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Analysis of 203 Patients with Penetrating Neck Injuries

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Abstract

Background Selective nonoperative management (SNOM) of penetrating neck injuries (PNI) has steadily gained favor, but indications for surgery and adjunctive diagnostic studies remain debated. The purpose of the present study is to validate a protocol of SNOM of PNI based on physical examination, which further dictates complementary investigations and management.

Patients and methods A prospective observational study was conducted in a South African tertiary urban trauma center with a high prevalence of penetrating trauma. All consecutive patients admitted with penetrating neck injuries over a 13-month period were included.

Results A total of 203 patients were included in the study: 159 with stab wounds and 42 with gunshot wounds. A vascular injury was identified in 27 (13.3%) patients, pharyngoesophageal injury in 18 (8.9%) patients, and an upper airway injury in 8 (3.9%) patients. Only 25 (12.3%) patients required surgical intervention. A further 8 (3.9%) patients had therapeutic endovascular procedures. The remaining 158 (77.8%) patients, either asymptomatic or with negative work-up, were managed expectantly. There were no clinically relevant missed injuries.

Conclusions Selective nonoperative management of neck injuries based on clinical examination and selective use of adjunctive investigational studies is safe in a high-volume trauma center.

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Introduction

Penetrating neck injuries (PNI) are a common occurrence in the urban trauma population. The risk of airway, vascular, neurological, and/or pharyngoesophageal injuries leads to many difficult diagnostic decisions. While some clinicians advocate mandatory neck exploration for asymptomatic patients with PNI [1], selective nonoperative management (SNOM) has slowly gained favor [2–6]. The routine application of specialized diagnostic investigations, some of which are invasive, for stable, asymptomatic patients remains controversial [4, 5, 7–13]. The aim of the present study was to validate a protocol of SNOM of PNI based on history and physical examination, findings of which determine further investigations and management.

Patients and methods

Groote Schuur Hospital in Cape Town, South Africa, is a tertiary referral university hospital with a busy urban trauma center with a high incidence of penetrating trauma. The details of patients presenting with penetrating neck injuries that breached the platysma muscle were prospectively collected on a neck injury computer database from July 2004 to July 2005 (13 months). Patients with superficial neck wounds and those who died prior to admission were excluded. The data were retrospectively analyzed for demographics, mechanism of injury, hemodynamic status, triangle and zone/s of injury, clinical manifestations, indications for special investigations, viscera injured, operative or conservative management, and outcome. All patients were initially resuscitated according to the Advanced Trauma Life Support (ATLS®) guidelines [14]. Hemodynamically unstable patients were transferred

immediately to the operating room. Foley catheter balloon tamponade (FCBT) was used in an attempt to gain temporary hemorrhage control in actively bleeding patients. If no major arterial injury was detected at angiography, the patient was observed and the catheter removed in 48–72 h in the operating room. Surgical intervention was performed if bleeding occurred [15]. Hemodynamically stable patients and those whose condition stabilized after simple resuscitation were evaluated with a thorough systemic enquiry and clinical examination. Patients with airway compromise with hemodynamic stability, were intubated either by oral endotracheal intubation or, if that failed, emergency cricothyroidotomy. Once an airway was established and the patient remained stable, investigations were performed as indicated. Wounds were described as related to the different triangles and zones of the neck: posterior triangle: posterior to the posterior border of the sternocleidomastoid muscle; anterior triangle: anterior to the posterior border of the sternocleidomastoid muscle. Wounds in the anterior triangle were further classified into 3 zones, as follows: zone 1: sternal notch to cricoid cartilage, zone 2: cricoid cartilage to angle of the mandible; and zone 3: superior to the angle of the mandible.

After a thorough history and clinical examination, a chest and a lateral soft-tissue cervical spine radiograph was obtained. Special investigations were selectively requested according to a pre-established neck injury evaluation protocol (Table 1). Angiographic embolization was attempted for accessible small-vessel false aneurysms. Patients requiring surgical intervention were transferred to the operating room for immediate or delayed definitive surgical care, according to the type of injury. Isolated pharyngeal injuries were managed nonoperatively with antibiotics and nasogastric tube feeds for a period of 7–10 days. Patients with a negative clinical examination and/or special investigations were admitted to the high-care area in the trauma surgical ward for serial clinical neck examination (4-hourly) and, hemodynamic and airway monitoring. Patients were fed the next morning and if tolerating an oral diet, discharged the following day with a neck injury form that listed all the symptoms of a vascular and aerodigestive injury. The patient was instructed to return immediately if any of the symptoms developed.

