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ORIGINAL RESEARCH

Predicting the 28-Day Mortality of Non-Trauma Patients using REMS and RAPS; a Prognostic Accuracy Study

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Abstract: **Introduction:** Various scoring systems have been designed for calculating the mortality risk of patients. This study evaluated the accuracy of Rapid Emergency Medicine Score (REMS) and Rapid Acute Physiology Score (RAPS) in predicting the 28-day mortality of non-trauma patients. **Methods:** This prospective cross-sectional study was conducted on 1003 adult non-trauma patients, who referred to the emergency department of Imam Khomeini Hospital, Urmia, Iran, in the second half of 2018, using the census sampling. We determined the screening performance characteristics of REMS and RAPS in predicting the 28-day mortality of patients. **Results:** This study examined 1003 non-trauma patients with a mean age of 61.5±18.05 years (60.6% male). The mean REMS (8.7 ± 3.2 vs. 6.0 ± 3.6; $p < 0.001$) and RAPS (3.7 ± 2.8 vs. 2.7 ± 2.0; $p < 0.001$) scores were significantly higher in deceased cases. Sensitivity and specificity of REMS in predicting the risk of non-trauma patients' mortality were 85.19% (95%CI: 78.05% - 90.71%) and 78.34% (95%CI: 75.45% - 81.04%), respectively. While, the Sensitivity and specificity of RAPS in this regard were 61.39% (95%CI: 53.33% - 69.02%) and 71.12% (95%CI: 67.94% - 74.16%), respectively. The area under the receiver operating characteristic (ROC) curve of REMS and RAPS were 0.72 (95% CI: 0.68 -0.75) and 0.62 (95% CI: 0.56 - 0.65) in predicting the patients' 28-day mortality, respectively ($p = 0.001$). **Conclusion:** The total accuracies of REMS and RAPS in predicting the 28-day mortality of non-trauma patients were in good and poor range, respectively. The screening performance characteristics of REMS were a little better in this regard.

Keywords: Emergencies; Emergency Service, Hospital; Mortality; Clinical Decision Rules; Prognosis

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1. Introduction

Various scoring systems have been designed for calculating the mortality risk of patients. These systems are methods designed to quantify the severity of the disease and the patient's condition by integrating the various properties affecting it (1, 2).

Several scoring systems have been proposed to assess disease severity in recent decades (3, 4). They are mainly used in critically ill patients and their common goal is to measure deviations in various physiological variables to provide an objective measure of the severity of the disease known to physicians worldwide. A wide range of applications of the tools envisioned by Hazy are described (5). Classifying the severity of illness in the emergency department (ED), along with an ac-

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curate history of the disease, can classify critically ill patients. Scoring systems can also be used to evaluate the use of hospital resources and compare different emergency departments in short- and long-term. Scoring systems could also be a potential triage tool for emergency nurses. One of these scoring systems is Acute Physiology and Chronic Health Evaluation II)APACHEII(, , described by Knaus et al., which classifies the severity of disease (6). However, the APACHE II score contains several blood chemical variables and is, therefore, not suitable for rapid assessment in the emergency department. Rapid Acute Physiology Score (RAPS) is a summary of APACHE II, which was initially used as a hospital scoring system for the patients transported by helicopter (7). An important advantage of RAPS is the simplicity of its assessment method.

Rapid Emergency Medicine Score (REMS) is an attenuated version of APACHE II score and can predict mortality in non-surgical patients (8). A study on performance of REMS in predicting the in-hospital mortality of trauma patients confirmed its simplicity and accuracy in this regard (9).

Due to the limited number of variables in the RAPS and REMS, it is possible to evaluate and calculate scores based on these models and easily use them in ED. However, only a few studies have compared the two models (7, 10, 11), and there are still controversies over their use in evaluating the mortality of non-trauma patients. Given this, we intended to evaluate the accuracy of REMS and RAPS in predicting the 28-day mortality of non-trauma patients.

2. Methods

2.1. Study design and setting

This descriptive cross-sectional study was conducted on 1003 non-trauma patients, who referred to the emergency department of Imam Khomeini Hospital, Urmia, Iran, in the second half of 2018, using census method. We determined the screening performance characteristics of REMS and RAPS in predicting the 28-day mortality of adult non-trauma patients. This study was registered in Urmia University of Medical Sciences with the ethics code of IR.UMSU.REC.1397.213. While following the patients, we explained the research plan to them and ensured their willingness to participate in the study. The participants were assured that their information would be kept confidential.

2.2. Participants

In this study, adult non-trauma patients with complete patient files were included. We excluded patients who had died before reaching the ED.

