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COMPUTED TOMOGRAPHY AS A DIAGNOSTIC TOOL IN IMAGING OF NECK INJURIES IN A LARGE TRAUMA UNIT IN GAUTENG

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A research report submitted to the Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, in partial fulfilment of the requirements for the degree of Master of Medicine in Diagnostic Radiology

Johannesburg, 2023

Declaration

I, Busisiwe Venus Makhubela, declare that this research report is my own work. It is being submitted for the degree of MMed (Diagnostic Radiology) at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at this or any other University.

Dr Busisiwe Venus Makhubela

On this 02 August 2023

Dedication

I dedicate this thesis to my mom, Khavisa Sayina Makhuvele, who gave me her unselfish love and continuous support with encouragement while you didn't go to school yourself but always wanted the best for me.

To my niece Hloniphani Teressa Makhuvele who stood by me even when it was not easy and gave your weekends to support this dream.

To my children, Nsimeko Precious Makhubela and Luyanda Muhluri Makhubela who continued to be patient with me while I kept telling them that mommy will finish and spend time with you and understood as young as you were.

Publications and presentations

This work has never been published.

It has never been presented at a congress.

Abstract

INTRODUCTION:

Sparse data exists on computed tomography (CT) imaging evaluation of neck injuries in South Africa and no data found on the incidence in Gauteng province. The rates of South African crime and trauma are high with commonest being the penetrating neck trauma.

AIM:

This study aims to audit and review findings of CT scans of the neck requested for patients with neck trauma, summarizing and categorizing them according to mechanism of injury and the systems injured.

METHOD:

A retrospective qualitative cross-sectional study evaluating and auditing 200 CT scan reports of male and female patients of all age groups with neck trauma and referred from the Emergency Trauma unit of Chris Hani Baragwanath Academic hospital. CT scan reports from the 01 January 2017 to 25 January 2018 accessed from Picture Archiving and Communication System (PACS).

RESULTS:

A total of 200 CT scan reports were audited and descriptive statistics of percentage and frequencies used to summarize the categorical variables. The median age was 25 years and the majority (84.50%) of the participants were males. Median time of the scan was 22:00. 26% and 19.5% of the scans were performed on Saturday and Sunday respectively and the least on Thursday (7%). The commonest type of injury was penetrating injuries (83%). Stab (67%) followed by gunshot (12.5%) injuries were the most common causes. Soft tissue injuries were the most common recorded damages (79%) followed by respiratory (36%) and injury to blood vessels (22.5%). The oesophagus was the most damaged gastrointestinal structure.

CONCLUSIONS:

This audit of CT scan reports of patients who experienced neck trauma showed a considerable number of male patients' involvement ranging from 21-30 years old, Penetrating neck injury (PNI) being the most common mechanism of injury. Female patients showed more blunt neck injuries than penetrating mechanisms. Most blunt neck injuries resulted from attempted hanging associated with parasuicide followed by strangulation and Motor Vehicle accident (MVA).

Our study demonstrated that most neck trauma occurred on weekends and was associated with alcohol consumption. CT angiogram has been proven to be a diagnostic imaging tool in patients with neck injuries in Gauteng. It aids in guidance of further management of these patients.

Our study aimed to improve reporting of potential neck injuries, and this was initiated as a contribution to the development of reporting templates so that vital structures are assessed for definitive patient management.

Acknowledgements

First and foremost, I would like to thank almighty my God for the strength and wisdom to start and complete this work.

I would like to express my special thanks of gratitude to my supervisors Dr Promise Nonceba Koranteng and Prof Hopewell Ntsinjana, thank you so much for your continuous guidance, support, supervision, and mentorship. This wouldn't have been possible without you.

To my family, especially my mother, Khavisa Makhuvele, thank you for your continuous encouragement, timely guidance, support, and your availability to take care of my children when I was not available to do it myself.

To my friends, thank you for your continuous support and encouragement.

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List of Abbreviations and Terminology

AVF - Arteriovenous malformation

CHBAH - Chris Hani Baragwanath Academic Hospital

CT - Computed tomography

CTA - Computed tomography angiography

DSA - Digital subtraction angiography

MDCTA - Multidetector computed tomogram angiography

MOI - Mechanism of injury

MVA-Motor vehicle accident

PACS - Picture archiving communication system

PNI - Penetrating neck injuries

WHO - World Health Organization

1. Introduction

1.1. Introduction

It is argued that nowhere else in the human body is there a collection of vital structures packed into such a small space than in the neck. The neck connects the head, trunk and upper limbs and contains vital structures such as vessels, nerves, cervical spine, and the spinal cord. It also contains important endocrine glands like the thyroid and parathyroid glands(1), pharynx, oesophagus, larynx and trachea (2). The superficial anatomy of the neck is formed by platysma, sternocleidomastoid and trapezius muscles (1).

The mortality from neck injuries ranges from 2% to 10%, predominantly from vascular injuries (3). These injuries require immediate medical attention by experienced surgeons (4).

The neck injuries have been divided into blunt and penetrating depending on the mechanism of injury. Blunt neck trauma, in contrast to penetrating neck trauma, may not be initially detected due to emergent injuries of other anatomical areas. The laryngotracheal airway and cervical spine are the most clinically susceptible to injury. Vascular injuries in blunt neck trauma are uncommon, occurring only in 0.08% to 1.5%, however they can be potentially devastating (5).

Neck trauma causes significant mortality and morbidity, especially vascular injuries. Exsanguination from vascular injury accounts for 50% of the mortality rate from neck injuries (6). There was historically a low thresh-hold for surgical exploration, however over 50% of these explorations were seen to be non-therapeutic (7). Surgical exploration as an initial approach in the management of neck injuries in haemodynamically stable patients is therefore no longer seen as an appropriate initial management approach. The approach has evolved to heavily rely on imaging, specifically Computed Tomography (CT), which plays a critical role in prompt diagnosis and subsequent management of these injuries (6).

Imaging evaluation of the traumatic neck injuries for patients who don't necessarily need prompt surgical intervention and those who are haemodynamically stable has included CT scan of the neck and specifically the CT angiogram (8).

CT angiography can be used to promptly evaluate the penetrating neck injuries because of its inherent benefits of high spatial resolution, non-invasiveness, and a provision of global assessment of large anatomical areas. It also provides information with regards to the integrity of the vasculature, skeletal structures, airway and the gastrointestinal tract. The tract of the

wound can also be used to determine to follow the lead to the potential vital structures involved. The CT scan also forms part of the assessment of the need for further diagnostic imaging, for example water soluble contrast swallow for suspected pharyngoesophageal injuries (4).

Penetrating neck injuries can be quickly evaluated with multidetector CT angiography by non-invasive means, as it provides a global assessment of large anatomic regions with high spatial resolution. Multidetector CT angiography can provide information about the integrity of the neck vasculature, skeletal structures, airway, and digestive tract. By delineating the wound track, it can be used to determine the potential for injury to vital structures when a definitive diagnosis cannot be rendered; this can be especially useful when evaluating pharyngoesophageal injuries. As a result, multidetector CT angiography can be used to determine the need for further diagnostic evaluation with endoscopy, oesophagography, or conventional angiography, in addition to helping definitively identify injuries that require surgical or endovascular repair (4).

CT scan has become readily available however, there is limited staff available for reporting in a large trauma centre like Chris Hani Baragwanath Hospital. Due to high trauma rates, there is an increase in number of patients with neck injuries (4) thus high CT scan volumes. The staff shortage result in limited numbers of staff to report the high volumes of CT scans which impacts on reporting efficiency. The results from this study can thus be used to improve protocols and develop reporting templates as part of patient management.

1.2. Epidemiology of neck injuries

According to the World Health Organization (WHO) 9% of the global mortality results from injuries (9). More than 90% of global deaths from injuries occur in low to medium income countries such as South Africa (10). In South Africa injury related mortality rates have been established to be 6 times the global rate (9). Approximately 5.8 million people perish annually secondary to injuries and this accounts to 10% of the world deaths, 32% more than the number of fatalities that resulted from malaria, tuberculosis and HIV/AIDS combined (9).

Injuries to the head, face or neck are the most prevalent type of injuries amounting to 16% of all the injuries (11). The rates of South African violent crime and trauma are high with the commonest being the penetrating neck trauma in South African trauma units. These types of injuries result in high morbidity and mortality rates ranging between three and six percent

secondary to major neck vascular injuries (3). According to a study conducted in 2012 by Curtis Offiah and Edward Hall on traumatic injuries in developing countries it is stated that females were less likely to have been involved in a traumatic injury when compared to their counterparts (12).

1.3. Anatomy of the neck

The neck is a small yet very important part of the body that connects the head with the torso, supports the position of the head and enables one to turn the head towards stimuli. The contents of the neck have been grouped into four neck compartments: Vertebral compartment: contains cervical vertebrae and postural muscles. Visceral compartment: contains glands (thyroid, parathyroid and thymus), the larynx, pharynx, and trachea. Two vascular compartments: contain the common carotid artery, internal jugular vein, and the vagus nerve, on each side of the neck. Protection of these parts of the neck and its mobility are ensured by the vertebrae and muscles of the neck (1). Each side of the neck is divided into two triangles, anterior and the posterior by the sternocleidomastoid muscle:

The anterior triangle of the neck is made by the anterior border of the sternocleidomastoid muscle, the inferior border of the mandible and the midline of the neck. Contents of this triangle are pharynx, glands, common carotid, internal carotid and external carotid arteries, internal jugular vein, facial, glossopharyngeal, vagus and hypoglossal nerves. This triangle can be further divided into the submandibular, submental, muscular, and carotid triangles.

The boundaries of the posterior triangle are the posterior border of the sternocleidomastoid muscle, the anterior border of the trapezius muscle and the middle third of the clavicle. Contents are external jugular vein, subclavian artery, accessory nerve, cervical plexus, and trunks of the brachial plexus. This triangle can also be further divided into the occipital and the omoclavicular triangles (1). The high negative mandatory surgery rate has shifted management of penetrating neck injuries to the development of a zonal selective surgery approach to patients with penetrating neck injuries as illustrated in figure 1.1 below (18).

These anatomical zones are (7),(13):

- **Zone 1:** Extends from the level of the clavicles and sternal notch to the cricoid cartilage. This zone has vital structures that include the aortic arch, proximal CCAs, vertebral arteries,

subclavian vessels, innominate vessels, lung apices, oesophagus, trachea, brachial plexus, and the thoracic duct.

- **Zone 2:** Extends from the level of the cricoid cartilage to the angle of the mandible, this is the largest and most exposed zone. This zone contains vital structures, which include common, internal, and external arteries, jugular veins, larynx, upper oesophagus and pharynx.

- **Zone 3**: Extends from the level of the angle of the mandible to the base of the skull and its important structures include the ICA, Vertebral arteries, ECA branches, IJV and pharynx.

