Prognostic indicators related to risk of death in shock patients: a new simplified score

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ABSTRACT

Introduction: We analysed the parameters associated with mortality outcome in shock patients.

Methods: The databases of intensive care unit patients were retrieved, and shock patients were selected for further analysis. Logistic regression was used to identify the predictors of mortality outcome. The area under curve (AUC) of receiver operating characteristic (ROC) curve was calculated for the power of prediction model.

Results: A total of 467 patients were recruited, of which 183 patients were diagnosed with shock. The variables predicting mortality outcomes were heart rate above 130 beats/minute (p-value is 0.015, odds ratio [OR] 4.38, 95 percent confidence interval [CI] 1.338–14.321), pH less than or equal to 7.24 (p-value is 0.001, OR 6.11, 95 percent CI 2.17–17.18), creatinine more than 1.5 mg/dl (p-value is 0.048, OR 3.05, 95 percent CI 1.01–9.19), and Glasgow Coma Score less than 7 (p-value is 0.038, OR 3.476, 95 percent CI 1.07–11.27). The sensitivity, specificity and AUC of ROC of this model was 82.5, 60.5 and 0.826 percent, respectively. The positive and negative predictive values and AUC of ROC at a score below 2 was 82.8, 67.3 and 0.81 percent, respectively. The results revealed a significant improvement in survival in shock patients with a score below 2 (p-value less than 0.001). We prospectively validated the score in 107 shock patients and found very high AUC of ROC.

Conclusion: Acidosis, tachycardia, renal impairment and impaired consciousness within the first 24 hours are the main predictors of shock state, and should be used for assessment of survival outcome in shock patients.

Keywords: intensive care units, mortality, outcome assessment, prognosis, shock

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INTRODUCTION

Septic shock is one of the most common causes of death in intensive care units (ICUs).[1] Almost all patients of septic shock usually die from multiple organ failure. Currently, there are several scores (e.g. simplified acute physiology score II [SAPS II],[2] acute physiology and chronic health evaluation II [APACHE II],[3] sequential organ failure assessment [SOFA],[4]) that can be calculated for predicting the mortality rate of ICU patients. However, in shock patients, few prediction scores are currently available. In 1991, Arregui et al demonstrated that the multiple organ failure scoring system, APACHE II and the acute organ system failure scoring system, with minor modifications, could be the predictors of mortality in septic shock patients.[5] However, these scoring systems require many parameters for calculating the estimated risk of death. A retrospective study conducted by Baumgartner et al in 1992[6] has found the simplified septic shock score to be a beneficial tool for predicting the mortality outcomes of septic shock patients. However, the widespread use of this score has not been observed in clinical practice. We conducted this retrospective study to analyse the variables that can predict the mortality outcomes of shock patients admitted in a medical ICU and to create a new simplified score for predicting mortality outcome in these patients.

METHODS

We conducted this retrospective study by analysing data from the ICU database. The software supporting this database was developed by the patient information team of the Faculty of Medicine, Mahidol University in 2001 and has been utilised ever since. The database contained patients' general information, final diagnosis, clinical data and numerous laboratory results from the first 24 hours of ICU admission, when the worse parameters were recorded. Doctors from the pulmonary department were assigned to complete this database. Database validation was performed by a data analyst every month.

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Table. I Characteristics of survivors and non-survivors among shock patients.

	Mean ± SD		p-value	95% CI
	Survivor (n = 129)	Non-survivor (n = 54)		
Age (yrs)	60.48 ± 17.09	58.80 ± 17.41	0.550	−3.81, 7.19
Gender (%)			0.470	
Female	46.5	40.7		
Male	53.5	59.3		
BT (°C)	37.40 ± 1.35	37.40 ± 1.68	0.990	−0.47, 0.46
SBP (mmHg)	81.31 ± 18.35	68.09 ± 23.71	< 0.001	6.79, 19.64
DBP (mmHg)	47.34 ± 12.62	40.48 ± 17.60	0.003	2.29, 11.42
MAP (mmHg)	58.69 ± 13.83	49.69 ± 18.59	< 0.001	4.09, 13.92
HR (beats/min)	114.95 ± 24.62	130.61 ± 39.35	0.001	−25.16, −6.17
RR (breaths/min)	26.00 ± 5.22	27.48 ± 8.46	0.240	−3.95, 0.99
pH	7.38 ± 0.13	7.19 ± 0.198	< 0.001	0.11, 0.25
HCO^3 (mmol/L)	19.61 ± 5.48	18.43 ± 6.58	0.507	−2.35, 4.71
PaO^2 (mmHg)	116.28 ± 56.28	104.37 ± 59.80	0.332	−12.33, 36.15
Cr (mmol/L)	2.64 ± 3.02	2.82 ± 3.36	0.716	−1.18, 0.81
Hct (%)	29.81 ± 7.52	29.75 ± 7.31	0.957	−2.32, 2.45
WBC (cell/mm^3)	18.18 ± 69.83	10.79 ± 9.11	0.444	−11.63, 26.41
GCS	13.10 ± 3.10	9.00 ± 5.06	< 0.001	2.89, 5.31
APACHE II	21.26 ± 7.19	32.20 ± 9.73	< 0.001	−13.51, −8.38

