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Evaluating APACHE II and APACHE IV Scoring Systems in Predicting Mortality Rate and Length of Hospital Stay in Patients with Head Trauma

Mastaneh Rahmdel Tajan Gouce¹, Atefeh Ghanbari ^{2*}, Tahereh Khaleghdoost Mohammadi³, Ehsan Kazemnejad Leili⁴, Sadra Ashrafi⁵

¹ Master of critical care nursing, School of Nursing and Midwifery, Guilan University of Medical Science, Rasht, Iran.

² Professor, PhD in Nursing, Social Determinants of Health Research Center, School of Nursing and Midwifery, Guilan University of Medical Science, Rasht, Iran.

³ Department of Nursing (Medical-Surgical), Instructor, Social Determinants of Health Research Center (SDHRC), School of Nursing and Midwifery, Guilan University of Medical Sciences, Rasht, Iran.

⁴ Bio-Statistics, Associate professor, Social Determinants of Health Research Center (SDHRC), School of Nursing and Midwifery, Guilan University of Medical Sciences, Rasht, Iran.

⁵ Student of Medical Sciences, Student Research Committee, Shahid Beheshti University, Tehran, Iran.

*Corresponding Author: Atefeh Ghanbari, Social Determinants of Health Research Center, School of Nursing and Midwifery, Guilan University of Medical Science, Rasht, Iran. Phone+981333555058, Fax +981333550097, Email: at_ghanbari@gums.ac.ir

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Abstract

Introduction: A series of criteria are developed to assess the patients' severity of illness in the ICU. Acute Physiology and Chronic Health Evaluation (APACHE) is a widely used scoring system (SS). The current study aimed to determine the difference between APACHE II and APACHE IV scoring systems in predicting mortality rate and length of hospital stay in patients with head trauma referred to **Poursina Hospital in Rasht**.

Methods: In this retrospective analytical study, medical records of patients hospitalized due to head trauma **in the ICU of Poursina Hospital** from February 25, 2009, to August 21, 2019, were studied.

Results: The mortality rate of 1472 ICU patients was 39.3%. The predicted mortality rate by the APACHE II SS before and after surgery was 28.7% and 12.8%, respectively; While APACHE IV predicted 39% of deaths. The mean hospitalization duration of patients was 15 ± 41.35 days. Also, the mean ICU hospitalization was 9.77 ± 9.24 days. Although, the mean estimated length of stay based on APACHE IV was $6.23 \pm 67 \pm 8$ days. The APACHE IV SS underestimated the length of stay ($p < 0.001$). According to the ROC chart, the best cut-off for APACHE IV was 66, with a sensitivity of 85.8% and specificity of 85.4%. For APACHE II, the best cut-off score was 20 with a sensitivity of 86.4% and specificity of 81.3%.

Conclusion: Both APACHE II and APACHE IV SS can be used to predict the mortality of ICU patients, but APACHE IV is more effective and more accurate.

Keywords: APACHE II · APACHE IV · Mortality rate · Length of hospital Stay · Head Trauma.

Introduction

Trauma is a significant global public health challenge.^{1,2} The world health organization has estimated that the global burden of trauma will increase from 14 to 20% by 2020.³ Traffic accidents and injuries are the leading causes of death and disability in developing countries.^{3,4} With a death rate of 30 per 100 000 deaths, Iran

has the highest rate of road traffic accidents in the whole of the world.⁵

Trauma patients require specialized care provided in specific departments.^{6,7} In recent decades, several models have been developed to evaluate the prognosis of patients with severe illness.^{8,9}

The application of patient classification systems is useful for preventing unpleasant events contributing to patients' survival. During the past three decades, several tools have been developed to predict patients' mortality and assess the severity of diseases to create better clinical conditions.^{12, 11, 10}

The APACHE (Acute Physiology and Chronic Health Evaluation) scoring system was developed in 1981 in the United States. APACHE IV was introduced in 2006, which could predict mortality rate and length of ICU hospitalization.^{10,14}

Using a valid index to evaluate patients requiring ICU hospitalization is essential so that only high-priority patients be admitted to the ICU, which in turn increases the patients' survival. Tools also can be used by health systems to manage hospitalization duration and costs.

According to the best knowledge of the authors, no similar study is performed in the Guilan province to investigate the differences between APACHE II and APACHE IV scoring systems in predicting the mortality rate and hospitalization duration of patients with head trauma in Rasht.

Methods

In this analytical-retrospective study, medical records of all patients older than 18 years with a definitive diagnosis of head trauma referred to the Poursina hospital from February 25, 2009, to August 21, 2019, are investigated. A total of 4409 medical records were found, which 2937 of them were excluded based on the inclusion criteria. Hence, 1472 cases with head trauma were investigated. Medical records were obtained from the health information management department.

