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Severe Traumatic Brain Injury at a Tertiary Referral Center in Tanzania: Epidemiology and Adherence to Brain Trauma Foundation Guidelines

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Abstract

Background—Severe traumatic brain injury (TBI) is a major cause of death and disability worldwide. However, prospective TBI data from sub-Saharan Africa are sparse. This study examines the epidemiology, and explores management of severe TBI patients and adherence to the Brain Trauma Foundation (BTF) Guidelines at a tertiary care referral hospital in Tanzania.

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Author Contributions

RH and HSM conceived of the study. RH, HSM, and LRS designed the registry. LRS, BI, and PM collected the data. LRS, XW, and LMG analyzed the data. LRS, HSM, BI, and PM wrote the first draft. All authors critically reviewed the manuscript and revised it for content.

Methods—Patients with severe TBI hospitalized at Bugando Medical Centre, Mwanza, Tanzania, were recorded in a prospective registry. Epidemiological, clinical, treatment and outcome data were recorded.

Results—Between September 2013 and October 2015, 371 patients with TBI were admitted. 33% (115/371) had severe TBI. Mean age was 32.0±20.1 years, and the majority were male (80.0%). Vehicular injuries were the most common cause of injury (65.2%). Half of the patients (47.8%) were hospitalized on the same day as their injury. Only 49.6% underwent computed tomography (CT) of the brain, and 58.3% were admitted to the intensive care unit (ICU). Continuous arterial blood pressure (cABP) monitoring and intracranial pressure (ICP) monitoring were not performed on any patient. 38.3% of patients with severe TBI received hyperosmolar therapy and 35.7% underwent craniotomy. Two-week mortality was 34.8%.

Conclusion—Mortality of patients with severe TBI at Bugando Medical Center, Tanzania, is approximately twice that in high-income countries. ICU care, CT imaging, cABP and ICP monitoring are underutilized or unavailable in the tertiary referral hospital setting. Improving outcomes after severe TBI will require concerted investment in pre-hospital care as well as improvement in availability of ICU resources, CT imaging and expertise in multidisciplinary care.

Keywords

Sub-Saharan Africa; adherence; guidelines; mortality; traumatic brain injury; Tanzania

INTRODUCTION

Injuries are a leading cause of death and disability around the world totaling 4.8 million per year and are responsible for approximately 10% of all deaths globally. [1, 2] Head injuries are amongst the most likely to result in death or disability.[3] Traumatic brain injury (TBI) is a rural as well as urban problem, [4–6] and patients from low and middle income countries have more than twice the odds of dying after severe TBI compared to patients in high income countries, with mortality reaching above 50% in some low and middle income countries (LMIC). [7, 8] The incidence of TBI in sub-Saharan Africa (SSA) may be as much as 3.5 times higher than the global incidence and is predicted to reach 14 million per year by 2050.[9, 10]

Early predictors of prognosis after severe TBI include age, Glasgow Coma Scale (GCS) score, pupillary reactivity, systemic hypotension, abnormality on brain computed tomography (CT) and presence of an intracranial surgical lesion.[11–14] Guidelines for the management of severe TBI formulated based on the best clinical evidence by the Brain Trauma Foundation (BTF) focus on avoidance and treatment of hypotension and hypoxia, monitoring and treatment of raised intracranial pressure (ICP) and decreased cerebral perfusion pressure (CPP). Surgical intervention along with utilization of sedation-analgesia, hyperosmolar agents, hyperventilation, therapeutic coma as well as early implementation of nutrition and the avoidance of steroids are recommended for the optimal medical management of severe TBI.[15, 16]

Adherence to these guidelines has been shown to improve outcomes after severe TBI with reduction in mortality and long-term disability.[11, 17] The feasibility of implementing BTF

guidelines and the current adherence in the care of TBI patients in SSA has not been assessed. In this study, we analyzed the epidemiology, treatment and outcome of severe TBI in northwestern Tanzania.

METHODS

Study Design & Procedure

We established a prospective TBI registry at Bugando Medical Centre (BMC), Mwanza, Tanzania in 2013 for the purpose of quality improvement. Data on management of TBI were collected prospectively between September 1, 2013, and October 31, 2015. Ethical approval was obtained from the ethics committee of BMC and the institutional review board of Weill Cornell Medical College, and all data was de-identified to maintain patient confidentiality. Patients hospitalized with TBI at BMC were entered into the registry within 24 hours of arrival. Registry data were recorded daily up to the 14^{th} day of hospitalization, and again on the day of discharge. Two-week mortality was also recorded. Two medical students visited the surgical wards and intensive care unit (ICU) daily, and recorded pre-specified data elements on TBI patients on paper forms. These were transferred onto a secure computer at the supervising investigators office and paper forms were destroyed.

