a result, definitive exploration may require more extensive exposure strategies and careful coordination with imaging and specialty services [2][3][4].

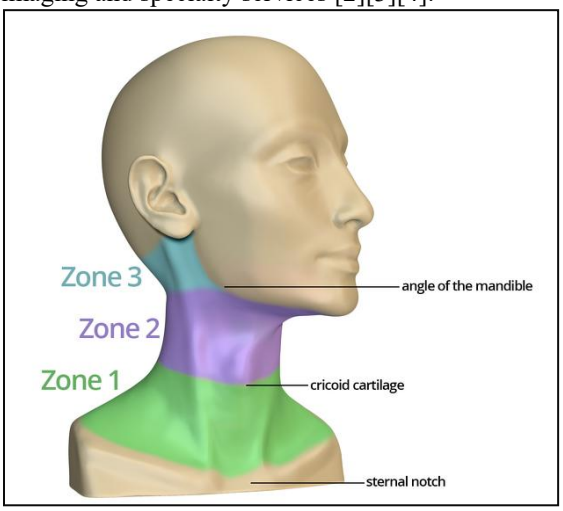

Fig. 1: Neck anatomy zones.

Zone II extends from the cricoid cartilage to the angle of the mandible and contains many of the structures most frequently threatened in cervical trauma, including the carotid and vertebral arteries, the internal jugular veins, and the trachea and esophagus. This zone is typically the most accessible for bedside inspection, palpation, and operative exploration, which historically contributed to more aggressive surgical approaches in penetrating injuries. It is also the largest cervical zone and is commonly involved in traumatic mechanisms, making it a frequent focus of emergency evaluation and surgical consultation. Zone III spans from the angle of the mandible to the base of the skull. It includes the distal segments of the carotid and vertebral arteries and portions of the pharynx. Because of its proximity to the skull base, Zone III is relatively difficult to assess through physical examination alone and can be technically challenging to explore surgically. These constraints increase reliance on advanced imaging and specialized procedural approaches when significant injury is suspected. In addition to zonal classification, the neck is often described using anatomic triangles, an approach that supports both examination and procedural planning. The sternocleidomastoid muscle divides the neck into anterior and posterior triangles. The anterior triangle contains many of the major cervical structures, including the larynx, trachea, pharynx, esophagus, and principal vascular elements. The posterior triangle, in contrast, is dominated by muscular compartments and contains the spinal

accessory nerve as well as structures associated with the spinal column, features that carry specific implications for neurologic injury patterns and functional morbidity [3][4].

Etiology

Neck trauma arises through several principal mechanisms, each associated with distinctive patterns of injury and specific diagnostic priorities in emergency care. Broadly, three major mechanisms are commonly described: blunt trauma, penetrating trauma, and near-hanging or strangulation. Although these categories are conceptually straightforward, their clinical importance lies in the fact that the same external mechanism can produce injuries to vascular, aerodigestive, neurologic, and musculoskeletal structures, sometimes with minimal early physical findings. Accordingly, etiologic classification should immediately prompt mechanism-specific vigilance for occult injury and guide the selection of imaging, observation, and specialist consultation. Blunt neck trauma is frequently encountered in motor vehicle collisions, sports-related impacts, falls, and other high-energy mechanisms. In this setting, injury may result from direct compression, rapid deceleration, or shearing forces transmitted through the soft tissues of the anterior neck. A key clinical concern is that blunt trauma can produce delayed or evolving pathology, particularly involving the larynx, major cervical vessels, and the upper digestive tract. Laryngeal injury may initially manifest as mild hoarseness or discomfort yet progress due to edema or hematoma formation, potentially leading to airway compromise hours after the inciting event. Vascular injury, including intimal disruption, dissection, or pseudoaneurysm, may likewise be occult initially and present later with neurologic deficits or expanding cervical swelling. Digestive tract injuries to the pharynx or esophagus may be subtle early and may only become clinically apparent with pain, dysphagia, subcutaneous emphysema, or infectious complications. Importantly, clinicians must maintain a high index of suspicion for occult cervical spine injury in patients with blunt neck trauma, as associated spinal fractures or ligamentous injuries may coexist even when neck pain is not prominent. In addition, restraint systems, particularly shoulder harness seatbelts, can generate focused anterior neck forces during sudden deceleration and may contribute to shearing injuries and soft-tissue trauma [4].

Penetrating neck trauma constitutes a smaller but clinically significant proportion of overall trauma presentations, accounting for approximately 5% to 10% of trauma injuries. Typical mechanisms include gunshot wounds and stab wounds. In clinical terms, violation of the platysma muscle is the defining threshold for a penetrating neck injury, because penetration through this layer indicates potential entry into deeper fascial planes where vital structures reside. Once the platysma is breached, there is meaningful risk of injury to the carotid and vertebral arteries, jugular veins, airway, and esophagus, even if the external wound appears small. Stab wounds generally represent lower-energy penetration and may produce more localized injury trajectories than firearm-related trauma, yet they still require careful evaluation due to the density of critical structures within the cervical region. Near-hanging or strangulation represents a distinct etiologic mechanism characterized by external compressive force applied to the neck. The primary pathophysiologic threat is cerebral hypoxia resulting from venous outflow obstruction and, in more severe cases, arterial inflow compromise. Associated injuries may include airway edema, laryngeal trauma, vascular injury such as carotid dissection, and neurologic sequelae related to hypoxic insult. Because clinical deterioration can occur after an initially stable presentation, careful monitoring and a structured evaluation strategy are essential. From an anatomic perspective, Zone II is the most commonly injured region and is generally more accessible for examination and surgical intervention. By contrast, injuries involving Zones I and III pose greater challenges because exposure and vascular control are more difficult to achieve, increasing the complexity of definitive management and often necessitating advanced imaging and multidisciplinary coordination.[4]

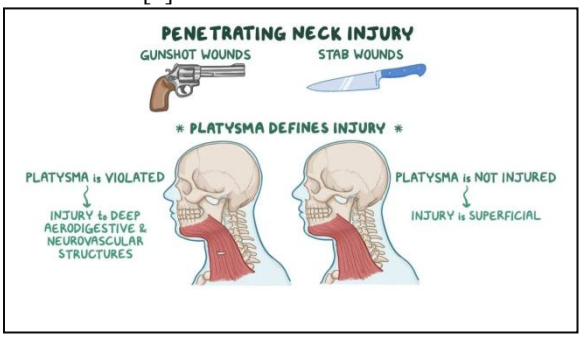

Fig. 2: Neck Trauma.