2.3. Data collection procedures

A predesigned checklist that included information about patients' age, gender, and final outcome (deceased or discharged), and the REMS and RAPS was filled out for all patients using their profiles. REMS variables included age, level of consciousness, mean blood pressure, respiration rate, and oxygen level; and the RAPS consisted of pulse rate, blood pressure, respiration rate, and Glasgow Coma Scale (GCS) score (appendix 1 and 2). All the information was recorded upon patients' arrival at the emergency department and patients were also contacted for a 28-day follow-up of death or recovery. An emergency physician was responsible for data gathering.

2.4. Statistical analysis

The data were analyzed using SPSS18, and the findings were reported using descriptive statistics (mean ± standard deviation) or frequency (%). The screening performance characteristics of REMS and RAPS in predicting the 28-day mortality of non-trauma patients were calculated using a calculator (http://vassarstats.net/clin1.html) and the area under the receiver operating characteristic (ROC) curve. The analysis results were reported with 95% confidence interval (CI).

3. Results

This study examined 1003 non-trauma patients with a mean age of 61.5±18.05 years (60.6% male). Table 1 compares the baseline characteristics and REMS and RAPS between deceased and discharged patients. The mean REMS (8.7 ± 3.2 vs. 6.0 ± 3.6; $p < 0.001$) and RAPS (3.7 ± 2.8 vs. 2.7 ± 2.0; $p < 0.001$) scores were significantly higher in deceased cases. Table 2 shows the screening performance characteristics of REMS and RAPS in predicting the risk of 28-day mortality in non-trauma patients.

Sensitivity and specificity of REMS in predicting the risk of in hospital mortality of non-trauma patients were 85.19% (95%CI: 78.05% - 90.71%) and 78.34% (95%CI: 75.45% - 81.04%), respectively. While, the Sensitivity and specificity of RAPS in this regard were 61.39% (95%CI: 53.33% - 69.02%) and 71.12% (95%CI: 67.94% - 74.16%), respectively.

The area under the ROC curve of REMS and RAPS was 0.72 (95% CI: 0.68 -0.75) and 0.62 (95% CI: 0.56 - 0.65), respectively, (figure 1; $p = 0.001$) in predicting the 28-day mortality.

4. Discussion

Based on the findings of the present study, it seems that REMS is a better predictor of the 28-day mortality of non-trauma patients in emergency department compared to RAPS. In this study, there was a significant difference between the two groups (discharged and deceased patients) in

terms of mean REMS. The mean REMS of deceased patients was higher compared to that of discharged patients. There was also a significant difference between the two groups (discharged and deceased patients) regarding the mean RAPS. The mean RAPS of deceased patients was higher than that of discharged patients.

In a similar study, Seak et al. (12) evaluated the performance of REMS in predicting in-hospital mortality in non-surgical emergency department patients. In their study, REMS was a powerful predictor of in-hospital mortality in patients admitted to the emergency department with a wide range of common internal disorders. The results of that study were similar to our study. In a study by Ha et al. (13), on predicting the prognosis of patients based on REMS and the Worthing Physiological Assessment System (WPS) in the emergency department, both REMS and WPS had a good performance in predicting death in critically ill patients.

In similar studies, Plunkett et al. (14) and Nakhchivan et al. (7) showed that REMS is a better predictor of mortality at the time of admission of inpatients compared to RAPS. The results of these studies are consistent with our study. REMS seems to be a powerful predictor of in-hospital mortality among patients referring to the emergency department with a wide range of common internal disorders. One of the laboratory scoring methods was described based on biochemistry tests on admission, which identified high-risk patients for in-hospital death. Risk profiles on admission could be a means of improving outcomes (15). Identifying high-risk patients can be the basis for purposeful intervention after emergency medical care. This study confirms that the REMS has better discriminatory power than the RAPS regarding in-hospital mortality. Olson et al. used similar methods to calculate REMS and evaluate the predictive power of RAPS. They found that REMS was a better predictor of nosocomial mortality compared to RAPS (16).

In our study, the accuracy of REMS in prediction of mortality was 72.2%, this rate was 62.6% for RAPS based on the area under the ROC curve (AUROC). Sensitivity of REMS (72.2%) was higher than the sensitivity of RAPS (62.6%). The cut-off points for REMS and RAPS criteria were 6.5 and 2.5, respectively. According to the linear regression model, it can be concluded that age, MAP, HR, respiratory rate (RR), Spo2, and GCS (54.7%) could predict the REMS criterion. Olsson's estimation of AUROC for RAPS (0.65) was very similar to ours (0.56 - 0.65), though their estimation of AUROC for REMS (0.85) was significantly higher (0.68 - 0.75). Bahrmann et al. (17) found that all six components of REMS were associated with hospital mortality, while the relationship between mean arterial pressure and mortality was not significant in multivariate analysis. Our findings and results clearly suggest that blood pressure is not a good predictor of mortality. In contrast to our study, heart rate and respiration were independent predictors of mortality in their study.

