

Paula Ferrada  
Ricardo Ferrada  
*Editors*

# Atlas of Trauma

Operative Techniques,  
Complications and  
Management

 Springer

**EXTRAS ONLINE**

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Operative Techniques, Complications  
and Management

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*Editors*

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*We dedicate this book to all surgeons who practice trauma care and for all professionals who pour their hearts and souls to help patients survive grave injuries.*

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## Preface

Regardless of the sub-specialization or the place where we practice, the majority of surgeons will need at some point to take care of trauma patients. This is crucial in situations of a natural disaster and war or in places where the social situation can result in violence.

Trauma is a disease that when it requires surgery, it is more technically challenging than any other elective procedures. In acutely injured patients, the anatomy is distorted, the physiological state is labile. In order to save a life trauma procedures need to be done fast and efficiently. Therefore, it is imperative that we all place our efforts in training ourselves and those who come after us to be the best technicians we can be. In trauma, patient lives depend on our technical ability and capacity to work under pressure.

This atlas is the collaborative work of surgeons from Latin America and North America, describing techniques that can come in handy when treating trauma patients.

Richmond, VA, USA  
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## Contents

<b>1 Neck Exploration</b> .....	1
Stefan W. Leichtle and Paula Ferrada	
<b>2 Operative Exposures for Chest Trauma: The Median Sternotomy and Left Anterolateral Thoracotomy</b> .....	9
Aditi Kapil and Paula Ferrada	
<b>3 Cardiac Penetrating Trauma</b> .....	15
Ricardo Ferrada	
<b>4 Open Repair of Traumatic Thoracic Aortic Injury Without Shunt, and Using a Woven Dacron Graft</b> .....	19
Aurelio Rodriguez and David C. Elliott	
<b>5 Surgical Stabilization of Rib Fractures: Indications and Technique</b> .....	23
Babak Sarani	
<b>6 Abdominal Exposures and Bowel Anastomosis for Trauma</b> .....	29
Levi Procter and Paula Ferrada	
<b>7 Liver and Spleen</b> .....	41
Roberto C. Castillo and Paula Ferrada	
<b>8 Vena Cava Injury</b> .....	49
Ricardo Ferrada and Paula Ferrada	
<b>9 Genitourinary Operations in Trauma</b> .....	55
Asanthi Ratnasekera and Paula Ferrada	
<b>10 Vascular Exposures in the Upper Extremities</b> .....	67
Ana Milena Del Valle and Juan Carlos Herrera	
<b>11 Vascular Exposures in the Lower Extremities</b> .....	75
Ana Milena Del Valle and Juan Carlos Herrera	
<b>12 Lower Extremity Fasciotomy: Indications and Technique</b> .....	85
Matthew K. George and Rahul J. Anand	
<b>13 Resuscitative Endovascular Balloon for Occlusion of the Aorta (REBOA) and Other Endovascular Techniques</b> .....	91
Megan Brenner and Elizabeth R. Benjamin	
<b>Index</b> .....	97

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# Neck Exploration

1

Stefan W. Leichtle and Paula Ferrada

## Introduction

Severe trauma to the neck is rare but can rapidly become life-threatening. Even patients without immediate concern for airway loss or exsanguinating hemorrhage are at risk for permanent, potentially disabling neurologic deficits. Neck trauma requires rapid, systematic assessment and timely, appropriate interventions to ensure best outcomes. Despite the high stakes, a majority of patients with blunt and even penetrating neck trauma will not require operative intervention [1].

The structure of this chapter follows the presentation of a trauma patient with injury to the neck from (1) presentation to the Emergency Department (ED) to (2) the initial diagnostic and management decisions to (3) the Operating Room (OR) for neck exploration. The chapter focuses on concise reviews of anatomy, physiology, decision-making, and operative steps.

## In the Emergency Department: Initial Assessment and Airway Management

Initial attention must follow Advanced Trauma Life Support protocols and focus on the safety of the patient's airway. When arrival of a trauma patient with neck injury to the ED is anticipated, a cricothyroidotomy set (or its individual components required for this procedure), should be readily available: a size 11 or 15 scalpel, Kelly clamp, tracheal hook, and size 6 Fr endotracheal tube (ETT) or tracheostomy canula. A plan for airway management should be clearly laid out between the trauma surgery, ED, and anesthesiology teams present in the trauma bay. Cricothyroidotomy should not

necessarily be considered an option of last resort (when the patient is severely hypoxic), but might well be one of the first maneuvers, depending on a patient's presentation.

Any patient with a compromised airway upon arrival to the ED should undergo immediate endotracheal intubation, which may be difficult or impossible in severe facial trauma, or expeditious cricothyroidotomy. If a patient's airway is threatened but still maintained, intubation in the OR rather than the ED should be considered, where a non-surgical or surgical airway can be established under more favorable circumstances.

