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A comparative audit of gunshot wounds and stab wounds to the neck in a South African metropolitan trauma service

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ABSTRACT

INTRODUCTION The aim of this comparative study of gunshot wounds (GSWs) and stab wounds (SWs) to the neck was to quantify the impact of the mechanism of injury on the outcome and management of penetrating neck injury (PNI).

METHODS A prospective trauma registry was interrogated retrospectively. Data were analysed pertaining to demographics and injury severity score (ISS), physiology on presentation, anatomical site of wounds and injuries sustained, investigations, management, outcome and complications.

RESULTS There were 452 SW and 58 GSW cases over the 46 months of the study. Patients with GSWs were more likely to have extracervical injuries than those with SWs (69% vs 63%). The incidence of a 'significant cervical injury' was almost twice as high in the GSW cohort (55% vs 31%). For patients with transcervical GSWs, this increased to 80%. The mean ISS was 17 for GSW and 11 for SW patients.

Those in the GSW cohort presented with threatened airways and a requirement for an emergency airway three times as often as patients with SWs (24% vs 7% and 14% vs 5% respectively). The incidence among GSW and SW patients respectively was 5% and 6% for airway injuries, 12% and 8% for injuries to the digestive tract, 21% and 16% for vascular injuries, 59% and 10% for associated cervical injuries, 36% and 14% for maxillofacial injuries, 16% and 9% for injuries to the head, and 35% and 45% for injuries to the chest. In the GSW group, 91% underwent computed tomography angiography (CTA), with 23% of these being positive for a vascular injury. For SWs, 74% of patients underwent CTA, with 17% positive for a vascular injury. Slightly more patients with GSWs required operative intervention than those with SWs (29% vs 26%).

CONCLUSIONS Patients with GSWs to the neck have a worse outcome than those with injuries secondary to SWs. However, the proportion of neck injuries actually requiring direct surgical intervention is not increased and most cases with PNI secondary to GSWs can be managed conservatively with a good outcome. Imaging should be performed for all GSWs to the neck.

KEYWORDS

Penetrating neck injury – Gunshot wounds – Stab wounds

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The management of penetrating neck injury (PNI) has evolved from a strategy of mandatory exploration to a policy of selective non-operative management (SNOM) based on diagnostic imaging modalities and physical examination.[1–11] Many of these algorithms were derived from clinical audits of predominantly stab wounds (SWs) to the neck. As the frequency of gunshot wounds (GSWs) increased around the world, so some authors tended to treat the two wounding mechanisms as essentially similar and apply SNOM approaches to both groups.[7–9,11] However, the two wounding mechanisms are quite distinct.[12,13]

The magnitude of damage, secondary to a GSW to the neck, is extensive, and clinical signs of injury are often minimal and difficult to elicit.[4,6,14] In light of this, some authors advocated mandatory neck exploration for all GSW cases.[2,4] This was especially felt to be necessary if the trajectory of the bullet crosses the midline.[15] In our institution, we have tended to follow a SNOM philosophy for trauma. This comparative audit of GSWs and SWs to the neck was undertaken to evaluate this strategy, and to focus particularly on the differences between GSWs and SWs.

Methods

The Pietermaritzburg Metropolitan Trauma Service maintains a prospective digital trauma registry. Ethics approval to maintain the registry has been obtained from the Biomedical Research Ethics Committee of the University of KwaZulu-Natal and from the Research Unit of the Department of Health.[16] All patients presenting to the emergency department with signs of life and a SW or GSW to the neck between January 2011 and November 2014 were included in the

study. The two groups were then compared. The GSW cohort was also divided into those cases with a transcervical trajectory and those without (TCGSW and non-TCGSW). Data were retrieved on all corpses with a PNI at the medicolegal mortuary for the same period.

Classification

Neck wounds were classified as either anterior or posterior to the posterior border of the sternocleidomastoid muscle. Anterior wounds were further subclassified into the traditional three zones of the neck.[3]

Management

Patients are managed according to *Advanced Trauma Life Support*® protocols.[17] Non-responders and transient responders are subjected to urgent operative exploration. Stable patients with a SW to the neck are investigated selectively if they have hard or soft signs of vascular injury and/or aerodigestive tract injury. Computed tomography angiography (CTA) excludes vascular injury, and identifies aerodigestive tract injuries by demonstrating subtle amounts of surgical emphysema and delineating the trajectory of the penetrating object. Formal catheter directed angiography (CDA) is used selectively. The indications for CDA include equivocal CTA findings, obscuring artefacts that compromise CTA interpretation and cases amenable to endovascular therapy. Water soluble contrast swallow is used selectively to exclude pharyngeal and oesophageal injuries. Oesophagoscopy and bronchoscopy are reserved for select cases.

