Prospective study of surgery for traumatic brain injury in Addis Ababa, Ethiopia: Surgical procedures, complications and postoperative outcomes.

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Running title: Traumatic brain injury in Ethiopia: Surgical procedures.

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Key words: Traumatic brain injury, surgical outcome, neurotrauma, low- and middle-income countries.

Manuscript word count: 3515 words.

Abstract word count: 250 words.

Abstract

Background: Traumatic brain injury (TBI) is an important cause of trauma-related mortality and morbidity in Ethiopia. There are significant resource limitations along the entire continuum of care, and little is known about the neurosurgical activity and patient outcomes.

Methods: All surgically treated TBI patients at the four teaching hospitals in Addis Ababa, Ethiopia were prospectively registered from October 2012 to December 2016. Data registration included surgical procedures, complications, reoperations, discharge outcomes and mortality.

Results: A total of 1087 patients were included. The most common procedures were elevation of depressed skull fractures (DSF; 49.5%) and craniotomies (47.9%). Epidural hematoma was the most frequent indication for a craniotomy (74.7%). Most (77.7%) patients were operated within 24 hours of admission. The median hospital stay for DSF operations or craniotomies was four days. Decompressive craniectomy was only done in 10 patients. Postoperative complications were seen in 17% of patients and only 3% were reoperated. Cerebrospinal fluid leak was the most common complication (7.9%). The overall mortality was 8.2%. Diagnosis, admission Glasgow coma scale score (GCS) score, surgical procedure and complications were significant predictors of discharge GCS score ($p < 0.01$). Age, admission GCS score and length of hospital stay were significantly associated with mortality ($p \leq 0.005$).

Conclusion: The injury panorama, surgical activity and outcome are significantly influenced by patient selection due to deficits within both prehospital and hospital care. Still, the neurosurgical services benefit a large number of patients in the greater Addis region and are qualitatively comparable to reports from high-income countries.

Introduction

The majority of trauma-related mortality worldwide occurs in low- and middle-income countries (LMICs) and traumatic brain injury (TBI) is the leading cause of death.[1] The estimated TBI incidence in Sub-Saharan Africa (SSA) is 801 per 100.000, and the mortality rate for severe TBI is approximately 50%.[2,3] TBI is particularly frequent in younger people,[4] and Ethiopia has more than 70 million citizens under 30 years of age.[5,6] TBI-related injuries and deaths therefore take a significant toll on society.[7,8] In a recent Ethiopian study of 4206 postmortem reports, 67% of deaths were caused by accidents, homicide and suicide.[9] Almost 40% of deaths were accidental, of which close to 70% were traffic-related. Moreover, in a study from an Ethiopian emergency department (ED) of almost 10000 patients, TBI was the most common cause of mortality, causing close to 23% of all deaths.[10]

Many TBI patients in SSA do not have adequate access to neurosurgical treatment,[11] and there are substantial deficits throughout the entire chain of care.[2,12,13] Prehospital care is underdeveloped, and ambulance personnel usually lack appropriate training.[2,12] There are few neurosurgeons and centers that can provide neurosurgical treatment.[14,15] Those that exist have significant shortages when it comes to equipment, infrastructure and human resources in the ED, operating rooms (OR), intensive care units (ICU) and wards. Guidelines for the management of severe TBI are also missing or poorly adapted.[16] Many patients who survive the initial phase end up in health centers or hospitals that are even less capable of giving proper or timely treatment.[2,12] Rehabilitation is virtually non-existent and most TBI survivors are left to be cared for by their families. These limitations result in a substantial selection of patients, where many succumb to their injuries before reaching definitive care and many are not operated because their prognosis is considered poor. However, it is largely unknown how these limitations affect the complication rate and outcome of those who are operated as structured registries capturing data on the clinical care and outcome of patients are lacking.[17] This knowledge can potentially help to develop tailored guidelines, improve patient care and identify focus areas for preventive efforts.[4,18,19]

Building on the Ethiopian/Norwegian training program in neurosurgery,[20] we established a prospective TBI database at the four teaching hospitals in Addis Ababa. Here, we present the surgical procedures, postoperative complications and discharge outcomes for surgically treated TBI in the period 2012-2016. Predictors of postoperative complications and mortality were also identified. Trauma causes, injury types and clinical presentation are described elsewhere.[21]

