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ORIGINAL ARTICLES

Results of Selective Non-Operative Management for Penetrating Neck Trauma in 594 patients.

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Abstract

Background: The management of penetrating neck trauma (PNT) evolved from a policy of mandatory exploration to one of selective non-operative management (SNOM) based on clinical examination, and the liberal use of Computed Tomography Angiography (CTA) irrespective of the zone of injury for those patients who are stable on presentation.

Aim: To analyze the result of treatment for PNT in a major trauma centre

Study Design*:* Retrospective Audit

Methods: A retrospective audit of patients with penetrating neck injuries managed at Chris Hani Baragwanath Academic Hospital (CHBAH) Trauma Unit, from 2010 to 2015 was conducted. Statistical analysis was performed for all collected variables. A *p*-value of ≤ 0.05 was considered statistically significant.

Results: The results of treatment of 594 patients were reviewed. There was a predominance of young males (93.4%) with a median age of 28 years (IQR 18-67) presenting with injuries in zone 2, left side of the neck, commonly due to stab wounds (89.3%). Immediate surgical exploration was needed in 145(24.4%), while the remaining (75.4%) were investigated with CTA. CTA showed a sensitivity and specificity of over 90% for vascular injuries and more than 80% for aerodigestive injuries. Major vascular injuries were the most common surgical finding. The overall negative exploration rate was 6%.

Conclusions: Our unit's SNOM protocol relies on liberal CTA use. Despite the obvious limitations of a retrospective study our results showed an acceptable negative and non-therapeutic exploration rate and a low incidence of complications and mortality.

Keywords: penetrating neck trauma, CT Angiogram, selective non operative management (SNOM)

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Introduction

The management of penetrating neck injuries has changed over the past 30 years. Mandatory exploration of all injuries, with its associated decrease in mortality, progressed to mandatory exploration of zone 2 injuries, due to a percieved high rate of vascular trauma affecting that zone; this, however, resulted in high rates of negative and non-therapeutic interventions [1-4]. Mandatory exploration was challenged in the 1990s by several authors that proposed a selective conservatism approach based on clinical findings augmented by CTA imaging, aiming at reducing negative and non-therapeutic interventions and their associated morbidity. Nowadays, all patients with shock and hard signs of vascualr or aero-digestive injuries are explored irrespective of injured zone and the rest are investigated with CTA and other adjuct modalities such as endoscopy and contrast swallow if findings suggest a possible aero-digestive, irrespective of injured zone [1-4]. Current SNOM is possible by the liberal use of multislice helical computed tomograpgy angiogram resulting in a significant reduction of negative and non-theraputic interventions, non-operative management of some specific injuries (i.e., pahryngeal injuries, venous injuries) or endo-vascular management of arterial injuries that were previously subjected to surgical exploration [1-5].

South Africa interpersonal violence and homicide rates are seven times greater than the global rate [6]. Many international studies lack the significant numbers of patients seen in the South African trauma setting [1-12]. *Madsen et al.*, published several studies focusing on penetrating neck injuries in the Pietermaritzburg metro area [13-16]. Studies from Cape Town have also been published analysing the incidence and results of patients with penetrating neck trauma including the use of balloon tamponade [17-19].

Recent studies evaluating the results of SNOM in other major trauma centres in South Africa are lacking.

Material and Methods

An audit of records including patients with neck injuries managed at the Chris Hani Baragwanath Academic Hospital Trauma Unit between 2010 and 2015 was conducted. Patients with blunt trauma, age under 18 years, and patients with incomplete data were excluded. Ethics approval was received from the University of the Witwatersrand Research Ethics Committee. Data was entered into Excel worksheets and analysed using the STATA software (STATA statistical package Version 16, Stata Corp LLC, College Station, Texas, USA).

Variables included age, gender, mechanism of injury, affected neck zone, confirmed anatomical i njuries and the indications for surgical exploration and/or CTA, use of balloon tamponade, complications and mortality. Age is reported as median and interquartile range, categorical variables are reported as percentages. *Pearson's Chi squared test* or *Fischer's exact test* were used to determine statistical significance between categorical v ariables. A p-value of $\leq$ 0.05 was considered statistically significant. Surgical or CTA findings were defined in five categories: 1- Major Vascular Injuries including injuries to the Carotid arteries, Subclavian arteries, Vertebral arteries, Brachiocephalic artery, Internal Jugular, and External Jugular veins; 2- Minor Vascular Injuries included Thyrocervical trunk, branches of the external Carotid artery and other superficial veins and arteries), 3- Aero-digestive Injuries-ADI (Larynx, Trachea, Pharyngeal and Oesophageal injuries alone or in combination), 4- Major lacerations requiring surgical debridement and suture but without vascular or ADI present (thyroid gland injuries are included in this group and finally, 5- Patients with negative surgical explorations.

