MAGNITUDE AND PATTERN OF HEARING LOSS AMONG POST-HEAD INJURY OUTPATIENTS AT NEUROSURGICAL CLINIC, MUHIMBILI ORTHOPAEDIC INSTITUTE (MOI)

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By

Aggrey Ibrahim Kibuta

A Dissertation Submitted in (partial) Fulfillment of the Requirement of the Degree of Master of Medicine (Otorhinolaryngology) of Muhimbili University of Health and Allied Sciences

October, 2021

CERTIFICATION

The undersigned certifies that they have read and hereby recommend for acceptance by the Muhimbili University of Health and Allied Sciences a dissertation titled: "**Magnitude and pattern of hearing loss among post-head injury outpatients at Neurosurgical clinic, Muhimbili Orthopaedic Institute (MOI)"** in (partial) fulfillment of the requirement for the Master of Medicine in Otorhinolaryngology of the Muhimbili University of Health and Allied Sciences (MUHAS).

_____

Dr Aveline A. Kahinga

(Supervisor)

Date_____

DECLARATION

I**, Aggrey Ibrahim Kibuta** declare that this dissertation is my original work and that it has not been presented and will not be presented to any other university for a similar or any other degree award.

Signature_____ **Date**_____

ACKNOWLEDGEMENT

To the Almighty God, from whom we receive grace and blessings for our living.

I would like to express my sincere gratitude to my supervisor, Dr Aveline A. Kahinga for her mentorship, guidance and support to the completion of this work.

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Lastly but not least, to my colleagues for their mutual cooperation during my entire period of studies.

DEDICATION

To my wife Jackline Hermens, and my son Calvin.

ABSTRACT

Background: Hearing loss is a common sequela of traumatic head injury, associated with substantial social and economic costs as it compromises communication.

Objective: To determine the magnitude and pattern of hearing loss among post-head injury adult outpatients attending Neurosurgical clinic at Muhimbili Orthopaedic Institute (MOI).

Methodology: This was a hospital-based descriptive cross-sectional study, involving post-head injury adult outpatients at Neurosurgical clinic, MOI. Information on demography, cause and duration of injury was collected using a structured questionnaire; each participant then underwent a pure tone audiometric (PTA) test to assess the hearing status. Head computed tomography (CT) scans taken post-admission were reviewed for evaluation of the temporal bone. The data were entered into the Statistical Package for Social Sciences (SPSS) version 23.0 and analyzed. Fisher's Exact test was used to test for associations between variables, with a p-value of < 0.05 accepted as statistically significant.

Results: A total of 226 participants were enrolled. Their ages ranged from 18 to 65 years with a mean age of 34.1±11.3 years. The majority 132(58.4%) were in the age group of 18-35 years. Males constituted more than three quarters 195(86.3%) of the participants, with a male to female ratio of 6.3:1. Out of 226 participants, 37(16.4%) were found to have hearing loss which was unilateral in more than 90% of the affected individuals, and nearly half 18(48.7%) had sensorineural hearing loss (SNHL). The severity of hearing loss ranged from mild to severe, with the majority 21(56.8%) exhibiting mild hearing loss. Longitudinal temporal bone fractures were the commonest 18(48.7%) temporal bone CT scan findings among the affected individuals, followed by transverse fractures, and were associated with conductive ($p < 0.01$) and sensorineural ($p = 0.034$) types of hearing loss respectively.

Conclusion: The study showed that 37(16.4%) individuals out of the studied population had hearing loss, with sensorineural type of hearing loss being the commonest, and the severity of hearing loss was significantly increasing as the severity of head injury raised.

Recommendations: A multidisciplinary approach involving Neurosurgeons, Otorhinolaryngologists, Radiologists, and Audiologists is important in the early diagnosis of hearing loss, treatment and audiological follow up of patients with head injury.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

ABR - Auditory Brain Response

CHL - Conductive hearing loss

CI - Confidence interval

CN - Cranial nerve

CT - Computed tomography

ENT - Ear, Nose and Throat

GCS - Glasgow coma scale

MoHCDEC- Ministry of Health, Community Development, Gender, Elderly and Children

MOI - Muhimbili Orthopaedic Institute

MTA - Motor traffic accident

MUHAS - Muhimbili University of Health and Allied Sciences

SNHL - Sensorineural hearing loss

SPSS - Statistical Package for Social Sciences

DEFINITIONS OF TERMS

Head injury - Open or closed trauma to the head, with or without skull fracture, with resultant brain dysfunction.

Brain concussion - Brain injury resulting from shearing forces or acceleration-deceleration movement of the brain following blunt head trauma.

Labyrinthine concussion - Damage to the inner ear due to acceleration-deceleration movement of the membranous labyrinth following head trauma with no skull fracture, resulting in SNHL.

Hearing loss - Reduced or complete inability to perceive sounds.

Conductive hearing loss - Hearing loss resulting from impaired conduction of sound from either external or middle ear to the cochlear.

Sensorineural hearing loss - Hearing loss resulting from impaired transduction of sound waves in the cochlear, or transmission of impulses to the brain for interpretation.

Mixed hearing loss - co-existence of conductive and sensorineural hearing loss

CHAPTER ONE

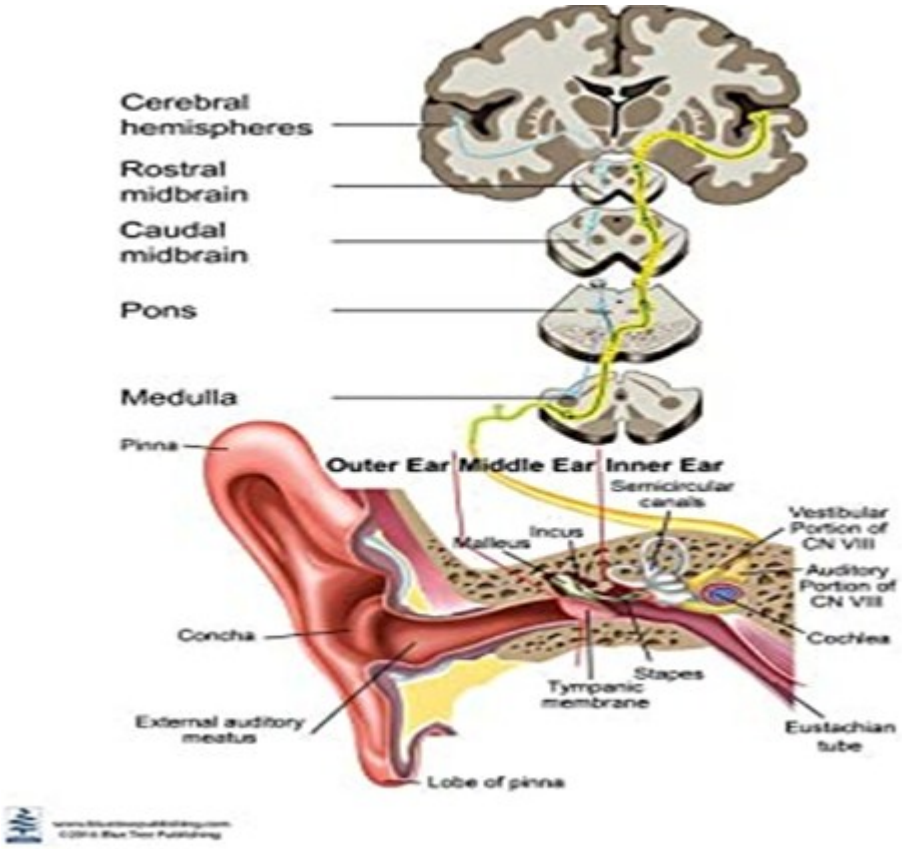
1.0 INTRODUCTION

1.1 Background

Hearing loss is a reduced or complete inability to perceive sounds; thus, impairing communication. It is an important public health concern, affecting millions of people around the world, with significant social and economic costs. In infants and children hearing loss impairs speech and educational progress while in adults results into difficulties in both professional and social life.[1]

The auditory pathway includes the ear and the auditory centers in the brain, with the auditory nerve (CNVIII) in between, (Figure 1). The ear, which is a sensory organ for hearing and postural equilibrium of the body is located on the temporal region of each side of the head to within the temporal bone, and has three distinguishable parts namely the external, middle and inner ear.

