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Outcome prognosticators in patients with severe traumatic brain injury

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OUTCOME PROGNOSTICATORS IN PATIENTS WITH SEVERE TRAUMATIC BRAIN INJURY

By

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A research report submitted in fulfilment of the requirements for the degree of

Masters of Medicine in Neurological Surgery

In the

Faculty of Health Sciences

University of the Witwatersrand

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DECLARATION

I, Dr Lebohang Modikeng, declare that the research report that I hereby submit for the degree of Masters of Medicine in Neurological Surgery at the University of the Witwatersrand is my own work. The research report has not been submitted by me for any other degree or examination at this or any other university. The study will be submitted for publication.

X _____

…… day of …… 20…… in …….

DEDICATION

This research report is dedicated to the Almighty, of which without him I wouldn't be here.

My family and friends who have supported me in this journey to aim high and achieve. My parents Motshilisi and Tohlang Modikeng, my siblings, Mamonaheng, my nieces and nephews, Puleng, Tshegofatso, Kopano, Bokang, Neo and Kutlwano. I want to thank you for all the prayers.

To my colleagues for their support and motivation throughout this journey.

ABSTRACT

Background: Many Coma scales have evolved for the assessment of patients with Traumatic Brain Injury (TBI), but the widely used Glasgow Coma Scale (GCS) has limitations. These limitations can be overcome by the new Coma Scale called the Full Outline of UnResponsiveness score (FOUR).

Objectives: The aim and objective of this study was to define and compare the GCS and the FOUR score in predicting in-hospital mortality, functional outcome at discharge by using the Glasgow Outcome Scale (GOS) in patients who sustained severe TBI.

Methods: A cross sectional study was conducted in consecutive adult patients who were admitted in Chris Hani Baragwanath Academic Hospital and Charlotte Maxeke Johannesburg Academic Hospital between July and December 2015 with Severe Traumatic Brain Injury. A data sheet was used to collect study information.

Results: 54 patients were recruited in the study, 93% (n=50) were male patients and most of the male patients were assaulted. The FOUR score of 6 and below predicted poor outcome whilst a FOUR score of 10 predicted good outcome.

Conclusion: The FOUR score can be used together with the GCS for those patients who are intubated, as the FOUR score didn't show much significant difference in predicting outcome.

ACKNOWLEDGEMENTS

I would like to thank and send my gratitude to the following people who helped and guided me through this journey

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- The Chief Executive Officers of Chris Hani Baragwanath Academic Hospital and Charlotte Maxeke Johannesburg Academic hospital for allowing me to pursue my studies and to go ahead with the research

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NOMENCLATURE

CT scan - Computed Tomography Scan

CMJAH - Charlotte Maxeke Johannesburg Academic Hospital

CHBAH - Chris Hani Baragwanath Academic Hospital

FOUR score - Full Outline UnResponsiveness score

GCS - Glasgow Coma Scale

GOS - Glasgow Outcome scale

TBI - Traumatic Brain Injury

1.0 CHAPTER 1

1.1 INTRODUCTION

Neurological assessment of patients in neurosurgery is done on all patients, and it guides with the severity of injury, management of patients, and helps with prediction of outcome i.e. in-hospital mortality and when to discharge patients. There are numerous scoring systems that have been described, but only the Glasgow Coma Scale (GCS) has reached popularity and it is used worldwide for assessment of alterations of consciousness in patients. The GCS has been shown to have limitations, which can be overcome by the new scoring system called the Full Outline of Unresponsiveness (FOUR) Score.

Traumatic Brain Injury (TBI) is a burden in our community, there are no statistics of TBI in our community, but it's reported that in the American population it affects 1.7 million patients and accounts for 60 billion healthcare dollars annualy[1]. We need a Coma score that can help us to predict in-hospital mortality and functional outcome of patients with severe TBI.

The GCS accuracy has been questioned, especially when measuring the GCS for intubated patients[2] with severe TBI, and for outcome prognostication. The FOUR score is a simple tool that can be used to assess the patients who sustained TBI and to prognosticate outcome.

1.2 LITERATURE REVIEW

Traumatic brain injury (TBI) is very common and is one of the major causes of death and severe disability worldwide[3]. Traumatic brain injury represents a serious public health problem.

Traumatic brain injury is classified into mild TBI (Glasgow Coma Scale ranging from 13 to 15), moderate TBI (Glasgow Coma Scale ranging from 9 to 12), and severe TBI (Glasgow Coma Scale of 8 or less following resuscitation or a Glasgow Coma Scale deteriorating to 8 or less within 48 hours of injury), according to the United States National Traumatic Coma Data Bank.

The evaluation and neurological assessment of patients is very important in neurosurgery, and thus coma scales were devised because of the need to standardize the language used and facilitate communication between health professionals. The Coma scales provide a consistent system and follow the evolution of the patient's level of consciousness, and they also provide prognostic data, allowing treatment to be optimized and costs rationalized[4]. Many Coma scales have evolved, but none of the Coma scales reached widespread acceptance like the Glasgow Coma Scale (GCS).

1.2.1 Glasgow Coma Scale

The GCS is a worldwide tool used for evaluating the alterations of consciousness in patients[5]. It has been a standard scoring system since 1974 as designed by Teasdale and Jennett and revised in 1976 with the addition of a sixth point in the motor response subscale for withdrawal from painful stimuli[6]. The GCS was devised as a formal scheme to overcome the ambiguities and misunderstandings that arose when information about comatose patients is presented and groups of patients were compared[7].The GCS was only used to evaluate the degree of altered consciousness

in patients who sustained TBI, but now has a wide spectrum of use, on patients with an altered level of consciousness[8].

The GCS measures 3 aspects of consciousness i.e. eye opening, motor response and verbal response (Appendix A). A total score is assigned by taking the best response of each category and a total sum will range from 3 to 15 and values of 8 or less portends to serious conditions requiring intubation[4]. The score will determine the coma depth and severity of injury (i.e. mild, moderate or severe). The main advantage of this scale is that it can be utilized by physicians, nurses, and other care providers due to its simplicity[6].

The GCS describes and assesses coma, monitors changes in coma, is an indicator of severity of illness, facilitates information transfer, and is used as a triage tool in patients with TBI.

The main advantage of the GCS is that it can be utilized by physicians, nurses and other healthcare providers due to its simplicity and provides for the building of common language among health professionals [6, 9, 10]. Many coma scales evolved from the GCS, such as, Age and Chronic Health Evaluation, the Simplified Acute Physiology score and Traumatic Injury Scoring System, and the GCS is the basis of the World Federation of Neurosurgical Societies for subarachnoid haemorrhage [6].

The GCS has been utilized as a clinical indicator for management, and the well-known recommendation is in a patient with a GCS score of 8 or less, who is unable to protect the airway and requires endotracheal intubation [7]. The GCS identifies patients requiring CT scan [11], by distinguishing mild, moderate and severe TBI.