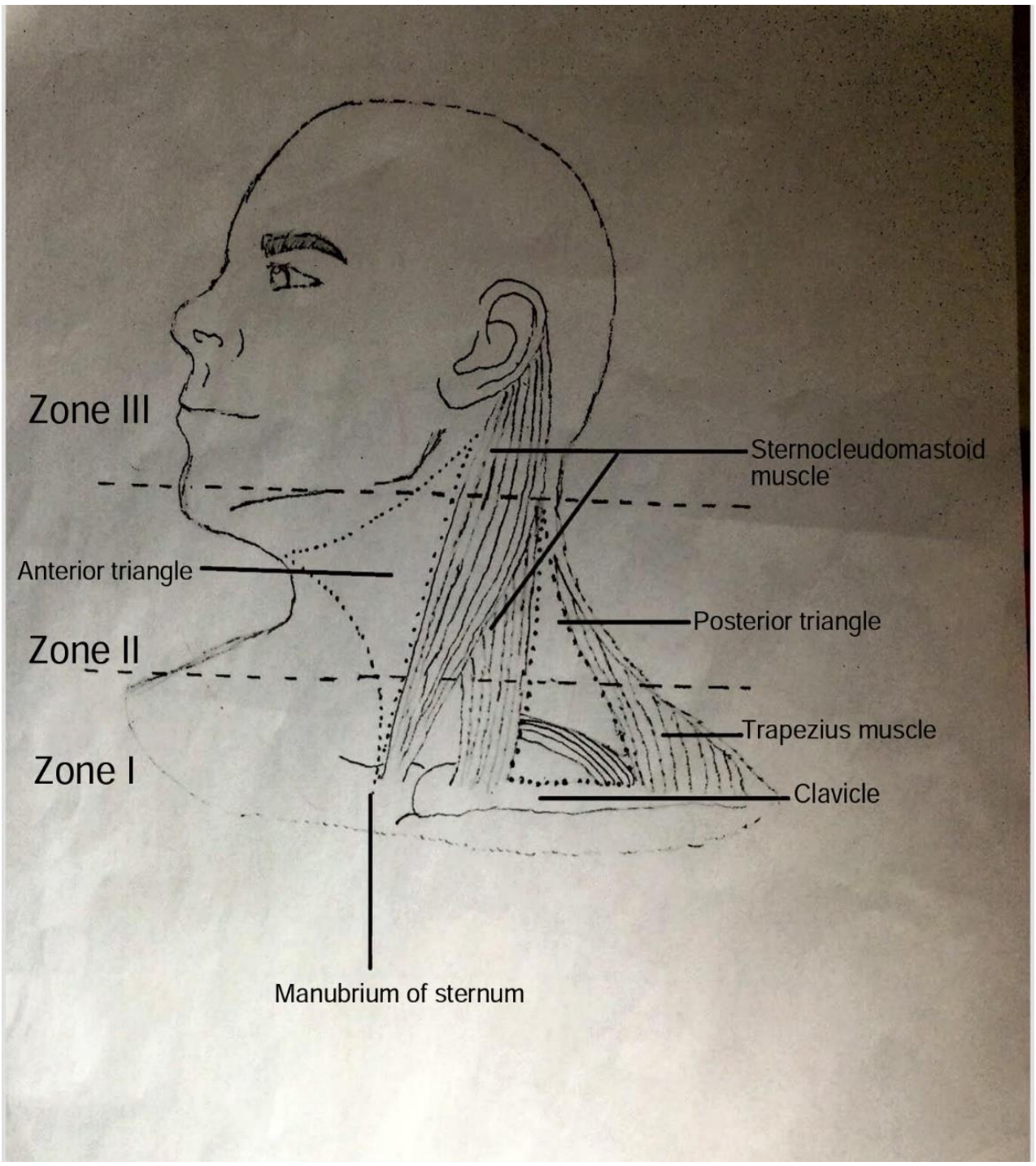


Figure 1.1 Zones of the neck (Image drawn by the Principal Investigator)

1.4. Imaging approach to neck injuries

Recent literature has demonstrated that clinical examination alone may be as precise as any other invasive diagnostic imaging technique in diagnosing major vascular injuries. These include using factors like determining the zone (anatomic) of the entry wound, location of the injury, depth of the injury (determined by violation of platysma muscles), hard signs and soft signs (13). Hard signs are signs found on physical examination that when present prompt for immediate surgical neck exploration. Soft signs of injury in PNI are those found in haemodynamicaly stable patients and require CT scan of the neck as part of initial management (14). This will be further discussed in the next paragraphs.

These three anatomical zones have been described and used to standardize the reporting of penetrating neck injuries to improve the rates of diagnosis of the imaging investigations. The use of the anatomical zones was not only used to standardize reporting but also to correlate the potential injury pattern internally. This was also used to guide the management approach, for example there was a low threshold of operative management for Zone 2 injuries due to its easy surgical accessibility. This was unlike Zone 1 and Zone 3 injuries, which are not easily surgically accessible and therefore required imaging evaluation to avoid technical difficulty as an initial management approach.

This zonal approach has been reviewed because the zone of the external wound does not necessarily predict the tract of the injury and thus may not accurately inform the injury pattern which may be extensive and remote from the site of injury. It resulted in high negative-result surgical explorations for zone 2 injuries with resultant increased risks of iatrogenic injury to these patients (13).

Clare et al has demonstrated a new approach of a concept called a “HARD bruit” approach, which constitutes of hard signs namely: haemodynamic instability, haemoptysis, hematemesis, arterial bleeding, rapidly expanding haematoma, deficit whether vascular or neurologic, bruit or thrill. Any patient who presents with any of the hard signs is a candidate for surgical exploration prior to imaging however, for haemodynamically stable patients with no hard signs imaging such as CT scan is required prior to any surgical intervention even if the platysma muscle is violated (14). Patients with soft signs are treated with CT scan as a form of their initial management. Soft signs include minor haemoptysis, dysphonia, dysphagia, subcutaneous or pneumomediastinum and non-expanding haematoma and these are patients who receive imaging with CT as part of their initial management (7,13).

Physical clinical examination regardless of the zone of injury should thus be the primary guide to CT scan (7).

The management of neck injuries, whether penetrating or blunt remains controversial, with a shift from mandatory surgical exploration to CT scan as an initial management approach.

Patients who have experienced penetrating neck trauma should be well evaluated for haemodynamic stability to reduce morbidity and mortality (15). Some patients are unnecessarily radiated due to lack of thorough clinical examination. These evaluations play a role in prompt diagnosis and subsequent management of these injuries (15).

Once the patient's injury is indicative of CT scan of the neck it should be performed urgently (12). Diagnostic imaging plays an integral role in the diagnosis and management of neck injuries. Traditionally the plain radiograph was often used to image the neck after trauma but now computed tomography and magnetic resonance imaging (MRI) have been considered and are in use because they provide further useful information (16).

CT scan of the neck after trauma has been proven to be a diagnostic tool in imaging these patients. The minimally invasiveness, non-operator dependence and readily availability are the key attributes of the CT scan (16). CT scan is also fast to perform, reliable and provides a global assessment of the neck (4). CT angiogram of the neck also allows evaluation of the non-vascular soft tissues and bones of the neck, and it allows this with great accuracy. It has replaced conventional digital subtraction angiography (DSA) as it allows for complete evaluation of neck injuries (3). Conventional neck angiography was previously considered a standard of reference for detection of vascular injuries in patients who had suspicious clinical signs of vascular injuries whose immediate surgical intervention was not indicated (15).

Once the patient's injury is indicative of CT scan, CT angiogram (CTA) of the neck should be performed urgently. Spatial resolution of the helical CTA is lower than that of the conventional angiography. This may limit detection of subtle pathology such as isolated contour irregularities or intimal flaps. Other things that can obscure arterial segments are artifacts caused by metal such as bullet fragments or dental fillings. To avoid inability to diagnose clinically important arterial injury, conventional angiography should be performed whenever the integrity of the entire length of the clinically suspicious artery or arteries cannot be assessed fully by means of helical CTA (17).

CTA is also less expensive than the conventional angiography (17). On reporting of the CT scan, it is important for the radiologist to determine the injury in terms of the vascular involvement. These include occlusion (partial or complete), the presence of a pseudoaneurysm, focal intimal injury, dissection, active bleeding and AVF (7).

DSA was previously accepted as a gold standard imaging technique for major neck vessels however due to the increased number of patients with negative results and increased risk associated with the procedure, less invasive procedures, like CT have been sought (13). DSA is not only the most sensitive and specific imaging modality to detect vascular neck injuries. It has multiple advantages to other imaging modalities. It provides detail and has an ability to demonstrate subtle intimal irregularities. Another advantage is that it provides increased ability to the clinicians to appreciate the types and degree of vascular injury. It has an ability to deliver intervention at the same time as diagnosis through treatment of thrombi or via stenting. It can also be used to promptly treat the AVF or transections at the same time they are diagnosed. DSA has the ability to observe circulation in real time versus taking snapshots. It gives important information to the assessment of the collateral circulation and also the direction of flow (13).

The disadvantages of the DSA include its invasiveness, increased risk of procedural complications and increased manpower demands. The procedure itself carries up to 15 % risk of complications that could include iatrogenic injury to the vertebral artery, embolic stroke, or access site haematoma. DSA is not always practical to perform in an unstable patient with multiple traumas even though there is suspicion of the vascular injury. The availability of the experienced interventional or diagnostic radiologist is also necessary with knowledge of the procedure.

Due to these negatives DSA is reserved for patients in whom vertebral artery injury is strongly suspected from neurologic symptoms, neuroradiological intervention is necessary or the results of other imaging studies are equivocal or inconclusive (13).

CTA has predominantly replaced DSA as the imaging of choice for initial evaluation of the neck vessels in blunt and penetrating trauma. It allows appropriate triaging of patients to either conventional angiography or surgery for relevant treatment and guide conservative management when applicable (13).

1.5. Possible types of neck injuries

Neck injuries can be separated into penetrating and blunt injuries.

1.5.1. Penetrating injuries

These are defined as any injury that violates the platysma muscle. The platysma muscle is a broadsheet of muscle arising from the pectoral and deltoid muscles, rising over the clavicle superiorly along the sides of the neck to attach at the base of the mandible, skin of cheek, lower lip, and angle of the mouth. These can further be divided into high and low velocity injuries (13). High velocity injuries like those from military-style rifles have the potential to cause more widespread tissue destruction than low velocity injuries. Low velocity injuries result from handgun ammunition and sharp objects like knives, glass or any other thin sharp objects (4).

1.5.2. Blunt injuries

These are caused by any direct blow/trauma to the neck. Mechanisms include falls, quad bike/motorbike injuries, motor vehicle accidents, sports injuries and strangulation/assault (13). Strangulation accounts for up to 10 % of violent or criminally related deaths. Strangulation techniques include hanging, throttling, garrotting and chokeholds. They cause unconsciousness or death from compression of either airway or the major vessels of the neck (13).

2. Research proposal

2.1.1. Aim

This study aims to detail the radiological findings on CT scan of the neck requested for traumatic neck injuries and categorize these according to the systems injured.

2.1.2. Study objectives

The objectives are:

Primary:

- To audit and review the radiological findings in CT scans performed for neck injuries.

Secondary:

- To categorize these findings according to the mechanism and systems injured, for example: penetrating or blunt, vascular, aero-digestive, soft tissue, haematoma, skeletal and neurological.

2.2. Methodology

2.2.1. Research paradigm

This was a retrospective, qualitative, cross sectional study evaluating CT findings of the patients who sustained neck injuries that were referred from the Emergency Trauma unit of CHBAH. The CT scans reports were assessed from 01 January 2017 to 25 January 2018 until the maximum number of 200 is reached.

2.2.2. Study sample

The study population included CT scan reports of male and female patients of all age groups scanned, reported, and issued by CHBAH Radiology Department from 01 January 2017 to 25 January 2018 until 200 patients reports were captured from the emergency trauma unit. Power calculation has been done using a significance level of 5 % and a statistically significant sample size of 200.

2.2.3. Inclusion criteria

CT scan of the neck reports of male and female patients of all age groups from CHBAH emergency trauma unit scanned, reported, and issued by the radiology department. Reports stored on the Picture archiving and Communication System (PACS).

2.2.4. Exclusion criteria

- Non-trauma related CT scan reports.
- Incomplete reports with no conclusions.
- Reports that are not reviewed by the consultants.
- Handwritten reports.
- Repeat scans.

2.2.5. Materials and Methods

- This was a retrospective qualitative cross-sectional study-reviewing findings of CT scan of patients with neck injuries.
- These CT scans were performed to diagnose neck injuries in trauma patients from the emergency trauma unit at CHBAH from 01 January 2017 to 25 January 2018 (period of a year) until 200 patients 'reports were captured.
- The study population was identified from the CT scan daily register that was used as a guide and from the indication section that stated history of injury on the CT scan reports in the indication section that will be acquired from the Radiology department records on PACS.
- The population included all scans reported by the registrars during working hours and after-hours. The after-hours scans were reported by the registrars and reviewed by the consultants in the morning. CT scans that were not reviewed were excluded from the study.
- CT scans were performed from either a 64-slice MDCT or a 128-slice MDCT Toshiba scanner.
- The raw data included the PACS retrieved completed CT scan reports of the patients with original patient data.
- Data collected included patients' demographics, which are age and gender, mechanism of injury, day of the week, time of the scan and the organ system injured.

- This raw data was recorded in a book that was kept safe by the principal investigator. Patients' details were then anonymized.
- Final data was retrieved and categorized from the collected raw data onto the data collection sheet designed by the principal investigator. See appendix A for the Data collection sheet.
- Data has been analysed using descriptive stats, which were categorical and continuous.
- Categorical statistics utilized frequencies and percentages in the form of bar graphs.
- Continuous stats have been assessed with the use of the Shapiro Wilk test. This has classified them as a normal distribution, which has analysed them in a form of mean and standard deviation. The continuous descriptive stats that do not fall under normal distribution have been analysed in a form of median using IQR.
- Data has been analysed as detailed above with the use of STATA statistical software version 16.

