

Original research

Value of physiological scoring systems in prediction of long-term mortality in traumatic brain injury patients

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Abstract: **Background:** Rapid acute physiological score (RAPS) and Worthing physiological scoring system (WPSS) models have received much attention in recent years. Yet, the value of these systems in outcome prediction of traumatic brain injury (TBI) patients has not been assessed. Therefore, the present study was designed aiming to compare the value of the 2 mentioned models in prediction of 6-month mortality of head trauma patients.

Methods: The present study is a diagnostic accuracy one evaluating head trauma patients presenting to emergency department. Each patient had a WPSS score and a RAPS score, and then the discriminatory powers of the 2 models with 95% confidence interval (95% CI) were compared.

Results: Data of 735 head trauma patients was assessed. During the 6-month follow-up, 48 (6.53%) patients died. Area under the curve of RAPS and WPSS in prediction of 6-month mortality were 0.93 (95% CI: 0.88-0.98) and 0.97 (95% CI: 0.96-0.98), respectively. The 2 evaluation models had similar value in prediction of mortality in head trauma patients ($p=0.10$). The best cut off point for RAPS and WPSS in prediction of trauma patients' mortality was 5 and 2, respectively. RAPS had sensitivity and specificity of 89.58 (95% CI: 76.56-96.10) and 85.15 (95% CI: 82.22-87.68), respectively. Sensitivity and specificity of WPSS model were 100.0 (95% CI: 90.77-100.0) and 87.92 (95% CI: 85.19-90.21), respectively.

Conclusion: Findings show that there is a significant correlation between physiological factors on admission and mortality of head trauma patients. In addition, it was determined that RAPS and WPSS physiological scoring systems have high value in prediction of mortality following TBI.

Keyword: Brain injuries; Mortality; Diagnosis; Emergency Service, Hospital; Physiology Scoring System

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1. Introduction

Traumatic brain injuries (TBI) make up a considerable portion of annual emergency department (ED) visits, one fourth of which have post-injury symptoms (1, 2). Strong evidence exist that show TBI leads to brain failure and neural damage even when computed tomography (CT) scan findings are normal (3). This has caused difficulty for many physicians in patient management and decision making regarding these cases. There is no reliable scale for prediction of brain injury following head trauma (4-6). Therefore, researchers are seeking to find an ideal tool or marker that

has sufficient accuracy a for predicting brain injury (7). This tool will enable physicians to monitor those with TBI but have no neurologic symptoms more accurately. Emergency ward staffs are one of the most important circles of care in managing those injured in accidents. Meanwhile, overcrowding in this department may lead to physicians and nurses not having enough time for managing patients. Therefore, using tools that decrease the time required for patient evaluation and increase the quality of care (8) can significantly increase the effectiveness of treatments and reduce mortality and disability of the patients.

Currently, using scoring systems for prediction or determination of status or the outcome of disease is so popular among physicians (9-21). This popularity is the result of acceptable accuracy of scoring systems in detection of high-risk patients (22). This helps physicians

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treat and manage patients more accurately and according to priorities. However, each scoring system has its own limitations.

Physiological factors such as age, vital signs, level of consciousness, and arterial oxygen saturation level are variables routinely evaluated in ED. Measuring these factors is easy and all the staff of the medical team can easily assess them. Therefore, designing a scoring system based on physiological variables can have acceptable effectiveness in ED. Many physiological scoring systems have been proposed until now but rapid acute physiological score (RAPS) and Worthing physiological scoring system (WPSS) have received much attention in the researches carried out in recent years (19-23). Yet, the value of these systems in outcome prediction of head trauma patients has not been assessed. Therefore, the present study was designed aiming to compare the value of the 2 mentioned models in prediction of 6-month mortality of head trauma patients.

2. Method

2.1. Study design and participants

Data gathering in the present diagnostic accuracy study was done between April 2014 and November 2015 evaluating head trauma patients presenting to an ED in a tertiary hospital, Tehran, Iran. Protocol of this study was approved by the ethics committee of Tehran University of Medical Sciences. The researchers adhered to the principles presented in the Declaration of Helsinki throughout the study. It should be noted that before being included, the patient or their relative would sign the informed consent form for participation in the research. In this study, adult (over 18 years old) head trauma patients presenting to ED were included. Exclusion criteria consisted of death before being admitted to ED and not being able to contact the patient 6 months after being discharged.

