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Thirty-day clinical outcome of traumatic brain injury patients with acute extradural and subdural hematoma: a cohort study at Mulago National Referral Hospital, Uganda

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Abstract

Background: Increasing traumatic brain injury (TBI) has paralleled the need for decompression surgery for acute subdural (ASDH) and acute extradural haematoma (AEDH). Knowledge of key determinants of clinical outcomes of such patients is mandatory to guide treatment protocols.

Objective: To determine the 30-day clinical outcomes and predictor variables for patients with extra-axial hematomas at Mulago National Referral Hospital in Uganda.

Methods: Prospective observational cohort study of 109 patients with computed tomography (CT) confirmed extra-axial hematomas. Ethical clearance was obtained from the School of Medicine Research and Ethics Committee of College of Health Sciences, Makerere University (REC REF. 2018-185). Admitted patients were followed-up and reassessed for Glasgow Outcome Scale (GOS) and final disposition. Multivariate regression analysis was performed using Stata 14.0 (StataCorp. 2015) at 95% confidence interval, regarding $p < 0.05$ as statistically significant.

Results: The overall proportion of favorable outcome was 71.7% ($n = 71$), with 42.3% ($n = 11$) and 81.7% ($n = 58$) for ASDH and AEDH, respectively ($p = 0.111$). Factors associated with a favorable outcome were admission systolic BP > 90 mmHg [IRR = 0.88 (0.26–0.94) 95%CI, $p = 0.032$), oxygen saturation > 90% [IRR = 0.5 (0.26–0.94) 95%CI, $p = 0.030$] and diagnosis AEDH [IRR = 0.53 (0.30–0.92) 95%CI, $p = 0.025$). Moderate TBI [IRR = 4.57 (1.15–18.06) 95%CI, $p = 0.03$] and severe TBI [IRR = 6.79 (2.32–19.86) 95%CI, $p < 0.001$] were significantly associated with unfavorable outcomes.

Conclusion: The study revealed that post resuscitation GCS, systolic BP, oxygen circulation, and diagnosis of AEDH at admission are the most important determinants of outcome for patients with extra-axial intracranial hematomas. These findings are valuable for the triaging teams in resource-constrained settings.

Keywords: Epidural-hematoma, Subdural-hematoma, Clinical outcome, Factors, Uganda

Introduction

As the number of general trauma casualties increase worldwide, so do the number of patients with traumatic brain injury (TBI). According to [21], the international pooled annual incidence of TBI, for all ages, is reported at 349 per 100,000, disproportionately affecting developing countries. TBI is the number one cause of mortality among trauma patients in low-income countries [18], in both pre-hospital and in-patient settings [5]. Intracranial hemorrhage alone contributes to 80% mortality of admitted trauma patients [7].

At the Mulago National Referral Hospital (MNRH), TBI is the second most reported form of trauma, accounting for 27% just after orthopedics at 37% [20]. According to the monthly reports of casualty registry, casualty theater, and main operating theater (unpublished), MNRH

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admitted a total of 3866 patients at casualty during the first quarter of 2018. Over 827 (21%) had some form of TBI of which 15.7% (130) had a clinical radiological diagnosis of acute subdural or extradural haematoma, increasing the number of craniotomies and craniectomies for extra-axial haematoma by 3-fold in a period of 1year. Whereas this in part could be due to increased skilled personnel and diagnostic technology, the treatment outcomes of such patients and how such injuries impact on their quality of life should be studied.

To date, the outcome of ASDH and AEDH vary from center to center, depending on the resources and quality of care in different regions. One of such controversial determinants has been the time duration from trauma to decompression surgery [31], being cited as not significant predictor of outcome if kept within a median of 3 h [30]. In our setting, however, the majority of patients take more than 4 h to reach hospitals after major trauma [17, 19]. This means that those who require surgery in our settings will have delays well over the 3 to 4 h that have been recommended previously [31].

The clinical outcomes of the patients that suffer TBI have not been well documented in Uganda. Whereas the current mortality rates from well-established neurosurgical centers are reported at 20–40% for ASDH and at most 5% for AEDH [9], depicting more than 50% reduction in mortality rates over the past 3 decades, there are no documented statistics in Uganda for comparison. The currently available recent studies have grouped all patients with TBI to report their overall outcome regardless of their anatomical pathology [5], including one at the present study site (MNRH) that reported mortality of up to 55% [17]. We argue that vast information could be missed in such results as the prognosis of TBI might be variable depending on the primary anatomical lesion sustained. The present baseline study was thus deemed timely to document determinants and outcomes of patients with ASDH and AEDH at MNRH. The two main objectives of this study were to determine the proportion of patients with a favorable outcome and establish clinical and socio-demographic determinants of favorable outcome of patients treated for ASDH and AEDH at the Ugandan National Referral Hospital, Mulago.

Methods

Study design

This was a prospective observational cohort study conducted between December 2018 and April 2019.

Study participants and settings

The study was a hospital based at the Mulago National Referral Hospital (NRH) (https://health.go.ug/content/mulago-national-referral-hospital), which is also the teaching hospital for the School of Medicine, College of Health Sciences-Makerere University (https://www.mak.ac.ug/). The hospital is located in the Kampala Capital City of Uganda. Eligible adult patients who presented to accident and emergency (A&E) department with CT confirmed extra-axial hematoma were recruited consecutively. This tertiary hospital has a formal bed capacity of 1500 and bed occupancy rate of between 180 and 200%. However, due to the renovations and upgrade of the hospital at the time of data collection, the number of beds at casualty and neurosurgical wards were 35 and 42, respectively. The 42 beds of the neurosurgical ward are inclusive of 8 high dependence unit (HDU) beds. The neurosurgical patients who require intensive care have access to the general hospital intensive care unit (ICU). The ICU has 8 bed capacities with an average of 25 patients per month. If there is no free bed, the patients have to wait at the A&E, neurosurgical ward or HDU. At the time of this study, the hospital had access to two functional computed tomographic (CT) scanners: one in a private hospital about 1.6 km from the casualty and the second one in a public hospital that is 15 km away from the casualty. Both scanners require an out-of-pocket payment of about 70 USD, since majority of patients attending MNRH have no medical insurance.