Epidemiology

Neck trauma represents a relatively small proportion of overall traumatic injuries, yet it carries disproportionate morbidity and mortality because of the concentration of major vascular structures and the aerodigestive tract within a confined anatomical space. Penetrating neck trauma is particularly high risk, with reported mortality rates reaching approximately 10%, a figure that underscores how rapidly these injuries can become fatal when critical structures are compromised. The dominant mechanism of death in penetrating neck injury is vascular trauma, reflecting the potential for exsanguination from injury to the carotid arteries, vertebral arteries, jugular veins, or other major cervical vessels. Anatomically, injuries at the base of the neck—corresponding to Zone I—are frequently emphasized as carrying the greatest risk, as this

region contains large-caliber vessels at the thoracic inlet and poses technical challenges for surgical exposure and vascular control. The combination of high vascular density and limited access contributes to the severity profile of Zone I wounds and helps explain why these injuries are overrepresented among fatal outcomes. In addition to immediate hemorrhagic death, delayed mortality remains a critical epidemiologic and clinical concern in penetrating neck trauma. Esophageal injuries are repeatedly identified as a leading cause of delayed death, largely because they may be subtle or clinically silent at first assessment and can be missed during initial triage. When diagnosis is delayed, leakage of esophageal contents can lead to deep neck infection, mediastinitis, sepsis, and subsequent mortality. This epidemiologic pattern has practical implications: even when initial hemodynamic status is stable and external wounds appear limited, clinicians must maintain a high index of suspicion for occult aerodigestive tract injury, particularly when symptoms evolve over time or when imaging and endoscopic evaluation have not definitively excluded esophageal disruption [3][4][5]. Mechanism-specific data further illustrate the epidemiologic gradient of risk across penetrating injury types. Firearm-related trauma is associated with particularly severe injury patterns due to higher-energy transfer, complex wound tracts, and the potential for multiple structures to be affected simultaneously. It has been reported that up to 50% of gunshot wounds are accompanied by significant associated injuries, and these presentations carry an estimated mortality rate in the range of 10% to 15%. By contrast, stab wounds, which typically involve lower-energy penetration, still produce serious injury in a substantial subset of cases—approximately 20% to 30%—but are associated with a lower overall mortality, reported at about 5%. Across these mechanisms, delayed mortality continues to be driven most commonly by occult esophageal injury, reinforcing the principle that epidemiologic risk is shaped not only by immediate vascular catastrophe but also by the potential for missed aerodigestive tract injury at initial presentation.[5][6]

Pathophysiology

The pathophysiology of neck trauma is determined primarily by the mechanism of injury, the trajectory or direction of force, and the specific anatomical compartment involved. The neck is a uniquely vulnerable region because it contains multiple critical organ systems—vascular conduits, the aerodigestive tract, major neural structures, and the cervical spine—arranged in close proximity with limited protective skeletal coverage. As a result, injuries that appear superficially minor may conceal significant damage to deep structures, producing either immediate life-threatening compromise or delayed deterioration through progressive edema, hematoma expansion, infection, or evolving vascular injury. This anatomic density explains why emergency clinicians must approach cervical trauma with a high index of suspicion even when external findings are subtle. In penetrating injuries, the risk is amplified because the wounding object may traverse multiple compartments; accordingly, clinically meaningful cervical injury often does not occur in isolation and may be accompanied by neurologic deficits or other system involvement. Indeed, penetrating neck trauma frequently involves structures whose compromise can yield neurologic manifestations, and it is uncommon for substantial penetrating injury to be entirely devoid of neurologic implications, whether through direct neural injury or secondary ischemic mechanisms.[7] In blunt trauma, energy transfer may produce compressive, shearing, or distraction forces that affect the larynx, trachea, esophagus, cervical vessels, and cervical spine. The pathophysiologic consequences often evolve over time. Laryngotracheal injury may begin with mucosal disruption or cartilaginous fracture and progress to airway compromise as soft tissue swelling and hematoma develop. Vascular injury may occur through intimal disruption or dissection of the carotid or vertebral arteries, with delayed thromboembolic phenomena culminating in neurologic deficits hours to days later. Similarly, pharyngeal or esophageal injury can be clinically silent early and later present with deep neck infection or mediastinitis after leakage of contents into fascial planes. In this context, the clinician's task is not merely to identify immediate threats but to anticipate delayed pathophysiologic processes that may emerge after an initially stable presentation [7].

