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EVALUATION AND MANAGEMENT OF NECK TRAUMA

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ABSTRACT

Aim: A literature review was undertaken to discuss the assessment and management of this injuries to find out thecurrent evidence and guidelines that support surgical management of Penetrating neck injuries.
Introduction: The neck region contains a high density of vital organ structures in a relatively small and unprotected anatomic region, making it one of the most vulnerable areas of the body for all types of injuries.[25]Penetrating neck injuries (PNIs) and stab wounds are not uncommon in the Iran. Because of this type of injuries, we would establish a national guideline in collaborations with trauma centre hospitals and trauma associations. The spectrum of vascular injuries ranges from obvious life-threatening injuries that require immediate treatment to subtle injuries that may appear innocuous on initial examination and yet lead to a major neurologic event Vascular trauma to the neck may result in a catastrophic neurologic deficit or death if not recognized and properlytreated.
As we know, every University hospital has its own local surgical routines which might be different from each other. But the Most guidelines are from the USA or South Africa.
Method: Authors reviewed 24 articles and literature search for current evidence that can support surgical management ofPenetrating neck injurie.
Result: PNIs injuries to the two large neurovascular bundles that are vital to life and might occur with associated injuries to midline aero digestive structures. A detailed knowledge of vascular anatomy and operative exposures along with keen surgical judgment is crucial, especially in the unstable patient where immediate surgical intervention is required.
As endovascular skills and technology continue to improve, cerebrovascular injuries are increasingly managed by these methods, relieving the patient of large incisions and their accompanying operative morbidity.
Violence in Iran especially in big cities like Tehran, has led to Increasing. There is a need to develop a national PNI guideline that based on international neuro-vascular experiences and reflects the pathology of this type of injurie for general surgeons in Iran.
Conclusion: Vascular trauma to the neck and thoracic outlet may result in a catastrophic neurologic deficit or death if not recognized and properly treated.

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INTRODUCTION

The surgical management of carotid artery injuries dates to the 1500s. In 1552, Ambroise Paré authored the first report of successful management of a carotid artery injury by ligation (Watson, 1939). Both the common carotid artery and the jugular vein were ligated. The patient survived but developed aphasia and hemiplegia. Fleming later reported a successful outcome after ligating an injured common carotid artery, and this became the standard for surgical management until the Korean War (Fleming, 1817). The Korean War marked the beginning of primary repair of arterial injuries, and carotid repair was attempted with success. Subsequently, these reconstructive techniques were applied to civilian carotid artery injuries as well as to the subclavian and, to a lesser extent, to the vertebral artery. More recently, endovascular techniques have replaced operative repair for selected injuries of the neck and thoracic outlet vessels (Burlew, 2010).

Introduction

Penetrating neck injuries remain challenging, as there are many important structures in a small area and injury to any of these structures may not be readily apparent.

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Penetrating neck trauma is an important area of trauma care that has undergone evolution in the recent past. Therapy has evolved from no treatment (before effective anesthesia and instrumentation), to no operative management, to routine exploration, to selective exploration and adjunctive invasive or noninvasive assessment. The neck is located between the head and torso, and contains vital structures, such as the trachea, esophagus, carotid artery, jugular veins, and spinal cord. Vascular trauma to the neck and thoracic outlet may result in a catastrophic neurologic deficit or death if not recognized and properly treated. The spectrum of vascular injuries ranges from obvious life-threatening injuries that require immediate treatment to subtle injuries that may appear innocuous on initial examination and yet lead to a major neurologic event. This wide variation in presentation and potentially devastating nature of certain neck and thoracic outlet vascular injuries has led to a reappraisal of methods of diagnoses, imaging, and surgical management. These refinements have prompted changes in the management paradigm for both penetrating and blunt neck- and thoracic-outlet vascular injuries. While relatively uncommon in comparison with other mechanisms of injury, the potential morbidity of PNT is apparent because of the high density of vital structures confined to a relatively small and poorly protected area (Kasbekar, 2017).