Study procedure

The participants were recruited after review by a multidisciplinary team following interpretation of a brain CT image to characterize the nature of TBI. In general, patients at Mulago National Referral Hospital are received and triaged by the medical team on duty at the accident and emergence department. The first contact clinician is usually a general doctor who then consults a general surgery or neurosurgery resident, general surgeon, trauma surgeon, neurosurgeon, radiologist, and or maxillofacial and plastic surgeons when there is a need. The team routinely carries out several ward rounds in a day at the accident and emergence to determine if there is a need to amend the initial treatment decisions. The recruitment process and flow of participants is summarized in Fig. 1

Inclusion criteria

We included adults with clinical-radiological diagnosis of ASDH and or AEDH based on head and brain CT imaging, following trauma, who presented at Mulago NRH during the data collection period. Whereas ASDH and AEDH are seemingly two different pathologies, they have several aspects in common that were of interest to this study. For example, both hematomas are extra-axial and surgical evacuation is thus the treatment of choice [26]. Also, once surgery is indicated, the duration from decision to actual surgical intervention is the most important determinant of outcome for both hematomas [13, 22]. In this regard, the authors desired to recruit a

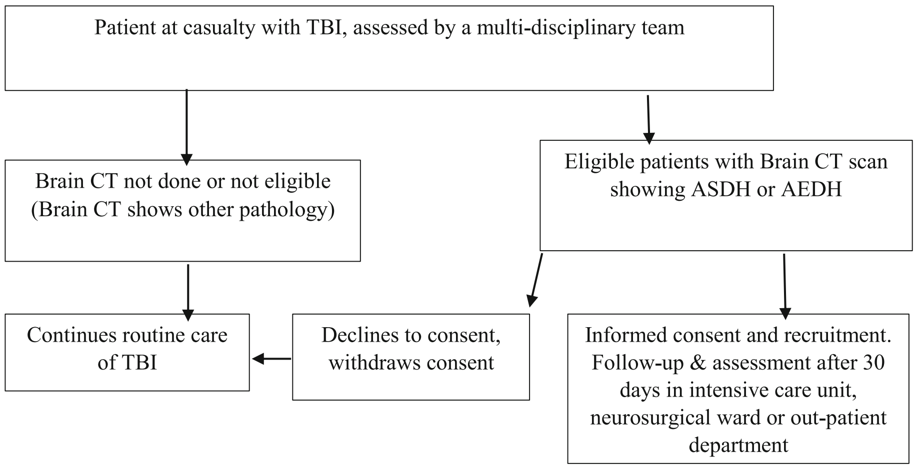

Fig. 1 Showing flow of participants

reasonable sample size of patients in the limited approved duration for which surgical decompression is the major determinant of outcome. However, to avoid loss of any information, we report the overall outcomes alongside the individual outcomes for each hematoma.

The hospital did not have intracranial pressure monitoring facilities by the time of the study. However, patients with suspected cerebral edema based on brain CT scan findings were included as long as they had ASDH or AEDH. The treatment offered for cerebral edema involved hypertonic saline or mannitol with subsequent clinical radiological assessment. Also, participants with cranial and skull base fractures who concurrently sustained ASDH or AEDH were included in the study. This is because in practice, it is not uncommon for more than one category of TBI to occur in the same patient [12], more so with ASDH. Thus, patients with cranial and basilar fracture comorbidities were included in order to report an outcome that is a true reflection of the practical clinical picture.

Exclusion criteria

Patients with acute on chronic subdural hematoma were excluded because this entity has a variable pathogenesis. Although such hematoma may be related to trauma, theoretically the presence of aberrant friable blood vessels and a localized bleeding disorder that trigger hemorrhage even with trivial trauma cannot be ignored. Acute on chronic subdural hematoma may occur in the absence of trauma [27]. In some cases, the trauma may be as trivial as a slap [16]. This aetiology does not match that of ASDH or AEDH, where the severity of injury corresponds to the gravity of trauma involved [8]. On the other hand, acute on chronic subdural hematoma may take several weeks before a diagnosis is made. In such cases, the date of onset becomes difficult to define which is not in line with our study design, assessing the outcomes 30 days from onset of trauma. Also, patients with cerebral contusions, cerebral edema, cranial, or basilar fractures but without ASDH or AEDH were beyond the scope of this study.

Sample size estimation

For objective one, aimed at determining the proportion of participants with favorable outcome, Kish Leslie formula was used.

$$\mathrm{ns} = \mathrm{Z}\alpha^2 * \frac{\mathrm{P}\,(1-\mathrm{P})}{\delta^2}$$

where ns is the sample size, p is the expected proportion of patients with functional recovery outcome assumed to be 0.5, (1-P) is the proportion of patients with non-functional recovery outcome assumed to be 0.5, and $Z\alpha$ is the standard normal value corresponding to set level of confidence = 1.96 whereas δ = degree of accuracy = 0.05,

$[(1.96)^2 \times (0.5 \times 0.5)]/(0.05 \times 0.05)$. Thus, ns = 384.

Adjusting for finite population

$$\text{Sample size } (N) = \frac{\mathrm{ns}}{1 + \frac{\mathrm{ns}-1}{n}}$$

where N is the adjusted population size, ns is the estimated sample size, and n is the population under study = 125 (based on the hospital data registry).

$$N = \frac{384}{1 + \frac{383}{125}}$$
$$N = 94$$

The second study objective aimed at determining factors associated with favorable outcome. Thus, the formula for sample size of two proportions in cohort studies was deemed suitable because it takes into account of binary outcome variables.

$$N = \frac{\left[Z_{\alpha/2}\sqrt{p(1-p)\left(1/_{q_1} + 1/_{q_2}\right)} + Z_\beta\sqrt{p_1(1-p_1)1/_{q_1} + p_2(1-p_2)1/_{q_2}}\right]^2}{(p_1-p_2)^2}$$

