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ROLE OF THE APACHE II SCORE IN PREDICTING SURVIVAL AND LENGTH OF ICU STAY AMONG CRITICALLY ILL PATIENTS

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ABSTRACT

Objective:
To determine the predictive ability of the Acute Physiology and Chronic Health Evaluation II (APACHE II) score for ICU mortality and prolonged ICU stay among critically ill adults.

Material & Methods:
This study was a descriptive-observational design. 237 consecutive patients aged 18-65 years were included in the study. APACHE II scores were obtained using the worst physiological data recorded over the preceding 24 hours for each patient in the first 24 hours of their ICU stay. ICU mortality and the extended stay in the university were verified. Data on ICU mortality was collected, along with data on long stays within the ICU. Outcomes analysis of a stay lasting 10 days or longer was categorized as prolonged. Mann-Whitney U test was conducted for non-normally distributed variables. Spearman correlation and receiver operating characteristic analyses were also made. Exploratory logistic regression was performed to assess individual associations between APACHE II scores and study outcomes.

Results:
Average patient age was 43.84 (+12.22) years. Among 237 patients, 140 (59.1%) were male, while ICU mortality occurred in 25 (10.5%) patients. At the ICU, 20.7% (49/234) of patients had a prolonged ICU stay. Higher scores in the APACHE II at admission were associated with non-survival. The median value for non-survivors was higher at 14 [IQR 6-18] versus survivors at 5 [3-7] overall ($p<0.001$). Patients with longer stays had higher scores. Overall, their median was 13 [10-17] compared to 4 [2-6] in those who did not stay long; $p<0.001$. For mortality, APACHE II achieved AUC 0.791 (95% CI 0.682-0.899). The best threshold of mortality was computed at 13 points overall. At this cut-off, the sensitivity was 60.0% while the specificity was 92.5% when predicting the mortality of critically ill adults admitted to the ICU. Prolonged-stay discrimination reached AUC 0.906 (95% CI 0.859-0.954). An optimal

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sensitivity of 77.6% and a specificity of 92.0% for predicting prolonged stay in the intensive care unit (ICU) were obtained with a cut-off of 10. The higher the number of APACHES II points, the greater the chances of outcome. The adjusted mortality odds ratio for each point was 1.219. In exploratory regression, each point was normalized to an OR of 1.529 for long stay.

Conclusion:

APACHE II score was an independent predictor of poor outcome. They were linked with a longer stay in the intensive care unit and death in acutely ill adult patients in general. The score could also be used for early risk stratification and resource planning. However, clinical judgement and local validation are still important.

INTRODUCTION

Critical illnesses can monopolize specific resources, like organ support, tailored staff, and extensive monitoring. Severity-of-illness scales help summarize early and sustained derangements in a part of a system. They can also help adjust risks, and they serve as an effective communication and audit tool. Of all severity-illness scores, APACHE II is the most popular. It is the only score that uses the first 24 hours of an ICU stay to assess 12 acute physiological variables, health status, and age. Recent studies of mixed-ICU populations demonstrate a clear correlation between APACHE II scores and mortality. This, however, comes with issues of poor discrimination and poor calibration for certain case mixes.[1,2]

Recent studies have also focused on the estimation of APACHE II after single admissions to an ICU. The implementation of a similar estimate on day 3, as opposed to the classical day 1, enhanced mortality estimations in the group studied. Additionally, automated electronic versions of APACHE II have correlated a decrease in ICU length of stay to a 10-point increase in APACHE II with a C-statistic of 0.83.[3,4] Many studies with large datasets have integrated APACHE II and models of ICU resource utilization and length of stay.[5,6] APACHE II is reported to outperform many emergency and ICU scoring systems in the general population. However, when working with sepsis and intermediate care populations, APACHE II can underperform. This emphasizes the importance of local validation.[7,8]

Recent studies in Pakistan have focused on APACHE II but in a limited manner. Studies conducted in Lahore, Peshawar, and Karachi have shown increasing mortality across APACHE II strata. However, one study performed in Karachi demonstrated APACHE II to be inferior to both SOFA and SAPS II in discrimination ability.[9-12] There is limited data from Jinnah Postgraduate Medical Center regarding APACHE II and its association with ICU mortality and prolonged stay in a clinically significant manner. This study aimed to understand how well APACHE II predicts ICU mortality and ICU stay of at least 10 days in critically ill adults.