Despite the widespread use of the GCS in trauma care, several limitations have been identified which are:

(i) The interobserver variability or reliability:
There are discrepancies on measuring the GCS, the most inaccuracy was by the inexperienced personell, and the distinction between ‘abnormal’ and ‘normal’ flexion movements has achieved

consistency only amongst experienced neurosurgeons and research workers[11].

(ii) Does not cover the severity of coma (lack of brainstem reflexes evaluation and altered breathing patterns):

The brainstem reflexes are considered good indicators of brainstem arousal activity. The GCS does not incorporate the size and reactivity to light of the patient's pupils [6]. Dilatation of the pupil might be secondary to a rapidly expanding traumatic hematoma which leads to mechanical compression of the oculomotor nerve.

The breathing patterns (ranging from Cheyne stokes, regular shallow, rapid breathing, slow irregular breathing and to apnoea) and the involvement of other cranial nerves may be due to increased intracranial pressure causing a diffuse bilateral hemisphere dysfunction leading to brainstem damage [12].

(iii) Inability to obtain verbal response from patients who are intubated or those with aphasia:

Failure to assess verbal response in intubated patients can cause confusion and inaccuracy, and the addition of a letter 'T' or assignment of 1 has not been validated [13]

(iv) Limitations in scoring children:

Scores in children are more subjective and prone to misinterpretation. The GCS is in applicable to infants and children below the age of 5 years [6, 14], though some GCS subscores are used in scoring children.

(v) Eye opening:

Eye opening is considered to indicate wakefulness but it should be remembered that the eye opening does not mean that the content of consciousness is intact. Eye subscore 4 is indicative of activity of brainstem arousal activity but not necessarily of alertness [6, 10]

Many scoring systems have emerged and have been compared to the GCS, due to its limitations[8]. The new scoring system, called the Full Outline Unresponsiveness

(FOUR) score has been developed to overcome some limitations of the GCS, especially in intubated patients[5.7.8].

1.2.2 Full Outline Unresponsiveness score

The new coma score called the FOUR score was described by Wijdicks et al. in 2005[5,7,8]. The variety of conditions such as intubation, sedation or delirium preclude a reliable assessment of a verbal response, and therefore the FOUR score is an attractive tool as it provides a more comprehensive neurological assessment, and thus has a higher predictive value for patients in Intensive Care Unit (ICU).

The FOUR score has four components i.e. eye tracking, brainstem reflexes, motor response and respiratory pattern (Appendix B); the evaluator assigns a score of 0 to 4 on each of the 4 functional categories. The maximum total score is 16 and the lowest is 0. The FOUR score includes brainstem reflexes, eye tracking, breathing patterns and respiratory drive and thus may have a higher prognostic value for intubated patients in ICU. It eliminates the verbal response from the scale due to the documented limitations of the verbal score in the GCS score. The brainstem reflex component was created to assess the function of the mesencephalon, pons and the medulla, this provides information about the stages of brainstem injury. Attention to respiratory patterns in the FOUR score, not only indicates the need for respiratory support in stuporous or comatose patients, but also provides information about the presence of a respiratory drive[14].

Patients with the lowest GCS score could be further distinguished using the FOUR score. The FOUR score provides a greater neurological detail than the GCS, it recognizes a locked in syndrome, any subtle neurological changes, is superior to the GCS due to the availability of brainstem reflexes, breathing patterns, ability to recognize stages of herniation, presence of vegetative state[3,4,5,7,14,15]. The probability of in- hospital mortality is higher in the lowest total FOUR score when compared with the lowest GCS score. The FOUR score further characterizes the severity of the comatose state in patients with lowest GCS scores.

Several studies have shown that there is a high degree of inter-rater reliability of the FOUR score, as demonstrated by a study done by Wijdicks et al. where they

enrolled 120 patients in their study, and the overall reliability was excellent for both the FOUR score (K_w=0.82; 95% CI, 0.77-0.88) and the GCS (K_w=0.82; 95% CI 0.76-0.88)[14] and as also shown by the study done in Italy by Marcati et al. FOUR score and GCS (K_w=0.953 and K_w=0.943, respectively)[16], whilst Bruno et al. demonstrated a good inter-rater reliability that was good for both the FOUR score and the GCS (K_w=0.75 and K_w=0.65, respectively)[15].

The FOUR score provided no significant advantage over the GCS in predicting morbidity and mortality in children with head injury[9] and in a study conducted on multiple trauma patients which concluded that the sensitivity and specificity of GCS were 84.25 and 88.6% on admission and sensitivity and specificity for FOUR were 89.5% and 100% on admission [13]. In contrast to most of the studies that were done in adults. The outcome prediction of the FOUR score showed that for every 1- point increased in the total score, there is an estimated 20% reduction in the odds of in-hospital mortality (OR=0.80, 95% CI, 0.72-0.88). A 1-point increase in the total score is also associated with the lower odds of poor outcome defined as a modified Rankin scale of 3 or more (OR=0.84; 95% CI, 0.77-0.92)[14].

The brainstem reflex subscore had the biggest area under the curve in predicting mortality, and this illustrates that brainstem damage and failure to maintain adequate ventilation is a reflection of injury severity[2,14,16]. The motor response of both the FOUR score and the GCS score were independent predictors of mortality [8] .There was no difference between both scores in predicting poor outcome and favourable outcome [8, 14]. The cut-off point of the FOUR score was 9 (sensitivity=0.75; specificity=0.76), and the GCS total score of 7 (sensitivity=0.80; specificity=0.80)[14] in a study done by Wijdicks et al, and another study done by Marcati et al. in 84 patients concluded that the optimal score to predict mortality at discharge was 10 for the FOUR score (sensitivity=91%;specificity=86%) and 9 for the GCS (sensitivity=100%; specificity=86%). The cut-off by Akavapit et al. for a poor outcome and in-hospital mortality are 14 and 10 respectively [17]. This shows that the average of the FOUR score to predict mortality is 9.

1.2.3 Glasgow Outcome Score

There are multiple outcome scores being used, but the most widely used assessment of the outcome after TBI is the Glasgow Outcome Scale (Appendix C). The GOS was first described by Jennet and Bond in 1975. The GOS is based upon the ability of recovering TBI patients to perform activities of daily living and the degree of assistance required [18], but these survivors face many years of disability, which commonly affects both mental and physical function [19]. The GOS applies to patients with brain injury allowing the objective assessment of their recovery in 5 categories i.e. 1- death, 2- persistent vegetative state, 3- severe disability, 4- moderate disability and 5- good recovery. This allows a prediction of long-term course of rehabilitation to return to work and everyday life. The early identification of brain injury severity is extremely important in TBI patients since many secondary damages can be prevented or minimized by applying correct therapeutic maneuvers, reducing in this way their adverse effects in the final patient outcome [20].

