Management of penetrating neck injuries

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Background: **Routine surgical exploration after penetrating neck injury (PNI) leads to a large number of negative neck explorations and potential iatrogenic injury. Selective non-operative management (SNOM) of PNI is gaining favour. The present study assessed the feasibility of SNOM in PNI.**

Methods: **Seventy-seven consecutive patients with PNI presenting to a tertiary trauma centre were included in this prospective study from September 2009 to December 2009. All patients were managed according to Advanced Trauma Life Support guidelines, and either underwent emergency surgery or were managed without surgery, based on clinical presentation and/or outcome of special investigations.**

Results: **Eight patients (10 per cent) were haemodynamically unstable at presentation. Foley catheter balloon tamponade (FCBT) was successful in stopping active bleeding in six of these patients, and diagnostic angiography revealed an arterial injury in five. The remaining 69 patients were managed using SNOM. Angiography or computed tomography was done in 41 patients (53 per cent), and showed arterial injury in 15. These injuries were treated surgically (7 patients), radiologically (stenting in 3) or conservatively. Contrast swallow and/or endoscopy were performed in 37 patients (48 per cent) for suspected oesophageal injury, but yielded no positive results. During follow-up no missed injuries were detected.**

Conclusion: **FCBT was useful in patients with PNI and active bleeding. Stable patients should undergo additional investigation based on clinical findings only.**

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Introduction

The low incidence of penetrating neck injury (PNI) in many European countries makes it impossible for trauma surgeons to gain adequate management experience. Moreover, patients with stab injuries or gunshot wounds usually present to the emergency department unannounced, and therefore the local trauma team may not be prepared for immediate clinical assessment, especially in smaller hospitals.

PNI is considered difficult to manage because of the complex anatomy, immediate proximity of vital structures, and potential for rapid haemodynamic and airway deterioration[1–3]. A well prepared trauma team is essential to improve the outcome. In the past, routine neck exploration was common practice for these patients, resulting in a large number of unnecessary procedures and iatrogenic injuries[4,5]. Based on the experience from high-volume hospitals in developing countries, selective non-operative management (SNOM) is currently the standard of care[6–8].

Groote Schuur Hospital in Cape Town, South Africa, is a high-volume, tertiary referral trauma centre managing in excess of 200 patients with PNI each year[6]. The centre adheres to a treatment protocol of SNOM for PNI[6]. The present study was undertaken to evaluate the SNOM protocol.

Methods

All patients presenting with a PNI to the trauma centre in Groote Schuur Hospital, Cape Town, during an interval of

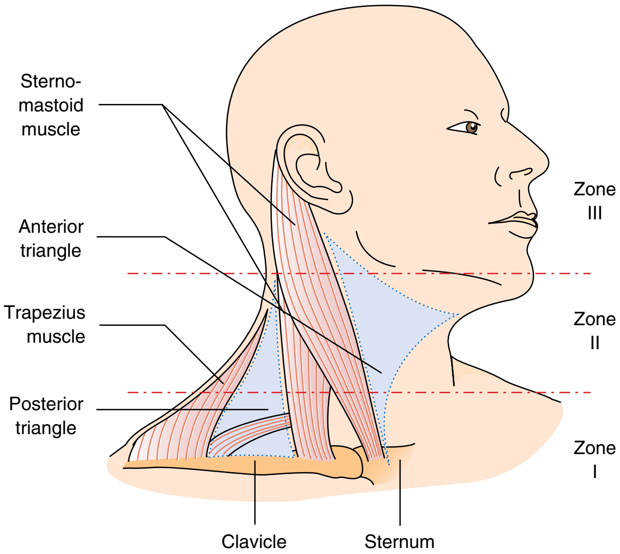

Fig. 1 Classification of zones of injury for penetrating neck injury. The neck is divided into a posterior and an anterior triangle; the anterior triangle is subsequently divided into three horizontal zones

3·5 months (September to December 2009) were included in this prospective observational study. Patients aged over 18 years with a PNI that penetrated the platysma muscle were included. Patients who died within 24 h from other injuries were excluded. Age, sex, mechanism of injury, New Injury Severity Score (NISS), clinical manifestations including presenting vital signs, indications for special investigations, viscera injured, and treatment strategy of all patients were collected prospectively and analysed. All patients were managed and treated according to the local protocol for PNI, as described below[6].

Protocol for management of penetrating neck injury

Patients with penetrating injuries of the neck were resuscitated according to the Advanced Trauma Life Support (ATLS®) guidelines. Haemodynamically stable patients and those who became stable after initial simple resuscitation (normal pulse rate, blood pressure, breathing rate, etc.) using 1–2 litres of crystalloid were evaluated with a thorough history and clinical examination. Wounds were classified according to the different anatomical zones of the neck (*Fig. 1*)[9]. A chest X-ray and a lateral soft tissue shoot-through X-ray of the cervical spine was performed in all patients to look for signs of aerodigestive or vascular trauma. Patients with a transmidline gunshot wound had routine computed tomography angiography (CTA).