PNT represents approximately 5%–10% of all trauma cases that present to the emergency department. Approximately 30% of these cases are accompanied by injury outside of the neck zones as well (McConnell, 1994; Thal, 1992). The current mortality rate in civilians with PNI is 3%–6% (McConnell, 1994; Thal, 1992). During World War II, the mortality rate was 7%, and in World War I, it was 11% (McConnell, 1994; Thal, 1992). Higher mortality rates occur with injuries to large vessels, such as the carotid or subclavian arteries and veins.PNI involves a missile or sharp object penetrating the skin and violating the platysma layer of the neck. This includes gunshot wounds, stab or puncture wounds, and impalement injuries (Brennan *et al*., 2011; Dubois-Marshall, 2011; Gupta *et al*., 2011). Experience in the treatment of casualties from the Iraq War reported the common carotid artery as the most frequently injured cervical vessel (Woo *et al*., 2005). PNI in Iraq War was estimated in 10% of all trauma patients, overall mortality rates were estimated at 3%– 6%, most commonly because of injury to vascular structures and hemorrhage (Brennan, 2013; Burgess *et al*., 2012; Mahmoodie *et al*., 2012). Anatomically, the neck can be divided into three major zones according to Monson *et al*. (1969). These three zones allow for easy initial assessment and management, including surgical exploration and hemorrhage control.Successful management of PNT depends on a clear understanding of the anatomy of the neck (Thompson *et al*., 2002).

Zone I extend from the clavicle to the cricoid cartilage,
Zone II from the cricoid cartilage to the mandibular angle,

particularly in zone II, many important structures (the carotid arteries, jugular veins, thyroid, larynx, trachea, and esophagus) are present and unprotected. Therefore, damage to zone II is very fatal and often requires immediate surgical intervention (Koehler *et al*., 2011).

Zone III from the mandibular angle to the base of the skull

The usefulness of the zone concept of PNT has declined in recent years (Burgess *et al*., 2012; Bell *et al*., 2007).

The platysma is a very thin muscular sheet that surrounds the superficial fascia of the neck, and its integrity determines whether a PNI is superficial or deep. Neck injuries are very life-threatening because of the high concentration of the airway structures, arteries, and veins. The possibility for injury to a vital organ exists when this structure is penetrated. If the platysma is penetrated in the initial survey, active surgical intervention is required (Miller, 1991).

Fig-1Carotid zones of the neck

- Zone I extend from the sternal notch to the cricoid cartilage.
- Zone II extends from the cricoid cartilage to the angle of the mandible.
- Zone III extends from the angle of the mandible to the base of the skull.

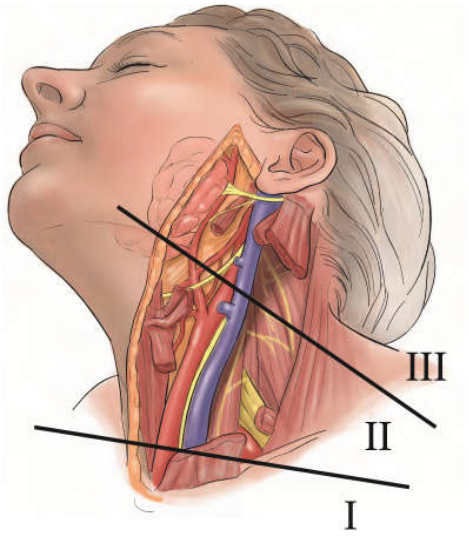

Fig. 1. From Rich's Vascular Trauma, 3E (2016)

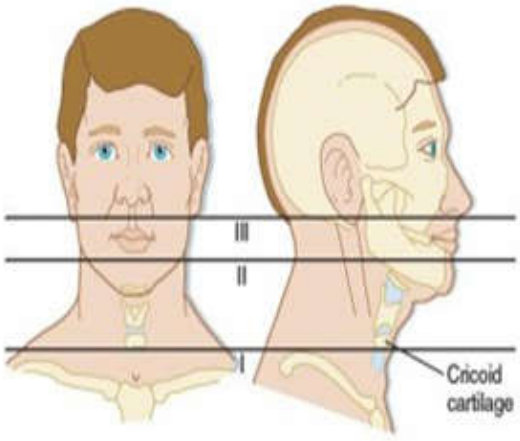

Fig-2 photo from text book of trauma surgery

METHODS

Nonoperative management of neurologically intact patients with specific penetrating injuries is occasionally warranted. For patients with a carotid or vertebral artery occlusion and normal neurologic exam, observation and anticoagulation with heparin is an acceptable approach. Likewise, patients diagnosed with a minimal arterial injury do not require repair.