The aim of the study was to assess the effectiveness of the SNOM policy, with liberal use of CTA as well as the results of surgical treatment in the context of a significant volume of penetrating trauma.

Results

The database search yielded 755 records of patients with neck injuries, 161 records were excluded, the final audit and statistical analysis was performed on 594 patients.

There was a male predominance (93.4%) with a median age of 28 years (IQR 18-67 years). Stab wounds were the most common mechanism of injury. Majority of the wounds occurred on the left side of the neck, in zone 2. *(Table 1)*

One quarter of the patients (n=145, 24.4%) underwent urgent surgical exploration. The most common indication for immediate surgery was the presence of active haemorrhage (28.9%), followed by shock (24.1%) and expanding hematoma (15.1%). *(Table 1)*

The remaining 448 patients (75.4%) were investigated with CTA. "Proximity", defined as a penetrating wound whose tract lies in the vicinity of a major anatomical structure, was the most common "soft sign" on presentation that led to investigation. *(Table 1)*

Based on the fact that the majority of patients had zone 2 injuries CTA was most commonly used in this group (63.9%) as oppossed to undergoing surgery (33.2%) ($p=0.05$). The use of CTA instead of surgery was also significant for Zone 3 injuries ($p=0.003$). *(Figure 1)*

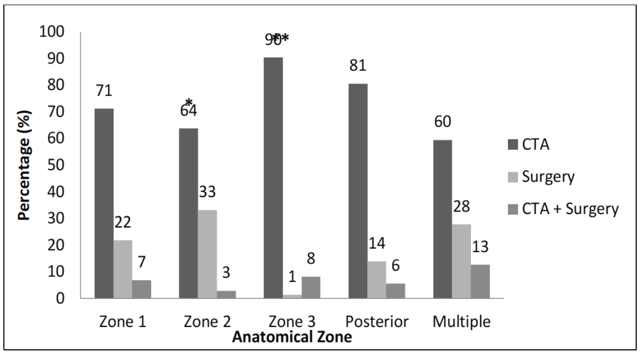
Variable	***Value***	***%***
Age	Median 28 years (Range 18-67)	
Gender		
Males	555	93.4
Females	39	6.5
M.O.I.		
Stabs	531	89.4
GSW	63	10.6
Injury Location		
Left	403	68
Right	140	23.6
Bilateral	50	8.4
Neck Zone		
1	160	27
2	245	41.3
3	73	12.3
Posterior	36	6
Multiple	79	13.3
Clinical Presentation		
Shock / Hard Signs	249	42
Soft Signs	57	9.6
Proximity	288	48.5
Management on Admission		
Immediate Neck Exploration	146	24.5
Immediate CTA	412	69.4
CTA + Neck exploration	36	6
Indications: Immediate Exploration		
Active Haemorrhage	43	29.4
Shock	35	24.1
Expanding Hematoma	22	15.1
Hematoma + Emphysema	19	13.1
Air/Saliva Discharge	11	7.5
Airway Obstruction	4	2.7
Brui/Thrill	3	2.0
GSW across midline + Shock	3	2.0
Massive Haemothorax	2	1.3
Haemoptysis/Haematemesis	2	1.3
Impaled Foreign Body	1	0.6
Chylothorax	1	0.6
Injury Findings: Immediate Exploration		
Major Vascular	58	40
ADI	28	19.3
Major Laceration (Debridement & Suture)	27	17.9
Major Vascular + ADI	14	9.6
Minor Vascular	9	6.2
FB removal (no other injuries)	3	2.0
Minor Vascular + ADI	1	0.6
Negative Exploration	***6***	***4.1***

M.O.I.: Mechanism of Injury, GSW: Gunshot Wound. CTA: Computed Tomography Angiography, ADI: Aero-digestive organ injury, FB: Foreign Body

Table 1: Patient Characteristics

Major vascular injuries were identified in 14.5%, and Aero-digestive injuries were found in 0.7% patients investigated with CTA. The majority (63.3%) were reported as having no abnormalities detected (NAD) and therefore facilitated early discharge of these patients. Major vascular trauma was found in 40% and ADI in 20.6% of those undergoing immediate surgery. A combination of aero-digestive and major vascular injuries was found in 14 (7.8%) of those undergoing surgery. *(Table 1)*

CTA had a Sensitivity of 93.5% for the detection of major vascular injuries (Specificity 94%, PPV 70%, NPV 99%), however, it was less robust for the detection of aero-digestive injuries (Sensitivity 87.5%, Specificity 80%, PPV 8.9% and NPV 99,6%). Thirty-six patients were explored after a CTA was obtained, a report of injury correlated well with a surgical finding in 75.6% of cases. Nine patients were explored having had a CTA reported NAD due to ongoing bleeding, suspected ADI, and disagreement with the report.



