Original article

Performance of physiology scoring systems in prediction of in-hospital mortality of traumatic children: A prospective observational study

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ABSTRACT

Background: This study is designed to compare the value of four physiologic scoring systems of rapid acute physiology score (RAPS), rapid emergency medicine score (REMS), Worthing physiology scoring system (WPSS) and revised trauma score (RTS) in predicting the in-hospital mortality of traumatic children brought to the emergency department.

Method: We used the data gathered from six healthcare centers across Iran between the April–October 2016. Included patients were all children with trauma. Patients were assessed and followed until discharge. Moreover, patients were divided to two groups of died and alive, and discriminatory power and general calibration of models in prediction of in-hospital mortality were compared.

Results: Data was gathered from 814 children (average age of 11.65 ± 5.36 years, 74.32% boys). Highest measured area under the curve was for RAPS and REMS with 0.986 and 0.986, respectively. Areas under the curve of WPSS and RTS were 0.920 and 0.949, respectively ($p = 0.02$). Sensitivity and specificity of RAPS were 100.0 and 95.05, respectively. These amounts for REMS were 100.0 and 94.04, respectively. Two models of RTS and WPSS had the same sensitivity of 84.62. Specificity of these two was 98.22 and 96.95, respectively. Three models of RAPS, REMS and RTS had proper calibrations in predicting mortality; however, it seems that WPSS overestimates the mortality in high risk patients.

Conclusion: As calculations of RAPS is easier than REMS and their proper calibrations, it seems that RAPS is the best physiologic model in predicting in-hospital mortality and classifying in traumatic children based on severity of injury. However, further validation of the recommended score is essential before implementing them into routine clinical practice.

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1. Introduction

Predicting the outcome of traumatic patients in the emergency ward is a topic which has gained a lot of attention in recent years and many models are proposed to achieve this goal. Using scoring

systems is the most emphasized method in many articles.^{1–6} For this purpose; researchers have designed different scoring systems and have done modifications on them to improve their efficacy and accuracy.^{7–9} Using scoring systems helps in treatment and management of traumatic patients more accurately and according to their priority

The importance of scoring systems is more pronounced in emergency ward as rapid management of patients can have profound beneficial effects on their outcome. On the other hand, overcrowded emergency wards cause physicians and nurses to

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have less time for patient care. For this reason, using scoring systems which lessen the time required for patient evaluation and improve medical care quality¹⁰ can increase the efficacy of the care given. In the face of their many benefits there are many barriers to their usage. These barriers are complicated calculations, having many variables and sometimes lack of validity assessment of scoring systems in different clinical settings. Therefore, research in this topic is ongoing and new models are introduced every year. In addition, most of these models are meant for adults and their validity for children and adolescents has not been evaluated yet.

Physiologic scoring systems can be used as a tool for classification of patients and identifying high risk individuals because of their easy calculations and more feasible factors such as pulse rate, blood pressure, body temperature, respiratory rate and level of consciousness. There are many physiologic scoring systems which “acute physiology and chronic health evaluation (APACHE)” is the most renowned one.¹¹ However, too many included factors and subsequent difficult calculations have led to emergence of other models. Rapid Acute Physiology Score (RAPS) is another physiologic model which is considered the abbreviated version of the APACHE II score with pulse rate, blood pressure, respiratory rate and Glasgow Coma Scale (GCS) considered prognostic factors in traumatic patients. Although its predictive value is good, researchers are looking forward to improve its accuracy.¹² Studies in 2003 and 2004 by Olsson et al. showed that addition of age and arterial oxygen saturation to the factors increases the RAPS value, so “rapid emergency medicine score (REMS)” was suggested. This model was suggested for predicting mortality of non-surgical patients of the emergency department.^{12,13} However, its validity in traumatic patients has been tested in limited studies. Worthing physiology score (WPSS) is another physiologic model which was introduced in 2007¹⁴ but, data regarding its overall validity is very scarce. At last, Revised Trauma Score (RTS) is one of the easiest physiologic models for predicting the outcome of traumatic patients using three factors of GCS, systolic blood pressure and respiratory rate.¹⁵

In the face of many studies investigating the validity of different physiologic scoring systems in adult traumatic patients, there is no study in this aspect targeting children. This study is designed to compare the value of four physiologic models of RAPS, REMS, WPSS and RTS in predicting in-hospital mortality of traumatic children brought to emergency department.