2.2.6. Data collection

This commenced once the protocol had been approved and ethics clearance had been obtained and permission granted by the research committee and the CHBAH management team to access and utilize the data, which were the reports of the CT scan of the neck from the PACS.

Data collection had been determined by the predefined inclusion criteria as alluded to above. For every CT scan report, the presence of any injury be it vascular, soft tissue related, respiratory, gastrointestinal, neurological, or musculoskeletal has been recorded.

These findings have been categorized and grouped according to the demographics, mechanism of injury and the system injured, as the history would have stated in the relevant section in the CT scan report. Data collection sheet in Appendix A used to record the findings.

2.2.7. Data analysis and statistics

Data recorded has been entered into an electronic excel spreadsheet for analysis (Microsoft Excel). STATA version 16 was utilized to perform statistical analyses. Statistician employed at the University of the Witwatersrand has been approached for technical assistance.

Descriptive analysis of the data was used to summarize data points. Discrete variables were illustrated in charts. Continuous data was described using means, medians and standard

deviations. The systems injured were analysed using frequencies and percentages then presented as graphs for illustration.

2.3. Ethics approval

The study was approved by the Human Research Ethics Committee of the University of the Witwatersrand, approval number **M200201**. This certificate is attached as Appendix B.

2.4. Turnitin report

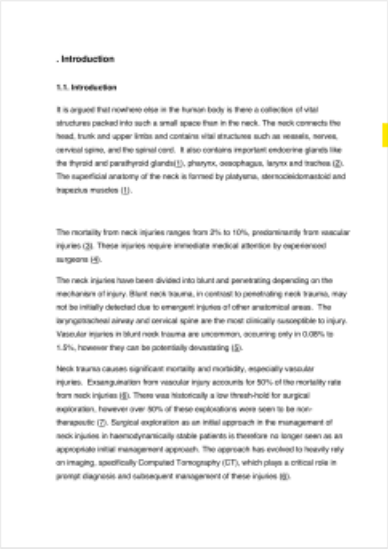
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. Introduction

1.1. Introduction

It is argued that nowhere else in the human body is there a collection of vital structures packed into such a small space than in the neck. The neck connects the head, trunk and upper limbs and contains vital structures such as vessels, nerves, cervical spine, and the spinal cord. It also contains important endocrine glands like the thyroid and parathyroid glands(1), pharynx, oesophagus, larynx and trachea (2). The superficial anatomy of the neck is formed by platysma, sternocleidomastoid and trapezius muscles (1).

The mortality from neck injuries ranges from 3% to 10%, predominantly from vascular injuries (3). These injuries require immediate medical attention by experienced surgeons (4).

The neck injuries have been divided into blunt and penetrating depending on the mechanism of injury. Blunt neck trauma, in contrast to penetrating neck trauma, may not be initially detected due to emergent injuries of other anatomical areas. The laryngotracheal airway and cervical spine are the most clinically susceptible to injury. Vascular injuries in blunt neck trauma are uncommon, occurring only in 0.08% to 1.5%, however they can be potentially devastating (5).

Neck trauma causes significant mortality and morbidity, especially vascular injuries. Exsanguination from vascular injury accounts for 50% of the mortality rate from neck injuries (6). There was historically a low threshold for surgical exploration, however over 50% of these explorations were seen to be non-therapeutic (7). Surgical exploration as an initial approach in the management of neck injuries in haemodynamically stable patients is therefore no longer seen as an appropriate initial management approach. The approach has evolved to heavily rely on imaging, specifically Computed Tomography (CT), which plays a critical role in prompt diagnosis and subsequent management of these injuries (8).

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3. Results

This was a retrospective qualitative cross-sectional audited 200 CT scan reports of neck injuries and descriptive statistics of percentage and frequencies used to summarize the categorical variables. Median and interquartile range was used to summarize the age in years (p=0.00) and time of scan (p=0.00) (Table 3.1.).

The median age was 25 years and the majority (84.50%) of the participants were males. Median time of the scan was 22:00. 26% and 19.5% of the scans were performed on Saturday and Sunday respectively and the least on Thursday (7%). The commonest type of injury was penetrating injuries (83%). Stab (67%) followed by gunshot (12.5%) injuries were the most common causes. Soft tissue injuries were the most common recorded damages (79%) followed by respiratory (36%) and injury to blood vessels (22.5%). The oesophagus was the most damaged gastrointestinal structure.

Table 3.1 Normality test

	Shapiro-Wilk test		
	Statistic	**df**	**p-value**
Age in years	0.95	195	0.00
Time of scan	0.93	195	0.00

Baseline demographics and patient characteristics are presented in figure 3.1. The median age of the participants was 25 years and the majority (84.50%) of the participants were males (Figure 3.1). Further characterization of this age distribution has demonstrated that 40% of the population was of the range 21-30 years old. The 35% were 31-40 years,11 % were 41-50 years, nine percent were less than 20 years and three percent were 51-60 years old. 61-year-olds and above made up only two percent of the study population (Figure 3.1).

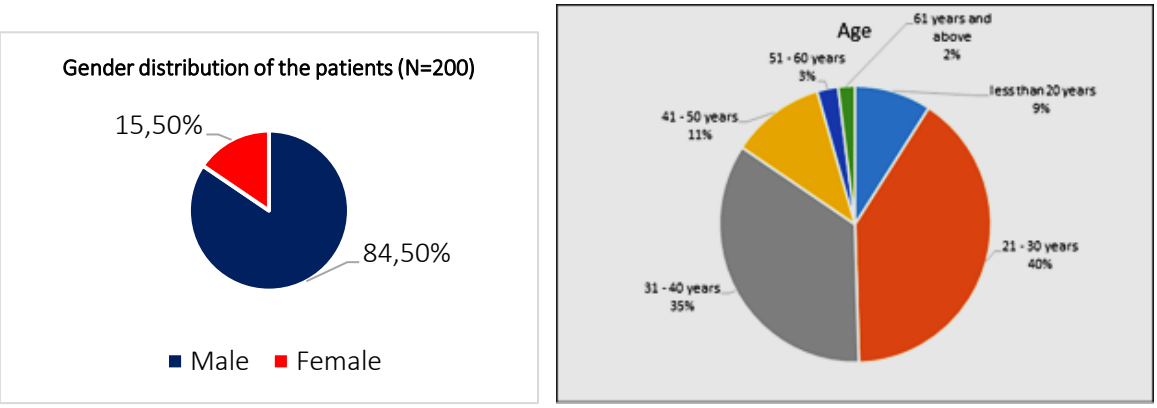


Figure 3.1 Gender and age distribution of the participants (N=200)

Regarding the mechanism of injury, the most common type was penetrating injury which made up 84% of total injuries while blunt injuries only made up 16 % (Figure 3.2). One point two percent of the population had no history and was recorded as a trauma patient on the CT scan daily register and the images demonstrated features in keeping with penetrating trauma (Figure 3.2).

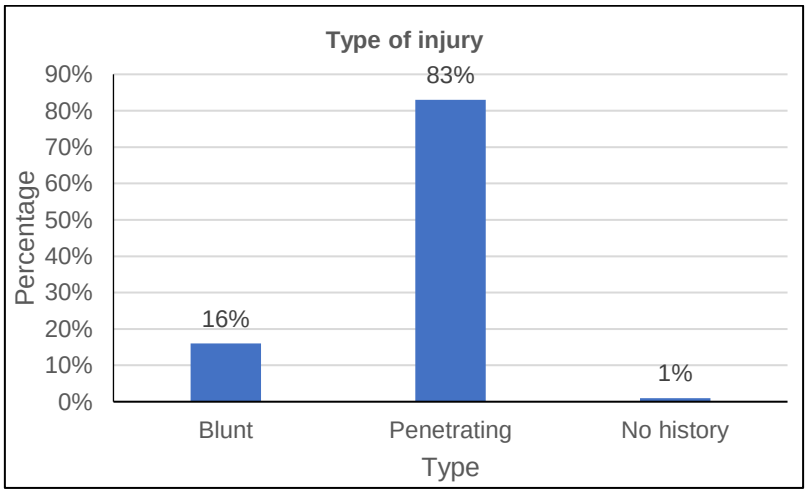


Figure 3.2 Type of injury according to the mechanism (N=200)

The injuries were also categorized according to gender, which demonstrated that penetrating neck injuries were more common in males making up 89.9% and blunt injuries in females making up 54.8% (Figure 3.3).

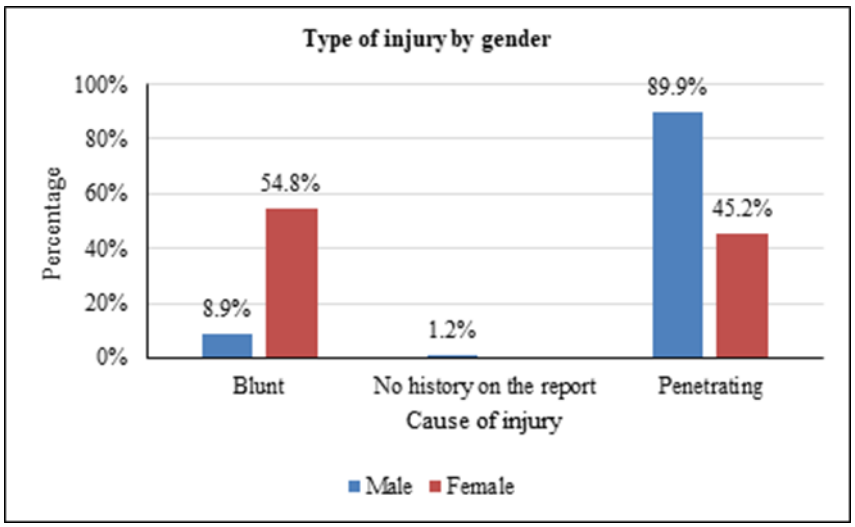


Figure 3.3 Type of injury by gender (N=200)

The frequencies of blunt and penetrating injuries between male and female patients in different age categories were described. The highest number of penetrating neck injuries were seen in ages between 21 and 40 years (127) and the least in patients older than 60(Figure 3.4).

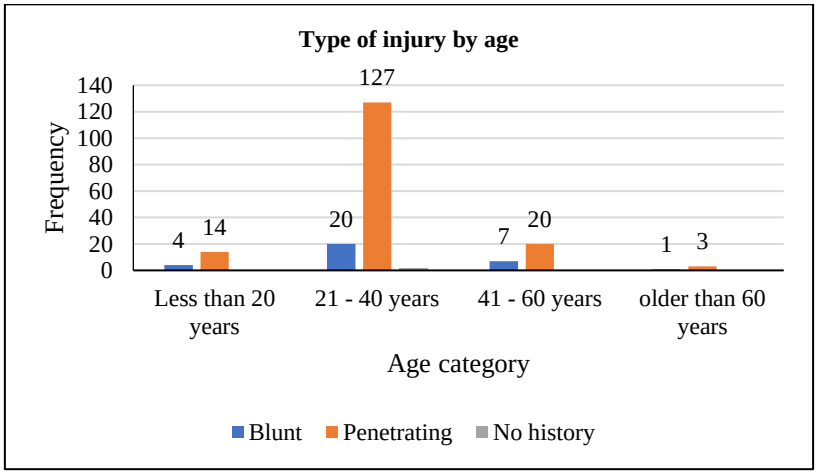


Figure 3.4 Type of injury by age (N=198)

Median time of the scan was 22:00:00. 26% and 19.5 % of the scans were performed on Sunday and Saturday respectively and the least number of scans (7%) was performed on Thursdays shown in figure 3.5.

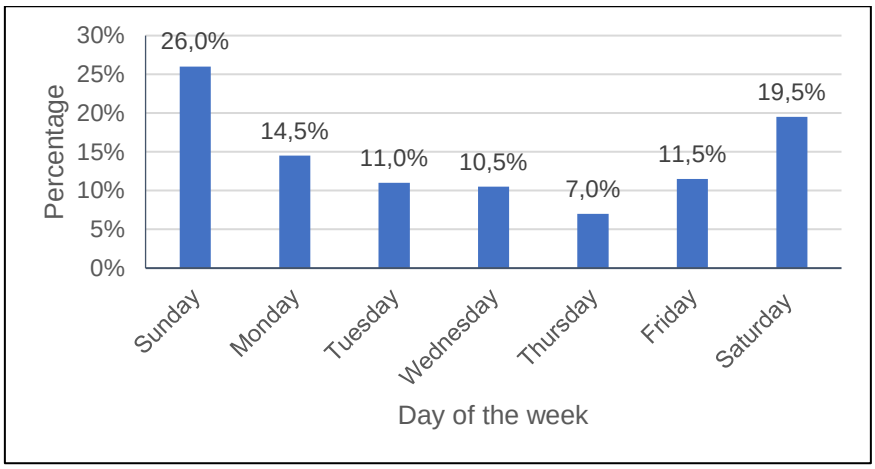


Figure 3.5 Day of scan (N=200)

Of all the penetrating neck injuries, stab wounds (79,8%) were the most common type followed by gunshot wounds making up 14.3%. These were followed by assaults secondary to penetrating sharp objects not specified, slit with razor and dog bite being the least common mechanism (Figure 3.6 and 3.7).

