



The Evolving Management of Penetrating Neck Injuries

Haim Paran MD, Ivan Shwartz MD and Uri Freund MD

Department of Surgery A, Meir Hospital [Affiliated to Sackler Faculty of Medicine, Tel Aviv University], Kfar Saba, Israel

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The management of penetrating neck injuries has changed tremendously in the last 20 years. During the 1960s and 1970s the golden rule for such injuries was mandatory neck exploration. This policy became generally accepted because of the anatomical proximity of the neck to important structures, the potential of disastrous consequences, and previous military experience. However, experience in the civilian setting of large trauma centers, together with economic considerations regarding unnecessary surgery prompted critical retrospective studies in the mid-seventies and early eighties. These studies revealed the staggering rate of up to 70% of non-therapeutic neck operations for penetrating injuries. As a result trauma surgeons set out to define a more selective and conservative approach, leading to the development of investigational management algorithms to treat these injuries.

In this review we present our assessment of the literature on the evolving management and treatment of penetrating neck injuries, and an evaluation of the results of recent prospective studies and treatment algorithms.

Mandatory neck exploration

The management protocol of mandatory exploration for penetrating neck injuries that violate the platysma emerged from the military experience during wartime [1,2]. This policy was based on the favorable results obtained with this approach and the complex anatomy of the neck. The multitude of vital structures in this area, and the potential for catastrophic consequences in cases of undiagnosed injuries to vascular and aero-digestive structures, supported this policy in the 1960s and early 1970s [3,4]. This concept was also corroborated by Fogelman and Stewart [5], whose findings demonstrated that mandatory neck exploration led to decreased morbidity and mortality from neck injuries. It is important to stress that at that time if an initial exploration was not initially performed, there was no work-up other than a plain radiographic examination in these patients. In spite of the changes in policy towards a selective management of penetrating trauma, mandatory neck exploration is still advocated in some modern studies.

In 1994 Apffelstadt and Muller [6] described their 21 month experience at a trauma center in South Africa using mandatory neck exploration for 393 consecutive stab wounds penetrating the platysma. Although they reported 226 (57%) negative neck explorations, the authors concluded that this approach is still justified based on a very low complication rate and early hospital discharge in those patients, and a 30% rate of potentially missed injuries found in patients with absent clinical signs. They concluded that mandatory neck exploration avoids unnecessary and expensive invasive diagnostic studies and is associated with low morbidity and short hospital stay.

In a retrospective study Hirshberg and colleagues [7] reported their 4 year experience treating trans-cervical gunshot wounds at a trauma center in Houston, Texas. During this period 41 patients were treated. In 30 of the 36 neck explorations (83%) they found major injuries to cervical structures. The authors concluded that penetrating gunshot injuries that cross the cervical midline should be treated by mandatory neck exploration, and emphasized the role of bilateral exploration of the neck, associated with minimal morbidity, in the management of these injuries. The authors also conclude that trans-cervical gunshot neck injuries present a severe form of neck trauma with a high incidence of damage to important vascular and visceral structures and should be managed by aggressive surgical treatment.

In another study Lebos and Saadia [8] report three cases of unsuspected injury in patients admitted with penetrating neck wounds. In all three otherwise initially asymptomatic patients, the injury to the carotid artery was supposedly caused by a blunt mechanism. Although the authors do not advocate the mandatory surgical exploration of penetrating neck injuries, they stressed the possibility of missing significant vascular injuries in an initially asymptomatic patient.

Selective management of penetrating neck injuries

The high rates of negative neck exploration of up to 75% [9] and the relatively high number of serious injuries

overlooked at these operations resulted in critical reappraisals of the recommended policy of mandatory exploration [9–11]. Improved investigative radiological techniques, especially arteriography, were advocated by some authors as better alternatives in the management of zone III injuries, where establishing proximal and distal vascular control is difficult [12–14]. In the early 1980s retrospective studies supported a more selective approach to assess asymptomatic patients [15,16].

In 1989 Wood and colleagues from Memphis, Tennessee [17] reported their 4 year experience treating 225 patients with penetrating neck injuries, including stab wounds (59%), gunshot (32%) and shotgun wounds (9%). Patients were selectively managed according to clinical presentation and radiographic studies, which included barium esophagograms and angiography. Patients with obvious serious injuries were explored immediately. Patients initially stable with equivocal physical findings were also surgically explored, regardless of the radiological findings. Patients asymptomatic but with positive radiological findings were explored as well. Only 80 patients with negative physical findings and negative radiological studies were treated by observation. There were no undiagnosed injuries in this group. It is of interest that among patients with equivocal physical findings and negative radiological studies, who were operated upon, only 28% had positive explorations. In three patients who were explored, injuries were missed during the operation, namely esophageal injuries in two and carotid artery injury in one. Both esophageal injuries were in the mandatory exploration group that had not undergone radiographic studies prior to the neck exploration, thus stressing the fact that these injuries can be missed during operation.