The chi-square test was used for the categorical variables. A p value <0.05 was considered statistically significant.

Table 1 Symptoms and signs associated with underlying visceral injuries and investigation performed

Structure	Symptoms/signs	Investigation
Pharynx/ esophagus	Odynophagia	Esophogram
	Dysphagia	±Endoscopy
	Saliva leak from wound	
	Blood in nasogastric tube (NGT)	
	Hematemesis	
	Subcutaneous emphysema	
	Prevertebral air on lateral cervical spine	
	Pneumomediastinum on chest x-ray (CXR)	
Larynx	Dysphonia/hoarseness	Laryngoscopy
Trachea/ bronchus	Tension pneumothorax	Bronchoscopy
	Severe surgical emphysema	
	Persistent air leak from chest drain	
Vascular	Moderate to large hematoma	Angiography
	Pulsatile stable hematoma	
	Pulse deficit	
	Bruit	
	Any mediastinum changes on CXR	
	Transmidline gunshot	
	Foley-catheter balloon tamponade	

Results

During the 13-month study period, 203 patients with PNI were admitted to the trauma center. There were 184 men and 19 women, with a mean age of 29.5 years (range: 16–66 years). Forty-two (20.7%) patients sustained gunshot wounds (GSW), and 159 (78.3%) had stab wounds (SW); two had other types of penetrating neck injury: one automobile part related to a motor vehicle accident, and one part of an explosive device. Fourteen patients had multiple GSW involving the face, torso, or limbs and 54 patients sustained multiple stab wounds. All GSW were of the low velocity-type. There were no shotgun injuries. Among the GSW victims, 9 had either the entry wound or the exit wound outside of the cervical area, 47 had multiple gunshot wounds to the neck, 18 of which had transmidline trajectories according either to entry and exit wound or to the bullet position on the neck x-ray. Among GSW victims, 14 had no exit wounds with retained bullets.

Some 177 patients were hemodynamically stable at the time of presentation; 25 others were initially unstable but responded rapidly to simple fluid (1–2 l crystalloid) resuscitation. Only one patient who remained unstable and failed Foley-catheter balloon tamponade, leading to an emergency neck exploration for repair of a common carotid artery injury and ligation of an internal jugular vein injury. Overall there were 29 (14.2%) zone 1, 73 (36%) zone 2, 37 (18.2%) zone 3, and 86 (42.4%) posterior triangle injuries.

Twenty-five (12.3%) patients were treated surgically for 53 visceral injuries (Table 2). Sixteen neck explorations were performed for vascular or aerodigestive injuries. In

Table 2 Injuries detected and their management (operative versus nonoperative) according to mechanism

		Total	SW	GSW	Other	*p* Value[a]
Total		203	159	42	2	
Vascular		27	16 (10.1%)	10 (23.8%)	1	<0.05
Surgery	14		10 (6.3%)	4 (9.4%)	0	NS
Nonoperative	5		1 (0.63%)	4 (9.4%)	0	<0.01
Endovascular	8		5 (3.1%)	2 (4.8%)	1	NS
Digestive tract		18	9 (5.7%)	8 (19%)	1	<0.01
Surgery (including tracheostomy)	7		3 (1.96%)	4 (9%)	0	<0.02
Nonoperative	11		6 (3.8%)	4 (9.5%)	1	NS
Airway		8	4 (2.5%)	3 (7.1%)	1	NS
Surgery (including tracheostomy)	4		1 (0.63%)	3 (7.1%)	0	0.01
Nonoperative	4		3 (1.9%)	0	1	NS
Total		53	29 (18.2%)	21 (50%)	3	<0.01