Because cervical spine injury carries catastrophic potential, evaluation of neurologic risk and the need for imaging is central to the early management of neck trauma, especially in blunt mechanisms. Clinical decision instruments such as the National Emergency X-radiography Utilization Study I (NEXUS I) criteria are used to identify patients at low risk for cervical spine injury, in whom clinically significant spinal cord injury is unlikely. Under NEXUS I, a low-risk profile is present only when the patient is alert and awake, not intoxicated, demonstrates no signs or symptoms of neurologic injury, and has no midline spinous process tenderness. When these conditions are met, the probability of significant cervical spine injury is reduced, enabling more selective imaging strategies while maintaining patient safety. Conversely, failure to satisfy these criteria implies increased risk and necessitates a more conservative approach, including immobilization and appropriate imaging, because occult fractures or ligamentous injuries may exist even in the absence of dramatic symptoms. For penetrating neck trauma, the zone-based anatomical concept helps contextualize pathophysiologic risk. Zone I, spanning the thoracic inlet, is particularly dangerous and is frequently associated with high

lethality because of its concentration of major vessels and the technical challenges of achieving rapid surgical exposure and vascular control. Injuries in this region place the great vessels at risk and may extend into the mediastinum, while also threatening the cervical and upper thoracic esophagus. The potential for rapid exsanguination and the complexity of definitive control contribute to the high mortality associated with Zone I injuries. Across penetrating neck trauma as a whole, vascular injuries are the most common major injury type and have been reported in up to 40% of patients, reflecting the vulnerability of the carotid and vertebral arterial systems and the jugular venous structures to penetrating mechanisms. Because vascular injury can lead to immediate hemorrhagic shock or delayed cerebral ischemia, early recognition of vascular compromise is critical [7].

The clinical pathophysiology of vascular injury is often inferred through "hard signs," which indicate a high likelihood of serious vascular disruption and typically necessitate urgent intervention. These findings include a rapidly expanding or pulsatile hematoma, severe hemorrhage or bleeding that is difficult to control, and shock that remains refractory despite fluid resuscitation, all of which suggest ongoing major blood loss. Decreased or absent peripheral pulses may indicate arterial disruption or occlusion, while the presence of a vascular bruit or palpable thrill implies turbulent flow from arteriovenous fistula or partial arterial injury. Neurologic deficits detected on examination, particularly those consistent with focal cerebral ischemia, can reflect compromised carotid or vertebral flow due to dissection, thrombosis, embolization, or direct arterial injury. In combination, these manifestations reflect distinct pathophysiologic pathways—hemorrhage, hypoperfusion, and ischemia—that can coexist and evolve rapidly, making them high-priority targets in emergency assessment. Aerodigestive tract injuries produce a different pathophysiologic profile. Esophageal disruption is especially concerning because its early clinical signs may be minimal despite the potential for severe delayed complications. Leakage of saliva, gastric contents, and bacterial flora into cervical fascial planes can precipitate deep neck infection, abscess formation, and mediastinitis, leading to sepsis and death if not recognized early. "Hard" clinical features that raise concern for significant aerodigestive injury include massive hemoptysis, significant hematemesis, and respiratory distress, findings that may indicate disruption of the airway or upper gastrointestinal tract with associated bleeding and compromised ventilation. However, the absence of these dramatic signs does not exclude injury. "Soft signs" of penetrating neck trauma—such as minor hemoptysis or hematemesis, dysphonia, dysphagia, subcutaneous or mediastinal emphysema, and non-expanding hematoma—may reflect less extensive but still clinically significant injury to the larynx, trachea, pharynx, or esophagus. These findings derive from pathophysiologic processes including mucosal tearing, air leakage into tissue planes, and localized bleeding that does not immediately threaten airway patency or hemodynamic stability but may progress [6][7].

Penetrating trauma involving Zones I and III warrants special caution because these regions carry increased risk for occult vascular injury. The anatomic constraints in these zones can limit direct examination and complicate definitive exposure, and injuries may also coexist with significant trauma to adjacent regions, including the head, chest, or abdomen. Such concurrent injuries can confound clinical interpretation, distract from cervical threats, or worsen physiologic instability. In this setting, clinicians must integrate a high index of suspicion with structured evaluation, recognizing that the absence of external dramatic findings does not preclude serious internal injury. Airway injury remains a critical pathophysiologic concern across mechanisms. Signs such as dyspnea, stridor, hoarseness, dysphonia, hemoptysis, and subcutaneous emphysema suggest compromise of the laryngotracheal framework or mucosa. Air leakage into soft tissues reflects disruption of airway integrity, while progressive edema or hematoma can produce delayed airway obstruction. Because the trajectory from mild symptoms to critical obstruction can be rapid, airway assessment must be iterative rather than static, and management planning must anticipate the possibility of deterioration. Esophageal injuries add an additional layer of risk because they may not be apparent on initial evaluation and may escape detection even when early imaging appears unremarkable. Importantly, normal radiographs do not exclude esophageal injury, emphasizing that reliance on plain films alone is insufficient when clinical suspicion remains. The pathophysiologic basis for this limitation is that small perforations may not generate immediate or visible air collections, and early signs may be absent until inflammatory and infectious sequelae develop. Consequently, the pathophysiology of neck trauma demands a vigilant approach that accounts for immediate hemorrhagic and airway threats while also anticipating delayed vascular and aerodigestive complications that can emerge after the initial emergency assessment [7].

History and Physical

The assessment of neck trauma in the emergency setting depends on rapid stabilization coupled with a meticulous and structured evaluation, in which the physical examination is often the most decisive component. Although imaging and specialist consultation may ultimately be required, the initial bedside assessment guides the urgency of airway intervention, the likelihood of major vascular or

