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Original Contribution

The intracranial number of foreign bodies as a predictor of mortality after penetrating brain injury

Mustafa Bolatkale, MD [a,*], Ahmet Cagdas Acara, MD [b]

[a] Medipol University Hospital, Department of Emergency Medicine, Istanbul, Turkey
[b] Bozyaka Research and Training Hospital, Department of Emergency Medicine, Izmir, Turkey

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ABSTRACT

Introduction: Penetrating brain injury (PBI) is the most lethal form of traumatic brain injury, which is a leading cause of mortality. PBI has a mortality rate of 23%–93% and 87%–100% with poor neurological status. Despite the use of various prognostic factors there is still a need for a specific prognostic factor for early prediction of mortality in PBI to reduce mortality and provide good outcomes with cost-effective surgical treatments. The aim of this study was to investigate the predictive value of the number of intracranial foreign bodies (FBs) on mortality in PBI in the Emergency Department.
Methods: The study included 95 patients admitted with PBI caused by barrel bomb explosion. The intracranial number of FB was examined by brain computed tomography. Logistic regression was used to assess the association of the intracranial number of FB on mortality. Correlation analyses were performed to investigate the association of Glasgow Coma Scale (GCS) with intracranial number of FB.
Results: The optimal cut-off value of the intracranial number of FB calculated for mortality was 2, which was effective for predicting mortality ($p < .001$). In patients with >2 intracranial FB, the mortality rate was statistically significantly 51-fold higher than those with ≤2 ($p < .001$). A statistically significant negative correlation was determined between GCS and number FB ($r = -0.697$; $p < .001$).
Conclusion: When the intracranial number of FB was >2, mortality significantly increased in patients with PBI. The intracranial number of FBs may be considered as a novel prognostic factor for the prediction of mortality in PBI.

1. Introduction

Traumatic brain injury (TBI) is the fourth leading cause of death in the USA and is the leading cause of death in persons aged 1–44 years. Approximately 2 million TBIs occur each year and the annual estimated costs for treating TBI exceed US$ 25 billion in the USA [1]. Many TBI cases are military casualties who die on the battlefield (50–70%) [2]. Penetrating brain injury (PBI) is defined as TBI which is not the result of a blunt mechanism [3]. PBI is the most lethal form of TBI and has a mortality rate ranging from 23% to 93%, with rates as high as 87%–100% in patients presenting with poor neurological status [4]. Of the 333,169 USA military TBIs recorded between 2000 and 2015, 4904 were classified as PBI [5]. Approximately 32,000–35,000 civilian deaths are attributed to PBI each year [6]. PBIs caused by explosions lead to high rates of mortality and morbidity in both civilian and military personnel. Explosives injuries are considerable clinical issues in military medicine, with a significant number of casualties being injured by improvised explosive devices in Iraq and Afghanistan [2]. In Syria, severe injuries have occurred due to barrel bomb explosives used in the war between government forces and civilians for a period of over 7 years. Understanding injury from explosives is essential for all providers of Emergency Department (ED) treatment in both civilian and military settings [7]. PBIs due to barrel bomb explosions have a poor prognosis and require prompt care [8].

A barrel bomb is a large barrel-shaped metal container that has been filled with shrapnel and high explosives [9]. Dropping these bombs from a certain height creates an uncontrolled explosion, causing military and civil injuries in the surrounding area. These devices are cheap, made from easily acquired materials, and cause devastating destruction [2]. Barrel bombs have been widely used by the Syrian air force during the Syrian civil war, bringing the weapon to public attention [10].

PBIs are very important pathologies for emergency practice due to their higher mortality and morbidity rates as well as the potential for improved patient outcomes with timely and appropriate treatment [11]. Neuroimaging is vital for surgical decision-making, the type of surgery, the size and site of craniotomy, the route for extraction of the foreign body, etc. as well as the decision to choose non-surgical management and prognosis in PBI. Computed tomography (CT)

* Corresponding author.
E-mail address: dr.mustafa46@hotmail.com (M. Bolatkale).