Special investigations were requested according to a pre-established neck injury evaluation protocol based on clinical manifestations and findings on the plain cervical spine and chest radiographs (*Table 1*). If any additional investigations were positive and surgical intervention was needed, the patient was transferred immediately to the operating room.

Haemodynamically stable patients with a negative history and clinical examination were admitted to the high-care trauma surgical ward, with haemodynamic and airway monitoring, and clinical neck examination every 4 h by the surgical registrar on call. After 24 h an oral diet was commenced and, if tolerated, the patient was discharged 12 h later. All patients were given a neck injury form that listed alarm signs and symptoms of vascular and/or aerodigestive injuries; if these occurred, patients were advised to return to the hospital immediately.

In haemodynamically unstable patients with a bleeding neck wound, haemorrhage control was attempted by means of Foley catheter balloon tamponade (FCBT)[10,11] (*Fig. 2*). If control of the bleeding was not achieved, surgical exploration of the neck followed immediately. If haemorrhage was controlled by FCBT and the patient stabilized after

Table 1 Symptoms and signs associated with underlying visceral injuries, and investigations performed

Structure	Symptoms and signs	Investigation
Vascular	Moderate to large haematoma Pulsatile stable haematoma Pulse deficit Bruit Any mediastinal changes on chest X-ray Foley catheter balloon tamponade employed	Angiography/CTA
Pharynx/ oesophagus	Odynophagia Dysphagia Saliva leak from wound Blood in nasogastric tube Haematemesis Subcutaneous emphysema Prevertebral air on lateral cervical spine Pneumomediastinum on chest X-ray Depressed level of consciousness	Barium studies/ endoscopy
Larynx/trachea/ bronchus	Dysphonia/hoarseness Tension pneumothorax Severe surgical emphysema Persistent air leak from chest drain	Laryngoscopy/ bronchoscopy

CTA, computed tomography angiography.

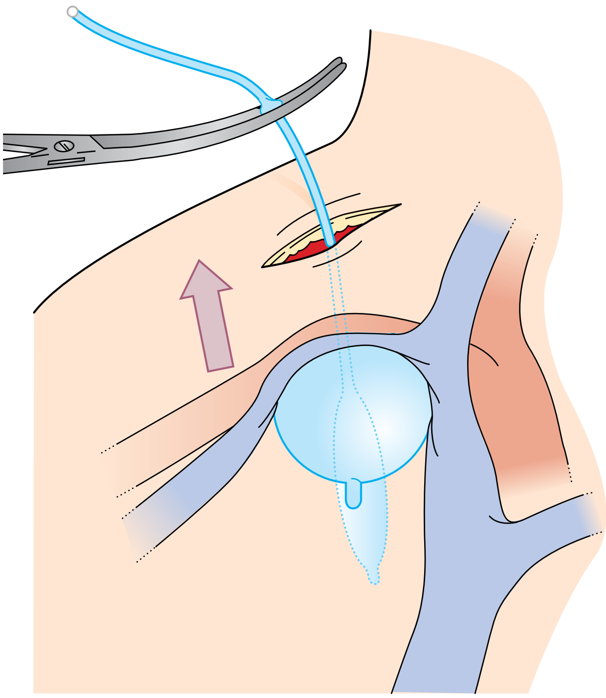

Fig. 2 Foley catheter balloon tamponade. A Foley catheter is introduced into the bleeding neck wound following the wound track. The balloon is inflated with 10–15 ml water or until resistance is felt. The catheter is clamped to prevent bleeding through the lumen. The neck wound is sutured around the catheter. Continuing bleeding around the catheter is an indication to proceed to surgery

resuscitation, angiography was undertaken. Positive findings were treated surgically or using endovascular methods. A venous injury was diagnosed if angiographic findings were normal. If no arterial injury was diagnosed, the patient was observed for 48–72 h, after which the Foley catheter was removed in the operating room. In case of rebleeding, surgical intervention was required.

Results

A total of 78 patients with PNI presented to the trauma centre during the study interval. One patient died from associated abdominal bleeding within 24 h and was excluded from the study. The median NISS of the 77 included patients was 25 (range 9–59). There were 84 neck wounds in the 77 patients; 61 patients (79 per cent) patients had 67 stab wounds, the majority in zone II of the left anterior triangle of the neck (*Table 2*).

