Comparison of APACHE II and three abbreviated APACHE II scores for predicting outcome among emergency trauma patients

Jorge Roberto Polita[1], Jussara Gomez[1], Gilberto Friedman[3*], Sérgio Pinto Ribeiro[2]

[1] São Vicente de Paulo Hospital – University of Passo Fundo, Passo Fundo, RS, Brazil.
[2] Federal University of Rio Grande do Sul – Medical School, Porto Alegre, RS, Brazil.
[3] Federal University of Rio Grande do Sul – Medical School – Graduate Program in Pulmonology, Porto Alegre, RS, Brazil.

Summary

Objective: to compare the ability of the APACHE II score and three different abbreviated APACHE II scores: simplified APACHE II (s-APACHE II), Rapid Acute Physiology score (RAPS) and Rapid Emergency Medicine score to evaluate in-hospital mortality of trauma patients at the emergency department (ED).
Methods: retrospective analysis of a prospective cohort study. All patients' victims of trauma admitted to the ED, during a 5 months period. For all entries to the ED, APACHE II score was calculated. APACHE II system was abbreviated by excluding the laboratory data to calculate s-APACHE II score for each patient. Individual data were reanalyzed to calculate RAPS and REMS. APACHE II score and its subcomponents were collected, and in-hospital mortality was assessed. The area under the receiver operating characteristic (AUROC) curve was used to determine the predictive value of each score.
Results: 163 patients were analyzed. In-hospital mortality rate was 10.4%. s-APACHE II, RAPS and REMS scores were correlated with APACHE II score ($r^2 = 0.96$, $r^2 = 0.82$, $r^2 = 0.92$; $p < 0.0001$). Scores had similar accuracy in predicting mortality ([AUROC 0.777 [95% CI 0.705 to 0.838] for APACHE II, AUROC 0.788 [95% CI 0.717 to 0.848] for s-APACHE II, AUROC 0.806 [95% CI 0.737 to 0.864] for RAPS, AUROC 0.761 [95% CI 0.688 to 0.824] for REMS.
Conclusion: abbreviated APACHE II scores have similar ability to evaluate in-hospital mortality of emergency trauma patients in comparison to APACHE II score.

Keywords: APACHE, injury severity score, trauma severity indices, trauma, mortality.

Work conducted at the São Vicente de Paulo Hospital, Passo Fundo, RS, Brazil

Article received: 8/23/2013
Accepted for publication: 1/13/2014

***Correspondence:**
Address: Rua Fernandes Vieira 181/601, ZIP 90035-091
Porto Alegre, RS - Brazil
Phone/Fax: +55 51 3395 8223
gfriedman@hcpa.ufrgs.br

http://dx.doi.org/10.1590/1806-9282.60.04.018
Conflict of interest: none

Introduction

Illness severity scoring systems have become important tools for studying patient outcomes. Early efforts to measure the efficacy of trauma centers and trauma systems assessed the rates of preventable mortality. The risk stratification of trauma patients has traditionally focused on anatomic or physiologic scores specific to trauma populations. Trauma scoring systems were initially developed to triage patients in the field and needed to be straightforward and user friendly. There are several systems such as the triage Revised Trauma Score, Triage Score, and Trauma and Injury Severity Score (TRISS) for predicting the severity of trauma patient's conditions along with patient outcomes.[1,2]

However, there are few methods for precisely and easily predicting the outcomes both in the emergency room and in the intensive care unit (ICU) trauma patients. The trauma patient population is different from the general patient population. Trauma patients are considered younger, healthier and with unique pathophysiologic patterns. All these factors might limit the usefulness of scores addressing broader categories of patients and diseases like the Acute Physiology and Chronic Health Evaluation (APACHE) II.[3,4]