CTA: Computed Tomography Angiography, * $p<0.05$ CTA vs Surgery ** $p = 0.003$ CTA vs Surgery

Figure 1: CTA vs Surgical Exploration Utilization by Zones

Five of the nine patients had a negative exploration in this group.

The negative exploration rate for patients undergoing immediate surgery was 4.1%. When all surgical explorations were included, the negative exploration rate increased to 6%, largely due to explorations performed on the suspicion of oesophageal injuries based on CTA findings, that yielded no injuries during exploration. *(Tables 1-2)*

Twenty-three (23) patients had a balloon (Foley catheter) inserted to control haemorrhage, seven (7) patients proceeded directly to surgery due to persistent haemodynamic instability, all had injuries requiring surgical repair. Balloon tamponade allowed haemostasis and obtaining a CTA in 16 patients, 13 CTAs were reported as normal. The use of balloon tamponade to facilitate CTA avoided surgical exploration in 12 patients. *(Figure 2)*

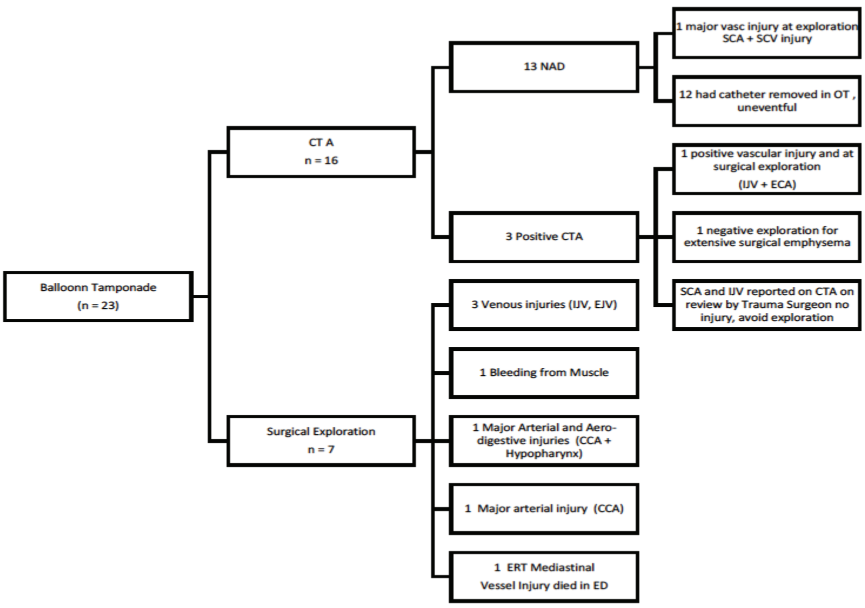
There were no missed injuries recorded; major complications occurred in 11 patients (1.8% overall) and 14 patients died, all in the surgical group, mainly from stroke, sepsis and uncontrolled haemorrhage resulting in an overall mortality rate of 2.5%. *(Table 2)*

Discussion

SNOM is well established as the preferred modality of assessment and treatment for patients with PNT, we audited the results of treatment in a major academic trauma centre.

The patient profile demonstrated the typical age and gender distribution for trauma victims [6,9-18].

CTA was used in 75.4% of our patients; the use of CTA varies between institutions and reports [13-19]. Investigation with CTA resulted in the avoidance of unnecessary surgical



CTA: Computed Tomography Angiography, NAD: No Abnormalities Detected, Vasc: Vascular, SCA: Subclavian Artery, SCV: Subclavian Vein, OT: Operating Theatre, IJV: Internal Jugular Vein, ECA: External Carotid Artery, EJV; External Jugular Vein, CCA: Common Carotid Artery, ERT: Emergency Room Thoracotomy

Figure 2: Management Results after Balloon Tamponade

Variable			**%**
Reported Finding Overall	CTA n=448	Exploration n=181*	
No Abnormalities Detected/Negative	284 (63.4%)	11 (6%)	
Major Vascular Injury	65 (14.5%)	71 (39.2%)	
Minor Vascular Injury	29 (6.5%)	46 (25.4%)	
Aero-digestive Injury	3 (0.6%)	44 (24.3%)	
Major Vascular + Aero-digestive Injury	-	16 (8.8%)	
Deep Surgical Emphysema	67 (14.9%)	-	
Complications	**11**		**1.8**
Stroke post Carotid Repair	*3*		
Stroke unknown Source	*3*		
Deep SSI (Sternum)	*3*		
Oesophageal Leak	*1*		
Mediastinitis	*1*		
Mortality	**14**		**2.5**
Occlusive Stroke	5		
Sepsis/MOF	5		
Uncontrolled Haemorrhage	4		

CTA: Computed Tomography Angiography, SSI: surgical site Infection, MOF: Multiple Organ Failure. (*) Excluding one (1) patient that died during emergency department thoracotomy for massive haemothorax

Table 2: Management Results

exploration in 63.4% of patients, who would have been operated if historical management guidelines were to be followed [2].