Study Site

This study was conducted at a tertiary care referral center located in Mwanza, the second-largest city in Tanzania with a population of over 700,000 people. BMC is the largest hospital in the northwestern part of the country, and serves as the primary referral and teaching hospital for the Lake Zone with a catchment of approximately 13 million people.

BMC hospital has 900 beds with a capacity of 150 surgical beds with approximately 1300 surgical admissions per year. The surgical department has six subspecialties: general, cardio-thoracic, orthopedic, otolaryngology, urology and neurological surgery. Two surgeons primarily provide neurosurgical services, one of whom has completed postgraduate education, while the other has completed one year of internship and accumulated several years of experience. They are assisted as needed by orthopedic and general surgery staff. There is also a 24-hour emergency department staffed by general practice doctors. The ICU has 13 beds and serves as a multi-specialty ICU including for pediatrics. A senior house officer with critical care experience of at least 6 months staffs it during daytime. An anesthetist-intensivist who is in the operating room supervises the medical officer. The nursing ratio is 4:1 and the nurses are not critical care certified. Table 1 illustrates basic resource availability as would be required to implement guidelines based standards.

Study Population

During the first year of the registry, all patients with TBI who were admitted to the ICU were registered. During the second year, the registry was expanded to include patients admitted to surgical wards since many TBI patients were not being admitted to the ICU.

Patients with TBI who died in the emergency department or who were dead on arrival were not included in the registry as records of these were frequently not available.

Study Variables

Severe TBI was defined as GCS score≤8.[18] Data elements used in the registry were based on known predictors of TBI outcome (age, initial GCS and pupillary reactivity, arterial hypotension, abnormal brain CT, and presence of a surgical lesion on brain CT) as well as basic demographics (gender, mechanism of injury, days between injury and hospitalization), and elements related to guideline-based treatment (anti-seizure therapy, hyperosmolar therapy, mechanical ventilation, intracranial monitoring).[16] Arterial hypotension was defined as systolic blood pressure (SBP)<90mmHg, hypoxia was pulse saturation (SpO_2) <90%, abnormal pupillary reactivity was <1mm response to light, asymmetric pupils were >1mm difference, and abnormal CT was with any one feature: cerebral edema, intracranial hematoma, compressed basal cisterns, midline shift, traumatic subarachnoid hemorrhage (tSAH) or infarction. In addition to above data, in the second year we included additional details on day of ICU admission, day of CT imaging, deep vein thrombosis (DVT) prophylaxis and enteral nutrition.

Statistical Analyses

SAS version 9.3 (SAS Institute, Inc., Cary, NC) was used for data analyses. We calculated summary statistics using frequencies and proportions for categorical variables and means, standard deviations, medians and interquartile ranges for continuous variables depending on the distribution of the data. Univariate logistic regression models were used to assess the association of 2-week mortality to individual risk factors that were identified a priori: age, gender, admission GCS, pupillary response, hypotension, days between injury and hospitalization, CT scan abnormality and surgical lesion. Variables associated with 2-week mortality in the univariate analyses were included in the multivariable logistic regression model. Patients with missing covariate data were excluded from regression analyses. Crude and adjusted odds ratios (OR) with 95% confidence interval (CI) were reported. All statistical tests were 2-sided, with a significance level of $p < 0.05$.

RESULTS

Patient Characteristics

Between September 2013 and October 2015, 371 patients with TBI were admitted to BMC ICU. Of these, 115 patients suffered severe TBI and were included in the registry. Severe TBI patients were also admitted to general wards, so in second year those were also included. 67 patients were included in total in the second year. The mean age of patients with severe TBI was 32.0±20.1 years and most were male (80.0%) (Table 2). Road traffic injuries were the most common cause of injury (66.1%), followed by assault (20%). Approximately half of the patients (47.8%) were hospitalized on the same day as their injury. After resuscitation, the median GCS was 7 (IQR 5–7): 27.8% had GCS 3–5, and 72.2% had GCS 6–8. At the time of hospitalization, 31.3% had abnormal pupils, and 6.1% had documented hypotension.

