Research Article

Role of Acute physiology and chronic health evaluation II scoring system in determining the severity and prognosis of critically ill patients in pediatric intensive care unit

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Abstract

Objective: This study was conducted to validate the use of Acute Physiology and Chronic Health Evaluation II (APACHE II) scoring system in pediatric population in predicting the risk of mortality and to compare the predicted death rate (using APACHE II) with the actual death rate of the patients. **Design:** Hospital-based prospective study. **Setting:** Tertiary care Pediatric Intensive Care Unit (PICU) in Western Rajasthan, India. **Methods:** A total of 100 critically ill children between 1 and 18 years of age admitted to PICU and fulfilling the inclusion criteria were enrolled. APACHE II score was calculated in each patient on the day of admission. The predicted mortality was calculated on the basis of this score. **Results:** The mean APACHE II score was 21.35 ± 5.76. Mean APACHE II score among the survivors was 16.60 ± 6.12, and mean APACHE II score among the nonsurvivors was 26.11 ± 5.41, and the difference was statistically significant ($P = 0.00$). The area under the receiver operating characteristic curve for APACHE II score was found to be 0.889 ($P = 0.008$) indicating good discrimination. **Conclusion:** APACHE II scoring system has a good discrimination and calibration when applied to a pediatric population.

Keywords: Acute Physiology and Chronic Health Evaluation score, calibration, critically ill, discrimination, Pediatric Intensive Care Unit

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Introduction

Various scoring systems for prediction of morbidity and mortality in Intensive Care Unit (ICU) have been developed in the last 30 years. According to Gregoire and Russel,[1] these scoring systems serve four major purposes. First, they are used in clinical trials for matching. Second, they are used to quantify the severity of illness for administrative decisions such as resource allocation. Third, as an audit tool, they can be used to assess ICU performance and compare the quality of care. Finally, they help to assess the prognosis.

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Acute Physiology and Chronic Health Evaluation (APACHE)[2] series is one of the most well-received generic severity measures, based upon clinical data, which calculates the probability of death independent of diagnosis. The APACHE score is based on acute physiological parameters and other clinical information. APACHE is actually less disease specific than other severity measurements, in that it predicts the probability of dying independent of the disease.

The first score developed in this series was developed by Knaus *et al.* at the George Washington University Medical Centre in 1981. This score demonstrated the ability to evaluate the severity of disease in an accurate and reproducible form.[3] Another simplification of the original APACHE system, the APACHE II was published in 1985.[4]

APACHE II is a composite score of acute physiology score, age points, and chronic health points. In acute

physiology, there are 13 variables and each variable is assigned a score varying from 0 to 4. Similarly, age and chronic health are graded from 0 to 6 and 0 to 5 score, respectively. Based on the cumulative of these scores mortality is predicted.

The APACHE II severity score has shown a good calibration and discriminatory value across a range of disease processes and remains the most commonly used international severity scoring system worldwide.[5] It has been found to have the best Youden index, highest positive predictive value, and best specificity in predicting mortality outcome.[6] This scoring system has been widely applied in medical and surgical ICUs to predict the outcome of adult patients. Vasilyeva *et al*.[7] found in their study that APACHE II score was useful for assessing outcomes in children with severe mechanical trauma. However, due to limited data on the use of this score in pediatric age group, it is still not widely used for this population.

This study was conducted to validate the use of APACHE II scoring system in pediatric population in predicting the risk of mortality and to compare the predicted death rate (using APACHE II) with the actual death rate of the patients.

Methods

It was a prospective study conducted in Pediatric ICU (PICU) of Umaid Hospital, Dr. S N Medical College, Jodhpur over a period of 1-year from December 2012 to November 2013.

All children between 1 and 18 years of age admitted in PICU for >24 h were included in the study. Those children who were <1-year of age or expired in <24 h of their admission or were discharged against medical advice were excluded.

Demographic details, vital signs-pulse, blood pressure, respiratory rate and temperature, complete clinical examination, and investigations including liver function test, renal function test, hemogram, arterial blood gas analysis, and serum electrolytes were recorded in a predesigned and pretested Performa. Based on these APACHE II score was calculated on the day of admission. The predicted mortality was calculated on the basis of this score.

