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CLINICAL STUDY

The initial factors affecting in-hospital mortality rate of patients undergoing surgery for post-traumatic extra-axial hematomas

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ABSTRACT

INTRODUCTION: Traumatic brain injury (TBI) is one of the most important causes of disability and death among young adults and referred to as “silent” epidemic. The most frequent consequences of a TBI are extra-axial hematomas, comprising of acute subdural (SDH) and epidural hematoma (EDH). Most of the factors affecting the mortality have been analyzed in a wide group of TBI. The aim of this study is to identify factors affecting in-hospital mortality in patients undergoing surgery for acute traumatic subdural and epidural hematoma.

PATIENTS AND METHODS: The study included 128 patients operated on due to extra-axial hematomas. Twenty-eight patients were operated on for EDH and 100 on for SDH. Patients were treated at the Department of Neurosurgery Medical University in Lublin, during almost three years. The following factors were analyzed: demographic data, physiological factors, laboratory factors, computed tomography scan characteristics and time between the trauma and the surgery. All the factors were correlated with in-hospital mortality rate.

RESULTS: The univariate analysis has confirmed the influence of many factors affecting the in-hospital mortality.

CONCLUSION: It is interesting that factors such as GSC score, systolic blood pressure, respiratory rate and glycemia were associated with in-hospital mortality rate with highly statistically significant differences *(Tab. 3, Fig. 2, Ref. 40)*. Text in PDF *www.elis.sk*

KEY WORDS: traumatic brain injury, epidural hematoma, subdural hematoma, factors, mortality.

Introduction

Head injury is one of the most important causes of disability and death among young adults. It is estimated that about sixty-nine million people around the world experience traumatic brain injury (TBI) every year (1). The Center for Disease Control and Prevention described the TBI as a “silent” epidemic “of developed countries (2). One of the most common consequences of severe TBI are extra-axial hemorrhages, i.e. an acute subdural (SDH) and epidural hematoma (EDH). Treatment usually includes surgical removal of the hematoma (3). The prognosis after head injury is difficult to determine as it is captured in the Hippocratic aphorism, ‘No head injury is too severe to despair of, nor too trivial to ignore’ (3, 4). In hospital mortality rate after this type of injury is difficult to predict, but usually high. Most of the factors affecting mortality have been analyzed in a broad group of TBI. There are few studies that analyze initial factors affecting TBI mortality complicated by extra-axial hematomas. The aim of this study is to identify factors affecting in-hospital mortality in patients undergoing surgery for acute traumatic subdural and epidural hematoma.

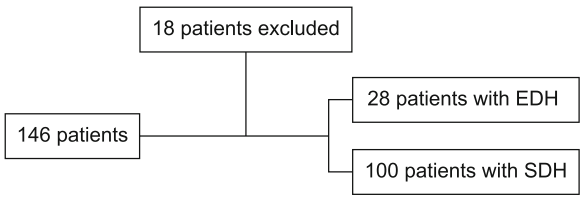

Fig. 1. Patients inclusion scheme.

Patients and methods

Of all 146 patients operated on for extra-axial hematoma, 128 patients were included in the study. Two groups were formed, 100 patients were treated for acute subdural hematoma (SDH group), and 28 patients for epidural hematoma (EDH group). All patients were treated at the Department of Neurosurgery and Pediatric Neurosurgery of the Independent Public Clinical Hospital No. 4 (IPCH

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Tab. 1. Impact of factors on in-hospital mortality rate in the EDH group.