BT: body temperature; SBP: systolic blood pressure; DBP: diastolic blood pressure; MAP: mean arterial pressure; HR: heart rate; RR: respiratory rate; Cr: creatinine; Hct: haemocrit; WBC: white blood cell count; GCS: Glasgow Coma Score

Table. II Four major predictors derived from the logistic regression model.

	Odds ratio (95% CI)	
	Univariate	Multivariate
Chronic disease[a]	1.981 (0.872–4.500)	-
Impaired immune status[b]	1.385 (0.723–2.652)	-
Steroid usage[c]	1.228 (0.492–3.068)	-
HR > 130 (beats/min)	3.679 (1.853–7.302)*	4.377 (1.338–14.321)†
RR > 24 (breaths/min)	2.488 (1.262–4.904)†	0.636 (0.194–2.087)
pH ≤ 7.24	7.361 (2.970–18.24)*	6.109 (2.172–17.180)†
Cr > 1.5 (mmol/L)	2.560 (1.286–5.095)†	3.046 (1.009–9.191)†
WBC ≤ 4,010 (cell/mm^3)	2.849 (1.310–6.198)†	3.077 (0.829–11.424)
GCS ≤ 7	8.044 (3.460–18.69)*	3.476 (1.072–11.270)†

* $p < 0.001$ † $p < 0.05$

[a] Defined as the chronic underlying disease of patients, such as chronic liver disease or chronic renal failure. [b] Patient was prescribed immunosuppressive agents such as cyclophosphamide. [c] Patient was prescribed long-term corticosteroids.
HR: heart rate; RR: respiratory rate; Cr: creatinine; WBC: white blood cell count; GCS: Glasgow Coma Score

In cases of errors or missing values, the doctor handling the case would be approached to correct or complete the data. Approval was obtained from the ethics committee of Ramathibodi hospital.

Patients admitted into our medical ICU from January 1, 2007 to December 31, 2007 were enrolled in this study. The admission criteria included all medical conditions with shock and/or multiple organ failure, severe hypoxaemic respiratory failure, coma, severe intoxication and those requiring invasive monitoring. Cases with post-cardiac arrest and end-stage disease (e.g. end-stage cancer from data analysis) were excluded. At the end of the year, all data derived from this database was revalidated by another data analyst. All data was subsequently analysed using the Statistical Package for the Social Sciences (SPSS) version 15 (SPSS Inc, Chicago, IL, USA). Finally, another data analyst validated the database until it was free from mistakes. All data analysts were blinded to the individual outcome, except for one analyst who was involved with the preparation of annual reports and thus had access to information related to the overall hospital mortality of ICU patients in our department.

Shock patients were defined as those suffering from hypotension, with mean arterial pressure (MAP) < 65 mmHg[7] and signs of poor perfusion, namely oliguria, deterioration of consciousness and/or acidosis. Patients were mainly transferred from the emergency room

Table III. Calculation of shock scoring system.

Predictor	Score
pH	
≤ 7.24	1
> 7.24	0
HR (beats/min)	
> 130	1
≤ 130	0
Cr (mmol/L)	
> 1.5	1
≤ 1.5	0
GCS	
≤ 7	1
> 7	0

HR: heart rate; Cr: creatinine; GCS: Glasgow Coma Score

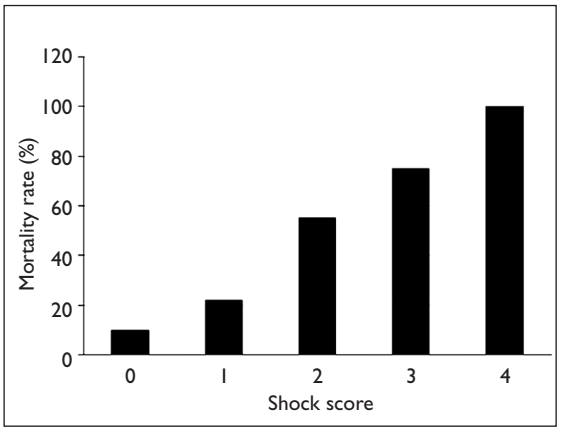

Fig. 1 Bar chart shows the increase in mortality rate of shock patients according to the increment in shock score.

or medical wards, and were treated by the medical intensive care team, including second year medical residents, pulmonary and critical care fellows and staff. Pulmonary artery catheter insertion was performed if haemodynamic measurement was required.

