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Original Article

ASSESSING THE EFFICACY OF TWO SEVERITY SCORING SYSTEMS IN PREDICTING PROGNOSIS FOR ACUTE KIDNEY FAILURE, BHAGALPUR: A COHORT STUDY.

[1]Ravi Anand*, [2]Sneha Bhushan

[1]Assistant Professor, Department of Medicine, Jawahar Lal Nehru Medical College and Hospital, Bhagalpur, Bihar, India.

[2]Senior Resident, Department of Obstetrics and Gynaecology, Jawahar Lal Nehru Medical College and Hospital, Bhagalpur, Bihar, India.

ABSTRACT

Background

Acute kidney failure (AKI) causes waste buildup and fluid-electrolyte imbalances due to rapid renal function loss, necessitating accurate outcome prediction using APACHE II and SOFA scores due to its high morbidity and death. The study aims to compare the predictive accuracy of the SAPS 3 and APACHE IV severity scoring systems in forecasting mortality among patients with AKI admitted to the intensive care unit (ICU).

Methods

The cohort study involves 150 AKI ICU patients. Detailed medical histories, systemic exams, and pertinent blood testing were collected. SAPS 3 and APACHE IV scores were determined within one hour and 24 hours of ICU admission, respectively. Mortality rates were predicted using calculators. SPSS 20 was used for statistical analysis.

Results

The study comprised 150 patients with an average age of 58 years; 65% were male. Common co-morbidities were hypertension (42%), diabetes mellitus (28%), and cardiovascular disease (18%). Mean SAPS 3 and APACHE IV scores were 52 and 46, respectively. Predicted mortality rates were 30% (SAPS 3) and 28% (APACHE IV), with an observed mortality of 30%. Deceased patients had higher mean scores (SAPS 3: 62, APACHE IV: 58). ROC analysis showed AUCs of 0.85 for SAPS 3 and 0.82 for APACHE IV. Sensitivity and specificity were 76% and 82% (SAPS 3), and 72% and 79% (APACHE IV). Both scores were considerably related to mortality ($p < 0.001$).

Conclusion

Both SAPS 3 and APACHE IV scoring systems demonstrated good predictive accuracy for mortality in AKI individuals admitted to the ICU, with no significant difference in their performance.

Recommendations

Further research should explore integrating machine learning algorithms and additional biomarkers to enhance the predictive accuracy of these scoring systems. Continuous evaluation and refinement are essential to improve their utility in clinical practice.

Keywords: *Acute Kidney Injury, Sequential Organ Failure Assessment 3, Acute Physiology and Chronic Health Evaluation IV, Severity Scoring Systems, Intensive Care Unit Mortality Prediction.*

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Corresponding Author*: Ravi Anand**

Email: ravianand_kmc@yahoo.co.in

Assistant Professor, Department of Medicine, Jawahar Lal Nehru Medical College and Hospital, Bhagalpur, Bihar, India.

INTRODUCTION

Acute kidney failure, also known as acute kidney injury (AKI), is a serious illness that causes waste products to accumulate in the blood and an electrolyte imbalance. This condition can result from various causes, including severe infections, sepsis, dehydration, medication toxicity, and trauma. AKI is correlated with major morbidity and death, particularly in critically ill patients, making the accurate prediction of patient outcomes crucial for effective management and resource allocation in clinical settings [1].

To improve the prognosis of individuals with AKI, healthcare professionals have developed and utilized several severity scoring systems. These systems aim to provide a standardized method to assess the severity of disease, predict patient outcomes, and guide clinical decision-making [2]. Among the various scoring systems available, the Acute Physiology and Chronic Health Evaluation II (APACHE II) and the Sequential Organ Failure Assessment (SOFA) scores are two widely used tools. Both scoring systems incorporate physiological and clinical parameters to evaluate the degree of organ dysfunction and predict mortality risk in critically ill patients, including those with AKI.

The APACHE II score, developed in the 1980s, is one of the earliest and most extensively validated severity scoring systems. It combines acute physiological measurements, chronic health conditions, and age to

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generate a composite score that correlates with mortality risk [3]. Despite its widespread use, APACHE II has limitations, including its complexity and the need for extensive data collection, which may limit its applicability in some clinical settings.

The SOFA score, introduced in the 1990s, focuses on the degree of organ dysfunction rather than the underlying disease processes. It assesses six organ systems (respiratory, renal, hepatic, cardiovascular, coagulation, and neurological) and assigns points based on the severity of dysfunction in each system. The SOFA score is particularly useful in monitoring the progression of organ failure over time and has been shown to correlate well with patient outcomes in various critical care settings.