Group of factors	Factors		Death n (%)	Alive n (%)	p
Demographic data	Gender	Men	2 (7.69%)	24 (92.31%)	0.5
		Women	1 (50%)	1 (50%)	
	Age	≤35 years old	0 (0%)	10 (100%)	0.47
		>36 years old	3 (16.67%)	15 (83.33%)	
Physiological factors	GCS score	3–8 score GCS	3 (33.33%)	6 (66.67%)	0.03*
		9–15 score GCS	0 (0%)	19 (100%)	
	Pupil reaction	Normal	1 (5.26%)	18 (94.74%)	0.48
		unreactive one or both	2 (22.22%)	7 (77.78%)	
	Saturation	>96 %	1 (4.35%)	22 (95.65%)	0.12
		≤96 %	2 (40%)	3 (60%)	
	Systolic blood pressure	90–140 mmHg	1 (5.56%)	17 (94.44%)	0.58
		<89 or >141 mmHg	2 (20%)	8 (80%)	
	Heart rate	60–120 pulse	1 (5%)	19 (95%)	0.03*
		<59 or > 121 pulse	3 (37.5%)	5 (62.5%)	
	Respiratory rate	10–25 breaths per minute	1 (4.55%)	21 (95.45%)	0.2
		<9 or >26 breaths per minute	2 (33.33%)	4 (66.67%)	
Laboratory factors	WBC	4.8–10.8x10^3/mm^3	1 (11.11%)	8 (88.88%)	0.54
		<4.7 or >10.9x10^3/mm^3	2 (10.53%)	17 (89.47%)	
	HGB	12–18mg/dl	2 (9.52%)	19 (90.48%)	0.72
		<11 mg/dl	1 (14.29%)	6 (85.71%)	
	PLT	130–400x x10^3/mm^3	1 (4.55%)	21 (95.45%)	0.20
		<129 or >401 x10^3/mm^3	2 (33.33%)	4 (66.67%)	
	Glycaemia	70–110 mg/dl	0 (0%)	7 (100%)	0.72
		>111mg/dl	3 (14.29%)	18 (85.71%)	
	Sodium	135–157mEq/lt	1 (4%)	24 (96%)	0.02*
		<134 mEq/lt	2 (66.67%)	1 (33.33%)	
	Coagulopathy	INR≤1.2 or PT≤12.7 s	18 (90%)	2 (10%)	0.85
		INR>1.3 or PT>12.8 s	7 (87.5%)	1 (12.5%)	
	Ethanol	≤0.5 $^{0}/_{00}$	1 (11.11%)	8 (88.89%)	0.54
		>0.6 $^{0}/_{00}$	2 (10.53%)	17 (89.47%)	
Computer Tomography scan characteristics	Skull fracture	Present	2 (10%)	18 (90%)	0.63
		Absent	1 (12.5%)	7 (87.5%)	
	SAH	Present	3 (27.27%)	8 (72.73%)	0.10
		Absent	0 (0%)	17 (100%)	
	IPH	Present	1 (6.25%)	15 (93.75%)	0.79
		Absent	2 (16.67%)	10 (83.33%)	
	IVH	Present	1 (33.33%)	2 (66.67%)	0.72
		Absent	2 (8%)	23 (92%)	
	Basal cistern	Normal size	0 (0%)	9 (100%)	0.02*
		Compressed and absent	3 (15.79%)	16 (84.21%)	
	Hematoma thickness	<30 mm	1 (5.56%)	17 (94.44%)	0.10
		>31 mm	3 (30%)	7 (70%)	
	MLS	<10 mm	0 (0%)	23 (100%)	00.06*
		>11 mm	3 (50%)	3 (50%)	
Time injury – surgery		≤4 hours	1 (14.29%)	6 (85.71%)	0.51
		5–9 hours	2 (15.38%)	11 (84.62%)	
		≥10 hours	0 (0%)	8 (100%)	

…. – normal value of physiological factors and reference values of laboratory factors
* statistically significant value

4) in Lublin from 1.10.2014 to 31.08.2017. Exclusion criteria for the examined group of patients included: lack of complete medical documentation, incomplete laboratory tests, lack of computed tomography description of the head (Fig. 1).