The external ear comprises the pinna; which is the visible part of the ear, the external auditory canal and the tympanic membrane. The middle ear is an air-filled cavity located in the temporal bone, medial to the tympanic membrane, consisting of three small bones called ossicles, joined to each other by synovial joints. This chain of small bones is connected to the tympanic membrane laterally and to the oval window medially which connects to the inner ear. The inner ear is a fluid-filled part of the ear located deep within the rock-hard petrous part of the temporal bone, with two functional units; the cochlear and the vestibular apparatus. The cochlear is a snail-shell-like structure containing the sensory organ of hearing (i.e. the organ of Corti). The vestibular apparatus consists of the vestibule and three semicircular canals which are sensory organs for body balance.



Source: www.amazon.com

Figure 1: A diagram showing the auditory pathway (the ear and its parts, the auditory nerve and the auditory parts of the brain).

When a sound is produced outside the external ear, the sound waves travels down the external auditory canal and strikes the tympanic membrane which vibrates. The tympanic membrane vibrations are then passed through the ossicular chain in the middle ear, which amplifies the sound waves before sending them into the hearing organ (the organ of Corti) in the inner ear where the sound waves are converted into electrical signals. The cochlear nerve sends these signals to the auditory centers in the brain where they are translated as sound.

There are three types of hearing loss, namely conductive, sensorineural, and mixed hearing loss depending on the part(s) of the auditory system involved.

- Conductive hearing loss occurs following impaired sound conduction from either the external or middle ear to the cochlear.
- Sensorineural hearing loss (SNHL) occurs when there is damage to the cochlear or nerve pathways from the inner ear to the brain.
- Mixed hearing loss occurs when both conductive and sensorineural hearing loss occurs concomitantly.

The severity of hearing loss ranges from mild to profound hearing loss depending on the hearing threshold, measured in decibels (dB).[2]

Hearing loss results from a number of causes, which can be broadly categorized into congenital and acquired causes. Head injury is among the acquired causes of hearing loss, with motor traffic accidents (MTA) being the commonest cause of the injury; others include falls from height, physical assaults and sports. The incidence of head injuries is progressively increasing due to urbanization and the growth human and vehicular populations with limited infrastructure.[3] According to the World Health Organization (WHO) Global status report on road safety 2018, MTA-related injuries and deaths continue to climb, reaching 1.35million in 2016, with more than 90% of the fatalities occurring in developing countries.[4] Tanzania is among countries with high rates of road traffic crashes, mostly involving motorcycles.[5]

Hearing loss as sequela of head injury may result from injury to the peripheral or central auditory structures of the auditory system, with or without skull base fractures. The most pronounced injury is the fracture of the temporal bone, which houses the peripheral auditory structures (i.e. the inner, middle, and part of the external ear). Other mechanisms include labyrinthine and brain concussion without temporal bone fractures.[6] Around one-third of head trauma victims sustain skull fractures, and approximately one-fifth of skull fractures involve the temporal bone. Temporal bone fractures are categorized as longitudinal, transverse or mixed depending on the relationship of the fracture line to the long axis of the petrous part of the temporal bone. Longitudinal type of temporal bone fractures is by far the most common, accounting for more than 70% of temporal bone fractures, often results from blows to the temporal or parietal areas while transverse fractures commonly follows occipital or frontal

blows. Transverse fractures often violets the otic capsule and are likely to result in immediate and severe SNHL.[7]

The mechanisms responsible for SNHL include direct injury to the cochlear nerve and the membranous labyrinth, vascular impairment, bleeding or hematoma formation in the inner ear, peri-lymphatic fistula and endolymphatic hydrops.[8] Longitudinal fractures commonly result in perforation of the tympanic membrane, disruption of the ossicular chain due to fracture or luxation, and accumulation of blood clots in the external auditory canal, with resultant conductive hearing loss. The stapedial footplate may be forced inwards through the oval window leading to rupture of the oval window with resultant peri-lymphatic leak and damage to the organ of Corti leading to SNHL.[7,9] Hearing loss may also occur without skull or temporal bone fractures, rather from concussive events in the inner ear, and the auditory parts of the brain.[10,11]

Sensorineural hearing loss is the most common type of hearing loss in head injury subjects, most pronounced in higher frequencies (especially at 4000Hz), however the whole frequency range can be involved.[9,12] Unlike with SNHL, most cases of conductive hearing loss will resolve during the first few months, approximately six months after the injury, but it is also possible that the initial loss may progress or worsen particularly when there is ossicular chain disruption.[13]

1.2 PROBLEM STATEMENT

Hearing loss is a common sequela of head injury, associated with significant social and economic costs as it compromises communication. Several studies on hearing loss following head injury have been done in various settings, and have shown that almost one-third of patients suffer from hearing loss following head injury.[12] Despite that approximately 1300 patients with traumatic head injury are admitted annually in the Department of Neurosurgery at MOI, no study has been done in our setting; therefore, the magnitude and pattern of hearing loss as a result of head injury are not known.

This study aimed to determine the magnitude and pattern of hearing loss among post-head injury adult outpatients attending Neurosurgical clinic at MOI, which is a specialized institute whereby neurosurgical services are provided to patients with traumatic head injury and other neuronal-related illnesses.