Imaging

Brain CT was performed in 49.6% of patients with severe TBI (57/115). Of those who had CT scan performed, 43.9% were abnormal (Table 3a). Amongst year 2 patients, when including severe TBI patients admitted to the general wards, an overall lower percentage (40%; 27/67) had CT performed whilst a greater proportion of CTs performed were abnormal (70.8%) (Table 3b). Only 33% of patients who underwent CT had it on the day of arrival.

Management and Outcomes

During the first 14 days of hospitalization, 36.5% of all severe TBI (42/115) were mechanically ventilated. Treatment was frequently based on signs of cerebral herniation – pupillary dilatation and loss of reactivity, extensor posturing, unilateral localizing signs. ICP monitoring was not performed on any patient. Hyperosmolar therapy was given to 38.3% on the basis of signs of cerebral herniation. Mannitol was the universal agent, and hypertonic saline was available but only used if mannitol did not reverse signs of herniation. Surgery was performed on 35.7% (41/115) of those with severe TBI, of whom 26.8% (11/41) had no CT scan performed. Antiepileptic drugs were used for prophylaxis in 22.6% of patients.

Additional data from the second year including severe TBI patients admitted to general wards showed that only 28.4% (19/67) were admitted directly to the ICU while 59.7% were never admitted to the ICU (Table 3b). On the wards no cardio-respiratory monitors were available. Intermittent blood pressure monitoring was performed with a manual manometer by nursing staff between daily and 6 hourly. In the ICU, cardio-respiratory monitors with automated blood pressure cuffs and finger pulse-oximeters were available and hourly readings were recorded in the patient's bedside flowsheet. Intra-arterial blood pressure can be monitored on two beds, but arterial blood pressure monitoring catheters were not available and intra-arterial cABP monitoring was never performed. 38.8% (26/67) patients had documented hypoxia after admission and 9% had documented hypotension. No blood gas analyzers were available for blood gas analyses. Enteral feeding via nasogastric tube was started within 48 hours in 94% (63/67) of patients. Prophylaxis against deep vein thrombosis was not used in any patient.

The median length of stay (LOS) was 12 days (IQR 5–22). Only 2 patients died during the first 24 hours. Two-week mortality for all patients with severe TBI was 34.8% while 43.5% died before discharge (Table 4). Of those who had CT and underwent surgery, 8 had no outcome data recorded, 8 were dead at 2 weeks (n=30), and in patients who had surgery without CT 3 of 11 died.

Predictors of Two-Week Mortality

Univariate regression among patients with severe TBI demonstrated that age, admission GCS, and an abnormal pupillary response were all significantly associated with 2-week mortality (Table 5). Age≥60 years old was the strongest predictor for 2-week mortality after TBI (OR 6.80, 95% CI 1.43–32.37, p=0.02). After multivariable regression, all three factors remained significant. Neither CT abnormalities nor recorded hypotension on admission were

associated with 2-week mortality, although many patients did not have a CT obtained, and blood pressure was measured infrequently.

DISCUSSION

In this study, we explored the management of severe TBI at a tertiary referral hospital in Tanzania and compared management principles to evidence-based BTF guidelines, in order to understand the potential gaps in care provision. Since this work was completed, new Guidelines from the BTF have been published,[19] however, in this discussion we will compare management to the 3rd edition of the BTF Guidelines which were current at the time of data collection. We discuss below our results by separate stages of care of TBI.

Pre-hospital Care

Patients experienced long delays between injury and hospitalization. At BMC, less than half of patients with severe TBI arrived on the day of their injury. Pre-hospital care in low and middle-income countries is still in its infancy especially in rural areas.[20, 21] There exists no formal pre-hospital care system in Mwanza, the second most populated area in Tanzania. A majority of patients are transported in private vehicles including taxis. Private ambulances, which are available as ‘pay-per-use’ basis, are used and the drivers and care-providers do not have standardized paramedical training. Training in first-aid must extend beyond first responders such as police and firefighters to lay persons for patients to reach the hospital in a timely manner with proper care.[22] This requires considerable infrastructural support at a governmental level.

On admission, blood pressure pulse saturation measurements were intermittent at best and no continuous recordings were made. While the frequency of monitoring was different between the general surgical ward and ICU, the equipment used was similar and no invasive devices were used in ICU. Therefore, while our data regarding hypotension and hypoxia on arrival to hospital do not seem to be associated with outcome, it is possible that the first measurement of SBP and SpO_2 may have happened well after all resuscitation occurred, as there is no algorithm on triage and treatment of trauma patients in the emergency department. It is also possible patients with severe TBI most affected by hypoxia and hypotension may not have survived the journey.