All factors were collected retrospectively at the admission of patients at the emergency department (ED) IPCH 4 in Lublin. The following factors from the groups were analyzed: demographic data, physiological factors, laboratory factors, computed tomography scan characteristics and the time between trauma and surgery. The records were examined for demographic data, such as gender and age. Physiological factors included initial GCS, pupil reaction to light, saturation, systolic blood pressure (SBP), heart rate (HR) and respiratory rate (RR) (normal or abnormal value). Laboratory factors included the number of white blood cells (WBC), hemoglobin (HGB) value, number of platelets (PLT), glycemia value, sodium concentration, coagulopathy and alcohol levels. Laboratory

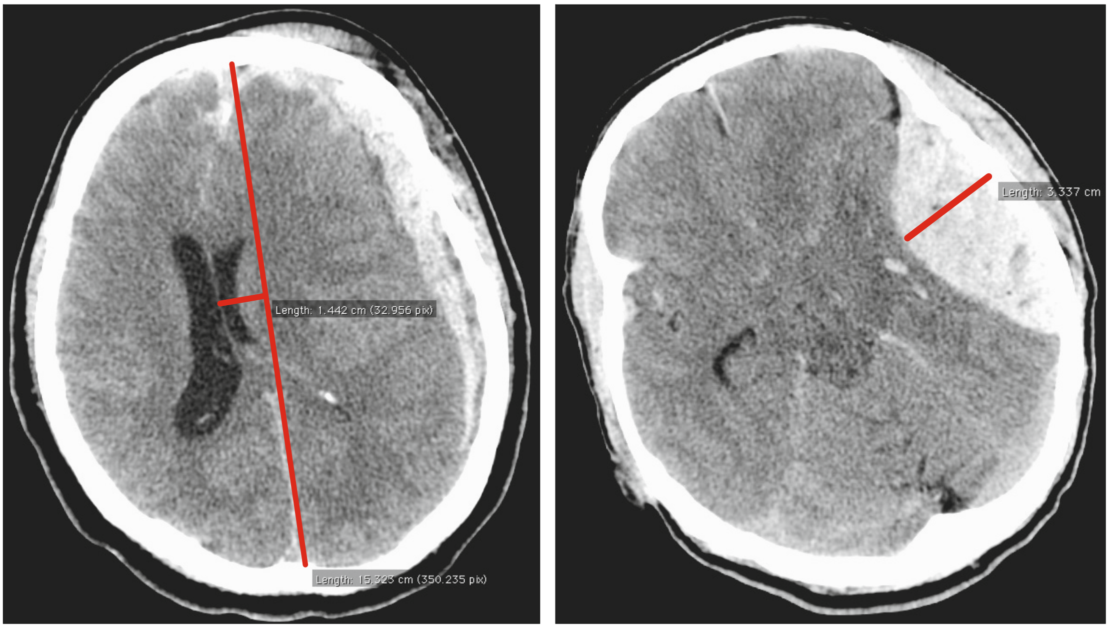

Fig. 2. Subdural hematoma with midline shift of 14 mm and epidural hematoma with maximum thickness of 33 mm.

factors, similarly to physiological factors, were analyzed on the basis of two groups: normal values and outstanding ones (Tab. 1). Additionally, the influence of coagulopathy and the state after alcohol intoxication on the prognosis were examined. Coagulopathy was defined as INR > 1.2 or PT > 12.7 s. For the state of intoxication, the alcohol concentration was higher than 0.5 ‰. Each patient included in the study had a computed tomography (CT) of the head as soon as it was possible. The study contained particular characteristics from the CT, such as the present skull fracture, subarachnoid hemorrhage (SAH), intraventricular hemorrhage (IVH), intraparenchymal hemorrhage (IPH), maximum thickness of the hematoma, midline shift (MLS) and obliteration basal cistern. Skull fracture, SAH, IVH and IPH were analyzed in two categories, either present or absent. The maximum hematoma thickness and MLS were calculated using the Ozirix version 2.5 program based on cross sections from the pre-operative CT scan (Fig. 2). Basal cisterns were examined in three categories, namely a normal size, the compressed one and the absent one. The last factor was the time between the injury and the surgery.

We investigated the in-hospitality mortality of patients at the time of discharge.

