Resident Manual of Trauma to the Face, Head, and Neck

First Edition

AMERICAN ACADEMY OF
OTOLARYNGOLOGY–
HEAD AND NECK SURGERY
FOUNDATION

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eBook Format: First Edition 2012.

ISBN: 978-0-615-64912-2

Preface

The surgical care of trauma to the face, head, and neck that is an integral part of the modern practice of otolaryngology–head and neck surgery has its origins in the early formation of the specialty over 100 years ago. Initially a combined specialty of eye, ear, nose, and throat (EENT), these early practitioners began to understand the inter-relations between neurological, osseous, and vascular pathology due to traumatic injuries. It also was very helpful to be able to treat eye as well as facial and neck trauma at that time.

Over the past century technological advances have revolutionized the diagnosis and treatment of trauma to the face, head, and neck—angiography, operating microscope, sophisticated bone drills, endoscopy, safer anesthesia, engineered instrumentation, and reconstructive materials, to name a few. As a resident physician in this specialty, you are aided in the care of trauma patients by these advances, for which we owe a great deal to our colleagues who have preceded us. Additionally, it has only been in the last 30–40 years that the separation of ophthalmology and otolaryngology has become complete, although there remains a strong tradition of clinical collegiality.

As with other surgical disciplines, significant advances in facial, head, and neck trauma care have occurred as a result of military conflict, where large numbers of combat-wounded patients require ingenuity, inspiration, and clinical experimentation to devise better ways to repair and reconstruct severe wounds. In good part, many of these same advances can be applied to the treatment of other, more civilian pathologies, including the conduct of head and neck oncologic surgery, facial plastic and reconstructive surgery, and otologic surgery. We are indebted to a great many otolaryngologists, such as Dr. John Conley's skills from World War II, who brought such surgical advances from previous wars back to our discipline to better care for patients in the civilian population. Many of the authors of this manual have served in Iraq and/or Afghanistan in a combat surgeon role, and their experiences are being passed on to you.

So why develop a manual for resident physicians on the urgent and emergent care of traumatic injuries to the face, head, and neck? Usually the first responders to an academic medical center emergency department for evaluation of trauma patients with face, head, and neck injuries will be the otolaryngology–head and neck surgery residents. Because there is often a need for urgent evaluation and treatment—bleeding and

airway obstruction—there is often little time for the resident to peruse a reference or comprehensive textbook on such trauma. Thus, a simple, concise, and easily accessible source of diagnostic and therapeutic guidelines for the examining/treating resident was felt to be an important tool, both educationally and clinically.

This reference guide for residents was developed by a task force of the American Academy of Otolaryngology—Head and Neck Surgery (AAO-HNS) Committee on Trauma. AAO-HNS recently established this standing committee to support the continued tradition of otolaryngology–head and neck surgery in the care of trauma patients. An electronic, Portable Document Format (PDF), suitable for downloading to a smart phone, was chosen for this manual to facilitate its practical use by the resident physician in the emergency department and preoperative area.

It should be used as a quick-reference tool in the evaluation of a trauma patient and in the planning of the surgical repair and/or reconstruction. This manual supplements, but does not replace, more comprehensive bodies of literature in the field. Use this manual well and often in the care of your patients.

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Acknowledgments

This quick reference guide for resident physicians in trauma management reflects the efforts of many individuals in the American Academy of Otolaryngology—Head and Neck Surgery and a special task force of the AAO-HNS Committee on Trauma.

The editors would like to thank all of the authors who generously gave their time and expertise to compose excellent chapters for this Resident Manual in the face of busy clinical and academic responsibilities and under a very narrow timeframe of production. These authors, experts in the care of patients who have sustained trauma to the face, head, and neck, have produced practical chapters that will guide resident physicians in their assessment and management of such trauma. The authors have a wide range of clinical expertise in trauma management, gained through community and military experience.