2. Materials and methods

2.1. Study design and setting

This is an observational study comparing value of four scoring models of RAPS, REMS, WPSS, and RTS in predicting in-hospital mortality of traumatic children between the April–October 2016 in six healthcare centers across Iran. Data gathering was done prospectively by an emergency medicine specialist in each center. The six centers were in Tehran (Iran's capital, two hospitals), Urmia and Tabriz (west of Iran), Ilam and Jahrom (south of Iran). The study protocol was approved by the ethics committee of Tehran University of Medical Sciences. During the study period, all researchers adhered to the principles of the Helsinki declaration. In addition, a consent form was obtained from patients or their accompaniments before entering the study.

2.2. Study population

Traumatic patients between 1 to 18 years of age brought to emergency wards were entered in this study. Exclusion criteria were patient death before admitting to the emergency ward. Convenience sampling method was used. According to in-hospital mortality prevalence of 5.2% in traumatic patients¹⁶, a confidence interval of 95% ($\alpha = 0.05$), power of 90% ($\beta = 0.1$) and a maximum error of 1.5% ($d = 0.01$) in estimating mortality prevalence, a minimum of 189 individuals were needed for study population. At the end, data from 814 individuals were entered.

Table 1
Cut offs used for calculating of scoring systems in paediatric trauma patients.

	Body temperature (degree of Celsius)	MAP/SBP ^a (mmHg)	Heart rate (pulse per min)	Respiratory rate (per min)	Oxygen Saturation (%)	Level of consciousness ^b
RAPS						
+4	–	>159 or <49	>199 or <39	>49 or <5	–	<5
+3	–	130–159	160–199 or 40–54	40–49	–	5–7
+2	–	110–129 or 50–69	130–159 or 55–69	6–9	–	8–10
+1	–	–	–	30–39 or 10–11	–	11–13
0	–	70–109	70–130	12–30	–	>13
REMS						
+4	>40.9 or <30	>159 or <49	>199 or <39	>49 or <5	<75	<5
+3	39–40.9 30–31.9	130–159	160–199 or 40–54	40–49	75–85	5–7
+2	32.0–33.9	110–129 or 50–69	130–159 or 55–69	6–9	–	8–10
+1	38.5–38.9 or 34.0–35.9	–	–	30–39 or 10–11	86–89	11–13
0	36.0–38.4	70–109	70–130	12–30	>89	>13
RTS						
+4	–	>89	–	10–29	–	13–15
+3	–	76–89	–	>29	–	9–12
+2	–	50–75	–	6–9	–	6–8
+1	–	1–49	–	1–5	–	4–5
0	–	0	–	0	–	3
WPSS						
+3	<35.3	–	–	–	<92	Other
+2	–	<100	–	≥40	92–94.9	–
+1	–	–	≥131	30–39	94–95.9	–
0	≥35.3	≥100	≤130	<30	96–100	Alert

LOC: Level of consciousness; MAP: Mean arterial pressure; RAPS: Rapid acute physiology score; REMS: Rapid emergency medicine score; RTS: Revised trauma score; WPSS: SBP: Systolic blood pressure; Worthing physiology scoring system.

^a We used systolic blood pressure in calculation of WPSS and RTS and mean arterial pressure for RAPS and REMS.

^b Based of paediatric Glasgow coma scale.

