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ORIGINAL RESEARCH

How to score acute pancreatitis in the emergency setting: five systems against ED-SAS

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Abstract

To assess the effectiveness of a new scale known as "*Emergency department SpO2* (*peripheral capillary oxygen saturation*), *age*, *and SIRS* (*Systemic inflammatory response syndrome*)" (ED-SAS) that can be used to predict prognosis within 24 hours following presentation compatible with acute pancreatitis in patients admitted to the emergency department. This research project was conducted as a single-center, retrospective, cohort study. The Acute Physiology and Chronic Health Evaluation II (APACHE II), SIRS, Bedside Index for Severity in Acute Pancreatitis (BISAP), ED-SAS, modified Glasgow Scale and Ranson criteria scoring of the patients were evaluated using their presentation data screened from the hospital automation system. Then, the efficiencies of these evaluation systems were compared using the receiving operating curve (ROC). The conformity of the data to the normal distribution was checked with the Kolmogorov-Smirnov test. The ROC analyses were employed to identify the cut-off values of the scoring systems in calculating death rates. The method developed by DeLong *et al*. was used to compare the ROC curves of the scoring systems. The study has been completed with 235 patients, 91 (38.7%) male and 144 (61.3%) female, with a mean age of 63.1 $\pm$ 17.7 years. In the ROC analysis of the ED-SAS evaluation tool to predict death rates, the area under the curve (AUC) value was found to be 0.85 (95% confidence interval: 0.79–0.89), and the Youden index was 0.62, with a p value of 0.001. Mortality prediction with ED-SAS significantly differed compared to the Ranson and SIRS scoring systems (P = 0.001 and P = 0.03, respectively). However, no statistically significant difference was found in the comparison of the ED-SAS score with the modified Glasgow and APACHE II scores (P = 0.12 and P = 0.54, respectively). It was concluded that the Baseband ED-SAS scores provided equally significant results in terms of AUC at the 95% confidence interval (P = 0.05). Statistical analyses revealed that the APACHE II, SIRS, BISAP, modified Glasgow and ED-SAS scores were found to be significantly higher among the dead in comparison to the survivors ($P < 0.05$). ED-SAS constitutes a simple, fast, expedient and effective evaluation system that can be utilized to predict mortality in acute pancreatitis in the emergency setting.

Keywords

Acute pancreatitis; Predictive scores; Emergency department

1. Introduction

Acute inflammatory disease of the pancreatic tissue with a typical sudden-onset abdominal pain is referred to as acute pancreatitis (AP) [1]. It ranks first among the causes of admission to hospital due to gastrointestinal (GI) entities [2]. The clinical presentation of AP can vary from one person to another [3]. Although parenteral intravenous fluid, analgesic and supportive treatment are sufficient in 65–85% of patients, serious clinical course of AP may be encountered in 20–30% of the patients [1, 4, 5].

In AP, events starting from responses relating to acute inflammation and progressing to systemic inflammatory response syndrome (SIRS), multiorgan dysfunctions, necrosis of the pancreatic tissue and sudden cardiac arrest are the main determinants of mortality and also considered to indicate the severe form of the disease according to the current classifications [6–10]. Although the mortality rate is 3–10% in general, it can reach 36–50% in severe cases [8, 10, 11]. This group with high mortality rates can benefit from interventional procedures, such as aggressive fluid resuscitation, close monitoring, appropriate antibiotic use, and endoscopic sphincterotomy [3]. In this regard, the early recognition of severe AP can contribute to reduction of the mortality and morbidity rates associated with the disease. However, this is difficult to achieve due to the limitations of

available prognostic tools [12].

There are several scoring systems employed in the early identification of patients with AP. In particular, the Ranson Criteria and Acute Physiology and Chronic Health Evaluation-II (APACHE II) systems have been utilized for many years to estimate the outcome of AP [13, 14]. However, it has been shown that these multi-factor, complex scoring systems have high negative predictive and average sensitivity values [9, 15–17]. Other scoring methods used for this purpose include the Bedside Index for Severity in Acute Pancreatitis (BISAP), modified Glasgow, and SIRS. The modified Glasgow and Ranson scores include a larger extent of biochemical parameters obtained within the first 48-hour period following the onset of signs and symptoms [18, 19]. The remaining scoring systems mentioned use parameters evaluated within the first 24 hours.