King et al. did a study on 159 patients with severe TBI, and they demonstrated that the GOS at 3 months was the strongest independent predictor of outcome at 12 months (odds ratio [OR] =15.2, p=0.001). Prolonged hypotension (OR=3.7, p=0.047), diffuse axonal injury (OR=5.5, p=0.001), and fixed and dilated pupils on admission (OR=12.1, p=0.032) were also significant predictors. There was no independent association between poor outcome and age, sex, GCS on admission or emergency surgery[18]. There is a significant change in GOS over time, where patient's GOS may improve [18], as shown in a study done by Jennet et al. 10% of patients who were severely or moderately disabled at six months were in the next better category by one year [19].

The study done in Brazil by Oliveira et al. showed that the GCS at hospital admission was not indicative of worst prognosis by univariate logistic regression analysis (p=0.1088)[20] as seen in the study by King et al [18]. Oliveira et al compared the GOS at hospital discharge and at 12 months, and the study showed that there was a neurological improvement in patients classified as moderate recovery and good recovery by the GOS at hospital discharge when compared to those that were graded as vegetative state and severe disability at the same time.

A revision of the GOS (Extended GOS) was proposed to better classify patients who had regained consciousness [19] and the lack of sensitivity to detect small but clinical relevant changes in outcome [21] such as cognition, mood and behaviour. In the extended GOS, each of the three categories applicable to conscious patients are subdivided into an upper and lower band resulting in eight possible categories [19].

Jennet et al. reported a 95% agreement between the observers[22]. The implementation of a structured interview has resulted in improved inter-rater reliability and has validated the extended GOS for use through the mail and telephone, where the GOS and extended GOS yielded weighted kappa values of 0.89 and 0.85, respectively. The overall agreement between raters was 92% for the GOS and 78% for the extended GOS [22].

.

1.3 JUSTIFICATION OF THE STUDY

Traumatic brain injury imposes both direct and indirect social and economical costs to the society [31]. The GCS is easily accessed but we need a better coma scale to further evaluate the degree of coma.

1.4 Study Aim and Objective

The aim and objective of the study is to define and to compare the GCS score and the FOUR score in predicting in-hospital mortality and functional outcome at discharge (by using the Glasgow Outcome Score) in patients who sustained severe TBI.

2.0 CHAPTER 2: METHODS

2.1 Research design

A cross sectional study design was used.

2.2 Setting and Period of Study

This study was conducted at Chris Hani Baragwanath Academic Hospital and Charlotte Maxeke Johannesburg Academic hospital over a period of 6 months from July to December 2015.

2.3 Patient Selection

2.3.1 Inclusion Criteria

The criteria for inclusion in the study were

a) Patients more than 18 years of age
b) Patients with isolated head injury
c) Patients with GCS of 8 or less, or intubated patients

2.3.2 Limitations

The time frame was short for this study

2.3.3 Measurements

A data collection sheet was used (Appendix D), the patients' identifiers i.e. name and hospital number are kept separately from the data sheet. The data collection should comprise patient's age, sex, mode of injury, GCS and Four score. The patients were clerked by the author and colleagues.

The management guidelines were followed for patients with Severe Traumatic Brain Injury.

- Resuscitation according to the ATLS protocols.
- Investigations: CT brain scan
- Treatment: intravenous fluids, mannitol, anticonvulsants, insertion of an ICP monitor and/or surgery for patients with indications.
- The Glasgow Outcome Score was used to evaluate the outcome of patients.

The Human Ethics Committee approved the study (Appendix E). The patient or next of kin had to sign a consent form (Appendix F).

2.3.5 Data analysis

There were 54 patients who met the criteria for the study. The data was captured on an Excel spreadsheet and analysed. The analytical tools that were used are descriptive statistics in the form of graphs and tables, and analytical statistics. Statistical calculations such as the mean, median, frequency and percentages were calculated on the Excel spreadsheet. The age is a continuous variable, while the categorical data analysis was used for the gender and mode of injury. The student t test was used for data analysis.

3.0 CHAPTER 3

3.1 Results

The study was done at two academic hospitals in Gauteng i.e. Chris Hani Baragwanath Academic Hospital and Charlotte Maxeke Johannesburg Academic Hospital. The CHBAH Neurosurgical unit is larger than CMJAH, with 65 beds, 11 of the 65 beds are for high care and/or ICU patients. CMJAH has 8 ICU beds.

There were 54 patients which were entered in the study from July to December 2015 in consecutive patients who sustained Severe TBI. Forty three of the patients were from CHBAH whilst 11 patients were from CMJAH. The patients were first assessed with the GCS, and those patients with GCS below 9 with no other injuries qualified to be in the study. The GCS verbal score was given one for all patients as all patients were intubated. The FOUR score was then assessed after qualifying for the study.

The variables which were measured were demographics (age, gender), mode of injury, GCS, FOUR score, CT scan results, Management, ICU length of stay and the GOS on discharge. These variables used for the study are important predictors of mortality and morbidity. The outcome considered is in-hospital mortality and neurological outcome on discharge.

<u>Demographics</u>

Age ranged from 18 years to 87 years, with a mean age of 30 years. Most of the patients ranged between 26 to 35 years of age, which shows that the patients who are mostly prone to TBI are the younger patients. Only 2 patients were above the age of 65 as shown in figure 3.1 below.

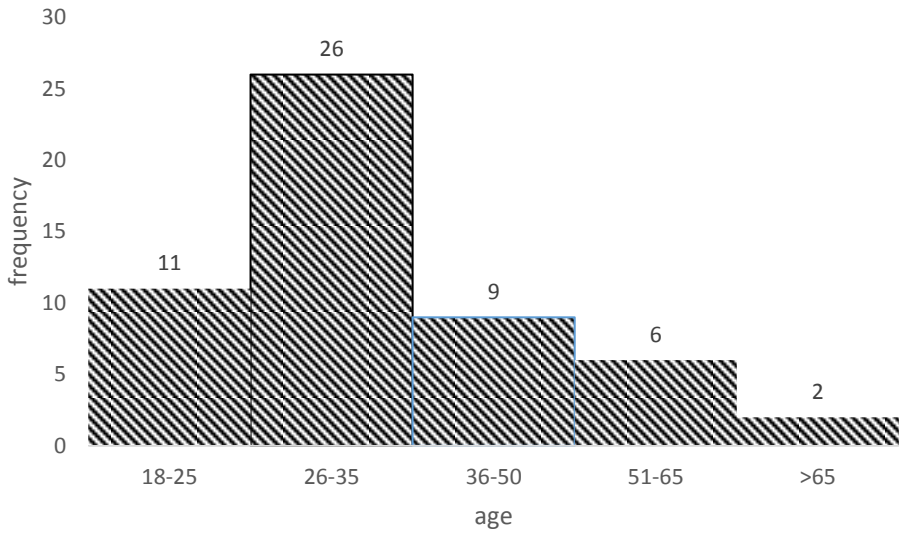

Figure 3.1: Age of patients at presentation

From the 54 patients that were enrolled, only 7% (n=4) of the patients were females whilst 93% (n= 50) were all males.