aerodigestive injury, and the prioritization of diagnostic pathways. Equally important is the acquisition of accurate information regarding the mechanism of injury, because mechanism frequently predicts both the pattern and the tempo of deterioration. A high-quality history is therefore not ancillary to the examination but an essential element of risk stratification, particularly given that cervical injuries may be occult and that clinical signs can evolve over time. History taking should be organized around clear mechanistic descriptors. Establishing the timing of injury is critical, because the risk of delayed airway compromise, evolving hematoma, and progressive edema increases with time, and because therapies such as airway management, hemostasis, and antimicrobial coverage may be time sensitive. Clarifying the location of injury and the number of wound sites is equally important, especially in penetrating trauma where entry and potential exit wounds may suggest trajectory and the likelihood that critical structures have been traversed. Documentation should include proximity to recognized high-risk anatomy, including the carotid sheath, the suprasternal notch, and the mandibular angle, as well as whether the injury involves zones that are more difficult to examine and control surgically. The “how” of the injury—specifically the wounding agent or mechanism, such as knife, firearm, blunt impact from a motor vehicle collision, or compressive force in strangulation—must be elicited because energy transfer and trajectory differ markedly and influence the probability of vascular disruption, airway injury, esophageal perforation, and cervical spine trauma. Contextual details surrounding the event can be obtained from emergency medical services documentation and, when applicable, law enforcement reports, which may clarify the weapon type, distance, number of shots, observed bleeding, prehospital airway status, and any initial neurologic findings. Finally, a review of relevant comorbidities and medications is essential, as conditions such as anticoagulant use, bleeding disorders, vascular disease, or prior neck surgery may alter bleeding risk, complicate airway management, and influence diagnostic and therapeutic decisions [7][8].

A central principle in neck trauma evaluation is that cervical injuries are often not isolated, particularly in blunt mechanisms where energy transfer frequently produces multisystem trauma. Accordingly, clinicians should deliberately assess for associated injuries, including head trauma, thoracic injury, and abdominal injury, while maintaining cervical spine precautions as indicated. Even in penetrating mechanisms, the possibility of contiguous injury to the chest or face must be considered, and the overall examination should be framed within a trauma-systems approach rather than a narrowly localized inspection. The physical examination should begin with immediate appraisal for hemorrhage and airway compromise. The neck should be inspected for active bleeding, expanding hematoma, ecchymosis, edema, and any visible distortion of normal anatomy. Particular attention should be paid to asymmetry, tracheal deviation, and swelling that may threaten the airway or indicate deep tissue injury. Palpation should assess tenderness, stability of laryngeal structures when relevant, and the presence of subcutaneous emphysema. Crepitus is a critical finding because it suggests air tracking into the soft tissue planes and should prompt urgent evaluation for injury to the trachea, larynx, esophagus, or pulmonary tree. The wound itself should be examined carefully to characterize size, depth, and orientation, while recognizing that superficial appearance may be misleading. In penetrating trauma, determining whether the platysma has been violated is a pivotal step in distinguishing superficial wounds from those with potential to involve deeper vital structures. However, wounds should not be probed blindly, as indiscriminate exploration may dislodge clots, precipitate uncontrolled hemorrhage, or worsen tissue disruption. When detailed evaluation is required beyond visual inspection and gentle palpation, it should be undertaken in controlled settings with appropriate preparation for hemorrhage control and airway intervention [7][8].

Auscultation provides additional bedside clues. Carotid bruits may suggest vascular injury with turbulent flow, while stridor may indicate upper airway narrowing due to laryngeal trauma, edema, or hematoma. The examiner should also look for bubbling or air emanating from a wound, which can imply a tracheal injury and represents a high-risk sign for airway compromise and aspiration. Because symptoms and signs may be delayed—particularly with evolving edema, contained vascular injury, or occult esophageal perforation—documentation of baseline findings and repeated reassessment are essential components of the physical examination strategy. Finally, a complete neurologic examination is mandatory. Assessment should include mental status, cranial nerve function when feasible, motor and sensory testing, and evaluation for focal deficits that might reflect cerebral ischemia from carotid or vertebral artery injury or spinal cord involvement from cervical spine trauma. The integration of careful mechanistic history, systematic examination of the neck, deliberate search for associated injuries, and comprehensive neurologic assessment establishes the foundation for safe triage, appropriate imaging, timely consultation, and effective early management in patients with suspected neck trauma [7][8].

Evaluation

The evaluation of neck trauma in the emergency department should begin with early activation of appropriate resources, including notification of a trauma team and/or surgical services when available, given the potential for rapid deterioration and the frequent need for

multidisciplinary intervention. Although bedside assessment is indispensable for identifying immediate threats, physical examination alone is not sufficiently reliable to exclude clinically significant vascular or aerodigestive injury, particularly when wounds are small, swelling is evolving, or injuries are located in anatomically complex regions such as Zones I and III. For this reason, clinicians should maintain a low threshold for advanced imaging and specialist consultation, especially in patients with penetrating mechanisms, suggestive examination features, or concerning symptom evolution. Equally important is the recognition that injury patterns may be occult at presentation and that deterioration can occur over time; therefore, serial examinations are required to detect changes in airway status, expanding hematoma, emerging neurologic deficits, or progressive respiratory compromise. A thorough secondary survey is also essential, as cervical trauma is frequently accompanied by additional injuries, and failure to identify concomitant thoracic, cranial, or abdominal trauma can adversely affect outcomes. Diagnostic testing is most often performed in hemodynamically stable patients who demonstrate "soft signs" of injury and, in selected circumstances, even in patients who appear initially asymptomatic, reflecting the limitations of early clinical assessment and the potential for delayed presentation.[8][9]

