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Prevalence and Risk Factors of Acute Brain Injury In Polytrauma Patients

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ORIGINAL ARTICLE

Prevalence and Risk Factors of Acute Brain Injury In Polytrauma Patients

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Abstract

Background: ***Acute brain injury is a significant source of mortality in polytrauma patients. However, epidemiological data on ABI prevalence in polytrauma is limited.***

Aim: ***To investigate the Prevalence and risk factors of acute brain injury in polytrauma and to uncover the in-hospital mortality rates associated with acute brain injury in this population.***

Methods: ***This prospective cross-sectional study included 80 adult polytrauma patients who presented to the Emergency and Critical Care Department of Sayed Galal Al-Azhar University Hospital. Demographic and clinical data were collected between January 2023 and December 2023.***

Results: ***We enrolled 80 polytrauma patients who is NISS > 18 admitted to the Emergency and Critical Care Department of Sayed Galal Al-Azhar University Hospital; they showed a mean age of 28.6±8.7 years old, males represented 70% of the included patients. Road traffic collisions emerged as the predominant cause of injuries, constituting 55%. The mortality rate was 35% of the included patients, and full recovery was reported in 30%. All of the non-survivors were shocked and had associated injuries compared to survivors. CPK was significantly higher among the deceased group compared to survivors. All non-survivors groups were indicated for ICU admission, and surgical interventions and showed positive CT and abdominal US findings. 15***

Conclusion: ***Among all emergency department presentations, traumatic brain injury stands out as a widespread type of injury in polytrauma. It has a high rate of in-hospital mortality. Risk factors associated with mortality of TBI were vital instability, elevated CPK, and need for ICU admission.***

Keywords: Traumatic brain injury; polytrauma; emergency medicine; fracture skull base

1. Introduction

Trauma is a significant contributor to both morbidity and mortality across all age demographics, especially in individuals under 60 years of age, ranking as one of the top five reasons for death. The majority of fatalities are seen in adults aged 15 to 44 years. Polytrauma patients experience intricate pathophysiological alterations that necessitate efficient management to enhance both morbidity and mortality rates.[1]

Complications such as bleeding, systemic inflammatory immune response (SIRS), and multiple organ dysfunction (MODS) from trauma have widespread effects, leading to acute brain injury in polytrauma cases, which exacerbates the prognosis.[2]

An estimated 1.7 million individuals in Egypt experience traumatic brain injury (TBI) each year, leading to approximately 52,000 fatalities. TBI involves a complex injury process, starting with the primary trauma followed by a secondary injury to the central nervous system (CNS) caused by disruptions in the inflammatory and coagulation systems.[3]

Inflammation is a necessary immediate reaction to injury, but when this response becomes distorted and prolonged, it can disrupt the body's balance and lead to negative consequences. Likewise, coagulation disorders in TBI can lead to the growth of brain bleeding areas and a bleak outlook.[3]

After a TBI, the initial impact and subsequent inflammation within the central nervous system compromise the integrity and functionality of the blood-brain barrier. This breakdown allows immune cells from the bloodstream to enter the brain abnormally, leading to further neuronal damage and a poorer outcome. The presence of multiple injuries alongside TBI intensifies this inflammatory reaction, worsening the effects of the injury.[4]

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Thus, we conducted a prospective cross-section analytical study to assess the prevalence and outcomes of TBI in polytrauma patients in Egypt and to determine the risk factors magnifying the mortality.

2. Patients and methods

This study is a prospective observational cross-sectional study. It included 80 polytraumatic patients who presented to the Emergency and Critical Care Department of Sayed Galal Al-Azhar University Hospital.

Adults aged more than 18 years presented with Polytrauma with suspected brain injuries and NISS score ≥18 were enrolled in the current study. At the same time, patients who had early mortality or early discharge during the first day of admission or those who have been previously diagnosed with neurologic disorders were excluded.