Imaging

Approximately half the patients with severe TBI underwent a CT scan during their stay; this number dropped to a third when severe TBI patients admitted to the general wards were also included. The hurdles in getting a CT performed in this setting were numerous. The CT scanner was occasionally malfunctioning, which required a technician to travel to Mwanza, or at times required a new part, which took several weeks. At the time of hospital admission, CT could often be performed without a charge, however, once a patient was admitted, CT could only be performed after pre-payment of the cost. In addition, once a patient was mechanically ventilated, the logistics of transport to obtain neuroimaging was a further obstacle, and as a general rule mechanically ventilated patients were never able to undergo brain CT. Optional CT imaging was available at a nearby private imaging center

approximately 2 km from the hospital, which was at times availed by the families by taking the patient from the emergency room via taxi to the imaging facility and returning with the requested brain CT. Skull x-rays while not considered the standard of care were frequently used to demonstrate skull fractures. Cerebral angiography is not performed at BMC.

Management

Critically ill patients at BMC were admitted to a 13-bed multi-disciplinary ICU that is supervised by an anesthetist-intensivist and staffed by a medical officer who provides daily care to surgical patients. However, amongst patients with severe TBI, only a little more than a quarter were admitted directly to the ICU, usually because there were no beds available in the ICU at the time of admission. A large proportion was admitted to the surgical wards where it is very difficult to provide high acuity care. For example, it is rare for vital signs to be checked on the surgical wards more frequently than 3–4 times daily, and this level of attention can only be provided to a few patients. Blood pressure has been shown to correlate with mortality, and it does not require significant technology to monitor.[23] The largest obstacle to close blood pressure monitoring is human resources. A surgical ward may have as many as 40 patients and 3 nurses: nurse to patient ratios are high and no nursing aides are available to record vital signs. This may also explain the low frequency of hypotension identified in our registry.

ICP monitoring is recommended in the management of severe TBI.[16] ICP monitoring assists in treatment of intracranial hypertension and adherence to cerebral perfusion pressure thresholds, both of which have been shown to significantly decrease mortality.[17] However, none of the patients with severe TBI had an ICP monitor placed. Surgeons at BMC are trained in the use of ICP monitors, but ICP monitors were available via donation only and rarely in stock. External ventricular drains were also not routinely available, and ICU care of these is a key reason for non-placement. Implementation of ICP monitoring would be a challenge in the ICU, requiring significant nurse education and vigilant infection control.

No arterial blood gas analyzer was available; therefore, hyperventilation was never purposefully performed. Hyperosmotic therapy was utilized in 38% of patients, essentially based on clinical signs of evident cerebral herniation. GCS was not recorded, making the determination of neurological deterioration difficult. Mannitol and hypertonic saline are available; however, mannitol is most often the agent of choice, and as stated earlier, hypertonic saline was used only when mannitol did not reverse signs of cerebral herniation.

Mechanical ventilation is performed in the ICU only but not routinely for comatose TBI patients due to a scarcity of ventilators. There are 3 ventilators available and intubation equipment is available.

Surgical management was undertaken even in absence of CT scan in patients with lateralizing signs of herniation and rapid deterioration. Exploratory burr holes were made and converted to a craniotomy if an extra-axial blood collection was seen. Patients with a CT scan available were more than twice as likely to receive surgery (52.6%) however 19% of patients without CT also underwent surgery. Patients have been managed for many years without the use of CT and continue to be managed so, but obtaining timely affordable CT

imaging will be an essential step towards achieving better outcomes for severe TBI patients in low resource settings.[5, 24, 25] Surgical management was predominantly burr holes and craniotomies. Craniectomies are rarely performed.

Mortality

The 2-week mortality among patients with severe TBI at our center was 34.8%. This is twice the mortality at the best trauma centers, but similar to 2-week mortality at many centers worldwide.. In Argentina, a country with arguably more resources, the early mortality rate from 2000–2003 was 53.4% in one study, although more than half of those patients died during the first 24 hours and would likely not have been included in our registry.[23] TBI interventions and outcomes were compared prospectively between Jamaica and the USA from 2003–2005. Mortality among all patients did not differ according to the country, but when analysis was restricted to patients with severe TBI, mortality was substantially higher in Jamaica (56.4%) versus the USA (32.3%) (p=0.005).[26] Two recent studies from SSA also had similar mortality rates. In Moshi, Tanzania, a smaller city than Mwanza, among prospectively enrolled severe TBI patients the mortality was 47.0%, however, there is no trained neurosurgeon at Moshi.[27] In a retrospective chart study from Uganda, the mortality was 25.8%.[28] The 2-week mortality in the recent BEST-TRIP trial conducted in South America was 21–30% and at 6-months 40% in severe TBI patients.[29] It is likely that our mortality rate is actually an underestimate. The most severe injuries cannot reach our center in time for treatment, and patients who die in the emergency department were not included in our registry. Yet, based on these results we can estimate that at 6 months the mortality can only be higher.