1.3 CONCEPTUAL FRAMEWORK

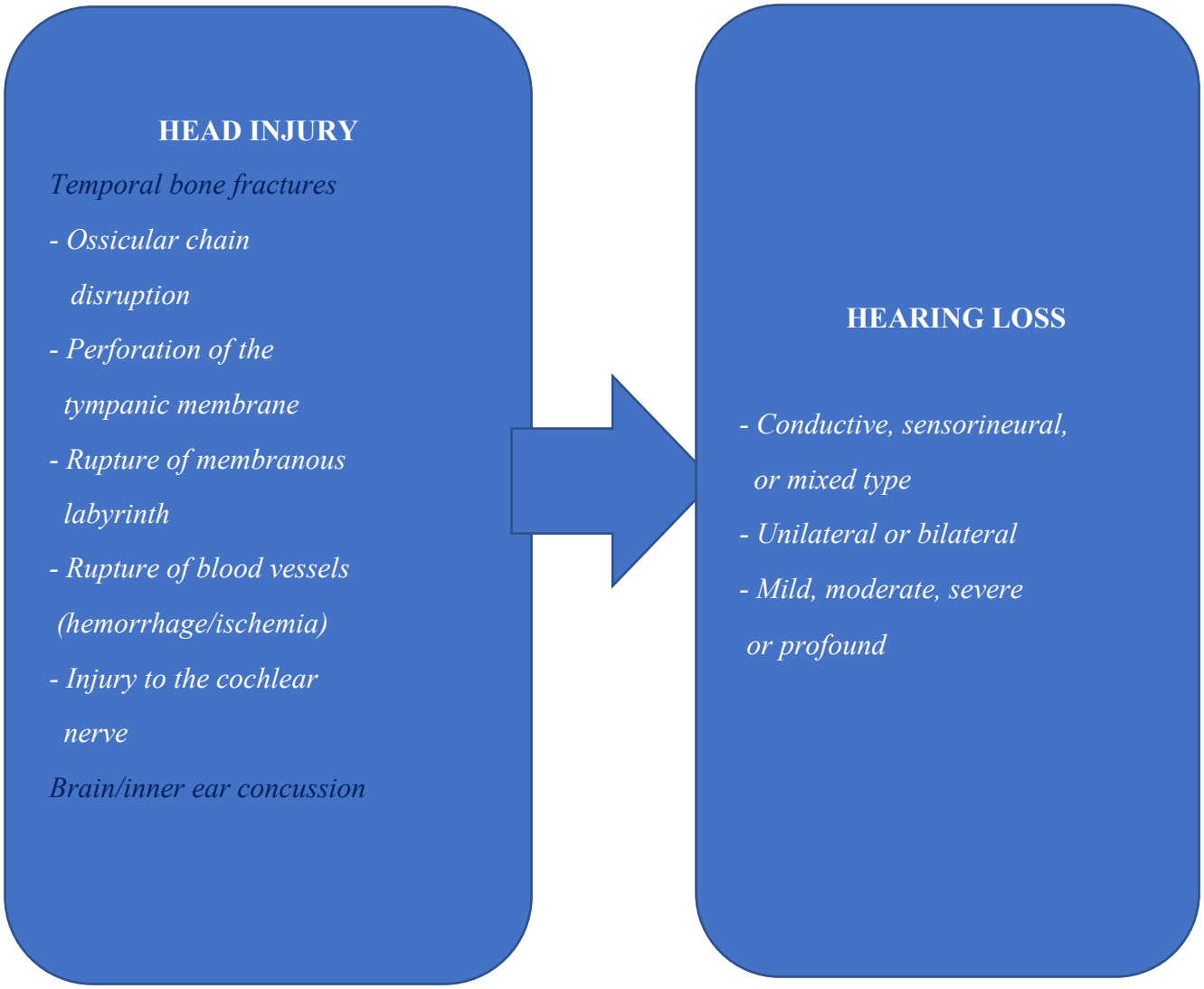


Figure 2: A conceptual framework on hearing loss following head injury.

The resultant hearing loss may be conductive, sensorineural, or mixed type depending on the damaged structure(s), and may involve one (unilateral) or both ears (bilateral); the severity may be mild, moderate, severe or profound depending on the hearing thresholds.

1.4 RATIONALE

The results of this study will call for awareness among clinicians on possible otological injuries with consequent hearing impairment, thus requiring a multi-disciplinary approach involving Neurosurgeons, ear, nose and throat (ENT) surgeons, Radiologists, and audiologists in the management of patients with head injury.

It will also help to create awareness to the community on hearing loss as a possible sequela of head injury.

Moreover, it will help policymakers and the Ministry of Health in planning for the allocation of resources in the management of head injuries and the related otological complications including hearing loss.

The study will also be used as a partial fulfillment of my training for a master's degree in Otorhinolaryngology.

1.5 RESEARCH QUESTIONS

i) What is the magnitude of hearing loss among post-head injury adult outpatients attending Neurosurgical clinic at MOI during the study period?

ii) What is the pattern of hearing loss among post-head injury adult outpatients attending Neurosurgical clinic at MOI?

iii) What is the association between the temporal bone CT scan findings and the type of hearing loss post-head injury?

1.5.1 Null hypothesis: There is no association between the temporal bone CT scan findings and the type of hearing loss post head injury.

1.5.2 Alternative hypothesis: There is association between the temporal bone CT scan findings and the type of hearing loss post head injury

1.6 OBJECTIVES

1.6.1 Broad objective

To determine the magnitude and pattern of hearing loss; and the association between temporal bone CT scan findings and the type of hearing loss among post head injury adult outpatients attending Neurosurgical clinic at MOI.

1.6.2 Specific objectives

i) To determine the proportion of hearing loss among post-head injury adult outpatients attending Neurosurgical clinic at MOI.

ii) To identify the type of hearing loss among post-head injury adult outpatients attending Neurosurgical clinic at MOI.

iii) To determine the lateralization of hearing loss among post-head injury adult outpatients attending Neurosurgical clinic at MOI.

iv) To determine the severity of hearing loss among post-head injury adult outpatients attending Neurosurgical clinic at MOI.

v) To identify the association between the temporal bone CT scan findings and the type of hearing loss among post-head injury adult outpatients attending Neurosurgical clinic at MOI.

1.7 LITERATURE REVIEW

Traumatic head injury constitutes a major medical concern in most countries, and is associated with various neuro-otological complications, including hearing impairment. It commonly results from motor traffic accidents, which are more prevalent in developing countries.[11] The global incidence of all-causes, all-severity of traumatic head injury is estimated at 939 cases per 100,000 people, thus an estimated 69.0 million (95% CI 64.2 – 73.8million) people worldwide suffer from traumatic head injury each year. In the United states and Canada, it is estimated that 4.6million people suffer from head injury each year.[14]

Sub-Saharan Africa demonstrate a higher incidence rate of head injuries due to rapid urbanization with limited infrastructure for the growing human and vehicular populations.[15] A study which was done in Tanzania revealed that majority of injuries results from MTA; and motorcycles accounts for most of the MTA, with majority of the victims being in the economically active age group of 18 – 45 years.[5]

1.7.1 The Incidence of hearing loss post head injury

Several studies have demonstrated hearing loss as a common sequela of traumatic head injury; in both adults and children.[16] In a hospital-based study which was done at a busy Casualty Department in the United States, among 84 head injured patients, more than half (56%) suffered from hearing loss.[10] This was also evident in a similar study which was a National house hold survey in Canada on the prevalence of hearing loss among 12,000 adults with traumatic head injury, about one third (33.3%) of the participants reported hearing loss post injury, and the majority were males (75%).[17] A study by Podoshin and Fradis, among 365 patients, 22.5% were found to have hearing impairment.[18] In a large-scale cohort study in Taiwan, it was revealed that individuals with traumatic head injury had 2.125 times higher risk of developing hearing loss than their counterpart without traumatic head injury.[19]

In Egypt, the Northern part of Africa; among 40 patients with mild and severe TBI, 20% suffered from hearing loss post head injury.[20] In Sub-Saharan Africa, a similar study was done among 100 pediatric traumatic brain injury population in South Africa, whereby 20% of the

subjects underwent formal audiological testing and about 14% of the tested subjects had a hearing loss of varying degrees.[21]

1.7.2 Type of hearing loss post head injury

The literature shows that all types of hearing loss may occur following head injury depending on the site of injury along the auditory pathway; however, SNHL is the most common, followed by conductive and mixed types of hearing loss.[9,12,17,21]

A study by Sanjay K. Munjal et al on audiological deficits after closed head injury; among 137 patients who underwent an audiometric test, SNHL was demonstrated in more than 90% of the patients, and higher frequencies were the mostly affected.[3] Similar findings were demonstrated in a prospective study by Emerson et al, whereby SNHL loss was the commonest type of hearing loss, followed by mixed and conductive hearing loss respectively.[11]

1.7.3 Lateralization of hearing loss post head injury

Hearing impairment following head injury may be unilateral or bilateral based on the mechanism of injury and involvement of the temporal bone.[7] Unilateral hearing loss is much common, and often involves the ipsilateral side of injury; In a study by Podoshin L and Fradis M, among those who suffered hearing loss post head injury, majority had unilateral hearing loss,[17] similar findings were observed by Munjal et al.[3]

Bilateral temporal bone fractures commonly result in bilateral hearing loss; in unilateral temporal bone fractures, the hearing loss occurs frequently in the side of injury and rarely involves the opposite side. The hearing loss in the contralateral side of the temporal bone fracture can be explained by concussive events in the labyrinth due to a bone conducted pressure wave created by a severe blow to the head, resulting into SNHL due to disruption of the organ of Corti.[22,23]

1.7.4 Severity of hearing loss post head injury

The severity of hearing loss ranges from mild to profound level, and has a significant association with the severity of the injury. However, unlike SNHL which may range from mild to profound, conductive hearing loss most often ranges from mild to moderate level and tend to resolve within six months post injury, unless there is ossicular chain disruption.[3,13] In a

hospital based study in Israel, it was found that majority of the patients with conductive type had mild hearing loss, while those with SNHL had mild to moderately severe hearing loss.[18] According to Per-Olof Bergemalm et al, unlike those with SNHL, there was a significant improvement in hearing function among individuals who had sustained conductive hearing loss during follow up at six months.[24]