2.2. Data gathering and outcome

Data were gathered by an emergency medicine specialist. Patients were clinically examined on admission and their age, gender, mechanism of trauma, arterial oxygen saturation (SpO₂), heart rate, respiratory rate, axillary temperature, and level of consciousness based on Glasgow coma scale (GCS) were recorded. Data were entered to a pre-designed checklist. The studied final outcome was the patient's death or survival during 6 months after being discharged. Method of calculation for RAPS and WPSS physiological models have been reported in previous studies (19, 23). Patients were followed for 6 months mortality.

2.3. Statistical analyses

The required sample size in the present study considering 5.2% prevalence of mortality in trauma patients (20), 95% confidence interval (CI) ($\alpha=0.05$), 90% power ($\beta=0.1$) and maximum error of 1.0% ($d=0.01$) in estimation of mortality prevalence was calculated to be 189 patients.

Data were analyzed using STATA 11.0 statistical software. Initially, the correlation of physiologic variables evaluated in ED with mortality of head trauma patients was assessed using a multivariate logistic regression model. Then, discrimination of RAPS and WPSS models was evaluated by calculating area under the receiving operating characteristics (ROC) curve (AUC), sensitivity, specificity, positive and negative predictive value, and positive and negative likelihood ratio with 95% CI. AUC of the 2 models was compared based on the method suggested by Cleves and Rock (24). Finally, to assess concordance between REMS-predicted and RAPS-predicted percentage of mortality and poor outcome, Spearman's rank coefficient was calculated. In all analyses, $p<0.05$ was considered as significance level.

3. Result

Data of 735 head trauma patients was assessed. Mean age of the participants was 41.08 ± 18.46 years. 554 (75.37%) of the patients were male. Motorcycle (32.52%), car (39.12%), and pedestrian (19.86%) accidents were the most common mechanisms of trauma. Mean and standard deviation of systolic and diastolic blood pressure of the patients were 117.91 ± 14.72 and 74.68 ± 9.25 mmHg, respectively. Traumatic head injury was mild in 663 (90.20%) patients, moderate in 27 (3.68%), and severe in 45 (6.12%). Demographic data

Table 1: Baseline characteristics of the patients

Variable	Value
Age (year)	41.09±18.47
Gender (n, %)	
Male	554 (75.37)
Female	181 (24.63)
Mechanism of trauma (n, %)	
Motorcycle accident	239 (32.52)
Car rider accident	214 (29.12)
Pedestrian	146 (19.89)
Falls more than 3 meters	60 (8.16)
Other	76 (10.34)
GCS (mean ± SD)	14.25±2.45
Head trauma (n, %)	
Mild	663 (90.20)
Moderate	27 (3.68)
Severe	45 (6.12)

GCS: Glasgow coma scale

and baseline characteristics of the patients are reported in table 1. During the 6-month follow-up, 48 (6.53%) patients died.

Table 2: Independent predictors of 6-month mortality in trauma patients

Variable	Odds Ratio	95% CI	P
Age \geq 40	4.96	1.45-17.01	0.01
GCS $<$ 15	16.50	8.44-32.23	0.00
HR	1.02	0.99-1.04	0.21
Temp	1.41	0.61-3.28	0.42
SBP	1.01	0.98-1.04	0.57
DBP	0.94	0.89-0.98	0.01
RR	1.01	0.96-1.96	0.76
SpO2	0.87	0.81-0.93	0.00

CI: Confidence interval; DBP: Diastolic blood pressure; GCS: Glasgow coma scale; HR: Heart rate; RR: Respiratory rate; SBP: Systolic blood pressure; SpO2: Oxygen saturation; Temp: Body temperature.

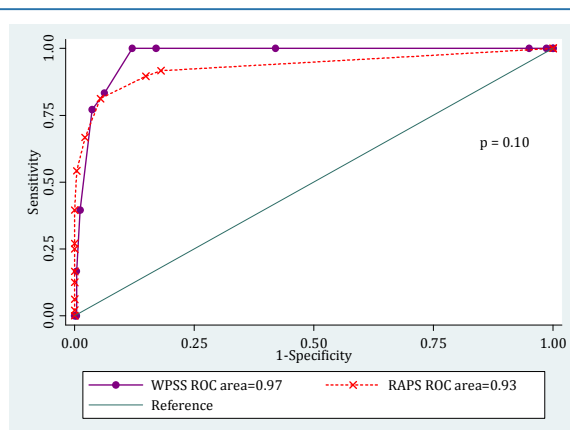


Figure 1: Area under the curve (AUC) of rapid acute physiological score (RAPS) and Worthing physiological scoring system (WPSS) in prediction of 6-month mortality.