All patients were assessed initially by taking swift medical history, including Mechanism and timing of injury, associated medical conditions, drug allergies and previous operations. A thorough clinical examination from head to toe was performed, including assessment of circulation (blood pressure (BP), pulse rate, and capillary filling), airway patency and breathing (Respiratory rate (RR), and proper respiratory movement of the chest, oxygen saturation), the temperature was documented on admission. [5]

Hemodynamics will be recorded, including urine output and fluid replacement therapy for the first 6 hours of arrival at the hospital every hour and whether the patient received blood or not.[6]

Clinical assessment included Glasgow Coma Score (GCS) and the 5 cardinal neurological assessment (Strength, Reflexes, Coordination, Balance, and Hearing). We recorded all patients on their admission. Jugular venous oxygen saturation and jugular vein carbon dioxide level were determined, and technical aspects of internal jugular venous oxygen and carbon dioxide concentration measurement were done through placement on an internal jugular catheter. Under careful aseptic precautions, the IJV on the side to be cannulated is typically punctured under ultrasound guidance at the level of the triangle's apex formed in the neck by the two heads of the sternocleidomastoid muscle and the clavicle. A 5 cm of blood was drawn in a heparinized syringe and sent to the lab immediately after withdrawal.

Laboratory assessment included Blood tests for full blood count (CBC), blood grouping, random blood glucose (RBS), Venous blood gases (VBG), Bleeding profile, Amylase, Creatine phosphor kinase (CPK), and fibrin degradation products, which were performed for the patient immediately after his admission to the hospital.

The radiological assessment included CT brain and MRI to detect any suspected traumatic brain injury, visualize fractures, and uncover evidence of intracranial haemorrhage. Any brain insults were recorded for all patients on their admission.

Sample size.

Sample size was calculated using Epi Info STATCALC based on a study by Muhamed Hussein et al., 2021, considering the following allegations: 95% two-sided confidence level, with a power of 80%. & α error of 5%. The final largest size taken from the Epi-Info output was 63. Thus, the sample size was increased to 80 subjects to allocate any dropout cases during follow-up.7

Statistical analysis

The data set was analyzed using SPSS 27th version. The qualitative variables were stated in percentage, and quantitative variables were input as mean ± standard deviation. Comparisons between study groups (survivors versus deceased) were conducted using the Chi2 test for categorical variables and the Mann-Whitney U test for quantitative variables.

Ethical consideration

The Local Ethics Committee approved the study, and written informed consents were obtained from the patients or their first-degree relatives.

3. Results

We enrolled 80 polytrauma patients NISS ≥ 18 admitted to Emergency and Critical Care Department of Sayed Galal Al-Azhar University Hospital, they showed a mean age of 28.6±8.7 years old ranging between 18 and 59 years, males represented 70% of the included patients, hypertension prevalence was 20% among the included patients. Vital signs assessment at the time of presentations showed a mean of Systolic BP 109.3±34.9 mmHg, Diastolic BP 64.8±23.9 mmHg, MAP 79.2±27.4 mmHg, Pulse 111.4±27.7 b/min, Resp. rate 29.2±10.2 b/min, and mean UOP 52.8±42.6 ml/hour (Table 1).

Table 1. Demographics and base line variables.

		Count	%
AGE		28.6±8.7	18-59
GENDER	Female	24	30%
	Male	56	70%
NISS	≥ 18	80	100
HYPERTENSION	No	64	80%
	Yes	16	20%
SYSTOLIC BP	mmHg	109.3±34.9	60-200
DIASTOLIC BP	mmHg	64.8±23.9	30-120
MAP	mmHg	79.2±27.4	43-140
PULSE	b/min	111.4±27.7	50-160
RESP. RATE	b/min	29.2±10.2	16-40
UOP	ml/hour	52.8±42.6	5-103

FLUID REPLACEMENT THERAPY IN ER	L	3.6±2.3	0.5-12

Thirty-two (40%) patients showed vital instability up to shock, Glasgow coma scale showed that 28 (35%) patients were 13-15, while 16 (20%) patients were between 8-12, and 36 (45%) patients were <8 GCS, Jugular venous oxygen saturation was low and Jugular vein carbon dioxide was elevated in 52 (65%) patients. Neurological assessment showed that there was limb weakness in 24 (30%) patients, reflexes were Absent in 28 (35%) patients, and decreased in 24 (30%) patients, coordination was impaired 24 (30%) patients, balance was Impaired in 16 (20%) patients, and hearing was impaired in 40 (50%) patients. During resuscitation, the mean fluid replacement was 3.6±2.3 L, and mean blood transfusion 2545.2±1109.3 ml (Table 2).