1.7.5 Temporal bone CT scan findings and the type of hearing loss post head injury

Temporal bone fractures are commonly associated with hearing loss, whereby longitudinal fractures are more common than transverse fractures; however transverse fractures are the most commonly associated with hearing loss, predominantly SNHL as the fracture involves the otic capsule which houses the inner ear. Longitudinal fractures mainly involve the external and middle ear, and are mostly associated with conductive hearing loss.[25]

In a study among 365 head injured patients, skull fractures were demonstrated in 16% of patients, whereby nearly half (49%) had temporal bone fractures; longitudinal fractures were more common (67.8%), the remaining were transverse and mixed fractures. Thirteen (64.4%) out of 19 patients with longitudinal temporal bone fractures and 7 (77.8%) out of 9 patients with transverse fractures suffered from hearing loss respectively. Among those (308) without skull fractures, 55(18%) suffered from hearing loss.[18]

In Denmark, a study which was done by Mirko Tos, among 248 patients with temporal bone fractures following head injury, all patients 26 (100%) with transverse temporal bone fractures had hearing impairment (SNHL), which remained the same after 2-7years follow up; while among those with longitudinal fractures, 83 (37%) had hearing impairment, predominantly conductive hearing loss.[26]

Non-fracture findings are also common, and are potentially associated with hearing loss. Pneumolabyrinth, inner ear opacifications and perilymphatic fistulae are among the CT findings associated with SNHL.[25] A study by Aguilar III, temporal bone fractures were evident in 28%, however, those without fractures also showed abnormal auditory brainstem response (ABR) recordings, and the majority exhibited a mass effect on head CT scan; diffuse cerebral edema was present in 30%.[27] Diffuse axonal injuries due to shearing of the brain, brain

contusion with hemorrhage and cerebral edema are responsible for increased intracranial pressure with resultant secondary injury to the brain stem and/ auditory cortex.[3,25]

CHAPTER TWO

2.0 METHODOLOGY

2.1 Study design

This was a hospital-based descriptive cross-sectional study.

2.2 Study area

The study was conducted at the ENT clinic and Audiology Unit, in the Department of Otorhinolaryngology, Muhimbili National Hospital (MNH). The clinic is equipped with all the necessary instruments for ear examination, cerumen or foreign body removal and aural toileting; and an audiology unit which is a sub-section within the Department, with specialized sound proof rooms, conducive for audiometric tests.

The participants were recruited from Neurosurgical clinic, Department of Neurosurgery, at MOI, which is the largest Orthopaedic and Neurosurgical Referral Center in Tanzania, providing specialized services to patients from all over the country. Approximately 1300 patients are admitted annually in the department due to head injury. The Department is equipped with highly qualified neurosurgeons, nurses together with registrars; running outpatient clinics from Monday to Friday.

Therefore, all participants were sent from the area of recruitment to the ENT clinic for ear examination; cerumen removal and or aural toileting if indicated, before going for a pure tone audiometric test at the audiology unit, which is equipped with clinical audiologists who performed the test to assess the hearing status.

2.3 Target population

The target population was all adult outpatients who sustained head injury within six months, attending Neurosurgical Clinic at MOI during the study period.

2.4 Study population

The study involved all post head injury adult (aged 18years and above) outpatients, who met the inclusion criteria, selected and consented to participate in the study at the Neurosurgical clinic, MOI.

2.5 Study duration

The study was conducted in duration of six months, from January 2021 to June 2021.

2.6 Sample size

The sample size was calculated from the formula expressed below;

$$N = \frac{Z^2 \times P(1-P)}{E^2}$$

Where, N = The required minimum sample size

Z = 95% Confidence Interval (1.96)

P = Prevalence of subjects with hearing loss post head injury in previous studies

E = Standard error (0.05)

Using the above formula, with the prevalence (20%) taken from a similar study in Egypt, the minimum sample size will be 246 participants.

Adjusting for non-responses as 10% of the sample size (i.e. the response rate (R) will be 90%)

The adjusted sample size is expressed as

$n = N \times 1/R$

where N = the calculated sample size (246)

R = the response rate (90%)

Therefore, $n = 246 \times 1/0.9$

$= 273$

Thus, 273 participants were to be included in the study, however, this sample size was not met due to poor return of patients to the clinic for follow up, and some consented but didn't complete audiometric test, thus only 226 participants were included in this study.

2.7. SAMPLING PROCEDURE

2.7.1 Sampling method

Convenient sampling method was employed to select the study participants. Every post head injury adult outpatient attending Neurosurgical clinic during the study period, who met the inclusion criteria and voluntarily consented for participation was included in the study.

2.7.2 Inclusion criteria

All post head injury adult outpatients attending Neurosurgical Clinic at MOI, and whom their injury was sustained within six months during the study period.

2.7.3 Exclusion criteria

i) Patients with pre-traumatic hearing loss.
ii) Patients with loss of memory/confusion.
iii) Patients with head injury sustained more than six months before the commencement of this study.

2.8 VARIABLES

Dependent variables: hearing loss; sensorineural hearing loss, conductive hearing loss, mixed hearing loss.

Independent variables: Head injury

Temporal bone fracture
Concussive events of the brain and labyrinthine

2.9 DATA COLLECTION

2.9.1 Data collection procedure

Prior information about the study was given to the clinicians and other staff members in the Neurosurgical Department. The principle investigator visited the clinic during outpatient clinic hours, and informed the eligible patients about the study. Those who met the inclusion criteria and voluntarily consented to participate in the study were interviewed on their demographic

information and traumatic history including the cause and duration of injury. Each participant underwent an otoscopic examination at the ENT clinic by the principal investigator to assess the status of the external auditory canal and the tympanic membrane**.** A cerumen hook was used to remove impacted cerumen or any other debris found in the ear canal apart from blood clots; aural toilet was done in those who had ear discharge. All participants were then taken to the Audiology unit for a PTA test which was performed by a clinical audiologist, to assess the hearing status. Research assistants, who are medical doctors working in the neurosurgical clinic helped in providing information to the eligible patients, interviewed them through a structured questionnaire, and informed the principal investigator who then took the participants for the next steps (i.e. physical examination and sending them for a PTA test). Head CT scans which were taken post-admission were reviewed for temporal bone evaluation by the principal investigator for the findings and the associated type of hearing loss.

2.9.2 Data collection and investigation tools

i) Structured questionnaire

A structured questionnaire was used to collect information from each of the participants. It was divided into three parts. Part one was for basic information including the demographic data. Part two was for traumatic history including the cause and duration of the injury, and part three comprised patient's examination findings, including the severity of head injury, PTA results and head CT scan for temporal bone evaluation.

ii) Otoscope

Was used for evaluation of the external auditory canal and the tympanic membrane.

iii) Cerumen hook

Was used for cerumen or any debris removal from the external auditory canal.

iv) Head light

Was used for illumination during cerumen or any debris removal from the external auditory canal.

v) Pure tone audiometer

A clinical audiometer (*Piano Inventis SRL, 2013*) was used to assess the hearing status, whereby air as well as bone conduction thresholds were measured at the frequencies of 250, 500, 1000, 2000, 4000, 6000, and 8000 Hz for each ear separately.

The hearing status was classified into five categories depending on the hearing thresholds as *normal hearing (below 25dB), mild hearing loss (26-40dB) moderate (41-60dB), severe (61-80dB),* and *profound (81dB and above)*. Hearing loss was categorized as conductive when air-bone gap is ≥15 dB or mixed when the air bone gap is less than 15dB.[28]

The severity of head injury is normally assessed immediately post trauma, and measured according to the Glasgow coma scale (GCS), which focuses on the eye, motor, and verbal responses, with a total score of 15 points. It is classified depending on the total points scored as *mild (13 – 15), moderate (9 – 12) or severe (<8)*.[29] The information on the severity of head injury was obtained from the patient discharge summary.