Statistical analysis

Statistical analysis correlated all of the factors with in-hospital mortality rate. The obtained results of the tests were subjected to statistical analysis. To compare two independent groups the Mann–Whitney U test was performed. The Chi^2 homogeneity test was performed to detect differences in unrelated qualitative characteristics between the groups. The Chi^2 independence test was adopted to investigate the existence of the relationship between the studied features. A significance level of $p < 0.05$ was assumed indicating the existence of statistically significant differences. The database and statistical research were based on the STATISTICA 13.0 computer software (StatSoft, Poland).

Results

Groups characteristics

The average age of patients in the SDH group (57.86 ± 18.26) was statistically significantly higher than in the EDH group (38.81 ± 13.37 years) (p = 0.00001). In both groups, men were most often hospitalized. The GCS score among patients with SDH (median-6) was statistically significantly less points than in EDH group (median-11,5) (p = 0.0006). Skull fractures were more often associated with patients with EDH (71.43 %) than with SDH (30 %), (p = 0.00007). The median thickness of the hematoma was significantly higher in the group of patients with EDH (26.5mm) than in the group with SDH (17 mm) (p = 0.00004) (Tab. 2).

Impact of factors on in-hospital mortality rate in EDH I SDH group (Tabs 1 and 3)

Demographic data

In the EDH group in-hospital mortality rate was more frequent in case of women than men. Anyone who was 35 years old and less, didn't die during hospitalization in comparison with elderly patients (0 % vs 16.67 %). In the SDH group, no significant dif-

Tab. 2. Demographic data in groups.

Demographic data	Groups	ADH (n=28)		SDH (n=100)	
		n	%	n	%
Sex	Female	2	7.14	14	14.00
	Male	26	92.86	86	86.00
Age	under 60 years	27	96.43	56	56.00
	over 60 years	1	3.57	44	44.00

Tab. 3. Impact of factors on in-hospital mortality rate in the SDH group.

Group of factors	Factors		Death n (%)	Alive n (%)	p
Demographic data	Gender	Men	40 (46.51%)	46 (53.49%)	0.45
		Women	5 (35.71%)	9 (64.29%)	
	Age	≤60 years old	24 (42.86%)	32 (57.14%)	0.16
		>61 years old	21 (47.73%)	23 (52.27%)	
Physiological factors	GCS score	3–8 score GCS	41 (68.33%)	19 (31.67%)	0.00001*
		9–15 score GCS	4 (10%)	36 (90%)	
	Pupil reaction	Normal	14 (31.11%)	31 (68.89%)	0.01*
		unreactive one or both	31 (56.36%)	24 (43.64%)	
	Saturation	>96 %	13 (27.66%)	34 (72.34%)	0.001*
		<96 %	32 (60.38%)	21 (39.62%)	
	Systolic blood pressure	90–140 mmHg	12 (27.91%)	31 (72.09%)	0.0003*
		<89 or >41 mmHg	33 (57.89%)	24 (42.11%)	
	Heart rate	60–120 pulse	35 (44.3%)	44 (55.7%)	0.78
		<59 or >121 pulse	10 (47.62%)	11 (52.38%)	
	Respiratory rate	10–25 breaths per minute	15 (25.86%)	43 (74.14%)	0.00001*
		<9 or >26 breaths per minute	30 (71.43%)	12 (28.57%)	
Laboratory factors	WBC	4.8–10.8x10^3/mm^3	18 (37.5%)	30 (62.5%)	0.15
		<4.7 or >10.9x10^3/mm^3	27 (51.92%)	25 (48.08%)	
	HGB	12–18mg/dl	37 (46.84%)	42 (53.16%)	0.42
		<11 mg/dl	8 (38.1%)	13 (61.9%)	
	PLT	130–400x x10^3/mm^3	29 (42.65%)	39 (57.35%)	0.49
		<129 or >401 x10^3/mm^3	16 (50%)	16 (50%)	
	Glycaemia	70–110 mg/dl	0 (0%)	22 (100%)	0.00001*
		>111mg/dl	45 (57.69%)	33 (42.31%)	
	Na	135–157mEq/lt	40 (44.94%)	49 (55.06%)	0.77
		<134 mEq/lt	5 (45.45%)	6 (54.55%)	
	Coagulopathy	INR≤1.2 or PT≤12.7 s	37 (53.62%)	32 (46.38%)	0.68
		INR>1.3 or PT>12.8 s	18 (58.06%)	13 (41.94%)	
	Ethanol	≤0.5 ‰	35 (50.72%)	34 (49.28%)	0.09
		>0.6 ‰	10 (32.26%)	21 (67.74%)	
Computer Tomography scan characteristics	Skull fracture	Present	11 (46.67%)	16 (53.33%)	0.83
		Absent	31 (44.29%)	39 (55.71%)	
	SAH	Present	26 (55.32%)	21 (44.68%)	0.05
		Absent	19 (35.85%)	34 (64.15%)	
	IPH	Present	19 (51.35%)	18 (48.65%)	0.33
		Absent	26 (41.27%)	37 (58.73%)	
	IVH	Present	12 (70.59%)	5 (29.41%)	0.02*
		Absent	33 (39.76%)	50 (60.24%)	
	Basal cistern	Normal size	5 (29.41%)	12 (70.59%)	0.04*
		Compressed and absent	40 (48.19%)	43 (51.81%)	
	Hematoma thickness	<20 mm	26 (34.67%)	49 (65.33%)	0.0007*
		>21 mm	19 (76%)	6 (24%)	
	MLS	≤20 mm	34 (39.54%)	52 (60.46%)	0.005*
		>21 mm	11 (78.57%)	3 (21.43%)	
Time injury – surgery		≤4 hours	8 (42.11%)	11 (57.89%)	0.9
		5–9 hours	29 (46.77%)	33 (53.23%)	
		≥10 hours	8 (42.11%)	11 (57.89%)	