In the International Conference of the American Pancreatic Association in 2013, SIRS was accepted as an effective system for the evaluation and estimation of the clinical outcome of AP [20]. Some studies have shown that especially the first 24-hour period after symptomatology is critical for identifying those patients carrying greater likelihood to develop untoward events and/or mortality [4, 21]. In light of this information, in previous studies, the ED-SAS scoring system was derived from simple variables, namely SIRS criteria, age and oxygen saturation levels evaluated in the emergency department in the 24 hours following manifestations [22–24].

The objectives of the current study were to analyze the efficacy of the ED-SAS score in predicting 30-day mortality within the first day after initial manifestations in patients with a diagnosis of AP in the emergency department. The secondary aim was to compare ED-SAS with other scoring systems used for this purpose.

2. Materials and methods

2.1 Design

The study is designed as a single-center, retrospective, observational cohort and conducted between January 2015 and December 2020 with patients admitted to the emergency department of Kartal Dr. Lutfi Kirdar City Hospital and admitted with a diagnosis of AP. Ethical approval of the study was recorded by the Institutional Review Board of the hospital (decision number: 514/192/27 date: 30.12.2020).

2.2 Participants

Patients who presented to the emergency department within six-years period (between January 2015 and December 2020) and were hospitalized due to AP in accord with the International Classification of Diseases (ICD) (9th revision, code 577.0 or 10th revision, code K 85) were sought and abstracted from the hospital automation system. Among these patients, those who fulfilled two or more of the criteria according to the current guidelines of the American College of Gastroenterology [7] were enrolled to the sample: (1) typical epigastric pain in the back (radiating), (2) elevation of relevant serine enzymes levels (i.e., lipase or amylase) by at least three times upper normal limits, and (3) typical findings on abdominal computed tomography (CT) (pancreatic edema, necrosis, etc.). The other inclusion criteria of the study were the management processes initiated in the emergency department and age over 18 years. Pregnant women, patients with chronic pancreatitis, those under the age of 18 years, those with a history of pancreatic surgery, and those whose data could not be accessed from the hospital automation system were excluded from the study using the complete case analysis method.

2.3 Data collection and processing

Patients admitted to the community-based hospital emergency department and were registered with the K.85 ICD code (acute pancreatitis) and subcodes between January 2015 and December 2020 were identified using the hospital automation system. The demographic features, clinical complaints, vital signs, and findings on physical examination, laboratory and radiological work up of the patients on admission were recorded and analyzed in detail.

All the CT images were assessed and rated by two experienced radiology specialists blinded to the clinical and laboratory findings of the patients. Similar to previous studies, the APACHE II, SIRS, BISAP and ED-SAS scoring points were recorded based on the evaluation within the first 24 hours, while the first 48-hour data were used in the calculation of the Ranson criteria and modified Glasgow scores (Table 1, Ref. [1–5, 7]) [9, 25].

While calculating the scores, detection of shock that is, systolic blood pressure reading below 90 mmHg, PaO_2 <60 mmHg or need for mechanical ventilation and/or renal failure (creatinine value >2 mg/dL after hemodialysis or hydration) has been evaluated to indicate organ failure, as previously described in the literature [9]. All scores except ED-SAS were calculated via MedCalc 12.3.0.0 for Windows (MedCalc Software, Mariakerke, Belgium). Since the ED-SAS score is not included in this software, it was manually calculated for each patient individually.

2.4 Endpoints/outcome measures of the study

The primary endpoint was the efficacy of ED-SAS in predicting 30-day mortality in AP. The secondary outcome was the comparison of the efficacy of the ED-SAS scoring system with the others.

2.5 Statistical analysis

Statistical analyses were conducted via SPSS 15.0 (IBM Corp., Chicago, IL, USA) for Windows and MedCalc 12.3.0.0 for Windows (MedCalc Software, Mariakerke, Belgium). Descriptive statistics were presented as mean and standard deviation, median, range (minimum and maximum values), and percentages. The conformity of the data to the normal distribution was sought with the Kolmogorov-Smirnov method. The receiver operating characteristic (ROC) analysis was used to identify the cut-off levels of the risk scores in estimating death rates. The methodology launched by DeLong *et al.* [22] was employed to compare the ROC curves of the risk scores. The significance level was taken as $P < 0.05$. The statistical power of the research was calculated from

TABLE 1. Parameters used in the scoring systems.