Material and methods

Study setting

This study was done at Black Lion Specialized Hospital, Myung Sung Christian Medical Center, Zewditu Memorial Hospital and Alert Hospital in Addis Ababa, Ethiopia. These four neurosurgical teaching hospitals are currently the main providers of neurosurgical care in the country. Most TBI patients in this study were treated at Black Lion Specialized Hospital and Myung Sung Christian Medical Center. Zewditu Memorial Hospital and Alert Hospital first started treating TBI patients in 2015 and were not fully operational before 2016. Regulatory approvals were obtained from the Institutional Review Board (#003/16/surg), Addis Ababa

University, Ethiopia, and by the Regional Ethical Committee (#2018/53), University of Bergen, Norway.

Study design and data collection

This was a prospective cohort study on surgically treated TBI patients. Data was prospectively collected from October 2012 to December 2016 and all surgically treated TBI patients were registered by neurosurgical residents using a paper-based case report form (CRF). The CRF included demographic information, cause of trauma, time of injury, computerized tomography (CT) findings, other injuries, surgical procedures, postoperative complications, mortality and time of events. The Glasgow Coma Scale (GCS) score was registered at admission and discharge. TBIs were defined as mild (GCS score 14-15), moderate (GCS score 9-13) and severe (GCS score 3-8).[22]

Statistical analysis

Data was analyzed using SPSS version 21 (SPSS Inc., Chicago, IL, USA). Age, time to admission, geographical distance, clinical status at admission and diagnosis were used as independent variables. Discharge clinical status, presence of postoperative complications, duration of hospital stay, and mortality were used as dependent variables. Binomial and multinomial regression analyses were used to assess how much the independent variables affected the dependent variables. Chi-square test was used for categorical variables. T-test and Mann-Whitney U test were used for continuous variables. Missing data were checked for random distribution. A p-value < 0.05 was considered significant.

Emergency care of TBI patients

Prehospital services are not well developed in Ethiopia, and ambulances are not equipped with trained paramedics.[2] As a consequence, families or bystanders usually brought patients to the hospitals. Ambulances were typically used for interhospital transfers, and nurses often escorted severe TBI patients during such transports. During the study period, Zewditu Memorial Hospital and Alert Hospital did not receive direct transfers from district hospitals. Most patients treated at these two hospitals were transferred either from Black Lion Specialized Hospital or Myung Sung Christian Medical Center.

At admission, TBI patients were first evaluated by intern physicians in the ED. Emergency medicine physicians were also available in the ED. After registration of vital signs and clinical suspicion of a TBI, responsibility was transferred to neurosurgery residents supported by an on-call consultant neurosurgeon. Emergency TBI management was based on the Advanced Trauma Life Support (ATLS) guidelines and the Brain Trauma Foundation (BTF) guidelines.[23,24]

A head CT was generally done for all patients with moderate and severe TBI. The Canadian CT head rule was followed for patients with mild TBI.[25] CT scanning services and radiology expertise was available 24-7 at Black Lion Specialized Hospital and Myung Sung Christian Medical center. Zewditu Memorial Hospital and Alert Hospital did not have CT scanners, and patients transferred to these centers brought CT scans from other centers.

Standards of perioperative care

Surgical protocols were similar at the four neurosurgical teaching hospitals. Salvageable patients were given priority for surgical treatment, and patients with an admission GCS score of 3-4 and/or fixed and dilated pupils were generally not intubated, treated in the ICU or operated.[26] Families of these patients were counseled thoroughly about the fatal prognosis. There were six ICU beds and four mechanical ventilators at Black Lion Specialized Hospital during the study period, and these resources were shared with other surgical departments. Myung Sung Christian Medical Center was equipped with eight ICU beds and eight mechanical ventilators, and these resources were shared with other surgical and medical departments. Zewditu Memorial Hospital and Alert Hospital had operative ICUs from 2016 with three ICU beds and one mechanical ventilator, and three ICU beds and two mechanical ventilators, respectively.