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scanning of the head is now the primary modality used in the neuroradiological evaluation of patients with PBI [12]. CT is the most valuable method in the detection of metallic bodies and even foreign bodies (FBs) as small as 0.06 mm^3 can be detected [13]. It gives information about complications such as parenchymal damage and bleeding. CT scan is mandatory to be able to know the extent of intracranial injuries and is essential in decision-making regarding surgical intervention [14].

Many studies have attempted to associate various prognostic factors with outcome. It has been determined that many factors affect mortality rates of PBI and the rate is particularly affected by the patient Glasgow Coma Scale (GCS), age, hypotension, coagulopathy, bilaterally fixed and dilated pupils, intracranial pressure (ICP) and several CT scan findings such as bihemispheric lesions, multilobar injuries, intraventricular hemorrhage, uncal herniation, and subarachnoid hemorrhage (SAH) [15-17]. Currently, the management of PBI represents a challenge for emergency specialists and neurosurgeons and it requires innovative planning. Early surgical intervention is important to decrease the rate of mortality and complications [18]. No consensus has been reached yet regarding an appropriate cranial firearm injuries classification and the indications for operation. Some authors have recommended aggressive surgery and rapid treatment, whereas others have advocated conservative treatment in cases of multilobular injury and a GCS < 5 [19]. Urgent surgery should be performed as there have been reports of 53% morbidity in cases of late surgery and 62% morbidity in non-operated cases [20]. Without surgical removal of the FB, patients are at increased risk of mortality and morbidity due to bleeding, increasing ICP, and intracranial infections. Nevertheless, surgical removal of the FB may itself provoke secondary parenchymal and vascular injuries [8].

The introduction of Guidelines for the Management of PBI has revolutionized the medical and surgical management of PBI during the last decade. Research in this area is highly warranted as PBI patients still present a significant challenge to ED practice worldwide [21]. However, there is still a need for further randomized controlled trials to evaluate the current guidelines to improve outcomes and reduce mortality and morbidity in patients with PBI [15]. Despite the use of various prognostic factors there is still a need for a specific and prognostic factor for early prediction of mortality in PBI to reduce mortality and provide a good outcome with cost-effective surgical treatments.

However, there are no studies in literature regarding the impact of the intracranial number of FBs in the prediction of mortality in patients with PBI due to barrel bomb explosion. The aim of the present study was to investigate the impact of the intracranial number of FBs in predicting mortality in patients who presented at the ED with PBI due to barrel bomb explosion.

2. Material-methods

Approval for this prospective study was granted by Medipol University Clinical Research Ethics Committee. The study was conducted in Kilis State Hospital ED at the border of Syria within 12 months of approval. (18.11.2015/E.3867–540).

2.1. Data collection

Evaluation was made of patients admitted to the ED and diagnosed with PBI due to barrel bomb explosion sustained in the Syrian Civil War. Patients with intracranial metallic foreign body such as shrapnel fragments were selected for the study. Evaluation was made of gender, age, mortality, GCS of the patient, prehospital intubation (PI), brain CT findings of intracranial number of FB, epidural hematoma (EDH), subdural hematoma (SDH), SAH, intracranial hemorrhage (ICH), midline shift, and pneumocephalus, with reference to the anatomical regions and localization of the skull fracture of the study group. The intracranial number of FB were examined by brain CT. The impact of the intracranial number of FB was investigated on mortality and the relationship between intracranial pathologies, GCS scores and PI in patients with PBI due to barrel bomb explosion. Logistic regression was used to assess the association of the intracranial number of FB on mortality. Correlation analyses were performed to investigate the association of GCS with intracranial number of FB. Exclusion criteria were injuries to any part of the body except the head, injury caused by gunshot, tangential head injury, no metallic shrapnel fragment in the skull and death on the battlefield or transfer within 24 h.

