

Clinical Article



# Brain Trauma Mortality Rate Score Scale (BTMRSS): Postmortem Evaluation of the Events

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**Conflict of Interest**

The authors have no financial conflicts of  
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## ABSTRACT

**Objective:** Brain trauma and its burden is becoming a significant cause of permanent damage and deterioration. Prioritization at the place of the incident and calculation of mortality are leading factors for the final management, but all of them are obtained from living patients. When the autopsies are made there is no actual score system to guide the forensic scientists in their conclusions. Should all of the cadavers with traumatic brain injury (TBI) have been dead? Therefore, we aim to present a score system—brain trauma mortality score scale (BTMSS), aiming to evaluate postmortem the actual risk of mortality.

**Methods:** We established a score scale, which could be used on cadavers for the evaluation of the events. Afterwards, we applied this score scale on the reports of the cadavers who suffered blunt force TBI for a 10-year period of time between 2007 and 2016. Thereafter, the results were processed with SPSS version 25.

**Results:** The outcome showed that there is a significant difference between the scores of the cadavers who died at the place of the incident and those who died in hospital thus approving that the BTMSS works well, as well as the importance of level I trauma center.

**Conclusion:** Every score system could show something useful for the management of the TBIs. The solution and improvement in the outcome of the current study would be a level I trauma center with a qualified neurosurgical department.

**Keywords:** Traumatic brain injury; Injury severity score; Mortality; Trauma center

## INTRODUCTION

On almost every day around the world, people suffer traumatic brain injury (TBI) that needs to be treated. TBI is a topic concerning a lot of health care practitioners, because of its need to take decisions without delay and give high quality care.<sup>7,29)</sup>

The majority of the traumatic brain injuries is part of polytrauma, multiple or massive trauma, every one of which necessitates a level I trauma center, qualified personnel and a high level of support. According to the advance trauma life support protocol in cases of multiple or massive trauma, the patients are prioritized based on their condition and their survival/mortality prognostic rate. In this term, there are plenty of score systems evaluating the TBI and its risk of mortality, based on living patients. However, there is no score system

evaluating the impact of the brain trauma in cadavers. Moreover, there is no evidence on how the score systems work when the hospitals do not have a neurosurgical department.

The forensic evaluation of the TBIs include appropriate classification and diagnosis, neuropsychological and medicolegal evaluations.<sup>19,27)</sup> However, there is a lack of a postmortem evaluation system, suggesting or helping to clarify the events related to the TBI. It is difficult to say that a concrete brain trauma was preventable, but it would be helpful to have a system to guide us and help us evaluate the risk of mortality based on postmortem analyses. Due to that, the current study aims to present a new score system for TBIs, mainly developed to help the forensic scientists in their conclusions.

## MATERIALS AND METHODS

In order to evaluate the mortality risk of TBIs, we used a brain trauma mortality score scale (BTMSS), which helps the forensic evaluation of TBIs (**TABLE 1**). Afterwards, it was applied to the data collected from the laboratory of forensic science and toxicology to prove that this score system works.

The laboratory of forensic science that was our source is located in the regional hospital “Stamen Iliev” of Montana, Bulgaria and investigates cases from 2 municipalities—Montana and Vidin, while the hospitals of both regions do not have neurosurgical departments.

**TABLE 1.** Mortality score system (total score: 15)

Factors	Score	Total score
Substances		1
No substances	0	
Alcohol or drugs	1	
Place of death		1
Hospital	0	
Outside hospital	1	
No. of skull injuries		4
1	1	
2	2	
3	3	
More than 3	4	
Age (yr)		1
Over 60	1	
Under 18	1	
19–59	0	
Open/closed trauma		1
Open	1	
Closed	0	
Clinical findings		3
Polytraumatic injuries	1	
Brain hemorrhage/hematoma/edema	1	
Chronic co-morbidity	1	
Autopsy findings		4
Atherosclerosis of the aorta	1	
Atherosclerosis of brain vessels	1	
Atherosclerosis coronary artery	1	
Atherosclerosis of kidney vessels old scar of MI, kidney dystrophy, OKI	1	

MI: myocardial infarction, OKI: old kidney inflammation/scars.