NS not significant, *SW* stab wound, *GSW* gunshot wound

[a] Compares incidences for SW versus GSW

addition, three patients required sternotomy for proximal vascular control. Six patients had a tracheostomy: four had oropharyngeal injuries with mandibular fractures with severe intraoral swelling compromising the airway, one had a laryngeal injury, and one patient with a complete C4-level paralysis following spinal cord injury required long-term ventilation. One SW patient with a negative work-up required a delayed incision and drainage procedure for a deep wound abscess; there was no associated oropharyngeal injury. Overall surgical treatment and emergency surgery were more frequently necessary in patients with GSW than in those with stab wounds ($p < 0.001$). Transmidline GSW (TMGSW) were more likely to produce organ injuries than non-transmidline GSW (NTMGSW) ($p < 0{,}001$), but there was no difference in the frequency of surgical intervention following TMGSW or NTMGSW. The overall injury rate and length of hospital stay were significantly greater for GSW patients than for SW patients ($p < 0{,}001$). There were no negative neck explorations.

Vascular injuries and management

Eighty-three patients (40.9%) had four-vessel digital subtraction angiography and five patients had a color flow duplex-Doppler examination, that revealed arterial injuries in 24 patients (Table 3). Eight patients underwent endovascular intervention during the same angiography session. Transluminal embolization failed in one patient who had subsequent operative ligation of a proximal left vertebral artery injury. In total, 14 patients required surgical repair of a vascular injury. Foley catheter balloon tamponade for temporary control of bleeding was used in 18 patients. Seventeen of these had angiograms, three of which revealed arterial injuries that were subsequently repaired. One patient cited earlier had urgent neck exploration without angiogram because of ongoing bleeding, and one bled on removal of the catheter after 72 h and underwent neck exploration for ligation of the internal jugular vein. There was no delayed detection of any missed vascular injury during the mean 24-h in-hospital neck observation period.

Table 3 Angiography indications and vascular injuries detected

Indication for angiography	
Pulse deficit (upper limb)	7
Bruit and/or thrill	12
Pulsating hematoma	8
Moderate to large hematoma	14
Foley-catheter balloon tamponade	18
Transmidline trajectory	24
Arterial injuries detected at angiography	
Carotid	13
Common	3
Internal	4
External	1
Branches of external	5
Vertebral	7
Subclavian	3
Branch of subclavian	1

Patients presenting with a pulse deficit, bruit, thrill, pulsating hematoma, or arterial bleeding on initial clinical examination were found to have a significantly higher incidence of vascular injuries than those without these signs ($p < 0.001$). The use of a Foley-catheter balloon for hemorrhage tamponade and transmidline wound tract, were

found not to be statistically significant signs of a vascular injury.

Digestive tract injury and management

Table 4 shows the clinical manifestations suggestive of digestive tract injury, investigations performed, and their sensitivity and specificity. A total of 99 esophograms and 17 esophagoscopiesy/pharyngoscopies were performed. Sixteen patients had both studies. Digestive tract injuries were identified in 18 patients (8.9%), and 15 (7.4%) were pharyngeal injuries. Fifteen of these injuries were identified by either esophogram or direct pharyngoscopy. Only three patients with pharyngeal injury had surgical treatment: two had maxillofacial bony lesion debridement; the pharyngeal injury itself was not explored but was managed conservatively, and one patient who required an emergency neck exploration for a vascular injury without diagnostic work-up, had a pharyngeal tear that was identified intraoperatively and repaired. In 12 patients, the pharyngeal injury was treated nonoperatively with antibiotic therapy and nasogastric tube feeds. None of these patients had local complications and none required delayed surgical intervention. Patients complaining of odynophagia, dysphagia, or presence of blood in the mouth and patients with a transmidline wound tract were found to have a significantly higher incidence of pharyngeal injuries than those without these signs and symptoms ($p < 0.001$). Esophageal injuries were identified in three patients, all of whom had clinical manifestations suggestive of digestive tract injury. Barium swallow was positive in only one case, but was technically suboptimal and could not differentiate between a pharyngeal leak and an esophageal leak. Esophagoscopy was performed in two patients and identified the esophageal injury in both cases. One esophageal injury was identified intraoperatively in a patient with a normal barium swallow who required urgent neck exploration for a vascular injury.