In a series of four studies led by Moore in Denver, Colorado, one can follow the evolving treatment of penetrating neck wounds. Their 1980 study shows that their experience with mandatory exploration policy was revised for the period 1973 to 1978 [11]. The study reveals that 56% of neck explorations were non-therapeutic. Beginning in 1978 a prospective evaluation of a selective operative plan for penetrating neck injuries was followed. The preliminary results were published in 1984 [18]; this selective surgical and diagnostic approach was then validated in the authors' first 124 patients [19] and finally in their 1997 report of 18 years experience with 312 patients [20]. The authors developed a selective management algorithm based on the initial clinical evaluation. After initial stabilization and routine antero-posterior and lateral chest and cervical X-rays (soft tissue X-rays), immediate surgery was performed in patients with persistent shock, profuse bleeding, airway compromise or evolving stroke. In patients who were initially stable but with other signs of injury (ongoing hemorrhage, hemoptysis, dysphonia, crepitation, hematemesis, dysphagia or peripheral neurologic deficit), various diagnostic procedures were conducted depending on the specific symp-

toms and the anatomy of the injury. Zone I injuries were investigated by arteriography and/or esophageal studies, injuries in zone II were explored immediately and those in zone III were investigated by arteriography alone (eventual bleeding at this zone was treated by embolization). Asymptomatic patients with zone I wounds were routinely investigated by arteriography, while asymptomatic patients with zone II and III injuries were observed with no further investigation. The authors reported a very satisfactory outcome with this approach. In all, 105 of the patients (34%) underwent surgery early with a relatively low rate of non-therapeutic explorations (16%). Of the 207 patients observed, only one required delayed operation. The highest rate of non-therapeutic explorations (19%) was for zone II injuries in patients who were explored early without any other investigation. Most investigative procedures were performed for zone I injuries (69%). The authors report no false-negative investigative studies. They conclude that their selective management of penetrating neck injuries is safe and does not mandate routine diagnostic testing or exploration for asymptomatic patients.

Demetriades et al. [21] also published a series of three studies on the evaluation of penetrating neck injuries by physical examination and with selective use of radiological investigatory procedures. In a large study in South Africa in which 335 patients were treated over a 3 year period, immediate surgery was performed in 66 patients (20%) for severe bleeding, shock, large expanding hematoma, air leak from the wound or hemoptysis, while the remaining 269 patients (80%) were managed by observation and clinical assessment of the wound. Selective use of arteriography, barium swallow and endoscopy was performed, regardless of the cervical zone. Only 2 of the latter patients (0.7%) eventually needed surgical exploration. There were no deaths in the group initially selected for non-operative treatment. It was concluded that physical examination is a reliable method for detecting significant injuries. In two additional studies, Demetriades and co-authors [22,23] reported the results of a prospective study during a 2 year period in Los Angeles, California. They evaluated the sensitivity of physical examination for identifying patients with penetrating injuries of the neck among those who require immediate exploration as opposed to those who need diagnostic studies namely arteriography. They also addressed the role of color flow Doppler as an alternative to angiography. During the 2 year period 223 patients entered the study. In the group of 34 patients with equivocal clinical signs, only 1 required surgical treatment. The authors concluded that physical examination reliably predicted major vascular trauma. In 152 patients without clinical signs of esophageal or tracheal trauma, the negative predictive value of physical examination alone was 100% for aero-digestive injuries.

In 1997 Klyachkin and co-authors [24] described their experience with 91 patients treated for penetrating neck

trauma. The treatment protocol was based on a selective management according to neck zones and angiography, barium swallow, and rigid esophagoscopy. The indications for mandatory exploration were similar to those in previous studies [20,23]. The authors concluded that using a selective management algorithm avoided unnecessary exploration in 52% of the cases, regardless of the location of the wound, and that patients with penetrating neck injuries can be safely managed selectively.