Patients with severe TBI were intubated and sedated in the ED by emergency medicine physicians. For other patients, this was done in the OR. Preparation and draping of the surgical site were done by the operating surgeons; a senior resident with four to five years of training and a junior resident. In a few cases, a consultant attended the procedures. All patients received prophylactic antibiotics (typically ceftriaxone) just before induction of anesthesia and this was continued postoperatively for 24 hours. Patients with open fractures or contaminated wounds were started on antibiotics in the ED. One suction device plus mono- and bipolar cautery were available. Hemostatic agents (e.g. Surgicel®) were occasionally available via visiting neurosurgeons. Duraplasties were performed using pericranial tissue or fascia lata (glue or dura substitutes were not available). For craniotomies, blood was routinely cross-matched and prepared. Patients were transfused if they bled more than the allowable blood loss. This was calculated by multiplying the estimated blood volume of the patient with by the difference between the patient's hematocrit and target hematocrit and dividing it by the patient's hematocrit.

Depressed skull fractures (DSF) were treated if they were compounded, or closed with significant depression and associated neurologic deficit.[27] A compound DSF was treated primarily with debridement and elevation.[27,28] If the wound edges were contaminated, thorough irrigation and debridement would be done. The wound would then be extended to expose all the edges of the depressed bone fragment. A burr hole would be done adjacent to the depressed bone edge and the fractured bone segment would circumferentially be freed and removed.[29] Dural tears were closed using sutures and/or fascia, and watertightness was checked with Valsalva maneuver. If there was no infection associated with the wound, the removed bone would be generously washed and replaced.

Craniotomies were done using a Hudson drill and Gigli saw, and typically lasted two hours or more. Epidural hematomas (EDH) were treated according to the BTF guidelines.[23] A large trauma craniotomy (minimum 12 cm) was routinely done for all patients with an acute subdural hematoma (ASDH).[30] The decision to do a decompressive craniectomy (DC) adhered to published consensus statements.[30] An expansile duraplasty was performed if there was established or anticipated brain edema. It was customary to close with a floating bone flap if there was no brain edema above the inner table of the skull. If it was difficult to replace the bone, a DC would be done and the bone flap would be stored subcutaneously in the abdomen and typically replaced three months later.

Patients with severe TBI were routinely transferred intubated to the ICU after surgery. They were transferred to the ward when they showed improvement in their neurologic status. Neurologic development (vital signs, GCS score, pupillary reactions, motor function and occurrence of seizures) was monitored and documented on a neurological observation chart. Intracranial pressure (ICP) monitors were not available. The ICU was equipped with mechanical ventilators, standard monitors and managed by one anesthesia resident with a daily morning round with a senior anesthesiologist. There was one nurse per two ICU patients. A postoperative CT scan was not done routinely unless patients displayed significant neurological deterioration.

Other patients were transferred from the OR to the ward a few hours after extubation. Resources were limited at the ward, but some routines were present (e.g. urethral catheterization, transnasal oxygen, administration of drugs, insertion of nasogastric tubes and wound care). However, most of the care, mobilization and physical rehabilitation were done by relatives who were instructed by a nurse or physiotherapist. Patients were discharged when there was marked improvement in their clinical condition and after relatives were thought to be able to care for the patient.

Results

Surgical procedures and length of hospital stay

Trauma causes, injury types and clinical presentation of our patient population were reported elsewhere.[21] In short, the most common trauma cause and injury type were assault and DSF, respectively. A total of 1087 TBI patients were operated, mean age was 29 years, 91.3% were males, 17.1% were < 18 years, 15.5% of TBIs were severe and 3.1% had polytrauma.

The most frequent diagnoses were DSF (44.9%) and EDH (39%), and the most common surgical procedures were elevation of a DSF (49.5%) and craniotomy (47.9%; **Table 1**). A craniotomy was most often done for an EDH (74.7%) and ASDH (12.7%; **Table 2**).

Most (77.7%) patients were operated within 24 hours of admission, 13.7% patients were operated the next day and the remaining (8.6%) were operated after two days or more. The majority of patients with a severe TBI (88.7%) were operated within 24 hours of admission; corresponding figures for moderate and mild TBI were 87% and 69.3%, respectively ($p < 0.01$).

The median length of hospital stay for a craniotomy or elevation of a DSF was four days while patients undergoing a DC stayed a median of nine days. However, only 10 patients underwent a DC. There was a significant difference in the length of hospital stay between different diagnoses ($p < 0.01$; **Table 1**).