N = minimum required sample size, $Z_{\alpha/2}$ = 1.96, the standard normal value corresponding to *95%* confidence level, Z_β = *0.84,* the standard normal value corresponding to *80%* power**,** *q1* = 0.847, proportion of patients who recovered with favorable outcome with a fall as the cause of the ASDH [3], *p1* = 0.50, proportion of patients who recovered with unfavorable outcome with a fall as the cause of the ASDH [3], *q2* = 0.153, proportion of patients who recovered with favorable outcome with road traffic crush (RTC) as the cause of ASDH [3], *p2* = 0.769, proportion of patients who recovered with unfavorable outcome with RTC as the cause of ASDH [3]; *p = p1q1 + p2q2 = 0.541.*

Therefore, the minimum sample size required to answer objective 2 was 192 patients. We adjusted our sample size to take into account a 10% loss to follow-up as below, where n = requires sample size, n_1 = 192.

$$\text{ns} = n_1 * \frac{1}{(1-10\%)} = 192 * \frac{1}{(1-0.1)} = 213$$

Adjusting the sample size for a finite population of 125 patients that were expected to be admitted during 5-month study period,

$$(N) = \frac{\text{ns}}{1 + \frac{\text{ns}-1}{n}}$$

where ns = 213, n = 125; thus, N = 79 participants. The larger sample size of 94 was considered.

Sampling procedure

Patient who met the inclusion criteria were consecutively recruited until the estimated minimum sample size was attained. This was intended to attain a sample size large enough for validity of the study.

Study variables

Our data tool captured independent variables including socio-demographic (*age, sex, occupation, commute distance from nearest health facility*) and clinical (*Glasgow Coma Score (GCS) at admission*-assessed at casualty after the initial resuscitation, *post-operative care area*—whether the patient was admitted to the general ICU or neurosurgical ward after surgery). In addition, we captured dependent variables such as *disposition at 30 days after admission*—either discharged, died, or still admitted; *Glasgow Outcome Scale (GOS) at 30 days after injury*—assessed in outpatient clinic or on phone interview with the patients and/or care takers and recorded as 1 = death—confirmed brain dead; 2 = persistent vegetative state—severe damage with prolonged state of unresponsiveness and a lack of higher mental functions; 3 = severe disability—severe injury with permanent need for help with activities of daily living; 4 = moderate disability—no need for assistance in everyday life, employment is possible but may require special equipment; and 5 = good recovery—light damage with minor neurological and psychological deficits. We dichotomized the GOS at two levels as (a) favorable outcome (4 or 5) and (b) unfavorable outcome (1, 2, or 3). The scope of this observational study was limited to these clinical variables that are routinely assessed during the care of patients with TBI.

Data analysis

Data was entered into EpiData software (Christiansen TB & Lauritsen JM (version 2.0.8.56) EpiData-Comprehensive Data Management and Basic Statistical Analysis System. Odense Denmark, EpiData Association, 2010) and exported to Stata software version 14 (StataCorp. 2015. Stata Statistical Software: Release 14. College Station, TX: StataCorp LP) for cleaning and analysis.

We summarize the participants' socio-demographic and clinical categorical baseline characteristics using frequencies and percentages in tables. The mean and standard deviation were used for continuous participant characteristics that were normally distributed; otherwise, the median and inter-quartile range were used.

We used chi-square test (X^2) to compare the patients in care and those lost to follow-up, for categorical variables, whereas the student's t test was used for continuous variables.

We used the modified Poisson regression (with robust standard errors) model to determine the socio-demographic and clinical factors that influence favorable outcomes. At bivariate analysis, factors with p value less than 0.2 were assumed to be important and considered for multivariate analysis. At multivariate level, interaction and confounding were assessed in the model before the reaching the final adjusted model. The variables with $p < 0.05$, in the final model, were considered to be of statistical significance at 95% confidence interval.

Results

Socio-demographic and clinical characteristics of patients with extra-axial hematoma at Mulago NRH

Of the 109 recruits, 9.1% (n = 10) were lost to follow-up whereas 99 (90.8%) data were complete for analysis. Of the 99 participants, 90.9% (n = 90) were males, with a median age of 29 years (IQR 23–36), and 50.5 % (n = 49) were married. The cause of trauma for the majority participants was road traffic accidents (RTA) with 51 out of 97 participants (52.6 %). Mostly, patients commuted a distance of more than 100 km (39.5%, n = 48), were brought to the hospital by attendants using private vehicles (39.2%, n = 38), and the pre-hospital treatment (if any) was mainly IV fluids (70.7 %, n = 53). The majority participants had admission systolic blood pressure (BP) greater than 90 mmHg (75.7 %, n = 53), with median post-resuscitation GCS of 13 (IQR = 8–15). At the time of admission, over 38.4% (n = 38) of participants had at least an episode of projectile vomiting, and 24.2% (n = 24) had a pre-hospital convulsion whereas 3.3% (n = 3) had CSF rhinorrhea and or otorrhea. There was radiological evidence of concurrent maxilla-facial fractures in 2.2% (n = 2) of patients with neurological deficits such as limb weakness in 5.6% (n = 5). Majority of participants were diagnosed with AEDH (71.7%, n = 71) and received craniotomy as definitive surgical intervention (90.9 %, n = 50). The post-operative care area was neurosurgical ward for 87 out of 98 participants (88.8 %) as shown in (Table 1).

The proportion of patients with a favorable outcome after 30 days among patients treated for extra-axial hematoma at Mulago NRH

In terms of disposition by the end of 30 days of follow-up, out of 99 patients, 81 were discharged home (81.8 %), 2 were still admitted (2.0 %), and 16 died (16.2 %). Over 71.7% participants had favorable as opposed to 28.3% who had unfavorable outcome.

The outcome differed by clinical radiological diagnosis. Out of the 26 patients diagnosed with ASDH, only 11 (42.3 %) had favorable outcomes as opposed to 58 (81.7%) diagnosed with AEDH, although the corresponding average post resuscitation GCS had been 10 and 12, respectively ($p < 0.01$).

The clinical and demographic factors that relate to unfavorable outcome among patients treated for extra-axial hematoma for 30 days in Mulago NRH

At bivariate analysis, factors—oxygen saturation > 90%, systolic BP > 90 mmHg at admission, GCS- Moderate TBI and Severe TBI, and Diagnosis AEDH were statistically significant determinants of outcomes. Nonetheless, the factors—other causes of trauma, were included for multivariate analysis since they had a p value less than 0.2 (p value = 0.078) (see Table 2).