A very special appreciation is extended to Audrey Shively, MSHSE, MCHES, CCMEP, Director, Education, of the AAO-HNS Foundation, for her unwavering efforts on behalf of this project, and her competent and patient management of the mechanics of the Resident Manual's production. Additionally, this manual could not have been produced without the expert copyediting and design of diverse educational chapters into a cohesive, concise, and practical format by Joan O'Callaghan, Director, Communications Collective, of Bethesda, Maryland.

The editors also wish to acknowledge the unwavering support and encouragement from: Rodney P. Lusk, MD, President; David R. Nielsen, MD, Executive Vice President and CEO; Sonya Malekzadeh, MD, Coordinator for Education; and Mary Pat Cornett, CAE, CMP, Senior Director, Education and Meetings, of the AAO-HNS/F. We also appreciate the administrative support of Rudy Anderson as AAO-HNS/F Staff Liaison for the Trauma Committee.

Since it takes a group of dedicated professionals to produce an educational and clinical manual such as this, all have shared in the effort, and each individual's contribution has been outstanding.

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Chapter 7: Penetrating and Blunt Neck Trauma

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I. Penetrating Neck Trauma

A. INTRODUCTION

Penetrating neck trauma has historically carried a high mortality rate, ranging as high as 16 percent during World War I when nonsurgical management was performed.[1] During World War II, when mandatory neck exploration was instituted, the mortality fell to 7 percent and remained 4–7 percent during the Vietnam War.

Surgical management has evolved over the last two decades, based on the advent of advanced radiographic studies and endoscopic techniques. Most civilian centers currently practice selective neck exploration, with mortality rates ranging 3–6 percent for low-velocity penetrating neck trauma (LVPNT).[2-6] Most recently, U.S. military surgeons have treated high-velocity penetrating neck trauma (HVPNT) patients with selective neck exploration and have reported mortality rates equivalent to civilian mortality rates for LVPNT.[6]

B. PROJECTILES, BALLISTICS, AND MECHANISMS OF INJURY

Different types of projectiles are associated with different ballistics and mechanisms of injury, since the severity of projectile injury is directly related to the kinetic energy that the missile imparts to the target tissue (Box 7.1).[7]

Box 7.1. Formula for the Relationship Between Projectile Injury and Kinetic Energy

The formula for the relationship between the severity of projectile injury and the kinetic energy that the missile imparts to the target tissue is as follows:

$KE = \frac{1}{2} M (v1-v2)^2$

KE = kinetic energy of the missile

M = missile mass

V1 = entering velocity

V2 = exiting velocity[7]

1. The Most Lethal Missiles

The most lethal missiles are high-velocity projectiles that impart all of their energy into the tissues without exiting (V2 = 0). These types of projectiles include:

- Tumbling missiles.
- Expanding bullets.
- Explosive bullets.

2. Temporary and Permanent Bullet Cavities

Given the above understanding of kinetic energy of missiles, a single projectile will form two bullet cavities upon tissue impact:

- The permanent cavity follows the injury tract due to the direct disruption of tissue from the missile.
- The temporary cavity is proportional to the kinetic energy of the missile, and may be up to 30 times the cross-section of the missile along the injury tract.[7]

3. Historical Categorization, Types, and Treatment of Penetrating Neck Wounds

High-velocity projectiles cause significantly more damage and tissue destruction when compared to low-velocity projectiles. Table 7.1 presents the categories of missiles resulting in penetrating neck trauma and the types of wounds they cause. Historically, these wound types have been divided into low- and high-velocity trauma.