Minimal injuries are defined as nonconstructive or adherent intimal flaps and pseudoaneurysm less than 5 m in size. A ten years retrospective, descriptive, analytical study from Iran, in PNI for epidemiology, mechanism of injury, zone of injury, therapeutic method, injuries to other organs, complications, and mortality among 192 penetrating neck injuries, showed that: the mean age at the time of injury was 25.08 ± 15.02 years. Of these cases, 96.4% occurred in men. The common mechanisms of trauma were stab wounds (85.93%). Zone 2 was involved in 56.3% of PNI. 84.4% of neck exploration were positive, and 52.1% of patients underwent surgery. Vascular exploration was the most common cause of surgery (67.2% of patients). Vein ligation was (50.8% of cases) the most common surgical intervention. In 11.98% of cases, another organ injury occurred simultaneously, and chest injury was the most common coexisting problem (65.2%). Complications were reported in 9.3% of patients, and the need for into
bation was the most common complication (5.2% of patients). Mortality rate was 1.5%.

Presentation

Evidence of significant injury to vital structures of the neck may be indicated by the following clinical manifestations:

- Dysphagia – Tracheal and/or esophageal injury
- Hoarseness – Tracheal and/or esophageal injury (especially recurrent laryngeal nerve)
- Oronasopharyngeal bleeding – Vascular, tracheal, or esophageal injury
- Neurologic deficit – Vascular and/or spinal cord injury
- Hypotension – Nonspecific; may be related to the neck injury or may indicate trauma elsewhere

Proposed hard signs of airway injury include the following:

- Subcutaneous emphysema – Tracheal, esophageal, or pulmonary injury
- Air bubbling through the wound
- Stridor or respiratory distress – Laryngeal and/or esophageal injury

Several so-called hard signs that strongly indicate vascular injury are as follows:

- Hematoma (expanding) – Vascular injury
- Active external hemorrhage from the wound site – Arterial vascular injury
- Bruit/thrill – Arteriovenous fistula
- Pulselessness/pulse deficit
- Distal ischemia (neurologic deficit in this case)

Indications

The mechanism of penetration is important in determining the extent of damage and treatment options. Ballistic missile trauma can cause extensive damage that is highly correlated with the velocity of the projectile. Stab wounds are relatively low velocity, but can still lead to serious injury. It is useful to divide the neck horizontally into 3 zones. Patients with either penetrating or blunt neck/thoracic outlet vessel injury frequently have severe concomitant injuries as well as nonvascular injuries remote from the site of injury. Therefore, a careful application of *ATLS protocol* for stabilization and treatment is crucial. Initial examination should include a thorough *neurologic examination*, *auscultation for bruit*, and *palpation* of the carotid and superficial temporal pulses. Upper extremity pulses and blood pressure in both arms should be evaluated, because pressure differentials or decreased pulses may suggest an arch or thoracic outlet injury.Patients with carotid injuries may exhibit a contralateral neurologic deficit, *aphasia*, *Horner's syndrome*, or evidence of anterior neck soft tissue trauma. Vertebral artery injuries may be associated with *ataxia,* dizziness, *vomiting*,*facial and body analgesia*, or *visual field deficit*. Complaints of headache, neck,ear, face, or periorbital pain may indicate mural hemorrhage or dissection (Burlew, 2010). Because of the high association of blunt carotid and vertebral injuries with closed head injury, many patients have a decreased Glasgow Coma Scale (GCS) on arrival, which can complicate the diagnostic process. Patients with blunt carotid/vertebral injuries may also arrive at the emergency department (ED) with minimal to no overt vascular findings and yet develop a focal neurologic deficit 10 to 72 hours later (Biffl, 2009). Penetrating subclavian artery injuries are particularly lethal and patients who survive to reach the hospital, over half are hypotensive and require resuscitative thoracotomy (Sobnach *et al*., 2009; Stain *et al*., 1989; Frykberg, 1989).

Contraindications

No role exists for probing or local exploration of the neck in the trauma bay or emergency department because this may dislodge a clot and initiate uncontrollable hemorrhage. If no significant injuries requiring surgery are present, surgical therapy is unnecessary and observation or expectant management may proceed.

Pathophysiology

Two factors in the mechanism of injury or kinematics in penetrating neck trauma determine the extent of damage to the tissue

Weapon characteristics

- The amount of kinetic energy delivered by the wounding agent must be considered together with its interaction with the involved tissue.
- Kinetic energy (KE) is described by the following equation: KE = 1/2 mass X velocity (squared).
- Low-energy weapons include *hand-driven weapons*, such as knives or ice picks, which damage with only their sharp point or cutting edge.
- Firearms may be classified as medium-energy (i.e. handguns) and high-energy weapons (i.e. military assault weapons), with the latter usually defined as having 461 joules or more.
- Projectiles (i.e. bullets, missiles) often are differentiated by mass, velocity, shape, and construction because these characteristics affect the extent of tissue disruption.
- Bullet velocity is the most important characteristic considered, with high velocity defined as greater than 2500 ft/s.

