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Clinical Outcomes and Imaging Features of Traumatic Brain Injuries in Intensive Care Unit

Yoğun Bakım Ünitesinde Travmatik Beyin Hasarının Klinik Sonuçları ve Görüntüleme Özellikleri

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ABSTRACT

Objective: To analyse demographic data, aetiological factors and the clinical status of traumatic brain injury (TBI) patients in an intensive care unit, and to investigate relationships between clinical status and imaging findings.
Methods: Sixty-seven TBI patients who were treated and followed-up in the intensive care unit from January 2010 to February 2016 were enrolled in this study. Patients were divided into groups according to TBI severity, Glasgow outcome score and mortality status. Duration of hospitalisation in the intensive care unit, trauma aetiology, intubation status and duration, mannitol administration and duration, tracheostomy opening, intracranial pathology and surgical data were analysed. Radiologically, epidural, subdural, subarachnoid, parenchymal haemorrhage and diffuse axonal injury (DAI) indices were evaluated.
Results: Sixty-seven (18 female, 49 male) patients with a mean age of 33.8 ± 20.3 years were included. The mean Glasgow coma score of patients upon admission was 6.2 ± 4.3. TBI, Glasgow outcome score and mortality did not differ in terms of age and gender distribution. Subarachnoid haemorrhage was the most common radiological finding (56.7%). DAI was significantly higher in the severe TBI group ($p = 0.028$) and was found to be a risk factor for severe TBI development ($r = 0.276$, $p = 0.024$). Admission Glasgow coma scores were significantly lower in both non-survivor and negative Glasgow outcome score groups ($p < 0.001$ and $p < 0.001$, respectively).
Conclusion: Various factors affect TBI prognosis. DAI is an independent risk factor for severe TBI. Diffusion weighted imaging should be performed in patients with suspected DAI.
Keywords: glasgow coma score, glasgow outcome score, imaging, intensive care, traumatic brain injury

ÖZ

Giriş: Yoğun bakım ünitesinde bulunan travmatik beyin hasarı (TBH) hastalarının demografik verilerini, etiyolojik faktörlerini, klinik durumunu analiz etmek ve klinik durum ile görüntüleme bulguları arasındaki ilişkileri araştırmak.
Yönem: Ocak 2010'dan Şubat 2016'ya kadar yoğun bakım ünitesinde tedavi edilen 67 TBH hastası bu çalışmaya dahil edildi. Hastalar TBH şiddeti, Glasgow sonuç skoru ve mortalite durumuna göre gruplara ayrıldı. Yoğun bakımda yatış süresi, travma etiyolojisi, entübasyon durumu ve süresi, mannitol uygulaması ve süresi, intrakraniyal patoloji, trakeotomi ve kraniektomi durumu incelendi. Radyolojik olarak epidural, subdural, subaraknoid, parankimal hemoraji ve diffüz aksonal hasar (DAH) değerlendirildi.
Bulgular: Çalışmaya ortalama yaşı 33,8 ± 20,3 yıl olan 67 (18 kadın, 49 erkek) hasta dahil edildi. Hastaların başvuru anında ortalama Glasgow koma skoru 6,2 ± 4,3 idi. TBH, Glasgow sonuç skoru ve mortalite yaş ve cinsiyet dağılımı açısından farklılık göstermedi. Subaraknoid kanama en sık görülen radyolojik bulguydu (%56,7). DAH, şiddetli TBH grubunda anlamlı olarak daha yüksekti ($p = 0,028$) ve şiddetli TBH gelişimi için bir risk faktörü olduğu bulundu ($r = 0,276$, $p = 0,024$). Başvuru Glasgow koma skoru hem sağ kalmayan hem de negatif Glasgow sonuç skoru gruplarında anlamlı olarak daha düşüktü (sırasıyla $p < 0,001$ ve $p < 0,001$).
Sonuç: TBH prognozunu çeşitli faktörler etkiler. DAH, şiddetli TBH için bağımsız bir risk faktörüdür. DAH şüphesi olan hastalarda difüzyon ağırlıklı görüntüleme yapılmalıdır.
A**nahtar Kelimeler:** glasgow koma skoru, glasgow sonuç skoru, görüntüleme, yoğun bakım, travmatik beyin hasarı