The primary aim of this study was to identify the variables that could predict the 30-day mortality among shock patients. For all categorical data, the statistical significance was calculated using chi-square test. For continuous variables, the student's *t*-test was applied for calculating the significant difference of each variable between the mortality outcomes. The logistic regression model was used for analysing predictor variables, and survival data was analysed using log-rank test. The area under the receiver operating characteristic (ROC) curve was used to test the power of prediction of the model and scoring system.

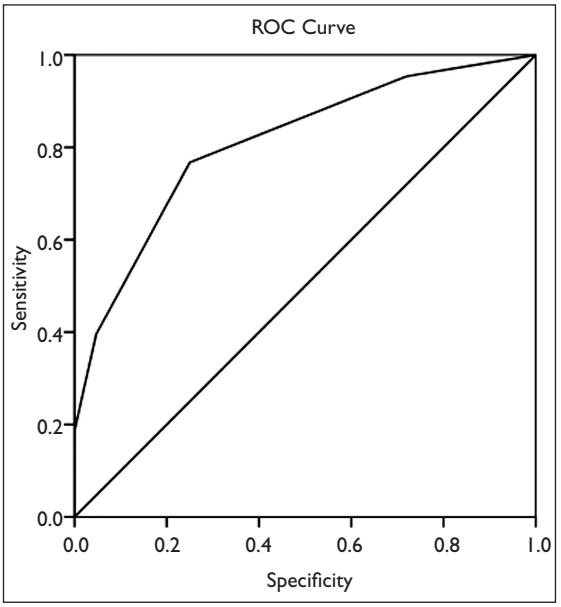

Fig. 2 Graph shows the ROC curve of the shock score for predicting survival outcome. At the cut point value < 2, the sensitivity and specificity were 75.0% and 76.7%, respectively, and the area under ROC curve for this model was 0.81.

RESULTS

Data of 467 patients was recorded in this database, out of which 183 were diagnosed with shock. The percentages of septic shock, hypovolaemic shock and other types of shocks were 77%, 11% and 12%, respectively. The overall mortality rate in shock patients was 29.5%. Table I shows the characteristics between the survivors and non-survivors. By univariate analysis, the variables related to mortality outcome were: heart rate (HR) > 130 beats/min ($p < 0.001$), pH value ≤ 7.24 ($p < 0.001$), creatinine (Cr) > 1.5 mg/dl ($p = 0.007$), Glasgow Coma Score (GCS) ≤ 7 ($p < 0.001$), total white blood cell in complete blood count ≤ 4,010 cell/mm^3 ($p = 0.007$), and respiratory rate > 24 breaths/min ($p = 0.008$).

Results from the logistic regression model, as shown in Table II, demonstrated that the variables predicting mortality outcomes were: HR > 130 beats/min ($p = 0.015$, odds ratio [OR] 4.38, 95% confidence interval [CI] 1.338–14.321), pH ≤ 7.24 ($p = 0.001$, OR 6.11, 95% CI 2.17–17.18), Cr > 1.5 mg/dl ($p = 0.048$, OR 3.05, 95% CI 1.01–9.19), and GCS ≤ 7 ($p = 0.038$, OR 3.476, 95% CI 1.07–11.27). By this model, the sensitivity and specificity were 82.5% and 60.5%, respectively. The area under the ROC curve for this model was 0.826. In the septic shock group, the variables predicting survival outcome were: HR > 130 beats/min ($p = 0.023$, OR 4.09, 95% CI 1.213–13.759), pH ≤ 7.24 ($p = 0.001$, OR 8.29, 95% CI 2.306–29.848), Cr > 1.5 mg/dl ($p = 0.043$, OR 3.90, 95% CI 1.042–14.599). However, inclusion of GCS ≤ 7 in this model did not affect its sensitivity and specificity. The areas under the ROC curve of the model with and without GCS ≤ 7 were 0.826 and 0.809, respectively.