All the mentioned data collection tools were pre-tested for their correctness before commencing the study.

2.10 Data processing and analysis

The data were entered into the Statistical Package for Social Sciences (SPSS) software version 23.0 for inspection of their completeness and analysis. Quantitative variables were described by the measures of central tendency and dispersion while categorical data were summarized as proportions. Cross-tabulation tables and figures were used to present the study results. Fisher's Exact Test was used for establishing the association between variables. A p-value of <0.05 was considered statistically significant.

2.11 Ethical consideration and clearance

Ethical review and clearance to carry out this study was obtained from the Directorate of Research and Publications of the Muhimbili University of Health and Allied Sciences (MUHAS).

The approval to conduct the study at the ENT and Neurosurgical clinics was obtained from the Head of Otorhinolaryngology Department-MNH, the Directorate of Clinical Services of both the MNH and MOI respectively before commencing the study.

Every participant was given all the necessary information about the study before voluntarily signing a consent to participate in the study, the information collected were kept confidential, and used only for the study purposes. Those who were found to have hearing loss and other ear diseases were treated accordingly.

2.12 Study limitation

- Being a descriptive cross-sectional hospital- based study, the results could not generalize the whole community.
- The study didn't exclude some other causes of hearing loss e.g. ototoxicity and noise.

CHAPTER THREE

3.0 RESULTS

Table 1:Age and sex distribution of the studied population

Age group (years)	Sex		TOTAL
	Males	Females	
	N (%)	N (%)	N (%)
18-35	116 (87.9)	16 (12.1)	132 (58.4)
36-53	65 (82.3)	14 (17.7)	79 (35.0)
54 and above	14 (93.3)	1 (6.7)	15 (6.6)
TOTAL	**195 (86.3)**	**31 (13.7)**	**226 (100)**

A total of 226 participants were recruited in this study, their ages ranged from 18-65years, and the mean age was 34.1±11.3 years. Majority 132(58.4%) of the participants were in the age group of 18-35 years. Males constituted more than three quarters 195(86.3%) of the studied population, with a male to female ratio of 6.3:1.

Table 2: Distribution of severity and cause of head injury in the studied population

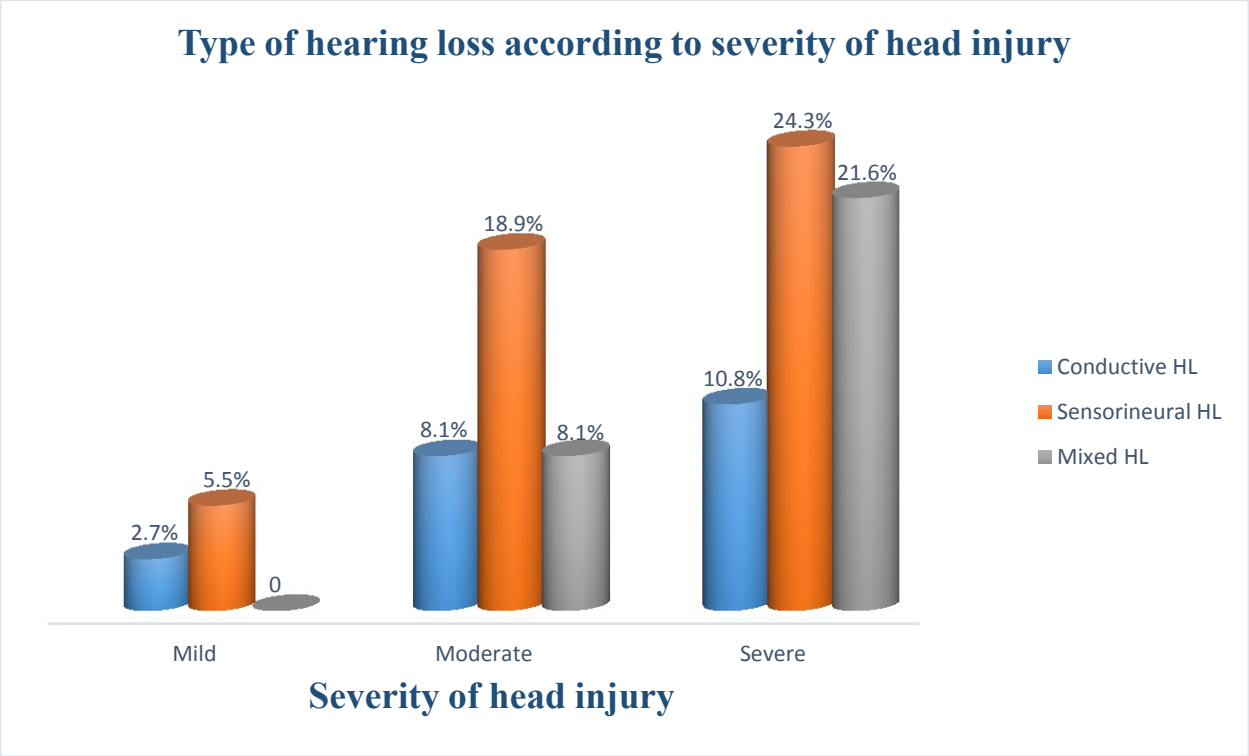
Severity of head injury	**N (%)**
Mild	134 (59.3)
Moderate	61 (27.0)
Severe	31 (13.7)
TOTAL	**226 (100)**
Cause of head injury	
Motor traffic accidents	211 (93.4)
Assault	8 (3.5)
Fall from height	6 (2.7)
Others	1 (0.4)
TOTAL	**226 (100)**

More than half 134(59.3%) of the participants had mild head injury. The cause of injury was mainly motor traffic accidents 211(93.4%)

Table 3: Proportion of hearing loss among post-head injury patients by age and sex

Age group (years)	Hearing status		TOTAL
	Hearing loss	Normal hearing	
	N (%)	N (%)	N (%)
18-35	26 (19.7)	106 (80.3)	132 (58.4)
36-53	9 (11.4)	70 (88.6)	79 (35.0)
54 and above	2 (13.3)	13 (86.7)	15 (6.6)
TOTAL	**37 (16.4)**	**189 (83.6)**	**226 (100)**
Sex			
Males	33 (16.9)	162 (83.1)	195 (86.3)
Females	4 (12.9)	27 (87.1)	31 (13.7)
TOTAL	**37 (16.4)**	**189 (83.6)**	**226(100)**