Plain radiography remains a useful early adjunct in many trauma systems. In patients with significant neck trauma, anterior and lateral radiographs of the neck and chest can provide rapid, accessible screening information and may reveal indirect evidence of serious injury. Clinicians should specifically evaluate for hemothorax, pneumothorax, and pneumomediastinum, findings that may indicate vascular injury, airway disruption, or esophageal perforation with air tracking into mediastinal spaces. Although plain films lack the sensitivity of modern cross-sectional imaging, they can assist in early triage and prompt timely escalation of care, particularly in patients with Zone I injury where thoracic inlet structures are at risk and thoracic complications may coexist. Computed tomography angiography (CTA) has become the preferred initial vascular imaging modality in many emergency settings because it offers rapid, high-resolution assessment with broad anatomic coverage and is less invasive than catheter-based angiography. CTA is used to evaluate suspected vascular injury and may simultaneously provide information regarding adjacent structures, including airway integrity, soft tissue emphysema, hematoma extent, and potential trajectory of a projectile in firearm-related trauma. This dual capacity to characterize both vascular and nonvascular anatomy contributes to its central role in contemporary evaluation pathways, particularly in stable patients with penetrating mechanisms or soft signs suggestive of vascular compromise. Conventional catheter angiography remains the reference standard for detailed vascular assessment in neck trauma. Four-vessel angiography with venous-phase imaging is reported to have sensitivity greater than 99% and has historically been regarded as the "gold standard" for identifying vascular injury. When employed, a complete study should include the carotid and vertebral systems, with additional emphasis tailored to injury location: in Zone III trauma, imaging should incorporate the intracranial segments of the carotid arteries, whereas Zone I injuries warrant evaluation of the aortic arch and its major branches given the proximity of the thoracic inlet vasculature. While catheter angiography is highly accurate and can facilitate endovascular intervention when indicated, its invasive nature and resource intensity have contributed to increased reliance on CTA as the initial diagnostic study in many institutions [8][9].

Duplex ultrasonography may be considered in stable patients as a noninvasive and relatively low-cost vascular assessment tool. However, its diagnostic performance is operator dependent, and limitations are particularly relevant in trauma settings where subtle non-occlusive injuries may be missed. Intimal flaps and small pseudoaneurysms can be difficult to detect when luminal flow is preserved, and acoustic windows may be constrained by patient habitus, subcutaneous emphysema, dressings, or overlying hematoma. Its utility in Zone III evaluation is also limited, given the anatomic depth and proximity to the skull base, which can reduce accessibility and image quality. Accordingly, duplex ultrasonography is typically viewed as an adjunct rather than a definitive study in suspected significant vascular injury. Evaluation for aerodigestive injury must proceed with similar rigor. When esophageal perforation is suspected—based on symptoms, mechanism, soft tissue emphysema, hematemesis, dysphagia, or concerning trajectory—esophagography is recommended to assess esophageal integrity. Because esophageal injuries may be clinically silent early yet carry a high risk of severe delayed morbidity, timely diagnostic testing is critical when suspicion exists, and negative early bedside findings should not be used to prematurely exclude esophageal disruption. In practice, the overall evaluation strategy in neck trauma is therefore defined by early team activation, repeated clinical reassessment, and judicious use of imaging modalities to compensate for the limited sensitivity of physical examination and to safely identify injuries that demand urgent intervention.[8][9]

Treatment / Management

The management of neck trauma is inherently time sensitive because the cervical region contains structures whose compromise can precipitate rapid death from airway obstruction, exsanguination, or neurologic catastrophe. Accordingly, prompt evaluation and decisive early intervention are

required, and the initial approach should follow Advanced Trauma Life Support (ATLS) principles to ensure that immediately reversible threats are addressed in the correct sequence. Early consultation with trauma surgery is essential, and urgent involvement of a trauma service—or the most appropriate surgical team available—should be obtained whenever vascular, tracheal, or esophageal injury is suspected.[10][11][12] This early escalation is not merely procedural; it reflects the reality that definitive management of major cervical vascular injury, aerodigestive disruption, and complex zone-based trauma frequently exceeds the scope of isolated emergency department interventions and requires coordinated operative or endovascular capability. Initial priorities mirror those used in any life-threatening emergency: secure the airway, maintain ventilation, control hemorrhage, and treat shock while continuously reassessing physiologic stability. At the same time, clinicians must recognize that patients with neck trauma often sustain additional injuries, particularly in high-energy mechanisms, and those associated injuries may take precedence or complicate airway and hemodynamic management. Rapid vital-sign assessment and repeated reassessment are therefore integral to early management, and deterioration should be anticipated rather than reacted to, especially when cervical swelling, hematoma formation, or expanding soft tissue injury is present. Airway management is the foremost priority, particularly because progressive airway compromise can occur abruptly even in patients who initially appear stable. In penetrating neck trauma, up to 10% of patients may present with airway compromise, and the risk of rapid deterioration remains significant despite a reassuring early appearance. Airway stabilization should be performed while maintaining cervical spine precautions when there is concern for spinal injury, using in-line stabilization during airway manipulation to minimize secondary neurologic injury. Clinicians must remain vigilant for signs of impending obstruction such as hoarseness, stridor, increasing work of breathing, expanding neck hematoma, or distorted anatomy. Importantly, swelling and hematoma associated with facial or cervical injury can convert a manageable airway into a difficult or impossible airway within a short time window. For this reason, early airway control should be strongly considered when there is evidence of progressive edema, significant bleeding into the soft tissues, or anticipated deterioration, rather than delaying until overt obstruction occurs. This proactive approach is especially relevant when the anticipated airway is technically challenging due to distorted anatomy, blood in the oropharynx, or limited neck mobility from immobilization [10][11][12].