MATERIAL & METHODS

A descriptive observational study was performed at the Department of Anaesthesia, Jinnah Postgraduate Medical Centre (JPMC), Karachi, Pakistan. This was conducted over six months after research synopsis approval. A target sample size of 237 participants was calculated with a presumed area under the receiver operating characteristic (ROC) curve (AUC) of 0.623, a 5% level of allowable error, and a 95% level of confidence. All 237 patient records analyzed were complete and met the study's scope; thus, complete records were analyzed. We conducted non-probability consecutive sampling. Aiming to complete the sample size, consecutive enrollment was done on patients who met the eligibility criteria and presented to the study setting during the study period.

Inclusion criteria consisted of critically ill patients of both sexes aged 18 to 65 years. Patients were excluded from the study if they had a history of stroke, arrhythmia, renal failure, chronic liver disease, or malignancy. Other exclusion criteria were cardiac arrest, chronic disease, pregnancy, and incomplete data on APACHE II score. After

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obtaining consent, we documented participants' age, gender, admission diagnosis, and the presence or absence of diabetes, hypertension, and smoking on a structured proforma. We determined the APACHE II scores after the first 24 hours using the worst values of temperature, mean arterial pressure, heart rate, respiratory rate, the (PaO2) and (SaO2) values, Arterial (pH), Sodium, Potassium, creatinine, haematocrit, white-cell count, and the Glasgow Coma Scale; chronic health and age points were assessed. The need for mechanical ventilation and the use of vasopressors were also noted. Patients were tracked until death or discharge from the ICU, and the prolonged ICU stay was determined if the stay was greater than or equal to 10 days.

The analyses were independently repeated with the 237-record data set provided. Categorical data were expressed as counts and proportions, and continuous data were expressed as mean (±SD) or median (IQR) as appropriate. APACHE II data were compared across outcome groups using the Mann-Whitney U test. The length of ICU stay was assessed for correlation with APACHE II using Spearman's rank correlation coefficient. To determine the APACHE II score's ability to predict outcomes, a series of receiver operating characteristic (ROC) analyses with distribution-free 95% confidence intervals was performed along with a calculation of the Youden index. The odds of an outcome were determined by performing a binary logistic regression analysis for each 1-point increase in APACHE II score. Statistical significance was set at a two-tailed p-value of less than 0.05. Ethical approvals were acquired from the JPMC institutional review boards. Written informed consent was

RESULTS

A total of 237 complete patient records were obtained. There were 200 participants with a mean age of 43.84 ± 12.22 years (range: 18-65 years). The number of men was 140, with 59.1% of the overall sample of the respondents. The greatest proportion of admissions was for sepsis (26.2%) and septic shock (12.8%). The remaining third of the most frequent categories of admission were respiratory failure (25.3%) or postoperative complications (18.6%). 127 patients (53.6%) needed mechanical ventilation. 81 patients (34.2%) received vasopressor support, and 10.5% of all patients died in the intensive care unit. 20.7% had prolonged admissions to an intensive care unit. Prolonged stay was defined as 10 or more days in the ICU (Table I).

Table I: Baseline characteristics and outcomes (n=237)

Characteristic	Value
Age, years	43.84 ± 12.22
Male gender	140 (59.1)
Hypertension	112 (47.3)
Diabetes mellitus	100 (42.2)
Never / ex / current smoker	160 (67.5) / 33 (13.9) / 44 (18.6)
Sepsis/septic shock	62 (26.2)
Respiratory failure	60 (25.3)
Postoperative complication	44 (18.6)
Trauma	25 (10.5)
Mechanical ventilation	127 (53.6)
Vasopressor support	81 (34.2)

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Characteristic	Value
APACHE II score	5 (3-9)
ICU stay, days	7 (5-9)
ICU mortality	25 (10.5)
ICU stay ≥10 days	49 (20.7)

The median APACHE II score was 5 (IQR 3-9), with a median of 7 days (IQR 5-9) for ICU length of stay. APACHE II had a strong positive correlation with the length of stay in the ICU (Spearman rho=0.692; p<0.001). It was also shown to have a strong ability to discriminate between death and an outstanding ability to discriminate between lengthy ICU stays (Table II; Figure 1).