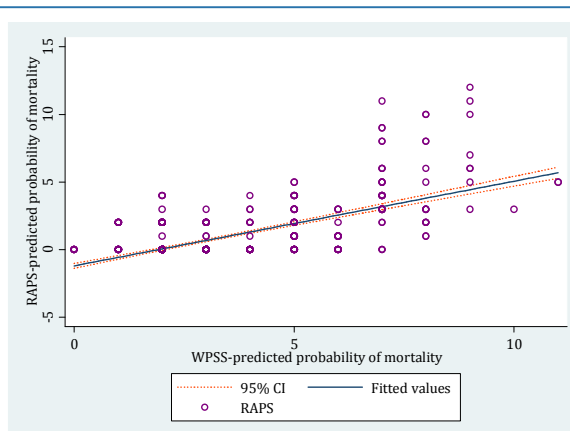


Figure 2: Concordance between rapid acute physiological score (RAPS) predicted and Worthing physiological scoring system (WPSS) predicted percentage of mortality.

Studying the correlation of physiological variables evaluated in ED with mortality of patients showed that age over 40 years, consciousness level less than 15, diastolic blood pressure and SpO2 were the most important factors predicting 6-month mortality of the patients (table 2). Among the mentioned factors, level of consciousness based on GCS (OR=16.50; 95% CI: 8.44-32.23) and age of the patient (OR=4.96; 95% CI: 1.45-17.01) had a stronger correlation.

These factors are the most important components of both studied physiological scoring systems predicting injury severity, namely RAPS and WPSS. AUC of the mentioned models in prediction of 6-month mortality were calculated to be 0.93 (95% CI: 0.88-0.98) and 0.97 (95% CI: 0.96-0.98), respectively. The 2 evaluation models had similar value in prediction of mortality in head trauma patients ($p=0.10$) (figure 1). According to ROC curve, the best cut off point for RAPS and WPSS in prediction of trauma patients' mortality was 5 and 2, respectively. RAPS had sensitivity and specificity of 89.58 (95% CI: 76.56-96.10) and 85.15 (95% CI: 82.22-87.68), respectively. Sensitivity and specificity of WPSS model were 100.0 (95% CI: 90.77-100.0) and 87.92 (95% CI: 85.19-90.21), respectively (table 3).

Finally, there was good concordance between RAPS and WPSS in prediction of mortality ($r=0.67$; $p<0.001$) (Figure 2).

4. Discussion

The present study assessed the value of physiological factors routinely evaluated in ED in predicting mortality of head trauma patients. Findings show that there is a significant correlation between these factors and patient mortality. In addition, it was determined that RAPS and WPSS physiological scoring systems have high value in prediction of mortality following TBI.

Physiological factors such as blood pressure, body temperature, heart rate, respiratory rate, and level of consciousness have been used to predict outcome and classify trauma severity in patients for a long time (18-21). The reason is that their measurement is easy. Physiological models like RAPS and WPSS are also designed completely based on physiological factors. WPSS and RAPS are both physiological scoring systems that require evaluations of respiratory rate, heart rate, body temperature, arterial oxygen saturation level, and level of consciousness for score calculation (20, 23). Their calculation being easy and their required factors for scoring being routinely assessed in ED, result in the scoring systems being easily used in the busy ED, in which the medical staff have little time to manage patients.