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INTRODUCTION

Head trauma is one of the most important public health issues in the world, in terms of death and disability in young people (1). According to data from the United States, every year 1.4 million people suffer from traumatic brain injury (TBI), of which 1.1 million are referred to emergency hospital services, with 235,000 hospitalised. According to this data, the annual mortality for TBI patients is approximately 50,000 patients (1). Worldwide, it is reported that on average, 10 million people are treated for TBI annually (2). Fifty-seven million people are known to have been hospitalised for one or more TBIs at any stage of their lives. In Turkey, there is a dearth of studies on the prevalence, incidence and epidemiology of TBI. According to some studies that have been published in a Turkish literature, head traumas are caused by traffic accidents, falls, occupational accidents and gunshot wounds. To prevent head trauma and provide effective treatments post-injury, more in-depth investigations are required in this area (2).

Here, we analysed demographic data from patients treated for TBI in an Intensive Care Unit (ICU) setting and investigated correlations between clinical and imaging findings.

MATERIAL and METHODS

This retrospective study was approved by local ethics committee with waived informed consent. A retrospective database search was performed. TBI patients who were treated and followed-up at our ICU between January 2010 and February 2017 were enrolled in the study. All age groups were included. Those patients with major thoracic and abdominal injuries that could affect the mortality were excluded. Age, gender, Glasgow coma score (GCS) at the time of hospitalisation and discharge, ICU stay, trauma aetiology, intubation status and duration, mannitol administration status and duration, tracheostomy opening, intracranial pathology and surgical data were evaluated. Glasgow outcome scores (GOS) were recorded at the third month.

Patients with TBI are graded as mild, moderate and severe TBI. However, since the number of patients with moderate TBI was relatively low (n = 4), the groups were rearranged as severe TBI and non-severe TBI. The patients were divided into two groups according to their GOS values. Patients with a GOS value of 1, 2 and 3 constituted the GOS I group, that is, a negative clinical outcome group, patients with a GOS value of 4 and 5 constituted the GOS II group, that is, a positive clinical outcome group. In addition, patients were evaluated in two groups as survived and non-survived.

IBM SPSS Version 21.0 package program was used for statistical analysis. Numerical variables are shown as mean ± standard deviation, and categorical variables as number and percentage. Whether numerical values show normal distribution was examined by One-Sample Kolmogorov-Smirnov test. While comparing the numerical values of the two independent groups, those who did not show normal distribution were evaluated with the Mann Whitney U test. When comparing the categorical values of the two groups, Chi-square and Fisher Exact test were used. Pearson test was used in the correlation analysis. Multivariate stepwise logistic regression

analysis was used to calculate risk factors. Significance level was accepted as p <0.05.

RESULTS

The study population included 67 patients. The mean age of the patients was 33.8 ± 20.3 (range = 3 months–78 years). The mean GCS at admission for all patients was 6.2 ± 4.3, and the mean GCS of 44 surviving patients was 11.5 ± 2.8. The mean hospitalisation duration was 15.3 ± 17.5 days (range = 1–70 days). Patient demographic and clinical characteristics are shown (Table 1).

Table 1. Patient Demographics and Clinical Data

Characteristics	Results (n, mean ± SD)	%
Age	33.8 ± 20.3	
Gender (F/M)	18/49	
GCS admission	6.2 ± 4.3	
GCS discharge	11.5 ± 2.8	
Length of stay (days)	15.3 ± 17.5	
TBI Group		
Severe	50	74.6
Non-severe	17	25.4
Intubation	58	86.6
Intubation Time (day)	6.5 ± 5	
Tracheostomy	18	26.9
Mannitol treatment	18	26.9
Mannitol duration (days)	3.1 ± 19	
Cranial surgery	11	16.4
Aetiology		
Traffic accident	57	85.1
Falls	8	11.9
Trauma	1	1.5
Occupational accident	1	1.5
Mortality	23	34.3
GOS 1	23	34.3
GOS 2	14	20.9
GOS 3	8	11.9
GOS 4	8	11.9
GOS 5	14	20.9

Categorical variables are shown as n (%). Continuous variables are shown as mean ± standard deviation.GCS: Glasgow coma score, GOS: Glasgow outcome score.

Patient cranial computed tomography (CT) and magnetic resonance imaging (MRI) findings are shown (Table 2). Subarachnoid haemorrhage was the most common radiological finding (n = 38, 56.7%). Diffuse axonal injury (DAI), which was considered the most serious finding, was detected in 18 patients (26.9%).