2.3. Data gathering

Patients were assessed by emergency medicine physicians on admission and their age, sex, mechanism of trauma and vital signs such as pulse rate, respiratory rate, systolic blood pressure, diastolic blood pressure, body temperature and level of consciousness by paediatric GCS were obtained. Blood pressure was measured by a paediatric sphygmomanometer from left arm (right arm, if left hand was injured) in supine position. Body temperature was checked using a mercury thermometer from the axillary region. Arterial oxygen saturation was obtained from the right index finger by a pulse oximetry.

Normal ranges of vital signs in children in studies of Fleming et al. and Falkler et al. were used in this study.^{17,18} As age of less than 40 years old was assigned a weight of zero in REMS scoring system, age was not entered in the study for REMS scoring system.

In the present study, paediatric cut-off points (for respiratory rate, pulse rate and blood pressure) were used in calculations of aforementioned models. In addition, paediatric GCS criteria were used in order to assess to the level of consciousness of children between 1 and 2 years of age. On the contrary, standard GCS criteria were used for older children. Cut-off points used in all models are shown in Table 1.

2.4. End-points

Patients were followed until discharge and their living status (died or alive) was assessed at discharge. All in all, in-hospital mortality was the end-point assessed.

2.5. Statistical analysis

Data were analysed by STATA version 11.0. Each patient was given a score based on RAPS, REMS, WPSS and RTS. Discriminatory power, general calibration and overall performance of models were assessed for comparison of the predictive value of the four mentioned models. Area under the receiving operating characteristics (ROC) curve (AUC), sensitivity, specificity, positive predictive value, negative predictive value, positive and negative likelihood ratio were calculated with a confidence interval of 95% (CI = 95%) in order to assess discriminatory power. AUC of the four models were compared by the suggested method of Cleves and Rock to compare their discriminatory power.¹⁹ General calibration was assessed by drawing calibration plot which compared observed versus predicted mortality per decile of the linear predictor of the models. Additionally, overall performance was assessed by measurement of Brier score, scaled reliability and Nagelkerke's R^2 . In all analyses $p < 0.05$ was considered significant.

3. Results

3.1. Demographic variables

Data was gathered from 814 children with average age of 11.65 ± 5.36 years. There were 605 (74.32%) boys and 209 (25.68%) girls. Demographic and basal characteristics of children are shown in Table 2. Mean level of consciousness according to paediatric GCS was 14.66 ± 1.57 . Mean values of pulse rate, respiratory rate, systolic blood pressure, diastolic blood pressure, body temperature were 90.72 ± 16.17 beat per minute, 17.33 ± 6.54 rate per minute, 108.02 ± 12.02 mmHg, 69.79 ± 9.69 mmHg, and $36.85 \pm 0.68^\circ$ of Celsius, respectively. In-hospital mortality rate was 3.19%.

Table 2

Baseline characteristics of studied patients.

Variable	n (%)
Age (year)	
1–3	95 (11.67)
4–6	89 (22.60)
7–11	158 (19.41)
12–18	472 (57.99)
Gender	
Boys	605 (74.32)
Girls	209 (25.68)
Mechanism of trauma	
Motorcycle accident	230 (28.26)
Car rider accident	152 (18.67)
Pedestrian	171 (21.01)
Falls more than 3 m	79 (9.71)
Falls less than 3 m	82 (10.07)
Other	100 (12.29)
Glasgow coma scale	
14–15	782 (96.66)
9–13	14 (1.73)
3–8	13 (1.61)
Heart rate	
Bradycardia	11 (1.35)
Normal rate	479 (58.85)
Tachycardia	324 (39.80)
Systolic blood pressure	
Hypotension	187 (22.97)
Normotension	583 (71.62)
Hypertension	44 (5.41)
Diastolic blood pressure	
Hypotension	73.49 $\pm$ 10.07
Normotension	187 (22.97)
Hypertension	583 (71.62)
Oxygen saturation	
Normal	604 (74.20)
Low	210 (25.80)
Temperature	
Hypothermia	36.81 $\pm$ 0.90
Normal	6 (0.74)
Fever	808 (99.26)
Respiratory rate	
Hypopnea	0 (0.0)
Normal	16.46 $\pm$ 6.15
Tachypnea	110 (13.51)
Outcome	
Alive	653 (80.21)
Death	51 (6.27)

Fig. 1. Area under the receiver operating characteristics curve (AUC) of rapid emergency medicine score (REMS), rapid acute physiology score (RAPS), Worthing physiology scoring system (WPSS) and revised trauma score (RTS) in prediction of in-hospital mortality.