Although APACHE II score has not been validated as a specific prognostic tool for trauma patients, several studies have shown its value to evaluate prognosis of trauma patients.[4-6] Criticisms of the use of APACHE II in the trauma population have been based primarily on the poor correlation between APACHE II and ISS or TRISS, and the inability of APACHE II to accurately predict hospital or intensive care unit length of stay.[7] Importantly, the criticism has not been based on an inability to predict death. In fact, when APACHE II has been evaluated as a predictor of clinical outcomes in trauma patients it has proven to be a useful predictor, particularly those who are critically injured.[4,6,8] In a previous study we have previously shown that APACHE II is a useful score to help triage and to predict in-hospital mortality in 163 trauma patients both at the ED and ICU.[9] On the other hand, risk adjustment score in the emergency care would use a limited number of variables that can be easily collected at presentation, to provide an accurate prediction of an important outcome such as mortality. Not surprising, APACHE II score implementation as a routine tool to evaluate trauma in our emergency department was abandoned during the next years. The main reason was that APACHE II score uses so many biochemical variables that turns it non-practical for a rapid evaluation of severity of disease in the ED, although adequate in the ICU setting.

Considering this particular difficulty for implementation of APACHE II in emergency scenario, we decided to reassess the data and found that the vast majority of laboratory data were normal or slightly altered. This finding is not surprising, because trauma acute changes of laboratory variables are not expected.[1] Thus we proposed a simplified APACHE II version (s-APACHE II), excluding the laboratory variables to evaluate trauma patients in the ED. Early in the last decade, other scores based on APACHE II, like RAPS (Rapid Acute Physiology score) and REMS (Rapid emergency medicine score), were evaluated in the emergency room and out-hospital medical and surgical acutely ill patients.[10-12] RAPS is an abbreviated version of APACHE II and includes only the physiologic variables pulse rate, blood pressure, respiratory rate, and Glasgow Coma Scale (GCS) score.[10] REMS is an extended RAPS version and includes age, peripheral oxygen saturation and laboratory tests.[13] The primary aim of this study was to evaluate the ability of APACHE II and three abbreviated APACHE II scores (s-APACHE II, RAPS and REMS) to predict in-hospital mortality among trauma patients in the ED.

Methods

Study design: this study is a secondary analysis of a prospective cohort study conducted from August to December of 2001. The primary purpose of the study was to evaluate the ability of APACHE II score to evaluate risk of death of trauma patients both in the ED and in the ICU.
Setting: emergency room (ER) at Hospital São Vicente de Paulo (HSVP), a regional reference hospital in Passo Fundo, RS, south of Brazil.
Ethics with study approval: this study was approved by the ethics committee of the institution. Informed consent was obtained from the patient or relatives.
Patients: all trauma patients, > 12 years old, admitted for more than 24 hours.
Data collection: all data were collected prospectively regarding demographical characteristics, origin of the patient, type, nature, and topography of the trauma. Arterial blood was collected on admission and 24 hours later. The following parameters were recorded for all patients: age and presence of chronic diseases or immune-compromised, body temperature, mean arterial pressure, heart rate, respiratory rate, Glasgow Coma Scale, arterial blood gas analysis, FiO_2, laboratory data (white blood cell count, hematocrit [PCV], and serum levels of sodium, potassium, creatinine). APACHE II, RAPS and REMS scores were calculated as previously described.[3,10,13] The s-APACHE II score was calculated using the five physiologic data, the age and the presence of chronic disease. The patients were followed from emergency admission to 24 hours and until hospital discharge and/or death.

Statistical analysis

Normally distributed continuous variables were reported as mean±standard deviation (SD) and were compared using standard *t*-tests. Non-normally distributed variables were reported as median (25-75% confidence intervals) and compared using Mann-Whitney test. Spearman rank correlation coefficients were used to estimate the correlation between the various severity scores. To compare the predictive ability of the severity scores or of the subcomponents variables to discriminate between survivors and non-survivors, a computation of the area under the receiver operating characteristic (AUROC) curve was performed. Level of significance used was a = 0.05. Data were analyzed using a SPSS program, version 10.