Statistical methods

SPSS (version 10.0, produced by SPSS Inc., and was acquired by IBM in 2009) was used to analyze the data. Student *t*-test and Chi-square test were used to compare quantitative and qualitative data, respectively. An one-way analysis of variance (ANOVA) was used to produce one-way ANOVA for the quantitative dependent variable by an independent variable. Receiver operating characteristic (ROC) curve was used to discriminate the survivor from nonsurvivor, and area under the curve was calculated to determine the degree of discrimination. An aROC >0.9 was defined as excellent discrimination, 0.8> aROC <0.9 as good discrimination and 0.7> aROC <0.8 as modest discrimination.[8,9]

Lemeshow-Hosmer goodness of fit test was used for calculation of calibration (correlation between estimated probability of death and observed death rate). $P > 0.05$ was taken as no significant difference between predicted and observed mortality. In addition, standardized mortality ratio (SMR) was also calculated to find out difference observed and expected mortality rate.

Results

A total of 100 critically ill patients were enrolled in the present study. In this group, neurological morbidity (51%) was the most common followed by, respiratory (17%), cardiovascular (13%), renal (8%), metabolic (6%), infection (6%), poisoning (6%), hepatic (3%), and hematological (2%). The mean age of the population was 4.95 ± 3.61 years, and there was slight male preponderance (55% males vs. 45% females).

Mortality is increased with increasing APACHE II score. Hundred percent mortality was observed with a score >34. Mean APACHE II score was significantly higher among expired as compared to survivors (26.11 + 5.41 vs. 16.60 + 6.12, $P < 0.00$). On comparing individual parameters of the score among the survivors and nonsurvivors, it was found that there were statistically significant correlation between survivors and nonsurvivors in relation to mean arterial pressure, heart rate, PaO_2, and total white blood cell counts [Tables 1 and 2].

Table 1: Association between APACHE II score and mortality

APACHE score	Number of cases	Mortality *n* (%)	
		Expired	Survived
0-4	03	01 (33.3)	02 (66.7)
5-9	05	-	05 (100.0)
10-14	08	-	08 (100.0)
15-19	16	01 (06.2)	15 (93.8)
20-24	24	14 (58.3)	10 (41.7)
25-29	32	28 (87.5)	04 (12.5)
30-34	09	08 (88.9)	01 (11.1)
>34	03	03 (100.0)	-

APACHE: Acute physiology and chronic health evaluation

The degree of discrimination among survivors and the nonsurvivors was calculated using the area under the ROC curve [Figure 1]. The aROC in the study, was found to be 0.889 indicating a good discrimination [Table 3]. The result on goodness of fit model as shown by Hosmer-Lemeshow goodness of fit, Chi-square test showed that there is no statistically significant difference between observed and expected outcome for survivors and nonsurvivors among study cases [Tables 2 and 4]. SMR was one and 95% confidence interval between 0.7607 and 1.292 (mid *P* exact test).

Discussion

Although many scoring systems exist for assessing the severity, a full proof qualitative and unbiased assessment of severity of illness is difficult, and controversy continues regarding the accuracy of prediction of mortality due to significantly different mortality rates reported in different studies.

In our study, the major cause of morbidity in the cohort was neurological (51%) followed by respiratory (17%) and cardiovascular (13%). Similar morbidity profile was reported by Haque and Bano.[10] They also observed major diagnostic categories of their admitting patients as neurological (10%), respiratory (10%), and cardiac (8%). El Halal *et al*.[11] in their study, observed the most common morbidities as neurological (11.5%) followed by oncologic/hematological (11.4%) and genetic (7.3%).

In our study, 55% cases expired. Another Indian study by Singhal *et al*.,[12] observed 21.95% mortality of the PICU admissions. On the contrary, data from the west suggest a PICU mortality ranging from 3.8% to 13% in North and South America and Europe, respectively.[13,14] A strikingly high PICU mortality observed in our study, can be attributed to delayed referrals from rural areas in Western Rajasthan with poor transport facilities, difficult terrain and lack of awareness for early medical attention.

We observed that mortality increased with increments in APACHE II score. Mortality was observed in 100.00% cases, when the score was >34. Similar findings were observed by Kim *et al*.[15] and Turner *et al*.[16] also. Mean APACHE II score among the survivors was 16.60 ± 6.12 as compared to 26.11 ± 5.11 among nonsurvivors in the present study. Kim *et al*.[15] also reported mean APACHE II score of 15 among survivors and 23.5 among the nonsurvivors. Adesunkanmi *et al*.[17] use modified APACHE II score range 0–18 and found mortality increased with increasing modified APACHE II score, A modified APACHE II score >15 was associated with a significantly greater mortality.