Table 2. Baseline criteria of the patients

		Count	%
SHOCKED	No	48	60%
	Yes	32	40%
JUGULAR VENOUS OXYGEN SATURATION	Low	52	65%
	Normal	28	35%
JUGULAR VEIN CARBON DIOXIDE	Elevated	52	65%
	Normal	28	35%
STRENGTH	No response	28	35%
	Normal	28	35%
	Weak	24	30%
REFLEXES	Absent	28	35%
	Decreased	24	30%
	Normal	28	35%
COORDINATION	Impaired	24	30%
	Normal	28	35%
	not testable	28	35%
BALANCE	Impaired	16	20%
	Normal	24	30%
	not testable	36	45%
	Slightly impaired	4	5%
HEARING	Abnormal	40	50%
	Normal	40	50%
TYPE OF INJURY	Explosion with subsequent fall debris.	4	5%
	Road traffic accidents	44	55%
	Fall from height	8	10%
	Industrial accident with heavy machinery.	12	15%
	Sports injury	12	15%

Traffic collisions represented the predominant mechanism of injury accounting for 55%, followed by Industrial accident with heavy machinery, and Sports injury representing 15% each, fall from height was reported in 10% of cases while explosion and fall of debris accounted for 5% of cases (Figure 1).

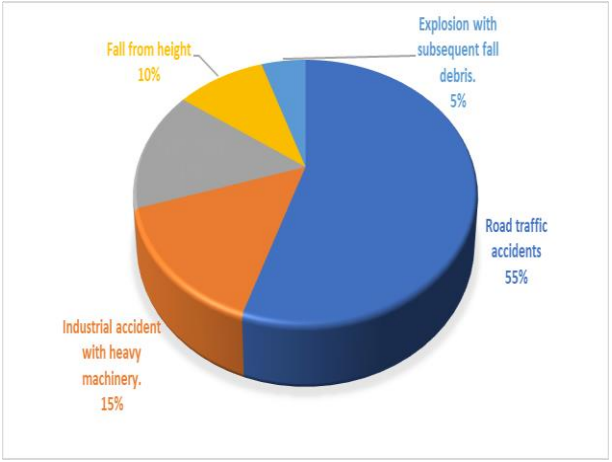

Figure 1. pie chart showing type of injury among the included patients.

Associated injuries were documented in 48 (60%) patients, acute brain injuries were found in 68 (85%) patients, fracture-based skull in 48 (60%) patients, abdominal injuries were found in 44 (55%) patients, 28 (35%) patients were found to have chest injuries, and orthopedic injuries were reported in 65% of the included patients.

CT imaging was conducted for all the included patients, it was normal in 16 patients, and showed Extra dural hemorrhage, multiple skull fractures, and brainstem compression among 28 (35%) patients, MRI was done for 24 patients, and was normal in 12 patients, with axonal shearing at the microscopic level, cerebral contusion without significant swelling, and mild concussion without significant injury accounting for 5% of the included patients each (Table 3).

Abdominal ultrasound (FAST) showed intra-abdominal collections or hemorrhage in 44 (55%) patients, and 28 (35%) patients showed intra thoracic collection.

The mortality rate was 35% of the included patients, full recovery was reported in 30%, while 12 (15%) patients recovered and required further rehabilitation, and 16 (20%) patients survived with disabilities (Figure 2).

Table 3 Imaging and labs of patients

		COUNT	%
ASSOCIATED INJURIES	No	32	40%
	Yes	48	60%
BRAIN INJURY	Absent	12	15%
	Present	68	85%
FRACTURE BASE SKULL	Absent	32	40%
	Present	48	60%
ABDOMINAL INJURIES	Absent	36	45%
	Present	44	55%
CHEST INJURIES	Absent	52	65%
	Present	28	35%
ORTHOPEDIC INJURIES	Absent	28	35%
	Present	52	65%
VASCULAR	Absent	70	87.50%

INJURIES			
	Present	10	12.50%
CT FINDINGS	Acute subdural hematoma	8	10%
	Extradural hemorrhage	28	35%
	subarachnoid and subdural hemorrhage	4	5%
	frontal bone fracture	4	5%
	Subarachnoid hemorrhage	8	10%
	Extensive bilateral hemispheric contusions	8	10%
	Possible concussion	4	5%
	Normal	16	20%
MRI FINDINGS	Axonal shearing	4	5%
	Cerebral contusion without significant swelling.	4	5%
	Mild concussion	4	5%
	Normal	12	15%
	Not done	56	70%
	Normal	36	45%
CPK	ng/dL	679.5±447.2	150-1390
FDPS	Elevated	52	65%
	Normal	28	35%
OUTCOMES	Died	28	35%
	Full Recovery	24	30%
	Recovery and rehabilitation	12	15%
	Survived with disabilities	16	20%