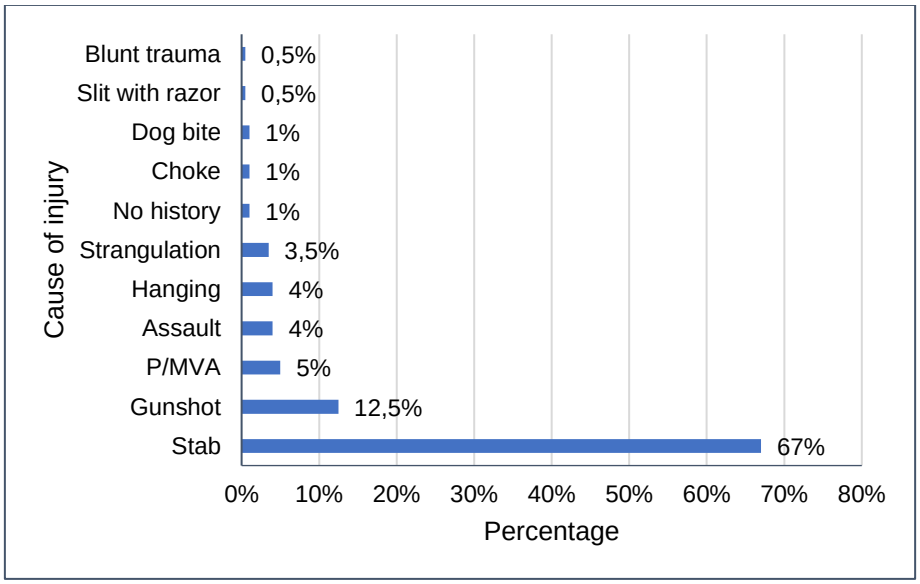


Figure 3.6 Cause of injury including penetrating and blunt mechanisms (N=200)

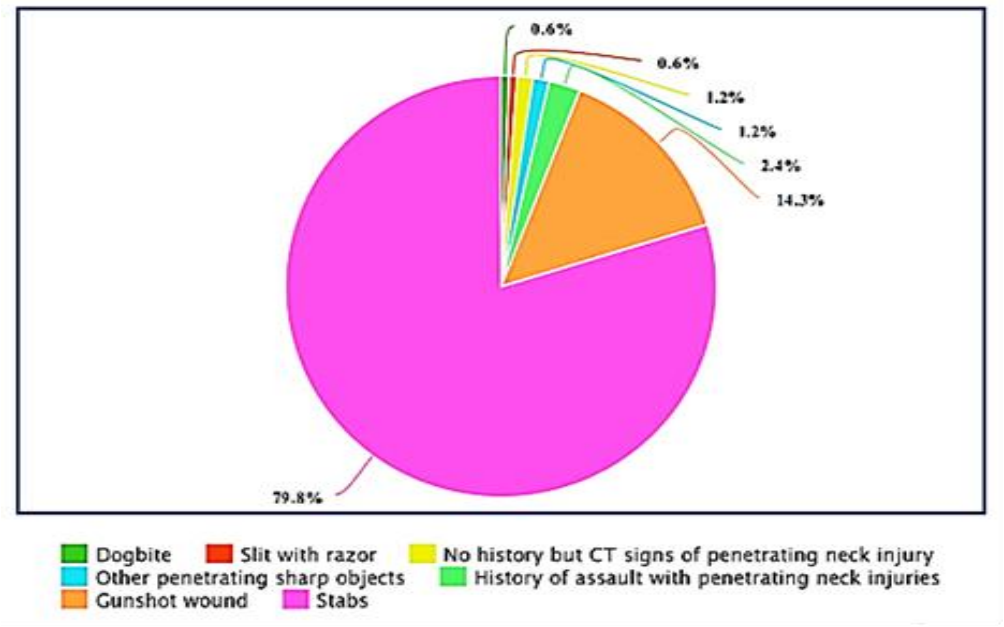


Figure 3.7 Chart to illustrate penetrating neck injuries (N=168)

Blunt injuries were 16% of the population with injuries secondary to hanging (28.1%) being the most common cause. The second common causes of blunt neck injuries were due to MVA and strangulation making 25% of the blunt injuries each. A category of other blunt unspecified forces made 15.6% as shown in figure 3.8).

Pedestrian vehicle accidents (PVA) and bicycle accidents made 3.1% of blunt forces each (Figure 3.8).

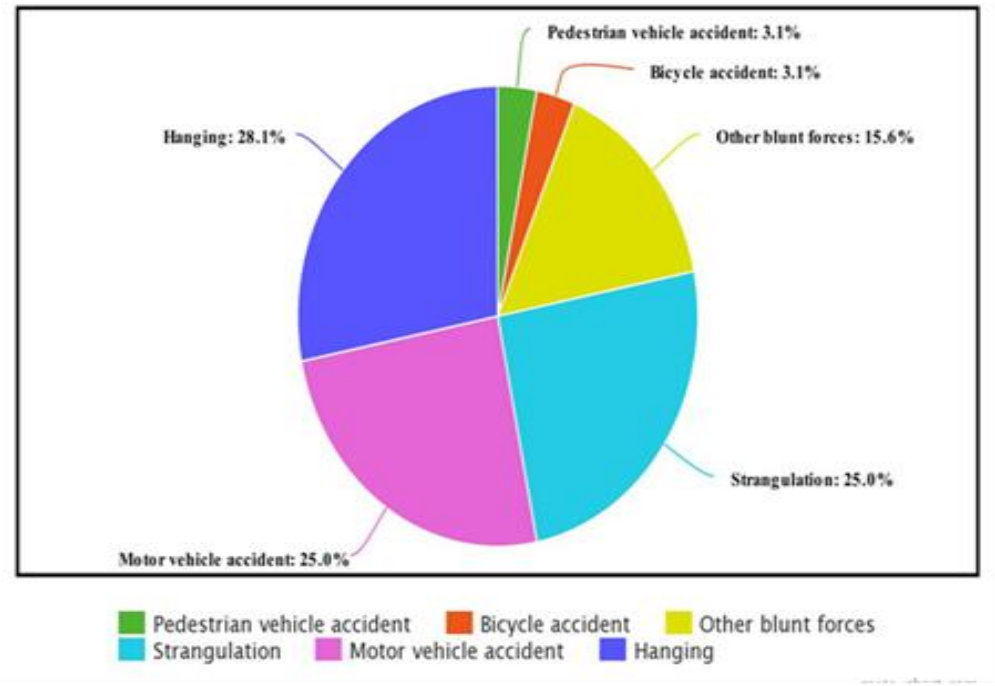


Figure 3.8 Chart to illustrate blunt neck injuries (N=32)

Figure 3.9 demonstrates that of all the systems evaluated, soft tissues were the most involved at 79%, with surgical emphysema being the most common finding followed by lacerations. The second most common involved system was the respiratory (32%), with pneumothorax forming the majority (40) followed by haemothorax (24), lung contusion (19) and pneumomediastinum (8) shown in figure 3.11. Seven of the patients were found to have lung collapse, three with attenuation of the airway and bronchopleural fistula in one patient. Airway attenuation was secondary to external compression resulting from soft tissue haematomas with sites illustrated in figure 3.10. Other findings were not only manifestation of trauma and that included pneumatocoeles and ground glass opacification however they were included in the study for completeness of reporting.

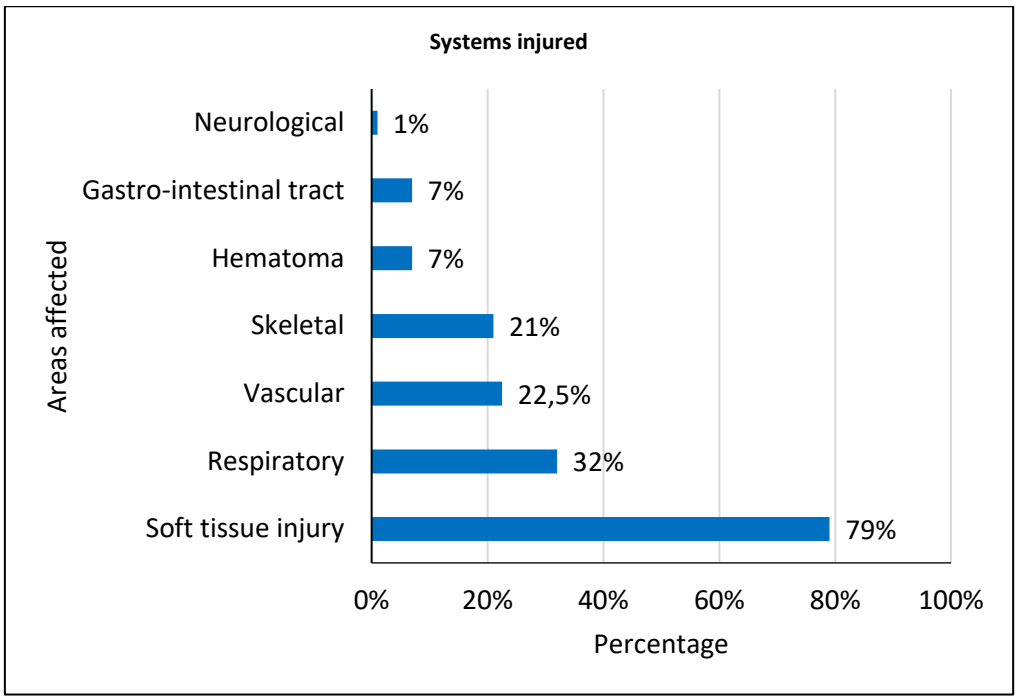


Figure 3.9 Systems injured (N=200)

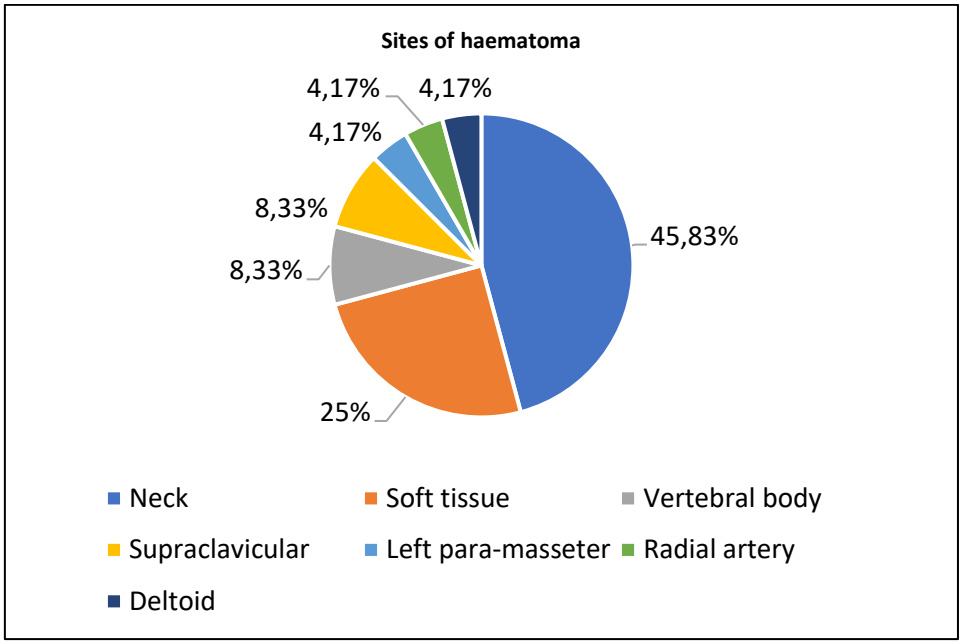


Figure 3.10 Sites of haematoma (N=14)