2.2. Statistical analysis

SPSS 22.0 (IBM Corporation, Armonk, New York, United States) and Medcalc 14 (Acacialaan 22, B-8400 Ostend, Belgium) programs were used for the analysis of the variables. Normal distribution of the data was assessed with the Shapiro-Wilk test and variance homogeneity was evaluated with the Levene test. The independent samples *t*-test with bootstrap results was used to compare two independent groups, whereas the Mann–Whitney *U* test was used with the Monte Carlo simulation technique. Fisher's exact test was used with exact results to compare categorical variables with each other. Odds ratio was used to determine the most important risk factor among categorical risk factors. Logistic regression test Enter method results were used to determine the cause-effect relationship between explanatory variables in diatom and multinomial categories and categorical response variable. Logistic regression modeling was used to assess the association of the intracranial number of FB on mortality. Sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) were analyzed and expressed by Receiver Operating Curve (ROC) analysis for the cutoff values of GCS and the number of FB according to mortality. Spearman's rho test was used to examine the correlation analysis of the variables. Quantitative variables were shown as mean ± SD (standard deviation) and median range (maximum-minimum), and categorical variables were shown as number (n) and percentage (%).Variables were examined at 95% confidence level and a value of $p < .05$ was considered statistically significant.

3. Results

During the study period, a total of 1035 patients were admitted to the ED with trauma related to an attack in the Syrian Civil War. After application of the exclusion criteria, 95 patients in the ED with PBI due to a bomb explosion were included as the study population. All patients (n:95) were treated in the ED, which included correction of hypotension and hypoxia, airway maintenance, control of any associated hemorrhaging, hyperosmolar therapy with mannitol or hypertonic saline, correction of traumatic coagulopathy, placement of a cervical immobilization device and tetanus and antibiotic prophylaxis. All patients were evaluated as emergency cases by a neurosurgeon in the ED. A total of 42/95 (44%) patients died despite the treatment in the ED and 53/95 patients survived in ED and were admitted for surgery. Of these 38 were taken for decompressive surgery and 15 for craniotomy. Perioperative mortality was seen in 10/53 patients, 4/53 patients died postoperatively in the Intensive Care Unit and 39 patients were discharged. Comparisons were made between those who survived and those who did not survive in ED. The groups were named 'Survivor' (n:53) and 'Non-survivor' (n:42). Factors affecting mortality were compared between the two groups. The impact of the intracranial number of FB on mortality was examined and an optimal cut-off value on mortality was determined by performing ROC analysis of the intracranial number of FB in the study population. The optimal cut-off value for mortality of FB was determined as 2. Two more sub-groups were formed according to this cut-off value and it was evaluated if there was a statistically significant difference between the two groups in terms of the evaluated parameters. The sub-groups were named 'FB ≤ 2' and 'FB > 2'.

Although parietal and temporal bone fracture, subdural and epidural hemorrhage, pneumocephalus, midline shift, trans-ventricular injury and brainstem involvement were related to a higher mortality rate, there was a significantly higher rate of GCS score > 8 and one lobe injury in the survivor group (*t*-test, $p < .05$) (Table 1). The optimal cut-off value of the intracranial number of FB calculated for mortality was 2, with sensitivity of 66.7%, specificity 96.2%, PPV 78.5, NPV 93.3%, the area under the curve (AUC) was 0.854 ± 0.043 and the obtained cut-off value was effective in predicting mortality ($p < .001$). In patients with >2 FB, the mortality rate was 51-fold higher than those with 2 or 1, and the difference was statistically significant (OR 51, 95% CI 10.8–240.6, $p < .001$). The optimal cut-off value of the GCS calculated for mortality was 8, with sensitivity of 90.5%, specificity 58.5%, PPV 88.6, NPV 63.3%, the AUC was 0.828 ± 0.04 and the obtained cut-off value was effective in predicting mortality ($p < .001$). In patients with GCS < 8, the mortality rate was 13.4 times higher than those with GCS ≥ 8, which was statistically significant (OR 13.4, 95% CI 4.2–42.9), ($p < .001$), (Table 2, Fig. 1). A statistically significant negative correlation was determined between GCS and the number of FB ($r = -0.697$; $p < .001$).

All variables were considered together to identify the factors associated with the number of FBs, and the factors that were directly affected by the number of FBs were determined by excluding the confounding effects. Among the factors affected by the number of FBs, GCS, EDH and midline shift were found to be statistically significant (*p*: 0.022–0.015–0.034 respectively). The GCS score was found to be 179.2-fold higher when the number of FB was ≤2 (95% CI 2.142–14,990.7, $p < .05$) Similarly, when the number of FB was >2, EDH risk was found to be increased by 123.2-fold (95% CI 2.5–6007.5, $p < .05$) and shift risk was found to be increased 3951.1-fold (95% CI 1.8–8370.9, $p < .05$), (Table 3, Fig. 2). Although EDH, SAH, midline shift, PI, trans-ventricular injury and brainstem involvement were determined to be related to a higher mortality rate, there was a significantly higher rate of frontal, parietal, temporal bone fracture, pneumocephalus, GCS > 8 and one lobe injury in the FB ≤ 2 group (*t*-test, $p < .05$) (Table 4).