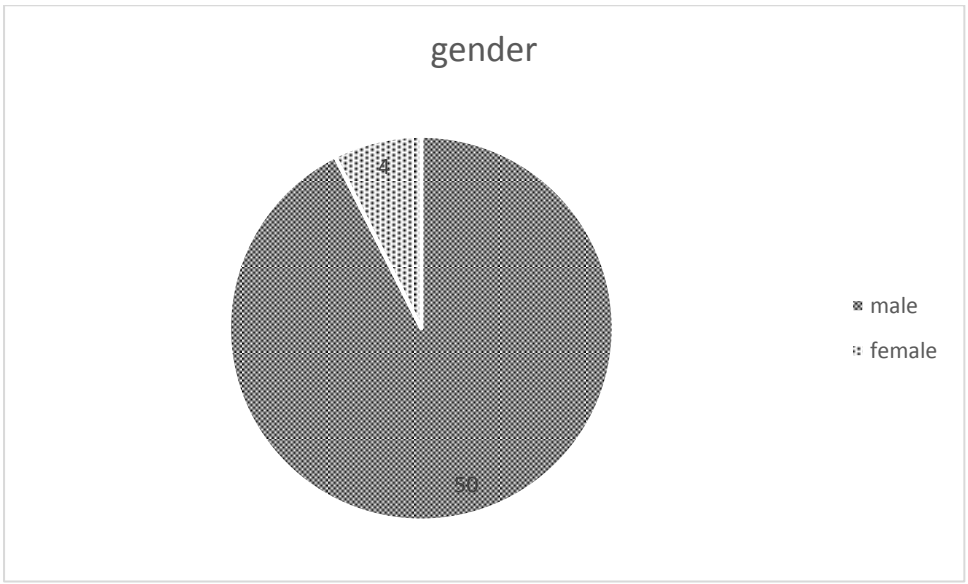

Figure 3.2: Gender distribution

Mode of injury

The mode of injury was also assessed where patients were grouped in either those who sustained injuries due to motor vehicle accidents/pedestrian vehicle accidents, assault, or other mechanism of injury e.g. Gunshot wounds. None of the patients had self-inflicted injuries. Most of the patients in the study were assaulted as illustrated in figure below.

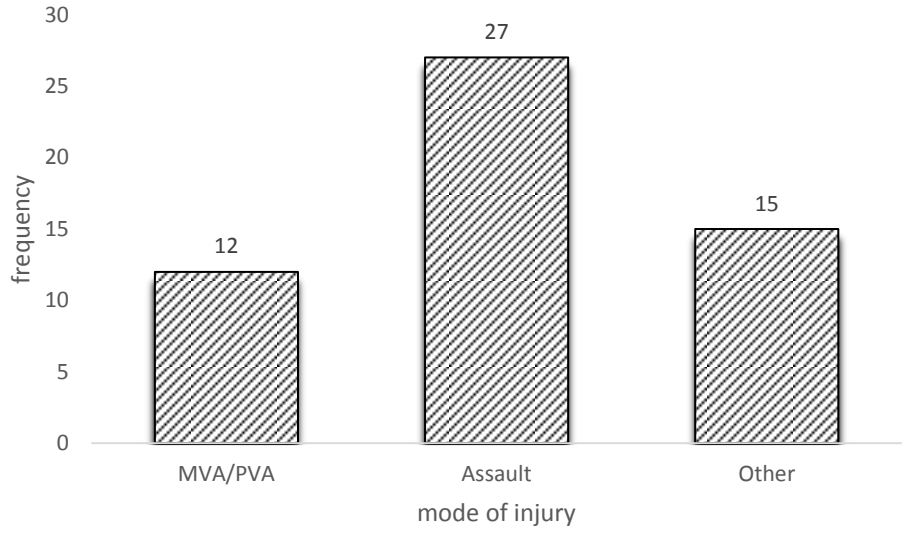

Figure 3.3: Mode of injury

Out of 54 patients, 50% (n=27) of the patients were assaulted, either with fists, blunt or sharp objects. All the females in the study were involved in motor vehicle accidents, none were assaulted.

Glasgow Coma Score

The GCS was evaluated after resuscitation, where it ranged from 3 to 8, and all patients were intubated. The verbal response was given 1 in all patients as all

patients were intubated. The GCS was categorized into 3 categories i.e. category 1: GCS 3-4, category 2: GCS 5-6 and category 3: GCS 7-8. See figure 3.4 below.

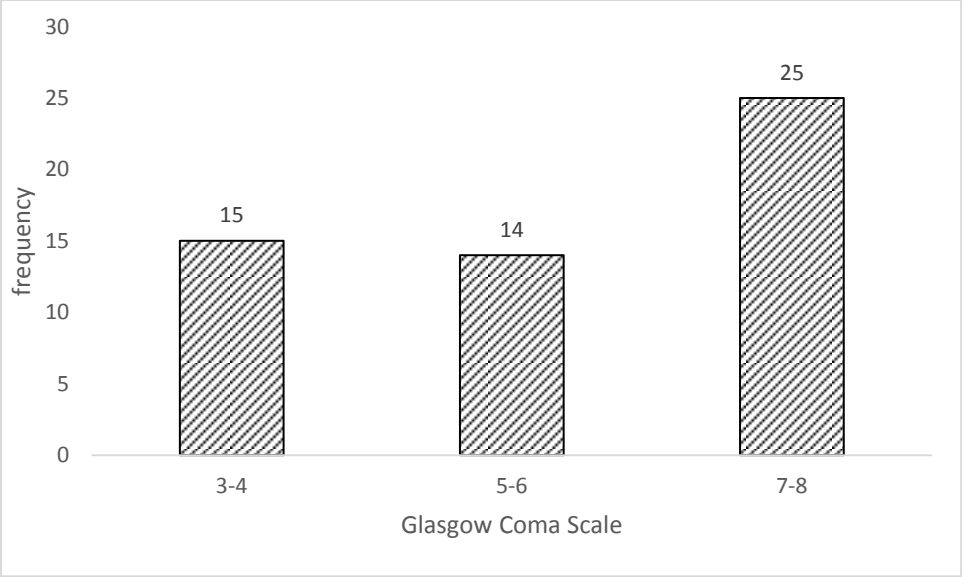

Figure 3.4: Categories of GCS and their frequencies

The GCS ranged from 3 to 8, where 46% (n=25) of patients had the highest score (GCS of 7-8). The other 2 categories were almost the same GCS 3-4 had 28% (n=15) of patients and GCS 5-6 had 26% (n=14).

Table 3.1: GCS score variables and results

Eye opening	Verbal response	Motor response
1 =35 patients	1= 54 patients	1= 11 patients
2= 11 patients	2= 0	2= 4 patients
3= 2 patients	3= 0	3= 7 patients
4= 6 patients	4= 0	4= 15 patients
	5= 0	5= 17 patients
		6= 0

Full Outline of UnResponsiveness Score

The FOUR score was assessed after the GCS score was done, for all the qualifying patients with GCS of less than 9. The FOUR score was divided into 3 categories; category 1: FOUR score of 0-4, category 2: FOUR score of 5-10, category 3: FOUR score of 11-12. Most patients were in category 2, which comprised of 69% of patients (n=37). As seen in figure 3.5 below. Only 4 patients were in FOUR score category 3.