Location of injury and human tissues involved

- Tissue injury results from either a direct impact by the penetrating projectile or tissue displacement from temporary cavitation.
- Wound sites and, if present, the wounding agent in the neck provide an indication of the likely injury complex.

Operative Strategy and Technique

In 1969, Monson divided the neck into three zones (Monson, 1969). The zones of the neck were devised for guidance in diagnosis and treatment of carotid artery trauma. The central issues in the operative management of vascular injury PNI are the maintenance of correct priorities and the need for rapid and effective operative maneuvers to prevent exsanguination and maintain perfusion to distal organs.

Zone I span from the clavicle to the cricoid cartilage
Zone II from the cricoid cartilage to the angle of the mandible, and
Zone III from the angle of the mandible to the skull base (Feliciano, 2007).

The zone II *carotid artery travels within the carotid sheath, which contains the vagus nerve and the jugular vein*.

The common carotid artery divides into the internal and external carotid within Zone II, in most instances one to two fingerbreadths below the angle of the mandible. An awareness of carotid bifurcation anatomy is important in preoperative planning, particularly for those injuries at the junction of zones II and III. It is also important to recognize that the zone classification describes the entry or exit site of the wound only. The course of a penetrating wound may traverse other zones of the neck or the thorax or intracranially. Vascular injuries in these patients may be either truncal or peripheral.
The PNI usually present an immediate threat to the patient's life, whereas the latter may present either as severe external bleeding. Vascular trauma is especially challenging in the context of damage control because an inherent conflict exists between the need for an elaborate and time-consuming reconstruction and the urgent need to abbreviate the procedure before the patient sustains an irreversible physiologic insult. The coagulopathy and unmanageable bleeding that set in once the patient's physiologic envelope is breached frustrate even the most heroic and technically perfect vascular reconstruction. Fig- 3 & 4 Enormous neck wound and Acute sternotomy for proximal control (photo from Dr Pazooki)

Table 1. Vascular Injuries Grading System

Grade 1	*Dissection/intramural hematoma with > 25% narrowing*
Grade 2	*Dissection/intramural hematoma with > 25% narrowing*
Grade 3	*Pseudoaneurysm*
Grade 4	*Occlusion*
Grade 5	*Transection with extravasation*

The evaluation of a patient with penetrating neck trauma always should start with advanced trauma life support (ATLS), a paradigm that begins with a directed primary survey emphasizing airway, breathing, and circulation (ABC). After patients are stabilized, they undergo a secondary survey that includes a complete history and a thorough physical examination.

Fig. 3.

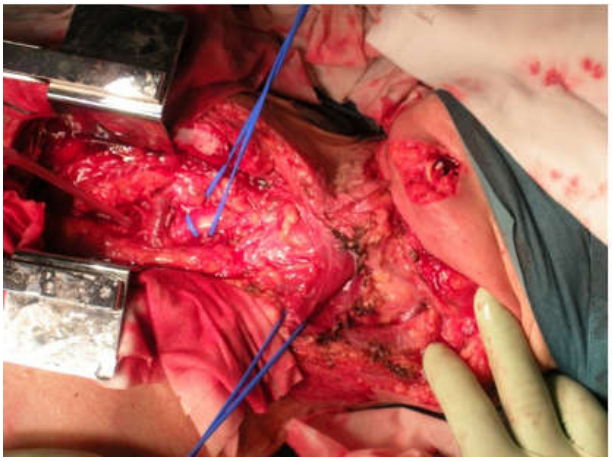

Fig. 4.

Fig. 3 and 4. Enormous neck wound and Acute sternotomy for proximal control *(photo from Dr Pazooki)*

The highest goal in damage control surgery PNI is to stop the bleeding.

- ***Temporary Occlusion:*** *In the prehospital or preoperative situation with extensive blood loss, temporary occlusion (manual or digital Pressure)A Foley catheter is placed through the trajectory of the injury and the balloon is inflated.*

Fig. 5.

Fig. 6.

