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REVIEW ARTICLE

Validity of Various Severity Scoring System in the Surgical Intensive Care Unit

Marwa H. Sayed,[1] Ahmed A. Abd El-Rahman,[2] Huda F. Mahmoud,[1] Mahmoud M. Hassan [1]

[1]Anesthesia, Critical Care & Pain Management,Faculty of Medicine - Aswan University

[2]Anesthesia, Critical Care & Pain ManagementFaculty of Medicine – Sohag University

ABSTRACT

Keywords: Intensive Care Unit, SOFA, APCHE, SAPS, Severity Score

*Corresponding Author:
Marwa Hussein Sayed
Anesthesia, Critical Care & Pain Management Faculty of Medicine - Aswan University
E-mail: merooouh@gmail.com
Mobile: +201007796062

Severity scoring systems are the most important adjuncts of treatment used in the intensive care unit to predict outcome, characterize disease severity, degree of organ dysfunction, and assess resource use. Even though disease severity scores are not the key elements of treatment, however, they are an essential part of improvement in clinical decisions and in identifying patients with unexpected outcomes. In fact, they have become a necessary tool to describe ICU populations and to explain differences in mortality. However, it is also important to note that the choice of the severity score scale, index, or model should accurately match the event, setting or application of such systems can lead to wastage of time, increased cost and poor science. Importantly, the different types of scores should be seen as complementary, rather than competitive and mutually exclusive, proper application of severity scores helps in decision making at the right time and in decreasing hospital cost. This review article provides a brief overview of intensive care unit severity scoring systems along with the prediction of death or survival rate calculations, although the article focused on Acute Physiology and Chronic Health Evaluation (APACHE), Simplified Acute Physiology Score (SAPS) and Sequential Organ Failure Assessment (SOFA).

INTRODUCTION

1. Scoring System in Intensive Care Unit (ICU)

Scoring systems for use in intensive care unit (ICU) patients have been introduced and developed over the last 30 years (**Table** 1). They allow an assessment of the severity of disease and provide an estimate of in-hospital mortality. This estimate is achieved by collating routinely measured data specific to a patient [(1).]

Various factors have been shown to increase the risk of in-hospital mortality after admission to ICU, including increasing age and severity of acute illness, certain preexisting medical conditions, and emergency admission to ICU. Before the 1980s, there were no scoring systems applicable to critical care populations which would allow outcomes from different critical care units to be compared [(2).]

Table (1): Patient data available for use in scoring systems [2].

Pre-existing conditions
Malignancy
Renal replacement therapy
Steroid therapy/immunosuppressant therapy (e.g. radiotherapy)
Liver disease
Haematological disease
Physiological measurements
Cardiovascular–mean arterial pressure, heart rate
Respiratory: FIO_2, A–a gradient, respiratory rate
Temperature
Glasgow coma score
Biochemical/haematological indices
Haemoglobin/haematocrit, white cell count, coagulation, creatinine, sodium, potassium, arterial pH
Source of admission
Medical or surgical
Planned or emergency
Patient data
Age
Anatomical regions/organ systems affected

2. Types of Severity Scoring System

Scoring systems used in critically ill patients can be broadly divided into those that are specific for an organ or disease such as: the Glasgow Coma Scale (GCS)) and those that are generic for all ICU patients [4].

In this article, we focus on the generic scores, which can broadly be divided into scores that assess disease severity on admission and use it to predict outcome such as, Acute Physiology and Chronic Health Evaluation (APACHE), Simplified Acute Physiology Score (SAPS), scores that assess the presence and severity of organ dysfunction, including; Sequential Organ 3 Assessment (SOFA) [5]

3. Assessment of Scoring System

Once a scoring system has been produced, its performance should be assessed and validated. This process refers to the ability of the score to predict mortality rate and must be carried out on a different population to that used to assemble the score. This can occur by randomly splitting the original population into two groups: the first to produce the score and the other to validate the model, or by using a completely separate population. Model calibration and discrimination are then assessed [5].