In our study, predictors of mortality in severe TBI included age, initial GCS, and pupillary response. These are largely consistent with those documented in the literature. TBI-related mortality has long been known to increase with advanced age, lower GCS, and pupillary abnormalities on presentation.[30–33] We were not able to validate hypotension or CT abnormalities as predictors of TBI. This may due to lack of frequent blood pressure recordings and of continuous monitoring of BP. Patients on the wards rarely have their blood pressure checked more than 3–4 times per day. Correlation with abnormalities on CT may be confounded by the fact that CT scanning was dictated by ability to pay, travel to the hospital CT scanner or the alternate imaging site in the city. In itself this may exclude sicker patients or patients with cerebral herniation.

While the current gap in TBI-related mortality between high-income countries and SSA is significant, the mortality rate found in this study resembles historical trends in the US and Europe. From the 1930s to the 1970s, mortality rates for severe TBI in the developed world were consistently high (51–53%); however, there was a sharp decrease in mortality in the 1990s, reaching present-day values in many centers by the late 1990s while continuing to decline even into the late 2000s in some locations.[17, 34] This initial decrease in mortality coincided with the beginning of ICP monitoring and institution of ICU care for these patients, and subsequent development of protocols and guidelines. Gerber et al. analyzed statewide data from 22 trauma centers (20 level 1 and 2 level 2) in New York and found that the 2-week mortality rate for severe TBI was 22% in 2001 and declined to 13.3% by 2009 in

association with improved implementation of the BTF treatment guidelines, especially utilization of ICP monitoring, treatment of intracranial hypertension and adherence to cerebral perfusion pressure thresholds. [17] In Austria, Brazinova et al. described a change of hospital mortality in moderate and severe TBI (GCS<13) from 31% to 23% over a 3-year time frame from 2009 and 2012.[35] The consensus is that while the first drop in mortality was due to institution of ICU based care for patients with severe TBI, the continuing decline in mortality remains based on protocolization of care including ICP and CPP monitoring. Therefore, successful implementation of TBI Guidelines could similarly improve patient outcomes in the African setting.

Limitations

Our study has several limitations. Patient selection bias is probably the biggest confounder. Patients were entered into the registry after hospitalization. Therefore, we were not able to describe pre-hospital care accurately for patients. Furthermore, patients who were brought in dead or died in the emergency room before hospitalization were not registered and were therefore not included. Admission of severe TBI patients to various surgical wards in addition to the ICU was a problematic hurdle, it is still possible that patents admitted to non-surgical wards due to bed availability issues may have not been included. To minimize this, starting from the second year, our research students went to each surgical ward daily to screen for severe TBI admissions. Medical records are also not kept in detail; it is common for some treatments to be instituted without entry into the medical record. The details of the surgical procedure performed were not recorded in the registry, so it was not possible to evaluate the type of surgery as a predictor of outcome. Finally, the inpatient registry does not currently link with the outpatient clinic registry, preventing analysis of any long-term outcomes or determination of predictors of long-term outcomes.

Perspectives for the Future

Education and awareness are an essential starting point for improved care of patients with TBI in SSA. Tanzania has worked hard for several years now to educate allied health professionals regarding neurosurgical disease.[6, 36, 37] BMC has forged relationships with other centers to receive continuing surgical education.[4, 38] Since obtaining the preliminary 2-year registry data for analysis, BMC has made several changes that will likely improve care for future TBI patients. Two postgraduate trained neurosurgeons have been hired in the surgical department. Operating theatre space has been increased, and a CT scanner will be available on-site in the near future. Perhaps more importantly, clinical care pathways for TBI management have been implemented in the ICU, and nursing management has attempted to admit TBI patients to a single surgical ward. This allows for greater TBI-specific nursing experience and improved patient monitoring. More emphasis has been placed on basic critical care monitoring such as oxygen saturation, blood pressure and neurological status using a reliable scale (GCS). We are hopeful that these changes will be reflected in consistent protocol-driven care and improved survival of TBI patients.