APACHE II [1, 2]	Ranson [3, 4]	Modified Glasgow [3, 5]	SIRS	BISAP	ED-SAS[7]
Age >45 yrs	Age >55 yrs	Age >55 yrs	Respiratory rate >20 or $PaCO_2$ <32 mm Hg	Age >60 yrs	Age >60 yrs
WBC <3000 or >14,900/mm^3	WBC >16,000/mm^3	WBC >15,000/mm^3	WBC >12,000/mm^3, <4000/mm^3, or >10% bands	**≥2 SIRS criteria**	**≥2 SIRS criteria**
Temp <36 °C or >38.4 °C	Glucose >200 mg/dL	Glucose >180 mg/dL	Temp >38 °C (100.4 °F) or <36 °C (96.8 °F)	Impaired mental status defined as disorientation, lethargy, somnolence, coma, or stupor	SpO_2 <96%
MAP <70 or Hg >109 mm	LDH >350 IU/mL	LDH >600 IU/mL	HR > 90	Pleural effusion present	
HR <70 or >109 bpm	AST >250 IU/L	AST >100 IU/L		BUN >25 mg/dL (8.92 mmol/L)	
RR <12 or >24 bpm	Hct decrease >10	Albumin <3.2 g/dL			
pH <7.33 or >7.49	BUN increase >5 mg/dL	BUN >96 mg/dL			
Na_ <130 or >149 mm	Calcium <8 mg/dL	Calcium <8 g/dL			
K <3.5 or >5.4 mm	PO_2 <60 mm Hg	PO_2 <60 mm Hg			
PO_2 <70 or >200 mm Hg	Base deficit >4 mEq/L				
Creatinine <0.6 or >1.4 mg/100 mL	Fluid sequestration >6 L				
Hct <30% or >45.9%					
GCS					
Chronic Health Points					

APACHEII, Acute Physiology and Chronic Health Evaluation II score; SIRS, Systemic inflammatory response syndrome; BISAP, Bedside Index for Severity in Acute Pancreatitis; ED-SAS, Emergency department SpO_2, age, and SIRS; WBC, White blood cell count; LDH, Lactate Dehydrogenase; AST, Aspartate Transaminase; Hct, Hematocrit; BUN, Blood urea nitrogen; PO_2, arterial partial pressure of oxygen; $PaCO_2$, arterial partial pressure of carbon dioxide; SpO_2, peripheral capillary oxygen saturation; MAP, Mean Arterial Pressure; HR, Heart Rate; bpm, beats per minute; Na, Sodium; K, Potassium; GCS, Glasgow Coma Score; RR, Respiratory Rate; mM, Millimolar.

http://biostatapps.inonu.edu.tr/WSSPAS/. To describe the power for the ROC analysis of the ED-SAS score, the power (1-beta) of the study was calculated as 69% with a type I error (alpha) of 0.05, single-group sample size of 22, and margin of error of 0.16. In the power analysis for the ROC analysis of the APACHE II score, the power (1-beta) of the study was calculated as 100% with 0.05 type I error (alpha), single-group sample size of 22, and 0.96 margin of error.

3. Results

The search in the hospital automation system yielded, 244 patients with AP within the study period. Two (0.8%) patients whose data were incomplete and seven (2.8%) who had been transferred to another hospital were incomplete data in the follow-up and were not included in the research analyses. Thus, the study was completed with 235 patients.

Ninety (38.7%) patients were men and mean age was 63.1 ± 17.7 years. On presentation, the mean systolic blood pressure of the patients was 133.2 ± 18.5 mmHg, diastolic blood pressure was 78.3 ± 10.7 mmHg, mean arterial pressure was 96.6 ± 11.7 mmHg, heart rate was 78.7 ± 12.4 beats per minute, fever was 36.4 ± 0.8 Centigrade Celsius., oxygen saturation was 96.5% ± 2.5 at room air, and respiratory rate was 15.4 ± 3.7 breaths per minute. The mean length of hospital stay was 7.8 ± 7.2 days. Twenty-two (9.4%) patients died. The underlying etiology was identified as biliary pancreatitis in 109 (46.4%) patients, hyperlipidemia-associated AP in 14 (6.0%), alcoholic pancreatitis in eight (3.4%), drug-associated pancreatitis in two (0.9%), and tumor-associated pancreatitis in five (2.1%), while 93 (39.6%) patients had idiopathic pancreatitis. On CT, pancreatic edema was detected in 12 (5.1%) patients, pancreatic necrosis in two (0.9%), and rectovesical fluid collection in seven (3%).