Fifty-six patients (73 per cent) underwent one or more additional investigations because of suspected visceral injury (*Table 1*); 37 patients underwent 38 barium swallows/endoscopic investigations because of suspected oesophageal injury (dysphagia/odynophagia, 17; prevertebral air, 10; odynophagia and prevertebral air, 5; depressed level of consciousness, 3; other, 2). None of the investigations uncovered an oesophageal injury (*Table 2*). In one patient, who underwent emergency surgery because of haemodynamic instability, an oesophageal perforation at the level of the seventh cervical vertebra was found during perioperative oesophagoscopy. The lesion was repaired primarily during neck exploration. No upper airway injuries were found.

A total of ten patients had computed tomography angiography (CTA) (*Table 3*). In eight, a protocol CTA was

Table 2 Demographics of 77 patients with penetrating neck injury

	No. of patients*
Sex ratio (M : F)	70 : 7
Age (years)†	26 (17–54)
Penetrating neck injury	
Type of injury	
Stab wound	67
Gunshot wound	17
Zone of neck injury	
I	30
II	39
III	7
Posterior triangle	8
Suspected injury‡	
Vascular	
Angiography	31 (14)
CTA	10 (1)
Oesophagus	
Barium swallow	34 (0)
Endoscopy	4 (1)

*Unless indicated otherwise; †values are median (range); ‡values in parentheses are numbers of additional investigations with positive findings. CTA, computed tomography angiography.

Table 3 Indications for, and results of, vascular investigations

	Investigation	
Indication for investigation	Angiography	CTA
Haematoma	16 (4)	
Foley catheter balloon tamponade	6 (5)	
Transmidline trajectory without signs of vascular injury		8 (0)
Pulsating haematoma	4 (3)	
Pulse deficit, upper limb	3 (2)	
Haemothorax	1 (0)	1 (1)
Bruit	1 (0)	1 (0)

Values in parentheses are numbers of additional investigations with positive findings. CTA, computed tomography angiography.

performed for a transmidline gunshot injury to the neck, although there were no clinical signs of active bleeding. No vascular injuries were detected.

Seven patients with active bleeding from a neck wound were initially treated with FCBT. In one patient haemostasis could not be achieved and urgent surgery was required. The other six, in whom haemostasis was secured, were observed and underwent diagnostic angiography within 24 h. Five of these patients had an arterial injury. Three had surgery (common carotid artery, internal carotid artery, subclavian artery), one had a radiological stent (false aneurysm of subclavian artery) and one was managed conservatively (dissected and occluded vertebral artery). The Foley catheter of both patients who did not need to undergo surgery or stenting was removed in the operating room 2 days after admission. No bleeding occurred on removal of the catheter.

Besides the patients with FCBT, a further 25 underwent angiography based on standard indications (*Table 3*). Only two patients (3 per cent) needed to undergo emergency exploration of the neck because of haemodynamic instability due to bleeding. Subsequently, a further seven patients (9 per cent) underwent elective vascular surgery and three (4 per cent) were treated by radiological intervention (*Table 4*). Sixty-five (87 per cent) of all patients who were haemodynamically stable, or who could be stabilized after initial resuscitation, were treated successfully conservatively. After conservative observation, none of the patients needed intervention for late onset complications.

The median hospital stay was 2 (range 1–36) days. Two patients (3 per cent) died from cerebral ischaemia. One had a transmidline gunshot injury, and did not wake up after general anaesthesia for an emergency tracheostomy. The second patient had a stab injury and underwent primary reconstruction of the carotid artery, but postoperative brain CT showed multiple infarcts and the patient was declared brain-dead 5 days later.

Table 4 Summary of arterial injuries and their management

	Treatment
CA injuries	
AV fistula, common CA and internal jugular vein ($n = 2$)	Surgery
Active bleeding, common CA	Surgery
False aneurysm, external CA	Conservative
Dissection, internal CA	Conservative
Central subclavian artery injuries	
False aneurysm, subclavian artery ($n = 2$)	Surgery
Dissection, subclavian artery	Surgery
False aneurysm, subclavian artery	Stenting
Peripheral arterial injuries	
Occlusion, brachial artery	Surgery
False aneurysm, costovertebral branch of subclavian artery	Embolization
Active bleeding, lingual artery	Embolization
Occlusion, vertebral artery	Conservative
Dissection, vertebral artery	Conservative
Occlusion, mammary artery	Conservative

CA, carotid artery; AV, arteriovenous.

Discussion

Owing to the low incidence of PNI in Europe, it is seldom possible for a trauma surgeon to gain experience in its management and treatment. In the past, routine neck exploration was the standard treatment for PNI, which led to a high rate of negative neck exploration (a quarter of patients) and significant associated morbidity (half of patients)[6,8,12,13].

In high-volume trauma centres, SNOM is becoming accepted for PNI. It is based on clinical examination and additional investigations[13,14]. Together, they have been shown to be reliable indicators of clinically significant injury, with a sensitivity of 93–95 per cent and a negative predictive value of 97 per cent[13–17].