Given the diverse etiologies and complex clinical manifestations of AKI, the efficiency of these severity scoring systems in predicting prognosis has been the subject of extensive research. Studies have evaluated the predictive accuracy, calibration, and discrimination abilities of APACHE II and SOFA scores in different patient populations and clinical scenarios [4]. These studies aim to identify the most reliable and practical tools for prognostication in AKI, ultimately improving patient management and outcomes.

Despite the advancements in severity scoring, there remains a requirement for continuous evaluation and refinement of these tools to enhance their predictive performance. Researchers are exploring novel approaches, such as integrating machine learning algorithms and incorporating additional biomarkers, to further improve the accuracy and utility of severity scoring systems in AKI. The ongoing efforts to assess and enhance the efficacy of these scoring systems underscore the importance of precision in critical care and the commitment to improving patient outcomes in acute kidney failure.

The study aims to compare the predictive accuracy of the SAPS 3 and APACHE IV severity scoring systems in forecasting mortality among patients with AKI admitted to the intensive care unit (ICU). Through comprehensive assessment and comparison of these scoring systems, the study seeks to determine their effectiveness in guiding clinical decision-making and improving prognostic outcomes in this patient population.

METHODOLOGY

Study Design

A prospective observational cohort design.

Study Setting

The study was taken out at Jawahar Lal Nehru Medical College and Hospital in Bhagalpur, Bihar, India, spanning from February 2023 to March 2024.

Participants

A total of 150 individuals were involved in the study.

Inclusion and Exclusion Criteria

Patients with an increase in serum creatinine by ≥ 0.3 mg/dL within 48 hours, an increase to ≥ 1.5 times baseline within 7 days, or urine output < 0.5 mL/kg/h for 6 hours were included. Exclusion criteria involved individuals with pre-existing chronic kidney disease or other diseases.

Sample size

To calculate the sample size for this study, the following formula was used for estimating a proportion of a population:

$$n = \frac{Z2 \times p \times (1-p)}{E2}$$

Where:

- n = sample size
- Z = Z-score corresponding to the desired level of confidence
- p = estimated proportion in the population
- E = margin of error

Bias:

Efforts were made to minimize bias through standardized data collection procedures and objective assessment criteria.

Variables

Variables included demographic data, laboratory test results arterial blood gas analysis, urine routine, and other relevant investigations.

Data Collection

Comprehensive medical histories, systemic examinations, necessary laboratory tests (CBC, sodium, blood glucose levels, urea, and creatinine), liver function tests, urine routines, arterial blood gas analysis, and other pertinent investigations needed for severity scoring were all part of the data collection process. Using the "risk" criteria of the RIFLE method, a fifty percent rise in baseline serum creatinine levels was considered acute renal damage.

Statistical Analysis

SAPS 3 data were collected within one hour of ICU admission, and APACHE IV scores were determined within the first 24 hours. Predicted mortality rates were determined using respective calculators. Patients were tracked until discharge, and outcomes were recorded. SPSS version 20 was utilized for statistical analysis, encompassing descriptive statistics (mean, standard deviation, frequency, proportions) and inferential statistics (chi-square test). Receiver operating characteristic (ROC) curves were produced to estimate the area under the curve (AUC), along with sensitivity, specificity, and cutoff values for APACHE and SAPS scores. Significance was set at 5%.

Ethical considerations

The study protocol was authorized by the Institutional Review Board Committee. Written informed consent was taken from the participants before the study. In cases where the patient was unable to comprehend, consent was obtained from a surrogate identified by bystanders.

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RESULT

Table 1: Patient characteristics

Characteristics	Values
Total patients	150
Mean age, years	58 ± 12.5
Gender	
- Male	65%
- Female	35%

Table 2: Clinical characteristics

Characteristics	Values
Comorbidities	
- Hypertension	42%
- Diabetes mellitus	28%
- Cardiovascular disease	18%
Deceased patients	45
Surviving patients	105

A total of 150 individuals with AKI were involved in the study, with an average age of 58 years (± 12.5). Most of the individuals were male (65%) and had various comorbidities, including hypertension (42%), diabetes mellitus (28%), and cardiovascular disease (18%).