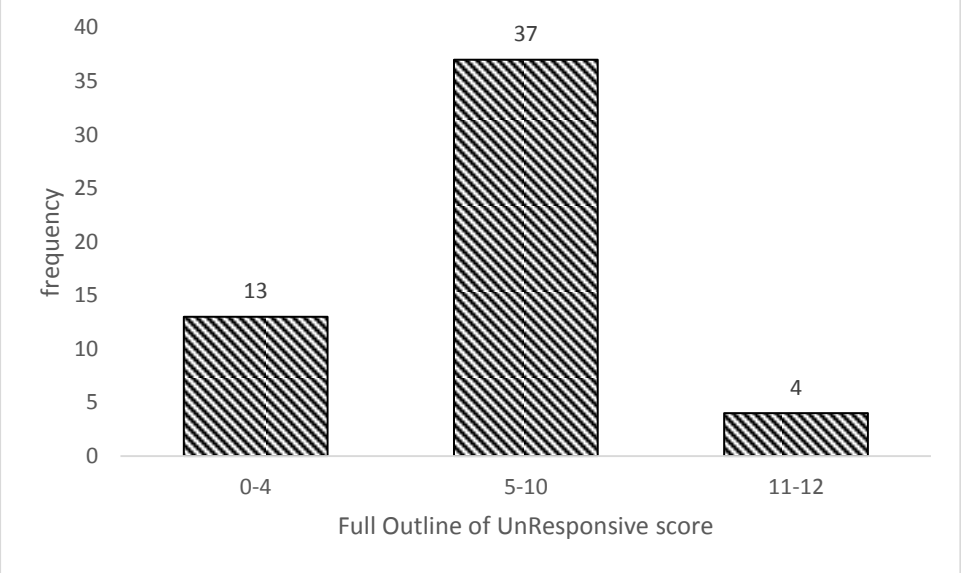

Figure 3.5: Categories of FOUR score and their frequencies

Table 3.2: Four score variables and results

Eye response	Motor response	Brainstem reflex	respiration
0= 29 patients	0= 9 patients	0= 1 patient	0= 9 patients
1= 16 patients	1= 8 patients	1= 6 patients	1= 45 patients
2= 3 patients	2= 21 patients	2= 5 patients	2= 0
3= 5 patients	3= 15 patients	3= 10 patients	3= 0
4= 1 patient	4= 1 patient	4= 32 patients	4= 0

Most (n=29) of the patients had no eye response, and only 1 patient obeyed commands. The motor response is regarded as a strong prognosticator, in this study 15 patients were localizing to the pain and only 1 patient obeyed commands, whilst 9 of the patients had no motor response which could add to poor prognosis. The FOUR score has replaced the GCS's verbal response with brainstem reflexes and respiration, these 2 variables help us recognise neurological deterioration and brainstem dysfunction. Most of the patients in the study had brainstem reflexes. As all our patients were intubated, they could only be scored from 0 to 1 for the respiration.

Management

The CT scans were done on admission, and the findings were showed acute extradural hematomas, acute subdural hematoma, intracerebral hematoma, diffuse brain injury and/or brain contusions. The patients received treatment in the form of medical and/or surgical treatment. Only 5 patients out of 54 had ICP monitoring which ranged between 11 and 31.

The patients who received surgical intervention were 54% (n=29) patients, whilst 46% (n=25) patients were treated non- surgically. Most of the patients who were treated non- surgically were those on category 1 for both GCS and FOUR score, and some had diffuse injuries.

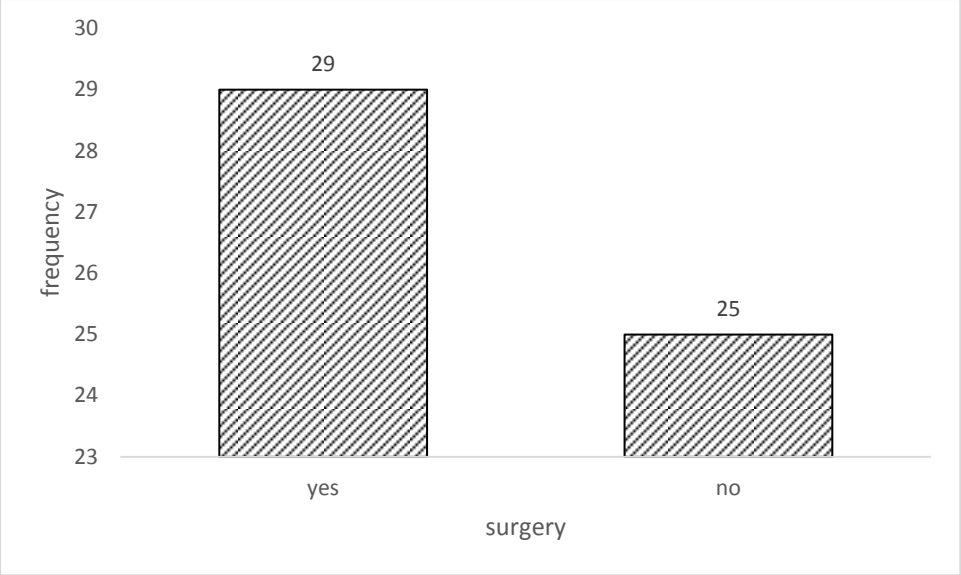

Figure 3.6: Results of surgeries done

ICU length of stay

Patients who presented with higher GCS scores and FOUR scores had a shorter stay in ICU, and had a favourable outcome. The ICU length of stay ranged from 2 days to 5 weeks. Most of the patients (67%) stayed in ICU for an average of 3 weeks.