In the ROC analysis of the ED-SAS scoring system to predict death rates, the area under the curve (AUC) was 0.85 (95% CI: 0.79–0.89), and the Youden index was 0.62, with a p value of 0.001 (Fig. 1). Statistical analyses revealed that the ED-SAS score was statistically significant in predicting mortality after being diagnosed with AP (P = 0.001). When the cut-off level of the ED-SAS score in determining mortality was taken as 1, the sensitivity of the score was 63.6%, while its specificity was 98.1%, positive predictive value was 77.8%, and negative predictive value was 96.3%.

When the survivor and non-survivor groups were compared by using the ROC curves, it determined the highest sensitivity and specificity values at a cut-off value of ≥8 for APACHE II, ≥1 for SIRS, ≥1 for BISAP, ≥2 for ED-SAS, ≥3 for modified Glasgow, and ≥3 for Ranson scoring systems. The statistical analysis showed that the APACHE II, SIRS, BISAP, modified Glasgow and ED-SAS scores were statistically significantly higher in non-survivors compared to the survivors (Table 2).

Findings of the ROC analysis performed on all scores are summarized in Table 3. When the ROC analysis results of the scores were compared with each other in terms of differences in the AUC values (Table 4, Ref. [26], Fig. 2), it was observed that mortality prediction with the ED-SAS score statistically significantly higher compared to the Ranson and SIRS scores (P = 0.001 and P = 0.03, respectively). However, statistically significance was not found in the comparison of the ED-SAS score with the modified Glasgow and APACHE II scores (P = 0.12 and P = 0.54, respectively). It was concluded that the BISAP and ED-SAS scores provided equally significant results in terms of AUC values at the 95% confidence interval (P = 0.05).

4. Discussion

Nowadays, AP carries an increasing global prevalence [20]. The diagnosis of the disease is often established in emergency departments. In literature, there are many evaluation systems devised to predict the clinical course of AP but each has their own limitations [3, 9, 18]. APACHE II, Ranson, and BISAP are among the most frequently used evaluation systems [27], which are widely employed to predict death resulting from AP. However, since these scoring systems were not devised to be used in the emergency department, they require data that cannot be rapidly obtained in this setting [22, 27].

APACHE II is a system for assessment for the prediction of severe disease in general, which covers many parameters, including blood gas and electrolyte levels [14]. There are several disadvantages of the Ranson scoring system. For example, the evaluation takes 48 hours to complete, it includes variables which are not routinely worked up in daily practice, and it can result in a waste/loss of valuable early therapeutic window. Similar to the results of the present study, the Ranson score was found to be a poor predictor in a previous meta-analysis [28].

The modified Glasgow score based on laboratory parameters and age is also used to predict mortality in AP [29]. The evaluation of data within the first 48 hours and the large number of variables are important limitations of this scoring system in practical use.

It is known that presence of SIRS criteria has an effect on the outcome in AP [20]. SIRS is one of the early predictors of severe AP, and there are studies showing that patients presenting with SIRS on the first day of manifestations experience more severe AP [13, 20, 22, 30]. However, the SIRS score significantly increases with the increasing age. This may cause the overestimation of the grave outcome of the disease in the advanced age group. The BISAP scoring system was designed by adding age over 60 years, pleural effusion, renal damage, and impaired mental status to the SIRS

BISAP is reported to have a specificity and sensitivity of 70% in various studies because it contains additional parameters that are not frequently observed [31]. It is easier to calculate compared to the APACHE II and Ranson criteria [32].

Various research demonstrated that the BISAP score has similar performance to APACHE II in the prediction of outcome in AP [27]. It is also much easier to calculate than the APACHE II system. In those with AP, a finding that is less well-known than SIRS is arterial hypoxia that develops due to respiratory damage caused by the inflammatory response associated with the disease [33]. Respiratory damage is frequently encountered in AP cases resulting in mortality [33].