Table II: APACHE II score and receiver operating characteristic performance

Outcome	APACHE II, no event	APACHE II, event	AUC (95% CI)	Cut-off	Sensitivity	Specificity
ICU mortality	5 (3-7)	14 (6-18)	0.791 (0.682-0.899)	≥13	60.0%	92.5%
ICU stay ≥10 days	4 (2-6)	13 (10-17)	0.906 (0.859-0.954)	≥10	77.6%	92.0%

For each additional point in the APACHE II score, the unadjusted odds of death increased by 21.9% and of prolonged ICU stay by 49.9%. This association was maintained after adjustments for age, sex, and the presence of diabetes, hypertension, and smoking (Table III). Since only 25 patients died, the death risk model is highly preliminary, and the estimates for the covariates should be taken with caution.

Table III: Association of APACHE II score with ICU outcomes

Outcome	Model	OR per point	95% CI	p-value
ICU mortality	Unadjusted	1.219	1.134-1.310	<0.001
ICU mortality	Adjusted	1.219	1.132-1.312	<0.001
ICU stay ≥10 days	Unadjusted	1.499	1.340-1.677	<0.001
ICU stay ≥10 days	Adjusted	1.529	1.356-1.725	<0.001

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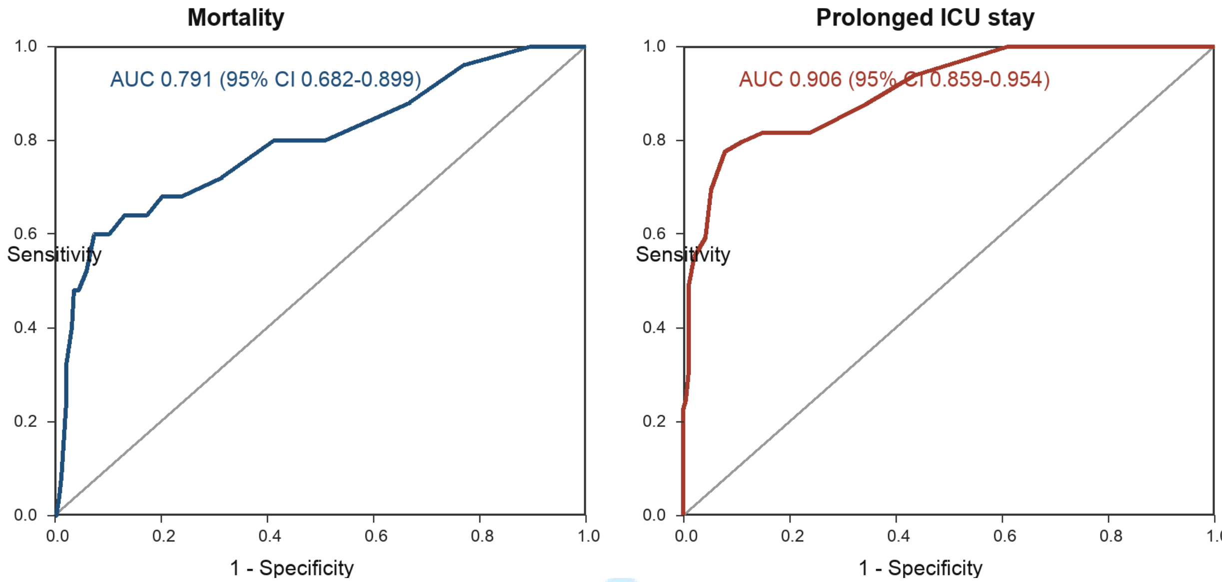

Figure 1: Receiver operating characteristic curves for ICU mortality and prolonged ICU stay

DISCUSSION

In this cohort, the findings show that the APACHE II score had an independent correlation with ICU mortality and also with the risk of prolonged ICU stay. An AUC of 0.791 for the mortality prediction model indicates some level of discrimination, but it is still far from perfect. This would be in contrast to the AUC of 0.906 for the prediction of a prolonged ICU stay of 10 days or more, which would be rated as excellent. Furthermore, the strong positive correlation with extended duration of stay in the ICU, and the persistence of these associations despite controlling for covariates, support the APACHE II score as a brief measure of early and developing physiological stress.