Table 7.1. Historical Categories of Missiles and Types of Penetrating Neck Wounds

Categories of Missiles Resulting in Penetrating Neck Wounds	Types of Penetrating Neck Wounds	
Knives	**Low Velocity (<610m/s)**	**High Velocity (>610m/s)**
Single Projectiles • Handguns • Rifles ***Multiple Projectiles*** • Shotgun pellets • Improvised explosive devices (IEDs) • Grenades • Mortars • Rocket	• Stab wounds • Handgun wounds • Long-range (>5 m victim-to-weapon range) birdshot wounds • Long-range buckshot wounds	• Close-range (<5 m victim-to-weapon range) birdshot wounds • Close-range buckshot wounds • Rifle wounds • Wounds from bombs, IEDs, grenades, mortars, and rockets

< = less than; > = more than; m/s = meters per second.

4. Historical Treatment of Penetrating Neck Wounds

Since World War II, surgeons have stratified management of penetrating neck trauma based on mortality rates and the rates of pathology discovered during neck exploration.[4]

a. Low-Velocity Penetrating Neck Trauma

LVPNT was typically managed with selective neck dissection, since the overall mortality rate was 3–6 percent with less than 50 percent of patients having major pathology found on neck exploration.

b. High-Velocity Penetrating Neck Trauma

On the other hand, HVPNT was historically treated with mandatory neck exploration, since those patients had mortality rates greater than 50 percent with 90–100 percent major pathology found on neck exploration due to the tremendous amount of kinetic energy (up to 3,000 foot-pounds) imparted to the tissue. However, as previously discussed, selective neck dissection is currently used by combat surgeons to treat HVPNT in both Iraq and Afghanistan, with resulting low morbidity and mortality similar to rates seen in civilian trauma centers managing LVPNT.[6]

C. EMERGENCY ROOM MANAGEMENT

1. Initial Orderly Assessment

Initial orderly assessment, using the Advanced Trauma Life Support protocol as developed by the American College of Surgeons, is appropriate in any trauma. This protocol includes rapid assessment of the "A, B, Cs" of trauma. Accordingly, airway management is the first priority in penetrating neck trauma.[8]

a. Airway Management

- Approximately 10 percent of patients present with airway compromise, with larynx or trachea injury.[5,9] While endotracheal intubation may be performed in these patients, nasotracheal intubation, cricothyroidotomy, or tracheostomy may be required in the presence of spinal instability.
- To avoid air embolism, the patient should be supine or in Trendelenburg's position.
- Direct pressure without indiscriminate clamping should be used to control active hemorrhage in the neck.
- Deeply probing open neck wounds below the platysma muscle should be avoided in the emergency room, as this may lead to clot dislodgement and subsequent hemorrhage.
- Two large-bore intravenous lines should be placed to establish access for fluid resuscitation. Subclavian vein injuries should be suspected in

Zone I injuries (as discussed below), and intravenous access should be placed on the contralateral side of the penetrating injury to avoid extravasation of fluids.
- Spinal stabilization should be maintained until cleared clinically and/or radiographically.
- Tetanus toxoid should be administered if the status is unknown or outdated.
- If possible, initial radiographic survey in the trauma bay should include chest x-ray and cervical spine x-rays.
- Prophylactic antibiotics and nasogastric tube suction placement should also be considered.

D. ANATOMY

1. Vital Structures in the Neck

To organize primary assessment, secondary survey, and surgical approaches to penetrating neck injuries, four types of vital structures in the neck must be considered:
- Airway (pharynx, larynx, trachea, and lungs).
- Blood vessels (carotid arteries, inominate artery, aortic arch vessels, jugular veins, and subclavian veins).
- Nerves (spinal cord, brachial plexus, cranial nerves, and peripheral nerves).
- Gastrointestinal tract (pharynx and esophagus).

2. Skeletal Anatomy

Skeletal anatomy should be considered as well:
- Mandible.
- Hyoid.
- Styloid process.
- Cervical spine.