4. Discussion

The results of this study indicated that mortality was significantly increased by the presence of more than two intracranial FB in patients with PBI. To the best of our knowledge, this is the first study to demonstrate that the number of FBs determined in ED is a novel sensitive, specific, prognostic factor with high PPV and NPV for predicting mortality in patients with PBI due to barrel bomb explosion.

PBI is defined as an injury with tearing of the dura mater, the outer layer of the meninges. The mortality rate for patients admitted to hospital with PBI is estimated to be 23% to 93% [4]. PBI is the most lethal form of TBI and literature on the clinical features for mortality prediction is limited [22].

Table 1
Findings of the non-survivor and survivor groups.

	N	Non-survivor	Survivor	*p* Value
Frontal bone fracture	55	28	27	.146
Parietal bone fracture	70	36	34	*.02*
Temporal bone fracture	60	34	26	*.001*
Occipital bone fracture	37	14	23	.398
Subdural hemorrhage	19	15	4	*<.001*
Epidural hemorrhage	26	20	6	*<.001*
Intracranial hemorrhage	92	41	51	1
Subarachnoid hemorrhage	19	10	9	.447
Pneumocephalus	80	42	38	*<.001*
Midline shift	23	15	8	*.029*
Prehospital intubation	26	18	8	*.005*
GCS score > 8	35	4	31	*<.001*
One lobe	25	5	20	*.005*
Two lobes	37	17	20	.834
Trans-ventricular	32	20	12	*.016*
Brainstem involvement	21	14	7	*.025*

The statistically significant p values are indicated in italics.

Table 2
ROC analysis for GCS and the number of FB.

	Survivor ($n = 53$)			Non-survivor ($n = 42$)			AUC ± SE.	Odds ratio (95% CI)	*p* Value
	n	Row N %	Column N %	n	Row N %	Column N %			
GCS									
>8	31	88.6%[c]	58.5%[b]	4	11.4%	9.5%	0.828 ± 0.040	13.4 (4.2–42.9)	<.001
≤8	22	36.7%	41.5%	38	63.3%[d]	90.5%[a]			
Number of FB									
≤2	51	78.5%[c]	96.2%[b]	14	21.5%	33.3%	0.854 ± 0.043	51 (10.8–240.6)	<.001
>2	2	6.7%	3.8%	28	93.3%[d]	66.7%[a]			

Roc (Receiver Operating Curve) Analysis (Honley&Mc Nell - Youden index J).
AUC: Area under the ROC curve Se: Standard Error C·I: Confidence interval.
[a] Sensitivity.
[b] Specificity.
[c] Positive predictive value.
[d] Negative predictive value.

A challenging aspect to the surgical management of PBI is the selection of appropriate candidates for surgery. There is extensive literature that has attempted to identify which patients may benefit from surgery [5]. Clinical and imaging features are important in the treatment approach, prognosis and decision for surgical intervention. Patients that survive reaching hospital require rapid triage and imaging evaluation. CT findings together with the GCS are typically used to determine which patients are candidates for surgery. In cases of PBI, CT findings have a significant impact on the management, treatment strategies and prognostic outcomes for these patients [17]. Clinical factors associated with poor prognostic indicators have previously been identified as advanced age, GCS < 5 post-resuscitation, high ICP, hypotension, coagulopathy, bilaterally fixed and dilated pupils, CT scan findings such as bihemispheric lesions, multilobar injuries, intraventricular hemorrhage, uncal herniation, subarachnoid hemorrhage and loss of the basal cisterns [4,5,15-17]. Other factors include the time to reach a neurosurgeon and weapon ballistics, including the caliber and proximity to the projectile source [5].