The initially collected data incorporated only cadavers who suffered TBI (n= 232) between 2007 and 2016. Afterwards, the TBIs were divided into categories based on the cause of the injury—road injury, blunt force trauma, falls, gunshot trauma and occupational TBIs. For the final analysis we included only TBIs due to blunt force trauma (n=34), because of its occasional incidence, which could be caused by accident, criminal act or suicide attempt. The rest of the clinical reports (different departments, emergency room and ambulance) are unavailable and irrelevant for the current analysis. Since the data were retrospectively reviewed on cadavers, consent was not needed. The paper, however, follows the Helsinki regulation rules and it is completely anonymous.

Among the current sample, 6 were females and 28 males. Mean age of the participants was 55.38 years (TABLE 2). All subjects had brain hematoma and edema, as well as clinical findings. Not all of them, however, had autopsy findings.

Thereafter, the sample was divided into 2 groups: those who died at the scene (group A) and those who died in the hospital (group B).

**TABLE 2.** Group scores

Patients	Age/sex	TBI	O/C	A/D	A	C	H
1	80/M	4	1	0	2	3	1
2	46/M	3	0	1	3	2	1
3	67/F	2	0	0	4	2	1
4	30/F	2	0	0	1	2	1
5	60/M	3	0	0	4	2	1
6	60/M	3	1	0	3	2	1
7	83/M	4	0	0	3	3	1
8	69/F	3	0	0	3	2	1
9	87/M	3	1	0	3	3	0
10	17/M	3	0	1	0	2	1
11	45/M	4	1	1	0	1	1
12	60/M	2	0	1	2	2	0
13	75/M	4	1	1	3	2	1
14	67/M	4	1	0	3	2	1
15	87/F	4	1	0	3	2	1
16	41/M	4	1	0	1	1	0
17	23/M	3	1	1	0	3	0
18	63/F	4	1	0	2	2	1
19	51/M	2	1	1	2	3	1
20	41/M	2	0	0	2	2	0
21	44/M	4	1	1	3	2	1
22	26/M	4	1	0	1	1	0
23	57/M	2	0	0	2	3	1
24	57/M	4	1	1	2	2	1
25	60/M	4	0	1	3	3	1
26	10/F	2	1	0	0	2	0
27	83/M	4	0	0	2	3	1
28	19/M	3	1	0	0	1	0
29	89/M	4	1	0	2	3	0
30	66/M	2	0	0	3	2	0
31	64/M	4	0	1	3	2	1
32	43/M	4	1	0	0	2	1
33	70/M	4	1	0	2	0	1
34	33/M	4	1	1	0	2	1
Group A mean value	58.79	3.46	0.50	0.40	2.21	2.13	1.00
Group B mean value	46.2	2.9	0.7	0.2	1.4	2.0	0

TBI: traumatic brain injury, O/C: open/closed trauma, A/D: alcohol or drugs, C: clinical findings, A: autopsy findings, H: place of death - (hospital).

### Statistical analysis

Statistical analysis was performed as the independent *t*-test using SPSS version 25 (IBM Corp., Armonk, NY, USA). Correlation and regression analysis were used to show important correlations between the parameters included in the BTMSS. The *p*-value was considered statistically significant if  $<0.05$ .

## RESULTS

Independent *t*-test was obtained between group A and group B for the total score and the included in the BTMSS parameters, illustrated in **TABLE 3**. The independent *t*-test based on the final score of the BTMSS had no differences between males and females ( $p$ -value=0.457).

Indeed the mean value of the scores was much lower among the subjects who arrived at the hospitals (mean score=7), compared to those who died at the location of the incident (mean score=10). Either way, in both cases the subjects had died, which could be based on the fact that the hospitals do not have a neurosurgical department. And this is exactly the main purpose of the score scale to help forensic scientists emphasize on cases with lower scores for the final conclusions.

According to the correlation analysis on the same 2 groups, there is a single negative correlation between open/closed trauma and autopsy findings (Pearson's  $r=-0.362$ ;  $p$ -value=0.018), while the rest of the correlations are positive (**TABLE 4**).

Finally, the linear regression analysis was performed for the parameter “place of death” and BTMSS total score. The results are illustrated in **TABLES 5** and **6** and suggest that except age the rest of the parameters have statistical significance.

## DISCUSSION

TBI has influenced people around the world with a lot of effort and eternity. The incidence of TBIs in the USA is estimated at 130–140 per 100,000 people,<sup>4)</sup> much higher in Australia<sup>1)</sup> and with a high degree of fluctuation in Europe and Asia.