Complications

Postoperative complications were seen in 17% of patients and 3% were reoperated (**Table 3**). The most common complication was cerebrospinal fluid (CSF) leak, which was seen in 7.9% of patients. Wound infection and hematomas were seen in 3.6% and 1.2% of patients, respectively. Wound infection was the most common cause of reoperation (39.4%). The complication rates for craniotomy and elevation of DSF were 21% and 12.8%, respectively. Patients with a wound infection had the longest hospital stays (median 21 days; data not shown). GCS score was the only significant predictor of postoperative complications in a logistic regression model including GCS score, age, time to admission and surgical procedure (**Table 4**).

Most patients (75.3%) lost less than 500 ml of blood while 13.3% lost 500-1000 ml. Blood transfusion was most commonly needed for DC (40%). Only 5.6% of craniotomy patients and 0.4% of patients undergoing elevation of a DSF required transfusion. Procedure and blood transfusion were strongly associated ($p < 0.01$).

Mortality

The overall mortality in our operated patients was 8.2%. Among 78 patients with recorded dates of admission and death, 15 died within 24 hours, 37 within a week and the remaining 26 died after more than a week.

Postoperative complications were seen in 46.1% of the patients who died. The odds of dying were higher in those who had postoperative complications as compared to those that had an uneventful course (OR = 4.908; 95% CI, 3.11-7.7; $p < 0.01$). Moreover, the mean discharge GCS score was lower in patients with complications than in those without complications (GCS score 10.6 vs. 12.6; $p < 0.01$). The amount of blood loss and mortality were significantly associated ($p < 0.01$); 32.3% of those who lost more than 1000 ml of blood died.

We compared time to admission, age and diagnosis among survivors and fatalities (**Table 5**). For patients who died, the mean rank of time from accident to admission was shorter and the mean age was higher ($p < 0.01$). The highest and lowest mortality rates were found in ASDH and DSF, respectively ($p < 0.01$).

Admission GCS score was strongly associated with mortality ($p < 0.01$; **Figure 1**). Among 168 patients with severe TBI, there were 42.3% deaths. A severe TBI with ASDH was associated with a mortality rate of 54.1% while the corresponding rates for moderate and mild TBI with ASDH were 25% and 10%, respectively ($p < 0.01$; **Table 6**). Comparable figures for EDH were 36.7% (severe TBI), 2.7% (moderate TBI) and 0.6 (mild TBI; $p < 0.01$).

Univariate analysis showed ASDH patients to be 45 times more likely to die than DSF patients. After adjusting for age, injury mechanism and time to admission, the odds of dying from an ASDH was approximately 34.5 (**Table 6**). Patients with EDH had about 7.7 times higher risk of dying. Furthermore, we did a regression analysis including age, GCS score, time to admission and length of stay. We found age, GCS score and length of stay to be significantly associated with mortality (**Table 7**). Diagnosis and surgical procedure had a collinear relationship, but this was not significant in multivariate analysis.

Discharge outcome

At discharge, 856 out of 1036 eligible patients had GCS score 14-15 (mild TBI), 87 had GCS score 9-13 (moderate TBI), four had GCS score 3-8 (severe TBI), and 89 were dead. Age, diagnosis, admission TBI severity, surgical procedure and complications were investigated as possible predictors in patients with discharge GCS score 9-15 (three cases with GCS score 3 and deaths were excluded). Age was not significant, whereas diagnosis, admission GCS score, procedure and complications were all significant predictors of discharge GCS score ($p < 0.01$).

Discussion

In this study, we present novel data on surgical procedures and outcome of TBI patients in Ethiopia. The most common surgical procedures were elevation of a DSF and craniotomy for

EDH. Significant delays along the entire continuum of care were associated with a substantial patient selection both before and after admission to the neurosurgical centers.[21] This has important consequences for the injury panorama, surgical activity and patient outcome. Procedures like elevation of a DSF and craniotomy for EDH are therefore significantly overrepresented in our study as compared to implantation of ICP probes, craniotomy for ASDH and DC in other surgical series, particularly from high-income countries.[31-34]

Elevation of a DSF was the most frequent operation and associated with good postoperative outcomes, similar to a comparable report on DSF surgery.[35] DC was rarely performed and associated with the longest hospital stays, as previously reported.[36] In concordance with a Ugandan study, we found significant delays in time from admission to surgery, but almost 90% of patients with severe TBI were operated within 24 hours of admission.[37] Other studies have shown time delays to be significantly associated with higher mortality rates.[37,38] In this study, we found that time from accident to admission was shorter for patients who died than for those who survived. We believe that this is a reflection of patient selection with a high mortality in the ED and the fact that less injured patients are more likely to survive prehospital delays.[9,2] Importantly, in a previous report from Black Lion Specialized Hospital in Addis Ababa, approximately 50% of patients with severe TBI died in the ED and only 62% of those who survived were operated.[2]