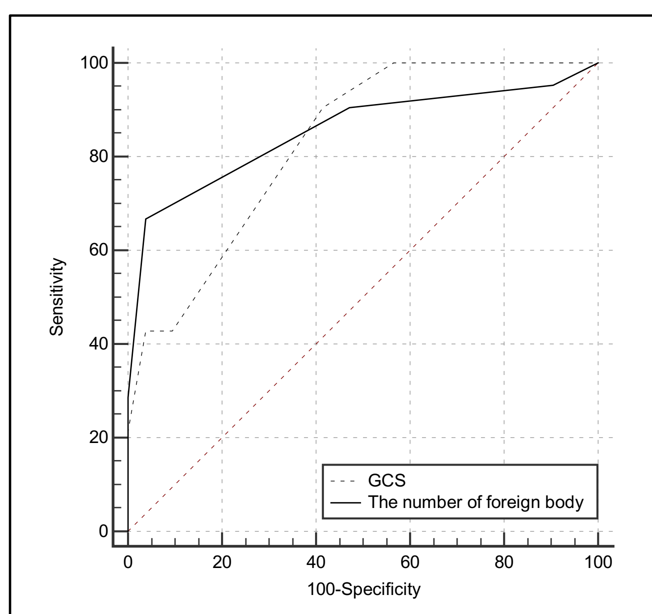

Fig. 1. Receiver operating characteristic curves of the number of FB and GCS (cut-off points are 2 and 8, respectively).

Table 3
The number of FB, GCS, EDH and shift of multiple logistic regression analysis.

	B	S.E.	*p* Value	Odds ratio	95% C.I. for odds ratio	
					Lower	Upper
GCS (≤8)	−5.189	2.259	0.022	179.212	2.142	14.990.747
EDH (+)	−4.814	1.983	0.015	123.232	2.528	6.007.542
Shift (+)	8.282	3.907	0.034	3.951.123	1.865	8.370.972.374
Dependent variable: Number of FB	Predicted (≤2) = 96.9 Predicted (>2) = 90 Predicted: 94.7					*p* Model <.001

Multiple Logistic Regression (Method = Enter) - C.I.: Confidence interval.
B: regression coefficients - Se: Standard error.

Although patients are typically triaged for surgical intervention based on the GCS, surgical management remains highly controversial [4]. GCS is currently considered to be the best single predictive factor of a good or bad outcome following PBI [5]. Patients with a GCS score of 3 with fixed pupils and patients with GCS of 4–5 with poor prognostic indicators on CT are generally not good candidates for surgery as there is only a very small chance of a favorable outcome [23]. The following are significant reasons for surgery: [24] to remove masses such as epidural, subdural, or intracerebral hematomas; [1] to remove necrotic brain and prevent further swelling and ischemia; [25] to control an active hemorrhage; and to remove necrotic tissue, metal, bone fragments or other FBs to prevent infections [26]. Indications for surgery include patients with unequal or reacting pupils, space-occupying hematoma or GCS > 5 [27]. The approach to surgery varies, with some surgeons taking a more conservative approach, while others are more aggressive. Surgical intervention should not be delayed for >12 h to reduce the risk of infectious complications [3]. Following PBI, infectious complications are common and are also associated with higher morbidity and mortality rates [28]. The risk of local wound infections, meningitis, ventriculitis, or cerebral abscess is particularly high among PBI patients because of the presence of contaminated FBs, such as skin, hair, and bone fragments driven into the brain tissue along the projectile track [3]. However, retained FBs have not been strongly associated with infection, and most authors have suggested that they should be removed only if the fragments are accessible [29]. In most cases, removal of a deep-seated bullet is not necessary, although some authors have advocated the use of computer-image guided procedures for the removal of FBs [1, 25]

Table 4
Findings of the FB ≤ 2 and FB > 2 groups.

	N	FBs ≤ 2	FBs > 2	*p* Value
Frontal bone fracture	55	32	23	*.014*
Parietal bone fracture	70	35	25	*.006*
Temporal bone fracture	60	34	26	*.001*
Occipital bone fracture	37	24	13	.652
Subdural hemorrhage	19	11	8	.282
Epidural hemorrhage	26	6	20	*<.001*
Intracranial hemorrhage	92	64	28	.234
Subarachnoid hemorrhage	19	8	11	*.011*
Pneumocephalus	80	50	30	*.002*
Midline shift	23	6	17	*<.001*
Prehospital intubation	26	6	20	*<.001*
GCS score > 8	35	34	1	*<.001*
One lobe	25	23	2	.003
Two lobes	37	28	9	.263
Trans-ventricular	32	14	18	.016
Brainstem involvement	21	10	11	.032

The statistically significant p values are indicated in italics.