This preliminary data is part of a much larger effort to partner with BMC to help improve care of neurotrauma patients. We are now able to capture all patients with severe TBI admitted to BMC. In addition, we have been organizing an annual educational course on

Brain and Spine Trauma for surgeons, nurses and emergency physicians for South, East and Central Africa for several years. This includes lectures, workstations and hands-on surgical training.[36] This has been coupled with providing scholarships for surgeon candidates from Tanzania to visit and train at our hospital by observing different surgical techniques and having access to cadaveric laboratory.

While we believe that information exchange and education is key to a sustained effect in improving clinical outcomes of patients with severe TBI as well as other neurosurgical and neurological diseases, material resources are also key in this advancement. This is the gap that can be filled by government, the church and other non-governmental organizations. It is hoped that publications such as this can help identify the gaps so that the distribution of resources be directed so as to have maximal impact in improving health in SSA and Tanzania particularly. In the meantime, we will continue to use registry maintenance, education by partnership, and protocolization of TBI care to provide the best care possible for patients with TBI in a resource-limited setting.

CONCLUSION

Severe TBI-associated mortality amongst hospitalized patients hospitalized at a tertiary referral hospital in Tanzania is approximately twice that of patients in high-income countries. ICU beds, specialized ICU care, CT imaging, hemodynamic and neurological monitoring are underutilized or unavailable in the tertiary referral hospital setting. Improving outcomes after severe TBI will require concerted investment in pre-hospital care as well as improvement in availability of neuroimaging, ICU resources and expertise in multidisciplinary care. While material resources are very important, education, information exchange and partnering with educational institutions can also result in intellectual advancement in areas of health care improvement.

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Abbreviations

TBI	traumatic brain injury
BTF	Brain Trauma Foundation
CT	computed tomography

ICU	intensive care unit
cABP	continuous arterial blood pressure
ICP	intracranial pressure
LMIC	low and middle income countries
SSA	sub-Saharan Africa
GCS	Glasgow Coma Scale
CPP	cerebral perfusion pressure
BMC	Bugando Medical Center
SBP	systolic blood pressure
SpO_2	peripheral capillary oxygen saturation
DVT	deep vein thrombosis
OR	odds ratio
CI	confidence interval
IQR	inter-quartile range
LOS	length of stay

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Highlights

- Data on acute severe traumatic brain injury (TBI) and its management in East Africa are sparse; our article details data from a tertiary referral university hospital in Tanzania.
- Patients with severe TBI are admitted to the intensive care unit (ICU) as well as general surgical wards due to shortage of ICU beds
- Routine continuous arterial blood pressure, intracranial pressure measurement in the treatment of severe TBI patients are lacking
- Computed tomography (CT) in the management of severe TBI is available inconsistently due to infrastructure, financial and logistical constraints.
- Specialists required to treat severe TBI are limited to neurosurgeons who are scarce in number and general surgical registrars and house officers
- Mortality from severe TBI is nearly threefold that seen in developed countries.

Table 1

Comparison of BTF Recommendations (3rd Edition) for severe TBI and status of locally available treatment in Tanzania.

Topic	BTF Recommendation	Data Class*	Status in Tanzania
Monitoring			
Blood Pressure	• Monitor blood pressure in all patients	II	Available
Oxygenation	• Monitor oxygen saturation in all patients	III	Available
Intracranial Pressure (ICP)	• Monitor ICP in patients with severe TBI and an abnormal CT scan	II	Unavailable
	• Monitor ICP in patients with severe TBI and a normal CT scan if ≥ 2 of the following present at admission: age >40y/o, unilateral or bilateral motor posturing, SBP <90mmHg	III	Unavailable
Brain Oxygen	• Monitor jugular venous saturation or brain tissue oxygen for cerebral oxygenation	III	Unavailable
Cerebral Perfusion	• Monitor cerebral perfusion parameters including blood flow, oxygenation, and metabolism to facilitate CPP management	III	Unavailable
Thresholds			
Blood Pressure	• Treat SBP<90mmHg	II	Attempted
Oxygenation	• Treat PaO2 <60 mm Hg or O2 saturation <90%	III	Attempted
ICP	• Treat ICP > 20 mm Hg	II	Unable to monitor
	• Use ICP values, clinical and brain CT findings to determine need for treatment	III	Unable to monitor ICP
Brain Oxygen	• Treat jugular venous saturation <50% or brain tissue oxygenation tension <15 mmHg	III	Unable to monitor
Cerebral Perfusion	• Avoid aggressive attempts to maintain cerebral perfusion pressure (CPP) above 70 mm Hg with fluids and vasopressors because of the risk of adult respiratory distress syndrome (ARDS)	II	Unable to monitor
	• Target CPP 50–70 mm Hg. Patients with intact pressure autoregulation tolerate higher CPP	III	Unable to monitor
	• Avoid CPP of < 50 mm Hg.	III	Unable to monitor
Treatments			
Hyperosmolar Therapy for elevated ICP	• Mannitol (0.25 gm/kg to 1 gm/kg) is effective	II	Available and used
	• Before ICP monitoring, use only for signs of transtentorial herniation or progressive neurological deterioration	III	Available and used
	• No current recommendation for use of hypertonic saline	--	
Prophylactic Hypothermia	• Does NOT decrease mortality	III	Unavailable
	• Increases GOS scores		