3.2. Discrimination

AUC of assessed physiologic parameters are shown in Fig. 1. Highest measured AUCs were for RAPS and REMS with amounts of 0.986 (95% CI: 0.978–0.995) and 0.986 (95% CI: 0.977–0.996), respectively. AUC of WPSS and RTS were 0.920 (95% CI: 0.847–0.992) and 0.949 (95% CI: 0.913–0.985), respectively. Analyses showed a significant higher AUCs in RAPS and REMS in comparison with other models ($p=0.02$).

According to ROC curve, best cut-off points for RAPS and REMS were 3. Best cut-off point for WPSS and RTS were 6 and 1, respectively. Sensitivity and specificity of RAPS were 100.0 (95% CI: 83.98–100.0) and 95.05 (95% CI: 93.3–96.41), respectively at cut-off point of 3. These amounts were 100.0 (95% CI: 83.98–100.0) and 94.04 (95% CI: 92.09–95.54) for REMS model, respectively. Sensitivities of RTS and WPSS were significantly lower than those of REMS and RAPS in predicting in-hospital mortality. Two models of RTS and WPSS had the same sensitivity of 84.62 (95% CI: 64.27–94.95). Specificity of these two were 98.22 (95% CI: 96.96–98.98) and 96.95 (95% CI: 95.43–98.0), respectively (Table 3).

3.3. Calibration

Calibration plot of scoring systems is depicted in Fig. 2. As shown three models of RAPS, REMS and RTS had proper calibrations however, it seems that WPSS overestimates mortality in high risk patients. The best calibration was observed in RAPS (slope = 0.99; intercept = 0.0009) because of close concordance of predicted and observed values.

3.4. Overall performance

Brier score and scaled reliability of RAPS were 0.015 and 0.0001, respectively. These amounts were 0.011 and 0.0001 for REMS, respectively. WPSS model had a Brier score of 0.022 and a scaled reliability of 0.0002, respectively. These amounts were 0.009 and <0.0001 for RTS, respectively. These results show proper reliability and predictive accuracy of all four models (Table 4).

4. Discussion

This study showed a high value for physiologic scoring systems in predicting in-hospital mortality of traumatic children brought to emergency department. However, RAPS and REMS have a higher value than WPSS and RTS.

Cut-off points used in calculations of RAPS, REMS and WPSS scoring systems are a bit different than cut-off points used in their derivation studies. The reason for this diversity is different normal ranges of physiologic variables between adults compared to children and adolescents. Overall, these physiologic models are

designed for adults. Therefore, paediatric cut-off points were used to validate using these models in children. Results of the present study showed that these physiologic models have a high value in prediction of mortality in traumatic children in face of these modifications.

Calculation of REMS scoring system consists of three additional variables than RAPS scoring system including age, arterial oxygen saturation and body temperature levels.^{12,20} However, addition of age as a variable for children is meaningless because in this model weight of age less than 40 years old is zero. Therefore, the only difference between RAPS and REMS in scoring of traumatic children is arterial oxygen saturation and body temperature level. The present study shows that the value of RAPS and REMS in predicting in-hospital mortality is equal and addition of arterial oxygen saturation and body temperature level to RAPS does not increase its value. All in all, it seems that RAPS is better than REMS in classifying traumatic children as RAPS has fewer variables to calculate.