Results

The demographic and clinical characteristics of patients are summarized in Table 1. Hundred ninety tree adult patients were admitted with trauma in the ED of HSVP, from August to December 2001. Thirty patients were excluded because the APACHE II score could not be applied by discharge from hospital (25) or death (5) within the first 24 hours

TABLE 1 Characteristics of patients

Variable	n=163
Male	**131 (80%)**
Age (years)	**38 ± 18**
Origin	
Passo Fundo region	60 (38%)
Other cities	103 (63%)
Nature of trauma	
Car crash	82 (50%)
Gun shot	16 (10%)
Stab injuries	14 (9%)
Falls	27 (17%)
Others	24 (15%)
Source	
Head	67 (41%)
Neck	11 (7%)
Thorax	41 (25%)
Abdomen	17 (10%)
Arms	33 (20%)
Thigh	20 (12%)
Leg	31 (19%)
Spine	15 (9%)
Pelvis	2 (1%)
Type	
Fracture	80 (49%)
Contusion	45 (27%)
Nerves	11 (7%)
Vascular injury	14 (9%)
Spine	13 (8%)
Head trauma	43 (26%)
Perforation of intra-abdominal organs	9 (5%)
Hemo-pneumothorax	27 (17%)
Ventilatory support	23 (14%)
Shock on admission	10 (6%)
Vasoactive drugs	3 (2%)
Destination	
ICU	14 (9%)
Operating room	98 (60%)
Recovery room	4 (3%)
Trauma units	47 (29%)

SD = standard deviation; ICU = Intensive Care Unit.

of admission; 163 patients finished the study. There were 17 deaths for an overall mortality of 10.4 %. Non-survivors had a significant greater mean APACHE II (10.7 ± 7.8 *vs.* 3.9 ± 4.5, p < 0.002), s-APACHE II (9.7 ± 7.6 *vs.* 3.2 ± 4.2, p < 0.001), RAPS (4.2 ± 3.3 *vs.* 1.3 ± 2.0, p < 0.001) and REMS (4.9 ± 4.1 *vs.* 1.5 ± 2.3, p < 0.001) scores on admission and a greater APACHE II score after 24 hour of admission (12.2 ± 8.8 vs. 3.4 ± 4.6, p < 0.001) than non-survivors.

APACHE II was strongly correlated (p < 0.0001) to s--APACHE II (R^2 = 0.96), REMS (R^2 = 0.92) and RAPS (R^2 = 0.82) scores. Table 2 describes the area under the receiver operating characteristic curve for each score and sub-components. At admission the AUROC were similar for all scores (Figure 1, Table 2). Of the individual sub-components, only Glasgow Coma Scale and heart rate discriminated survivors from non-survivors in the ED. Both GCS and HR had some predictive ability but lower than any score (p < 0.05).

TABLE 2 Comparison of the AUROC curves scoring systems and sub-components to predict in-hospital mortality

Variable	AUROC	(95% CI)
APACHE II	**0.777**	**0.705 to 0.838**
s-APACHE II	**0.788**	**0.717 to 0.848**
RAPS	**0.806**	**0.737 to 0.864**
REMS	**0.761**	**0.688 to 0.824**
Mean arterial blood pressure (0-4)	0.638	0.559 to 0.712
Heart rate (0-4)	**0.650**	**0.571 to 0.723**
Respiratory rate (0-4)	0.552	0.472 to 0.630
Chronic disease (0-5)	0.516	0.436 to 0.595
Oxygenation (0-4)	0.583	0.503 to 0.659
Peripheral oxygen saturation (0-4)	0.584	0.504 to 0.661
GCS (15 minus actual GCS)	**0.691**	**0.614 to 0.761**
GCS (RAPS and REMS 0-4)	**0.623**	**0.543 to 0.698**
Body temperature (0-4)	0.547	0.467 to 0.625
Hematocrit (0-4)	0.500	0.421 to 0.579
WBC (0-4)	0.540	0.461 to 0.619
Serum potassium (0-4)	0.536	0.456 to 0.614
Serum sodium (0-4)	0.500	0.421 to 0.579
Serum creatinine (0-4, double point score for ARF)	0.519	0.440 to 0.598
Arterial pH (0-4)	0.633	0.554 to 0.707
Age (0-6)	0.567	0.487 to 0.645

APACHE (Acute Physiology and Chronic Health Evaluation) II; s-APACHE II (simplified APACHE II); RAPS (Rapid Acute Physiology Score); REMS (Rapid Emergency Medicine Score), GCS (Glasgow Coma Scale); WBC (White Blood Cells); ARF (Acute renal failure). The bold value indicates p<0.05.