Airway injuries and management

Upper airway injuries were identified in eight (3.9%) patients, four with tracheal injuries and four with laryngeal injuries. Three patients with laryngeal injuries were managed conservatively, and one needed a tracheostomy. No laryngeal injury needed surgical repair. Two patients with tracheal injuries were managed surgically, one by temporary tracheostomy (tracheal injury being above) and one by direct surgical repair of the trachea. The latter patient needed neck exploration for repair of an associated vascular injury. None of these patients presented with upper airway compromise. Subcutaneous emphysema, sucking wound, hemoptysis, and hoarseness were all statistically associated with a higher incidence of upper airway injury ($p < 0.001$).

Nonoperative management

In this cohort of patients 158 (77.87%) were managed nonoperatively with a mean hospital stay of 31.2 h (range: 22–34 h). They were discharged with a neck injury form with no follow-up. None of these patients returned and there were no deaths.

Discussion

Recent publications have highlighted the ongoing controversy about the assessment and surgical and nonsurgical management of penetrating neck injuries [7–10, 12]. Trauma centers managing a high number of PNI have adopted a policy of SNOM, where investigation protocols are essentially based on clinical examination [3, 11, 15–19]. Centers less frequently confronted with PNI have a lower threshold for adjunctive investigation studies, and therefore most of their PNI patients undergo exploration [2, 12].

Table 4 Diagnostic evaluation of digestive tract injuries

Clinical manifestations	*N*	Esophageal injury (3) (sensitivity/specificity)	Pharyngeal injury (15) (sensitivity/specificity)
Odynophagia	71	2 (66.7/65.5)	9 (60/67)
Dysphagia	11	1 (33.3/95)	5 (33.3/96.8)
Blood in mouth	16	0 (0/92)	6 (40/94.6)
Saliva in wound	9	1 (33.3/96)	2 (13.3/96.3)
Subcutaneous emphysema	32	1 (33.3/84.5)	1 (6.7/83.5)
Prevertebral air	48	1 (0/76)	6 (33.3/77.1)
Transmidline trajectory	24	1 (33.3/88.5)	6 (46.6/90.9)
Diagnostic tests			
Esophogram	99	1	3
Endoscopy	17	2	13

The setting of this study is a high-volume trauma center (~11,000 patients/year) managing a very high number of penetrating trauma victims (~200 PNI/year). Mandatory neck exploration results in a high negative rate (30–89%) in asymptomatic patients [2, 3, 9, 12]. Our management protocol for PNI is based essentially on hemodynamic and airway status, together with the physical examination. There is no difference in initial management regarding the mechanism of injury. This study identified more injuries following GSW than that following SW, which explains the significantly longer hospital stay after GSW and the higher rate of emergency surgical treatment following GSW. The rate of therapeutic neck exploration, endovascular treatment, or debridement procedures was not significantly different between GSW and SW patients. The number of tracheostomies performed following GSW was significantly higher and the indication was mostly severe associated mandible fractures and intraoral soft-tissue swelling. There is no statistically significant difference in the rate of conservative management between GSW and SW, which means that it is not possible to predict whether management is more likely to be conservative according to the type of assault. In view of these facts, it appears that the rate of injuries necessitating direct surgical repair is not higher in either group and that initial management should not be different for GSW and SW. It seems reasonable and safe to pursue SNOM of GSWs to the neck, as already proposed by others [16, 20]. Nevertheless, the analysis shows that TMGSW lead to a significantly higher rate of injuries than NTMGSW, and the risk of organ damage by TMGSW is higher, both because these traumas involve at least two zones of the neck and the projectile potentially crosses all major organ systems. Only four (22.2%) patients with TMGSW underwent therapeutic neck exploration. Mandatory neck exploration as proposed by some authors [1, 21] would have been nontherapeutic in 77.7% of these patients, which further supports the feasibility of SNOM in TMGSW as proposed by Demetriades et al. [22].

Vascular structures were the most frequently injured organs in this study. While some authors advocate mandatory vascular imaging following PNI according to mechanism [7, 16] or zone [2, 12, 13], many studies have demonstrated the reliability of physical examination alone to exclude clinically relevant vascular injuries [3, 5, 8–11, 22–24].