## Procedure: Cricothyroidotomy

- Palpate the thyroid cartilage, which is usually the most obvious bony prominence of the anterior neck and is located about 4–5 finger breadths above the sternal notch. The cricothyroid membrane is immediately below, between the thyroid cartilage superiorly and the cricoid cartilage inferiorly.
- Stabilize the thyroid cartilage with your non-dominant hand and perform a vertical skin incision extending from the thyroid cartilage toward inferior. A 1–1.5-inch-long incision should suffice, but there should be no hesitation to extend the incision if needed for better exposure.
- Feel for the cricothyroid membrane (in the setting of bleeding this is often more palpable than visible structure) and make a horizontal incision through it. Be careful not to back wall into the esophagus, particularly when using an 11 vs. 15 blade.
- Dilate the opening with a Kelly clamp or tracheal dilator, if available.
- If available, use a tracheal hook to pull up the thyroid cartilage. This stabilizes the trachea.
- Insert an appropriately sized ETT (usually 6 Fr) or tracheostomy canula and secure it.
- Check end-tidal CO<sub>2</sub> to confirm correct placement in the airway.

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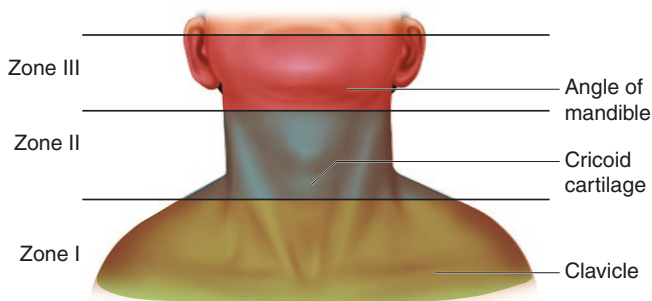
If the airway is secure, or once it has been secured, systematic assessment of the neck continues. Traditionally, the neck has been divided in three zones (Fig. 1.1):

- Zone 1, from sternal notch/clavicles to cricoid cartilage
- Zone 2, from cricoid cartilage to the angle of mandible
- Zone 3, from the angle of the mandible to the skull base

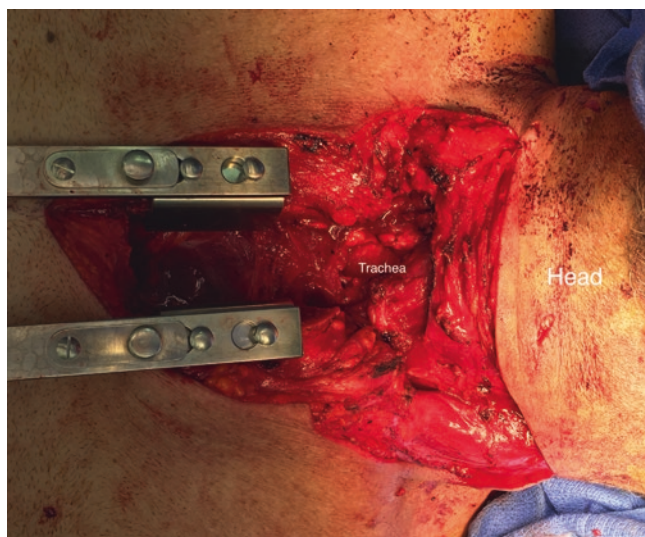
Initial assessment and management has evolved from this zone-based approach (historically, “mandatory exploration for zone 2 wounds”) to a selective approach taking into account individual patient stability and signs of injury [2]. Determination of injury zone is still helpful for clear communicating, to anticipate damaged structures, and to prepare for operative intervention. It is important to realize that penetrating wounds can easily traverse a zone, e.g., a zone 2 stab wound might well extend into zone 1.

Zone 1 injuries may require (partial) sternotomy or thoracotomy (Fig. 1.2). Injured structures may include:

- Mediastinal and superior thoracic vessels: innominate, proximal common carotid, subclavian, and vertebral arteries; internal jugular vein (IJ).



**Fig. 1.1** Zones of the neck



**Fig. 1.2** Partial sternotomy for low tracheal injuries

- Esophagus and trachea.
- Apex of the lung, thoracic duct, and brachial plexus.

Zone 2 is most accessible surgically, and an incision along the anterior border of the sternocleidomastoid muscle (SCM) is most versatile. Injured structures may include:

- Distal common, internal, external carotid arteries; vertebral artery; IJ and external jugular vein.
- Esophagus and trachea.
- Vagus nerve.

Zone 3 injuries are most difficult to access surgically and may involve the cranium. Exposure may require dislocation of the mandible or resection of the styloid process. If possible, temporary hemorrhage control (e.g., with a Foley catheter, described below), preoperative imaging, and use of endovascular techniques are preferable to immediate operative exploration. Injured structures may include:

- Distal carotid and vertebral arteries.
- Pharynx.
- Vagus, glossopharyngeal, and hypoglossal nerves.

## In the ED: Hemorrhage Control and Systematic Assessment

Severe active hemorrhage from a neck wound might require rapid hemostasis before further diagnostics or definitive surgical control can be planned. Even in the neck, direct compression is the initial maneuver and can control bleeding in many cases. For non-compressible hemorrhage in the neck or upper chest, balloon tamponade with a Foley catheter is an effective method to provide temporary hemostasis.