Results

Over the 46 months of the study, 510 patients were managed with PNI. The majority of these injuries (n=452, 89%) were secondary to SWs, with 58 (11%) being secondary to GSWs. Both cohorts shared a similar sex and age distribution. Patients with GSWs were more likely to have extracervical injuries. The mean injury severity score (ISS) was higher for the GSW group. The offending weapons used to inflict injury are described in Table 1.

Table 1 Study demographics

	GSW	SW
Patients		
Number of patients	58 (11.4%)	452 (88.6%)
Mean age in years	30.8 (range: 8–61)	29.0 (range: 11–73)
Female Male	6 (10.3%) 52 (89.7%)	42 (9.3%) 410 (90.7%)
Isolated cervical injuries	18 (31.0%)	169 (37.4%)
Additional injured regions	40 (69.0%)	283 (62.6%)
Significant cervical injury: all PNI	32 (55.2%)	139 (30.8%)
Significant cervical injury: TCGSWs	16/20 (80.0%)	N/A
Multiple injured cervical structures	18 (31%)	23 (5%)
Mean injury severity score	17 (range: 2–75)	11 (range: 2–75)
Weapons		
Low velocity firearm	54 patients	
Shotgun	3 patients	
Air rifle	1 patient	
Knife		293 patients
Bottle		54 patients
Screwdriver		11 patients
Spear		4 patients
Other penetrating objects		10 patients
Unknown		80 patients

GSW = gunshot wound; SW = stab wound; PNI = penetrating neck injury; TCGSWs = transcervical gunshot wounds

Physiology on presentation

The GSW cohort presented with threatened airways and a requirement for an emergency airway three times as often as patients in the SW group. Patients with a GSW had a lower Glasgow coma scale score and were hypothermic twice as often as those with a SW. Fourteen per cent of GSW patients were hypotensive on admission compared with eleven per cent of SW patients.

Anatomical distribution of wounds

Zone 2 was the most commonly injured zone for GSW cases and zone 1 the most common for SW cases. Twenty of the fifty-eight GSWs were transcervical.

Cervical injuries

The incidence of significant cervical injury was almost twice as high for GSWs (55%) as for SWs (31%). The incidence of such injury secondary to TCGSWs was 80%. Multiple cervical injuries were seen six times as often in the GSW cohort as among SW patients.

Airway and digestive tract injuries

Airway injuries were slightly more common in the SW group, as were injuries to the trachea, whereas injuries to the larynx were more common in GSW patients. All airway injuries secondary to GSWs required formal repair with a tracheostomy. Half of the airway injuries secondary to SWs were managed operatively, and two of the five repaired laryngeal injuries and five of the seven repaired tracheal injuries at the cervical level were protected with a tracheostomy. Digestive tract injuries occurred almost twice as often in the GSW cohort as among SW cases. Only one of the three patients with pharyngeal injuries secondary to GSWs was managed conservatively whereas more than half of the cases in the SW cohort with this injury were managed conservatively. Table 2 summarises the airway and digestive tract injuries.

Table 2 Airway and digestive tract injuries

Region	Structure	Management	GSW (*n*=58)	SW (*n*=452)
Airway			3 (5.2%)	27 (6.0%)
	Larynx		2 (3.4%)	5 (1.1%)
		Repair	2 (100%) (all received tracheostomy)	5 (100%) (2 received tracheostomy)
		Conservative	0 (0%)	0 (0%)
	Trachea – cervical		1 (1.7%)	17 (3.8%)
		Repair	1 (100%) (received tracheostomy)	7 (41.2%) (5 received tracheostomy)
		Conservative	0 (0%)	10 (58.8%)
	Trachea – thoracic		0 (0%)	5 (1.1%) (1 secondary to an extracervical SW)
		Repair		2 (40.0%)
		Conservative		3 (60.0%)
Digestive tract			7 (12.1%)	34 (7.5%)
	Pharynx		3 (5.2%)	21 (4.6%)
		Repair	2 (66.7%)	9 (42.9%) (1 leaked)
		Debridement and drainage	0 (0%)	1 (4.8%)
		Conservative	1 (33.3%)	11 (52.4%) (1 leaked)
	Oesophagus – cervical		4 (6.9%)	12 (2.7%)
		Repair	2 (50.0%) (1 leaked)	9 (75.0%) (2 leaked)
		Debridement and drainage	0 (0%)	3 (25.0%)
	Conservative	2 (50.0%) (1 palliative care)	0 (0%)	
	Oesophagus – thoracic		0 (0%)	1 (0.2%)
		Repair	0 (0%)	0 (0%)
		Conservative	0 (0%)	1 (100%)

GSW = gunshot wound; SW = stab wound

Vascular injuries

Half (50%) of all patients with vascular injuries secondary to GSWs had multiple injuries as opposed to only 22% of those with SWs. The internal jugular vein was the most commonly injured vein in both groups. The two cohorts differed in the spectrum of arterial injuries, with the most common injured artery secondary to SWs being the subclavian artery whereas in GSW patients, carotid artery injuries predominated. Table 3 summarises the vascular injuries.