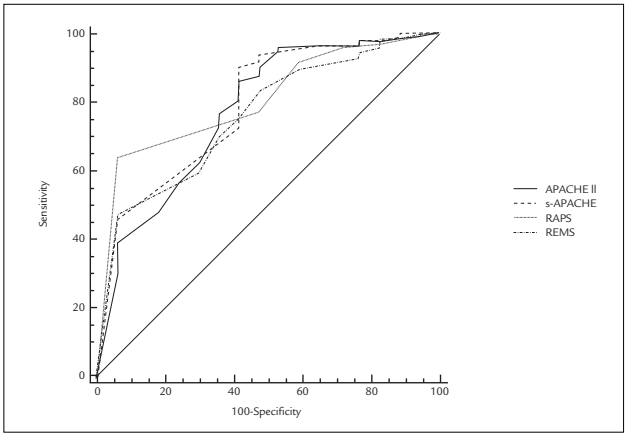

FIGURE 1 Receiver operating characteristic curves for APACHE (Acute Physiology and Chronic Health Evaluation) II, s-APACHE II (simplified APACHE II), RAPS (Rapid Acute Physiology Score) and REMS (Rapid Emergency Medicine Score) for predicting in-hospital mortality in a subset of trauma patients in the ED.

Discussion

The original aim of this study was to test the utility of APACHE II for prognostic in the evaluation of trauma patients in the ED and 24 hours after. APACHE II showed to be a good marker for prognosis in this population, at the ED and 24 hours after. The primary objective of this data re-analysis was to compare three abbreviated APACHE II scores in the ED. The study showed that APACHE II and the abbreviated APACHE II scores provide similar discriminatory power for in-hospital mortality. However we also found that only GCS and HR subcomponents were predictors of mortality.

There are many scores developed to access the severity of trauma patients admitted to ED.[1,14] However, trauma scores were developed in different populations. The knowledge of morbidity and mortality of our population is very important for planning strategies for management of trauma patients. In this regard, the choice of a proper score has an important role to standardize the management of trauma patients. Several scores are available in medical literature, but no one fills satisfactory the needs of trauma patients, making difficult to choose a specific score to apply in a particular population.[2,4,6,15,16] We were motivated to study APACHE II score in the ED because in Brazil the first evaluation is done in the emergency room and often a severe patient stayed in observation for hours or days until transferred to the operating room or ICU. Thus, we speculated that the application of a score in which the possibility of medical complications, including the possibility of death, could be useful in the ED. Even knowing that APACHE II was designed for patients in critical care units, we thought that the application of this score could help to follow-up these patients, once this score was familiar to our Emergency and ICU staff and both settings admits not only trauma patients. Like others, we've demonstrated that APACHE II was useful for predicting outcomes of trauma patients. Several studies showed that APACHE II score has good prognostic value even when compared to scores specifically developed to evaluate trauma patients.[4,6,17] As expected APACHE II scores were low. Low values can be explained because the patient population was young and healthy. Another explanation could be the short period between the trauma and the application of the score in the ED, in which the some physiological or laboratory acute changes are unlikely in trauma patients. However, similar low APACHE II scores were also observed in the ICU 24 hours later. Therefore, in spite of the lower APACHE II score in this population, compared with that one admitted in ICUs, APACHE II appeared useful to stratify risks for trauma patients in the ED.

Nonetheless, APACHE II score is difficult to apply in the emergency due to its complexity and the emergency medical staff faced this limitation in the following years. Thus, as highlighted before, the observation that almost all laboratory values were normal or slightly altered in this population motivated us to reanalyze the data and to propose a simplified APACHE II score similar to RAPS and REMS.[10,13] The comparison between APACHE II and those abbreviated APACHE II scores showed that in the ED and in trauma patients they are equivalent to stratify in-hospital mortality risk. The results of this study are comparable to other studies applying abbreviated APACHE II scores in general and surgical patients.[4,11,12,18] Our estimate of the AUROC for all scores was similar or even higher when compared to previous studies. Interestingly, none of these scores were applied to evaluate specifically trauma patients but general emergency patients. We must emphasize that the proposed s-APACHE II score was derived within our study and its performance may be similar by this reason.