Breathing assessment follows airway stabilization and should include evaluation for thoracic complications that may accompany neck injury, particularly in Zone I penetrating trauma where the thoracic inlet is involved. Clinicians should assess chest rise, breath sounds, oxygenation, and ventilation while maintaining a high index of suspicion for pneumothorax, hemothorax, or pneumomediastinum. These conditions may coexist with neck trauma due to contiguous injury trajectories or associated blunt thoracic trauma. Identifying and treating such injuries rapidly is crucial because hypoxia and ventilatory failure may worsen neurologic outcomes and amplify hemodynamic instability. Circulation and hemorrhage control are immediate imperatives because vascular injury is a leading cause of death in penetrating neck trauma. Initial hemorrhage management in the emergency department relies on direct, simple pressure over bleeding wounds. Techniques that increase risk—such as blind probing of wounds—should be avoided because they can disrupt clot formation, precipitate uncontrolled hemorrhage, or worsen tissue injury. Similarly, clamping vessels in the emergency department is not recommended due to the risk of injuring adjacent structures, provoking additional bleeding, or compromising cerebral perfusion. Clinicians must avoid maneuvers that could occlude both carotid arteries or inadvertently obstruct the airway, as such actions can have catastrophic consequences. When wounds demonstrate bubbling or “air-sucking” behavior, they should be covered with occlusive dressing such as petroleum (Vaseline) gauze to reduce air entrainment and minimize ongoing contamination. Hemodynamic management should be aligned with trauma principles, including rapid recognition of shock, initiation of appropriate resuscitation, and early transition to definitive hemorrhage control via operative or endovascular methods when indicated. Certain interventions may increase risk and should be undertaken cautiously or deferred. Nasogastric tube placement is generally avoided in penetrating neck trauma because mechanical agitation and local manipulation may destabilize a contained hematoma, precipitate bleeding, or exacerbate airway compromise. Additionally, in patients who are agitated, attempts at tube insertion can increase sympathetic drive, raise blood pressure, and provoke renewed hemorrhage. These considerations reinforce the broader principle that procedural decisions should be filtered through an awareness of fragile cervical hemostasis and the proximity of critical structures [10][11][12].

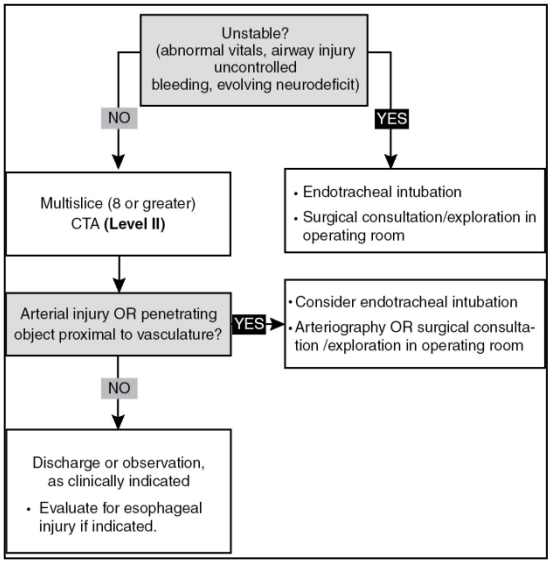

Fig. 3: Emergency management of neck trauma.

After immediate stabilization, further management of penetrating neck trauma depends on anatomic zone, symptom profile, and hemodynamic stability. Determination of the injury zone is clinically meaningful because it informs the feasibility of surgical exposure, the probability of occult vascular injury, and the choice of imaging or operative strategy. Zone I injuries are high risk because they involve the thoracic inlet and great vessels, and they are also difficult to expose surgically. A critical clinical challenge is that a substantial proportion of patients with clinically significant Zone I injury may be asymptomatic at initial presentation; therefore, many centers advocate systematic vascular evaluation of the aortic arch and great vessels, alongside assessment of the esophagus when the trajectory or presentation raises concern. This approach reflects the pathophysiologic reality that vascular injury may be contained initially and that esophageal injury may remain clinically silent until infection develops. Zone II injuries, extending from the cricoid cartilage to the angle of the mandible, are historically the most commonly injured and have comparatively easier surgical access. Because operative exploration in this zone is technically more feasible and has a lower risk of adverse sequelae from exposure, management has traditionally been more aggressive. However, contemporary approaches increasingly emphasize selective evaluation rather than universal exploration, with decisions guided by symptoms and objective findings. Symptomatic penetrating Zone II injuries—particularly those with evidence of vascular compromise, significant bleeding, or aerodigestive injury—should undergo neck exploration, as delayed intervention risks airway collapse, exsanguination, or missed esophageal injury. In contrast, asymptomatic patients with penetrating Zone II injury may be managed either with mandatory exploration or with directed evaluation and serial examinations, depending on institutional protocols, resource availability, and the reliability of clinical monitoring. The decision pathway must explicitly consider whether symptoms might be masked, whether the trajectory is concerning, and whether follow-up examinations can be performed safely and consistently. Indications for angiographic evaluation in stable patients include persistent hemorrhage and neurologic deficits, which may indicate carotid or vertebral involvement. Certain findings such as Horner syndrome, reflecting sympathetic chain injury, and hoarseness suggestive of recurrent laryngeal nerve injury may signal deeper violation of the carotid sheath and raise the probability of associated vascular injury. These clinical findings, particularly when combined with wound proximity to the carotid triangle, should prompt low-threshold vascular imaging and surgical consultation because they imply that the injury has traversed compartments where major vessels and cranial nerves reside [10][11][12].

Zone III injuries, located between the mandibular angle and the skull base, pose unique pathophysiologic and technical challenges. Major vascular structures and cranial nerves in close proximity to the skull base are at risk, yet the region is difficult to expose surgically and difficult to control for hemorrhage. A notable danger is that patients with arterial injuries in Zone III may be asymptomatic initially, particularly if bleeding is contained or if flow is preserved despite intimal injury. Because definitive surgical control can be challenging, many Zone III vascular injuries are amenable to endovascular therapy performed by interventional radiology, enabling diagnosis and treatment in the same procedural setting as angiographic evaluation. This capability has shifted many modern management strategies toward imaging-driven, selective intervention pathways, particularly for stable patients. A practical summary principle is that Zones I and III are less accessible for operative exposure and vascular control, and therefore routine mandatory exploration is generally less favored; instead, angiographic evaluation is commonly recommended to define vascular injury and guide endovascular or operative planning. In contrast, Zone II remains the most surgically accessible, and while mandatory exploration has historically been used when the platysma is violated, evolving evidence and advances in imaging have increasingly supported selective management based on hard signs, soft signs, and high-quality cross-sectional angiography. With improvements in multidetector CT technology, blanket strategies such as “mandatory” exploration for platysma violation and “mandatory” arteriography for Zones I and III are increasingly falling out of favor in many systems, provided that reliable imaging and monitoring are available. Nonetheless, a core safety principle

remains: any patient with platysma violation should be admitted to a surgical service or an observation unit for ongoing monitoring, regardless of initial stability, because delayed airway compromise, occult vascular injury, and missed aerodigestive tract injury can evolve after an initially benign presentation [10][11][12].