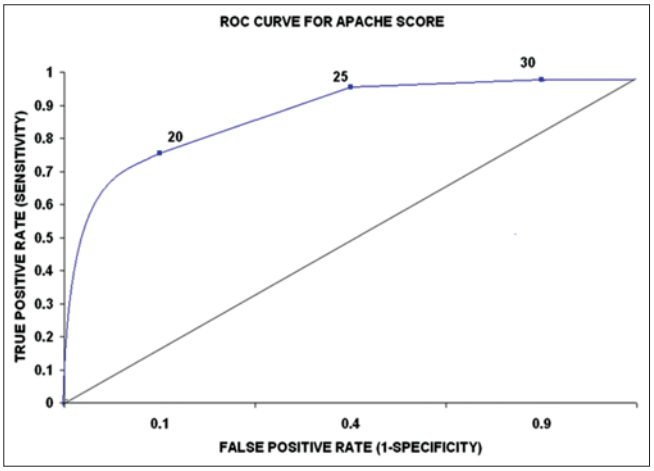

Figure 1: Receiver operating characteristic curve for Acute Physiology and Chronic Health Evaluation score

Table 2: Comparison of study variables in survivors and nonsurvivors of study cases

Variables	*n*	Survived	*n*	Expired	*P*
Age in years	45	4.97±3.31	55	4.92±3.87	0.945 (NS)
Temperature	45	38.78±1.01	55	39.12±1.31	0.146 (NS)
Mean arterial pressure	45	82.67±15.84	55	71.05±19.95	*0.002
Heart rate	45	132.80±22.58	55	145.44±25.56	*0.010
Respiratory rate	45	41.96±18.63	55	48.27±17.42	0.086 (NS)
A-a O_2	05	202.20±68.71	23	261.65±162.41	0.205 (NS)
PaO_2	40	101.20±21.21	32	87.78±28.25	*0.029
Total WBC count	45	15869.89±7537.13	55	20307.18±9036.40	*0.009
Serum sodium	45	138.64±7.59	55	139.78±9.52	0.507 (NS)
Serum potassium	45	4.34±0.92	55	4.73±1.86	0.176 (NS)
pH	45	7.30±0.14	55	7.30±0.13	1.000 (NS)
Serum HCO_3	45	20.82±8.67	55	20.55±7.84	0.872 (NS)
Serum creatinine (with ARF)	42	1.09±0.30	50	1.17±0.50	0.346 (NS)
Serum creatinine (without ARF)	03	3.97±2.11	05	5.18±1.69	0.431 (NS)
Hematocrit	45	33.47±7.58	55	32.74±8.87	0.658 (NS)

By ANOVA *Significant. NS: Nonsignificant; ANOVA: Analysis of variance; WBC: White blood cell; ARF: Acute renal failure

Table 3: AUC – APACHE II

Area	SE	Significance	95% CI	
			Lower bound	Upper bound
0.889	0.026	0.008	0.854	0.928

AUC: Area under curve; SE: Standard deviation; CI: Confidence interval; APACHE: Acute physiology and chronic health evaluation

Table 4: Goodness of predictive model

Score	Total number	Nonsurvivors		Survivors	
		Observed	Expected	Observed	Expected
1-9	05	01	0.8	04	3.8
10-19	17	01	0.8	16	15.7
20-29	45	22	22.3	23	23.4
30-39	33	31	31.1	02	2.1

P=0.726

The area under the curve in our study, was found to be 0.889 (P = 0.0089) indicative of a good discrimination. Tang *et al*.[18] in their study, on the comparison of severity scoring system observed an area under ROC curve of 0.790 for APACHE II score. Nguyen *et al*.[19] in their study, on the comparison of the outcome of scores also found APACHE II score to have higher discrimination when compared to other scores such as MPM II and SAPS II. Ratanarat *et al*.[20] and Livingston *et al*.[21] also found in their studies that APACHE II had better calibration.

The result on goodness of fit model, as well as SMR showed no statistically significant difference between observed and expected outcome of survivors and nonsurvivors among study cases thus showing that the prediction of mortality of APACHE II score shows good correlation with actual mortality. Similarly, Wong *et al*.[22] also found a good correlation between predicted outcome and observed outcome, thus validating the ability of the APACHE II system in predicting group outcome.

Conclusion

Acute Physiology and Chronic Health Evaluation II scoring system have a good discrimination and calibration when applied to a pediatric population. Hence, we recommend its use in PICU to predict the mortality.

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