* statistically significant value

ferences between the gender and mortality were found (p = 0.45). The patients who were older than 60 years had a higher in-hospital mortality rate than the younger ones. No difference was statistically significant.

Physiological factors

In the EDH group, only patients after a severe head injury (GCS score 3–8) died during hospitalization in comparison with patients with GCS between 9–15 points. In the SDH group, the patients after a severe head injury had a significantly higher mortality rate than other. In EDH and SDH patients with non-reactive pupils, an abnormal value of pulse rate, saturation, systolic blood pressure and respiratory rate more often died during hospitalization than the patients with normal reactive pupils and other physiological factors. In EDH group only the difference regarding GCS score and HR was statistically significant (p = 0.03). In SDH group all of the differences were statistically significant except for heart rate. In SDH groups, case of GSC score, SBP, RR differences were highly statistically significant ($p < 0.0003$).

Laboratory factors

Statistical analysis in EDH and SDH groups did not show a significant relationship between the number of WBC, the value of HGB, the presence of coagulopathy and in-hospital mortality. In case of sodium concentration statistical analysis showed that hyponatremia was associated with significantly higher mortality rate only in the EDH group ($p = 0.02$). An abnormal number of PLT was associated with higher in-hospital mortality rate in both groups. In both groups the state after the alcohol intoxication was associated with smaller in-hospital mortality rate. The differences were not statistically significant. In both groups anyone with normoglycemia didn't die compared with the patients with hyperglycemia. Only in SDH group the differences were statistically significant ($p < 0.00001$).

Computer Tomography scan characteristics

Patients with skull fracture in both groups more often died during hospitalization than patients without the fracture. Patients with the presence of traumatic SAH in both groups more often died during hospitalization than patients without SAH. In the case of the presence of IPH, only in the SDH group it was associated with higher in-hospital mortality rate. In both groups, patients with a present IVH more often died during hospitalization compared with patients with no ventricular bleeding. Only difference regarding present IVH was statistically significant in SDH group ($p = 0.02$). In both groups the state of basal cisterns correlated with in-hospital mortality rate. Differences were statistically significant ($p = 0.02$ and 0.04). In both groups, a greater maximum thickness of hematoma and MLS was associated with higher in-hospital mortality rate. Only in case of thickness of hematoma the difference wasn't statistically significant in the EDH group.