5. Limitations

The study was performed in a single center and thus, the results may not be generalizable. Further studies need to be carried out to validate the REMS and determine whether heart rate and respiratory rate are independent predictors of mortality. Ideally, risk classification tools for emergency care should be developed through pilot studies to identify all potentially useful variables and find variables having independent relationships with outcome, extract scores, and validate them in a different population. It should be noted that a risk classification tool that is useful for predicting death may not be useful for triage or clinical practice. Predicting mortality in triage or clinical practice may require distinguishing between avoidable and unavoidable mortality.

6. Conclusion

It seems that REMS is a better predictor of the 28-day mortality of non-trauma patients in an emergency department compared to RAPS. It should be noted that the total accuracy of REMS and RAPS in this regard was in good and poor range, respectively.

7. Declarations

7.1. Acknowledgments

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7.2. Financial resources

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7.3. Authors' contributions

Omid Garkaz (first author), was a statistical analyst (10%), Farzin Rezazadeh (second author), author of the article (15%), Saeed Golfiroozi (third author) author of the introduction (%10), Sahar Paryab (Fourth author) author of the discussion (20%), Sadaf Nasiri, lead researcher/ (fifth author) (10%), Hamid Reza Mehryar (sixth author), assistant researcher (25%), and Mousa Ghelichi-Ghojogh (seventh author) author of methodology (%10). The last version of manuscript was read and approved by all authors.

7.4. Conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this article.

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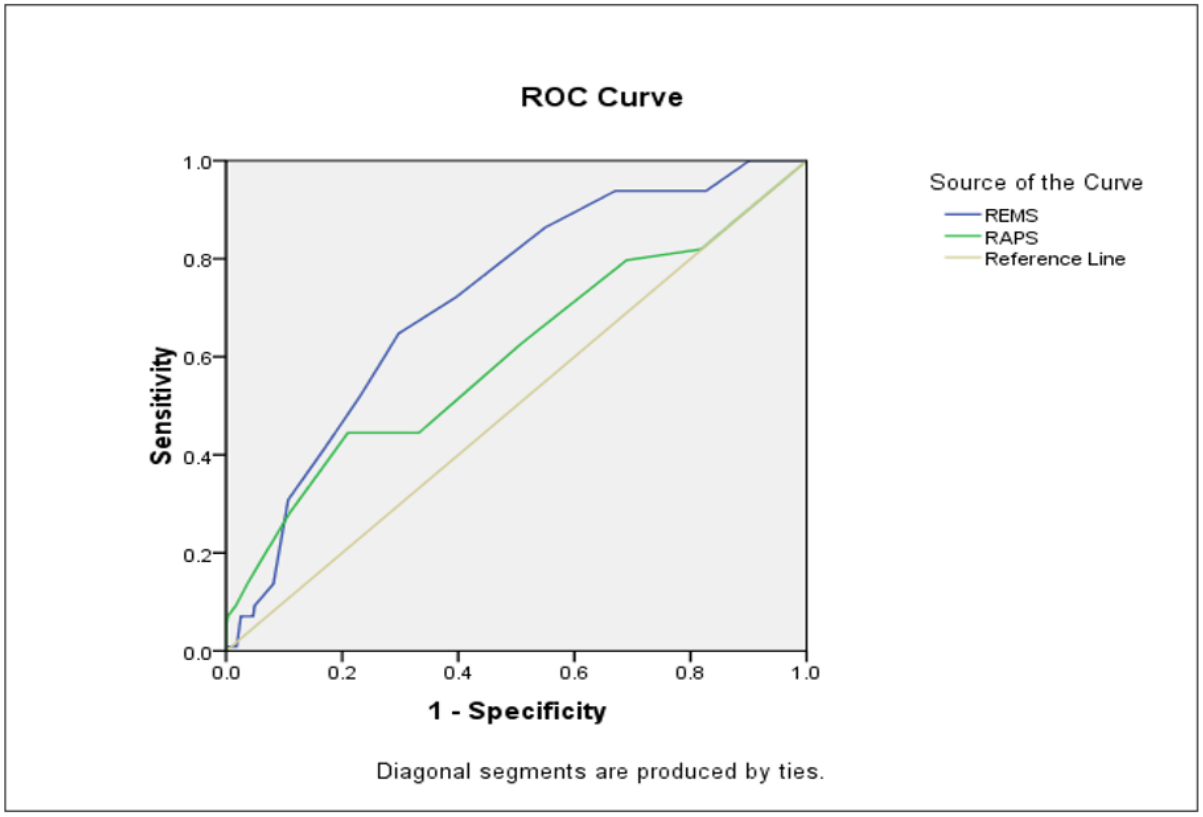

Figure 1: Area under the receiver operating characteristic (ROC) curve of Rapid Emergency Medicine Score (REMS) and Rapid Acute Physiology Score (RAPS) in predicting the risk of in-hospital mortality of non-trauma patients in emergency department (p = 0.001).