Data were collected using a questionnaire that included items on demographic characteristics, disease-related factors, cause of trauma, type of trauma, underlying disease, length of hospital stay, length of ICU stay, and occurrence of death, estimated hospital stay by APACHE IV, and estimated mortality rate by APACHE II and APACHE IV.

APACHE II is a scoring system based on disease severity. It contains three parts, which were calculated using the following link (<https://reference.medscape.com/calculator/apache>

[-ii-scoring-system](#)). The total APACHE II score ranges from zero to 71, which a score of 35 or higher indicates an 85% risk of mortality in patients without surgery and 88% in patients who had surgery.^{15,16,17}

The APACHE IV contains six parts and 142 variables. All data should be collected during the first 24 hours of ICU admission. The worst value of a variable should be recorded, if not available, it should be considered as zero. The APACHE IV score was calculated using the following link (<http://intensivecarenetwork.com/Calculators/Files/Apache4.html>). In the present study, the total score was 286, which the higher the score, the higher is the risk of mortality.^{6, 11, 18}

Data were analyzed using SPSS version 24. ROC diagram and logistic regression model were used. The current study is approved by the Ethics Committee of the Guilan University of Medical Sciences (code: IR.GUMS.RES.1398.232).

Results

The demographic characteristic of patients is described in Table 1. Data on the mean score of APACHE II and APACHE IV are described in Table 2.

The predictive level of APACHE IV was 0.925 - 0.007 (CI 95% 0.939-0.911). This level of predicting was statistically significant ($p < 0.001$). For APACHE II, the predicted mortality was 0.914 - 0.008 (CI 95%: 0.899-0.929). The optimal cut-off for APACHE IV and APACHE II was selected based on the highest sensitivity and specificity. The best cut-off for APACHE IV was 66, with a sensitivity and specificity of 85.8 and 85.4%, respectively. For APACHE II, the best cut-off was 20, with a sensitivity and specificity of 86.4 and 81.3%.

Investigating the correlation between APACHE II and APACHE IV revealed a strong correlation between the raw APACHE IV score ($r = 0.843$; $p < 0.001$) and estimated mortality ($r = 0.827$; $p < 0.001$). The correlation between APACHE II and APACHE IV was 86.1%. Logistic regression was used to investigate the association between actual hospitalization duration and ICU stay by APACHE IV and the results showed that APACHE IV could only predict 0.9 and 1.03% of changes in actual hospitalization and ICU

hospitalization, respectively (Figure 1 and Table 3).

Table1: Demographic characteristic of patients

Gender	N	%
Female	162	11.01
Male	1310	88.99
Total	1472	100
Age (in years)	44.49 ± 20.25 93). (19	

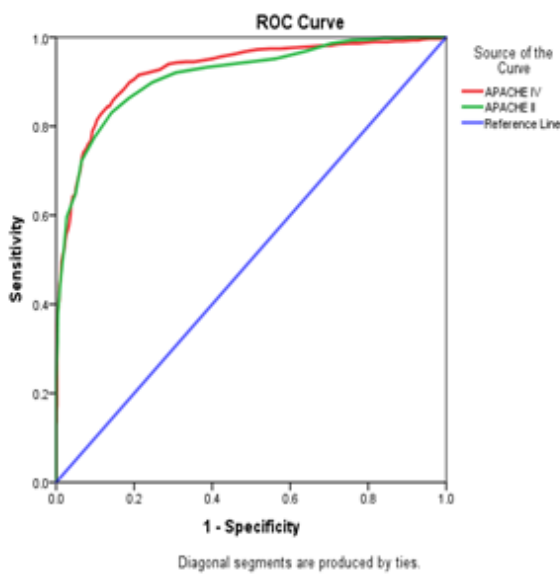


Figure 1: .ROC curve for APACHE-IV and APACHE-II for hospital mortality

Table 2: Mean and SD score of APACHEII, APACHE IV and other variable.