3. Muscular Landmarks

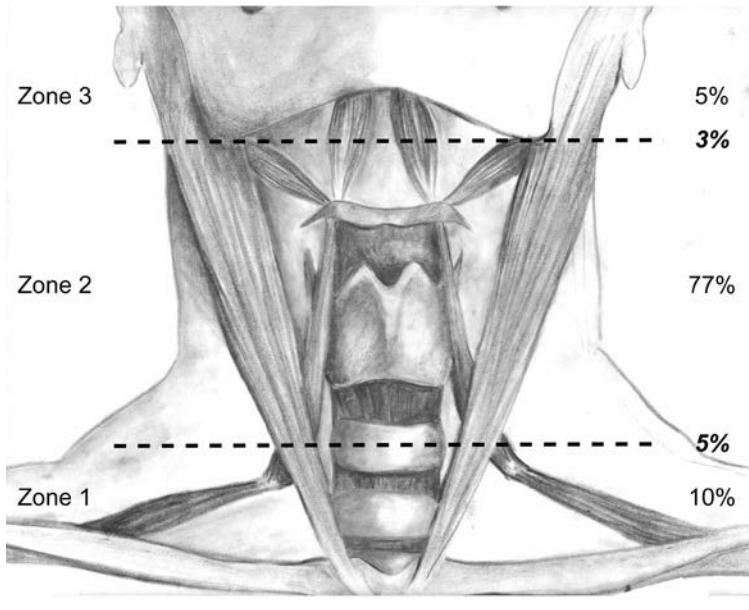
Muscular landmarks are also important:
- *Platysma muscle*—Penetration of the platysma muscle defines a deep injury in contrast to a superficial injury.
- *Sternocleidomastoid muscle*—The sternocleidomastoid muscle also serves as a valuable landmark, since this large, obliquely oriented muscle divides each side of the neck into anterior and posterior triangles.
- *Anterior triangle*—The anterior triangle contains airway, major vasculature, nerves, and gastrointestinal structures, while the posterior triangle contains the spine and muscle.

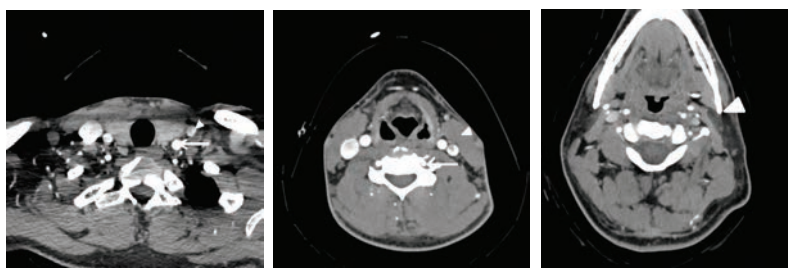
4. Neck Zones

The neck is commonly divided into three distinct zones, which facilitates initial assessment and management based on the limitations associated with surgical exploration and hemorrhage control unique to each zone (Figure 7.1).

Figure 7.1

The neck is divided into Zones 1, 2 and 3. The axial computed tomographic (CT) images below correspond to Zone 1, Zone 2, and Zone 3.





Zone 1 Zone 2 Zone 3

a. Zone 1

Zone 1, the most caudal anatomic zone, is defined inferiorly by the clavicle/sternal notch and superiorly by the horizontal plane passing through the cricoid cartilage. Structures within this zone include the:

- Proximal common carotid arteries.
- Vertebral and subclavian arteries.
- Subclavian, inominate, and jugular veins.
- Trachea.
- Recurrent laryngeal and vagus nerves.
- Esophagus.
- Thoracic duct.

Vascular injury management is challenging in Zone 1, and mortality is high. Due to the sternum, surgical access to Zone I may require sternotomy or thoracotomy to control hemorrhage.

b. Zone 2

Zone 2, the middle anatomic zone, is between the horizontal plane passing through the cricoid cartilage and the horizontal plane passing through the angle of the mandible. Vertically or horizontally oriented neck exploration incisions provide straightforward surgical access to this zone, which contains the:

- Carotid arteries.
- Jugular and vertebral veins, pharynx, and larynx.
- Proximal trachea.
- Recurrent laryngeal and vagal nerves.
- Spinal cord.

c. Zone 3

Zone 3, the most cephalad anatomic zone, lies between the horizontal plane passing through the angle of the mandible and the skull base. Anatomic structures within Zone 3 include the:

- Extracranial carotid and vertebral arteries.
- Jugular veins.
- Spinal cord.
- Cranial nerves IX–XII.
- Sympathetic trunk.