Table 3: Laboratory findings

Laboratory Test	Mean ± SD
Complete Blood Count (CBC)	
- Hemoglobin (g/dL)	12.5 ± 1.8
- White Blood Cell Count ($\times 10^9$/L)	9.5 ± 2.5
- Platelets ($\times 10^9$/L)	250 ± 50
Sodium (mmol/L)	140 ± 4
Blood Glucose (mg/dL)	110 ± 20
Urea (mg/dL)	45 ± 15
Creatinine (mg/dL)	2.5 ± 0.8
Liver Function Tests	
- ALT (U/L)	30 ± 10
- AST (U/L)	25 ± 8
- Bilirubin (mg/dL)	1.2 ± 0.4
Urine Routine	
- Protein (mg/dL)	20 ± 10
- Red Blood Cells (cells/HPF)	3 ± 1
- White Blood Cells (cells/HPF)	5 ± 2
Arterial Blood Gas Analysis	
- pH	7.35 ± 0.05
- PaCO2 (mmHg)	40 ± 5
- HCO3 (mmol/L)	24 ± 3

Table 4: Severity Scoring and Mortality Prediction.

Parameters	SAPS3	APACHE IV
Mean score	52 ± 10	46 ± 8
Predicted mortality rate (95% CI)	30% (28-32%)	28% (26-30%)
Mortality rate (observed)	30%	30%
SAPS 3 score (deceased)	62 ± 8	
SAPS 3 score (survivors)	48 ± 9	
APACHE IV score (deceased)		58 ± 7
APACHE IV score (survivors)		42 ± 6
The mean length of stay in ICU (days)	7.5 ± 3.2	8.2 ± 2.9
P-value (length of stay)	0.211	0.145

Upon admission, the mean SAPS 3 score was 52 (± 10), while the mean APACHE IV score was 46 (± 8). The predicted mortality rates based on SAPS 3 and APACHE IV scores were 30% and 28%, respectively.
During the follow-up period until discharge, 45 patients (30%) expired. Among the deceased patients, the mean SAPS 3 score was notably higher ($p < 0.001$) compared to survivors, with a mean score of 62 (± 8) in the deceased group and 48 (± 9) in the survivor group. Similarly, the mean APACHE IV score was notably higher ($p < 0.001$) among deceased patients, with a mean score of 58 (± 7) compared to 42 (± 6) in survivors.

Table 5: Predictive accuracy

Scoring system	SAPS 3	APACHE IVY
AUC	0.85	0.82
95% CI	0.79-0.91	0.76-0.88
Sensitivity	76%	72%
Specificity	82%	79%
Cutoff score	60	55
p-value	0.067	0.091

ROC curve analysis demonstrated that both SAPS 3 and APACHE IV scores had good discriminative ability in predicting mortality in AKI individuals. The AUC for SAPS 3 was 0.85 (95% CI: 0.79-0.91), while the AUC for APACHE IV was 0.82 (95% CI: 0.76-0.88). However, there was no statistically considerable difference between the AUCs of SAPS 3 and APACHE IV scores ($p = 0.312$).
Sensitivity and specificity analysis revealed that an SAPS 3 cutoff score of 60 had a sensitivity of 76% and specificity of 82%, while an APACHE IV cutoff score of 55 had a sensitivity of 72% and specificity of 79% in predicting mortality.

Table 6: Association with mortality outcomes

Scoring system	Chi-square	p-values
SAPS 3	28.67	<0.001
APACHE IV	25.91	<0.001

Furthermore, the chi-square test revealed a substantial relation between SAPS 3 scores and mortality outcomes ($\chi^2 = 28.67$, $p < 0.001$), as well as between APACHE IV scores and mortality outcomes ($\chi^2 = 25.91$, $p < 0.001$).
Overall, both SAPS 3 and APACHE IV scoring systems demonstrated good predictive accuracy for mortality in AKI individuals admitted to the ICU. However, there was no significant difference in their performance, suggesting that either scoring system could be effectively utilized for prognostication in this patient population.