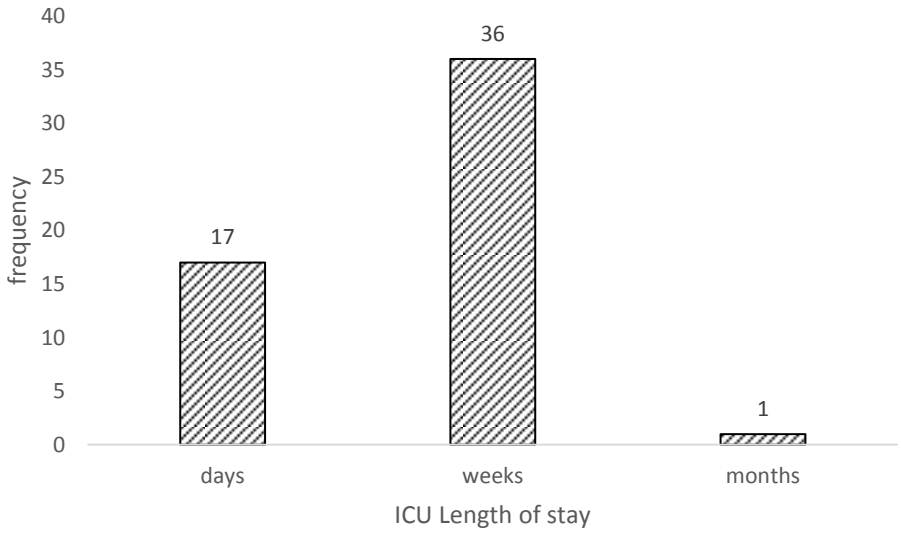

Figure 3.7: ICU length of stay

Glasgow Outcome Scale

The outcome was assessed as in-hospital mortality or neurological outcome on discharge using the Glasgow Outcome Scale was used to assess outcome. Where GOS 1 is dead, GOS 2 is persistent vegetative state, GOS 3 is severe disability, GOS 4 moderate disability, and GOS 5 is good recovery. Figure 8 shows that in-hospital mortality occurred in 26% (n=14) of patients, 13% (n=7) of patients had persistent vegetative state on discharge, 26% (n=14) of patients had severe disability, 12 patients (22%) had moderate disability whilst only 7 patients (13%) had good recovery.

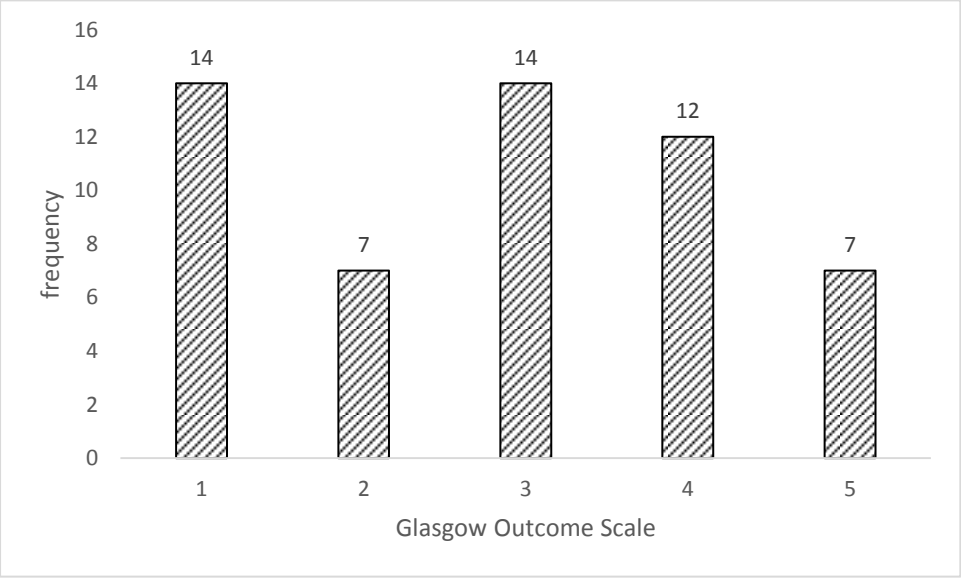

Figure 3.8: Glasgow Outcome Scale results

The patients who had low GCS and low FOUR score had a poor outcome. Figures 3.9 to 3.14 show the relationship between the 3 categories of both GCS and FOUR score with the GOS. On category 1, the GCS had 15 patients (28%), and out of that 15 patients, 14 of the patients died and 1 had a GOS of 2. Whilst out of 13 patients (24%) in category 1 of the FOUR score, all 13 patients died.

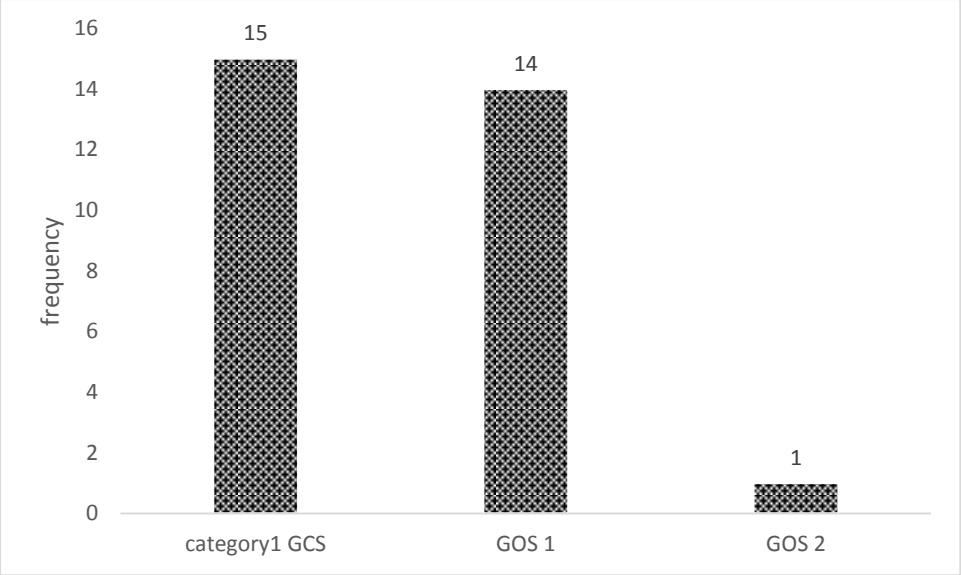

Figure 3.9: GCS category 1 and outcome

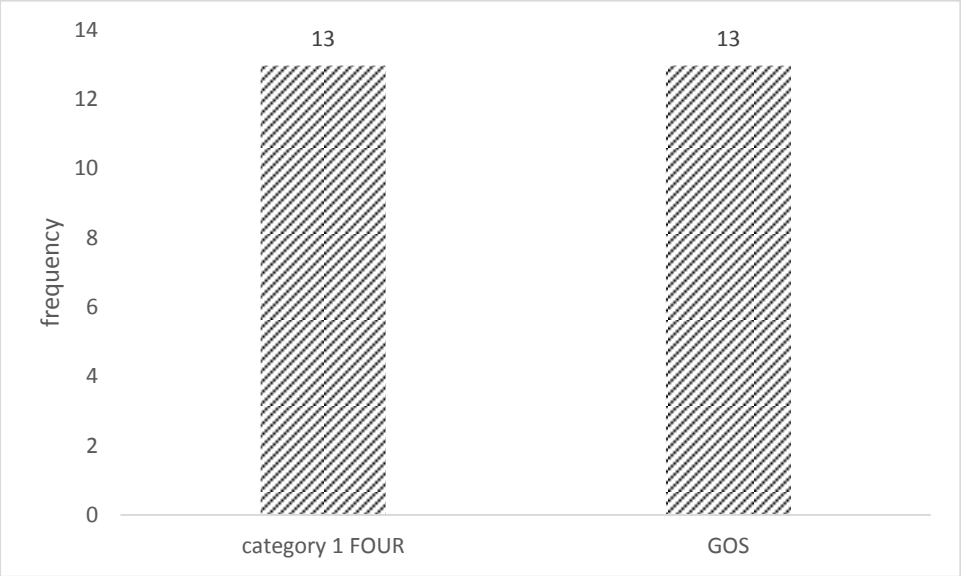

Figure 3.10: FOUR score category 1 and outcome

Category 2 of the GCS comprised 14 patients (26%), where the GOS ranged from GOS 2 to 4. Seven of the patients (50%) were discharged with a GOS of 3 and only 2 patients had a GOS of 4 on discharge. Most of the patients (37 of 54) were in category 2 of FOUR score, where 14 (38%) of the patients had a GOS of 3 on discharge and 3 (8%) of the patients were discharged with a GOS of 5.