Fifty patients (74.6%) were classified with severe TBI, and 17 (25.4%) were classified as non-severe TBI. In the severe TBI group, all patients were intubated, whereas eight (47.1%) in the non-severe group were intubated. The rate of intubation was significantly higher in the severe TBI group (p < 0.001).

Seventeen patients (34%) underwent tracheostomy in the severe TBI group, whereas one patient (5.9%) in the non-severe group had this procedure. The tracheostomy rate was significantly higher in the severe TBI group (p = 0.028).

Group comparisons in terms of radiological findings is provided (Table 2). In the severe TBI group, the number of patients who developed DAI was significantly higher than the non-severe group (p = 0.028). Comparisons of radiological findings according to GOS groups are shown (Table 2). The epidural haematoma rate was significantly more frequent in the GOS II group than the GOS I group (p = 0.034). No significant differences were observed between groups in terms of other radiological findings.

Table 2. Radiological Comparisons between Severe/non-severe TBI Groups and GOS I/ II Groups.

	n	%	Severe TBI (n =50)		Non severe TBI (n = 17)		P	GOS I (n = 45)		GOS II (n = 22)		P
			n	%	n	%		n	%	n	%	
EH	7	10.4	3	6	4	23.5	0.063	2	4.4	5	22.7	0.034
SH	25	37.3	18	36	7	41.2	0.703	18	40	7	31.8	0.516
SAH	38	56.7	29	58	9	52.9	0.716	27	60	11	50	0.438
PH	22	32.8	17	34	5	29.4	0.728	15	33.3	7	31.8	0.901
DAI	18	26.9	17	34	1	5.9	0.028	12	26.7	6	27.3	0.958

Categorical variables are shown as n (%). Continuous variables are shown as mean ± standard deviation.TBI: traumatic brain injury, EH: epidural haematoma, SH: subdural haematoma, SAH: subarachnoid haemorrhage, PH: parenchymal haemorrhage, DAI: diffuse axonal injury.

In the severe TBI group, 17 (34%) patients were administered mannitol, whereas this procedure occurred for one (5.9%) patient in the non-severe group. The mannitol application

rate was significantly higher in the severe TBI group (p = 0.028). Twenty-two patients (44%) in the severe TBI group died, whereas in the non-severe group, one (5.6%) patient died. When we compared groups according to mortality rates, the rate was significantly higher in the severe TBI group (p = 0.004). A comparison of group demographics and clinical parameters is provided (Table 3).

Table 3. Comparisons between Severe and Non-severe TBI Groups in terms of Patient Demographics and Clinical Parameters

Characteristics	Severe TBI (n=50)		Non-severe TBI (n=17)		P
	n	%	n	%	
Age(mean±SD)	32.4±20.9		37.9±18.5		0.173
Gender (F/M)	13/37		5/12		0.762
Length of stay	17.6±17.5		8.6±16.1		0.044

Intubation	50	100	8	47.1	<0.001
Tracheostomy	17	34	1	5.9	0.028
Mannitol	17	34	1	5.9	0.028
Cranial surgery	7	14	4	23.5	0.451
GOS I/II	40/10		5/12		<0.001
Mortality	22	44	1	5.9	0.004

Categorical variables are shown as n (%). Continuous variables are shown as mean ± standard deviation.GOS: Glasgow outcome score.

Forty-five (67.2%) patients were in the GOS I group and 22 (32.8%) were in the GOS II group. 44 patients were in surviving group and 23 patients were in non-surviving group. Twenty-two (50%) of surviving patients were included in the GOS I group. Patients across groups were similar in terms of age and gender distribution (Table 4). The mean GOS for patients in the GOS I group was significantly lower than the GOS II group ($p < 0.001$). Intubation and tracheostomy rates were significantly higher in the GOS I than the GOS II group ($p = 0.004$, and $p = 0.022$, respectively). Twenty-three (34.3%) patients who were followed-up because of TBI, died in the ICU. Mean GCS at the time of admission and the time of staying in ICU were significantly lower in non-surviving group ($p < 0.001$ and $p < 0.001$, respectively). While all non-surviving patients were intubated, this rate was 79.5% in alive patients ($p = 0.023$). Tracheostomy was performed in 36.4% of surviving patients, whereas this rate was 8.7% in non-surviving patients ($p = 0.015$). In terms of radiological findings, there were no differences between alive patients and those who died.