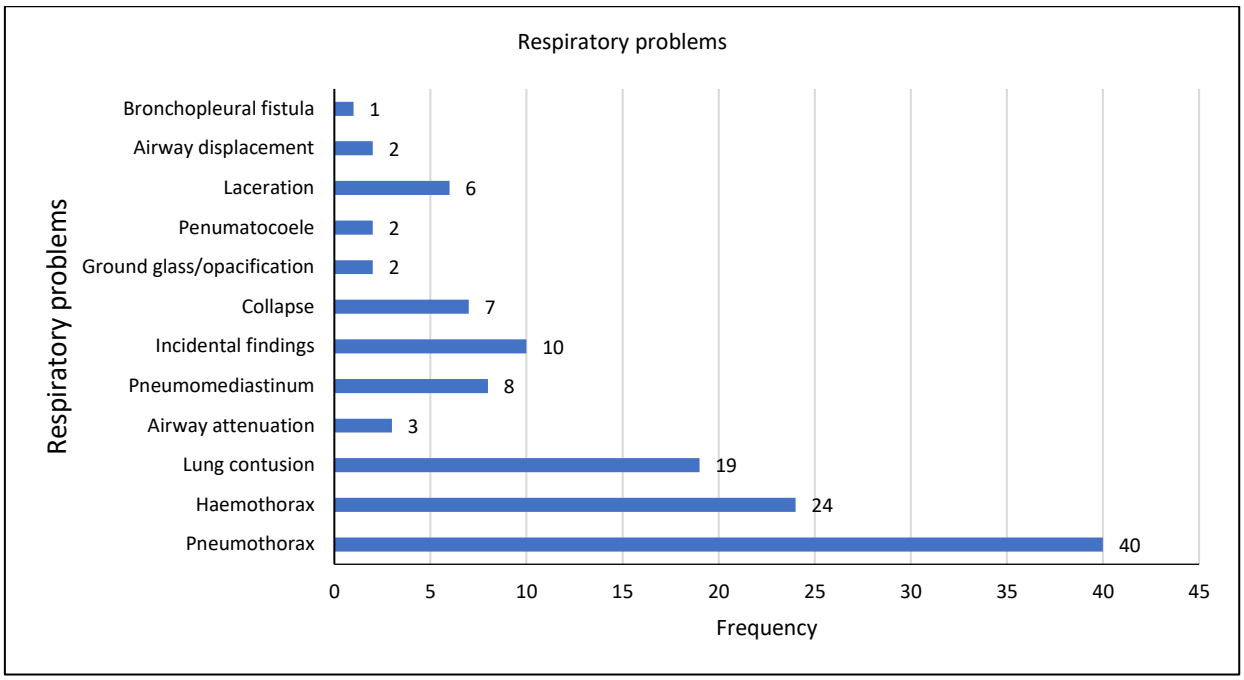


Figure 3.11 Respiratory findings

Our study has demonstrated 22.5% of vascular injuries of which the most common injured system was venous. The common injured vessel was the internal jugular vein, followed by the subclavian artery and then vertebral artery. Majority of the affected internal jugular veins were attenuated by external compression from surrounding soft tissue haematomas, followed by mural breach, which showed contrast extravasation, pseudo-aneurysms, arterio-venous fistula formation, intramural haematoma, and ligation in that order of occurrence. See figure 3.12 and figure 3.13. The internal jugular vein being more lateral and posterior than the rest of the major vessels in the neck puts it more at risk of being commonly injured than any other neck vessel (Figure 4.3).

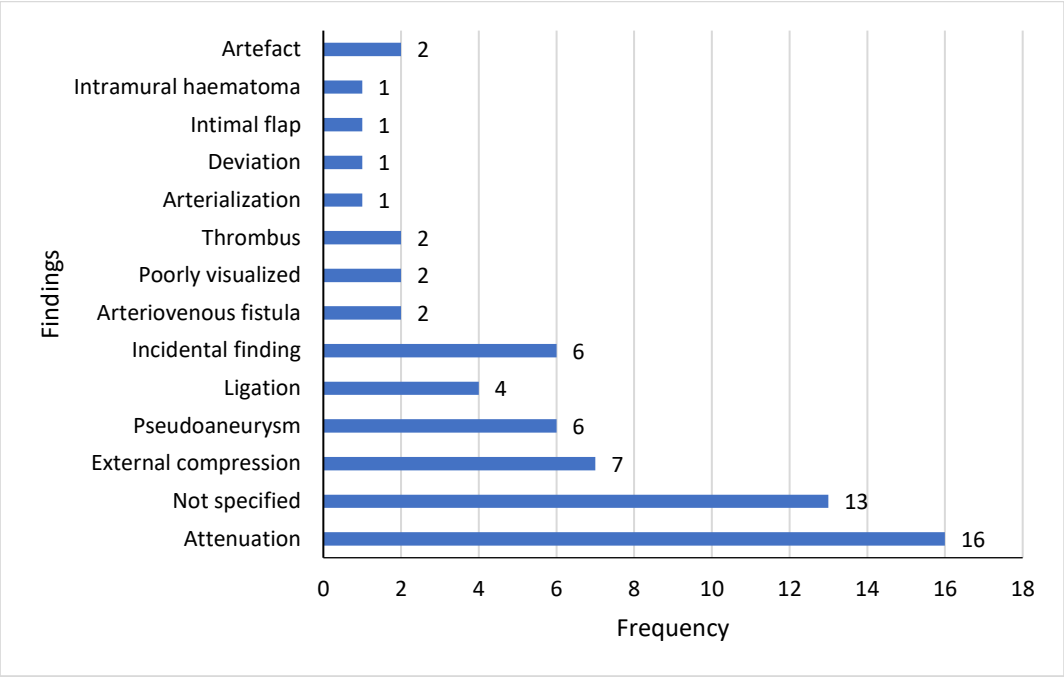


Figure 3.12 Vascular findings

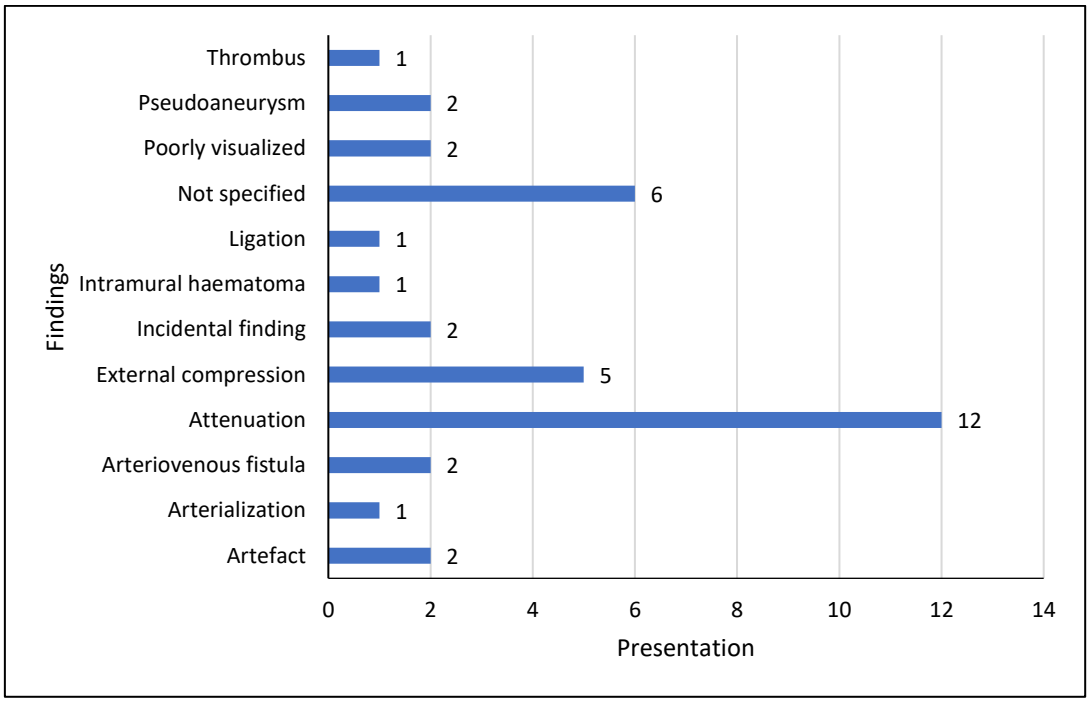


Figure 3.13 Venous vascular findings

Arterial injuries demonstrated the most common finding recorded as no specified injury seen as contrast extravasation, followed by vessel attenuation, and pseudo-aneurysms and incidental findings not related to trauma. Some arteries showed external compression from surrounding

haematoma. More manifestations of the arterial injuries included ligation, arterial dissection demonstrated by intimal flap and thrombus formation (Figure 3.14).

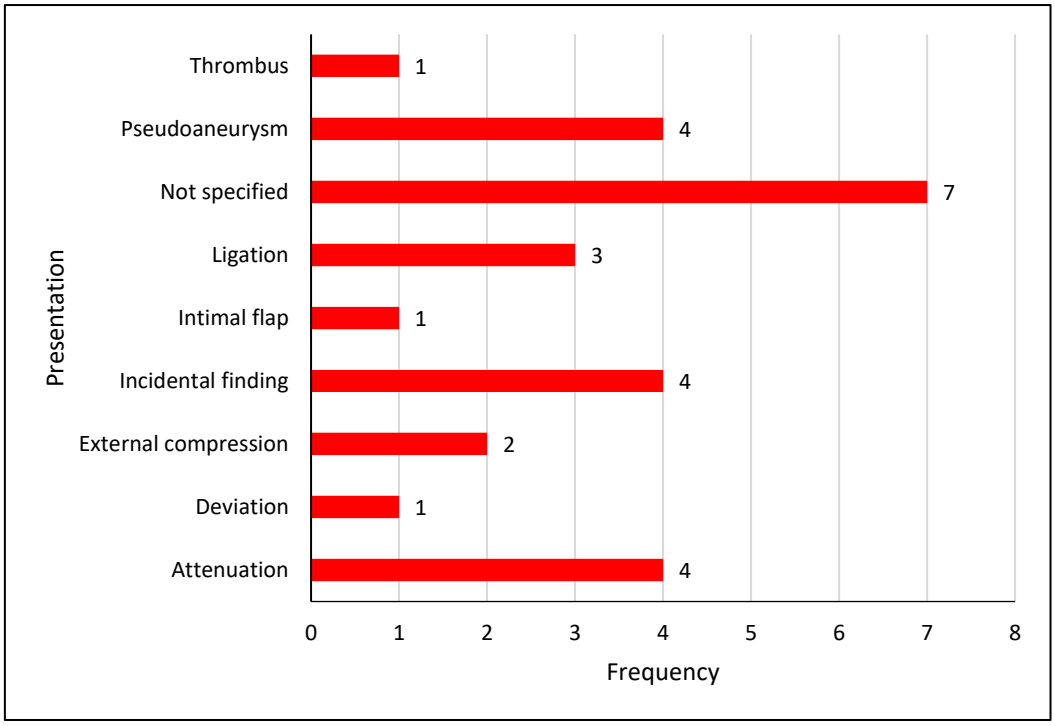


Figure 3.14 Arterial vascular findings

Skeletal system was involved in 21% of the population, which included fractures and dislocations. The bones affected were vertebrae, skull, ribs, clavicle, and scapula in that order of occurrence as shown in figure 3.15.