To achieve optimal treatment a hospital must have a well organized and dedicated trauma team. All of the patients described in the present study presented to Groote Schuur Hospital, Cape Town, which is a high-volume, tertiary-referral trauma centre where a multidisciplinary management approach for this kind of trauma is guaranteed. The protocol for assessing and treating patients with PNI is based on haemodynamic and airway status, together with a thorough physical examination. The initial management of gunshot and knife injuries is similar, as previous studies found no significant difference in the rate of successful SNOM between them[6,15]. Transmidline gunshot wounds, however, have a significantly higher rate of injury than other PNIs[18]. In the present study, eight patients with a transmidline gunshot wound underwent CTA, yet none had vascular, oesophageal or tracheal injuries, and all were treated successfully conservatively. Mandatory neck exploration would not have been useful. The value of routine CTA in patients with transmidline gunshot wounds remains debatable, especially when the patient is fully conscious[15].

Oesophageal injuries are uncommon and difficult to detect early, because clinical findings are not always obvious[19,20]. More than 90 per cent of patients survive when the diagnosis is made within 24 h, but thereafter the survival rate drops quickly[20]. Because the consequences of a missed oesophageal lesion are great, additional investigations are often done, even when the suspicion is low. Missed pharyngeal lesions are less likely to be fatal than oesophageal lesions[21,22]. Pharyngeal lesions can usually be treated conservatively with antibiotics alone, whereas oesophageal lesions needs surgery[22–24].

Vascular injuries were common in the present study. Even when vascular symptoms are present after PNI, emergency surgery is often not necessary. In patients with active haemorrhage, FCBT is indicated. Patients who are successfully stabilized with FCBT can subsequently undergo semiurgent diagnostic angiography or CTA[10,11]. Venous injuries are particularly amenable to FCBT, and in these patients it is often definitive treatment[10]. Emergency neck exploration is indicated only for the haemodynamically unstable, actively bleeding patient in whom FCBT was unsuccessful. In the present study, of seven unstable patients in whom FCBT was attempted, six stabilized and could undergo diagnostic angiography[25]. In two patients FCBT was the definitive treatment as no rebleeding occurred on removal of the catheter. Furthermore, none of the patients who were treated conservatively bled from a missed vascular injury. All of these findings indicate that initial SNOM of PNI is a feasible and safe approach[10,11,25,26].

An alternative to conventional angiography is CTA. Experience with CTA was limited in the institution at the time of the study, and was not often available after office hours. An advantage of using diagnostic angiography, however, is the possibility of proceeding to intervention (coiling or stenting), if indicated, during the same session.

Nevertheless, for diagnostic evaluation of PNI, CTA has several advantages: it is relatively fast, minimally invasive, and has fewer potential complications[1,13,27]. It is readily available in most trauma centres in Western countries. It is reliable and accurate, with a sensitivity and specificity of 90 and 100 per cent respectively, with a positive predictive value of 100 per cent and a negative predictive value of 98 per cent[1,13,27]. CTA is therefore becoming the diagnostic tool of choice during initial evaluation of stable patients with vascular injury.

The results of the present study suggest that the proposed algorithm (*Fig. 3*) should be appropriate for the management of penetrating neck injury in most trauma departments. The low failure rate also validates the SNOM protocol for initial management.

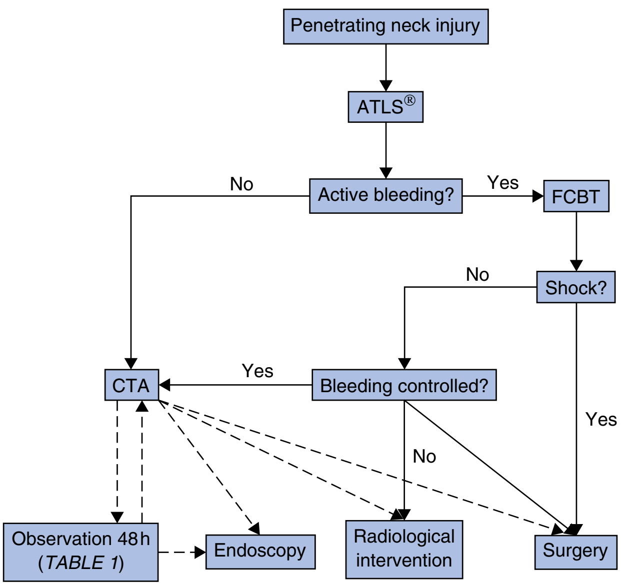

Fig. 3 Algorithm for initial management of patients with penetrating neck injury. ATLS®, Advanced Trauma Life Support; FCBT, Foley catheter balloon tamponade; CTA, computed tomography angiography

Disclosure

The authors declare no conflicts of interest.

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