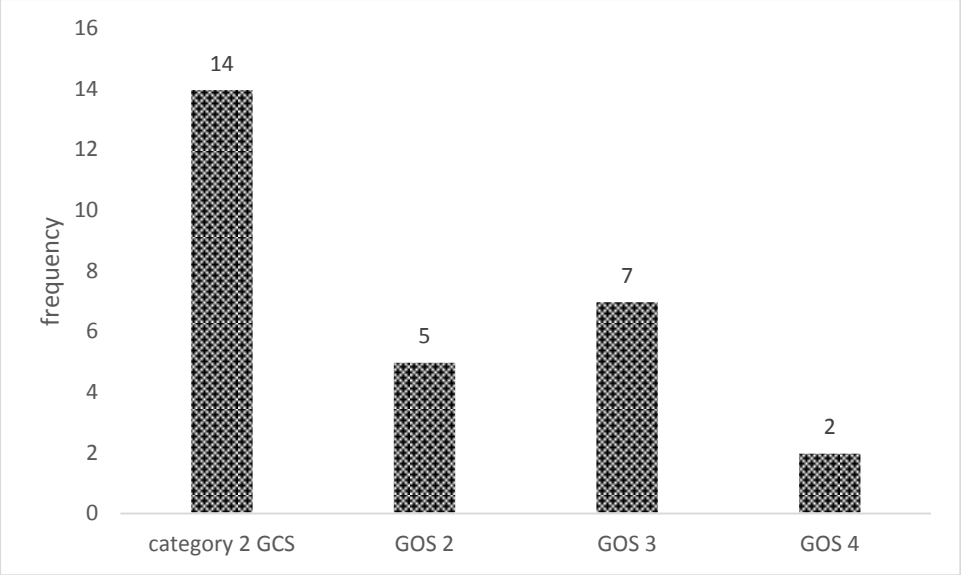

Figure 3.11: GCS category 2 and outcome

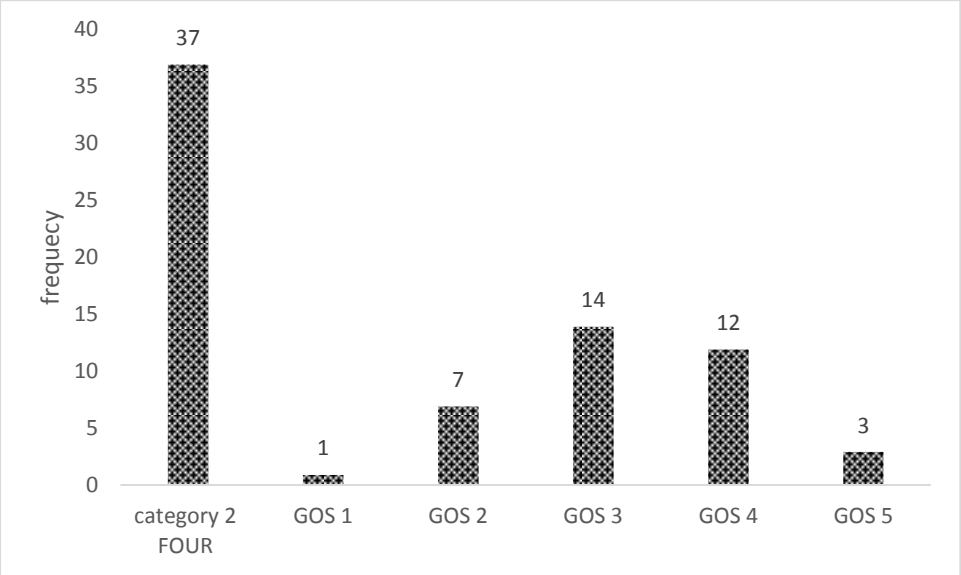

Figure 3.12: FOUR score category 2 and outcome

The GCS category 3 comprised of 25 patients (46%), where 10 (40%) of the patients were discharged with GOS of 4 and 1 patient had a GOS of 2. Of the 4 (7%) patients who were in category 3 of the FOUR score, all were discharged with GOS of 5.