Table 3: Screening performance characteristics of rapid acute physiological score (RAPS) and Worthing physiological scoring system (WPSS) in prediction of mortality

Variable	RAPS		WPSS	
	Value	95% CI	Value	95% CI
True positive	43	----	48	----
True negative	585	----	046	----
False positive	102	----	83	----
False negative	5	----	0	----
Sensitivity	89.58	(76.56-96.10)	100.0	(90.77-100.0)
Specificity	85.15	(82.22-87.68)	87.92	(85.19-90.21)
Positive predictive value	29.66	(22.51-37.87)	36.64	(28.53-45.55)
Negative predictive value	99.15	(97.91-99.69)	100.0	(99.21-100.0)
Positive likelihood ratio	6.03	(4.92-7.39)	8.28	(6.77-10.13)
Negative likelihood ratio	0.12	(0.05-0.28)	0.0	(0.0-0.0)

CI: confidence interval

In line with the present study, Duckitt et al. expressed that WPSS is a better scale compared to early-warning scoring system in prediction of patient mortality (23). Comparing WPSS to another scoring system, Ha et al. also showed in their study that rapid emergency medicine score and WPSS have equal value in prediction of mortality in ED (21). Brabrand et al. also show in their study that WPSS has acceptable discriminatory power and calibration in prediction of mortality in patients (25). Therefore, it seems that WPSS can be a helpful screening tool in classification of trauma patients in ED. In the present study, WPSS had higher value compared to RAPS in predicting mortality of head trauma patients as well.

In the analyses carried out in this study, it was found that the correlation of level of consciousness (OR=16.50) and patients' age (OR=4.96) with mortality of head trauma patients is stronger compared to other factors. This finding is not surprising since loss of consciousness reflects the severity of head injury. In addition, age has been reported as a risk factor of death in many studies (20).

In the present study, convenience sampling was used. This might lead to selection bias. In addition, evaluation of body temperature is not routinely done in ED or is evaluated with low accuracy. Due to the critical condition of ED, accurate measurement of body temperature for trauma patients is not possible. Axillary temperature was measured for this purpose in the present study, which might affect the final interpretation of data and scoring method to some extent.

5. Conclusion:

The present study assessed the value of physiological factors routinely evaluated in ED in predicting mortality of head trauma patients. Findings show that there

is a significant correlation between these factors and patient mortality. In addition, it was determined that 2 physiological scoring systems of RAPS and WPSS have high value in prediction of mortality following TBI.

6. Acknowledgment

We hereby express our gratitude to the patients corporate in this study.

7. Conflict of interest

None.

8. Funding source

None.

9. Author contribution

All authors passed four criteria for authorship contribution based on recommendations of the International Committee of Medical Journal Editor.

10. Reference

1. Bruns JJ, Jagoda AS. Mild traumatic brain injury. *Mt Sinai J Med.* 2009;76(2):129-37.
2. Alexander MP. Mild traumatic brain injury: pathophysiology, natural history, and clinical management. *Neurology.* 1995;45(7):1253-60.
3. Palchak MJ, Holmes JF, Vance CW, Gelber RE, Schauer BA, Harrison MJ, et al. A decision rule for identifying children at low risk for brain injuries after blunt head trauma. *Ann Emerg Med.* 2003;42(4):492-506.