4. Comparison of Scoring System Performance

Despite having a paucity of high-quality studies comparing the performance of the various models to each, after evaluating the current evidence, the following generalizations can be made:

Older models (APACHE II, APACHE III, SAPS II, and SOFA) to each other, the APACHE II and III predictive scoring system were shown to be superior in one study whereas the SAPS II was shown to be superior in another [5].

Characteristics	APACHE	SAPS	APACHE II	MPM[a]	APACHE III	SAPS II	MPM II[b]	SAPS 3	APACHE IV	MPM III
Year	1981	1984	1985	1985	1991	1993	1993	2005	2006	2007
Countries	1	1	1	1	1	12	12	35	1	1
ICUs	2	8	13	1	40	137	140	303	104	135
Patients	705	679	5,815	2,783	17,440	12,997	19,124	16,784	110,558	124,855
Selection of variables and their weights	Panel of experts	Panel of experts	Panel of experts	Multiple logistic regression	Multiple logistic regression	Multiple logistic regression	Multiple logistic regression	Multiple logistic regression	Multiple logistic regression	Multiple logistic regression
Variables										
Age	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Origin	No	No	No	No	Yes	No	No	Yes	Yes	No
Surgical status	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Chronic	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
health status										
Physiology	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Acute diagnosis	No	No	Yes	No	Yes	No	Yes	Yes	Yes	Yes
Number of variables	34	14	17	11	26	17	15[c]	20	142	16[d]
Score	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No
Mortality prediction	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Newer models (APACHE IV, SAPS III and MPM III (mortality probability model)) to the older models (APACHE II and III, SAPS II, MPM II and SOFA), the newer models were found to perform better [(5).]

In general, all of these models have very good discriminatory values with an area under the receiver operating characteristics curve between 0.80 – 0.90 while simultaneously demonstrating good calibration assessments [(5)].

5. Different Scoring System

5.1. Original Outcome Prediction

The original outcome prediction scores were developed more than 25 years ago to provide an indication of the risk of death of groups of ICU patients; they were not designed for individual prognostication demographics, disease prevalence, and intensive care practice have changed considerably since, and statistical and computational techniques have also progressed (Table 2). As a result, all three of the major scores in this category have been recently updated to ensure their continued accuracy in today's ICU [(6).]

Table (2) - Original Outcome Predication Scoring System [(6).]Predictive scoring systems are measures of disease severity that are used to predict outcomes, typically mortality, of patients in the intensive care unit (ICU). Such measurements are helpful for standardizing research and comparing the quality of patient care across ICUs.

APACHE, acute physiology and chronic health evaluation; CABG, coronary artery bypass graft; LOS, length of stay; MPM mortality prediction model;

SAPS simplified acute physiology score.

5.1.1. Acute Physiology and Chronic Health Evaluation (APACHE)

The original APACHE score was developed in 1981 to classify groups of patients according to severity of illness and was divided into two sections: a physiology score to assess the degree of acute illness; and a preadmission evaluation to determine the chronic health status of the patient [(6).]

In 1985, the original model was revised and simplified to create APACHE II, now the world's most widely used severity of illness score. In APACHE II, there are just 12 physiological variables, compared to 34 in the original score (**Table 3)** effects of age and chronic health status

are incorporated directly into the model, weighted according to their relative impact, to give a single score with a maximum of 71 [7].

APACHE III was developed in 1991 and was validated and further updated in 1998. Most recently, APACHE IV was developed using a database of over 100,000 patients admitted to 104 ICUs in 45 hospitals in the USA in 2002/2003, and remodeling APACHE III with the same

A: Acute physiological score (12 variables)