At multivariate analysis, after assessing for interaction and confounding, factors associated with a favorable outcome were admission systolic BP > 90 mmHg [IRR = 0.88 (0.26–0.94) 95%CI, p = 0.032), oxygen saturation > 90% [IRR = 0.5 (0.26–0.94) 95%CI, p = 0.030], and a diagnosis AEDH [IRR = 0.53 (0.30–0.92) 95%CI, p = 0.025). Sustaining a moderate TBI [IRR = 4.57 (1.15–18.06) 95%CI, p = 0.03] and severe TBI [IRR = 6.79 (2.32–19.86) 95%CI, $p < 0.001$] based on post resuscitation GCS were statistically and significantly associated with unfavorable outcome. Meanwhile, the cause of trauma was not statistically significant (see Table 3).

Comparison of baseline demographic and clinical characteristic between retained and lost to follow-up (LTFU)

Of 109 recruits, 10 (9.1%) were lost to follow-up. We sought to compare the baseline demographic and clinical characteristics to determine if these parameters differed significantly with the retained participants. We found that the mean pulse rates (p = 0.024) and total post resuscitation GCS (p = 0.043) of those LTFU were slightly higher. All other predictor variables did not differ significantly as shown in Table 4.

Discussion

Clinico-demographics of study participants

The present study intended to determine the proportion of favorable outcome, demographic, and clinical factors influencing the outcome of intracranial extra-axial hematoma. Like previous studies [1], the young male as a typical victim of road traffic crush and assault is well demonstrated by our study. Although in contrast to the existing literature, AEDH was more common than ASDH at 70.1% versus 26.7%, while only 2.3% of the participants had both. In a similar study by [30], it was found that of the 76 consecutive patients who had craniotomy, 48.7% presented with AEDH and 60.5% with ASDH, while 9.2% patients had both. Also [10] in their series of 171 patients, reported ASDH is at 64.9% vs. 35.1% for AEDH in conformity with [2]. For our study to find AEDH to be more prevalent is likely to result from a difference in the inclusion criteria and accessibility to diagnostics. Some patients who had more severe injury and a lower GCS might have deteriorated fast and passed on before ever having a CT scan done in our settings. A significant number of those left out could have had ASDH which is the more common finding in severe TBI and our findings show these had an unfavorable outcome.

Short-term treatment outcome for intracranial extra-axial hematoma

In terms of the outcome, our finding showed an overall mortality rate of 16.2%, which is significantly high given that the median GCS of our study population was 13 (IQR = 8–15). Only dismal proportion of patients (2.3%) had prolonged stay in hospital of more than 30 days, which implies that majority were discharged with varying degrees of disability. More than two thirds of the patients (71%) had a favorable outcome by 30 days from the date of injury. The proportion of favorable outcome

Table 1 Baseline demographic and clinical characteristics of patients with extra-axial haematoma at Mulago NRH

Variable	Category	Count	%
Sex	Male	90	90.9
Age	Female	9	9.1
	Below 30 years	50	50.5
	30 years and above	49	49.5
Commute distance in (Km)	< 14	33	33.3
	15–34	17	17.2
	35–100	14	14.1
	> 100	35	35.4
Marital status (*n* = 97)	Single	48	49.5
	Married	49	50.5
Cause of trauma (*n* = 97)	RTA	51	52.6
	Assault	35	36.1
	Fall	8	8.3
	Others	3	3.1
Who brought to hospital (*n* = 96)	Police	12	12.5
	Nurse	18	18.7
	Well wishers	11	11.5
	Attendants	55	57.3
Mode of arrival (*n* = 97)	Ambulance	37	38.1
	Motorcycle	6	6.2
	Police pickup	14	14.4
	Private vehicle	38	39.2
	Public vehicle	2	2.1
Pre-hospital treatment (*n* = 75)	Oxygen	11	14.7
	IV fluids	53	70.7
	Mannitol	4	5.2
	Antibiotics	2	2.7
	Analgesia	5	6.7
Total post resuscitation GCS (*n* = 98)	Mild TBI	54	55.1
	Moderate TBI	19	19.4
	Severe TBI	25	25.5
Pulse (*n* = 70)	(Mean = 84.9) (SD = 21.5)		
Oxygen saturation (*n* = 65)	< 90%	12	18.5
	> 90%	53	81.5
Systolic BP (*n* = 70)	< 90	17	24.3
	> 90	53	75.7
Pupillary size (*n* = 89)	Equal	84	94.4
	Dilated right	3	3.4
	Dilated left	2	2.3
Vomit	Yes	38	38.4
	No	61	61.6
Convulsion	Yes	24	24.2
	No	75	75.8
CSF leak (*n* = 93)	Nose	2	2.2

Table 1 Baseline demographic and clinical characteristics of patients with extra-axial haematoma at Mulago NRH *(Continued)*

Variable	Category	Count	%
	Nose and ears	1	1.1
	None	90	96.8
Facial fractures (*n* = 91)	Yes	2	2.2
	No	89	97.8
Limb weakness (*n* = 90)	Upper limb lift or right	2	2.3
	Lower limb left or right	1	1.1
	Both lower and upper limbs	2	2.2
	None neither upper or lower	85	94.4
Type of surgery (*n* = 55)	Craniostomy/burr hole	1	1.8
	Craniotomy	50	90.9
	Craniectomy	4	7.3
Diagnosis made	ASDH	26	26.3
	AEDH	71	71.7
	Both ASDH and AEDH	2	2.0
Findings at surgery (*n* = 97)	Subdural hematoma	25	25.7
	Epidural hematoma	69	71.1
	Contusion	1	1.0
	Others	2	2.1
Post-operative care area (*n* = 98)	ICU	1	1.0
	HDU	10	10.2
	Ward	87	88.8
Glasgow outcome	Dead	16	16.2
	Vegetative state (vs)	1	1.0
	Severe disability (sd)	12	12.1
	Moderate disability (md)	48	48.5
	Good recovery (gr)	22	22.2