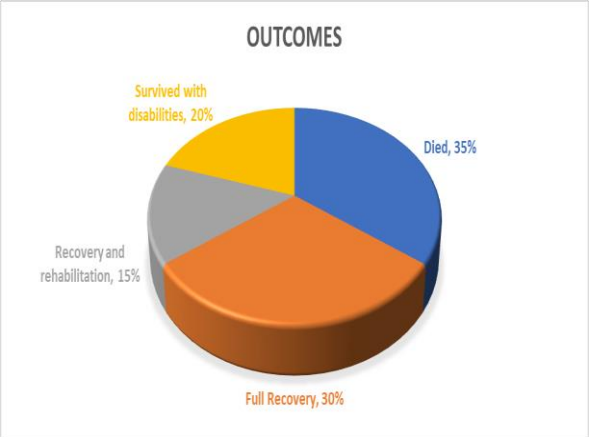

Figure 2. pie chart showing clinical outcomes

among the included patients.

ICU admission was indicated in 56 (70%) patients, while surgical intervention was indicated for 40 (50%) patients, in the form of craniotomy, external ventricular drain, exploration majorly, and to lesser extent surgical debridement of fracture (Table 4).

Table 4. Patient interventions

		Count	%
ICU ADMISSION	No	24	30%
	Yes	56	70%
SURGICAL INTERVENTION	Craniotomy and external ventricular drain [EVD]	8	10%
	Craniotomy	12	15%
	Craniotomy and EVD with Exploration	8	10%
	Craniotomy and fracture fixation with exploration	4	5%
	Surgical debridement of fracture	4	5%
	Surgical exploration of abdomen with craniotomy and EVD	4	5%
	No	40	50%

A comparison of individuals who survived and those who did not revealed no significant statistical disparities in terms of age, gender, and prevalence of hypertension with p values >0.05.

Systolic, diastolic, and mean arterial blood pressures were significantly lower among non-survivors compared to survivors with p values <0.001. Pulse and respiratory rates were significantly higher among non-survivors with p values <0.01 (Table 5).

Table 5. Clinical outcomes regarding patient's vital signs.

CLINICAL OUTCOME						
		Mean ±SD	Min-Max	Mean ±SD	Min-Max	P value
AGE		27.8±7.5	18-58	30±10.6	19-59	0.672
		Count	%	Count	%	
GENDER	Female	16	30.80%	8	28.60%	0.838
	Male	36	69.20%	20	71.40%	
HTN	No	44	84.60%	20	71.40%	0.160
	Yes	8	15.40%	8	28.60%	

SYSTOLIC BP (MMHG)	126.2±31.8	80-200	77.9±9.4	60-90	<0.001	
DIASTOLIC BP (MMHG)	78.1±18.8	40-120	40.3±6.6	30-52	<0.001	
MAP (MMHG)	94±22.7	53-140	51.7±5.1	43-60	<0.001	
PULSE		95.9±20.4	50-140	140±12.2	120-160	<0.001
RESP. RATE	23.4±8	16-40	40±0	40-40	<0.001	
UOP		76.7±34	10-103	8.6±2.3	5-10	<0.001

Fluid replacement and blood transfusion was significantly higher among non-survivors compared to survivors with p values 0.008, and <0.001 respectively, all non-survivors were shocked, had associated injuries in the form of brain, abdominal, fracture-base of skull, and orthopedic injuries compared to survivors with p values <0.001 each.

CPK was significantly higher among deceased group compared to survivors (1102.9±402.6 versus 451.5±269.5) with p value <0.001 (figure 4). All non-survivors' groups were indicated for ICU admission, surgical interventions, and showed positive CT and abdominal US findings with p values <0.001 each (Table 6- Table 7).

Table 6. Patient outcomes depending hemodynamic state, resustation fluid, type of injury and associated injury.