Associated injuries

Patients with a GSW were ten times more likely to sustain a cervical spine fracture than those with a SW and more than six times as likely to have an associated spinal cord injury. All patients in the GSW cohort with a spinal cord injury had an associated fracture compared with only 50% in the SW group. The incidence of an injury to the brachial plexus was four times more common after sustaining a GSW compared with a SW and the incidence of ischaemic cerebral or cerebellar infarcts was twenty times as high. Table 4 shows the distribution of associated cervical injuries and injuries to juxtaposed regions, some of which were caused by PNI. A haemopneumothorax was seen in 2% of GSW patients as opposed to 16% in the SW cohort. Table 4 summarises these associated injuries.

Investigations

In the GSW group, 91% of patients underwent CTA and in 23% of these, a vascular injury was identified. Only 74% of cases with SWs were investigated with CTA and a vascular injury was identified in 17% of these patients. The percentages of patients in the two cohorts investigated further with water soluble contrast swallow were similar. Slightly more injuries were identified among the GSW cases. Table 5 summarises the investigations.

Management

A greater proportion of patients with GSWs required operative intervention compared with those with SWs (29% vs 26%). However, 7% of patients requiring an operative intervention in the SW group were managed with an endovascular technique compared with none of the GSW patients. All in the

Table 3 Vascular injuries

		GSW (*n*=58)	SW (*n*=452)
Vascular injuries		12 (21%)	74 (16%)
Multiple vascular injuries		6 (50%)	16 (22%)
Distribution of injuries secondary to PNI	Cervical neck	8 (62%)	36 (47%)
	Root of the neck	5 (39%)	34 (44%)
	Mediastinum	0 (0%)	7 (9%)
Number of injured vessels		20	92
Cervical neck		15	43
	Internal jugular vein	6	25
	Internal carotid artery	3	3
	ECA	2	1
	Common carotid artery	2	8
	Branches of the ECA	2 (maxillary)	2 (facial and maxillary)
	External jugular vein	0	2
	Anterior jugular vein	0	2
Root of the neck		5	42
	Vertebral	4	6
	Subclavian artery	1	12
	Subclavian vein	0	10
	Axillary artery	0	3
	Thoracic duct	0	3
	Thyrocervical trunk / inferior thyroid artery	0	3
	Costocervical artery	0	1
	Deep cervical artery	0	1
	Dorsal scapular artery	0	1
	Internal thoracic artery	0	1
	Arterial trapezius muscle bleed	0	1
Mediastinum		0	7
	Innominate artery	0	4
	Aorta – arch	0	2
	Aorta – descending	0	1

GSW = gunshot wound; SW = stab wound; PNI = penetrating neck injury; ECA = external carotid artery

GSW cohort who underwent surgery for PNI had prior imaging. Of the 98 patients operated on for PNI secondary to SWs, 28 (29%) underwent emergency surgery without prior imaging. The majority of these operations were for vascular injuries. Three of these patients underwent a negative neck exploration without demonstration of any visceral injury. Excluding three patients selected for palliative care and two who exsanguinated in the emergency department, the percentage of cases managed conservatively was 78% for both groups. Table 6 summarises the management of these patients.

Transcervical vs non-transcervical gunshot wounds

Of the 58 GSWs, 20 (34%) were transcervical. Sixteen (80%) of the TCGSWs represented a significant injury (Table 1). Almost half (44%) of these involved a threatened airway and a third (31%) required an urgent airway intervention. Half of the 16 TCGSW cases required intensive care unit admission after surgery.