Recently, the ED-SAS score was created by adding advanced age and hypoxia to the SIRS criteria [20]. This is a simple scoring system designed to predict the clinical course

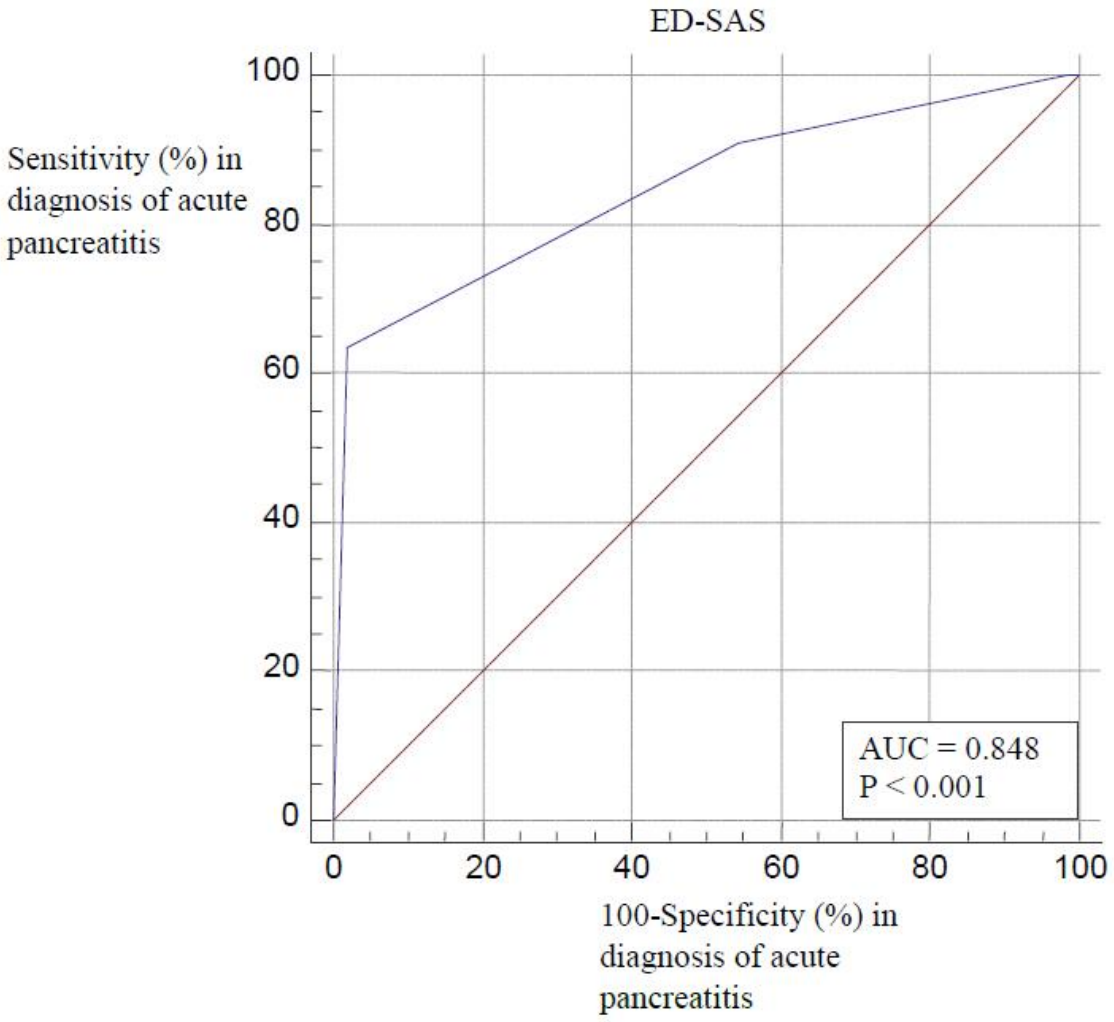

FIGURE 1. Receiver-operating characteristic curve, sensitivity and specifity of ED-SAS scoring system for mortality prediction in acute pancreatitis.
ED-SAS, Emergency department SpO_2, age, and SIRS.

TABLE 2. Comparison of the scores between the survivors and non-survivors.

	Survivor	Non-survivor	*P* value
	Median (Range)	Median (Range)	
APACHEII	8 (0–17)	13 (3–19)	0.001[a]
SIRS	0 (0–4)	2.5 (1–3)	0.001[a]
ED-SAS	2 (0–3)	3 (1–3)	0.001[a]
BISAP	1 (0–3)	2 (1–5)	0.001[a]
Ranson	3 (0–6)	3 (2–5)	0.080[a]
Modified Glasgow	3 (0–5)	4 (2–6)	0.001[a]

APACHEII, Acute Physiology and Chronic Health Evaluation II score; SIRS, Systemic inflammatory response syndrome; ED-SAS, Emergency department SpO2, age, and SIRS; BISAP, Bedside Index for Severity in Acute Pancreatitis.
[a]*Mann-Whitney U test.*

of patients on the first admission. This allows for different or more aggressive approaches to be considered when planning the treatment modalities of patients diagnosed during the initial presentation. A strong feature of ED-SAS is that it is calculated based on parameters that can be easily obtained for each patient and does not contain specific findings [22].