Physiologic variable	High abnormal range				Normal range	Low abnormal range			
	+4	+3	+2	+1	0	+1	+2	+3	+4
Temperature rectal (°C)	≥41	39-40.9	-	38.5-38.9	36-38.4	34-35.9	32-33.9	30-31.9	≤29.0
Mean arterial pressure (mm Hg)	≥160	130-159	110-129		70-109		50-69		≤49
Heart rate-ventricular response	≥180	140-179	110-139		70-109		55-69	40-54	≤39
Respiratory rate per minute-non-ventilated or ventilated	≥50	35-490		25-34	12-24	10-11	6-9		≤5
Oxygen: A-a DO_2 or PaO_2 (Torr)									
FiO_2≥0.5 record A-a DO_2	≥500	350-499	200-349		≤200	PO_2 61-70		PO_2 55-60	PO_2<55
FiO_2<0.5 record only PaO_2					PO_2>70				
Arterial pH	≥7.7	7.6-7.69		7.5-7.59	7.33-7.49		7.25-7.32	7.15-7.24	<7.15
Serum HCO_3 (mmol/L)-only if no ABGs	≥52	41-51.9		32-40.9	23-31.9		18-21.9	15-17.9	<15
Serum sodium (mmoL/L)	≥180	160-179	155-159	150-154	130-149		120-129	111-119	≤110
Serum potassium (mmoL/L)	≥7	6-6.9		5.5-5.9	3.5-5.4	3-3.4	2.5-2.9		≤2.5
Serum creatinine (μmoL/L)	≥350	200-340	150-190		60-140		<60		
Hematocrit (%)	≥60		50-50.9	46-49.9	30-45.9		20-29.9		≤20
White blood cell count (×1,000/mm³)	≥40		20-39.9	15-19.9	3-14.9		1-2.9		<1
Glasgow coma score=15 minus actual GCS									

B: Age points		C: Chronic health points			Apache II score
Age (years)	Points	History	Points for elective surgery	Points for emergency surgery	Sum of A+B+C
≤44	0	Liver: Biopsy-proven cirrhosis and documented portal hypertension or prior episodes of hepatic failure	2	5	A: APS
45-54	2	Cardiovascular: NYHA Class IV	2	5	B: Age points
55-64	3	Respiratory: e.g., severe COPD, hypercapnia, home O_2, pulmonary hypertension	2	5	score
65-74	5	Immunocompromised	2	5	C: Chronic health
≥75	6	Renal: Chronic dialysis	2	5	point score
Total score					

APACHE: Acute physiology and chronic health evaluation; A-a DO_2: Alveolar-arterial oxygen tension difference; PaO_2 (Torr) arterial oxygen tension; FiO_2 (%): Fractional concentration of inspired oxygen; HCO_3: Bicarbonate; ABG: Arterial blood gas; NYHA: New York heart association; COPD: Chronic obstructive pulmonary disease. To compute predicted death rates for groups of acutely ill patients, the individual risk of hospital death is calculated with the following equation; the individual risks are then summed up and the value is divided by the total number of patients. $R/1\text{-}R$=−3.517+(APACHE II score×0.146)+(0.603, only if post-emergency surgery)+(diagnostic category weight as shown below), where R is the estimated risk of hospital death

physiological variables and weights but different predictor variables and refined statistical methods. APACHE IV again provides ICU length of stay prediction equations, which can provide benchmarks for the assessment and comparison of ICU efficiency and resource use [7].

Table (3) - Acute Physiology and Chronic Health Evaluation (APACHE) [7].

The APACHE III prognostic system was designed to refineAPACHE II. It consists of two parts:

APACHE III score, which can provide initial risk stratification for severely ill hospitalized patients within independently defined patient groups [8].

APACHE III predictive equation, which uses APACHE III score and reference data on major disease categories and treatment location immediately prior to ICU admission to provide risk estimates for hospital mortality for individual ICU patients [8].

APACHE III largely uses the same variables as APACHE II, but a different way is used to collect the neurological data-no longer using the GCS. It adds particularly two important variables: The patient's origin and the lead-time bias. The acute diagnosis is taken into account; one diagnosis must be preferred (**Table 4).** The APACHE III scores (evaluated as the most deranged values from the first 24 h in the ICU) vary between 0 and 299 points, including 252 points for the 18 physiological variables, 24 points for age and 23 points for the chronic health status; all variables are chosen to increase the explanatory power of the model [8].

Table (4) - Acute physiologic and chronic health evaluation II-diagnostic category weight (9).