Appendix 1: Rapid Emergency Medicine Score (REMS)

Variable	Score						
	0	**1**	**2**	**3**	**4**	**5**	**6**
Age (year)	<45	-	45-54	55-64	-	65-74	>74
Emergency Score	70-109	-	110-129 50-69	130-159	>159 ≤49	-	-
Heart Rate (/minutes)	70-109	-	110-139 55-69	140-179 40-54	179 ≤39	-	-
Respiratory rate (/minutes)	12-24	25-34 10-11	6-9	35-49	>49 ≤5	-	-
SpO2 (%)	>89	86-89	-	75-85	<75	-	-
GCS	14 or 15	11-13	8-10	5-7	3 or 4	-	-

GCS: Glasgow Coma Scale; SaO2: oxygen saturation.

Appendix 2: Rapid Emergency Medicine Score (RAPS)

Variable	Points								
	+4	**+3**	**+2**	**+1**	**0**	**+1**	**+2**	**+3**	**+4**
MAP	160≥	130-159	110-129	-	70-109	-	50-69	-	49≤
HR	180≥	140-179	110-139	-	70-109	-	55-69	40-54	39≤
Resp*	50≥	35-49	-	25-34	12-24	10-11	6-9	-	5≤
GCS	-	-	-	-	14≥	11-13	10-8	5-7	4≤

MAP: Mean arterial pressure; HR: heart rate; Resp: respirations; GCS: Glasgow Coma Scale. Score of 0 is normal.
*Spontaneous or, if not spontaneous, ventilated rate.

Table 1: Comparing the baseline characteristics as well as Rapid Emergency Medicine Score (REMS) and Rapid Acute Physiology Score (RAPS) of studied cases between survived and non-survived cases

Variable	Outcome		P value
	Deceased	Discharged	
Age (year)			
Mean ± SD	66.5±13.9	56.5 ± 22.2	< 0.001
Gender			
Male	427(70.2)	181(29.8)	< 0.001
Female	330(83.6)	65(16.4)	
Vital Signs			
SBP (mmHg)	112.9 ± 31.4	125.5 ± 27.7	<0.001
DBP (mmHg)	69.5 ± 20.0	79.0 ± 20.8	<0.001
MAP (mmHg)	84.1 ± 22.8	94.7 ± 21.7	<0.001
HR (/minute)	101.1 ± 25.8	92.2 ± 22.2	<0.001
SaO2 (%)	91.9 ± 15.1	92.0 ± 7.3	<0.001
RR (/minute)	18.0 ± 2.9	21.1 ± 3.5	<0.001
GCS	8.1 ± 2.2	9.9 ± 2.2	<0.001
Predicting models			
REMS	8.7 ± 3.2	6.0 ± 3.6	<0.001
RAPS	3.7 ± 2.8	2.7 ± 2.0	<0.001

Data are presented as mean ± standard deviation (SD) or frequency (%). SBP: systolic blood pressure; DBP: Diastolic blood pressure; MAP: Mean arterial pressures; HR: Heart Rate; SaO2: oxygen saturation; RR: respiratory rate. GCS: Glasgow coma scale.

Table 2: Screening performance characteristics of Rapid Emergency Medicine Score (REMS) (cut-off = 6.5) and Rapid Acute Physiology Score (RAPS) (cut-off = 2.5) in predicting the risk of in-hospital mortality among non-trauma patients

Character	REMS (95%CI)	RAPS (95%CI)
True positive	115	97
True Negative	680	601
False positive	188	244
False negative	20	61
Sensitivity	85.19(78.05-90.71)	61.39(53.33-69.02)
Specificity	78.34(75.45-81.04)	71.12(67.94-74.16)
Positive predictive value	37.95(34.61-41.42)	97.58(97.17-97.94)
Negative predictive value	97.14(95.77-98.08)	8.84(7.35-10.60)
Positive likelihood ratio	3.93(3.40-4.55)	2.13(1.81-2.50)
Negative likelihood ratio	0.19(0.13-0.28)	0.54(0.44-0.66)
Accuracy	79.26(70.37-84.25)	61.88(58.79-64.90)

CI: confidence interval.