Predictive value of RAPS and REMS in mortality or classifying the severity of injury in traumatic children had not been assessed until now. However, there are some studies in adults showing confounding results. For example, Olsson et al. reported that AUC of RAPS in predicting mortality of neurosurgical patients brought to emergency ward was 0.65²⁰, but their other study reported an AUC of 0.87.¹² AUC of REMS in two studies by Olsson et al. was 0.910 and 0.85.^{12,20} The retrospective study of Imhoff et al. showed that AUCs of RTS and REMS in predicting in-hospital mortality were 0.91 and 0.89, respectively which did not have a significant difference.¹⁶ Predictive value reported by Ha et al. was lower than other studies. They say that AUCs of REMS and WPSS in predicting 30-day mortality of patients were 0.71 and 0.80, respectively. They believe that the value of WPSS model is significantly higher than REMS.²¹ Results of the present study were in contrast with those of Ha's. Our result showed that the value of RAPS and REMS is significantly higher than WPSS. These diverse results can be caused by the difference in patients and their age group. Ha et al's study was conducted on adults brought to emergency department with diverse etiologies however, traumatic children were studied in the present study.

The present study showed that WPSS has a poor calibration in high risk patients. In other words, the mentioned model overestimates mortality rate in high risk individuals. This result is consistent with Ha et al's study²¹ which showed similar results by drawing calibration plot of WPSS. It seems that this model has the mentioned weakness and the reason should be sought in the way of scoring in WPSS. In this model the weight of arterial oxygen saturation level and body temperature are high. Arterial oxygen saturation lower than 92% adds 3 points to WPSS, however 3 points are added in levels between 75 and 85% to REMS model. There is a similar pattern regarding body temperature.²² In addition, in other

Table 3
Screening characteristics of physiological scoring system in prediction of in-hospital mortality.

Performance ^a	RAPS	REMS	WPSS	RTS
True positive	26	26	22	22
True negative	749	741	764	774
False positive	39	47	24	14
False negative	0	0	4	4
Sensitivity	100.0 (83.98–100.0)	100.0 (83.98–100.0)	84.62 (64.27–94.95)	84.62 (64.27–94.95)
Specificity	95.05 (93.23–96.41)	94.04 (92.09–95.54)	96.95 (95.43–98.00)	98.22 (96.96–98.98)
Positive predictive value	40.0 (28.28–52.90)	35.61 (25.0–47.76)	47.83 (33.14–62.87)	61.11 (43.53–76.38)
Negative predictive value	100.0 (99.36–100.0)	100.0 (99.36–100.0)	99.48 (98.58–99.83)	99.49 (98.59–99.83)
Positive likelihood ratio	20.20 (14.87–27.43)	16.77 (12.71–22.12)	27.78 (18.13–42.57)	47.62 (27.63–82.09)
Negative likelihood ratio	0.0 (0.0–0.0)	0.0 (0.0–0.0)	0.16 (0.06–0.39)	0.16 (0.06–0.39)

^aData are presented as value (95% confidence interval); RAPS: Rapid acute physiology score; REMS: Rapid emergency medicine score; RTS: Revised trauma score; WPSS: Worthing physiology scoring system.

Fig. 2. Calibration plots of rapid emergency medicine score (REMS), rapid acute physiology score (RAPS), Worthing physiology scoring system (WPSS) and revised trauma score (RTS) in prediction of in-hospital mortality.

Table 4

Overall performance of physiological scoring system in prediction of in-hospital mortality.

Value	RAPS	REMS	WPSS	RTS
Brier score	0.015	0.011	0.022	0.009
Scaled reliability	0.0001	0.0001	0.0002	<0.0001
R ²	0.70	0.72	0.48	0.71

models level of consciousness is categorized as mild, moderate and severe groups and each has its own number of points^{15,20} but, the level of consciousness is categorized as alert versus other in WPSS scoring system.²² This can also lead to misclassification of patients and overestimation of mortality risk at the end.