Management algorithms diverge significantly based on hemodynamic stability. Unstable patients with evidence of vascular or aerodigestive injury require rapid transition to invasive intervention rather than prolonged diagnostic workup. In this setting, definitive care is typically delivered in the operating room, where airway control, hemorrhage management, and repair of aerodigestive structures can be performed with the resources and exposure necessary for safe intervention. The exact operative strategy depends on the suspected structure injured, injury location, and associated injuries, but the guiding principle is that physiologic instability represents an immediate threat that overrides the pursuit of exhaustive diagnostic imaging. For stable patients, the central controversies historically have included whether to perform mandatory exploration of all Zone II injuries and whether to mandate invasive evaluation for all Zone I and III injuries. In contemporary practice, decisions are increasingly individualized, integrating zone anatomy, wound trajectory, clinical signs, and advanced imaging findings. Even when a patient is stable, the clinician must avoid complacency; stability is a snapshot, not a guarantee. Therefore, stable patients with concerning symptoms, soft signs, or high-risk trajectories require directed evaluation and serial reassessment, and stability should be preserved through careful monitoring and readiness to escalate. Blunt neck trauma constitutes a smaller fraction of neck injuries, but it presents its own distinctive pathophysiologic challenges. It frequently occurs in motor vehicle collisions, particularly when an unrestrained passenger strikes the neck against the dashboard or steering wheel, and it often coexists with multisystem injury. Blunt trauma can damage cervical vessels through direct impact or through excessive rotation and hyperextension, which stretch arteries and veins and can cause shear injury to the vessel wall. These mechanisms can produce intimal disruption and dissection with delayed neurologic consequences. Because isolated blunt neck injuries are uncommon, clinicians must actively search for associated head, thoracic, and abdominal trauma, and must integrate cervical spine precautions with airway planning, given that neurologic injury and airway compromise can coexist. Ultimately, the treatment and management of neck trauma require disciplined adherence to trauma priorities, early specialist involvement, careful attention to zone-based anatomy, and a readiness to transition from observation to intervention as clinical status evolves.[10][11][12]

Differential Diagnosis

The differential diagnosis in patients presenting with suspected neck trauma is necessarily broad, because cervical injuries can involve the airway, vascular structures, aerodigestive tract, cervical spine, and cranial nerves, often with overlapping symptoms and time-dependent evolution. A structured diagnostic mindset is essential to prevent anchoring on a single apparent lesion while missing concurrent life-threatening pathology. Among the most critical considerations is injury to the spinal cord, which may arise from blunt mechanisms, penetrating trauma, or secondary injury from unstable cervical spine fractures and ligamentous disruption. Spinal cord involvement should be suspected in the presence of motor weakness, sensory deficits, altered reflexes, neurogenic shock, or signs of high cervical injury such as respiratory insufficiency. Even when initial neurologic findings are subtle, cervical spine injury remains a high-stakes possibility, and immobilization and appropriate imaging are warranted when clinical criteria indicate risk. Strangulation represents another key diagnostic entity within the broader neck-trauma spectrum and may present either as an obvious external compression injury or as an occult mechanism with delayed airway and neurologic sequelae. The pathophysiologic hallmark is cerebral hypoxia due to venous outflow obstruction and, in severe cases, arterial inflow compromise. Patients may exhibit hoarseness, dysphagia, neck pain, bruising, petechiae, or transient loss of consciousness, and they may deteriorate after an initially reassuring examination due to progressive airway edema or evolving vascular injury such as carotid dissection. Because strangulation can occur in assault contexts, clinicians must also consider safeguarding needs and ensure appropriate documentation and multidisciplinary support. More broadly, the differential diagnosis must account for alternative or concurrent sources of respiratory distress, bleeding, dysphonia, or neurologic change, including thoracic trauma, facial injury, toxicologic contributors, and preexisting neurologic disease, while prioritizing immediate threats to airway and circulation. In practice, the differential diagnosis is less a list of separate conditions than a set of high-risk injury domains that must be systematically excluded, often in parallel, with serial reassessment to detect delayed manifestations [13][14].

Complications

Neck trauma is associated with a diverse complication profile, reflecting the concentration of critical structures in the cervical region and the propensity for early subtlety with later deterioration. Airway obstruction is among the most urgent complications and can result from expanding hematoma, soft tissue edema, laryngeal fracture, tracheal disruption, or progressive inflammation, and it may develop rapidly even after a stable initial presentation. Aspiration is another common and