CLINICAL OUTCOME		Survivors		Deceased		
		Mean ±SD	Min-Max	Mean ±SD	Min-Max	P value
FLUID REPLACEMENT THERAPY IN ER		3.3±2.8	0.5-12	4±0	4-4	0.008
BLOOD TRANSFUSION		1250±577.4	2000-3000	3285.7±460	3000-4000	<0.001
SHOCKED	No	48	92.30%	0	0.00%	<0.001
	Yes	4	7.70%	28	100.00%	
TYPE OF INJURY	Explosion with subsequent fall debris.	4	7.70%	0	0.00%	<0.001
	Fall from height	8	15.40%	0	0.00%	
	Industrial accident with heavy machinery.	0	0.00%	12	42.9%	
	Road traffic accidents	28	53.80%	16	57.1%	
	Sports injury	12	23.10%	0	0.00%	
ASSOCIATED INJURIES	No	32	61.50%	0	0.00%	<0.001
	Yes	20	38.50%	28	100.00%	
BRAIN INJURY	Absent	12	23.10%	0	0.00%	0.006
	Present	40	76.90%	28	100.00%	
FRACTURE BASE SKULL	Absent	32	61.50%	0	0.00%	<0.001
	Present	20	38.50%	28	100.00%	
ABDOMINAL INJURIES	Absent	36	69.20%	0	0.00%	<0.001
	Present	16	30.80%	28	100.00%	
ORTHOPEDIC INJURIES	Absent	28	53.80%	0	0.00%	<0.001
	Present	24	46.20%	28	100.00%	
CT FINDINGS	Acute subdural hematoma	8	15.40%	0	0.00%	<0.001
	Extradural hemorrhage,	0	0.00%	28	100.00%	
	subarachnoid hemorrhage	16	30.80%	0	0.00%	
	Frontal bone fracture	4	7.70%	0	0.00%	
	Bilateral hemispheric contusions	8	15.40%	0	0.00%	
	Possible concussion	4	7.70%	0	0.00%	
	Normal	16	30.80%	0	0.00%	

Table 7. Patient outcomes depending on MRI finding, FAST, GCS, Cardinal score, ICU admission and labs.

CLINICAL OUTCOME		Survivors		Deceased		
		Mean ±SD	Min-Max	Mean ±SD	Min-Max	P value
MRI FINDINGS	Axonal shearing	4	7.70%	0	0.00%	0.001
	Cerebral contusion	4	7.70%	0	0.00%	
	Mild concussion	4	7.70%	0	0.00%	
	Normal	12	23.10%	0	0.00%	
	Not done	28	53.80%	28	100.00%	
FAST FINDINGS	Intraabdominal collection or hemorrhage	12	23.10%	28	100.00%	<0.001
	intrathoracic collection	0	0.00%	28	100.00%	
	Normal	36	69.20%	0	0.00%	
HB	gm/dL	10.1±2.1	6-13	4.7±0.5	45387	<0.001
INR		1.2±0.2	1-1.7	2.2±0.3	1.9-2.7	<0.001

CPK		451.5±269.5	150-900	1102.9±402.6	150-1390	<0.001
FDPS	Elevated	24	46.20%	28	100.00%	<0.001
	Normal	28	53.80%	0	0.00%	
GCS	<8	8	15.4%	28	100%	<0.001
	8-12	16	30.8%	0	0%	
	13-15	28	53.8%	0	0%	
JUGULAR VEIN SAO_2	Low	24	46.20%	28	100.00%	<0.001
	Normal	28	53.80%	0	0.00%	
JUGULAR VEIN CO_2	Elevated	24	46.20%	28	100.00%	<0.001
	Normal	28	53.80%	0	0.00%	
STRENGTH	No response	0	0.00%	28	100.00%	<0.001
	Normal	28	53.80%	0	0.00%	
	Weak	24	46.20%	0	0.00%	
REFLEXES	Absent	0	0.00%	28	100.00%	<0.001
	Decreased	24	46.20%	0	0.00%	
	Normal	28	53.80%	0	0.00%	
COORDINATION	Impaired	24	46.20%	0	0.00%	<0.001
	Normal	28	53.80%	0	0.00%	
	not testable	0	0.00%	28	100.00%	
BALANCE	Impaired	16	30.80%	0	0.00%	<0.001
	Normal	24	46.20%	0	0.00%	
	not testable	8	15.40%	28	100.00%	
	Slightly impaired	4	7.70%	0	0.00%	
HEARING	Abnormal	12	23.10%	28	100.00%	<0.001
	Normal	40	76.90%	0	0.00%	
ICU ADMISSION	No	24	46.20%	0	0.00%	<0.001
	Yes	28	53.80%	28	100.00%	
SURGICAL INTERVENTION	No	40	76.9%	0	0.00%	<0.001
	Yes	12	23.1%	28	100%	

4. Discussion

Yearly, TBIs result in over 1.4 million ER visits, 275,000 hospital admissions, and 52,000 case fatalities. A meta-analysis of 15 studies involving 25,134 people found that 12% had a previous TBI. Men were more than two times as likely to have experienced a traumatic brain injury (TBI) compared to women, indicating that being male is a risk factor for TBI. Butterworth et al. discovered that the prevalence of traumatic brain injury (TBI) was only 5.7% among 7,488 patients. We do a meta-analysis of published research to investigate the frequency of TBI in the general adult-based population.[5,6,7,8]