Non-operative	Y	Post-operative patients	Y
Respiratory failure or insufficiency from		Multiple trauma	−1.684
Asthma/allergy	−2.108	Admission due to chronic cardiovascular disease	−1.376
COPD	−0.367	Peripheral vascular surgery	−1.315
Pulmonary edema (non-cardiogenic)	−0.251	Heart valve surgery	−1.261
Post-respiratory arrest	−0.168	Craniotomy for neoplasm	−1.245
Aspiration/poisoning/toxic	−0.142	Renal surgery for neoplasm	−1.204
Pulmonary embolus	−0.128	Renal transplant	−1.042
Infection	0	Head trauma	−0.955
Neoplasm	0.891	Thoracic surgery for neoplasm	−0.802
Cardiovascular failure or insufficiency from		Craniotomy for ICH/SDH/SAH	−0.788
Hypertension	−1.798	Laminectomy and other spinal cord surgery	−0.699
Rythm disturbance	−1.368	Hemorrhagic shock	−0.682
Congestive heart failure	−0.424	GI bleeding	−0.617
Hemorrhagic shock/hypovolemia	0.493	GI surgery for neoplasm	−0.248
Coronary artery disease	−0.191	Respiratory insufficiency	−0.140
Sepsis	0.113	GI perforation/obstruction	0.060
Post cardiac arrest	0.393	If not in one of the above, which major vital organ system led to ICU admission post-surgery	
Cardiogenic shock	−0.259	Neurologic	−1.150
Dissecting thoracic/abdomina aneurysm	0.731	Cardiovascular	−0.797
Trauma		Respiratory	−0.610
Multiple trauma	−1.228	Gastro-intestinal	−0.613
Head injury	−0.517	Metabolic/renal	−0.19
Neurologic			
Seizure disorder	−0.584		
ICH/SDH/SAH	0.723		
Other			
Drug overdose	−3.353		
Diabetic ketoacidosis	−1.507		
Gastro intestinal bleeding	0.334		
If not in one of the groups above, which major organ system was the principal reason for admission			
Metabolic/renal	−0.885		
Respiratory	−0.890		
Neurologic	−0.759		
Cardiovascular	0.470		
GI	0.501		

ICH: Intra cranial hypertension; SDH: Sub dural hematoma; SAH: Sub arachnoid hemorrhage; COPD: Chronic obstructive pulmonary disease; GI: Gastrointestinal

5.1.2. Simplified Acute Physiology Score (SAPS)

SAPS, developed and validated in France in 1984, used 13 weighted physiological variables and age to predict risk of death in ICU patients (**Table 5).** Like the APACHE scores, SAPS was calculated from the worst values obtained during the first 24 hours of ICU admission (8).

In 1993, Le Gall and colleagues used logistic regression analysis to develop SAPS II, which includes 17 variables: 12 physiological variables, age, type of admission, and 3 variables related to underlying disease. The SAPS II score was validated using data from consecutive admissions to 137 ICUs in 12 countries (8).

In 2005, a completely new SAPS model, the SAPS 3, was created. Complex statistical techniques were used to select and weight variables using a database of 16,784 patients from 303 ICUs in 35 countries (11).

Table (5) - Simplified Acute Physiology Score [11].

Variables	Score																			
	26	13	12	11	9	7	6	5	4	3	2	0	1	2	3	4	6	7	9	10
HR (beats/min)				<40							40-69	70-119				120-159		≥160		
SBP (mmHg)		<70						70-99				100-199		≥200						
Temperature (°C)												<39			≥39					
PaO_2/FiO_2 only if VENT or CPAP				<100	100-199	≥200														
Urine output (L/day)				<0.5					0.5-0.999			≥1								
Urea (g/L)												<0.6					0.6-1.7			>1.8
TLC			<1									1-19.9		≥20						
Potassium										<3		3-4.9		≥5						
Sodium								<125				125-144	≥145							
Bicarbonate							<15			15-19		>20								
Bilirubin (mg/dl)												<40				40-59.9			≥60	
GCS	<6	6-8				9-10		11-13				14-15								

Age	Score	Chronic disease	Score	Type of admission	Score
<40	0	Metastatic cancer	9	Scheduled surgical	0
40-59	7	Hematological malignancy	10	Medical	6
60-69	12	AIDS	17	Emergency surgical	8
70-74	15				
75-79	16				
>80	18				
SAPS II score	29	40	52	64	77
Mortality risk %	10	25	50	75	90