The present study investigated the efficacy of the APACHE II, Ranson, Modified Glasgow, SIRS, BISAP, and ED-SAS scoring systems in patients with AP. Among these, APACHE II, SIRS, BISAP, modified Glasgow and ED-SAS significantly predicted mortality in these patients. However, there were some difficulties due to the large dataset required by APACHE

TABLE 3. ROC analysis results of the scores.

	Cut-Off	Time	AUC	SE	95% CI
APACHE II	≥**8**	24 h	0.808	0.06	0.75–0.86
Ranson	≥**3**	48 h	0.605	0.06	0.54–0.67
Modified Glasgow	≥**3**	48 h	0.757	0.05	0.69–0.81
SIRS	≥**1**	24 h	0.959	0.02	0.93–0.98
BISAP	≥**1**	24 h	0.943	0.02	0.91–0.97
ED-SAS	≥**2**	24 h	0.848	0.05	0.79–0.89

AUC, Area Under the Curve; SE, Standard Error; CI, Confidential Interval; APACHEII, Acute Physiology and Chronic Health Evaluation II score; BISAP, Bedside Index for Severity in Acute Pancreatitis; SIRS, Systemic Inflammatory Response Syndrome; ED-SAS, Emergency department SpO_2, age, and SIRS.

TABLE 4. Comparison of the ROC analysis results of the scores.

		APACHE II	Ranson	Modified Glasgow	SIRS	BISAP	ED-SAS
APACHE II	AUC difference	0	0.203	0.051	0.151	0.135	0.040
	P-value		0.002	0.370	0.005	0.004	0.540
Ranson	AUC difference		0	0.152	0.354	0.338	0.243
	P-value			0.004	0.001	0.001	0.001
Modified Glasgow	AUC difference			0	0.202	0.186	0.090
	P-value				0.001	0.001	0.120
SIRS	AUC difference				0	0.016	0.112
	P-value					0.520	0.030
BISAP	AUC difference					0	0.096
	P-value						0.050
ED-SAS	AUC difference						0
	P-value						

Method described by DeLong et al. [26] was used for the comparison. ROC, Receiver Operating Characteristic Curve; APACHEII, Acute Physiology and Chronic Health Evaluation II score; BISAP, Bedside Index for Severity in Acute Pancreatitis; SIRS, Systemic inflammatory response syndrome; ED-SAS, Emergency department SpO_2, age, and SIRS.

II and the evaluation covering the first 48 hours for the Ranson and Modified Glasgow Scoring systems.

The BISAP and ED-SAS scores can be easily calculated with parameters evaluated in the emergency department and they both focus on the presence of SIRS and lung injury. In our study, both systems are successful in prediction of short-term death rates in the emergency department. When the efficacy of these two systems which are used in the emergency department compared for the prediction of mortality, it has been determined that BISAP conveyed a sensitivity of 95.5% and a specificity of 87.8%, respectively, and ED-SAS had a sensitivity and specificity of 63.6% and 98.1%, respectively. We also postulate that BISAP had higher sensitivity but lower specificity since it contains less observed findings, such as pleural effusion and impaired mental status, while ED-SAS was more specific but less sensitive because it includes the saturation measurement criterion, which is a more general measurement.

BISAP and ED-SAS were compared in terms of their efficacy in predicting mortality, which revealed no significant difference in the AUC values. According to the results of this study, the ED-SAS score can also be used to predict mortality similar to BISAP in the emergency department.

5. Limitations

The main limitations of the present study are that it was retrospective and conducted with a limited population presenting to a single center. In particular, the low number of patients in whom the primary outcome (death) occurred was an important limitation in the assessment of the efficacy of these systems. Multicenter, prospective, population-based studies to be conducted with larger samples can yield more reliable results.