Because of the craniofacial skeleton, surgical access to Zone 3 is difficult, making surgical management of vascular injuries challenging with a high associated mortality at the skull base. Surgical access to Zone 3 may require craniotomy, as well as mandibulotomy or maneuvers to anteriorly displace the mandible.

5. Vascular Injuries

The incidence of vascular injuries is higher in Zone 1 and Zone 3 penetrating neck trauma injuries. This occurs because the vessels are fixed to bony structures, larger feeding vessels, and muscles at the thoracic inlet and the skull base. Consequently, when the primary and temporary cavities are damaged, these vessels are less able to be displaced by the concussive force from the penetrating missile. However, in Zone 2, the vessels are not fixed; therefore, they are more easily displaced by concussive forces, and the rate of vascular injury is lower.

Also, in Zone 1, the esophagus is at risk for injury. Missed esophageal injuries occur because up to 25 percent of penetrating esophageal injuries are occult and asymptomatic.[10] These missed esophageal injuries may be devastating, with reported mortality rates approaching 25 percent.[10] Therefore, for Zone 1 and for some Zone 2 penetrating neck injuries, it is imperative that esophageal injuries be ruled out with endoscopic examination and, possibly, swallow studies.

E. DIAGNOSTIC EVALUATION AND SURGICAL TREATMENT

1. Selective Neck Exploration

Selective neck exploration may be utilized to manage penetrating neck trauma when two important conditions are present at the trauma facility: reliable diagnostic tests that exclude injury and appropriate personnel to provide active observation.[6,11] In the setting of these two conditions, contemporary penetrating neck trauma management is selective neck exploration.

a. Patient's Symptoms at Presentation

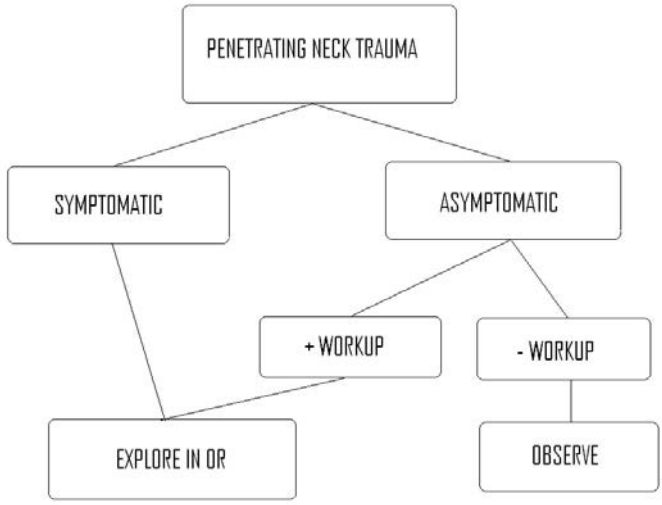
The decision whether to explore the penetrating neck wound is determined based on the patient's symptoms at presentation, regardless of the missile velocity.

- *Symptomatic patients* are explored in the operating room. If symptomatic patients are stable, computed tomographic angiography (CTA) may be obtained before exploration, since this study may better define anatomic approaches to Zone 1 and Zone 3 of the neck.
- *Asymptomatic patients* are evaluated with diagnostic studies and, if pathologic findings are discovered during this workup, are taken to the operating room for neck exploration (Figure 7.2). If asymptomatic patients have a negative diagnostic workup showing no neck pathology, then they will be observed.