Specific considerations for penetrating trauma according to cervical zones

When dealing with penetrating cervical trauma, the injuries are usually classified by the mechanism (i.e., gunshot, stabbing) and defined anatomically by the neck zones according to the Roon and Christensen criteria [25]. Zone I is defined as the area between the clavicles and the cricoid cartilage, zone II as the area between the cricoid and the inferior border of the mandible, and zone III as the area between the inferior border of the mandible and the base of the skull. Most authors advocate that all unstable patients with penetrating wounds to the neck should be explored immediately without any further investigation, regardless of the cervical zone or the mechanism of the injury. Stable patients should undergo investigative procedures and management adjusted to the zone or zones of the injury.

Zone I

This cervical zone warrants special consideration because of potential violation of the pleura with resulting pneumothorax, injury to the great vessels originating from the aortic arch and superior vena cava, and injury to the esophagus and to the trachea. Since these structures are difficult to assess clinically, most authors advocate routine mandatory arteriograms and barium or gastrografin swallow [20,24]. The Zone I Penetrating Neck Injury Study Group from Nashville, Tennessee, recently addressed the policy of mandatory arteriography in a multicenter study [26]. They retrospectively reviewed the records of five trauma centers over a 10 year period. In a group of 138 patients treated for zone I injuries, 36 had normal findings on physical examination and chest radiographs. None of these 36 patients had an arterial injury as demonstrated later by arteriography, with a negative predictive value of 100%. The authors concluded that patients with zone I injuries but normal physical examination and chest X-rays may be suitable for observation, without the need of routine mandatory arteriography. Notwithstanding this recent study that advocates a policy of selective rather than mandatory arteriography, it is generally accepted that mandatory angiography is still the gold standard, until further studies confirm the reliability of the selective approach.

Zone II

The management of zone II neck injuries is controversial. Early studies that advocated routine angiography for

every wound violating the platysma in this zone [17,27] have been challenged by recent prospective studies using a selective policy. Beitsch and colleagues [28] in 1994 retrospectively reviewed their 5 year experience with 178 patients with zone II penetrating neck trauma due to stab wounds, gunshot and shotgun wounds. They reported that a negative physical examination upon admission was reliable in ruling out 99% of critical injuries. Of 71 arteriograms performed in asymptomatic patients, only one indicated an arterial injury requiring surgery.

Atteberry's team [29] conducted a prospective study to evaluate physical examination alone in the management of zone II penetrating injuries. During a 22 month period 36 consecutive patients met the criteria of the study. Two patients were explored because of injuries requiring immediate interventions; another 6 patients underwent arteriography because of proximity to vertebral arteries to the injury tract; and the remaining 28 patients, having no obvious signs of injury, were examined for proximity of the wound to vascular structures or equivocal signs of injury. These patients were assessed by carotid ultrasound, and if any injury was suspected an arteriogram was performed. At a later stage of the study, after the initial 18 patients, ultrasound examination was omitted and only physical examination was relied upon. None of the 28 asymptomatic patients had evidence of vascular injuries that required treatment, and no complications were reported in this group of patients during 18 months of follow-up. The authors concluded that asymptomatic patients with zone II injuries penetrating the platysma can be safely and accurately managed on the basis of physical examination alone.

In another prospective study, Sofianos and colleagues from South Africa [30] reported their results in 1996 on 75 patients admitted with gunshot injuries to the neck. Forty-five patients underwent immediate exploration due to obvious severe vascular injuries or aero-digestive injuries. In 24 patients the decision for observation was made on the basis of clinical evaluation alone, and in only 2 patients in this group (6%) did surgery have to be performed within 24 hours – due to the development of clinical signs of esophageal injury in one patient and an arterial injury in the other. These injuries were confirmed by gastrografin swallow and arteriography respectively, and the outcome of surgery was satisfactory and without morbidity related to the delayed diagnosis. Based on the results of the study the authors concluded that penetrating wounds confined to zone II can be managed on the basis of clinical examination alone.

In view of these studies, it is reasonable to assume that careful physical examination and watchful observation can be practiced with caution in the management of most asymptomatic patients. In stable patients whose penetrating injuries are in proximity to vascular structures, or have equivocal clinical signs, arteriography and contrast material swallow should be done as soon as possible.