The findings with regard to the prediction of mortality are in agreement with findings from other recent studies. Sungono et al., for example, reported an AUC of 0.854 with 2,181 mixed ICU patients, and an automated calculation with 4,794 patient admissions reported an AUC of 0.83.[2,4] In septic shock, Bloria et al. reported an APACHE II AUC of 0.78, while Hai and Hoa cited APACHE II as beneficial in addition to SOFA, SAPS II, and mNUTRIC.[13,14] A 2025 sepsis study reported an AUC of 0.80, which is in line with the current study, although the optimal cut-off for that study was higher due to a baseline severity and mortality that were also higher.[22] These findings clearly demonstrate that the cut-off needs to be specifically defined for a given patient population.

The current ICU mortality rate of 10.5% is lower than that of other disease specific resource constrained cohorts, and shows some similarity to the 10% reported for the large Indonesian cohort.[2] The effect of case-mix on mortality has been reported extensively in the Pakistani literature. There have been reports of a rise in mortality in the lower ranges of the APACHE II, and an AUC of 0.584 was reported for the APACHE II in an intermediate care facility in Karachi.[9-12] In a study of mechanically ventilated patients in Peshawar, the risk of death became greater with increasing APACHE II Scores. Higher APACHE II scores have been associated with longer length of stay in a Pakistani Neurosurgical cohort.[19,20]

The relationship with length of stay in the ICU is of particular interest. Takekawa et al. designed a multi-centre model with an AUC of 0.827 to predict stays of greater than 14 days. APACHE II was integrated by Kim et al. into a length-of-stay equation.[5,6] Singh et al. reported that in COVID-19, each APACHE II point predicted an approximate ICU stay of 0.2 days, while automated scoring indicated a 1.1-day length of

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stay increase for every 10 points.[15,4] The nature of some cohorts has been to report weak or inverse relationships, as the most seriously ill patients are likely to die soon, and this shortens the length of stay in the ICU.[1] In this study, the ≥10-day binary outcome helps but does not fully address the competing risk.

Performance varies by disease and care setting. In validation studies for COVID-19, for example, AUC values were between 0.63 and 0.76. Also, APACHE IV was found superior to APACHE II.[16,17] In a different 2024 cohort, post-discharge mortality and readmission were not associated with the admission of APACHE II.[18] Information may be supplemented with Dynamic changes; however, the daily changes may be confounded by the initial levels of the disease and the survivor's status at the next assessment.[3] Consequently, the most appropriate use of the score is for population risk stratification, planning of resources, and audits. It is not recommended to use the score for a limited number of patients or as a single rule.

The results apply clinically to understaffed and underfunded ICUs. A threshold of 13 revealed a specific high-risk mortality group, and a threshold of 10 revealed patients likely to stay in the unit for a longer period. If the thresholds are specific, there is a higher chance of the patient getting senior review and a more formal discussion of the patient’s goals of care, and there is a higher chance that planning of the patient’s organ support and discharge is done. Several local studies link APACHE II and ventilator-associated pneumonia, delirium, and other ICU complications. These studies support the inclusion of the severity of the APACHE II score as part of the structured surveillance system.[19,21]

CONCLUSION

High scores on the APACHE II were related to longer stays in the ICU and higher rates of death in the ICU. APACHE II also provided a good discriminatory ability to assess the risk of death and of staying in the ICU for greater than 10 days. APACHE II score should also be integrated as an early assessment of risk in the ICU and an aid to optimize planning the available resources in the ICU. However, it is essential that local evaluations are carried out and that the application of clinical judgment is undertaken.

Author's contribution:

Dr Syed Muhammad Abbas: study design and data collection

Dr. Shoaib Malik and Dr Shahneela Raza: review and final approval

Dr Hassan Baig: data analysis and manuscript writing

Dr. Farhan Iqbal and Dr Syeda Aliza Batool: literature review

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