Fig. 5. and 6. Manual or digital Pressure and Foley catheter is placed through the trajectory of the injury and the balloon is inflated

- ***Flow Restoration (shunts)*** *Intraluminal shunts are used as temporary vascular conduit for any anatomic location. Shunts can Place in venous system.* (Iraq and Afghanistan war (Clouse, 2007)

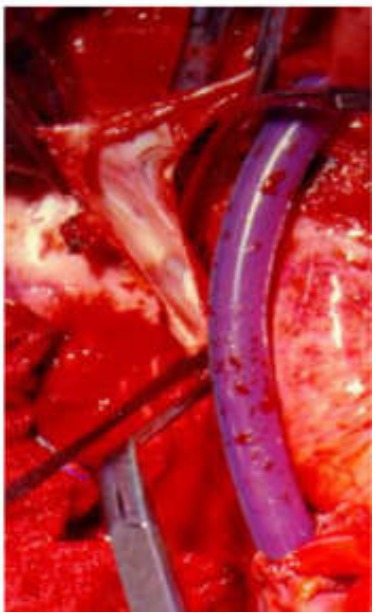

Fig. 7. Intraluminal shunt

Fig. 8. Extraluminal shunt

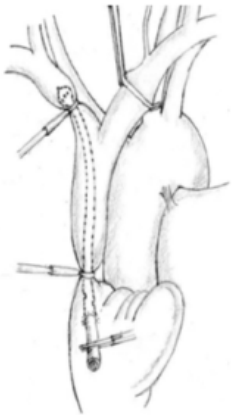

Fig. 9. Reconstruction of the superior vena cava

- ***Lateral repair*** *Simple lateral repair in suitable case is preferable. A major disadvantage is creating a stenosis* (Surg Clin, 2002)

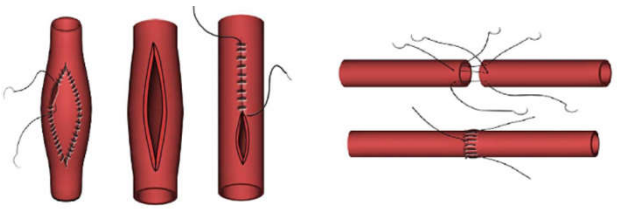

Fig. 10. Simple lateral& End to

- ***Stents*** *The main indication for stenting is the thoracic aorta, but for vascular repair in other regions as well.*

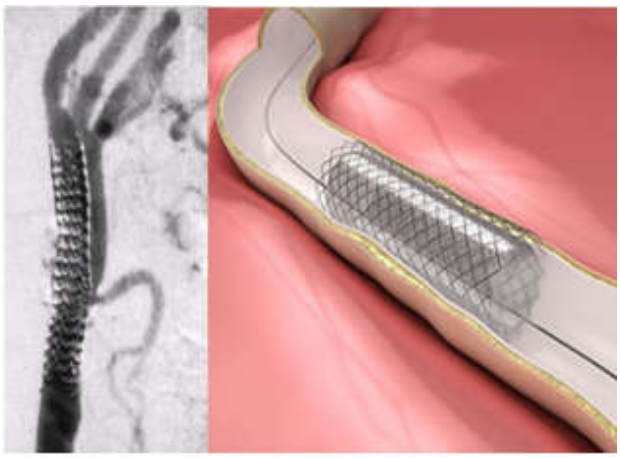

Fig. 11. Carotid stent (photo from vascular stent)

- ***Complex Repairs and Grafts:*** *In context of damage control surgery, Complex Repairs and use of Grafts are nor wise choices.Cold Patient, Coagulopathic, acidosis lethal triad.Extra anatomic bypass or extra anatomic vascular shunt is wise choice.*
- ***Ligation:*** *The simplest method for regaining bleeding control is clamping and ligation of the bleeder .Wild undirected clamping in pool of blood result in more damage. The venous structures are the most difficult ones to repair. Every named artery has its own rules as to whether a simple tie will be tolerated.*
- ***Coiling:*** *A modern method for occluding the bleeding vessel is coiling, but not in hemodynamic ally unstable patient.*