6. Conclusions

Although ED-SAS offers similar results to the classical scoring systems in terms of sensitivity and specificity, it is a fast,

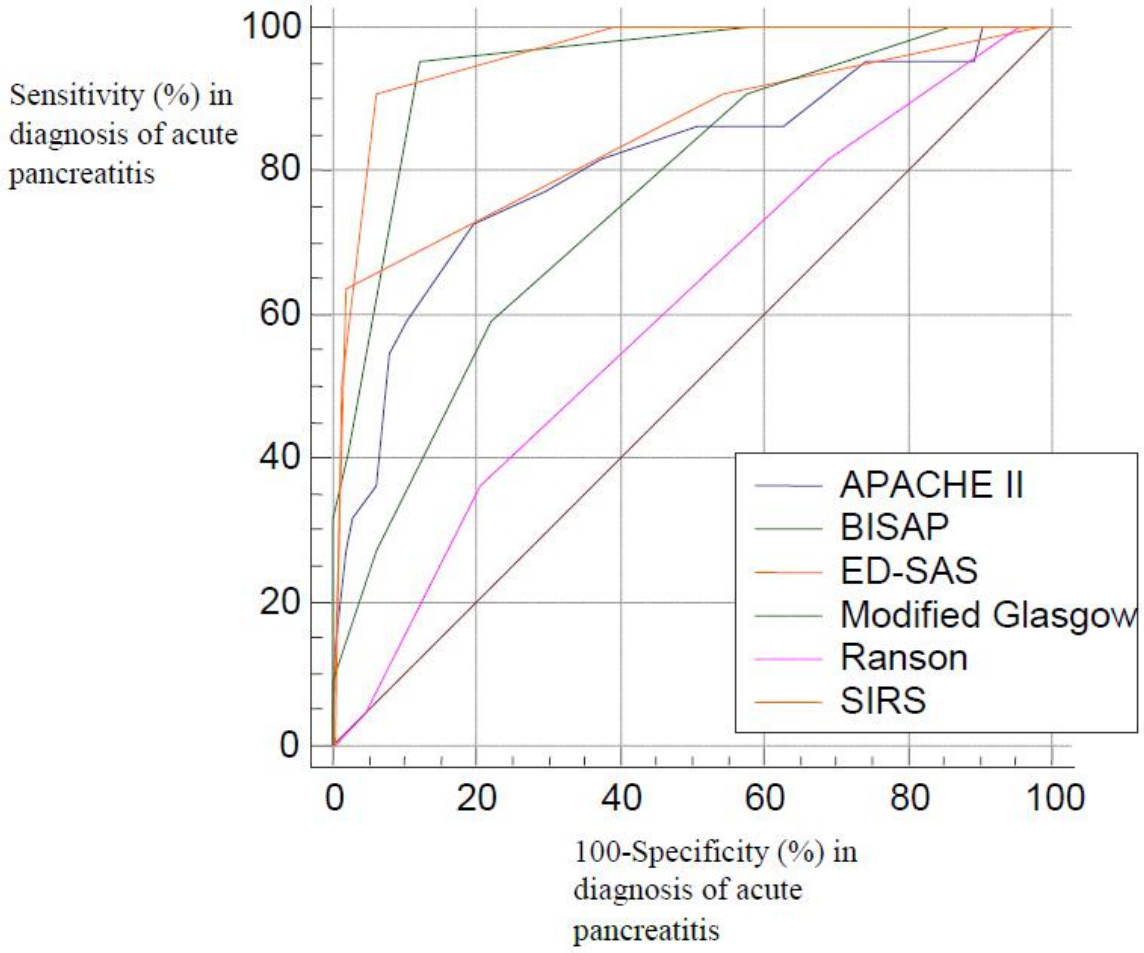

FIGURE 2. Area under the Receiver-operating curves of different scoring systems in prediction of mortality in acute pancreatitis.
APACHEII, Acute Physiology and Chronic Health Evaluation II score; BISAP, Bedside Index for Severity in Acute Pancreatitis; SIRS, Systemic inflammatory response syndrome; ED-SAS, Emergency department SpO_2, age, and SIRS.

simple and effective method that can be easily used in the emergency setting in the management of AP within the first 24 hours of admission.

AUTHOR CONTRIBUTIONS

Conceptualization: MÖE, NMH; Methodology: MÖE, NMH; Data curation: MÖE; Formal analysis: MÖE; Writing original draft preparation: MÖE, NMH; Writing — Reviewing and Editing: NMH; Supervision: MÖE.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Approval for the study was obtained from the local ethics committee of the Kartal Dr. Lutfi Kırdar City Hospital (decision number: 514/192/27 date: 30.12.2020).

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

DATA AVAILABILITY

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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