Active haemorrhage, shock and expanding hematomas remain the most common indications to perform surgical exploration [20-21], however reports have documented the use of balloon tamponade in many of these patients to arrest the initial bleeding, facilitate resuscitation and obtain a CTA once stable, reducing even further, the need for urgent surgery and the rate of negative exploration [18-19].

Immediate surgical exploration in our study was indicated in 24.4% of cases, resulting in a negative-non-therapeutic exploration rate of 4.1%, another 36 patients had surgery after the CTA, positive correlation between CTA report and surgical findings in this group was high (75.6%).

The utilization of surgical exploration varies depending on regional and institutional demands [7-19].

Our SNOM policy relies on liberal use of CTA. We found that CTA in our centre has a high sensitivity and specificity for the detection of vascular injuries (93.5% and 94% respectively), however the detection of aero-digestive injuries showed a much lower sensitivity and specificity (87.5% and 80% respectively), similar to reports of systematic reviews published recently [22, 23].

The lower sensitivity and specificity for the detection of aero-digestive injuries in our study translated to a perceived increase in the negative exploration rate from 4.1% to 6%. This increase can be largely explained by the presence of deep surgical emphysema on CTA, that prompted exploration to exclude oesophageal injury. The presence of deep surgical emphysema has been associated with a strong correlation to the presence of aero-digestive injuries [15, 16]. However, two recent systematic reviews have demonstrated that CTA alone has a low sensitivity and specificity to identify aero-digestive injuries, requiring further investigations or exploration if strong suspicious of oesophageal injury exist [22, 23]

It is universally accepted that haemodynamically unstable patients will require immediate exploration and that in haemodynamically stable patients the use of CTA is favoured over immediate exploration irrespective of zone of penetration [4, 5, 7-23].

There has been studies assessing the sensitivities and specificities of serial clinical examination alone in detecting injuries that require surgical exploration to reduce the number of negative explorations [5]. However, in our busy trauma unit we do not have the capacity to admit for serial clinical examination and observation; therefore, CTA is used to expedite the selection of patients to either be admitted for intervention (surgery) or be discharged.

In our cohort, patients with shock and hard signs but who responded to initial resuscitation were not automatically explored; 89 patients in this category (14.9%), including 16 patients in whom balloon tamponade was used to arrest ongoing haemorrhage were investigated with a CTA, the majority demonstrating no injuries requiring surgical repair. The need for balloon tamponade showed no statistically significant correlation with a positive surgical findings ($p = 0.150$), which the authors believe is due to the small sample size.

CTA can identify vascular that are amenable to endovascular repair and aero-digestive injuries managed non-operatively resulting in lower negative exploration rates [3, 4, 13-23]. No details of the utilization of endovascular intervention were available for our analysis.

We found that seven (7) of 78 patients (8.6%) who presented with hard signs had a negative exploration which emphasizes the benefit of preoperative imaging if the hemodynamic status allows, as described by several studies [3, 4, 13-26].

Balloon tamponade can also facilitate CTA for injuries that can be treated safely without surgery, particularly venous injuries, as long as the patient remains haemodynamically stable, with delayed removal of the balloon catheter, an approach adopted by major trauma centres in South Africa following local experience and available evidence [13-21].

There were 11 major complications in our cohort, mainly occlusive strokes and surgical site infections. Our series mortality resulted from stroke, sepsis and uncontrolled haemorrhage. Worldwide reports of management for PNT have indicated low complication and mortality rates [13-21, 24-28], including recent publications from military practice [29, 30].

Conclusion

Our unit's SNOM protocol relies on liberal use of CTA irrespective of the affected neck zone; our results showed that the utilization of clinical findings to select for immediate exploration versus investigating those who are stable but with a suspected injuries, resulted in safe management with an acceptable rate of negative and non-therapeutic interventions and low incidence of complications and mortality. CTA use in our centre also facilitated the identification of patients that could be safely discharged without admission for observation due to significant resources limitation.

The major limitation of our study is its retrospective nature. The utilisation of balloon tamponade was also limited to small number of patients reducing the value of the analysis of this sub-group of patients. Our database is lacking details regarding the use of complementary investigations (contrast swallow, endoscopy) in patients where CTA demonstrates signs of potential oesophageal injury, factors that may significantly influence the outcome of these patients.

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Conflict of Interest Declaration

The Authors Declare No conflict of Interest

Author Contribution

NL – Literature search and review, study design, data collection, data analysis and interpretation, drafting and manuscript writing

BIM – Literature review, 3 years of data collection, manuscript critical review and manuscript writing

MM – Data collection, manuscript critical review

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