GCS: Glasgow coma score; HR: Heart rate; SBP: Systolic blood pressure; PaO_2 (mm Hg) arterial oxygen tension; FiO_2: Fractional concentration of inspired oxygen; VENT: Ventilator; CPAP: Continuous positive airway pressure; TLC: Total leukocyte count; AIDS: Acquired immunodeficiency syndrome. Probability of death, *P* may be calculated using the following equation: $P=(e^{Logit})/(1+e^{Logit})$; Logit=−7.7631+0.0737 (score)+0.9971 (log [score+1])

The SAPS 3 score includes 20 variables divided into three sub-scores related to patient characteristics prior to admission, the circumstance of the admission, and the degree of physiological derangement within 1 hour (in contrast to the 24-hour time window in the SAPS II model) before or after ICU admission. The total score can range from 0 to 217 [10].

Unlike the other scores, SAPS 3 includes customized equations for prediction of hospital mortality in seven geographical regions: Australasia; Central, South America; Central, Western Europe; Eastern Europe; North Europe; Southern Europe, Mediterranean; and North America. It should be noted that the sample size for development of some of these equations was relatively small, which may compromise their prognostic accuracy [10].

SAPS 3 score has been shown to exhibit good discrimination, calibration, and goodness of fit. SAPS 3 has also been used to examine variability in resource use between ICUs using the standardized resource use parameter based on the length of stay in the ICU adjusted for severity of acute illness [11].

5.2. Organ Dysfunction Scores

Organ failure scores are primarily designed to describe the degree of organ dysfunction rather than to predict survival. The severity of organ dysfunction varies widely among individuals and within an individual over time and organ failure scores must be able to take both time and severity into account. Many organ dysfunction scores have been developed over the past few decades, but we will limit our discussion to three of the scores most commonly used in general ICU patients; SOFA [12].

5.3. Sequential Organ Failure Assessment (SOFA)

SOFA was developed in 1994 during a consensus conference. Six organ systems (respiratory, cardiovascular, renal, hepatic, central nervous and coagulation) were selected based

on a review of the literature, and the function of each is scored from 0 (normal function) to 4 (most abnormal), giving a possible score of 0 to 24 [12].

Another key difference is in the cardiovascular component; instead of the composite variable, the SOFA score uses a treatment-related variable (dose of vasopressor agents) **(Table 6).** This is not ideal, as treatment protocols vary among institutions, among patients and over time, but it is difficult to avoid, especially for the cardiovascular system [13].

Sequential assessment of organ dysfunction during the first few days of ICU admission is a good indicator of prognosis [13].

SOFA score known as the Modified SOFA (MSOFA) score. MSOFA score eliminates the necessity of laboratory examinations such as the platelet count and substitute measurements of Oxygen saturation to fraction of inspired oxygen ratio SPO_2/FiO_2 and serum bilirubin level with the SPO_2/FiO_2 ratio (obtained by dividing pulse oximeter saturation with a fraction of inspired oxygen) and clinical examination for jaundice. Although simpler, this score must have more validation [14].

Table (6) - Sequential Organ Failure Assessment [14].

Respiratory system	
PaO_2/FiO_2 (mmHg)	**SOFA score**
> 400	**0**
< 400	**1**
< 300	**2**
< 200 with respiratory support	**3**
< 100 with respiratory support	**4**
Nervous system	
Glasgow Coma Scale	**SOFA score**
15	**0**
13–14	**1**
10–12	**2**
6–9	**3**
< 6	**4**
Cardiovascular system	
Mean arterial pressure (MAP) OR administration of vasopressors required	**SOFA score**
MAP > 70 mmHg	**0**
MAP < 70 mm/Hg	**1**
Dopamine ≤ 5 µg/kg/min or dobutamine (any dose)	**2**
Dopamine > 5 µg/kg/min OR epinephrine ≤ 0.1 µg/kg/min OR norepinephrine ≤ 0.1 µg/kg/min	**3**
Dopamine > 15 µh/kg/min OR epinephrine > 0.1 µg/kg/min OR norepinephrine > 0.1 µg/kg/min	**4**
Liver	
Bilirubin (mg/dl) [µmol/L]	**SOFA score**
< 1.2 (< 20)	**0**
1.2–1.9 [20–32]	**1**
2.0–5.9 [33–101]	**2**
6.0–11.9 [102–204]	**3**
> 12.0 [> 204]	**4**
Coagulation	
Platelets $\times 10^3$/ml	**SOFA score**
> 150	**0**