Evaluation of the APACHE II score sub-components reveals important information regarding the physiologic parameters that are useful for severity scoring in this population. The analysis of the sub-components showed that only GCS (APACHE II score) and HR has discriminated survivors from non-survivors. Like others, GCS consistently appears as an important constituent element of these scores.[4] It is expected that patients with a severe traumatic brain injury will require admission to the ICU regardless of other injuries and will have a higher likelihood of subsequent mortality. Another physiologic parameter used to predict mortality in several trauma scores systems is heart rate and commonly tachycardia is a sensitive sign of cardiovascular disarrangement. However, heart rate and blood pressure as predictors are inconsistent in different studies.[4,13,19] One possible important explanation is that timing and quality of out-hospital resuscitation would influence these variables. Additionally, the finding that only GCS and HR predicted mortality may help understand why the scores have similar discriminatory power as both sub-components take part in each score.

The strengths of this study include its prospective nature and evaluation of several abbreviated APACHE II scores and their subcomponents. Our study may provide additional estimate of how APACHE II, RAPS and REMS perform in a validation study. Despite these strengths, there are several important limitations. One

limitation is the small sample size in a one single center which precincts better evaluation of the proposed simplified APACHE II and the comparison between all studied scores. Another limitation is that patients who died or were discharged prior to 24 hours were not a part of the original study cohort. It is unclear if those patients differ in a way from those in this cohort as to make our conclusions invalid. An additional limitation in the present work was that the data only represents patients from a small region and managed in the ED of a university teaching hospital. We must therefore be cautious in generalizing the results presented here to a non-university ED. Finally, the data are now 12 years old. Changes in structure and process within EDs may generate different results if the study were repeated now.

Conclusion

Our study confirmed that the APACHE II score is a good prognostic marker of trauma patients in ED scenario and after 24 hours in the ICU. However, our study also confirmed that abbreviated versions of the APACHE II score showed similar prognostic values at the ED for trauma patients. Better designed studies are needed to validate abbreviated APACHE II scores in the trauma population, particularly the simplified APACHE II score proposed in this study.

Resumo

Comparação do escore APACHE II e três escores APACHE II abreviados para predizer desfecho entre pacientes traumatizados na emergência.

Objetivo: escore *Acute Physiologic and Chronic Health Evaluation* (APACHE) II é considerado "inválido" e de difícil aplicação em pacientes traumatizados no departamento de emergência (DE). Objetivamos comparar a abilidade do escore APACHE II e três diferentes escores APACHE II abreviados: APACHE II simplificado (s-APACHE II), *Rapid Acute Physiology score* (RAPS) e *Rapid Emergency Medicine score* para avaliar a mortalidade hospitalar de pacientes truamatizados no DE.

Métodos: análise retrospectiva de uma coorte prospectiva. Todos são pacientes vítimas de trauma admitidos no DE, durante 5 meses. Para todas as admissões, o escore APACHE II foi calculado. O escore APACHE II foi abreviado através da exclusão dos dados de laboratório para calcular o escore s-APACHE II. Dados individuais foram reanalisados para calcular RAPS e REMS. APACHE II e seus subcomponentes foram coletados, e a mortalidade hospitalar foi assessada. A área abaixo da curva ROC (*receiver operating characteristic* - AUROC) foi usada para determinar o valor preditivo de cada escore.

Resultados: 163 pacientes foram analisados. A taxa de mortalidade hospitalar foi de 10,4%. s-APACHE II, RAPS e REMS escores se correlacionaram com o escore APACHE II ($r^2 = 0.96$, $r^2 = 0.82$, $r^2 = 0.92$; $p < 0.0001$). Os escores tiveram acurácia similar para predizer a mortalidade: ([AUROC 0,777 [95% CI 0,705 a 0,838] para APACHE II; AUROC 0,788 [95% CI 0,717 a 0,848] para s-APACHE II; AUROC 0,806 [95% CI 0,737 a 0,864] para RAPS; AUROC 0,761 [95% CI 0,688 a 0,824] para REMS.