Table 4. Comparisons of Patients According to GOS Groups and Mortality

Characteristics	**GOS I (n=45)**		**GOS II (n=22)**		**P**	**Survive(n=44)**		**Non-survive(n=23)**	
	n	**%**	**n**	**%**		**n**	**%**	**n**	**%**
Age (mean±SD)	35.4±21.8		30.5±17.0		0.602	32.5±18.7		36.2±23.3	
Gender F/M	12/33		6/16		0.958	13/31		5/18	
GCS admission	4.6±3.0		9.5±4.9		<0.001	7.5±4.7		3.8±2.1	
Length of stay	18.6±20.0		8.4±7.2		0.272	20.2±19.4		5.8±6.2	
Intubation	43	95.6	15	68.2	0.004	35	79.5	23	100
Tracheostomy	16	35.6	2	9.1	0.022	16	36.4	2	8.7
Mannitol	12	26.7	6	27.3	0.958	10	22.7	8	34.8
Cranial surgery	7	15.6	4	18.2	0.785	8	18.2	3	13

Categorical variables are shown as n (%). Continuous variables are shown as mean ± standard deviation. GOS: Glasgow outcome score. GCS: Glasgow coma score.

DISCUSSION

The incidence of TBI leading to high mortality and disability is 538 per 100,000 in the US, and 235 per 100,000 in European countries (3). Approximately 25% of patients who survive after a TBI, can continue to function independently in the long term (4).

Previous reports have indicated that the most common age group for a TBI is 0–4 years, followed by adolescents, and young adults aged between 15 and 24. Another common age group is > 65 years (1). However, in general the mean age of patients is variable. One study reported a mean age of 22, whereas another reported 49 (5, 6). In our study, patients were heterogeneous with respect to age distribution; the youngest patient was three months old, and the oldest was 78, with a mean age of 33.8 years. This mean was also affected by the patient age policy at our ICU; patients of all age groups were accepted regardless of agFor many trauma injuries, the TBI incidence is higher in men than women. This rate varies between 2-2.8/1 (7). In our study group, this ratio was 2.7/1, in accordance with the literature. This gender distribution difference may be attributed to different factors such as lifestyle, differences in business life, and socio-cultural orientation. In Turkey, TBI is more prevalent in men, due to the fact that men are more active in their working lives, their jobs are more risk prone, and their status in social life and due to many variables.

In the literature, falls and traffic accidents are reported as the most common cause of TBI. Falls are the most common aetiology in developed countries, whereas traffic accidents are most common cause of TBI in low and middle-income countries (1, 8, 9).In our patient group, traffic accidents were the leading cause of TBI aetiology, with an 85% frequency. This was followed by falls, but the difference was quite large.

Early intubation is generally recommended for patients with a GCS ≤ 8. The intrinsic value of intubation, performed before admission to hospital, is controversial because of conflicting results from the literature (10). Hyperventilation, temporary hypoxia, delayed transfer to hospital, and hemodynamic instability caused by intubation are listed as the causes of poor clinical results It is believed mask ventilation is more beneficial, if experienced staff are unavailable (11, 12). In our study, the mean GCS was 6.2 upon admission. Patient percentages with GCS at ≤ 8 at admission was 74.6% and all were intubated. The longer the intubation time, the increased complication rate secondary to intubation, with tracheostomy indicated. The mean duration for intubation was 6.5 days in our patients, with 31% having indications for tracheostomy.

Hyperosmolar therapies (mannitol and hypertonic saline) reduce intracranial pressure (ICP) by generating osmolar differences. Mannitol is the most commonly used agent for this purpose, and has been shown to improve cerebral blood flow (13). Serum osmolarity, fluid balance, renal functions and electrolytes should be monitored closely when administering mannitol. According to the TBI guidelines of the Brain Trauma Association, the use of mannitol is recommended if there is increased ICP (14). In our study, mannitol was used in 26.9% of patients, and almost all were in the severe TBI group. There was no difference between

the groups according to GOS and mortality status in terms of mannitol using status.

Emerging decompressive craniectomy may be life-saving for severe TBI cases (15). In the 2016 Randomised Evaluation of Surgery with Craniectomy for Uncontrollable Elevation of Intracranial Pressure (RESCUEicp) study on 408 patients, mortality and severe disability rates were lower in patients undergoing decompressive craniectomy in the 6th month of evaluation, in the presence of TBI and refractory intracranial hypertension (15). In our study, 16.4% of patients underwent cranial surgery, with no differences between groups in terms of the distribution of TBI, GOS and mortality.