## Procedure: Balloon Tamponade of Non-compressible Hemorrhage in Neck or Chest

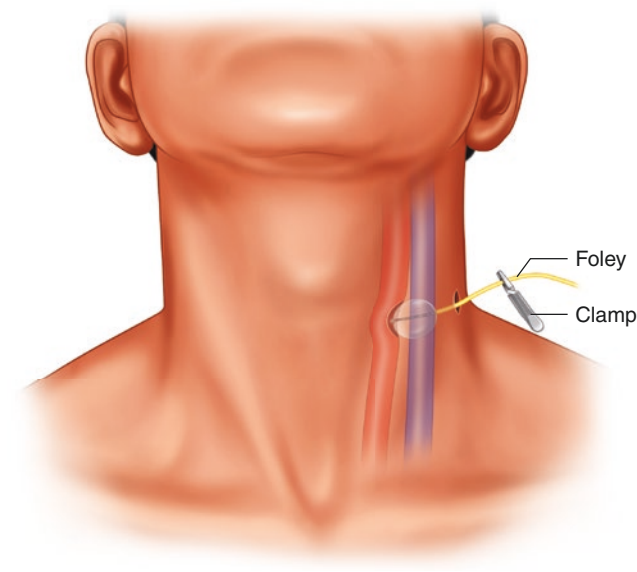
- Insert a large (16 or 18 Fr) Foley catheter carefully into the wound and inflate the balloon with a small amount of saline until bleeding stops.
- If inflation alone does not stop the hemorrhage, the catheter might have to be pulled back slowly to achieve hemostasis (Fig. 1.3).
- Clamp the catheter and secure it with suture or tape.
- Once temporary hemostasis has been achieved, obtain imaging if needed or transport the patient to the OR.

Once the patient’s airway has been secured and initial injuries have been assessed, management proceeds based on the patient’s hemodynamic status and presence or absence of

“hard signs” of vascular or aerodigestive injury. Any patient who is unstable (with neck trauma as likely cause) or has hard signs of vascular or aerodigestive injury should go directly to the OR. Patients with “soft signs” of injury might still require operative intervention but can usually undergo imaging workup first as long as they are not unstable or at risk for airway loss.

Hard signs of vascular or aerodigestive injury are:

- Pulsatile bleeding or expanding hematoma
- Audible bruit or palpable thrill overlying the major vascular structures
- Hemodynamic instability not explained by other injuries
- Neurologic deficits not explained by other injuries
- Air bubbling from the neck (Fig. 1.4)
- Severe hematemesis or hemoptysis



**Fig. 1.3** Foley tamponade



**Fig. 1.4** Hard sign of aerodigestive injury: air bubbling from neck

Soft signs of vascular or aerodigestive injury are:

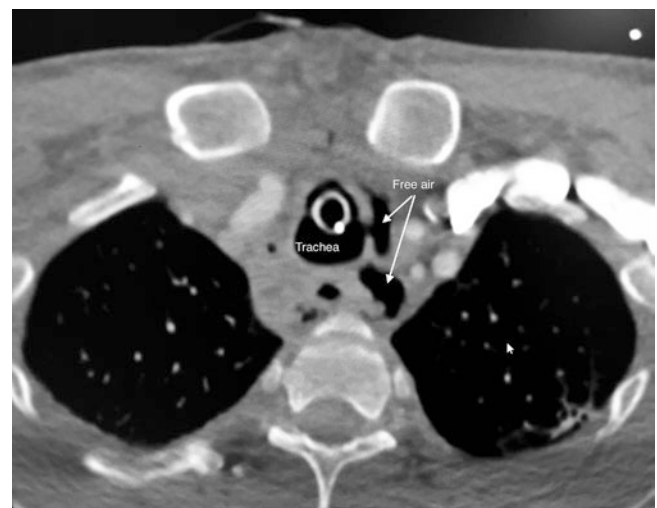
- Reported active bleeding or severe blood loss in the field
- Hematoma without active expansion
- Small amount of hematemesis or hemoptysis

### In the ED: Imaging for Neck Trauma

Computed tomography angiography (CTA) of the neck has essentially replaced traditional angiography as initial imaging tool. A negative neck CTA rules out significant vascular injury with very high sensitivity and specificity [3]. It is important to inject the IV contrast for the CTA on the contralateral side of the anticipated injury to adequately visualize the subclavian vessels without artifact from the contrast bolus. CTA of the neck might be limited if metallic shrapnel is present in the neck, and it is less sensitive for esophageal and tracheal injury. If there is concern for aerodigestive injuries (based on trajectory, clinical signs, and/or imaging findings; Fig. 1.5), a bronchoscopy and swallow study with water-soluble contrast should be performed to rule out tracheal and esophageal injury, respectively. Upper endoscopy in addition to a contrast study is the most sensitive way of ruling out digestive tract injury. If the neck CTA demonstrates isolated venous injury including the IJ, *hemodynamically stable* patients can still be successfully managed non-operatively [4].

### In the OR: Preparation and Positioning

Despite the advent of endovascular treatment options and increasing prevalence of hybrid operating rooms, open operative repair remains the mainstay of surgical treatment for



**Fig. 1.5** Large amount of air near trachea on imaging: concern for aerodigestive injury