< 150	**1**
< 100	**2**
< 50	**3**
< 20	**4**
Kidneys	
Creatinine (mg/dl) [µmol/L]; urine output	**SOFA score**
< 1.2 [< 110]	**0**
1.2–1.9 [110–170]	**1**
2.0–3.4 [171–299]	**2**
3.5–4.9 [300–440] (or urine output < 500 ml/day)	**3**

Quick SOFA Score

Quick Sequential Organ Failure Assessment (qSOFA) score is a simple score consisting of three items: respiratory rate (RR) ≥ 22 breaths per minute, altered mentation (Glasgow Coma Scale [GCS] < 15), and systolic blood pressure (SBP) < 100 mmHg. A qSOFA score ≥ 2 was found to be significantly predictive of increased all-cause mortality in patients outside of the ICU [12, 14]

6. her Uses of predictive scoring systems

Apart from the clinical uses describe able, predictive scoring systems do play a role in other aspects of medicine. Two key areas include its role during research and as a quality care benchmark tool [14].

6.1. Research

Scoring systems may be used in clinical trials to compare the baseline risks between comparative groups to ensure that they are similar. This is commonly used during clinical trials in patients with acute respiratory distress syndrome or sepsis whereby possible therapeutic interventions are being evaluated [14].

6.2. Quality care benchmark

Predictive scoring systems help evaluate the quality of care by confirming that patients with the same or similar baseline mortality risks are being compared. An example of such practices are studies that compare ICU outcomes with other ICU within the same hospital or in other hospitals. The implications of such findings are that policies and practices from ICU with favorable mortality rates may then be adopted and incorporated by other units to help improve their quality or care [14].

7. Limitations

ICU is the perfect environment for using predictive scoring systems since both the population group and patient care tends to be is well defined and the most significant predictor of mortality is the severity of the illness [15]. However, there are some limitations with regards to their use as follows:

- The scoring system may not be validated in the population group that it is being used to evaluate [15].
- The predictiveness of the scoring system deteriorates over time and as such, failure to periodically update the system results in a gradual loss of discrimination and/or calibration [16].
- The quality of care is better or worse than expected resulting in a lower or higher patient mortality rate[16]
- When predicting mortality within 24 hours of admission into the ICU, the current evidence suggests that scoring systems are not yet superior to clinical judgment [16].

Conclusion

Severity scores are widely used in the ICU to assess resource use, predict outcome, and characterize disease severity and degree of organ dysfunction. All the scores were developed to be used in mixed groups of ICU patients and their accuracy in subgroups of patients can be questioned; disease-specific scoring systems are increasingly being developed. As ICU

populations change and new diagnostic, therapeutic and prognostic techniques become available, all the scoring systems will need to be updated.

Importantly, the different scoring systems have different purposes and measure different parameters; we believe they should be seen as complementing each other, rather than competing with one another. For example, outcome prediction models cannot be used to assess the severity of individual organ dysfunctions or to monitor patient progress over time.

The workload scores complete the picture by offering information on how the patient's disease will impact on staffing requirement and resource use. We envisage that, increasingly, all patients will be initially evaluated using a general outcome prediction model computed on admission or within the first 24 hours, then by repeated organ failure (for example, SOFA) and nursing workload cores during their ICU stay. When used together, these three approaches could provide a more accurate indication of disease severity and prognosis, which could be of help both to the clinician in charge of the patient and to the manager involved in resource allocation and performance assessment.

Conversely, as scoring systems allow for an objective assessment of the clinical status of the patient, they may be used to assist the clinical decision-making since they mirror the probability of mortality in a similar cohort of patients. Ultimately, predictive scoring systems should be considered as a tool to assist, rather than replace the clinician.