Conclusão: escores APACHE II abreviados possuem habilidade similar para avaliar a mortalidade hospitalar de pacientes traumatizados na emergência quando compados ao escore APACHE II.

Unitermos: APACHE, escala de gravidade do ferimento, índices de gravidade do trauma, trauma, mortalidade.

References

1. Chawda MN, Hildebrand F, Pape HC, Giannoudis PV. Predicting outcome after multiple trauma: which scoring system? Injury. 2004;35(4):347-58.
2. Boyd CR, Tolson MA, Copes WS. Evaluating trauma care: the TRISS method. Trauma Score and the Injury Severity Score. J Trauma. 1987;27(4):370-8.
3. Knaus WA, Draper EA, Wagner DP, Zimmerman JE. APACHE II: a severity of disease classification system. Crit Care Med. 1985;13(10):818-29.
4. Dossett LA, Redhage LA, Sawyer RG, May AK. Revisiting the validity of APACHE II in the trauma ICU: improved risk stratification in critically injured adults. Injury. 2009;40(9):993-8.
5. Liang J, Zhou Z. Application of APACHE II scoring in ICU trauma patients. Chin J Traumatol. 1998;1(1):58-60.
6. Hwang SY, Lee JH, Lee YH, Hong CK, Sung AJ, Choi YC. Comparison of the Sequential Organ Failure Assessment, Acute Physiology and Chronic Health Evaluation II scoring system, and Trauma and Injury Severity Score method for predicting the outcomes of intensive care unit trauma patients. Am J Emerg Med. 2012;30(5):749-53.
7. McAnena OJ, Moore FA, Moore EE, Mattox KL, Marx JA, Pepe P. Invalidation of the APACHE II scoring system for patients with acute trauma. J Trauma. 1992;33(4):504-6.
8. Calvete JO, Schonhorst L, Moura DM, Friedman G. Acid-base disarrangement and gastric intramucosal acidosis predict outcome from major trauma. Rev Assoc Med Bras. 2008;54(2):116-21.
9. Polita JR. Perfil e escore apache II na avaliação de pacientes traumatizados atendidos na emergência do Hospital São Vicente de Paulo [dissertation]. Porto Alegre: Universidade Federal do Rio Grande so Sul; 2004.
10. Rhee KJ, Fisher CJ Jr, Willitis NH. The Rapid Acute Physiology Score. Am J Emerg Med. 1987;5(4):278-82.
11. 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.
12. Bulut M, Cebicci H, Sigirli D, Sak A, Durmus O, Top AA, et al. The comparison of modified early warning score with rapid emergency medicine score: a prospective multicentre observational cohort study on medical and surgical patients presenting to emergency department. Emerg Med J. 2013; Apr. 6. [Epub ahead of print].
13. 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):579-87.

14. Bertollo S, Rodenberg H. Correlation of the RTS (Revised Trauma Score) and RAPS (Rapid Acute Physiology Score) in rotor-wing prehospital care. Air Med J. 1994;13(3):91-5.
15. Aslar AK, Kuzu MA, Elhan AH, Tanik A, Hengirmen S. Admission lactate level and the APACHE II score are the most useful predictors of prognosis following torso trauma. Injury. 2004;35(8):746-52.
16. Champion HR, Sacco WJ, Carnazzo AJ, Copes W, Fouty WJ. Trauma score. Crit Care Med. 1981;9(9):672-6.
17. Rutledge R, Fakhry S, Rutherford E, Muakkassa F, Meyer A. Comparison of APACHE II, Trauma Score, and Injury Severity Score as predictors of outcome in critically injured trauma patients. Am J Surg. 1993;166(3):244-7.
18. 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):1008-13.
19. Goodacre S, Turner J, Nicholl J. Prediction of mortality among emergency medical admissions. Emerg Med J. 2006;23(5):372-5.