Time injury-surgery

No patient who waited for a surgery more than 10 hours died during hospitalization, compared to patients who waited for a surgery less than 10 hours. The difference wasn't statistically significant ($p = 0.51$). This is due to the fact that patients in good condition and without hematoma symptoms were operated on in the operating plan as a rule the next day. In the SDH group the statistical analysis did not find relationship between the time to surgery and in-hospital mortality.

In-hospital mortality rate

In patients with SDH, death during hospitalization was more frequent, it occurred in 45 out of 100 patients (45 %) compared to the group with EDH, where it occurred in 3 out of 28 patients (10.71 %). The difference was statistically significant ($p = 0.0009$).

Table 1. Impact of factors on in-hospital mortality rate in the EDH group

Table 3. Impact of factors on in-hospital mortality rate in the SDH group

Discussion

Demographic data

Age is one of the most powerful independent prognostic factor (5) and increasing age was associated with a worse outcome and higher mortality (3, 6), creating approximately linear function (7). The authors studying patients with extra-axial hematoma also found that increasing age was associated with a worse outcome and higher mortality rate (3, 8, 9, 10). In our study in ADH and SDH group increasing age was associated with higher mortality rate too. Though, differences weren`t statistically significant.

Gender did not affect the prognosis in TBI (5, 11). In the EDH group the ratio of women to men was 14:1. A similar ratio 14.3:1 was found by Ndoumbe et al (12). In the EDH group women had higher in-hospital mortality rate than men, ($p = 0.5$), which resulted from the fact that in the group women were much older than men (49.5 + 13.44 vs 38 + 13.27). Leitgeb et al observed a similar relationship in relation to the outcome (13). Authors examining patients operated on for SDH have proved that gender was nit related with mortality (10, 14). In the SDH group, no significant differences between the gender and in-hospital mortality rate were found too.

Physiological factors

The Glasgow Coma Scale (GCS) is the most common scale for assessing the patient's state of consciousness after a head injury. The age followed by the GCS motor score and the pupil response are most powerful independent prognostic factor after TBI (5, 15) especially with extra-axial hematomas (3, 14). In both groups GCS score was associated with in-hospital mortality with a statistically significant difference.

TBI causes paroxysmal sympathetic hyperactivity (PSH) manifested by increases in sympathetic activity involved in heart rate, blood pressure, respiratory rate and other. PSH has been reported in 33 % patients suffering from severe TBI and associated with poorer outcome (16, 17). Hypoxia and hypotension following TBI are recognized as a significant secondary disorder associated with a poor outcome (18). Hypoxia causes rapid destruction of brain tissue and it is important to prevent hypoxia. Similarly, in the case of hypotension, recent guidelines recommend maintaining systolic blood pressure above 90 mm Hg to optimize prognosis after TBI. Additionally, the results of randomized controlled studies showed that the increase in pressure should be maintained in people with normal blood pressure up to 140 mm Hg (19, 20). Petroni et al found that hypotension (SBP < 90 mm Hg) was associated with 90 % mortality rate (21). Kalayci et al studied patients undergoing craniectomy for SDH and found that a saturation less than or equal to 96 % was significantly associated with mortality rate ($p = 0.004$) (22). Respiratory rate higher than 25 and lower than 10 increased mortality rates. Similarly, heart rate value beyond a normal range is associated with a poor outcome in TBI (23). In our study, these factors were associated with mortality, especially in the SDH group where in the case GSC score, SBP and RR differences were highly statistically significant ($p < 0.0003$).