	Mean	SD	Middle	Min	Max	P-Value
APACHEII score	20.22	7.56	20	2	46	<0.001
APACHE IV score	66.70	29.1	60	4	152	<0.001
Estimation of mortality based on APACHE IV	42.21	28.8	36.05	0.9	97.2	<0.001
Estimation of length of hospital stay based on APACHE IV	8.67	6.23	8.70	1.1	108	<0.001
Length of actual hospital stay	15.40	12.35	12	3	175	<0.001
Length of actual hospitalization in the intensive care unit	9.78	9.24	7	2	171	<0.001
Days of hospitalization before admission the ICU	1.83	3.32	1	0	45	<0.001

Table3: ROC curve result for hospital mortality

Area Under the Curve											
Test Result Variable(s)	Area	Std. Error ^a	Sig.	95% Confidence Interval		Cut off	Sensitivity	Specificity	Accuracy	LR+	LR-
				Lower	Upper						
APACHE IV	.925	.007	<.001	.911	.939	66	85.8%	85.4%	85.6%	5.9	0.17
APACHE II	.914	.008	<.001	.899	.929	20	86.4%	81.3%	83.3%	4.62	0.17

Discussion

The mean age of participants was 44.49±20.57, which is consistent with the study by Mobaleghi et al. and Saatin et al., both of these studies mentioned that youngsters are at increased risk of head trauma. The higher incidence of trauma among younger people can be attributed to the fact

that they are more active than other age groups which increases their exposure to accidents.^{1,3} Most of the participants (88.9%) were male. The findings of this study are consistent with the studies conducted by Mobaleghi et al. and Venkataraman et al. ^{1, 18}

The mean actual and ICU hospitalization length were 15.41±12.35, 9.77±9.24 days, respectively.

The estimated hospitalization duration by the APACHE IV was 8.67 ± 6.23 days. The results of the present study are consistent with the results reported by Khatami et al.¹⁹

The frequency of actual mortality in patients with head trauma showed an overall mortality rate of 39.3%. The results of the present study are consistent with the study by Bahrami et al. which reported a mortality rate of 33.7% in Qazvin. Besides, Kamal et al. investigated Pakistan and reported a mortality rate of 32%.^{10,20} The APACHE II showed that 28.7% and 12.8% of patients died before and after surgery, respectively; while the actual death rate was 39.3%. APACHE IV predicted a mortality rate of 39%, the mortality rates anticipated by APACHE II, both before and after surgery, were different from the actual rates ($p < 0.001$). However, the mortality rates predicted by APACHE IV were close to the actual rates (only a 0.3% difference was observed, which was not statistically significant).

Therefore, APACHE IV had the highest consistency with the actual rates. The predicted level of APACHE IV was 0.007- 0.925. This level of prediction was significant ($p < 0.001$). For APACHE II, the prediction level of ICU patients with head trauma was 0.914-0.008. This level of prediction was significant ($p < 0.001$). Seldon et al., in a study, aimed to compare the accuracy of estimated mortality rates of ICU patients using APACHE II, APACHE IV tools, showed that the actual mortality rate was 10.9%, and the estimated mortality rates by APACHE II and APACHE IV were 16.6% and 9.8%, respectively.⁹ From the researcher's point of view, the differences between hospitals concerning the mortality rate can be attributed to the factors such as hospital standards, quality of care, available medical equipment, specialists, and a sufficient number of health workers in each shift. The optimal cut-off for APACHE IV and APACHE II was selected based on the highest sensitivity and specificity.

Based on the ROC curve, the best cut-off point for APACHE IV was 66, with a sensitivity and specificity of 85.8% and 85.4%, respectively. For APACHE II the best cut-off point was 20, with a sensitivity and specificity of 86.4% and 81.3%, respectively. The accuracy of APACHE II and APACHE IV was 83.3% and 85.6%, respectively.

Varghese et al. reported similar results and analyzed the ROC curve showed that APACHE IV had a better distinction than APACHE II.¹² Choi et al. described that the mortality rates predicted by APACHE II were lower than APACHE IV. With a cut-off value of 93, the APACHE IV can predict hospital mortality with high sensitivity.²¹ The study showed that a score > 15 has good diagnostic accuracy for estimating the mortality rate of critically ill patients admitted to the ICU.²² From the researcher's point of view, the difference in the value of cut-off in this study with previous studies can be attributed to factors such as the cause of ICU hospitalization.

Conclusion

The APACHE IV could better predict the mortality in patients with head trauma than APACHE II, but it was not accurate in estimating the length of hospitalization, which may be due to lack of timely access to advanced supportive equipment and lack of access to some new drugs and techniques used in ICU. The associated injuries in patients with head trauma, the quality of care, the standardization of the ward in terms of the number of experienced staff in each shift, hospital equipment, facilities, etc. may also affect the length of hospitalization. Using the software version of these tools makes it easier to evaluate patients, and it is suitable for saving the time spent collecting vital information. The most significant challenge in ICU is prioritizing patients for hospitalization, in which using these tools can be a great help in doing so.

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Conflict of Interest Disclosures

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Authors' Contributions

All authors pass the four criteria for authorship contribution based on the international committee of medical journal editors (ICMJE) recommendations.

Ethical Statement

This study was approved by the Ethics Committee of Gums, Rasht, Iran (Ethics Code: IR.GUMS.RES.1398.232)

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