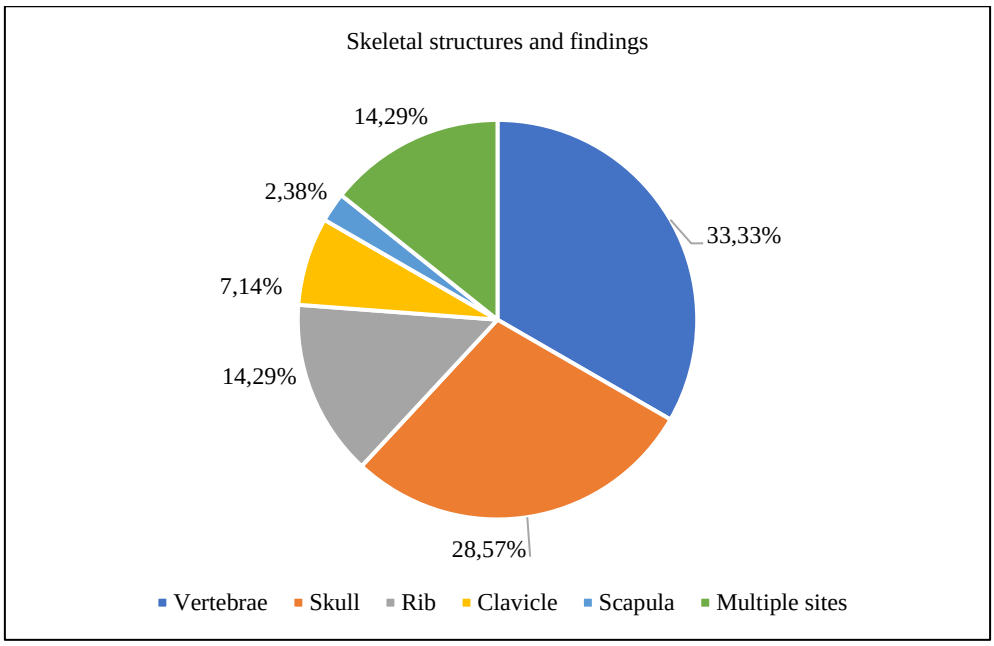


Figure 3.15 Injured skeletal structures (N=42)

The gastrointestinal tract injuries demonstrated the oesophagus as the common injured structure (Figure 3.16). The oesophagus follows a posterior course, and most soft tissue injuries were reported in the posterior surface of the neck, hence substantial risk of the oesophageal injury. The oesophageal injuries were suspected in patients with pneumomediastinum (Figure 4.2(a-c).

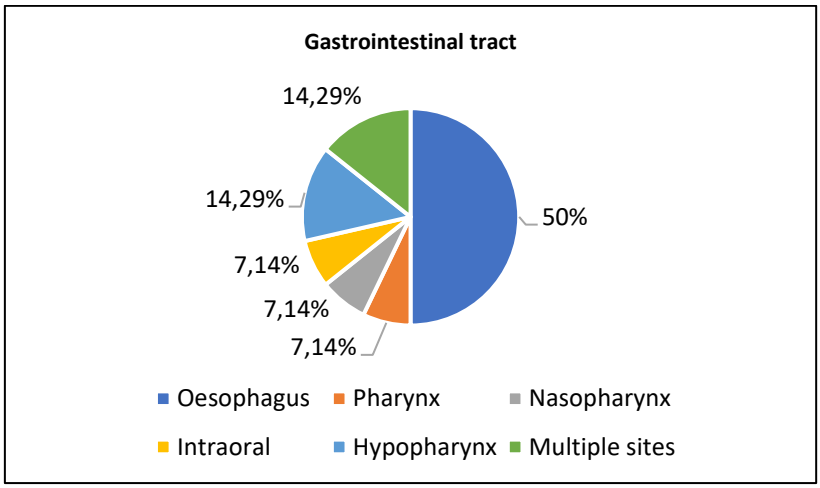


Figure 3.16 Injured gastrointestinal tract regions (N=14)

The soft tissues were the most involved at 79%, with surgical emphysema being the most common finding followed by lacerations (Figure 3.17). This observation is secondary to high numbers of penetrating injuries that result in skin defects.

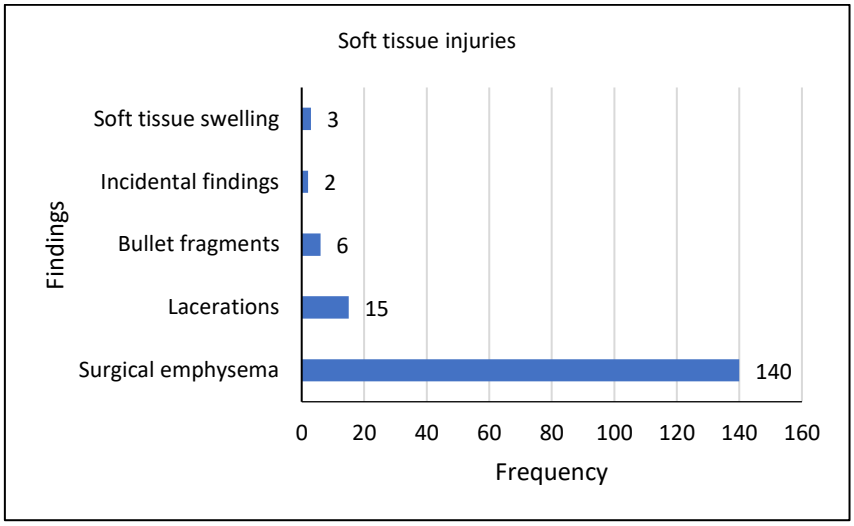


Figure 3.17 Findings related to soft tissue injuries

4. Discussion

4.1. Population and demographics

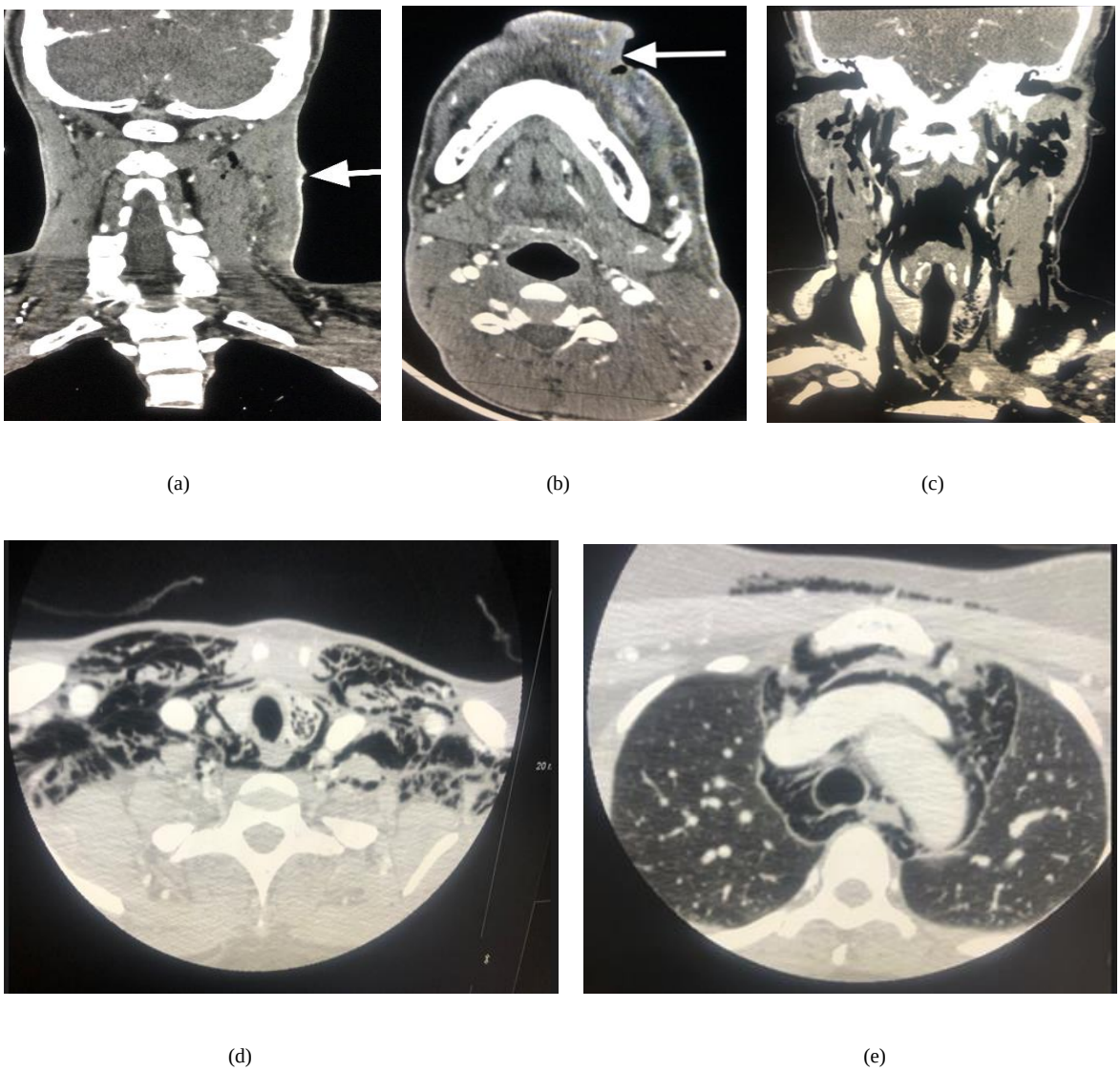
Our study population included 200 participants with a median age of 25 years, and most of them were males. This distribution was different from the studies done in and outside South Africa. A study conducted at AL Zahra hospital, Dubai had similar demographics, study population of 192 and ours 200 as well as majority being male patients. The major difference in the period may be attributed to less trauma compared to our country (19).

Scholtz et al also did a study in 2014 at Groote Schuur Hospital in South Africa using CT and DSA as the imaging modalities with 23 participants and the mean age was 30 years with 18 being males and five females with the age range of 19-51 years (3). M'unera et al performed a study at the University of Miami School of Medicine on penetrating neck injuries using a CTA for initial evaluation. Period of this study was 27 months with a population of 175 patients (16). Ibraheem et al study in 2018 had a population of 337, which was slightly higher than our study and this is more comparable however the demographics of the participants were not clearly stated in this study (20).

4.2. Penetrating neck injuries

The penetrating neck injuries were the most common type in our study compared to the blunt injuries and were recorded in 84% of the patients. Our study further demonstrated that 89.9% of penetrating neck injuries were in male patients and similar to our study the study done in Dubai demonstrated a slightly higher percentage (96.4%) of penetrating neck injuries occurring in men (13). In these penetrating neck injuries, the most leading types of PNI was stabs (79.8%) seen as lacerations in figure 4.1, followed by gunshot injuries (14.3%) shown by bullet fragments (Figure 4.2(c) & figure 4.3 (e & f)). This pattern was like the study conducted in Alzahra hospital (19). This is in contrast with the study done in Philadelphia by Gracias et al that demonstrated that 83% of the patients sustained gunshot wounds, 13% sustained shotgun wounds and only 4% sustained a stab wound (21).

In our study 1,2% of penetrating neck injuries were secondary to dog bite, which was more common in the paediatric population. Brogan et al in Washington also demonstrated dog bites that involved the head and neck affected children younger than 5 years old (22). Ibraheem et al demonstrated that all the participants in their study had penetrating neck injuries with violation of the platysma muscle. This study only examined adults and no other demographics stated in the methods (20).

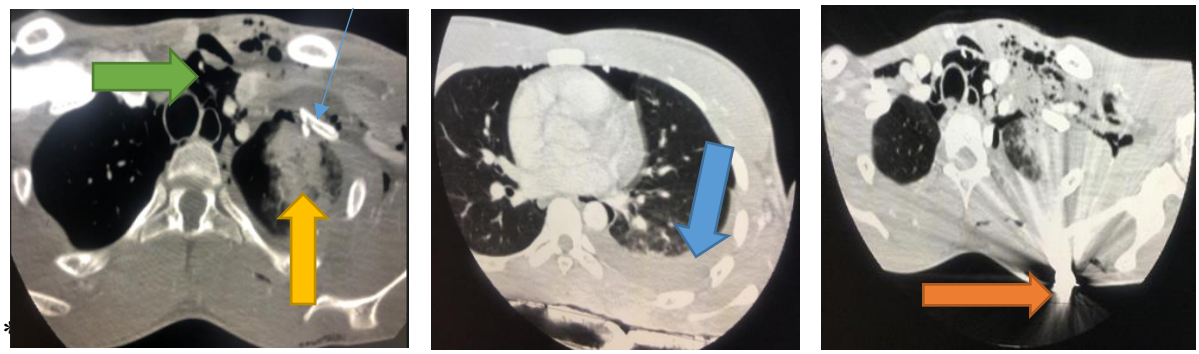


(a) (b) (c)

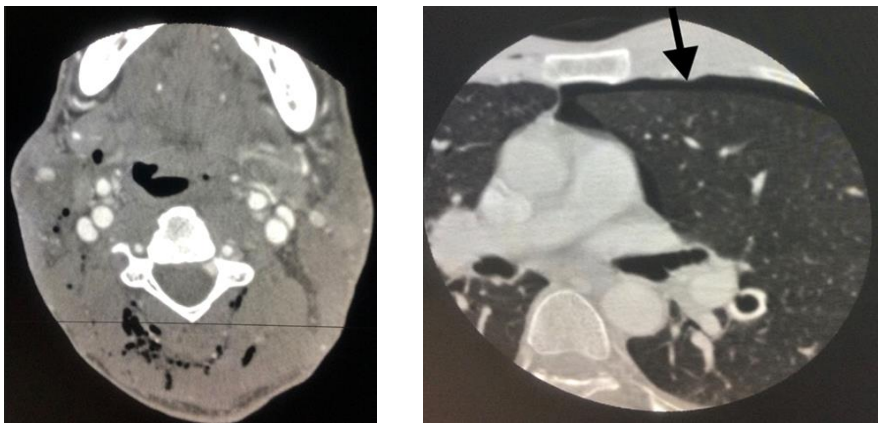
(d) (e)

Figure 4.1 Post contrast scans

Coronal image of the neck demonstrating left posterior neck skin irregularity with deep soft tissue lucencies in keeping with laceration and surgical emphysema (arrows) respectively(a). Similar findings in post contrast CT neck axial view (b). CT neck coronal and axial views showing bilateral extensive surgical emphysema along the superficial and deep soft tissue planes into the superior mediastinum (pneumomediastinum) including the thyroid gland (c-e)



(a) (b) (c)



(d) (e)

Figure 4.2 Post contrast axial views of CT scan of the neck and upper chest

Demonstrating the left supraclavicular space surgical emphysema extending to the superior mediastinum called pneumomediastinum (green arrow), (yellow arrow) hyperdensity in the left upper lobe (lung contusion) and posterior surface of the anterior left first rib fracture (blue arrow) in a-c. Axial view post contrast CT scan upper chest showing bright left posterior pleural space fluid in keeping with blood called haemothorax(b) indicated by blue arrow. Bullet fragment (orange arrow) in the left supraspinatus muscle with surgical emphysema and pneumomediastinum(c). Right neck submandibular & carotid space and posterior neck surgical emphysema (d) & left pneumothorax (black arrow) (e).