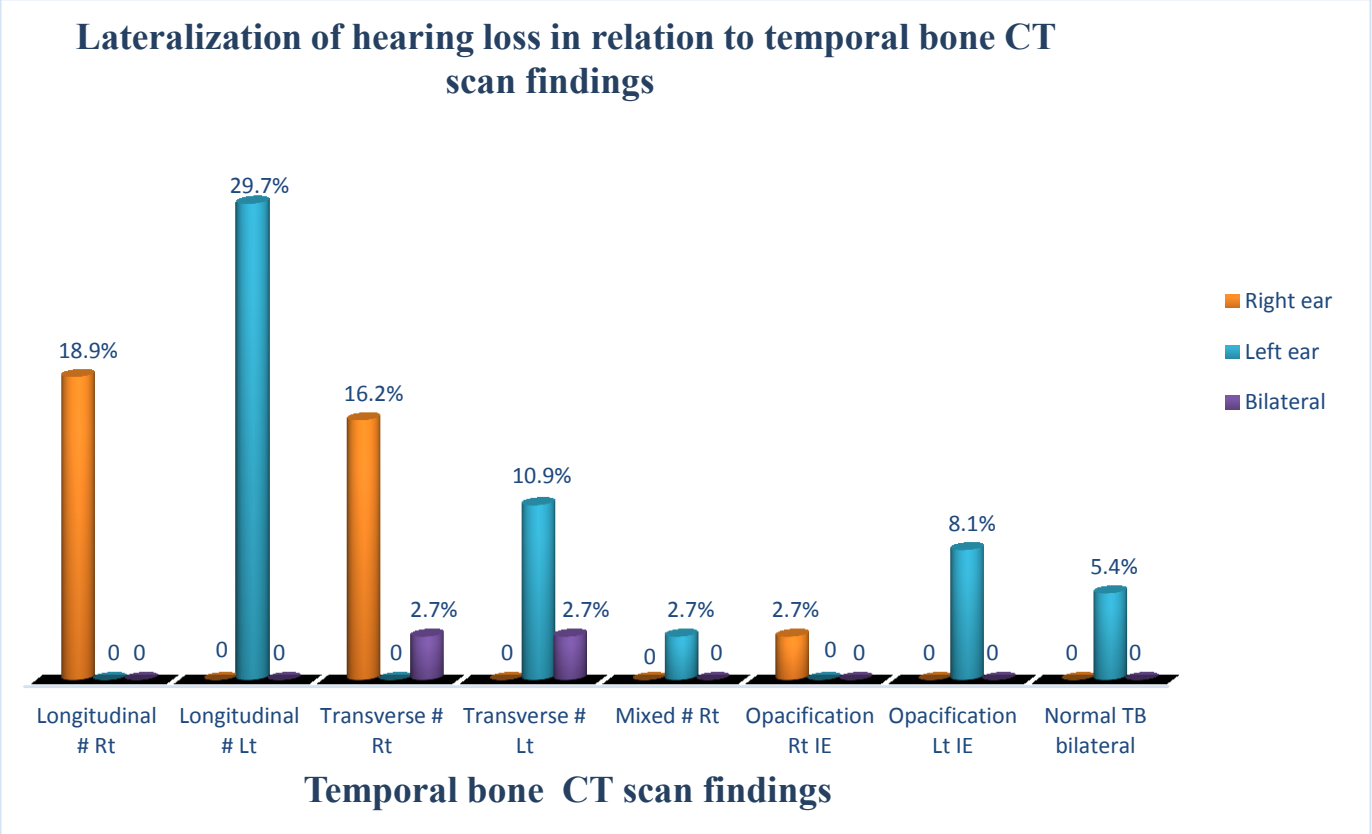
The table above shows that 37(16.4%) participants were found to have hearing loss, with the age group of 18-35years being the mostly affected 26(19.7%) Males 33(16.9%) were more affected than females (M: F 8.3:1).



(Key: HL = hearing loss)

Figure 3: Type of hearing loss according to severity of hearing loss

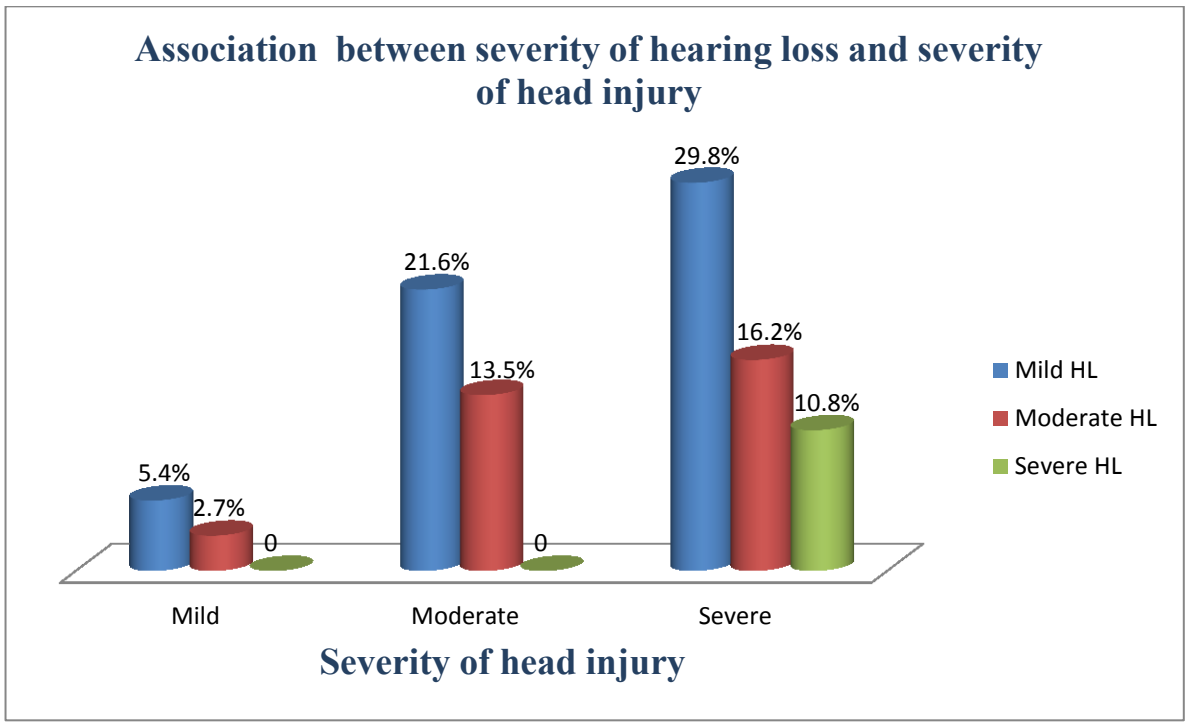
All types of hearing loss were observed, and were increasing with the severity of head injury (Fisher's Exact test = 71.252, p <0.01) with SNHL being the commonest type across all levels of head injury, demonstrated in nearly half (48.7%) of the affected individuals.



(Key: # = Fracture, Rt = Right, Lt = Left, IE=Inner ear, TB= Temporal bone)

Figure 4: Lateralization of hearing loss in relation to temporal bone CT scan findings

Majority 35(94.6%) of the affected individuals had unilateral hearing loss, with left ear 21(56.8%) being more involved than the right ear 14(37.8%). The lateralization of hearing loss was significantly associated with the side of temporal bone affected, (Fisher's Exact test = 240.421, $p < 0.01$).



(Key: HL = Hearing loss)

Figure 5: Association between severity of hearing loss and severity of head injury

The severity of hearing loss ranged from mild to severe, whereby majority 21(56.8%) had mild hearing loss. The severity of hearing loss was significantly associated with the severity of head injury (Fisher's Exact test =71.987, p <0.01).

Table 4: Association between temporal bone CT scan findings and the type of hearing loss

Head CT scan findings	Type of hearing loss			TOTAL	p-value
	Conductive	Sensorineural	Mixed		
	N (%)	N (%)	N (%)	N (%)	
Longitudinal#	8 (44.4)	3 (16.7)	7 (38.9)	18(48.7)	0.000
Transverse#	0 (0.00)	9 (75.0)	3 (25.0)	12(32.4)	0.034
Mixed#	0 (0.00)	0 (0.00)	1 (100)	1(2.7)	0.514
Opacification in the inner ear	0 (0.0)	4 (100)	0 (0.0)	4 (10.8)	0.122
Normal temporal bone	0 (0.0)	2 (100)	0 (0.0)	2 (5.4)	1.000
TOTAL	**8 (21.6)**	**18(48.7)**	**11(29.7)**	**37(100)**	

(Key: # = Fracture)

Longitudinal fracture of the temporal bone was the commonest CT scan finding, demonstrated in 18(48.7%) patients of which 8(44.4%) of them had conductive hearing loss. Transverse fracture was found in 12(32.4%) patients with three quarters of them having sensorineural type of hearing loss. There was a significant association between longitudinal and transverse temporal bone fractures with conductive (Fisher's Exact test = 17.525, $p < 0.01$) and sensorineural (Fisher's Exact test = 6.488, $p = 0.034$) types of hearing loss respectively.