A review of the literature demonstrates considerable disparity in the approach and management of PBI patients, with some taking an aggressive approach for all patients and others preferring a more supportive approach after evaluating the full clinical condition [6,11,17]. Joseph et al. recently reported a significant improvement in survival rates in patients with PBI after instituting a policy that aggressively resuscitated all patients with PBI, regardless of admission GCS [6]. Similarly, Gressot et al. performed a retrospective analysis to identify predictors of outcomes in patients with PBI and found that their data supported early aggressive surgical debridement and resuscitation of patients presenting with evidence of brain function, defined as reactive pupils, spontaneous respiration, etc. [30]. However, some authors do not advocate this aggressive approach in PBI, especially in patients presenting with a GCS of 3–5 in the absence of a hematoma causing a mass effect which would require emergent decompression [11]. Aldrich et al. recently reported that patients with a GCS score of 3–5 had a 96% mortality rate following non-surgical resuscitation, which was identical to patients with

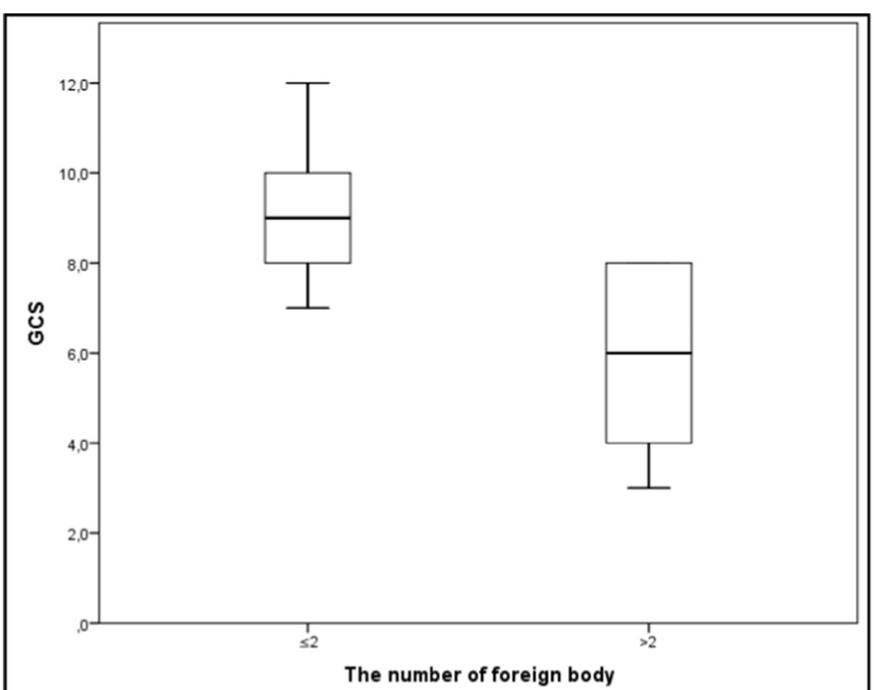

Fig. 2. Relationship between GCS and the number of FB.

the same GCS score who did not undergo resuscitation [31]. As mentioned previously, many surgeons will not operate or aggressively manage a PBI patient with a GCS of 3–5 unless there is the presence of a hematoma causing a mass effect [11] while other institutions aggressively resuscitate and manage these patients regardless of GCS or radiographic findings [6]. In the present study, when the number of FB was ≤2, GCS > 8 was associated with a significantly lower mortality rate (*t*-test, $p < .05$) (Table 4) and the GCS score was found to be 179.2-fold higher ($p < .05$) (Table 3).