DISCUSSION

The study included 150 individuals with AKI, predominantly male (65%) with a mean age of 58 years. Comorbidities such as hypertension (42%), diabetes mellitus (28%), and cardiovascular disease (18%) were prevalent among the participants.
Upon admission, the mean SAPS 3 score was 52, and the mean APACHE IV score was 46, with predicted mortality rates of 30% and 28%, respectively. During the follow-up, 30% of patients expired. Deceased individuals had significantly higher SAPS 3 and APACHE IV scores compared to survivors. Higher SAPS 3 and APACHE IV scores accurately predicted a 30% mortality rate among AKI patients, confirming their effectiveness in identifying those at higher risk of death.
ROC curve analysis exposed that both SAPS 3 and APACHE IV scores had good discriminative ability in predicting mortality, with AUCs of 0.85 and 0.82, respectively. Sensitivity and specificity analysis indicated that SAPS 3 had a sensitivity of 76% and specificity of 82%, while APACHE IV had a sensitivity of 72% and specificity of 79%.
The chi-square test revealed a substantial correlation between both SAPS 3 and APACHE IV scores and mortality outcomes. However, there was no statistically considerable difference in their performance.
Overall, both SAPS 3 and APACHE IV scoring systems demonstrated good predictive accuracy for mortality in AKI individuals admitted to the ICU. The results suggest that the scoring system could be effectively utilized for prognostication in this patient population.
Comparing the effectiveness of different severity rating systems in determining the prognosis for individuals with AKI has been the subject of a recent study. To predict the 28-day mortality of 2,954 AKI patients, a study compared the scores for the Oxford Acute Severity of Illness Score (OASIS), APACHE II, SAPS II, and SOFA. With an AUC of 0.82, OASIS was shown to have the highest predictive accuracy in the study. According to the findings, OASIS, APACHE II, and SAPS II outperformed

SOFA; OASIS was suggested as a more straightforward and efficient substitute [5].

A study assessing severity scoring systems for critically ill individuals receiving continuous renal replacement therapy (CRRT), found that kidney-specific scoring systems such as Demirjian's score (AUC 0.770) and Liano's score (AUC 0.728) outperformed general severity scores like APACHE II (AUC 0.710) in predicting mortality. The study highlighted the superior performance of kidney-specific scores over general severity scores in this patient population [6].

A review emphasized the need for a large multinational database to improve the accuracy of kidney-specific severity scores. The review noted that none of the existing scores showed good calibration or discrimination ability when validated externally. This underscores the importance of developing more precise severity scores based on large, diverse datasets [7].

A study investigated the predictive ability of red blood cell distribution width (RDW) in AKI patients requiring dialysis. RDW had an AUC of 0.904, significantly outperforming SOFA (AUC 0.828) and APACHE II (AUC 0.828), indicating RDW as a strong predictor of 30-day mortality in this patient population. The study highlighted the superior predictive ability of RDW compared to other prognostic models [8].

A study applying machine learning algorithms to improve mortality prediction for patients undergoing CRRT for severe AKI demonstrated that the random forest model achieved the highest AUC of 0.784 for ICU mortality. This outperformed traditional scoring models such as APACHE II (AUC 0.611) and SOFA (AUC 0.677), highlighting the potential of machine learning to enhance prognostic accuracy [9].

Another study showed that the SOFA score had a higher prediction accuracy for 28- and 90-day mortality in critically ill patients with AKI undergoing CRRT compared to the APACHE-II score. The SOFA score's adjusted hazard ratios (HR) for 28-day mortality were 1.18, 1.24, and 1.19 in three models, indicating its superior predictive value [10].

A study modified the SOFA score by replacing its renal component with the KDIGO classification for AKI. This KDIGO-based SOFA score showed comparable predictive validity to the original SOFA score for hospital and ICU mortality, with AUCs of 0.749 and 0.790, respectively, indicating that it was as effective as the original SOFA score [11].

Generalizability

The study findings suggest that SAPS 3 and APACHE IV scoring systems can effectively predict mortality in a larger population of AKI patients, enabling better risk stratification, resource allocation, and targeted interventions in diverse ICU settings

CONCLUSION

The study confirms the robust prognostic capability of both SAPS 3 and APACHE IV scoring systems in acute kidney injury patients in ICU settings. While SAPS 3 demonstrated slightly higher sensitivity and specificity compared to APACHE IV, both models showed significant associations with mortality outcomes, providing clinicians with reliable tools for risk assessment and treatment guidance. Overall, the findings contribute valuable insights into risk prediction models for improved outcomes in critical care settings.

Limitations

The limitations of this study include a small sample population who were included in this study. Furthermore, the lack of a comparison group also poses a limitation for this study's findings.

Recommendations

Further research is warranted to refine these models and explore the integration of novel biomarkers to enhance risk prediction and refine management strategies in acute kidney injury patients.

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List of abbreviations

AKI: Acute Kidney Injury
APACHE: Acute Physiology and Chronic Health Evaluation
AUC: Area Under the Curve
CI: Confidence Interval
CRRT: Continuous Renal Replacement Therapy
ICU: Intensive Care Unit
KDIGO: Kidney Disease: Improving Global Outcomes
RDW: Red Blood Cell Distribution Width
ROC: Receiver Operating Characteristic
SAPS: Simplified Acute Physiology Score
SOFA: Sequential Organ Failure Assessment
SPSS: Statistical Package for Social Sciences

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Conflict of interest

The authors have no competing interests to declare.

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