According to the Northern Finland birth cohort study, 3.8% of the population had been hospitalized for TBI by age 35. According to the Christchurch, New Zealand birth cohort study, 31.6% of individuals had suffered at least one TBI by the age of 25, necessitating medical care such as hospitalization, emergency department visits, or physician consultations. Approximately 43.3% of Americans experience lasting impairment one year post-injury. Approximately 3.2 million US civilian people are estimated to be living with a handicap after being hospitalized for TBI.[9]

In our study, we found that the prevalence of TBI among polytrauma patients presented to our department is 68 (85%), and mortality rate was 35%; these findings were consistent with the global mortality rate associated with TBI. TBI fatality and disability worldwide account for about 30% of all collision-related deaths. In Ethiopia, TBI prevalence is 39.7%, and it is the leading reason behind mortality and disability. Okidi et al. reported a fatality rate of 33% among patients who were admitted with TBI.[6-10-11]

We found that lower systolic, diastolic, and mean arterial blood pressure, as well as shock at the time of presentation, was significantly linked to higher mortality rates (Figure 4). These findings were consistent with Okaidi et al., who found that mean arterial pressure, respiratory rate, severe form of head injury, and Glasgow coma scale were independent predictors of mortality in TBI.

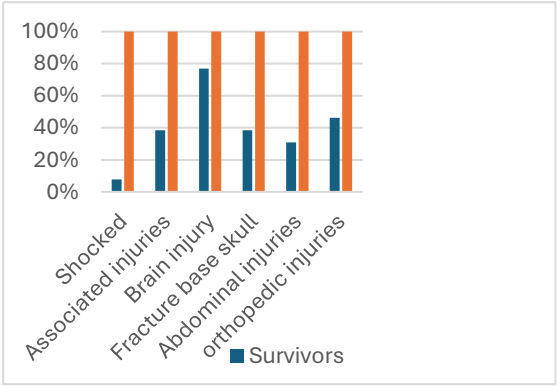

Figure 3. bar chart showing status at admission and injuries.

We found that internal jugular vein CO2 concentration was high in patients with TBI in addition to low internal jugular vein O2 concentration. Our results was similar to data

published by Okidi et al.,.[11]

We found that the most common CT finding in polytrauma patients is extradural haemorrhage, more than other features in CT 28 (38%) and found in all non-survivors.

Demlie et al. has found that severe traumatic brain injury, hypotension, coagulopathy, hyperthermia, and hyperglycemia were positively associated with mortality, which was consistent with our data.[12]

We found that CPK was significantly elevated among non-survivors compared to survivor group (Figure 4); our findings were consistent with Sowards et al., who

Found that higher CPK was an independent risk factor for fatality among TBI patients.[13]

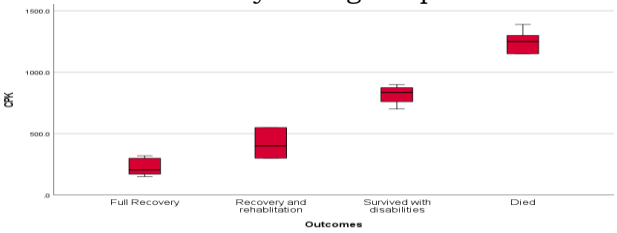

Figure 4. box plot showing association between CPK levels and clinical outcomes.

Saadat et al. investigated 2274 cases with TBI; they reported a mortality rate of 13.9%, and age, sex, Glasgow-Coma-Scale (GCS), Injury-Severity-Score (ISS), systolic, diastolic and mean arterial pressure (MAP), and respiratory-rate are all factors associated with the incidence of mortality.[14]

We realized some limitations in the current study, which included small sample size and severely traumatized patients, which included multiple types and sites of injuries among the included patients; all patients were enrolled from a single tertiary care institution, which may limit the generalizability of findings.

4. Conclusion

TBI is considered a prevalent form of polytrauma in all ER presentations. It is linked to increased hospital mortality rates. The most common CT finding in polytrauma patients was extradural haemorrhage, followed by other types of brain haemorrhage. Risk factors linked to TBI fatality were vital instability, associated injuries, elevated CPK, need for ICU admission, and surgical interventions.

Disclosure

The authors have no financial interest to declare in relation to the content of this article.

Authorship

All authors have a substantial contribution to the article

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Conflicts of interest

There are no conflicts of interest.

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