5. Limitations

Limitations to this study are its convenience sampling method. This strategy makes selection bias more probable. However, score calculations were done after data gathering because if these calculations were done on a real time basis in the emergency ward, it would be possible that the crowded situation and lack of enough time would affect the results. If scoring was done on a real time basis, value of models would be assessed more realistically.

6. Conclusion

For the first time, this article assessed the predictive value of physiologic scoring systems in predicting in-hospital mortality of traumatic children. This study showed that physiologic scoring systems are valid for predicting in-hospital mortality of traumatic children brought to emergency department. Among these models RAPS and REMS have higher values than WPSS and RTS. As calculations in RAPS are easier than those of REMS and its proper calibration, RAPS is the best physiologic scoring model in predicting in-hospital mortality and classifying the severity of injury in traumatic children. However, further validation of the recommended score is essential before implementing them into routine clinical practice.

Conflict of interest

None.

Author contribution

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References

- Hoffman JR, Mower WR, Wolfson AB, Todd KH, Zucker MI. Validity of a set of clinical criteria to rule out injury to the cervical spine in patients with blunt trauma. *N Engl J Med*. 2000;343(2):94–99.
- Safari S, Yousefifard M, Baikpour 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.
- Shojaee M, Dolatabadi AA, Sabzghabaei A, et al. New scoring system for intra-abdominal injury diagnosis after blunt trauma. *Chin J Traumatol*. 2014;17(1):19–24.
- Safari S, Yousefifard M, Hashemi B, 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):101–106.
- Aminiahidashti H, Bozorgi F, Montazer SH, Baboli M, Firouzian A. Comparison of APACHE II and SAPS II scoring systems in prediction of critically ill patients' outcome. *Emergency*. 2016;4: [in press].
- Mazandarani PD, Heydari K, Hatamabadi H, Kashani P, Danesh YJ. Acute physiology and chronic health evaluation (APACHE) III score compared to trauma-Injury severity score (TRISS) in predicting mortality of trauma patients. *Emergency*. 2016;4(2):88–91.
- Lefering R. Trauma scoring systems. *Curr Opin Crit Care*. 2012;18(6):637–640.
- Lecky F, Woodford M, Edwards A, Bouamra O, Coats T. Trauma scoring systems and databases. *Br J Anaesth*. 2014;113(2):286–294.
- Della Corte F, Vignazia G, Cavaglia M. Trauma scoring systems. *Anaesthesia, Pain, Intensive Care and Emergency Medicine—APICE*. Springer; 2002:351–361.
- 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.
- Mok SR, Mohan S, Elfant AB, Judge TA. The acute physiology and chronic health evaluation IV, a new scoring system for predicting mortality and complications of severe acute pancreatitis. *Pancreas*. 2015;44(8):1314–1319.
- 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):1040–1048.
- Olsson T, Terent A, Lind L. Rapid emergency medicine score can predict long-term mortality in nonsurgical emergency department patients. *Acad Emerg Med*. 2004;11(10):1008–1013.
- Duckitt R, Buxton-Thomas R, Walker J, 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):769–774.
- Champion HR, Sacco WJ, Copes WS, Gann DS, Gennarelli TA, Flanagan ME. A revision of the trauma score. *J Trauma Acute Care Surg*. 1989;29(5):623–629.
- 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).
- Falkner B, Daniels SR, Flynn JT, et al. The fourth report on the diagnosis, evaluation, and treatment of high blood pressure in children and adolescents. *Pediatrics*. 2004;114(2 III):555–576.
- Fleming S, Thompson M, Stevens R, et al. Normal ranges of heart rate and respiratory rate in children from birth to 18 years of age: a systematic review of observational studies. *Lancet*. 2011;377(9770):1011–1018.
- 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):301–313.
- Olsson T, Terent A, Lind L. Rapid Emergency Medicine Score: a new prognostic tool for in-hospital mortality in nonsurgical emergency department patients. *J Intern Med*. 2004;255(5):579–587.
- 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.
- Duckitt RW, Buxton-Thomas R, Walker J, 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):769–774.