CHAPTER FOUR

4.0 DISCUSSION

Hearing loss is among the frequently occurring sequela of head injury, associated with substantial social and economic costs as it compromises communication and brings about stigmatization to the affected individuals. No studies on hearing loss following traumatic head injury have been done in our setting, thus the magnitude and pattern of the problem are not known. This study aimed at determining the magnitude and pattern of hearing loss among post head injury adult outpatients aged 18years and above, who sustained the injury within six months during the study period.

A total of 226 participants were enrolled, whereby 195(86.3%) were males and 31(13.7%) were females, with a male to female ratio of 6.3:1. Their ages ranged from 18 to 65 years, with a mean age of 34.1±11.3 years. The majority 132(58.4%) of the participants were in the age group of 18-35years, followed by those who were 36 – 55 years. Only 15(5.5%) were aged 54 years and above. The overall male predominance and the risky age groups were also observed in previous studies.[3,10] This could be due to their active involvement in social and economic activities which predisposes them into injuries from different causes like motor traffic accidents, falls from height, sports and others. Several studies in Africa and other parts of the globe have shown that males, particularly in the economically active age groups constituted larger numbers of trauma patients receiving emergency services in casualties.[4,5] More than half 134(59.3%) of the participants had mild head injury, followed by moderate 61(27.0%) and severe 31(13.7%) head injury. The cause of injury was mainly motor traffic accidents 211(93.4%), followed by assault and fall from height.

Out of 226 participants, 37(16.4%) were found to have hearing loss post-head injury, with male predominance by a ratio of 8.3:1 and the mostly affected 26(19.7%) age group was of 18-35 years. This may be due to the fact that males were the majority of the participants, and more prone to head injuries with consequent hearing loss. In Egypt, the Northern part of Africa, the prevalence was found to be slightly higher, whereby about 20% out of 40 participants had sustained hearing loss of varying degrees post head injury;[20] also it was found

to be much higher (30%) in a similar study in India.[3] The differences in proportions could be due to different settings of the study, testing modalities and timing of the tests post injury. The later studies included inpatients, and more than one modality (PTA and Auditory Brainstem Response, ABR) were used and the timing of the tests was within two-weeks following the injury, while the present study involved stable outpatients attending neurosurgical outpatient clinic; excluded unstable/unconscious patients, and only one modality (PTA) was used and the timing of the test was within six months, a period by which some hearing losses might have undergone resolution.[9,10,13]

All types of hearing loss were identified among individuals who were found to have hearing loss, however, sensorineural type of hearing loss was the most common across all levels of head injury severity, but was found mostly in individuals who had severe head injury. It was demonstrated in nearly half 18(48.7%) of the affected population; followed by mixed and conductive types respectively. A number of studies have shown similar findings.[9,12]

Majority 35(994.6%) of the affected individuals were found to have unilateral hearing loss, with the left ear being slightly more involved than the right ear. The lateralization of hearing loss was highly related to the side of the temporal bone affected ($p < 0.01$). Only 2(5.4%) out of 37 affected individuals had bilateral hearing loss, which resulted from involvement of the contralateral side of the injury. Similar findings were also observed in previous studies done in India, Israel and Egypt .[3,18,20]

The severity of hearing loss ranged from mild to severe, where by majority 21(56.8%) had mild hearing loss, followed by moderate 12(32.4%) and severe 4(10.8%). None of the affected individuals had profound hearing loss. The severity of hearing loss was significantly associated with the severity of head injury ($p < 0.01$). This is consistent with a study done in India where by only <5% of the affected individual had severe to profound hearing loss and most of individuals with severe hearing loss had severe head injury.[3]

In this study, longitudinal fracture of the temporal bone was the commonest CT scan finding, demonstrated in nearly half 18 (48.7%) of the affected individuals and was associated with conductive type of hearing loss ($p < 0.01$); followed by transverse temporal bone fractures

12(32.4%) whereby more than half of the affected individuals had SNHL *(p = 0.034)*. Mixed fractures of the temporal bone were observed in only one individual (2.7%) and resulted to mixed type of hearing loss. The hearing loss was mostly ipsilateral to the side of injury. Similar findings were also observed in previous studies.[18,26]

The study also revealed non-fracture temporal bone CT scan findings which included opacifications in the inner ear, suggestive of hemorrhage and or hematoma formation which may be due to inner ear concussive injury, in 4(10.8%) out of the affected individuals, and were all associated with a sensorineural type of hearing loss. These findings were similar to those which were found in studies done in India and United States.[3,11,25]

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

In this study, it was found that 37(16.4%) individuals out of the studied population had hearing loss of varying degrees, with sensorineural type of hearing loss being the commonest, demonstrated in nearly half of the affected individuals, with males in the age group of 18 to 35 years being the most affected. The severity of hearing loss was significantly increasing as the severity of head injury raised.

5.2 Recommendations

i. A multidisciplinary approach involving Neurosurgeons, ENT surgeons, Radiologists and Audiologists is important in the early diagnosis of hearing loss, treatment and audiological follow-up of patients with head injury.

ii. Hearing rehabilitation for those who sustain hearing loss following head injury

iii. Road safety measures should be reinforced to reduce the number of motor traffic accidents which was observed to be the leading cause of traumatic head injury in this study.

iv. Further studies of longer duration are encouraged for individuals who acquired hearing loss post head injury; and those which will exclude all other causes of hearing loss, e.g. ototoxicity and noises.

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APPENDICES

APPENDIX I (QUESTIONNAIRES – English version)

A questionnaire on the magnitude and pattern of hearing loss among post-head injury adult outpatients attending Neurosurgical Clinic at Muhimbili Orthopaedic Institute (MOI), Dar es salaam Tanzania.

Instructions

Fill in the blanks, and or put a tick (**V**) for a correct answer in the bracket given in front of each option

NB: Confidentiality of the given information will be highly observed

Part I

Personal particulars

1. Participant Reg. No…… 2. Sex……... 3. Age……(years)
4. Occupation…… 5. Date……...

Part II

Traumatic history

6. When did you sustain the injury?

   (i) 0 – 3 months ago ( ) (ii) 4 – 6 months ago ( )

7. What was the cause of the injury?

   (i) MTA ( ) (ii) Fall from height ( ) (iii) Assault ( )

   (iv) Others ( )

PART III
EXAMINATION FINDINGS

8. Severity of head Injury	a) Mild		
	b) Moderate		
	c) Severe		
		Right ear	**Left ear**
9. Otoscopy	**External auditory canal**		
	a) Normal		
	b) Laceration of the EAC wall		
	Tympanic membrane		
	Intact		
	Color (a) Normal (translucent)		
	(b) Bluish		
	Mobility (a) Mobile		
	(b) Immobile		
	Position (a) Normal (neutral)		
	(b) Retracted		
	(c) Bulging		
	Perforated		
10. Pure tone Audiometry	**Type of hearing loss**		
	a) Conductive		
	b) Sensorineural		
	c) Mixed		
	Severity of hearing loss		
	a) Normal		
	b) Mild		
	c) Moderate		
	d) Severe		
	e) Profound		
11. Temporal bone CT scan findings	a) Normal temporal bone		
	b) Opacification in the middle ear		
	c) Opacification in the inner ear		
	d) Ossicular chain disruption		
	e) Temporal bone fracture		
	- Longitudinal		
	- Transverse		
	- Mixed		

APPENDIX II. QUESTIONNAIRE (Swahili version)

DODOSO KUHUSU UPOTEVU WA USIKIVU KUFUATIA MAJERAHA YA KICHWA MIONGONI MWA WAGONJWA WANAOHUDHURIA KLINIKI YA UPASUAJI WA MISHIPA YA FAHAMU KATIKA TAASISI YA MIFUPA MUHIMBILI (MOI)

Maelekezo

Jaza nafasi iliyoachwa wazi katika swali la 1- 5

Weka alama ya vema (**v**) kwenye kisanduku chenye jibu sahihi katika swali la 6 – 7