SD standard deviation

Table 2 Bivariate modified Poisson regression analysis to determine the factors that influence unfavorable outcomes

Variable	Category	IRR	95%CI	*p* value
Cause of trauma	RTA	1		
	Assault	0.76	0.37–1.64	0.508
	Fall	0.85	0.24–3.06	0.803
	Others	2.27	0.91–5.63	0.078
Oxygen saturation	< 90%	1		
	> 90%	0.45	0.23–0.88	*0.019*
Systolic BP	< 90	1		
	> 48	0.58	0.22–1.48	0.253
GCS	Mild TBI	1		
	Moderate TBI	0.68	0.48–0.97	*< 0.034*
	Severe TBI	0.35	0.19–0.62	*< 0.001*
Diagnosis	ASDH	1		
	AEDH	0.32	0.18–0.58	*0.001*

Table 3 Multivariate modified Poisson regression analysis to determine the factors that influence unfavorable outcomes

Variable	Category	IRR	95%CI	*P*-value
Cause of trauma	RTA	1		
	Assault	0.63	0.34–1.16	0.138
	Fall	1.28	0.27–5.98	0.754
	Others	0.78	0.39–1.59	0.497
Oxygen saturation	< 90%	1		
	> 90%	0.50	0.26–0.94	*0.032*
Systolic BP	< 90	1		
	> 90	0.88	0.26–0.94	*0.032*
GCS	Mild TBI	1		
	Moderate TBI	4.57	1.15–18.06	*0.030*
	Severe TBI	6.79	2.32–19.86	*<0.001*
Diagnosis	ASDH	1		
	AEDH	0.53	0.30–0.92	*0.025*

Table 4 Comparison of the baseline characteristics between retained and LTFU patients

Variable	Category	Retained Count (%)	LTFU Count (%)	Chi-square (X^2) *p* value
Sex	Male	90 (90.9)	9 (90.0)	0.924
	Female	9 (9.1)	1 (10.0)	
Age	Below 30 years	50 (50.5)	6 (60.0)	0.567
	30 years and above	49 (49.5)	4 (40.0)	
	35–100	14 (14.1)	2 (28.6)	
	> 100	35 (35.4)	2 (28.6)	
Marital status (*n* = 107)	Single	48 (49.5)	7 (70.0)	0.217
	Married	49 (50.5)	3 (30.0)	
Cause of trauma (*n* = 107)	RTA	51 (52.6)	6 (60.0)	0.912
	Assault	35 (36.1)	3 (30.0)	
	Falls	8 (8.2)	1 (10.0)	
	Others	3 (3.1)	0 (0.0)	
Who brought to hospital (*n* = 105)	Police	12 (12.5)	4 (44.4)	0.059
	Nurse	18 (18.7)	0 (0.0)	
	Well wishers	11 (11.5)	1 (11.2)	
	Attendants	55 (57.3)	4 (44.4)	
Mode of arrival (*n* = 107)	Ambulance	37 (38.1)	2 (20.0)	0.293
	Motorcycle	6 (6.2)	1 (10.0)	
	Police pickup	14 (14.4)	4 (40.0)	
	Private vehicle	38 (39.2)	3 (30.0)	
	Public vehicle	2 (2.1)	0 (0.0)	
Pre-hospital treatment (*n* = 80)	Oxygen	11 (14.7)	1 (20.0)	0.340
	IV fluids	53 (70.7)	3 (60.0)	
	Mannitol	4 (5.2)	0 (0.0)	
	Antibiotics	2 (2.7)	1 (20.0)	
	Analgesia	5 (6.7)	0 (0.0)	
Total post resuscitation GCS (*n* = 106)	Mild TBI	54 (55.1)	1 (12.5)	*0.043*
	Moderate TBI	19 (19.4)	2 (25.0)	
	Severe TBI	25 (25.5)	5 (62.5)	
Pulse (*n* = 75)		Mean = 84.9	Mean = 108.2	*0.024**
Oxygen saturation (*n* = 69)	< 90%	12 (18.5)	0 (0.0)	0.344
	> 90%	53 (81.5)	4 (100.0)	
Systolic BP (*n* = 77)	< 90	17 (24.3)	1 (14.3)	0.551
	> 90	53 (75.7)	6 (85.7)	
Pupillary size (*n* = 97)	Equal	2 (94.4)	8 (100.0)	0.789
	Dilated right	3 (3.4)	0 (0.0)	
	Dilated left	2 (2.2)	0 (0.0)	
Vomit	Yes	38 (38.4)	5 (50.0)	0.474
	No	61 (61.6)	5 (50.0)	
Convulsion	Yes	24 (24.2)	4 (40.0)	0.277
	No	75 (75.8)	6 (60.0)	
CSF leak (*n* = 101)	Nose	2 (2.1)	0 (0.0)	0.875

Table 4 Comparison of the baseline characteristics between retained and LTFU patients *(Continued)*

Variable	Category	Retained Count (%)	LTFU Count (%)	Chi-square (X^2) *p* value
	Nose and ears	1 (1.1)	0 (0.0)	
	None	90 (96.8)	8 (100.0)	
Facial fractures (*n* = 99)	Yes	2 (2.2)	0 (0.0)	0.672
	No	89 (97.8)	8 (100.0)	
Limb weakness (*n* = 98)	Upper limb lift or right	2 (2.2)	0 (0.0)	0.926
	Lower limb left or right	1 (1.1)	0 (0.0)	
	Both lower and upper limbs	2 (2.2)	0 (0.0)	
	None neither upper or lower	85 (94.4)	8 (100.0)	
Type of surgery (*n* = 64)	Craniostomy/burr hole	1 (1.6)	0 (0.0)	0.875
	Craniotomy	56 (91.8)	3 (100.0)	
	Craniectomy	4 (6.6)	0 (0.0)	
Diagnosis made	ASDH	26 (26.3)	3 (30.0)	0.881
	AEDH	71 (71.7)	7 (70.0)	
	Both ASDH and AEDH	2 (2.0)	0 (0.0)	
Findings at surgery (*n* = 107)	Subdural hematoma	25 (25.8)	3 (30.0)	0.946
	Epidural hematoma	69 (71.1)	7 (70.0)	
	Contusion	1 (1.0)	0 (0.0)	
	Others	2 (2.1)	0 (0.0)	
Post-operative care area (*n* = 106)	ICU	1 (1.0)	0 (0.0)	0.942
	HDU	10 (10.2)	1 (12.5)	
	Ward	87 (88.8)	7 (87.5)	

*Italics signify *p* value from a student's *t* test <0.05

is much higher than 57% reported in a Swiss study [30], although their cohort was generally older and a more sick population with a median age of 54 years and median GCS of 7 versus 23 years and GCS of 13 respectively at the Mulago NRH.