At our institution angiography is the mainstay of investigation because Doppler examination is rarely available after hours. Angiography also has the potential for interventional procedures during the same session. Endovascular intervention was performed in 8 (29.6%) of the 27 patients with positive angiograms. The incidence of vascular injury among patients presenting with pulse deficit, thrill, bruit, pulsating hematoma, and witnessed arterial bleeding was found to be significantly higher; while this could not be demonstrated for patients with moderate to large hematomas, the need for Foley-catheter tamponade and those with transmidline trajectories. The negative predictive value (NPV) and specificity although of all these signs and symptoms mandating angiography according to our protocol is high, 88.6%–95.5% and 90.7%, respectively.

The absence of any of the clinical signs and symptoms given above reasonably excludes significant vascular injury. The fact that no patient in our series unexpectedly bled from a missed vascular injury during in-hospital observation confirms the safety of the SNOM protocol for the detection of clinically relevant vascular injuries. One patient had delayed bleeding from an internal jugular vein injury that was initially controlled by Foley catheter tamponade and that bled after controlled removal of the catheter in the operating room. This case highlights the value of temporary control of major venous injuries with normal angiograms, and justifies the deflation and removal of the Foley catheter in the operative setting [15].

No patient in this study had a computerized tomography (CT) scan of the neck as a screening adjunct. We have subsequently introduced into our protocol a single-slice spiral CT scan with intravenous contrast for stable patients with TMGSW. When the results of this scan show the missile trajectory away from major vascular and aeordigestive structures, it is clear that the patient requires no further evaluation, as described by Gracias et al. [25].

Missed pharyngoesophageal injuries are among the most feared pitfalls in penetrating neck trauma, because clinical signs are not always obvious and delay in their treatment may lead to major morbidity and even death [6, 17, 26, 27]. Pharyngeal injuries were often obvious on presentation and intraoral examination. The difficulty lies in the diagnosis of occult injuries to the hypopharynx that could easily be missed by simple clinical examination. Patients presenting with blood in the mouth, odynophagia, dysphagia, or a transcervical wound tract have been found to have a significantly higher incidence of pharyngeal injuries than those without these clinical manifestations. In our series no patient had a delayed presentation or complications from a missed pharyngeal injury during hospitalization. The negative predictive value of all signs leading to ancillary pharyngeal investigation were high (91.8–95.5%), implicating a low rate of false negative clinical examinations. Our management of pharyngeal injuries is conservative, unless there is major facial bony destruction that needs debridement or swelling that is causing airway obstruction. Pharyngeal injuries discovered during emergency neck exploration are repaired and drained. Conservatively managed pharyngeal injuries are managed by enteral feeding through a nasogastric tube and antibiotic coverage for 10 days.

Esophageal injuries were identified in only three of our patients. The only symptoms and clinical signs associated with a higher rate of esophageal injury are dysphagia and saliva in the wound, although the negative predictive value of all clinical signs implicating adjunctive esophageal studies according to our protocol was high (98.4–98.9%). Conservative treatment failed in one patient whose injury was situated at the pharyngoesophageal junction and led to pharyngocutaneous fistula. Although this patient had a longer hospital stay, the outcome was good. Although some authors report successful conservative management of small esophageal injuries [17, 28] our results do not sustain this attitude, essentially because of the small number of esophageal injuries identified and the resulting high failure rate of conservative management. Single- and multicenter studies have shown a higher complication rate and a worse outcome of esophageal injuries with prolonged delay to surgical treatment [26, 29].

In summary, on the basis of our results, we advocate conservative management of uncomplicated pharyngeal injuries with a low threshold for adjunctive studies in the case of suspected esophageal injuries. Esophageal injuries must be addressed surgically and without delay. Some minor injuries could probably be treated conservatively, but because criteria for conservative management have not been clearly established, and because complications of failure are serious, we advocate surgical treatment of all demonstrated esophageal injuries.