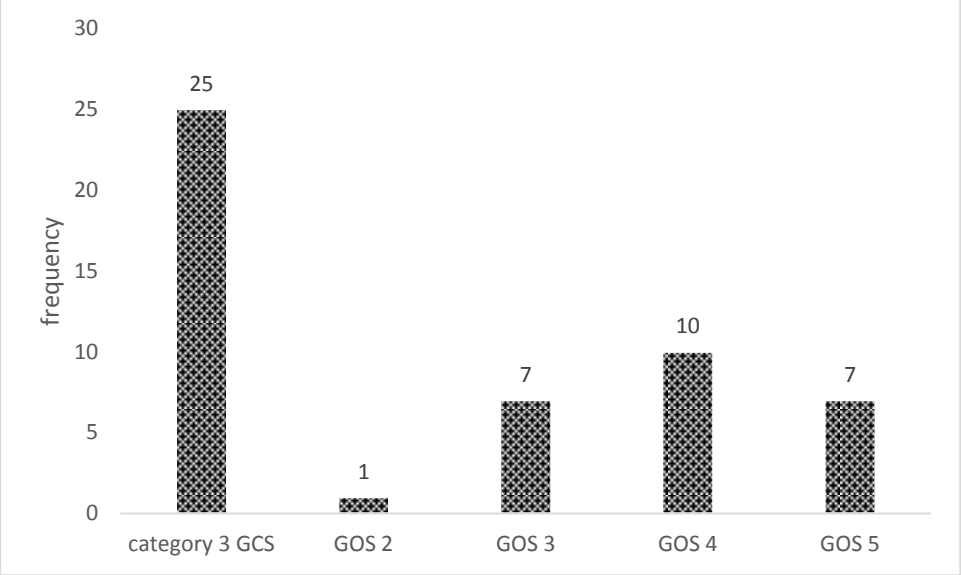

Figure 3.13: GCS category 3 and outcome

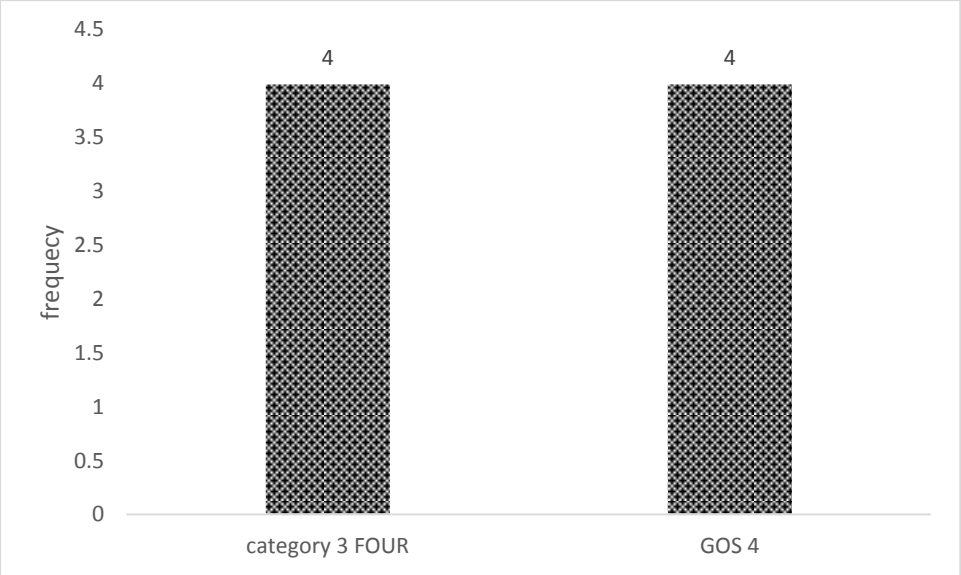

Figure 3.14: FOUR score category 3 and outcome

Data analysis

Table 3.3 shows a comparison of the FOUR score and the GCS with the other variables that were used in the study. The FOUR score predicted better on ICU length of stay, and this could be because the FOUR score has an advantage of

assessing brainstem reflexes and any subtle neurological changes. The prediction of in-hospital mortality and neurological outcome was much better in the FOUR score than the GCS score. The FOUR score predicted the need for surgery on admission and also when the patient deteriorating as shown by dilatation of the pupil and changes in breathing patterns which are the subscores of the FOUR score. The GCS score had an input in all the variables but not as good as the FOUR score.

Table 3.3: Comparison of the FOUR score and the GCS

Score	**Surgery**	**ICU stay**	**In-hospital mortality**	**GOS**
FOUR	Predicted better	Predicted better	Predicted better	Predicted better
GCS	Predicted need for surgery	Predicted the day of dicharge	Fair prediction	Good prediction

The data was analysed using the t test which showed a p value of 0.0014. This p value proves the hypothesis **'The FOUR score is superior to the GCS for in-hospiatl mortality and functional outcome prognostication'** is true.

The table above shows that the FOUR score has persistently been a better predictor than the GCS score.

4.0 Chapter 4

4.1 DISCUSSION

The GCS is a useful, quick and simple bedside tool to assess patients with TBI and critically ill patients. GCS was initially described by Teasdale et al. to assess level of conscious 6 hours post TBI, but the score is universally used to assess the level of consciousness beyond TBI.

The GCS has been criticized for the skewness (eye=4, verbal=5 and motor=6) and the possible (120) mathematical combinations/permutations of its subscores. As seen in the studies done by Teoh and colleagues and Bhatty et al, and the studies showed that the GCS has multiple possible permutations and there was statistically significant differences in mortality between permutations [23, 24].

There was a significant association between total GCS scores and outcome, where the motor and verbal subsores were associated with mortality when compared to the eye subscore.

There has been studies done to try to prognosticate for TBI patients, the GCS has been widely used to assess TBI patients and also for prognostication but there has been some lack of correlation between GCS and outcome. Wijdicks et al. has described a new Coma score in 2005 called the FOUR score to try and overcome some of the limitations that the GCS has such as in intubated patients and also for prognostication.

The study was done in 2 large hospitals in Gauteng, 54 patients were enrolled in the study where 93% of patients were males and mostly young, whilst only 7% (n=4) were females. This is consistent with previous studies done by Akapavit et al. (53.6%

vs 46.6%) [17] and Gorji et al. (79.2% vs 20.8%) [25]. The patients were young males who are more vulnerable to comprise risky behaviour.

There is a significant relationship between pre-resuscitation GCS (CI:95, 11.36-12.26) and post resuscitation GCS (CI:95, 13.24-14.14), but despite an increase in GCS scores in response to resuscitation 11.81 to 13.69, there wasn't a significant relationship between response to resuscitation and patients' prognosis[26] as shown in the study done by Gholipour et al.

While in this study the GCS post-resuscitation was documented, patients with GCS of <9 were enrolled in the study and then the FOUR score was assessed on qualifying patients. The FOUR score unlike the GCS doesn't include a verbal response, and thus is more valuable in ICU practices that typically have a large number of intubated patients, as patients with severe TBI.

The prognosis of patients with severe TBI is variable and often difficult to predict, so the GCS and its variables were compared to the FOUR score and its variables. A study done by King et al. have shown that some poor outcome indicators are prolonged hypotension, diffuse axonal injury and fixed pupils, which are independently associated with poor outcomes [18].

In this study the poor outcome predictors were those in category 1 (GCS 3-4 and FOUR score 0-4) and most of the patients in category 2 (GCS 5-6 and FOUR score 5-10). Where 93% of patients in GCS category 1 had in-hospital mortality whilst 100% of the FOUR score category 1 had in-hospital mortality. The patients with no brainstem reflexes, no motor response, and no respiratory drive as seen in FOUR score category 1 have a poor prognosis which results to in-hospital mortality.

The outcome in GCS category 2 and 3 were variable with 50% and 28% of the patients were discharged with severe disability (respectively) and none of the patients had good recovery, unlike the FOUR score category 2 comprised of 69% of patients and this could be because it had a big range from 5 to 10. Those patients who had a FOUR score of 10 and above had a good outcome as seen in other studies done.

The other variables that might have contributed to the outcome were CT scan diagnosis. Those patients who sustained acute extradural hematomas had a better

outcome when compared to those with acute subdural hematomas and intracerebral hematoma. Those with diffuse axonal injury had a poor outcome as seen in a study done by Leitgeb et al. The length of ICU stay was not a predictor of outcome as seen in the other studies [27]. The short stay in ICU could be due to the severity of the injury.

The prediction of outcomes in discharge time was very high level in either GCS or FOUR; their efficacy was close together as in mortality in hospital[28], as shown in this study also.

5.0 Chapter 5

5.1 CONCLUSION

The FOUR score is an easy coma score to use and to remember, it has an advantage on intubated patients and to recognize any neurological deterioration. The GCS has been widely used even though it has limitations that the FOUR score will overcome.

The FOUR score plays a significant role in prognostication of in-hospital and functional outcome at discharge as shown in this study. It is more accurate in patients with a low GCS, intubated patients, and provides more information on brainstem injury. The GCS is still a standard coma scale for assessment of TBI patients and can be used concurrently with the FOUR score to further describe the neurological state of patients with severe TBI, and characterizes the severity of the coma state as it assesses the brainstem function and the respiratory drive.

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