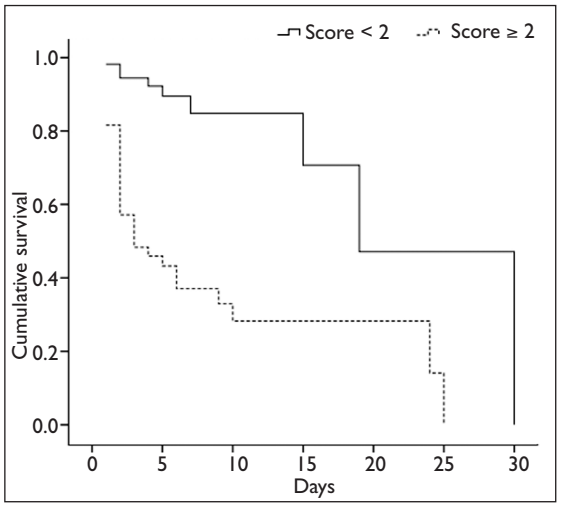

Fig. 3 Graph shows the difference in cumulative survival between shock patients with initial shock score < 2 and ≥ 2.

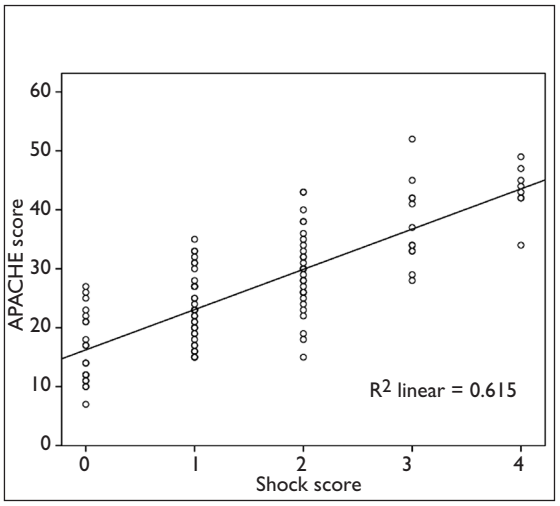

Fig. 4 Graph shows the linear correlation between APACHE II and shock score.

The shock scoring system was created and validated for its predictive power in 107 patients. We scored 0 for the given values of predictors associated with a lower risk of death, and 1 for those related to a higher risk of death (Table III). Fig. 1 illustrates that the higher the shock score value, the greater the mortality rate observed. With regard to the capability for prediction, the ROC curve revealed an area under curve (AUC) of 0.81 (Fig. 2). At the cut point value < 2, the sensitivity, specificity, positive predictive value (PPV) and negative predictive values (NPV) for survival prediction were 75.0%, 76.7%, 82.8% and 67.3%, respectively. In addition, the probability of survival in shock patients with shock score < 2 was significantly higher than that for patients with a score ≥ 2 (Fig. 3). We also found a good correlation between this score and the APACHE II score, with $r = 0.784$ and $p < 0.001$ (Fig. 4). Finally, shock patients with initial APACHE II score > 30 had a very high probability of death ($p < 0.001$), especially after 48 hours of admission.

DISCUSSION

The results from our study revealed four major variables associated with mortality outcome in shock patients, with low pH being the most important predictor. In clinical practice, it is a crucial surrogate indicator for poor tissue perfusion and is usually observed in multiple organ dysfunction. Likewise, changes in HR, GCS, and serum Cr are reasonable indicators of severity of shock, as they represent major organs that are essential for human survival. In terms of the power of prediction, the area under the ROC curve of 0.81 indicates a good predictor. Moreover, the good correlation between the shock score and APACHE II score ensures that this score can be used for survival prediction.

With regard to good PPV, a shock score of < 2 considerably increases the probability of survival. As a result, the decrement of shock score from a higher baseline value to < 2 may indicate an improvement of shock and may be used for monitoring during treatment. Another advantage of this score is its practicability. Unlike other scoring systems such as SOFA, APACHE II and SAP, which require many variables to calculate, this shock score requires only four variables for estimating the risk of death, thus allowing the physician to use it at bedside.

All variables calculated in this study were obtained from a single database. Thus, some important variables such as the amount of fluid administered for resuscitation, the time required to achieve the goal and lactate levels were not included.[8] This may have affected the accuracy of our model. Thus, we suggest that a prospective study that includes more shock-related variables be performed to verify if these predictors are indeed the main variables associated with mortality outcome. In addition, this score should be validated in a different population of shock patients so as to confirm its accuracy.

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