4.3. Blunt injuries

There are fewer blunt neck injuries reported in our study in comparison to PNI, and these were commonly reported in female patients. The highest cause of blunt neck injuries resulted from hanging associated with parasuicide (Figure 3.8). Parasuicide is commonly used as a solution to psychiatric patients when they encounter problems however there was no psychiatric history recorded in the request forms (23).

MVA's and strangulation are the second most common causes of blunt neck injuries, each accounting for 25% of blunt neck injuries. This is similar to a study done in the United States of America, which found that homicide; crime and MVA's were the leading cause of blunt neck trauma (24). The high rate of blunt neck injuries related to MVA's is possibly related to alcohol consumption. There is an increase in road traffic accidents when drivers are under the influence of alcohol (25). The aetiology of the cases of strangulation that resulted in blunt neck injuries was largely related to domestic violence.

All the strangulation victims were female patients, and one patient was strangled by an intimate partner. Chokehold was noted in one patient who was a three-year-old child who sustained a blunt neck injury. These injuries are suggestive of the incidence of domestic violence seen in South Africa (26, 27).

4.4. Injuries according to gender

Types of injuries were also categorized by gender. Our study identified that most patients who sustained neck injuries were males (Figure 3.1). It was further found that male patients sustained more penetrating neck injuries and females sustained more blunt injuries. This can be explained by general risk-taking behaviours observed in males when compared to females (28). This may further be related to the interpersonal violence that male gender experience with alcohol consumption. Interpersonal violence accounted for 42.8% of the injuries attributed to alcohol in males and 25.9% in females (29). This distribution in our study may be explained by alcohol consumption in most township areas surrounding CHBAH. Alcohol consumption in males has been shown to be higher than in females (30). This distribution may have resulted from the customary practice of drinking alcohol in shebeens at night until the early hours of the

morning. This behavioural pattern is commonly seen with the male gender as reported by Peltzer et al (30). There is a link between aggressive behaviour and alcohol usage (31). Alcohol intoxication is associated with mood, cognitive, emotional, and behavioural impairment and may result in violent altercation (32, 33). Individuals may use broken drinking glasses or beer bottles as weapons during altercation (34).

4.5. Injuries according to the days of the week with contributing factors

Majority of the neck injuries in our study were encountered in order of increasing frequency from Thursday throughout the weekend to Sunday. Then a drop in numbers was seen on Mondays however these numbers are still higher than the other days mid-week (Figure 3.5). The drinking patterns of young people over the course of the weekend were investigated and it was shown that alcohol consumption increased from Thursday to Saturday evenings in increasing order of number of drinks per evening (35). Our study duplicated this pattern in terms of frequencies of neck injuries with regards to the days of the week.

Other international studies also showed increased alcohol consumption peaking on Friday and Saturday; this pattern has been explained by lack of responsibilities in young people as there is no work or school responsibilities the following day (36). It was shown by Kuntsche et al in a study done in Switzerland that the average number of incidences, like injuries to self or others, happened more after alcohol consumption in bars, pubs, discos, or restaurants more than after drinking alcohol at home (37). Men in their late adolescence and early adulthood drink alcohol heavily on weekends for fun and to seek excitement, and to experience the effects of alcohol as a form of expression of a more general risk behavioural syndrome (37).

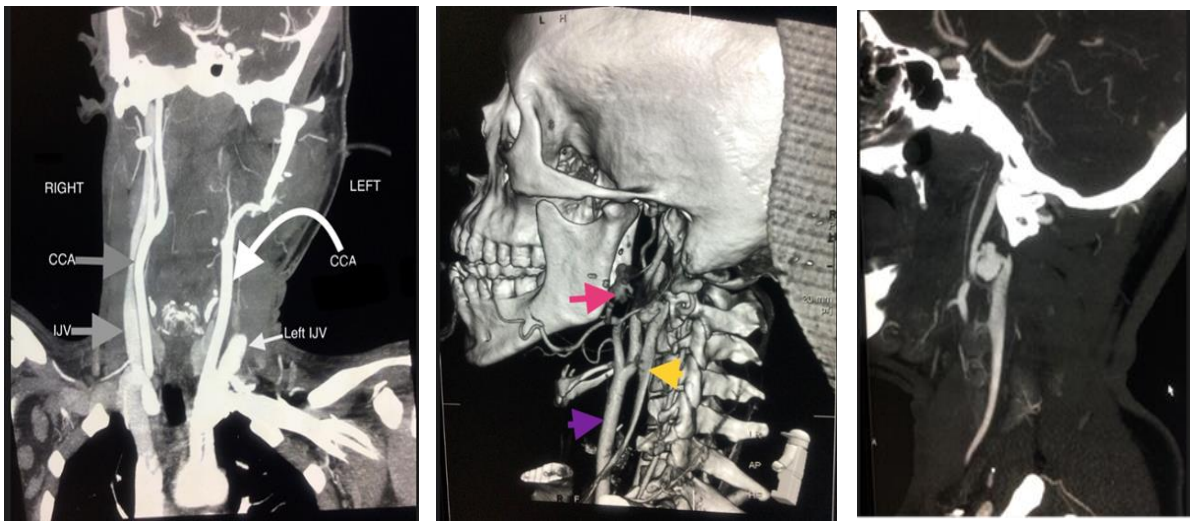
Young adults have a tendency of increasing drinking pace of alcohol in that they consume a higher number of drinks per hour and particularly on Saturday nights (37). Gauteng province was reported to be among the top provinces with highest numbers of adults who were in self-reported binge drinking category in terms of alcohol consumption and males showed high prevalence with age range of 25-34 years (38). This is comparable with the highest age distribution of neck injuries in our study, and it can therefore be inferred that age distribution of neck injuries is linked to alcohol consumption.

Most of the participants in a study done in the United States of America demonstrated starting drinking alcohol at the age of 25 (39), whereas the South African legal age to buy and consume alcohol is 18 years however alcohol consumption has been noted to start even earlier during adolescence (40).

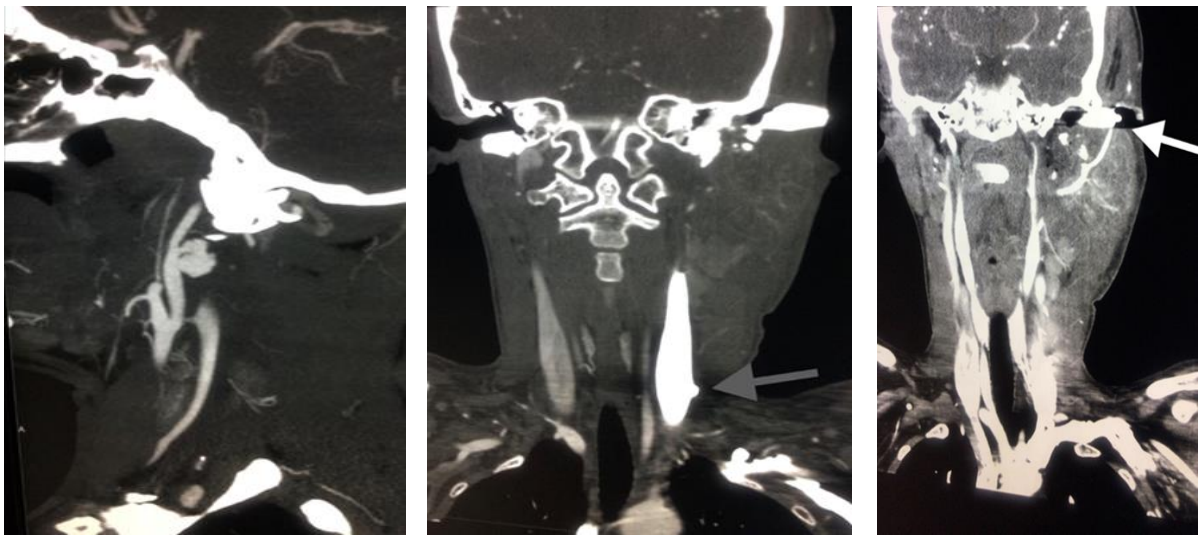
Some neck injuries in our study were as a result of armed robbery that occurred at residential premises during housebreakings however a study done by Abbas et al has reported that during house robbery neck was one of the least attacked sites during gunshot related armed robbery (41, 42).

4.6. Vascular injuries

Our study demonstrated that 22.5% of all neck injuries (blunt and penetrating) were vascular injuries. The most common vascular injuries in our study were venous in origin and the most common injured vessel was internal jugular vein (Figure 4.3). This was not demonstrated in studies elsewhere. In contrast to our study, a study done by Gracias et al. in Philadelphia identified more arterial injuries than venous injuries (21). Steenburg et al. demonstrated that in patients presenting with PNI, 10 - 25% of patients sustained arterial injuries and 16 – 18% of patients sustained venous injuries (7).



(a) (b) (c)



(d) (e) (f)

CCA, Common carotid artery; IJV, Internal jugular vein.

Figure 4.3 Multiplanar magnified reconstructed views of CT angiogram of the neck

(a)demonstrating avid contrast opacification (arterialization) of the internal jugular vein (IJV) in arterial phase (a) with annotations. Volume reconstructed sagittal image of the post contrast CT neck showing left maxillary artery blush (pink arrow), left internal jugular vein (yellow arrow) and the left common carotid artery (CCA) (purple arrow) in (b). Abnormal communication between the left IJV and the internal carotid artery (arteriovenous fistula) in c-d). Post contrast CT scan of the neck coronal view demonstrating abnormal outpouching or dilatation of the left internal jugular vein known as the false/pseudoaneurysm (grey arrow) in (e). Coronal view of the post contrast CT neck showing left external auditory meatus bullet causing streak artefact (f).