There are relatively few studies on surgical complications in TBI patients (most of these focus on DC) and these are difficult to compare due to major differences in data collection, definition and presentation. The complication rate after elevation of a DSF was 12.8% with CSF leak being the most common complication. Other studies have reported higher complication rates, particularly wound infections.[35,39] This difference might be related to antibiotic use, which was systematically used in our study. In another study from Addis Ababa, Salia and colleagues reported dural tears in more than half of DSF patients.[40] The high rate of postoperative CSF leak in our study was therefore probably related to difficulty of attaining a water tight closure of the dural defect (e.g. glue or dural substitues were not available). The reoperation rate for ASDH patients in our series was 5.3% which is lower than in a series of similar patients.[41] Overall, postoperative complications were seen in 17% of patients and 3% were reoperated; these numbers were lower than anticipated given the resource limitations and patient selection in this study.

Patients with mild to moderate TBI usually had uneventful postoperative courses with good discharge outcomes. Studies from other LMICs have shown similar proportions of mild and moderate TBI with favorable outcome.[42] A study on TBI patient outcome comparing HIC and LMICs showed that there was no difference in the odds of death in patients with mild and moderate TBI.[42] High age, short time to admission, low admission GCS score, ASDH, significant blood loss during surgery, postoperative complications and long hospital stays were associated with unfavorable outcomes.

The overall mortality rate was 8.2%. This was significantly lower than reported in a Malawian study,[43] but similar to a Ugandan study.[31] The mortality rates for patients with a GCS score of 8 or less was higher (42.3%) than previously reported.[44] Similar to other studies, we found admission GCS score to be a strong predictor of mortality.[19,43] Several reports on severe TBI have indicated that mortality in LMICs is higher than in HICs, and this can be attributed to lack of timely treatment and provision of care.[31] However, it is also important to keep in mind that the best decision for patients with severe injuries can be to withhold surgery, especially when elements like neuromonitoring and rehabilitation are completely missing. It is paramount in Ethiopian neurosurgical practice to not inflict an undue socioeconomic burden on the families of TBI survivors, and patients with an admission GCS score of 3-4 and/or fixed and dilated pupils are therefore generally not actively treated in the ICU or operated.

In this study, we have reported several important outcome determinants, but we did not address critical factors such as hypoxemia and hypotension. Data on secondary insults were unfortunately to a large extent nonexistent, specifically in the prehospital setting. We chose to use GCS score at discharge as an outcome parameter. This was done to simplify data registration and to make it easier to compare admission and discharge development. Moreover, it is difficult to track many of the patients after they have been discharged, particularly the most disabled. For ongoing projects, we have secured contact information and consent for more longitudinal follow-up data (e.g. Glasgow Outcome Scale). Finally, for a follow-up study, one needs to be aware of the risk of skewness towards a favorable outcome as many severely injured patients die before reaching definitive care or are never operated.[21]

Conclusions

Morbidity and mortality from trauma, particularly TBI, is an enormous challenge for Ethiopian authorities and the entire health care system. More knowledge is needed to improve the quality of patient care and to further develop cost-effective neurosurgical services. In this study, we present surgical activity data and simple outcome measures for a large number of operated patients in the greater Addis region. These data and data presented elsewhere,[21] clearly suggest that temporal delays and resource limitations in the continuum of care for TBI patients are associated with a significant patient selection that affects injury panorama, surgical activity and patient outcome. This knowledge is important to guide current resource allocations, legislative programs, preventive initiatives and neurosurgical management. There is still room for improvement both before, during and after hospital admission; nevertheless, many TBI patients in Ethiopia clearly benefit from surgical treatment, and the surgical results presented here bear comparison to a large number of reports from HICs.