clinically important complication, particularly when bleeding into the airway, altered mental status, or impaired protective reflexes are present; aspiration increases the risk of hypoxemia and pneumonia and can complicate both acute resuscitation and longer-term recovery. Neurologic complications include vocal cord paralysis, typically related to recurrent laryngeal nerve injury or laryngeal framework disruption, which may manifest as persistent hoarseness, weak cough, dysphagia, and aspiration risk. Aerodigestive tract injury can lead to perforated esophagus, a complication with high morbidity because missed perforation can progress to deep neck infection, mediastinitis, sepsis, and death. Severe vascular injury remains a leading cause of immediate mortality and may also cause delayed complications such as pseudoaneurysm, arteriovenous fistula, or thromboembolic phenomena. Stroke is a particularly consequential delayed outcome, often associated with carotid or vertebral artery dissection or thrombosis, and may occur after blunt or penetrating injury even when early neurologic examination is normal. Infectious complications can be catastrophic, especially when contamination from esophageal injury or devitalized tissue is present. Necrotizing infection may develop rapidly, causing systemic toxicity, airway compromise, and extensive tissue destruction. Air embolism, though less common, is a recognized risk when venous structures are injured and negative intrathoracic pressure draws air into the circulation, potentially leading to cardiopulmonary collapse or neurologic injury. Thoracic complications—pneumothorax and hemothorax—are particularly relevant in Zone I trauma and can accompany penetrating trajectories or blunt thoracic impact, contributing to respiratory failure and shock. Collectively, these complications emphasize the need for early recognition, careful imaging when indicated, and serial monitoring to detect evolving airway, vascular, neurologic, and infectious sequelae [13][14].

Enhancing Healthcare Team Outcomes

Optimizing outcomes after neck trauma requires coordinated interprofessional care, because effective management spans acute resuscitation, operative or endovascular intervention, critical care, rehabilitation, nutritional support, psychosocial stabilization, and discharge planning. In modern trauma systems, care is typically delivered by a multidisciplinary team that includes emergency physicians, trauma surgeons, anesthesiologists, radiologists, and critical care specialists, supported by nurses and allied health professionals such as physical therapists, occupational therapists, dietitians, and social workers. This team-based structure is particularly important because cervical injuries may produce prolonged disability, especially when neurologic deficits are present. Patients with spinal cord involvement often require extended treatment and rehabilitation that can last months, and coordinated planning is required to prevent complications such as pressure injuries, respiratory infections, and functional decline. Post-acute support frequently necessitates home-based or community resources. A visiting nurse can play a critical role in monitoring respiratory status, wound healing, tracheostomy care, medication adherence, and early identification of complications after discharge, particularly for patients with persistent neurologic deficits. Dysphagia resulting from esophageal injury or laryngeal dysfunction can necessitate nutritional adaptations, and some patients may require temporary enteral feeding support until swallowing function improves; dietitians and speech-language professionals are central to safe feeding plans and aspiration prevention. Patients with tracheostomy often require specialized home care nursing to manage airway hygiene, suctioning, tube maintenance, and gradual weaning, thereby reducing readmissions and improving quality of life. Social workers contribute by addressing safety concerns, insurance barriers, access to equipment, and coordination of rehabilitation placement, while occupational therapists support return to daily activities and functional independence. Only through sustained interprofessional coordination can complications be minimized, continuity maintained, and patient-centered recovery optimized, with improvements in both clinical outcomes and long-term quality of life.[13][14][2]

Outcomes

Outcomes after neck trauma are shaped by injury zone, mechanism, the structures involved, and the timeliness of definitive intervention. Injuries involving Zone I typically carry the highest morbidity and mortality because of the proximity to the thoracic inlet, great vessels, and mediastinal structures, and because achieving surgical exposure and vascular control is technically challenging. Zone II injuries are the most common in penetrating trauma and, due to comparatively favorable access for examination and operative exploration, often have the best prognosis when managed promptly. Nonetheless, Zone II can still pose challenges, particularly when injuries involve deeper structures or when swelling and anatomic complexity limit exposure, and outcomes may be guarded when critical neurovascular or aerodigestive structures are involved. Neurologic injury remains one of the strongest determinants of prognosis. Complete transection of the spinal cord is almost uniformly fatal, reflecting the severity of associated vascular and respiratory compromise. Patients who retain neurologic function—such as preservation of key exam findings including rectal tone—generally have more favorable outcomes, particularly when deficits are incomplete and early stabilization prevents secondary injury. However, persistent neurologic deficits are associated with poor

functional outcomes and long-term disability. Vascular injury due to blunt trauma is often associated with worse outcomes than penetrating injury, in part because blunt mechanisms can produce dissections, intimal injuries, and delayed strokes that may not be recognized immediately, while also coexisting with multisystem trauma. Across mechanisms and zones, the need to actively search for airway and esophageal injury is central to outcome optimization, because these injuries may not be clinically obvious at presentation and delays in diagnosis increase morbidity and mortality. Reported mortality rates for penetrating neck trauma overall vary, commonly cited in the range of 2% to 5%, but rupture of a major blood vessel dramatically worsens prognosis and is often fatal in approximately 70% of cases.[15] These figures highlight the decisive influence of vascular catastrophe on survival and reinforce why early hemorrhage control, rapid airway protection, and timely imaging or operative intervention remain the critical levers for improving outcomes in patients with traumatic neck injuries [15].

Conclusion:

Neck trauma represents one of the most challenging emergencies due to its potential for rapid deterioration and complex anatomy. The confined cervical region houses critical vascular, airway, and neurologic structures, making even minor injuries clinically significant. Immediate priorities include airway stabilization, hemorrhage control, and cervical spine protection, as failure in any domain can result in catastrophic outcomes. Zone-based classification remains central to risk stratification and management planning, with Zone I injuries posing the greatest technical challenges and mortality risk. Contemporary practice increasingly favors selective evaluation over mandatory exploration, leveraging high-resolution imaging such as CTA to identify vascular and aerodigestive injuries. Despite these advances, delayed diagnosis—particularly of esophageal perforation and vascular dissection—continues to drive morbidity and mortality, underscoring the need for serial examinations and multidisciplinary involvement. Trauma teams must anticipate evolving airway compromise and integrate surgical, radiologic, and critical care expertise early in the course of management. Ultimately, adherence to evidence-based protocols, proactive airway planning, and structured imaging strategies are pivotal for improving survival and functional outcomes in patients with acute neck trauma.

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