Topic	BTF Recommendation	Data Class*	Status in Tanzania
Infection Prophylaxis	• Antibiotics before intubation reduce pneumonia incidence (but NOT LOS or mortality)	II	Available and used
	• Early tracheostomy reduces ventilator days (but does NOT reduce mortality or pneumonia)	II	Available and used
	• Do NOT routinely change ventricular catheters	III	Catheters unavailable
	• Do NOT use prophylactic antibiotics for duration of ventricular catheter placement		
	• Early extubation does not increase pneumonia	III	Available, not used
Deep Vein Thrombosis Prophylaxis	• Use graduated compression stockings or intermittent pneumatic compression stockings	III	Unavailable
	• Use low molecular weight heparin or low dose unfractionated heparin in combination with mechanical prophylaxis	III	Available, not used
	• There is an increased risk of expansion of intracranial hemorrhage		
	• Insufficient evidence for preferred agent, dose, or timing of pharmacologic DVT prophylaxis		
Anesthetics, analgesics, and sedatives	• Do NOT use prophylactic high dose barbiturate coma	II	Available, not used for coma
	• Barbiturate coma may be used to control elevated ICP refractory to maximum medical and surgical treatment	II	Available, not used for coma
	• Propofol can improve ICP but NOT mortality or 6 month outcomes. High dose propofol can produce significant morbidity	II	Unavailable
Nutrition	• Feed to full caloric needs by day 7 post-injury	II	NG feeds used, but caloric content unmeasured
Anti-seizure Prophylaxis	• Do NOT use prophylactic phenytoin or valproate for late posttraumatic seizures (PTS) prevention	II	Available and used
	• Use Anticonvulsants to decrease incidence of early PTS within 7 days of injury. However, early PTS is NOT associated with worse outcomes	II	
Hyperventilation	• Do NOT use prophylactic hyperventilation	II	Available, not used.
	• Use hyperventilation only as a temporary measure to reduce ICP	III	
	• Avoid hyperventilation in initial 24 hours after injury	III	
Steroids	• Do NOT use steroids to improve outcomes or reduce intracranial pressure. High dose methylprednisolone increases mortality.	I	Available, not used

*Data Class according to BTF guidelines, see Table 1 of the BTF guidelines for details[16]

Table 2

Characteristics of 115 patients hospitalized at Bugando Medical Centre with severe traumatic brain injury between September 2013 and October 2015

	N	%
Age, mean (SD), year		32.0 (20.1)
<16	24	20.9
16–59	75	65.2
≥60	12	10.4
Missing	4	3.5
Gender		
Male	92	80.0
Female	22	19.1
Missing	1	0.9
Mechanism of Injury		
Road traffic injury	76	66.1
Fall	8	7.0
Assault	23	20.0
Blunt injury	8	7.0
Admission GCS, median (IQR)		7 (5–7)
3–5	3 2	27.8
6–8	83	72.2
Days from injury to admission		
< 1 day	55	47.8
≥ 1 day	56	48.7
Missing	4	3.5
Pupillary response on admission		
Normal	62	53.9
Abnormal	36	31.3
Unilateral	19	16.5
Bilateral	17	14.8
Missing	17	14.8
Hypotension after resuscitation		
< 90 mm Hg	7	6.1
≥ 90 mm Hg	95	82.6
Missing	13	11.3

Table 3

a. Management of 115 patients hospitalized at Bugando Medical Centre with severe traumatic brain injury between September 2013 and October 2015