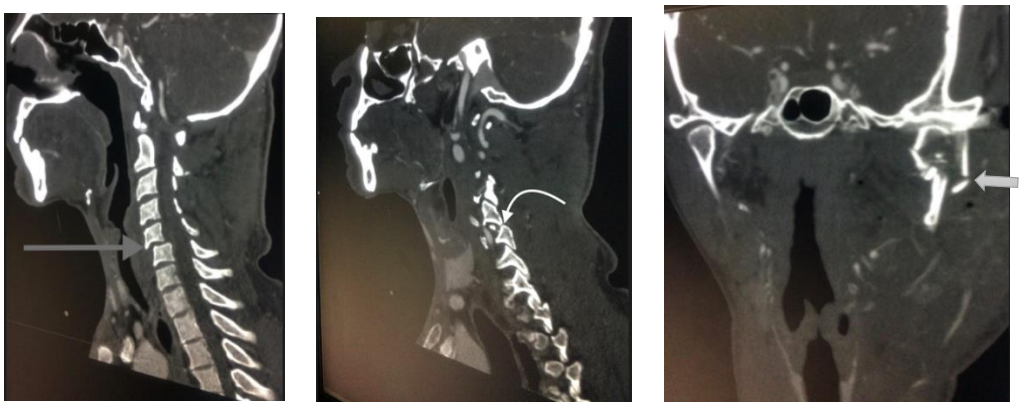
A local study by Scholtz et al. at Groote Schuur Hospital, conducted on PNI only focused on arterial injury (7). Our study showed vascular arterial injuries with the following findings however lower incidences: Contrast extravasation (n=7), partial occlusion (n=6), pseudo-aneurysm (n=4), incidental findings (n=4), ligation (n=3), intimal flap (n=1), partial thrombus (n=1) and deviation (n=1). Venous injuries included partial occlusion (n=17), contrast extravasation (n=6), pseudo-aneurysm with AVF (n=2), poorly visualised (n=2), incidental findings (n=2), streak artefact from contrast (n=2), partial thrombus (n=1), ligation (n=1) and intramural haematoma (n=1). This was like the findings of M'unera et al. in a study performed at the University of Miami School of Medicine on penetrating neck injuries that showed that the arterial injuries findings were twice as common when compared to our study. Their findings were arterial occlusion (n=14), pseudo-aneurysm (n=8), pseudo-aneurysm with AVF (n=4), partial thrombosis (n=2). One hundred forty-six patients had normal arteries, two scans were

inadequate for diagnosis, were referred for DSA, and had normal findings. Twenty-seven patients (15.6%) had arterial lesions that were detected. One patient had two arterial injuries (16).

4.7. Gastrointestinal and other injuries

In our study, the gastrointestinal tract injuries demonstrated the oesophagus as the common injured structure. The oesophagus follows a posterior course, and most soft tissue injuries were reported in the posterior surface of the neck, hence substantial risk of the oesophageal injury. The oesophageal injuries were suspected in patients with pneumomediastinum (Figure 4.2(c, d, and e). Steenburg et al. demonstrated that the oesophageal and tracheolaryngeal injuries were uncommon. Cervical spine and spinal cord injuries occurred in 11-14 patients (7).

Two patients with uncommon findings, one with air locules within the spinal canal and the second with haemorrhage. Fractures were common skeletal injuries in our study, and these involved the vertebrae, skull, ribs, clavicle, and scapula with associated dislocations. Most fractures were reported in patients who sustained gunshot wounds, and since the penetrating neck injuries were the leading mechanism of injury, this explains the high yield of fractures (Figure 4.4).



(a) (b) (c)

Figure 4.4 Sagittal views of bone windows of the CT scan of the neck

(a-b) demonstrating anterior displacement (anterolisthesis) of C5 on C6 vertebra (a) and C5 on C6 vertebra anterior facet joint dislocation (b). Coronal view bone window of the CT scan of the neck showing comminuted fracture of the left mandibular condyle(c).

Lesions other than vascular injuries were reported in 61 patients (34.9%). These lesions included vertebral fractures (n=21), mandible fractures (n=17) and major airway injuries (n=4) (28). Soft tissue haematoma compressing the airway (n=16) and haematoma causing cord compression was n=3 (16).

Whether penetrating or blunt, the management of neck injuries remains controversial, with a shift from mandatory surgical exploration to CTA as an initial management approach. A litany of studies has demonstrated that an excellent physical examination must always be performed to provide a clinical guide in evaluating and treating neck injuries (2, 5, 12). Richard Holt et al. in the "Resident manual of trauma to the face, head and neck" recommended that haemodynamic stability or instability be used as the guide to the urgency of management and intervention of neck injuries, including the performing CTA prior to the exploration of the neck to control haemorrhage and secure the vascular elements (43).

Table 4.1 Table of study comparison

Study	Scholz, Beningfield & Candy(3)	Offiah & Hall(12)	Munera, Soto, Palacio, Velez & Medina (17)	Munera, Soto & Nunez(16)	Scott, Steenburg & Leatherwood(7)	Ibraheem, Khan & Rhee(20)	**Makhubela, Koranteng & Ntsinjana**
Year	2014	2012	2000	2004	2016	2018	2023
Length of study	3 years	Not included	24 months	Not stated	Not stated	8 years	1 year
Imaging modality used	CT and DSA	CT	CT and DSA	CTA	CTA	CT	CT scan of the neck
No. of patients	23	Number not stated in the study	60	Not included	Not included	337	200
Age range and mean age	19-51 years and mean age was 30 years	Not stated	Not stated	Not stated	Not stated	Median age 30(26-40)	Range (25-36) Mean 25 years
Gender	18 male, 5 female	Not stated	Not stated	Not stated	Not stated	273 male 64 female	169 male 31 female
Mechanism of injury	Stab wounds-20 (87%) Gun shot -3(13%)	Not stated	Not stated	Penetrating and blunt injuries	Penetrating injuries	Stab wounds-233(62.1%) Gunshot-71(21.1%) Shot gun injury-33(9.8%)	Penetrating injuries: Stab 67% Gun shot 12.5 % Blunt injuries: Hanging 28.1% Motor vehicle accidents 25% Strangulation 25%
Commonest injuries	Not stated	Not stated	Vascular injuries	Vascular injuries	Not stated	Not stated	Soft tissue injuries
Vascular injuries	24 arterial injuries	Not stated	Arterial injuries in 10 (17%) of 60 patients	Occlusion, pseudoaneurysm, intimal, dissection and arteriovenous fistula.	Not stated	Not stated Not stated	Internal jugular vein, subclavian and vertebral arteries.
Criticism	The unavailability of unsubtracted DSA images because they were not always available may have resulted in false positive/negative results, as the mask image would have guided the anatomy of the imaged neck.	Population assessed and the period of the study not accounted for.	Small number of patients with abnormal findings may negatively have impacted on the outcome	Population assessed and the period of the study not accounted for.	Population assessed and the period of the study not accounted for in the study.	Length of the study is very long. Only adults are in the population examined. However, the results are significant.	The retrospective nature of the study is the most significant limitation. The experience of the reporting and reviewing Radiologists is variable ranging from the most junior specialist to the most senior therefore the report findings are not standardized.

6. Current and future applications

The current practice at Chris Hani Baragwanath Academic hospital is that the management of haemodynamically stable patients with a traumatic neck injury includes an urgent contrasted CT scan of the neck. This should prompt a development of a reporting template (appendix C) that includes all the systems that this study has included in the data collection sheet in appendix A so that important injuries are not overlooked and hence not reported. Templates will also result in uniformity with regards to reporting neck injuries.

7. Limitations of the current study

This research project was performed in the largest academic hospital in South Africa located in a township with a very high prevalence of trauma. Due to high rates of crime and trauma in South Africa, the prevalence of neck injuries might be higher than what has been recorded. The study population may predominantly be black Africans as CHBAH patients are mostly black Africans due to the population in Soweto and surrounding townships. The retrospective nature of the study is the most significant limitation.

The experience of the reporting and reviewing Radiologists is variable ranging from the most junior recently qualified specialist to the most senior experienced, therefore the report findings are not fully standardized or uniform as there is no template utilized. Some of the reports did not include the assessment of the soft tissues and bones hence subtle findings like intimal flaps and subtle linear fractures may have probably been missed while reporting. This may cause significant interpretational variance of the CT reports.

8. Conclusion

Our audit of CT scans of patients who experienced neck trauma showed a considerable number of male patients' involvement ranging from 21-30 years old, PNI being the most common mechanism of injury, occurred commonly on weekends with median time of 22:00:00 and were

associated with alcohol consumption. In these penetrating injuries the most leading types were stabs, which were followed by gunshot injuries.

In all these injuries the most common injuries were soft tissue damages among the patients, followed by respiratory system and then injury to the blood vessels. Among the vascular injuries, the internal jugular vein was the most common injured vessel followed by subclavian and the vertebral arteries respectively. The gastrointestinal tract injuries demonstrated the oesophagus as the common damaged structure. The skeletal injuries demonstrated fractures as the common type of injury.

Female patients showed more blunt neck injuries than penetrating mechanisms. Most blunt neck injuries resulted from attempted hanging associated with parasuicide followed by strangulation and MVA's.

Radiologists should be aware of life-threatening injuries associated with neck trauma including vascular injuries. The benefits of the reporting template suggested by the authors are as follow:

- Guide and improve reporting of potential neck injuries to ascertain that vital structures like vessels are evaluated thus help managing clinicians provide desired management.
- Systemic /complete assessment of the other structures in the neck other than vessels.
- Improvement of reporting typing errors.
- Improve efficiency in reducing the length of typing time.

CT scan is a modality of choice to assess neck injuries and its importance in holistic patient management. It forms an integral part of definitive management of hemodynamically stable patients at CHBAH.

As stated above that Radiologists should be aware of vascular injuries. Although these injuries were demonstrated to be the 3rd most involved, they represented a significant percentage which demonstrates the importance of thorough evaluation by the reporting Radiologist. Less life-threatening injury included soft tissues which were the most involved.

CT scan of the neck also guides further management for example, contrast swallow if there is suspicion of oesophageal injury.

Tackling trauma reduction strategies in terms of alcohol consumption using more strict age restrictions and early closing of bars by relevant stakeholders may be a relevant form of intervention.

9. References

Please note that the referencing in this thesis is a modification of the Vancouver Referencing style, done according to the Faculty of Health Sciences Style Guide as set out by the Wits Health Sciences Library.

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APPENDIX A: Data collection sheet

Unique patient ID	Gender	Age	Day of scan	Time of scan	Mechanism: Blunt/Penetrating	Vascular Y/N	Name of vessel	Respiratory	Gastrointestinal	Soft tissue	Haematoma	Skeletal	Neurological

APPENDIX B: Ethics clearance certificate

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG

R14/40 Dr BV Makhubela

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
CLEARANCE CERTIFICATE NO. M200201

NAME: (Principal Investigator)	Dr BV Makhubela
DEPARTMENT:	School of Clinical Medicine Department of Radiation Sciences Division of Radiology Chris Hani Baragwanath Academic Hospital
PROJECT TITLE:	Computed tomography as a diagnostic tool in imaging of neck injuries in a large trauma unit in Gauteng
DATE CONSIDERED:	28/02/2020
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Dr PN Koranteng
APPROVED BY:	Dr CB Penny, Chairperson, HREC (Medical)
DATE OF APPROVAL:	2020/03/19

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office Secretary on the 3rd Floor, Philip Tobias Building, Parktown, University of the Witwatersrand, Johannesburg.

I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated, from the research protocol as approved, I/we undertake to submit details to the Committee. I agree to submit a yearly progress report. When a funder requires annual re-certification, the application date will be one year after the date when the study was initially reviewed. In this case, the study was initially reviewed in **February** and will therefore reports and re-certification will be due early in the month of **February** each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical).

Principal Investigator Signature

19/03/2020
Date

PLEASE QUOTE THE CLEARANCE CERTIFICATE NUMBER IN ALL ENQUIRIES

APPENDIX C: Reporting template of neck injury

Mechanism	**Penetrating** Yes No ☐ ☐ If yes, name of object:	**Blunt** Yes No ☐ ☐ If yes, name of object:
Vascular injuries	Tick relevant findings then describe positive findings: **Arterial:** Yes No ☐ ☐ If yes, name of the vessel: • **Ligation** Yes No ☐ ☐ • **Contrast extravasation** Yes No ☐ ☐ • **Dissection** Yes No ☐ ☐ • **Attenuation/Stenosis/External compression** Yes No ☐ ☐ • **Pseudoaneurysm** Yes No	Tick relevant findings then describe positive findings: **Venous:** Yes No ☐ ☐ If yes, name of the vessel: • **Contrast extravasation** Yes No ☐ ☐ • **Attenuation/Stenosis/External compression** Yes No ☐ ☐ • **Pseudoaneurysm** Yes No ☐ ☐ • **Arterio-venous fistula** Yes No ☐ ☐ • **Vascular calcifications with names of vessels involved.** Yes No

	☐ ☐ • **Vascular calcifications with name of vessels involved.** Yes No ☐ ☐ • **Incidental findings** Yes No ☐ ☐	☐ ☐ • **Incidental findings** Yes No ☐ ☐
Non-vascular findings	• **Soft tissue injury** Yes No ☐ ☐ • **Haematoma** Yes No ☐ ☐ • **Skeletal system** Yes No ☐ ☐	• **Respiratory system** Yes No ☐ ☐ • **Gastrointestinal tract** Yes No ☐ ☐ • **Central nervous system** Yes No ☐ ☐