Usiri utazingatiwa kwa taarifa zote zitakazojazwa

SEHEMU YA KWANZA

Taarifa binafsi

1. Namba ya Usajili……..
2. Jinsia……..
3. Umri ……(miaka)
4. Kazi yako……
5. Tarehe ya ujazaji wa taarifa……

SEHEMU YA PILI

Taarifa kuhusu historia ya majeraha

6. Je, ni lini ulipata majeraha ya kichwa?
   i) Miezi 0 - 3 iliyopita ( )
   ii) Miezi 4 – 6 iliyopita ( )
7. Je, ni sababu gani iliyopelekea majeraha hayo?
   i) Ajali ya gari/pikipiki ( )
   ii) Kuanguka ( )
   iii) Kipigo ( )
   iv) Sababu nyinginezo ( )

APPENDIX III. CONSENT FORM (English version)

MUHIMBILI UNIVERSITY OF HEALTH AND ALLIED SCIENCES

DIRECTORATE OF RESEARCH AND PUBLICTIONS

Reg No. …… Date……

Consent to participate in a research study

Greetings. I am Dr. Aggrey Ibrahim Kibuta, a postgraduate student, pursuing a Master's degree in Medicine (MMed Otorhinolaryngology) at Muhimbili University of Health and Allied Sciences. I am conducting a research to determine the magnitude and pattern of hearing loss among post-head injury outpatients attending Neurosurgical clinic at Muhimbili Orthopaedic Institute (MOI).

Purpose of the study

To determine the magnitude and pattern of hearing loss among post-head injury adult outpatients attending Neurosurgical clinic at Muhimbili Orthopaedic Institute (MOI).

Participants of the study

All post head injury patients attending Neurosurgical clinic at Muhimbili Orthopaedic Institute (MOI) during the study period.

Participants will undergo a thorough history, head and neck examination, (paying much attention on ear examination) All participants will then undergo PTA test to ascertain the hearing status. Head CT scans which were taken post-admission will be reviewed to evaluate the status of the temporal bone and identify the associated type of hearing loss. If you decide not to participate in this study, your services will not be affected in any way.

Confidentiality

All the participants who will be included in the study will be identified by their numbers and thus their names will not appear. The information obtained will be kept under a strict locked environment where it is only the researcher will have access and will be destroyed after the dissertation has been submitted and accepted for the award of a postgraduate degree.

Risk

No harm is expected to occur upon your participation in this study.

Benefits

If you consent to participate in this study, you will benefit from understanding your condition, plan on treatment and prevention of future complications. The results of the study will also help bridge the gap of knowledge and awareness among Otorhinolaryngologists, Neurosurgeons, Radiologists and policy makers on the management of head injuries and the related otological injuries leading to hearing loss.

Right to withdrawal

Participating in this study is completely your choice. You can withdraw at any particular moment regardless of signing the consent form. You can even refuse to respond to any question in the questionnaire.

Whom to Contact

In case of any concern or question about the study, you can contact the researchers, Dr Aggrey I. Kibuta, P.O BOX 65001, Dar es salaam, Tel 0683357744; Dr Aveline A. Kahinga Muhimbili University of Health and Allied Sciences, P.O. BOX 65001 Dar es Salaam, Tel +255764608917. You may also contact the Chairperson of the Senate, Research and Publications Committee (Muhimbili University of Health and Allied Sciences) Dr. Bruno Sunguya P.O.BOX 65001, Dar es Salaam, for any matters concerning ethical violation of the study.

Declaration

I,……have read the contents in this form. My questions have been answered and I agree to participate in this study

Signature of participant……

Signature of researcher/research assistant…….

APPENDIX IV (CONSENT FORM - Swahili version)

CHUO KIKUU CHA AFYA NA SAYANSI SHIRIKISHI MUHIMBILI

KURUGENZI YA TAFITI NA UCHAPISHAJI

IDHINI YA KUSHIRIKI KWENYE UTAFITI

Namba ya usajili…… Tarehe……

Habari,

Mimi naitwa Dr Aggrey Ibrahim Kibuta, ni mwanafunzi wa shahada ya Uzamili ya udaktari bingwa wa masikio, pua na koo, katika Chuo Kikuu cha Afya na sayansi shirikishi Muhimbili. Nafanya utafiti kuangalia ukubwa wa tatizo, na aina ya upotevu wa usikivu baada ya kupatwa na majeraha ya kichwa, miongoni mwa wagonjwa wanaohudhuria katika kliniki ya upasuaji wa mishipa ya fahamu, iliyopo katika Taasisi ya Mifupa Muhimbili.

Usiri

Washiriki wote wa utafiti huu hawatatambuliwa kwa majina yao ila kwa namba. Habari zote za washiriki zitahifadhiwa/zitafungiwa mahali salama ambapo mtafiti mkuu tu ndiye atakayekuwa na funguo na makabrasha yote yatateketezwa mara baada ya utafiti kuisha.

Lengo la utafiti

Kuangalia ukubwa wa tatizo na aina ya upotevu wa usikivu baada ya kupatwa na majeraha ya kichwa, miongoni mwa wagonjwa wanaohudhuria katika kliniki ya upasuaji wa mishipa ya fahamu, iliyopo katika Taasisi ya Mifupa Muhimbili.

Washiriki wa utafiti

Washiriki kwenye utafiti huu ni wagonjwa wote waliopatwa na majeraha ya kichwa kutokana na sababu mbalimbali, wanaohudhuria kliniki ya upasuaji wa mishipa ya fahamu, iliyopo katika Taasisi ya Mifupa Muhimbili. Washiriki wote watasikilizwa matatizo yao, watafanyiwa uchunguzi ikiwemo kufanyiwa kipimo cha usikivu. Pia picha za CT scan zilizofanywa mara baada ya kulazwa zitaangaliwa tena kuona majeraha na kulinganisha na aina ya upotevu wa usikivu uliojitokeza.

Madhara

Hakuna madhara yanayotarajiwa kwa washiriki wa utafiti.

Faida

Ushiriki wako katika tafiti huu utakusaidia kutambua ugonjwa wako, matibabu, athari na pia njia mbali mbali ya kuzuia athari zaidi. Matokeo ya utafiti huu yatasaidia kuongeza ufahamu kwa wahudumu wa afya na watunga sera juu ya uwezekano wa kupoteza usikivu baada ya kupatwa na majeraha ya kichwa, na hivyo kuhamasisha ushirikiano baina ya watu kutoka kada mbalimbali kama madaktari bingwa wa upasuaji wa mishipa ya fahamu, madaktari bingwa wa maskio, pua na koo pamoja wataalamu wa mionzi katika kumhudumia mgonjwa.

Haki ya kujitoa

Ushiriki katika utafiti ni wa hiyari,na mshiriki yeyote ana haki ya kuamua kujiondoa katika utafiti wakati wowote. Kujiondoa hakutaathiri huduma anayopaswa kupewa.

Mawasiliano

Ikiwa kuna swali lolote kuhusu utafiti huu, tafadhali wasiliana na Dkt Aggrey Ibrahim Kibuta S.L.P 65001, Dar es salaam, Simu +255683357744; Dr Aveline A. Kahinga, Chuo kikuu Cha Afya na Sayansi Shirikishi Muhimbili, S.L.P 65001, Dar es salaam, Simu +255764608917. Hata hivyo, ikiwa kuna suala lolote linalohusu mwenendo wa kimaadili ya utafiti wa

kimatibabu, wasiliana na Mwenyekiti wa Kamati ya Tafiti na Machapisho wa Chuo Kikuu cha Afya na Sayansi shirikishi Muhimbili, Dkt. Bruno Sunguya, S.L.P 65001, Dar es Salaam.

Sahihi ya mshiriki…….

Sahihi ya mtafiti/mtafiti msaidizi…….