Significant symptoms from penetrating neck trauma will occur, depending on which of the four groups of vital structures in the neck are injured.

Figure 7.2

Management algorithm based on symptoms if computed tomographic angiography (CTA), panendoscopy, and appropriate personnel are available.



- *Vascular injury* may result in active hemorrhage, expanding hematoma, vascular bruit, and pulse deficit.
- *Airway injury* may cause subcutaneous emphysema, hoarseness, stridor, and respiratory distress.
- *Esophageal injury* is often asymptomatic and may result in leakage of saliva, subcutaneous emphysema, bleeding from the esophageal inlet, and ultimately neck or mediastinal abscess.
- *Nerve injury* may result in cranial nerve deficits or hemiparesis. These fixed neurologic deficits may not require immediate neck exploration in an otherwise stable patient.

2. Mandatory Neck Exploration

If appropriate diagnostic testing and personnel are not available, then penetrating neck trauma patients should undergo mandatory neck exploration, or if stable, should be immediately transferred to a facility with those capabilities.

3. Computed Tomographic Angiography

Computed tomographic angiography (CTA) is generally considered the initial procedure of choice to evaluate cervical vasculature in asymptomatic penetrating neck trauma. In the past, formal neck angiography via groin catheters was the procedure of choice. However, since CTA

has a sensitivity ranging between 90 percent and 100 percent, along with a specificity ranging between 93 percent and 100 percent, this procedure is currently used to evaluate neck vessels.[3,12-14]

a. Signs of Probable Injury on CTA

Signs of probable injury on CTA include:

- Hematoma.
- Subcutaneous air adjacent to the carotid sheath.
- Intravenous contrast extravasation.
- Missile tracts in close proximity to vital structures.[14]

b. Nondiagnostic Studies on CTA

CTA may have a 1.2–2.2 percent incidence of nondiagnostic studies due to the artifact from bullet fragments and metallic foreign bodies.[5,15] CTA is also useful in evaluating the trajectory of the missile tract and may help select patients who will benefit from further workup of the aerodigestive tract.

4. Evaluation of Aerodigestive Tract Injuries

Aerodigestive tract injuries, especially those involving the cervical esophagus, should be identified and repaired within 12–24 hours after injury to minimize associated morbidity and mortality. Evaluation of asymptomatic aerodigestive tract injuries includes contrast swallow studies and endoscopy (rigid and flexible esophagoscopy, bronchoscopy, and laryngosocpy).

a. Endoscopy

Endoscopy is more reliable than contrast swallow studies to identify injuries to the hypopharynx and cervical esophagus. Several authors have demonstrated that endoscopy will identify 100 percent of digestive tract injuries, whereas contrast swallow studies are less sensitive, especially for hypopharyngeal injuries.[16,17]

b. Rigid and Flexible Esophagoscopy, Rigid and Flexible Bronchoscopy, and Rigid Direct Laryngoscopy

Rigid and flexible esophagoscopy, rigid and flexible bronchoscopy and rigid direct laryngoscopy are performed in the operating room under general anesthesia. It is recommended that both rigid and flexible esophagoscopy be performed to rule out occult esophageal injuries.

c. Rigid and Flexible Esophagoscopy

Rigid esophagoscopy may provide a better view of the proximal esophagus near the cricopharyngeal muscle, while flexible esophagoscopy, with its magnification on the viewing screen and ability to insufflate, gives excellent visualization of more distal esophageal anatomy.

d. Swallow Studies

Finally, swallow studies with either gastrograffin or barium may not be available in austere environments to rule out occult esophageal injuries and, as noted above, are less accurate than endoscopy.[6] Missed esophageal injuries, which may be occult in 25 percent of patients, can be devastating, with mortality rates ranging up to 25 percent.[10]

F. CONCLUSION

Penetrating neck trauma patients can be divided into two categories on presentation: symptomatic and asymptomatic. Symptomatic patients are taken to the operating room for neck exploration. Asymptomatic patients undergo workup with CTA, panendoscpy, and possibly swallow studies. If the workup shows occult neck pathology, then those patients are taken to the operating room for neck exploration. Asymptomatic patients with a negative diagnostic workup are observed.