Laboratory factors

Laboratory factors routinely recorded on admission following TBI had a predictive value. Hyperglycemia is associated with a poorer outcome and is included to secondary insult in TBI (24). Early monitoring of blood glucose in the range of 80–110 mg/dl can protect against nerve ischemia damage, reduce disability and improve patient prognosis (25). In our study, nobody with normoglycemia died during hospitalization compared to patients with hyperglycemia. The presence of coagulopathy is a major death factor among patients suffering from traumatic intracranial hemorrhage. Platelets count and prothrombin time are of particular importance (19, 24, 26). Fujii et al found that lower INR I and PTT are associated with better outcome than higher values (27). Sodium revealed a U-shaped relationship with outcome, hyper and hyponatremia are associated with poorer outcomes. However, hyponatremia is more strongly connected with poorer outcome (19, 24). In the EDH group hyponatremia was associated with higher mortality rate (p = 0.02). Hemoglobin and platelets low values were associated with a poorer outcome, on the other hand leukocytosis was associated with poorer outcome too (24). In our study the statistical analysis did not show a significant relationship between hemoglobin concentration and number of white blood cells and in-hospital mortality. Alcohol intoxication can reduce the mortality after TBI but it remains uncertain (28, 29). In our study, alcohol intoxication was associated with lower in-hospital mortality, but both differences weren`t statistically significant. Neuroprotective properties of alcohol require further investigation (28).

Computer Tomography scan characteristics

Computer tomography scan after TBI provides an objective assessment of a structural damage to the brain and can help in predicting prognosis (3, 19). There is strong evidence that greater midline shift and the thickness of hematoma are associated with a higher mortality rate, our results also confirm that (30, 31, 32). Our analysis in both groups shows that skull fracture is associated with higher mortality rate, without the differences being statistically significant (p = 0.63 and p = 0.84). The presence of a skull fracture confirms that the injury had to be caused by high force (33). Fracture of the skull in patients with TBI is associated with an increased risk of hemorrhagic intracranial lesions, which may require surgery (34). However, some energy is absorbed by the skull when the skull is damaged and, as a consequence, the brain is not exposed to full impact force (19). The presence of a IVH and traumatic SAH predicts higher mortality (9, 13, 32). The patients with the presence of traumatic SAH and IVH more often died during hospitalization than the patients without SAH and no ventricular bleeding, in our both groups. In the EDH and SDH groups state of basal cisterns correlated with in-hospital mortality rate, with differences being statistically significant (p = 0.02 and 0.04). This has also been noticed by other authors (5, 7, 35, 36).

Time injury-surgery

Authors which study patients with EDH, found the most important prognostic factor is time between the trauma and surgery. Reduction of this time to a minimum can reduce mortality to zero (11). Seelig et al. found that surgery up to 4 hours after injury reduced mortality from 90 to 30 % among patients with SDH (37). According to Matsushima et al. performing surgery up to 200 minutes after arrival at the emergency department is associated with significantly lower in-hospital mortality (p = 0.03) (38). However, there are a few studies that didn`t find relation between a shorter time between injury-surgery and the mortality (13, 39). Although our statistical analysis wasn't associated with a significant relationship between time to surgery and in-hospital mortality rate, but it was reasonable to perform a surgery as soon as it is possible.

In-hospital mortality

The mortality rate among patients after surgery for EDH ranged from 2.6 % to 15.5 %, the average ratio is about 10 % (11, 12, 40). In case of SDH mortality rate varies from 22 to 75 %, most often the results oscillate around 40 % (9, 22, 40). In our study mortality rate were 10.7 % in the EDH group and 45 % in the SDH group, and the difference was statistically significant, (p = 0.0009).

Conclusion

To the best of our knowledge, this is one of the few studies analyzing factors affecting mortality among patients operated on due to non-axial hematomas. This study confirmed the impact of many different factors on hospital mortality. Interestingly, factors such as GSC score, SBP, RR and hyperglycemia were associated with in-hospital mortality, with highly statistically significant difference (p < 0.0003). In addition to the GCS score, other factors can be effectively treated at the place of an accident, which can help to achieve a better outcome. These results require confirmation in other studies in a larger group of patients. This study has a significant limitation such as small number of patients, especially the ones operated due to epidural hematomas and not including other routine factors to the examination at admission such as C-reactive protein, D-dimer.

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