**TABLE 3.** Independent *t*-test for group A and B

Factors	<i>p</i> -value (1-tailed)	t	df	<i>p</i> -value (2-tailed)	Mean difference	SE difference	95% CI
BTM score	0.930	4.083	32	0.0001	2.55	0.625	1.278–3.820
		3.952	15,793	<b>0.001*</b>	2.55	0.645	1.181–3.910
TBI	0.767	1.837	32	0.075	0.56	0.304	–0.061–1.180
		1.749	15,266	0.100	0.56	0.319	–0.121–1.240
Open/closed	0.070	–0.838	32	0.408	–0.16	0.189	–0.543–0.230
		–0.857	17,765	0.403	–0.16	0.185	–0.547–0.230
Substances	<b>0.007*</b>	1.194	32	0.241	0.22	0.181	–0.153–0.590
		1.287	20,101	0.213	0.22	0.168	–0.134–0.570
Autopsy findings	0.870	1.784	32	0.084	0.81	0.453	–0.114–1.730
		1.811	17,469	0.087	0.81	0.446	–0.131–1.750
Clinical findings	0.407	0.461	32	0.648	0.13	0.271	–0.428–0.680
		0.426	14,475	0.676	0.13	0.293	–0.502–0.750
Age	<b>0.034*</b>	1.580	32	0.124	12.60	7.970	–3.646–28.830
		1.311	12,090	0.214	12.60	9.610	–8.324–33.510

TBI: traumatic brain injury, BTM: brain trauma mortality, df: degrees of freedom, SE: standard error, CI: confidence interval.

\*Significant *p*-value with bold.

**TABLE 4.** Correlation analysis

Factors	TBI	Open/closed	Substances	Autopsy findings	Clinical findings	Place of death	Age
<b>TBI</b>							
Pearson correlation	1.000	<b>0.444<sup>†</sup></b>	0.110	-0.021	-0.147	<b>-0.309<sup>*</sup></b>	<b>0.297<sup>*</sup></b>
Sig. (1-tailed)		<b>0.004</b>	0.268	0.454	0.204	<b>0.038</b>	<b>0.044</b>
Number	34	34	34	34	34	34	34
<b>Open/closed</b>							
Pearson correlation	<b>0.444<sup>†</sup></b>	1.000	-0.007	<b>-0.362<sup>*</sup></b>	-0.236	0.147	-0.089
Sig. (1-tailed)	<b>0.004</b>		0.484	<b>0.018</b>	0.090	0.204	0.308
Number	34	34	34	34	34	34	34
<b>Substances</b>							
Pearson correlation	0.110	-0.007	1.000	-0.133	0.083	-0.207	-0.248
Sig. (1-tailed)	0.268	0.484		0.227	0.321	0.121	0.078
Number	34	34	34	34	34	34	34
<b>Autopsy findings</b>							
Pearson correlation	-0.021	<b>-0.362<sup>*</sup></b>	-0.133	1.000	0.243	<b>-0.301<sup>*</sup></b>	<b>0.721<sup>†</sup></b>
Sig. (1-tailed)	0.454	<b>0.018</b>	0.227		0.083	<b>0.042</b>	<b>0.000</b>
Number	34	34	34	34	34	34	34
<b>Clinical findings</b>							
Pearson correlation	-0.147	-0.236	0.083	0.243	1.000	-0.081	0.347 <sup>*</sup>
Sig. (1-tailed)	0.204	0.090	0.321	0.083		0.324	0.022
Number	34	34	34	34	34	34	34
<b>Place of death</b>							
Pearson correlation	<b>-0.309<sup>*</sup></b>	0.147	-0.207	<b>-0.301<sup>*</sup></b>	-0.081	1.000	-0.269
Sig. (1-tailed)	<b>0.038</b>	0.204	0.121	<b>0.042</b>	0.324		0.062
Number	34	34	34	34	34	34	34
<b>Age</b>							
Pearson correlation	0.297 <sup>*</sup>	-0.089	-0.248	0.721 <sup>†</sup>	0.347 <sup>*</sup>	-0.269	1.000
Sig. (1-tailed)	0.044	0.308	0.078	0.000	0.022	0.062	
Number	34	34	34	34	34	34	34

TBI: traumatic brain injury, Sig.: significance.