Outcome

Patients with PNI secondary to GSWs were admitted for twice as long compared with those with SWs and three times as

Table 4 Associated cervical injuries and injuries to adjacent regions

		GSW (*n*=58)	**SW** (*n*=452)
Cervical		34 (58.6%)	46 (10.2%)
	Cervical spine fracture	17 (29.3%)	14 (3.1%)
	Spinal cord injury	8 (13.8%) (all had an associated fracture)	10 (2.2%) (only 50% had an associated fracture)
	Brachial plexus	9 (15.5%)	17 (3.8%)
	Recurrent laryngeal nerve / phrenic nerve	0 (0%)	4 (0.9%)
	Thyroid	0 (0%)	1 (0.2%)
Maxillofacial		21 (36.2%)	64 (14.2%)
	Wounds	21 (36.2%)	63 (13.9%)
	Facial fracture	16 (27.6%)	6 (1.3%)
	Eye globe	2 (3.4%)	5 (1.1%)
	Nerve	2 (3.4%)	7 (1.5%)
Head		9 (15.5%)	40 (8.8%)
	Wounds	7 (12.1%)	39 (8.6%)
	Skull fracture / intracranial injury	5 (8.6%)	8 (1.8%)
	Ischaemic infarct secondary to local or general hypoperfusion	5 (8.6%)	2 (0.4%)
Chest		20 (34.5%)	202 (44.7%)
	Wounds	18 (31.0%)	117 (25.9%)
	Haemopneumothorax	12 (20.7%)	134 (29.6%)
	secondary to isolated PNI	1 (1.7%)	73 (16.2%)
	Penetrating cardiac injury	0 (0%)	3 (0.7%)
	Clavicle fracture	5 (8.6%)	2 (0.4%)
	secondary to isolated PNI	0 (0%)	2 (0.4%)
	Rib fracture	4 (6.9%)	5 (1.1%)
	secondary to isolated PNI	0 (0%)	2 (0.4%)
	Thoracic spine fracture	3 (5.2%)	2 (0.4%)
	secondary to isolated PNI	0 (0%)	2 (0.4%)
	Thoracic spinal cord	1 (1.7%)	1 (0.2%)
	Scapula fracture	2 (3.4%)	2 (0.4%)
	Sternum fracture	0 (0%)	1 (0.2%)

GSW = gunshot wound; SW = stab wound; PNI = penetrating neck injury

many required admission, for more than ten days. The in-hospital mortality rate was approximately threefold higher in the GSW cohort. In the SW group, all patients (except for one who died from a penetrating cardiac wound) died from exsanguination. Two patients exsanguinated in the emergency department before surgery could be performed and two died on the operating table. A further two patients died from profound neurological deficits secondary to prolonged shock. Once the mortuary data were included, the total mortality rate of PNI was found to be 27% for GSWs and 16% for SWs.

Complications

The rate of complications to management in patients who survived was 16% and 9% in the GSW and SW cohorts respectively. Six SW patients developed wound sepsis. One of these required incision and drainage of a neck abscess while the rest were managed with antibiotics. None of the GSW cases developed wound sepsis. The leak rate of repaired oesophageal injuries was 50% and 22% in the GSW and SW cohorts respectively. The failure rate for vascular repair was 25% among GSW patients and 11% in the SW group. Five patients presented with missed injuries 5–14 days following the injury.

Table 5 Investigations

Investigation	Result	GSW (*n*=58)	SW (*n*=452)
CT angiography		53 (91.4%)	335 (74.1%)
	Positive for a vascular injury	12 (22.6%)	57 (17.3%)
Catheter directed angiography		1 (1.7%)	15 (3.3%)
	Positive for a vascular injury	1 (100%)	8 (53.3%)
Water soluble contrast swallow		25 (42.1%)	187 (41.4%)
	Positive for a digestive tract injury	4 (16.0%)	25 (13.4%)
Endoscopy		0 (0%)	14 (3.1%) (5 bronchoscopy, 1 laryngoscopy, 8 upper endoscopy)
	Positive for a digestive tract / airway injury	0 (0%)	10 (71.4%)
Duplex Doppler imaging		1 (1.7%)	2 (0.4%)
	Positive for a vascular injury	1 (1.7%) (false positive)	0 (0%)

GSW = gunshot wound; SW = stab wound; CT = computed tomography

Table 6 Management

Management	Type of operative intervention	GSW (*n*=58)	SW (*n*=452)
Operative or endovascular intervention			
For PNI		10 (17.2%)	98 (21.7%)
	Endovascular	0 (0%)	7 (7.1%)
	Tracheostomy without exploration	2 (20.0%)	0 (0%)
	Neck exploration	7 (70.0%)	70 (71.4%)
	Thoracoscopy for retained haemothorax	0 (0%)	2 (2.0%)
	Local wound exploration / debridement or incision and drainage	1 (10.0%)	6 (6.1%)
	Sternotomy / thoracotomy as primary exposure	0 (0%)	13 (13.3%)
	Emergency surgery prior to imaging	0 (0%)	28 (28.6%) (3 negative explorations)
For all injury types		17 (29.3%)	119 (26.3%)
Conservative			
For PNI		48 (82.8%) (3 selected for palliative care)	354 (78.3%) (2 exsanguinated prior to reaching theatre)
For all injury types		41 (70.7%)	333 (73.7%)

GSW = gunshot wound; SW = stab wound; PNI = penetrating neck injury

All these patients had sustained injuries secondary to a SW and had been managed in a rural hospital or clinic.