Factors influencing short-term treatment outcome for intracranial extra-axial hematoma

The present study looked at the clinical and demographic factors influencing treatment outcome of extra-axial hematoma. We found that patients with AEDH were 53% more likely to have a favorable outcome and this remained statistically significant even at multivariate analysis (p value = 0.025). It is a well-established fact that AEDH is more likely to occur in isolation, while ASDH is more likely to be associated with brain parenchyma injury. It is the associated injuries in ASDH that account for the worse prognosis that is documented almost universally [24, 25, 28]. This assertion is supported by the finding of our study that the difference in average post resuscitation GCS of the two hematoma (12 vs. 10 for AEDH and ASDH, respectively) was statistically significant ($p < 0.01$). Thus, the resultant proportion of favorable outcome was 42.3% and 81.7% for ASDH versus AEDH respectively (p value = 0.025).

At both bivariate and multivariate analysis, a higher post resuscitation GCS remained a significant determinant of a favorable outcome. Patients with moderate TBI (GCS 9–12) were 4.6 times whereas those with severe TBI (GCS 3–8) were 6.7 times more likely to have unfavorable outcome compared to mild TBI (GCS 13–15) ($p < 0.001$). This is in agreement with the findings of other researchers [30, 31]. However, the etiology of injury did not meet statistical significance at both levels of analysis.

Our findings are in conformity with a well-established theory that TBI causes significant dynamic changes in cerebral blood flow [23]. In the present study, the risk for unfavorable outcomes was twice for patients whose oxygen saturation was less than 90% at room air during the time of admission compared to those with oxygen circulation greater or equal to 90% (p = 0.032). Secondary ischemic insults resulting from hypoxia have been shown to cause rapid deterioration of brain tissue, thus unfavorable outcome [11], supporting evidence for timely oxygen optimization for this patient category [23]. It should be noted, however, that whenever possible, a multi-model approach inclusive of oxygen circulation and ICP monitoring should be emphasized despite basic evidence that ICP is not a known surrogate for bran tissue oxygenation [6]. Thus, our findings have to be interpreted with caution as we did not include any invasive monitoring of the central nervous system but rather depict the minimum basic care such as pulse-oximetry given to TBI patients in low income countries.

On the other hand, our findings showed that patients with admission systolic blood pressure more than 90 mmHg were 88% less likely to have unfavorable outcome (p = 0.032) compared to those with systolic BP below 90 mmHg. When intracranial hypertension occurs in TBI due to extra-axial hemorrhage, the body may respond to cause an increase in blood pressure to maintain cerebral perfusion, may not result in any significant changes in systolic blood pressure, or could actually result into hypotension aggravated by exsanguination from extra cranial injuries or tension pneumothorax. Whereas both hypertension and hypotension could worsen the outcome, our results show reduced likelihood of unfavorable outcome if systolic blood pressure is not hypotensive. Findings from randomized controlled trials [4] have shown that increases in systolic blood pressure are independent determinants of improved survival in hypotensive TBI patients. In fact further evidence show that even substantial increases in BP seem not to endanger adult patients with normal BP as long as kept below 140 mmHg [4], although this is still controversial in the pediatric population [32]. In general, recent guidelines such as those from brain trauma foundation recommend maintenance of systolic BP above 90 mmHg in TBI for optimal outcome [14]. In a study by [29] that analyzed mortality versus pre-hospital blood pressure, it was found that for every 10-point increase of systolic blood pressure, there was a corresponding decrease in adjusted odds for mortality by 18.8%, but that this relationship was valid for an exceptionally a wide range of systolic blood pressures 40–120 mmHg, raising concern on whether 90 mmHg is the unique physiological cut off point for clinically meaningful hypotension in TBI. Whereas our study findings are based on a single value of blood pressure taken at admission and could not provide a firm basis to resolve this argument, the results support pre-hospital fluid administration as main care given before transfer of these patients in our settings.

Study limitations

There were some limitations encountered during this study. The study included only patients who had done a head and brain CT scan for a radiological diagnosis. A number of patients did not do a CT scan either due to fast clinical deterioration and death, or lack of finances or because the initial neurological deficits later on improved and they so no reason for the CT scan. As such, our results may not represent the clinical outcomes of such categories of patients who would otherwise have an extra-axial hematoma. There was 9.1% rate of LTFU. Since those LTFU had higher mean pulse rates, an early feature of shock and also mainly severe TBI, our unfavorable outcome might be underrepresented, although the study was conducted in the country's top-most referral hospital for which case very critically ill patients were expected and our retention rate of 90.8% was far above the recommended 60–80% for cohort studies [15]. Also our consecutive and relatively smaller sample size could limit generalizability of the findings.

Conclusions and implication of results

The study has established that AEDH is more frequent than ASDH among patients treated for extra-axial hematoma and that the proportion of these patients with a favorable short term outcome is higher in our settings despite resource constraints. Post resuscitation GCS > 13, Oxygen circulation>90%, systolic blood pressure > 90 mmHg and a diagnosis of AEDH at admission were the major determinants of favorable outcome. These findings could influence triage protocols in resource limited settings. Future research should be long-term follow-up cohort studies to evaluate the proportion of this cohort that return to productive work.