Upper airway injuries were fairly uncommon in our series (3.9%), but those patients who had such injuries displayed clinical manifestations suggestive of airway injury. The presenting symptoms or signs mandating further airway investigation studies according to our protocol revealed a significantly higher rate of airway injuries than in asymptomatic patients. Four patients (50%) were treated conservatively and three had a temporary tracheostomy. Only one patient with through-and-through tracheal injury after TMGSW needed tracheal repair. No patient needed delayed treatment of a missed airway injury. The other four airway injuries were treated conservatively without complications. The major concern about upper airway injuries is loss of airway, especially during intubation [30, 31]. Failed intubation mandating emergency surgical preservation of the airway did not occur in the study population. However, this might not be representative of all such cases because of the small number of airway injuries encountered. Clinical examination alone was found to have a high negative predictive value for absence of laryngotracheal injury, and the selective use of tracheoscopy appears to be safe based on the absence of clinical signs. Conservative management of clinically minor airway injuries appears to be safe, and tracheostomy should be performed for destructive injuries or when swelling compromises the upper airway. Because systematic endoscopic or radiologic investigations of the aerodigestive structures of the neck were not performed, and because minor injuries to these systems have been successfully treated conservatively [17, 28], it is possible that clinically irrelevant injuries were not detected with our management protocol.

As other investigators have shown, the results of the present study further validate the conviction that a clinical examination that dictates adjunctive diagnostic investigations will exclude clinically significant injury (Table 5). The low failure rate of SNOM and the high negative predictive values of the symptoms and signs leading to adjunctive studies validate this protocol for the safe initial management of PNI. In most cases a 24-h in-hospital observation period with repeated clinical assessment is mandatory to detect and rapidly address occult injuries. A low threshold should be kept for esophageal investigation. The mechanism of injury (SW or GSW) does not change the initial evaluation and treatment of PNI that are based on clinical and physiological findings. Low rates of detected laryngotracheal and esophageal injuries mandate further studies to identify specific criteria for nonoperative management of these injuries following PNI. Our institutional algorithm is shown in Fig. 1.

Table 5 Large prospective studies of penetrating neck injuries treated by selective conservative management

Author/year	*N*	Observed (%)	Surgery (%)	Negative findings (%)	Mortality (%)
Campbell and Robbs 1980 [18]	108	82	24	0	1.2
Narrod and Moore 1984 [19]	77	29	62	15	0
Ngakane et al. 1990 [17]	109	97	3	0	1.8
Demetriades et al. 1993 [11]	335	80	20	15	0
Demetriades et al. 1997 [3]	223	83	17	2.7	1
Current study, 2008	203	87.7[a]	12.3	0	0

[a] Includes 12 conservatively managed pharyngeal injuries and 8 patients undergoing endovascular procedures

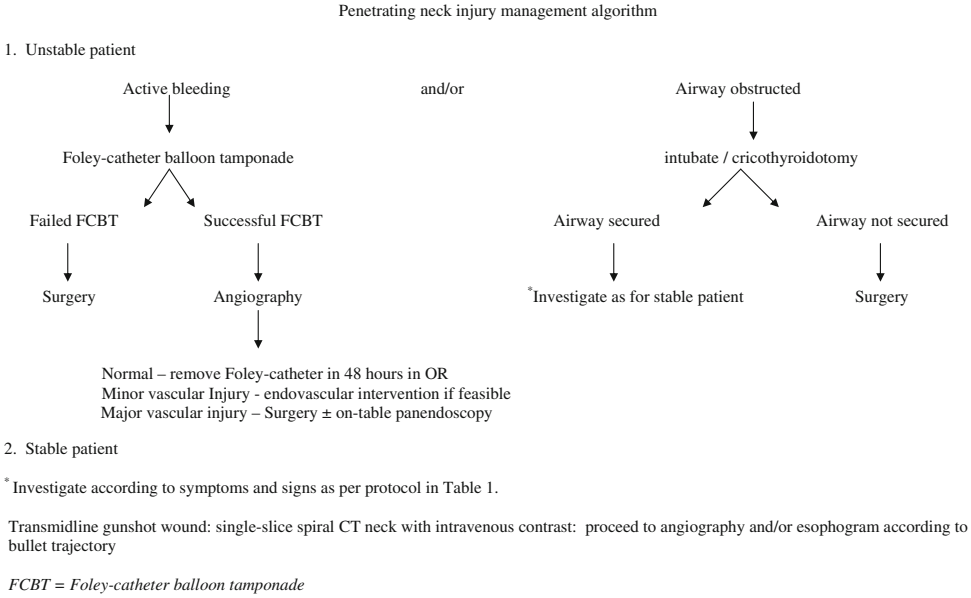

Fig. 1 Institutional penetrating neck injury management algorithm.

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