Discussion

Most of the algorithms for the management of PNI have been developed based on experience with the management of SWs and simply applied to GSWs. However, the two wounding mechanisms and the associated patterns of injury are quite distinct.[12,13]

Our results show that GSWs are more destructive than SWs, with a higher incidence of multiple injuries, a higher mortality rate (5% vs 2%), a longer mean length of hospital stay (8 vs 4 days), an increased need for intensive care unit admission and a higher complication rate (16% vs 9%). Furthermore, the incidence of fatal GSWs in the mortuary data suggests that many patients with a GSW to the neck do not survive to reach hospital. Despite this, our data indicate that SNOM is still appropriate for GSWs, and the vast majority of patients with both GSWs and SWs to the neck were

Table 7 Comparative data on gunshot wounds (GSWs) and stab wounds (SWs) from the literature

Injury	Ordog, 1985[6]		Demetriades, 1997[9]		Thoma, 2008[11]		Current study, 2015	
	GSW (*n*=110)	SW (N/A)	GSW (*n*=97)	SW (*n*=89)	GSW (*n*=42)	SW (*n*=159)	GSW (*n*=58)	SW (*n*=452)
Vascular	32 (29%)	N/A	26 (27%)	13 (15%)	10 (24%)	16 (10%)	12 (21%)	74 (16%)
Aerodigestive tract	13 (11%)	N/A	7 (7%)	3 (3%)	11 (26%)	13 (8%)	10 (17%)	61 (14%)
Spinal cord	15 (14%)	N/A	13 (13%)	1 (1%)	N/A	N/A	9 (16%)	11 (2%)
Peripheral / cranial nerve or sympathetic chain	8 (7%)	N/A	12 (12%)	4 (5%)	N/A	N/A	11 (19%)	28 (6%)
Haemo or pneumothorax	30 (27%)	N/A	15 (16%)	12 (14%)	N/A	N/A	1 (2%)	134 (30%)

ultimately managed successfully by SNOM (83% and 78% respectively). Table 7 provides a historical and comparative overview of the literature on this topic.[6,9,11]

The other area of controversy in the management of these two groups of patients is the approach to imaging.[6–10,14,18–21] Generally, SWs to the neck can be selectively imaged based on a detailed clinical assessment although the advent of CTA has increased the reliance of clinicians on imaging as it is non-invasive and can performed rapidly without the need for arterial cannulation. A number of authors advocate selective imaging based on clinical assessment.[7–10,21] The accuracy of clinical assessment of PNI has been reported to approximate 97–99% in detecting vascular injuries requiring surgical repair, which is similar to that of CDA.[7,10,21]

However, many of these studies reported predominantly on SWs to the neck and most authors advocate mandatory imaging for GSWs to the neck although there are notable dissenters to this approach.[6,18–20] In a study from our parent institution published in 2004, 59 GSWs were reviewed and it was concluded that the assessment of patients with GSWs by physical examination alone is very difficult.[20] The authors were especially concerned about injuries to zones 1 and 3, and their results demonstrated that physical examination alone would miss a significant number of injuries. They advocated mandatory imaging with CDA for all patients with a GSW to the neck. Since that publication over a decade ago, CDA has gradually been replaced by CTA as the imaging investigation most commonly used and in light of our findings, we continue to advocate mandatory imaging for all GSWs to the neck.

TCGSWs to the neck remain an ominous subset and are associated with a much higher incidence of significant injuries than non-TCGSWs.[15,22] The swelling associated with these TCGSW injuries often results in a compromised airway, which requires definitive airway intervention. This makes it very difficult to assess these patients clinically and mandates aggressive imaging. CTA is also useful in that it shows the tract of the missile[23] and can identify signs of aerodigestive tract injury, which should then prompt more detailed assessment of the digestive tract.

Conclusions

GSWs and SWs to the neck are not analogous, and the former are far more destructive. The yield of imaging for GSWs is very high and taken in conjunction with the difficulty in assessing these injuries clinically, we advocate mandatory investigation for all such injuries. Despite the increased destructiveness of GSWs, this study has shown that SNOM remains an appropriate strategy in this patient cohort.

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