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	N (%)	Median length of stay, IQR (days)
Injuries	**1087**	
Depressed skull fracture	488 (44.9)	4 (4)
Epidural hematoma	424 (39.0)	4 (4)
Acute subdural hematoma	76 (7.0)	5 (12)
Penetrating brain injury	74 (6.8)	7 (12)
Traumatic intracerebral hemorrhage/contusion	23 (2.1)	11 (13)
Other	2 (0.2)	12
Procedures	**1087**	
Craniotomy	521 (47.9)	4 (6)
Elevation of depressed skull fracture	538 (49.5)	4 (3)
Decompressive craniectomy	10 (0.9)	9 (28)
Burr hole	13 (1.2)	3 (7)
Other	5 (0.5)	61
Severity	1050	
Mild (GCS score 14-15)	566 (52.1)	4 (3)
Moderate (GCS score 9-13)	316 (29.1)	5 (5)
Severe (GCS score < 9)	168 (15.5)	8 (14)
Time to surgery	705	
Hours, median (IQR)	24.0 (60)	

Table 1: Injury types, procedures, severity and time to surgery. Length of stay is the time from admission to discharge. Abbreviations: IQR = Interquartile range. GCS = Glasgow Coma Scale.

Surgical procedure	DSF	EDH	ASDH	PBI	tICH	Other	Total
Elevation of DSF	481 (89.4)	21 (3.9)	3 (0.6)	33 (6.1)			538
Craniotomy	7 (1.3)	389 (74.7)	66 (12.7)	40 (7.7)	17 (3.3)	2 (0.4)	521
Burr hole		12 (92.3)			1 (7.7)		13
DC		2 (20.0)	7 (70.0)	1 (10.0)			10
Other					5 (100)		5

Table 2: Surgical procedures and main diagnosis. Abbreviations: DSF = Depressed skull fracture, EDH = epidural hematoma, ASDH = acute subdural hematoma, PBI = penetrating brain injury, tICH = traumatic intracerebral hematoma/contusion and DC = decompressive craniectomy.

Surgical procedure	Complications (N = 185)	Reoperations (N = 33)
Craniotomy	109	16
Hematoma	13	5
CSF leak	44	4
Pneumonia	28	
Wound infection	20	4
Other	4	3
Elevation	69	14
Hematoma		2
CSF leak	40	
Pneumonia	8	
Wound infection	17	8
Other	4	4
Burr hole	2	
CSF leak	2	
Decompressive craniectomy	3	1
Pneumonia	1	
Wound infection	1	
Other	1	1
Other	2	2
Wound infection	1	1
Other	1	1

Table 3: Postoperative complications and reoperations. Abbreviations: CSF = Cerebrospinal fluid.

	B	S.E.	Sig.	Exp (B)	95% C.I. for EXP (B)	
					Lower	Upper
Age (yrs)	0.001	0.007	0.839	1.001	0.987	1.016
Admission GCS score	0.165	0.029	0.000	1.179	1.114	1.248
Time from injury to admission (hrs)	-0.001	0.000	0.209	0.999	0.998	1.000
Decompressive craniectomy (yes/no)	-0.493	1.240	0.769	0.773	0.054	6.949
Craniotomy (yes/no)	-0.257	0.876	0.769	0.773	0.139	4.307
Elevation of DSF (yes/no)	-0.299	0.875	0.732	0.741	0.133	4.120

Table 4: Logistic regression analysis of predictors of postoperative complications in 693 patients with documented admission GCS score, time to admission and surgical procedure. Postoperative complications are categorized as present (yes) or absent (no). Abbreviations: GCS = Glasgow Coma Scale. DSF = Depressed skull fracture.

	Fatalities	Survivors	Total	p-value
Mean rank of time to admission (hrs)	227.95	362.55		< 0.01
Mean age (yrs)	35.8	28.3		< 0.01
Diagnoses (n (%))				< 0.01
Depressed skull fracture	7 (1.5)	481 (98.5)	488	
Epidural hematoma	41 (9.7)	383 (90.3)	424	
Acute subdural hematoma	30 (39.4)	46 (60.5)	76	
Penetrating brain injury	8 (10.8)	66 (89.2)	74	
Total	86	976	1062	

Table 5: Comparison of time to admission, age and diagnoses between the fatalities and survivors.