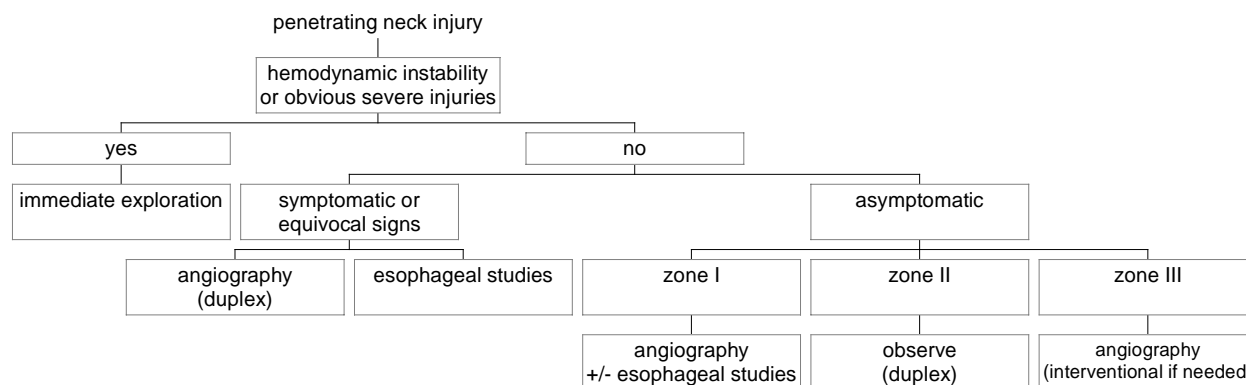


Figure 1. Algorithm for the evaluation and management of cervical wounds

The role of duplex ultrasonography as an alternative to angiography has been addressed in some studies. Demetriades et al. [23] reported the sensitivity of duplex ultrasonography in relation to arteriographic studies in 99 patients. This study showed 91.7% sensitivity and specificity of 100%, a positive predictive value of 99%, and a negative predictive value of 100%. In another study of 55 patients, Ginzburg and co-authors [31] also reported 100% sensitivity and 85% specificity (2 false negative tests) when comparing duplex to angiography or exploratory findings. Although this modality has clear advantages over angiography, it should be used with caution due to the lack of larger studies. It can be a reasonable choice in selected patients with equivocal clinical signs or when the wound is in proximity to vascular structures, provided that it is performed by experienced personnel.

Zone III

Some researchers have proposed improved investigative radiological techniques in the management of zone III injuries, where establishing proximal and distal control is difficult [12–14]. Due to the difficulty in assessing and surgically treating injuries of vital structures in this zone, the policy of routine angiography is warranted for every penetrating injury. Angiograms will either contribute to the planning of an operation if an injury is identified or allow the physician to safely manage the patient non-surgically by interventional radiological techniques such as embolization and stenting. Special consideration should be given to vertebral artery injuries that are rare but may present both diagnostic and therapeutic dilemmas. Most of these injuries are now treated by interventional radiological techniques.

Conclusion

Over the last decade numerous articles on penetrating neck injuries have appeared in the literature, shifting the pendulum from a policy of mandatory exploration of the neck towards a selective non-operative management. Recent studies recommend considerable reliance upon the initial physical examination and close follow up *by the same surgical team*. There is still debate regarding the reliability

Table 1. Considerations in the selective conservative management of penetrating neck injuries

Indications for immediate exploration of the neck	
•	Hemodynamic instability
•	Active hemorrhage
•	Hemoptysis
•	Stridor
•	Air bubbling through the wound
•	Evolving stroke
•	Airway compromise
Symptoms requiring investigation	
•	Persistent bleeding or expanding hematoma
•	Dysphonia
•	Dysphagia
•	Hematemesis
•	Absent peripheral pulses
•	Subcutaneous emphysema
•	Peripheral neurological deficit

of physical examination alone as opposed to routine angiograms in zone II injuries. Most studies, however, tend to advocate selective use of angiograms while relying on physical examination alone in asymptomatic patients. As for Zone I and III, routine mandatory arteriograms are still considered the gold standard [Figure 1]. In symptomatic patients, antero-posterior and lateral chest and cervical X-rays should be obtained to rule out retained fragments. Depending upon the physical findings and the hemodynamic, ventilatory and neurological status of the patient, other diagnostic studies should be obtained. In patients with obvious severe injuries to vital structures or with hemodynamic instability, immediate surgery should be performed without further delay [Table 1].

The use of duplex ultrasonography as an alternative to angiography, especially in zone II injuries, may be reliable, and when performed by experienced hands can be of great value. Despite a general trend toward a policy of non-surgical management and the use of newer diagnostic techniques, it is important to bear in mind the potential consequences of missed vascular and aero-digestive injuries in the neck, and to manage these challenging trauma cases by following sound general surgical principles.

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Correspondence: Dr. H. Paran, Dept. of Surgery A, Meir Hospital, Kfar Saba 44281, Israel. Tel: (972-9) 747-2105; Fax: (972-9) 899-8920; email: Paran620@green.co.il.