References

1. Richter S, Stevenson S, Newman T, Wilson L, Menon DK, Maas AIR. Handling of missing outcome data in traumatic brain injury research: A systematic review. Journal of Cardiothoracic Surgery, 8(3):75-79.
2. Sadaka F, Ethmaneabouelmaali C, Cytron MA, Fowler K, Javaux VM & O'brien J (2017): Predicting Mortality of Patients With Sepsis: A Comparison of APACHE II and APACHE III Scoring Systems. Journal of Clinical Medicine Research, 7(2):85-89.
3. Sendagire C, Lipnick MS, Kizito S, Kruisselbrink R, Obua D, Ejoku J, et al. (2017): Feasibility of the modified sequential organ function assessment score in a resource-constrained setting: A prospective observational study. BMC Anesthesiology, 6(2):74-86.
4. Singer M, Deutschman CS, Seymour C, Shankar-Hari M, Annane D, Bauer M, et al. (2016): The third international consensus definitions for sepsis and septic shock (sepsis-3). Academic Emergency Medicine, 23(9):115-124.
5. Tee YS, Fang HY, Kuo IM, Lin YS, Huang SF & Yu MC (2018): Serial evaluation of the SOFA score is reliable for predicting mortality in acute severe pancreatitis. Medicine (United States), 7(2):85-94.
6. Vincent JL, Takala J, Moreno RP, Sakr Y & Marshall JC (2016): The richmond agitation-sedation scale should not be used to evaluate neurologic function. Intensive Care Medicine, 65(3):74-82.
7. Naqvi IH, Mahmood K, Ziaullaha S, Kashif SM & Sharif A (2016): Better prognostic marker in ICU - APACHE II, SOFA OR SAP II! Pakistan Journal of Medical Sciences, 7(2):97-106.
8. Rahmatinejad Z, Tohidinezhad F, Reihani H, Rahmatinejad F, Pourmand A, Abu-Hanna A, et al. (2020): Prognostic utilization of models based on the APACHE II, APACHE IV, and SAPS II scores for predicting in-hospital mortality in emergency department. The American Journal of Emergency Medicine.38(9):1841-6.
9. Bennett CE, Wright RS, Jentzer J, Gajic O, Murphree DH, Murphy JG, et al. (2019): Severity of illness assessment with application of the APACHE IV predicted mortality and outcome trends analysis in anacademic cardiac intensive care unit. Journal of critical care. 50:242-6.

10. Lee H, Shon YJ, Kim H, Paik H, Park HP (2014): Validation of the APACHE IV model and its comparison with the APACHE II, SAPS 3, and Korean SAPS 3 models for the prediction of hospital mortality in a Korean surgical intensive care unit. Korean journal of anesthesiology. 67(2):115-22.

11. Sakr Y, Krauss C, Amaral AC, Rea-Neto A, Specht M, Reinhart K, et al. (2008): Comparison of the performance of SAPS II, SAPS 3, APACHE II, and their customized prognostic models in a surgical intensive care unit. British journal of anaesthesia. 101(6):798-803.

12. Hwang SY, Lee JH, Lee YH, Hong CK, Sung AJ, Choi YC (2012): Comparison of the Sequential Organ Failure Assessment, Acute Physiology and Chronic Health Evaluation II scoring system, and Trauma and Injury Severity Score method for predicting the outcomes of intensive care unit trauma patients. The American journal of emergency medicine. 30(5):749-53.

13. Ma QB, Fu YW, Feng L, Zhai QR, Liang Y, Wu M, et al. (2017): Performance of simplified acute physiology score 3 in predicting hospital mortality in emergency intensive care unit. Chinese Medical Journal. 130(13):1544-51.

14. El-Naggar TA, Raafat RH, Mohamed SA (2018): Validity of three scoring systems in assessing the severity and outcome in Al- Abbassia Chest Hospital Respiratory Intensive Care Unit patients. Egyptian Journal of Bronchology. 12(2):208-17.

15. Mansour M, Galal I, Kassem E (2013): Study of the role of different severity scores in respiratory ICU. Egyptian Journal of Bronchology. 7(2):55-9.

16. Lambden S, Laterre PF, Levy MM & Francois B (2019): The SOFA score - Development, utility and challenges of accurate assessment in clinical trials. New England Journal of Medicine, 12(6): 75-79.