II. Blunt Neck Trauma

A. INTRODUCTION

Although the same anatomic structures described in penetrating neck trauma (airway, vascular structures, nerves, and gastrointestinal tract) may be impacted during blunt neck trauma. The laryngotracheal airway and cervical spine are the most clinically susceptible to injury. Vascular injuries are potentially devastating but are uncommon overall, occurring in 0.08–1.5 percent of blunt neck trauma, depending on how aggressively asymptomatic patients are screened.[18,19] Despite the widespread use of advanced safety mechanisms, such as shoulder harness seatbelts and airbags, motor vehicle collisions remain the most common etiology for blunt neck trauma. Other mechanisms include blunt object impact sustained in assault, and sports injuries, crush injuries, and hanging or clothesline trauma.

B. PRESENTING SIGNS AND SYMPTOMS

As in penetrating neck trauma, the presenting signs and symptoms of blunt neck trauma injuries are based on the dysfunction of the anatomic structures in the neck. Therefore, evaluation of the blunt neck trauma patient should follow the rapid, orderly process of trauma assessment, starting with the airway.

1. Initial Diagnostic Airway Evaluation

Initial diagnostic airway evaluation with flexible laryngoscopy is helpful in documenting endolaryngeal findings as well as post-injury changes, since significant edema may occur during the first 12–24 hours.[20]

- Computed tomographic (CT) imaging may be considered for surgical planning in symptomatic patients or in asymptomatic patients with suspected laryngeal injury.
- Securing the airway is advocated in the setting of acute airway symptoms, such as stridor or respiratory distress, prior to considering imaging.

2. Hemodynamic Instability or Signs of Vascular Injury

Hemodynamic instability or signs of vascular injury, such as bruit, expanding/pulsating hematoma, hemorrhage, or loss of pulse, warrant surgical exploration, as described in the Penetrating Neck Trauma section (Section I) of this chapter.

3. Hemodynamically Stable Patients Showing Risk Factors

Hemodynamically stable patients should undergo initial diagnostic imaging with CTA if at-risk factors are present, including severe cervical injury, anoxic brain injury from hanging, closed head injury with diffuse axonal injury, midface or complex mandibular fractures, marked neck soft tissue swelling injury, high-risk cervical spine fractures (such as vertebral body subluxation, C1-3 vertebral body fracture, and any fracture extending into the transverse foramen), or basilar skull fractures involving the carotid canal.[21]

4. Cervical Spine Injury Assessment

After clinical examination, cervical spine injury assessment should include initial lateral and anteroposterior plain x-ray films if possible. Further evaluation with imaging should be based on the individual patient's musculoskeletal and neurologic complaints, as well as physical exam findings.

C. CONCLUSION

The laryngotracheal airway and the cervical spine are the two most integral structures that can be damaged in blunt trauma to the neck. Prior to any intervention, such as flexible fiberoptic evaluation of the airway, the neck must be stabilized securely in line. The status of the cervical spine takes evaluative precedence after the airway has been secured in a manner that does not compromise a potential cervical spine injury. Hemodynamic stability or instability will be an important guide to the urgency of intervention, including diagnostic CTA prior to exploration of the neck to control bleeding and secure the vascular elements. An excellent physical examination must always be performed and will be the clinical guide to the next steps in evaluation and treatment.

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The American Academy of Otolaryngology—Head and Neck Surgery Foundation's education initiatives are aimed at increasing the quality of patient outcomes through knowledgeable, competent, and professional physicians. The goals of education are to provide activities and services for practicing otolaryngologists, physicians-in-training, and non-otolaryngologist health professionals.

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