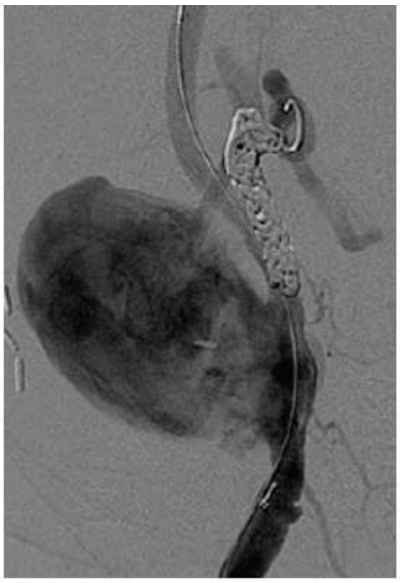

Fig. 12. Coil embolization of the ECA prior to stenting to avoid retrograde filling of the pseudo aneurysm, (from Endovascular today2016)

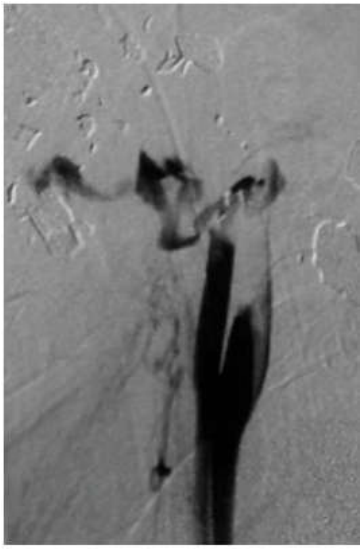

Fig. 13. Angiogram – GSW to Carotid Artery

- ***Haemostatic Agents and glues:*** *Gelatine haemostatic agents, Cyanoacrylate adhesives, Oxyfied regenerated glucose, Microfibrillar collagen, Thrombin and fibrinogen (fibrin glue),Tissucol (Baxter), Beriplast (Nycomed), Quixil (Johnson &Johnson), Tachosil (Nycomed), Autolog fibrin Vivostat system (Vivolution), Patches and pads e.tc.*

Penetrating neck trauma represents approximately 5-10% of all trauma cases that present to the emergency department. About 30% of these cases are accompanied by injury outside of the neck zones as well. The current mortality rate in civilians with penetrating neck injuries ranges from 3-6%. During World War II, the mortality rate was 7%, and, in World War I, it was 11%. Higher mortality rates occur with injuries to large vessels, such as the carotid or subclavian arteries and veins.

RESULTS

Two recent studies demonstrate the importance of the setting in which penetrating neck injuries occur, particularly treatment protocols in combat zones.

Sarkar *et al* presented 2 cases from Western Baghdad (Watson, 1939), and *Ramasamy et al* performed a retrospective medical review of casualties from Iraq and Afghanistan who sustained penetrating neck injuries to determine the need for prehospital cervical immobilization, given current ATLS protocols requiring spinal precautions when a significant mechanism of injury may damage the cervical spine (Fleming, 1817). In the study by *Ramasamy et al,* of 90 patients with a penetrating neck injury, 66 (73%) were from explosions and 24 (27%) were from gunshot wounds. In 20 (22%) patients, cervical spine injuries were present; only 6 (7%) survived to reach the hospital, and 4 of these 6 died within 72 hours of their injuries (Fleming, 1817). Of 56 survivors that reached a surgical facility, only 1 (1.8%) had an unstable cervical spine injury requiring surgical stabilization, and this patient subsequently died due to a concomitant head injury.

The investigators determined a high mortality rate is associated with penetrating ballistic trauma to the neck (Fleming, 1817). Furthermore, it appears unlikely that survivors of penetrating ballistic trauma to the neck will have unstable cervical spines; therefore, not only is the risk/benefit ratio of mandatory spinal immobilization unfavorable, but cervical collars may also hide potential life-threatening conditions, in addition to putting medical teams at prolonged personal risk (Fleming, 1817).

DISCUSSION

Penetrating injury to the neck can be challenging, fingers and Foleys are your friend, no blind clamping, Haematomas compress airways. knowledge and experience with endovascular techniques have become critical elements in the management of vascular trauma and are being applied with increasing frequency for a variety of neck and thoracic outlet vascular injuries. Carotid injuries go along with high mortality and morbidity A retrospective study of 124 patients with carotid injuries (Trauma, 1989). Most patients (56%) were dead on arrival to the hospital, Associated trauma to the internal jugular vein was present in 26%. the mortality was 22% (overall mortality, 66%) (Trauma, 1989). If the platysma is penetrated in the initial survey, active surgical intervention is required (Koehler *et al*., 2011).

Conclusions

Zone II is the most common site of injury (33-67%), Zone III (16-19%) and zone I(13-18%). Penetrating ballistic trauma to the neck is associated with a high mortality rate.

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