	Fatalities N (%)	Survivors N (%)	Total	Mortality risk, adjusted OR (95% CI)	P-value
DSF	7	481	14	1	
Severe	6 (42.9)	8 (57.1)	106		
Moderate	1 (0.9)	105 (99.1)	351		
Mild	0	351 (100)	17		
Missing	0	17	14		
ASDH	30	46	76	34.51 (8.78,135.60)	**0.000**
Severe	20 (54.1)	17 (45.9)	37		
Moderate	6 (25.0)	18 (75.0)	24		
Mild	1 (10.0)	9 (90.0)	10		
Missing	3	2	5		
EDH	41	383	424	7.73 (2.26,26.4)	**0.001**
Severe	36 (36.7)	62 (63.3)	98		
Moderate	4 (2.7)	142 (97.3)	146		
Mild	1 (0.6)	168 (99.4)	169		
Missing	0	11	11		
PBI	8	66	74	5.66 (1.24,25.75)	**0.025**
Severe	6 (60)	4 (40)	10		
Moderate	1 (3.1)	31 (96.9)	32		
Mild	1 (3.1)	31 (96.9)	32		
Missing	0	0			
tICH	3	20	23	16.11 (1.37,189.11)	**0.027**
Severe	3 (37.5)	5 (62.5)	8		
Moderate	0	8 (100)	8		
Mild	0	3 (100)	3		
Missing	0	4	4		

Table 6: Fatalities and survivors for different diagnoses and injury severities with mortality risk for different diagnoses. Odds Ratio (OR) adjusted for age (0-13, 14-44, 45-65, >65 years), mechanism of injury (assault, road traffic accident, fall, other) and time to admission (< 6, 6-12,

12-24, 24-72, 72-120, >120 hrs). Abbreviations: DSF = Depressed skull fracture, EDH = epidural hematoma, ASDH = acute subdural hematoma, PBI = penetrating brain injury and tICH = traumatic intracerebral hematoma/contusion.

	B	S.E.	Sig.	Exp (B)	95% CI for EXP (B)	
					Lower	Upper
Age	0.05	0.017	0.003	1.051	1.017	1.086
GCS score at admission	-0.59	0.082	0.000	0.555	0.472	0.652
Time to admission	-0.010	0.006	0.105	0.990	0.977	1.002
Length of stay	-0.066	0.024	0.005	0.936	0.893	0.980

Table 7: Multivariate analysis of predictors of mortality in 674 patients. Logistic regression (Cox & Snell R^2 = 20.2% and Nagelkerke R^2 = 54.9).

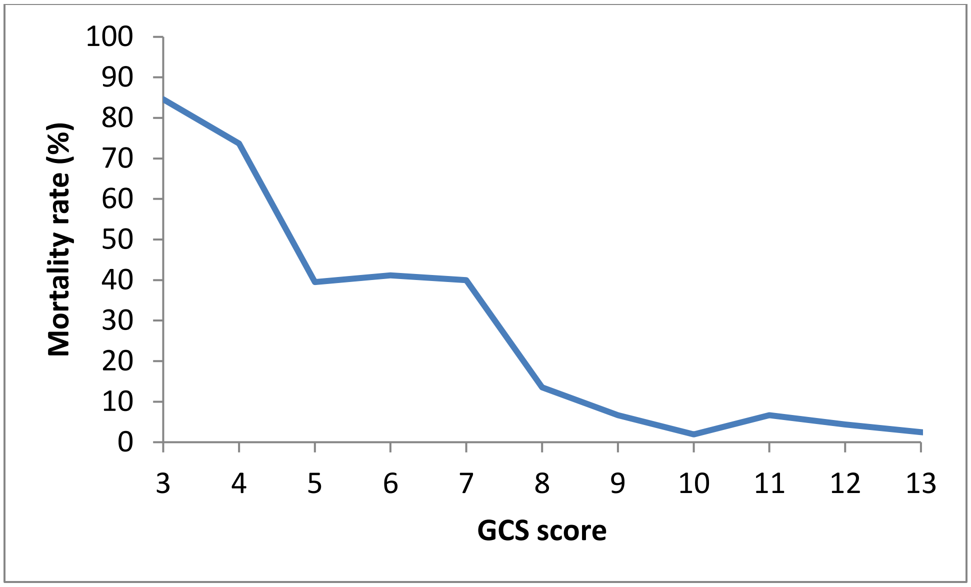

Figure 1: Admission GCS score and mortality rate for moderate (n = 319) and severe (n = 172) traumatic brain injury. Abbreviation: GCS = Glasgow Coma Scale.