\*Correlation is significant at the 0.05 level (1-tailed); <sup>†</sup>Correlation is significant at the 0.01 level (1-tailed) with bold.

**TABLE 5.** Linear regression analysis with dependent variable: BTMSS total score

Factors	OR	95% CI	p-value
Place of death	0.869	0.191-0.194	<0.001
TBI	1.291	0.113-0.533	<0.001
Autopsy findings	0.856	0.096-0.520	<0.001
Clinical findings	0.916	0.120-0.327	<0.001
Substances	0.958	0.172-0.229	<0.001
Age	0.001	0.006-0.009	0.903

BTMSS: brain trauma mortality score scale, OR: odds ratio, CI: confidence interval, TBI: traumatic brain injury.

**TABLE 6.** Linear regression analysis with dependent variable: "place of death"

Factors	OR	95% CI	p-value
Total score	0.481	0.107-2.185	<0.001
TBI	0.536	0.172-1.006	0.004
Autopsy findings	0.349	0.123-0.963	0.009
Clinical findings	0.406	0.137-0.657	0.006
Substances	0.361	0.173-0.392	0.046
Age	0.001	0.005-0.042	0.860

OR: odds ratio, CI: confidence interval, TBI: traumatic brain injury.

Many of the injured have afterwards permanent damage and disability. It is believed that the latter reaches up to 52% of the injured cases and in the next few years TBI could be the leading cause of deterioration.<sup>7,29)</sup> Moreover, the post-traumatic patients have a poor quality of life and social interaction, leading to psychological and behavior disturbances.<sup>2,5,8,30)</sup> What I mentioned later, further reduces the quality of life, isolating the patient socially. The cost of

care for a single TBI patient is estimated between 33–35 thousand dollars for mild cases and between 27 and 81 thousand dollars for moderately severe brain trauma.<sup>17)</sup> The cost of TBI patients, who have psychological, behavioral or post-traumatic need of supports increases further the cost of health care, while more than a billion dollars are lost due to brain trauma deaths per year.<sup>9)</sup> This spread of resources, as it is shown, is ineffective until a level I trauma center is available.

When an injury occurs, neurosurgical care is required for the management of the TBIs.<sup>3)</sup> A study based on TBIs due to road traffic incidents by Nikova et al.<sup>20)</sup> reports that the mortality rate at the side of the road is equal to the mortality rate in the hospital, when the hospital does not have a neurosurgical department. Normally, level I trauma center offers the appropriate health care for brain trauma. It is believed that the latter even decreases the mortality rate of the injured subjects if they are directly transferred to such.<sup>6)</sup> Additionally, following the established guidelines, when managing neurotrauma, will lead to decreased mortality rates.<sup>22)</sup>

Many score systems are made to calculate the prognosis of the patients, thus improving the health care, the therapeutical approaches and to some extent the final outcome.<sup>11,21)</sup> The most distinguished ones are the IMPACT and CRASH scales, which are based, however, on strict population and may not have any prognostic significance.<sup>14,18,26)</sup> For this reason, many suggest simpler prognostic models, such as Marschall-computed tomography (CT) score, Rotterdam CT score, abbreviated injury scale and Glasgow coma scale.<sup>12,16,23,28)</sup> Majdan et al.<sup>15)</sup> compared the latter score systems to that of the others and revealed that there is no significant difference between them, meaning that either one of them could equally predict the concrete result.

Forensic science is a specialty having the burden of legal issues. Roberts et al.<sup>24)</sup> reported a few basic criticisms concerning the forensic scientists and their role in the criminal law. Saks et al.<sup>25)</sup> recently raised an issue related to wrongful conviction. The most common cause was the eyewitness records but the most important one was the forensic science testing errors. On the other hand, Koc et al.<sup>10)</sup> and Madea et al.<sup>13)</sup> reported forensic evaluations of malpractice in Turkey and Germany respectively. Therefore we made a score scale based on cadavers to help the forensic scientists in their conclusions and to reduce wrongful diagnoses. The scale using cadavers has the advantage of knowing exactly the cause of death. However, data analysis on damage control and treatment after the accident was excluded, and clinical examination and coordination are necessary to determine how clinically the damage is affected.

In conclusion, the only thing available to improve the rates of mortality due to TBI is the establishment of a level I trauma center with qualified personnel.

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