4. Berger RP, Hymel K, Gao W-M. The Use of Biomarkers After Inflicted Traumatic Brain Injury: Insight into Etiology, Pathophysiology, and Biochemistry. *Clin Pediatr Emerg Med.* 2006;7(3):186-93.
5. Dash PK, Zhao J, Hergenroeder G, Moore AN. Biomarkers for the Diagnosis, Prognosis, and Evaluation of Treatment Efficacy for Traumatic Brain Injury. *Neurotherapeutics.* 2010;7(1):100-14.
6. DeFazio MV, Rammo RA, Robles JR, Bramlett HM, Dietrich WD, Bullock MR. The Potential Utility of Blood-Derived Biochemical Markers as Indicators of Early Clinical Trends After Severe Traumatic Brain Injury. *World Neurosurg.* 2014;81(1):151-8.
7. Schiavi P, Laccarino C, Servadei F. The value of the calcium binding protein S100 in the management of patients with traumatic brain injury. *Acta Biomed.* 2012;83(1):5-20.
8. de Souza Nogueira L, de Alencar Domingues C, Poggetti RS, de Sousa RMC. Nursing workload in intensive care unit trauma patients: analysis of associated factors. *PLoS One.* 2014;9(11):e112125.
9. Yousefifard M, Baikpour M, Ghelichkhani P, Asady H, Darafarin A, Esfahani MRA, et al. Comparison of Ultrasonography and Radiography in Detection of Thoracic Bone Fractures; a Systematic Review and Meta-Analysis. *Emergency.* 2016;4(2):55-64.
10. Shojaee M, Dolatabadi AA, Sabzhabaei A, Malekirastekenari A, Faridaalae G, Yousefifard M, et al. New scoring system for intra-abdominal injury diagnosis after blunt trauma. *Chin J Traumatol.* 2014;17(1):19-24.
11. Safari S, Yousefifard M, Hashemi B, Baratloo A, Forouzanfar MM, Rahmati F, et al. The value of serum creatine kinase in predicting the risk of rhabdomyolysis-induced acute kidney injury: a systematic review and meta-analysis. *Clin Exp Nephrol.* 2016;20(2):153-61.
12. Safari S, Yousefifard M, Baikpour M, Rahimi-Movaghar V, Abiri S, Falaki M, et al. Validation of thoracic injury rule out criteria as a decision instrument for screening of chest radiography in blunt thoracic trauma. *J Clin Orthop Trauma.* 2016;7(2):95-100.
13. Rahimi-Movaghar V, Yousefifard M, Ghelichkhani P, Baikpour M, Tafakhori A, Asady H, et al. Application of Ultrasonography and Radiography in Detection of Hemothorax: a Systematic Review and Meta-Analysis. *Emergency.* 2016;4(3):116-26.
14. Hosseini M, Ghelichkhani P, Baikpour M, Tafakhori A, Asady H, Ghanbari MJH, et al. Diagnostic Accuracy of Ultrasonography and Radiography in Detection of Pulmonary Contusion; a Systematic Review and Meta-Analysis. *Emergency.* 2015;3(4):127-36.
15. Safari S, Yousefifard M, Hashemi B, Baratloo A, Forouzanfar M, Rahmati F, et al. The Role of Scoring Systems and Urine Dipstick in Prediction of Rhabdomyolysis-induced Acute Kidney Injury: a Systematic Review. *Iran J Kidney Dis.* 2016;10(3):101-6.
16. Izadi A, Yousefifard M, Nakhjavan-Shahraki B, Baikpour M, Mirzay Razaz J, Hosseini M. Diagnostic Value of Urinary Neutrophil Gelatinase-Associated Lipocalin (NGAL) in Detection of Pediatric Acute Kidney Injury; a Systematic Review and Meta-Analysis. *Int J Pediatr.* 2016:3875-95.
17. Izadi A, Yousefifard M, Nakhjavan-Shahraki B, Baikpour M, Mirzay Razaz J, Ateai N, et al. Value of Plasma/Serum Neutrophil Gelatinase-Associated Lipocalin in Detection of Pediatric Acute Kidney Injury; a Systematic Review and Meta-Analysis. *Int J Pediatr.* 2016:3815-36.
18. Le Gall J-R, Loirat P, Alperovitch A, Glaser P, Granthil C, Mathieu D, et al. A simplified acute physiology score for ICU patients. *Crit Care Med.* 1984;12(11):975-7.
19. Olsson T, Lind L. Comparison of the Rapid Emergency Medicine Score and APACHE II in Nonsurgical Emergency Department Patients. *Acad Emerg Med.* 2003;10(10):1040-8.
20. Imhoff BF, Thompson NJ, Hastings MA, Nazir N, Moncure M, Cannon CM. Rapid Emergency Medicine Score (REMS) in the trauma population: a retrospective study. *BMJ Open.* 2014;4(5):e004738.
21. Ha DT, Dang TQ, Tran NV, Vo NY, Nguyen ND, Nguyen TV. Prognostic performance of the Rapid Emergency Medicine Score (REMS) and Worthing Physiological Scoring system (WPS) in emergency department. *Int J Emerg Med.* 2015;8(1):18.
22. Lefering R. Trauma scoring systems. *Curr Opin Crit Care.* 2012;18(6):637-40.
23. Duckitt R, Buxton-Thomas R, Walker J, Cheek E, Bewick V, Venn R, et al. Worthing physiological scoring system: derivation and validation of a physiological early-warning system for medical admissions. An observational, population-based single-centre study. *Br J Anaesth.* 2007;98(6):769-74.
24. Cleves MA, Rock L. From the help desk: Comparing areas under receiver operating characteristic curves from two or more probit or logit models. *Stata J.* 2002;2(3):301-13.
25. Brabrand M, Hallas J, Knudsen T. Nurses and Physicians in a Medical Admission Unit Can Accurately Predict Mortality of Acutely Admitted Patients: A Prospective Cohort Study. *PLoS One.* 2014;9(7):e101739.