	N	%
CT scan performed		
Yes	57	49.6
No	58	50.4
CT scan result		
Abnormal	25	43.9
Normal	32	56.1
Mechanical ventilation		
Yes	42	36.5
No	73	63.5
Anti-seizure medication		
Yes	26	22.6
No	85	73.9
Missing	4	3.5
Hyperosmolar medication		
Yes	44	38.3
No	70	60.9
Missing	1	0.9
Surgery performed		
Yes	41	35.7
No	74	64.4
ICP monitor/ventriculostomy placed		
Yes	0	0.0
No	67	100.0

b. Management of 67 patients hospitalized at Bugando Medical Centre with severe traumatic brain injury between October 2014 and October 2015

	N	%
Day of ICU admission		
On arrival	19	28.4
On day 1	0	0
On day 2	3	4.5
On day 3	4	6.0
On day 4	1	1.5
Never	40	59.7
Any hypotension during hospitalization		
< 90 mm Hg	6	9.0
≥ 90 mm Hg	54	80.6
Missing	7	10.5
Any hypoxia during hospitalization		
SpO2 < 90%	26	38.8

b. Management of 67 patients hospitalized at Bugando Medical Centre with severe traumatic brain injury between October 2014 and October 2015

	N	%
SpO2 ≥ 90%	40	59.7
Missing	1	1.5
CT scan performed		
Yes	24	35.8
No	43	64.2
CT scan result		
Abnormal	17/24	70.8
Normal	7/24	29.2
Day of CT scan		
Day of admission	8/24	33.3
1 day after admission	4/24	16.7
> 1 day after admission	12/24	50.0
Day enteral feeding started		
≤ day 2	63	94.0
≥ day 3	4	6.0
DVT prophylaxis		
Yes	0	0
No	67	100.0

Table 4

Outcomes of 115 patients at Bugando Medical Centre with severe traumatic brain injury hospitalized between September 2013 and October 2015

	Median	IQR
Length of Stay	12	5–22
Missing	8	
	N	%
24-hr Mortality		
Yes	2	1.7
No	110	95.7
Missing	3	2.6
2-week Mortality		
Yes	40	34.8
No	67	58.3
Missing	8	7.0
Mortality before discharge		
Yes	5 0	43 .5
No	62	53.9
Missing	3	2.6

Table 5

Predictors of 2-week mortality for patients with severe TBI.

	Severe TBI (n=107)						
Predictive V ariable	**2-week mortality N (%)**	**OR**	**Univariate 95% CI**	**P value 0.01**	**OR**	**Multivariate 95% CI**	**P value**
Age (continuous)	40 (37.4)	1.03	1.01–1.05	**0.01**			
Age group							
<16	5 (22.7)	ref	ref	ref	ref	ref	ref
16–59	25 (36.2)	1.93	0.64–5.87	0.25	6.08	1.29–28.69	**0.02**
≥60	8 (66.7)	6.80	1.43–32.37	**0.02**	31.12	3.69–262.24	**0.002**
Age group							
<30	12 (23.5)	ref	ref	ref			
≥30	26 (50.0)	3.25	1.40–7.57	**0.006**			
Gender							
Male	33 (38.4)	1.16	0.42–3.20	0.78			
Female	7 (35.0)	ref	ref	ref			
Admission GCS	40 (37.4)	0.66	0.51–0.87	**0.003**			
Admission GCS group							
3–5	17 (56.7)	3.07	1.28–7.34	**0.01**	2.12	0.67–6.69	0.20
6–8	23 (29.9)	ref	ref	ref	ref	ref	ref
Pupillary response							
Normal	14 (24.1)	ref	ref	ref	ref	ref	ref
Abnormal	21 (63.6)	5.50	2.17–13.94	<**0.001**	7.79	2.55–23.77	<**0.001**
Hypotension							
< 90 mm Hg	1 (16.7)	0.30	0.03–2.70	0.28			
≥ 90 mm Hg	35 (39.8)	ref	ref	ref			
Days until admission							
< 1 day	21 (38.9)	ref	ref	ref			
≥ 1 day	18 (36.7)	0.91	0.41–2.03	0.82			
CT scan abnormality							
Abnormal	8 (36.4)	0.88	0.27–2.85	0.82			

Severe TBI (n=107)							
Predictive V ariable	2-week mortality N (%)	OR	Univariate 95% CI	P value 0.01	OR	Multivariate 95% CI	P value
Normal	9 (33.3)	ref	ref	ref			

C statistic for multivariable model: 0.815