Surgeons are often less aggressive with intracranial FB and bone retrieval given the increased risk of morbidity associated with deep exploration [23]. Exceptions include bullet fragments that have migrated, are located near a vascular structure, or CSF communication in a cistern or ventricle [5]. A GCS of 3–5 and/or a projectile path crossing the midline at the level of the corpus callosum, through the bilateral thalami, basal ganglia posterior fossa/brainstem or through an area 4 cm above the dorsum sellae containing the vessels indicating the Circle of Willis known as the "zona fatalis" has historically resulted in the withholding of surgical care [23]. Lateral penetrating injuries have worse outcomes when compared with antero-posterior injuries [5]. Another common indicator, the "tram track sign" or a hypodense wound track with hyperdense blood on either side has been associated with poor outcomes [23]. Intracranial FBs may contain metals that cause electrolysis, may predispose to fibroglial scarring with secondary epilepsy, or may migrate within the intracranial or intraspinal compartments [29]. Vascular complication rates after PBI range from <5%–40% in various reports [15, 32]. The frequency of SAH in PBI patients ranges from 31% to 78%. The presence of SAH after PBI has been documented to correlate significantly with mortality. In addition, SAH near large vascular territories and intraventricular hemorrhage may lead to poor outcomes [33]. In the present study, when the number of FB was >2, EDH and SAH were related to a significantly higher mortality rate (*t*-test, $p < .05$) (Table 4) and the EDH risk was found to be increased 123.2-fold (95% CI 2.5–6007.5, $p < .05$) (Table 3).

Although there has been a paradigm shift toward less aggressive debridement of deep seated FBs, a more aggressive antibiotic prophylaxis approach is taken in an effort to improve outcomes [15]. Nevertheless, concern has developed that because patients who present in coma are thought to have a poor prognosis, less aggressive management is often used, contributing to the poorer outcome [5]. Once predictive and prognostic factors of mortality for PBI are better understood, the appropriate emergency treatment combined with surgical intervention may improve outcomes. This early prediction of mortality by intracranial number of FB is important as it may improve the ability for risk classification of patients with PBI and guide surgical intervention decisions. If these results are confirmed by further studies, the use of intracranial number of FB for predicting mortality may improve current medical and surgical treatment strategies for PBI due to bomb explosion. GCS is historically a strong predictor of mortality, and the number of FB may further assist the physician in decision-making regarding surgical intervention while awaiting laboratory results [5, 17].

In the present study, it has been has demonstrated for the first time that intracranial number of FB > 2 on admission is an independent predictor of mortality for PBI. The hypothesis was confirmed that number of FB may be useful as a predictive and prognostic factor for mortality of PBI because it can indicate the severity of the risk of mortality in patients with PBI.

5. Conclusion

Improvements in the understanding of the prognosis and prediction of mortality in the medical and surgical management of patients with these injuries may lead to improved outcomes. Early diagnosis and the initiation of appropriate surgical therapy within 12 h are essential to reduce PBI-related morbidity and mortality [18]. When combined with previously established mortality risk factors in patients with PBI, the results of this study demonstrated that the intracranial number of FB could be used to identify patients with potentially worse outcomes. Moreover, patients with PBI and intracranial FBs ≤ 2 have significantly lower mortality. The earlier prediction of a good prognosis can gain time for the physician as an opportunity for surgical interventions in patients to preserve organ function and improve outcomes

6. Study limitations

This study has some limitations, primarily that the patients were followed up for only 24 h and information about long-term complications was not available. The mortality rates of PBI are influenced significantly by a wide array of variables, including coagulopathy and hypothermia. However, it was not possible in this study to control all the variables that could influence mortality in PBI cases. Other than GCS and brain CT findings, there was no comparison of other predictive factors in the prediction of mortality in PBI. The GCS was calculated on initial ED arrival, therefore prehospital sedation medications could have depressed the GCS. In our hospital the CT does not have the capacity for angiography so vessel injury in patients with PBI could not be discounted. It was also not possible to perform ICP probe and external ventricular drainage in the ED. Only metallic intracranial FBs were taken into consideration in this study because magnetic resonance imaging (MRI) is generally not recommended for use in the acute management of PBI as it is time-consuming and contra-indicated in patients with metallic FBs. However, MRI can be a useful neuroradiological modality if the PBI is caused by a wooden object [4].

Conflict of interests

The author(s) declare no potential conflict of interests in respect of the research, authorship, and/or publication of this article.

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