Abbreviations

A&E: Accident and Emergency Department; AEDH: Acute extradural hematoma; ASDH: Acute subdural hematoma; CPP: Cerebral perfusion pressure; CSF: Cerebral spinal fluid; CT: Computerized tomography scan; GCS: Glasgow Coma Scale; GOS: Glasgow Outcome Scale; ICP: Intracranial pressure; ICU: Intensive care unit; LTFU: Lost to follow-up; MNRH: Mulago National Referral Hospital; RTA: Road traffic accident; RTC: Road traffic crash; TBI: Traumatic brain injury; WHO: World Health Organization

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Authors' contributions

MKS reviewed the relevant literature, designed the study, and collected the data. HL designed the study, interpreted the data, and drafted the manuscript. FO analyzed the data. JM and JK followed-up participants and supervised the study. All authors read and approved the final manuscript for submission.

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Availability of data and materials

The datasets generated and/or analyzed during the current study are not publicly available due to ethical restrictions but are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

Ethical approval was sought from School of Medicine Research and Ethics Committee of College of Health Sciences, Makerere University (REC REF. 2018-185). Informed consent was sought from all conscious participants and or their legally authorized representatives (for the unconscious) who endorsed their signatures or thumb prints on the consent form document, having been made to understand the risks and benefits of the study. When patients regained consciousness, their consent was re-obtained, and they were free to withdraw their consent at any stage of the study. Withdrawal of consent by any patient did not affect the quality of treatment or impinge on their entitlements.

Consent for publication

Not applicable

Competing interests

The authors declare that they have no competing interests

Glossary

RTC

The World Health Organization defines road traffic crash in its road safety manual of 2006. It is an incident, involving at least one moving vehicle that may or may not lead to an injury, which occurs on a public road. The terms road traffic accident (RTA), road traffic crash (RTC), and road traffic incident (RTI) are sometimes used interchangeably. In this study, RTC was used to mean the same as RTI and RTA.

TBI

Traumatic brain injury (TBI), defined as “an alteration in brain function or other evidence of brain pathology,” caused by an external force. Alternatively, it can be defined as a non-degenerative and non-congenital insult to the brain from an external mechanical force, possibly leading to permanent or temporary impairment of cognitive, physical, and psychosocial functions, with an associated diminished or altered state of consciousness (Pedretti et al., 2001).

Extra-axial hematoma

It means coagulated blood within the skull but outside the brain, i.e., the extradural and subdural hematoma. Although subarachnoid hemorrhage is extra-axial, it usually occupies the CSF spaces and does not usually coagulate.

Decompressive craniectomy

Surgical removal of part of the skull to allow the brain that is under compression room to expand to avoid coning and or to relieve refractory intracranial hypertension.

Craniotomy

Surgical removal of part of the skull to evacuate blood causing mass effect, followed by osteoplastic reconstruction of the defect in the same surgery.

Clinical outcomes

This study used the Glasgow Outcome Scale and the disposition of either dead, discharged, or still admitted. The two clinical outcomes have been assessed at the end of the study period of 30 days from the date of injury.

Glasgow outcome scale (GOS)

A structured tool that assesses functional outcome. It rates patient status into one of five categories (dead, persistent vegetative state, severe disability, moderate disability, and good recovery), allowing for standardized descriptions of the objective degree of recovery in head injury patients.

Favorable outcome

Patients with scores of good recovery and moderate disability as determined by the GOS 30 days after admission to Mulago NRH. It also means these patients are capable of independently doing all activities of daily leaving, and they can also do some work either with or without assistance.

Unfavorable outcome

Patients with scores of severe disability, persistent vegetative state, or who die as determined by the GOS 30 days after admission to Mulago NRH.

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References

1. Agrawal D, Ahmed S, Khan S, Gupta D, Sinha S, Satyarthee GD. Outcome in 2068 patients of head injury: experience at a level 1 trauma centre in India. Asian journal of neurosurgery. 2016;11. https://doi.org/10.4103/1793-5482.145081.
2. Antoniadis G, Richter HP. Treatment measures in traumatic extracerebral hemorrhage. Management of epi-/subdural hemorrhage and prognosis. Unfallchirurg. 1993;96(11):582–6.
3. Atanasov VA, Popov RV. Predictors for outcome after surgery for traumatic acute subdural hematoma. Romanian Neurosurgery. 2016;30(3):372–81. https://doi.org/10.1515/romneu-2016-0057.
4. Chakraborty S, Skolnick B, Narayan RK. Neuroprotection trials in traumatic brain injury. Current Neurology and Neuroscience Reports. 2016. https://doi.org/10.1007/s11910-016-0625-x.
5. Erem G, Bugeza S, Malwadde EK. Outcome at two weeks in patients with Traumatic brain injury following road traffic accidents in an urban tertiary hospital in Uganda. Cogent Medicine. 2017;4(1):1326205. https://doi.org/10.1080/2331205X.2017.1326205.
6. Eriksson EA, Barletta JF, Figueroa BE, Bonnell BW, Vanderkolk WE, McAllen KJ, Ott MM. Cerebral perfusion pressure and intracranial pressure are not surrogates for brain tissue oxygenation in traumatic brain injury. Clin Neurophysiol. 2012;123(6):1255–60. https://doi.org/10.1016/j.clinph.2011.08.035.
7. Gholipour C, Rad BS, Vahdati SS, Ghaffarzad A, Masoud A. Evaluation of preventable trauma death in emergency department of Imam Reza hospital. World J Emerg Med. 2016;7(2):135–7. https://doi.org/10.5847/wjem.j.1920-8642.2016.02.009.
8. Goldstein LN, Beringer C, Morrow L. What intracranial pathologies are most likely to receive intervention? A preliminary study on referrals from an emergency centre with no on-site neurosurgical capabilities. African Journal of Emergency Medicine. 2017;7(3):100–4. https://doi.org/10.1016/j.afjem.2017.04.012.
9. Hanif S, Abodunde O, Ali Z, Pidgeon C. Age related outcome in acute subdural haematoma following traumatic head injury. Ir Med J. 2009;102.
10. Haselsberger K, Pucher R, Auer LM. Prognosis after acute subdural or epidural haemorrhage. Acta Neurochir. 1988;90(3-4):111–6. https://doi.org/10.1007/BF01560563.
11. Honda M, Ichibayashi R, Yokomuro H, Yoshihara K, Masuda H, Haga D, et al. Early cerebral circulation disturbance in patients suffering from severe traumatic brain injury (TBI): a Xenon CT and perfusion CT study. Neurol Med Chir. 2016;56(8):501–9. https://doi.org/10.2176/nmc.oa.2015-0341.
12. Kanazawa A, Hyodoh H, Watanabe S, Fukuda M, Baba M, Okazaki S, et al. New pitfalls of high-density postmortem computed tomography. Legal Med. 2014;16(5):297–9. https://doi.org/10.1016/j.legalmed.2014.05.004.
13. Khachatryan TK, Fanarjyan RV, Patel K, Sanoufa M, Robinson JS. Outcome predictors after subdural hematoma with midline shifts greater than 10 MM. New Armenian Medical Journal. 2018;12(3):12–7.
14. Krishnamoorthy V, Chaikittisilpa N, Kiatchai T, Vavilala M. Hypertension after severe traumatic brain injury: friend or foe? J Neurosurg Anesthesiol. 2017. https://doi.org/10.1097/ANA.0000000000000370.
15. Kristman V, Manno M, Côté P. Loss to follow-up in cohort studies: how much is too much? Eur J Epidemiol. 2004;19(8):751–60. https://doi.org/10.1023/B:EJEP.0000036568.02655.f8.
16. Kumar A, A. Series study of sub acute and chronic subdural haematoma. Journal of Neurology & Stroke. 2016;5(2). https://doi.org/10.15406/jnsk.2016.05.00168.