The clinical course of TBI is influenced by several factors such as patient characteristics, TBI severity, medical complications and a secondary brain injury. Equally, GCS values, midline shifts, pupil findings, age, comorbid injuries and complications, hypotension, fever, increased ICP, low cerebral perfusion pressure and bleeding diathesis are reported as determinants for negative clinical outcomes (16). In cohort studies, mortality rates were approximately 30% in patients with severe TBI. Only 25% of survivors were functionally independent in the long term. Between 5 and 15% of patients followed-up for severe TBI were discharged in a vegetative state (17). In our study, the mortality rate was 34%, similar to the literature, and the present GCS values were significantly lower in the non-surviving group. 95% of non-surviving patients were in the severe TBI group. However, although the mean age of non-surviving patients was higher than survivors, this difference was not significant. The mean GCS of non-surviving patients was 3.8. Interestingly, the entire group was intubated, suggesting that clinical conditions for this group were very severe, culminating in early mortality (mean 5.8 days). The mean duration of hospitalisation was approximately four times higher in surviving patients than non-surviving patients. Similarly, the rate of tracheostomy was higher in the surviving group because tracheostomy was indicated in intubated patients with prolonged hospitalisation.

In a multicentre, prospective study in the Netherlands, epidemiological findings, TBI severity classification and clinical outcomes of 508 TBI patients were evaluated (18). Similar to our findings, the most common intracranial pathologies identified were subarachnoid haemorrhage (43%) and subdural haematoma (39%). Their mortality rate was 38% in the severe TBI group, and 11% in the non-severe group. In our study, mortality was 34% in the severe TBI group, and 5.9% in the non-severe group. In other similar studies, mortality was approximately 40% in the severe TBI group, and approximately 1% in the non-severe group (19). When we evaluated mortality rates according to TBI groups, our results were similar to the literature. Although the causes of TBI in our country and our study differed to European and US perspectives, the similar mortality rates in our cohort suggested that TBI aetiology did not affect mortality.

The effects of intracranial pathologies on TBI prognoses have been investigated previously. It was reported that patients with subdural haematoma have poor prognosis and higher mortality rates (20, 21). In addition, previous studies have reported that DAI is the most

important determinant for morbidity and mortality in TBI patients, and it is the most important cause of post-traumatic coma, disability and continuous vegetative status (22). In our study, the subdural haematoma rate was significantly higher in non-surviving patients, although no differences were observed for other radiological findings between non-surviving and surviving patients. However, when we compared patients according to TBI severity, the DAI rate was significantly higher in the severe TBI group ($p = 0.024$). Moreover, DAI was an independent predictor of severe TBI in the regression model used to identify intracranial pathology determining the degree of TBI.

Approximately 35–50% of patients admitted to ICU with severe TBI die, while those discharged must live with severe neurological disabilities. Only 25% of discharged group can continue to function independently in the long term (4). Unfortunately, no model has been developed to predict the long-term outcomes for TBI patients. To determine the disability/dependency status of patients during or after discharge, GOS values are used. In a study investigating prognostic factors on six-month GOS value, 8,721 moderate and severe TBI patients were evaluated. The present GCS value and pupil reactivity were strongly correlated with six-month GOS values (23). In a similar study, discharge GCS values were good predictors for one-year GOS values (24). In our study, we calculated GOS values at the third month, and divided patients into two groups; negative and positive GOS (GOS I/ II), similar to other studies (23, 24). Consistent with the literature, our mean GCS values were significantly lower in the negative GOS group (GOS I). In addition, intubation and tracheostomy rates were higher in the GOS I consistent with the clinical severity of TBI in the patient.In an original study with an 107 unknown patients with traumatic brain injury, GOS positive group (GOS II) were evaluated 37.4% , similar to our study, 32.8%(25).

This retrospective study reported demographic, clinical and radiological findings for TBI patients in ICU in a Turkish context. Several factors were identified that affected clinical outcomes in TBI. Further prospective and randomised studies investigating prognosis and prognosis related factors for TBI are required in the future.

Ethics Committee Approval: Ethical approval was obtained. Kocaeli Univesity Clinical Research Ethics Committee (14/07/2015 date and 19/13 number)
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