17. Kuo BJ, Vaca SD, Vissoci JRN, Staton CA, Xu L, Muhumuza M, et al. A prospective neurosurgical registry evaluating the clinical care of traumatic brain injury patients presenting to Mulago National Referral Hospital in Uganda. PLoS One. 2017;12(10):e0182285.
18. Landes M, Venugopal R, Berman S, Heffernan S, Maskalyk J, Azazh A. Epidemiology, clinical characteristics and outcomes of head injured patients in an Ethiopian emergency centre. African Journal of Emergency Medicine. 2017;7(3):130–4. https://doi.org/10.1016/j.afjem.2017.04.001.
19. Lule H, Ssebuufu R, Okedi XF. Prehospital factors associated with injury severity of motorcycle related femoral fractures at Mbarara and Kampala International University Teaching Hospitals in Uganda. IOSR Journal of Dental and Medical Sciences (IOSR-JDMS). 2017;16(8):79–92. https://doi.org/10.9790/0853-1608107992.
20. Mabweijano J, J. S. The care of injured patients admitted to Mulago National Referral Hospital in Kampala, Uganda. Emergency Medicine: Open Access. 2015;05(04):1–6. https://doi.org/10.4172/2165-7548.1000270.
21. Nguyen R, Fiest K, McChesney J, Kwon C-S, Jette N, Frolkis A, et al. The international incidence of traumatic brain injury: a systematic review and meta-analysis. The Canadian journal of neurological sciences Le journal canadien des sciences neurologiques. 2016;43. https://doi.org/10.1017/cjn.2016.290.
22. Niaz A, Nasir MH, Niraula K, Majeed S, Neupane J, Ghimire M, Vohra AH. Factors affecting the surgical outcome in extradural hematoma in Punjab Institute of Neurosciences, Lahore, Pakistan. Nepal Journal of Neuroscience. 2017;14(3):13–8. https://doi.org/10.3126/njn.v14i3.20519.
23. Okonkwo DO, Shutter LA, Moore C, Temkin NR, Puccio AM, Madden CJ, et al. Brain oxygen optimization in severe traumatic brain injury phase-II: a phase II randomized trial. Crit Care Med. 2017;45(11):1907–14. https://doi.org/10.1097/CCM.0000000000002619.
24. Ono JI, Yamaura A, Kubota M, Okimura Y, Isobe K. Outcome prediction in severe head injury: analyses of clinical prognostic factors. J Clin Neurosci. 2001;8(2):120–3. https://doi.org/10.1054/jocn.2000.0732.
25. Pollauer, E., Deinsberger, R., & Kohlfurst, G. (1999). Prognosis after acute epidural- and subdural hematoma. [German] TL - 31. Prognosis after Acute Epidural- and Subdural Hematoma. [German], 31 VN - r(SUPPL. 156).
26. Quach NT, Isaac L, Ehsanian R, Sechrist S, Balakrishnan SP, Duong T, Crew J. The impact of axial injury, extra-axial injury, and combined injury on functional status in traumatic brain injury (TBI). PM&R. 2016;8(9):S156–7. https://doi.org/10.1016/j.pmrj.2016.07.034.
27. Schmidt, E., & Moyse, E. (2012). Acute and chronic subdural haematoma. In Pathy's Principles and Practice of Geriatric Medicine: Fifth Edition (Vol. 1, pp. 701–710). https://doi.org/10.1002/9781119952930.ch60
28. Scotter J, Hendrickson S, Marcus HJ, Wilson MH. Prognosis of patients with bilateral fixed dilated pupils secondary to traumatic extradural or subdural haematoma who undergo surgery: a systematic review and meta-analysis. Emerg Med J. 2015. https://doi.org/10.1136/emermed-2014-204260.
29. Spaite, D. W., Hu, C., Bobrow, B. J., Chikani, V., Sherrill, D., Barnhart, B., … Adelson, P. D. (2017). Mortality and prehospital blood pressure in patients with major traumatic brain injury: implications for the hypotension threshold. In JAMA Surgery (Vol. 152, pp. 360–368). https://doi.org/10.1001/jamasurg.2016.4686
30. Taussky P, Widmer HR, Takala J, Fandino J. Outcome after acute traumatic subdural and epidural haematoma in Switzerland: a single-centre experience. Swiss Med Wkly. 2008;138.
31. Tian H, Chen S, Xu T, Hu J, Rong B, Wang G, et al. Risk factors related to hospital mortality in patients with isolated traumatic acute subdural haematoma: analysis of 308 patients undergone surgery. Chin Med J. 2008;121.
32. Vavilala MS, Bowen A, Lam AM, Uffman JC, Powell J, Winn HR, Rivara FP. Blood pressure and outcome after severe pediatric traumatic brain injury. J Trauma. 2003;55(6):1039–44. https://doi.org/10.1097/01.TA.0000101759.23607.57.

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