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Predictive value of outcome scores in patients suffering from cardiogenic shock complicating AMI

APACHE II, APACHE III, Elebute–Stoner, SOFA, and SAPS II

Abbreviations

AMI	Acute myocardial infarction
APACHE II/III	Acute Physiology and Chronic Health Evaluation II/III
AUC	Area under the curve
BMI	Body mass index
CI	Cardiac index
CPR	Cardiopulmonary resuscitation
CS	Cardiogenic shock
IABP	Intra-aortic balloon pump
IRA	Infarct-related artery
ICU	Intensive care unit
MAP	Mean arterial pressure
PCI	Percutaneous coronary intervention
PTCA	Percutaneous transluminal coronary angioplasty
ROC	Receiver operating characteristic
SAPS II score	Simplified Acute Physiology Score II
SIRS	Systemic Inflammatory Response Syndrome
SOFA	Sepsis-related Organ Failure Assessment
STEMI/NSTEMI	ST elevation/non-ST elevation myocardial infarction

Acute myocardial infarction (AMI) is complicated by cardiogenic shock (CS) in 7–10% of cases and the mortality rate is about 60–70% [13, 16]. Early revascularization by percutaneous coronary intervention (PCI) and intensive care including positive inotropic agents, vasopressors, and circulatory assist devices are routinely used to improve cardiac output and to prevent multiorgan failure [1, 5, 16]. Intra-aortic balloon pump (IABP) is a commonly used mechanical support system for patients with CS [25, 33]. Despite intensive therapy, these patients often develop a systemic inflammatory response syndrome (SIRS) progressing to multiple organ dysfunction syndrome (MODS) and subsequent death due to multiple organ failure [6, 39]. Identification of these patients in the ICU is clinically important [34]. Previous studies of patients with MODS or sepsis have shown the relevance of several scoring systems such as the APACHE II [22, 42, 43], APACHE III [23], Elebute–Stoner [9], SOFA [40], and SAPS II [24] as predictors of prognosis [41]. The APACHE II score was primarily designed to predict the mortality of patients in ICUs, but attempts have been made to apply this score to patients with severe trauma [37], abdominal complications [4], chronic obstructive pulmonary disease [12], acute pancreatitis [10], sepsis [42], and escalating SIRS after cardiac surgery [43]. The APACHE III score can describe severity in more detail, but its cal-

Tab. 1 Inclusion and exclusion criteria

Inclusion criteria	
Diagnosis of AMI	Symptoms >30 min
	ECG ST-segment elevation in 2 or more contiguous leads, new left bundle branch block, new pathological Q waves
	Serum creatinine kinase activity increase to ≥2.85 µmol/l*s and/or elevation in troponin I to >0.5 ng/ml or, finally, radiographic evidence of acute coronary artery occlusion on coronary angiography
Diagnosis of CS	Symptoms and signs of organ hypoperfusion (e.g., cool peripheries, oliguria)
	AND
	Systolic blood pressure ≤90 mmHg for at least 30 min or
	Hypotension requiring inotropic/vasopressor therapy at a heart rate of ≥60 beats/min or
	A cardiac index of ≤2.2 l/min/m^2 on invasive monitoring
Age >18 years	
Exclusion criteria	
Mechanical complications of AMI	Acute, severe mitral valve insufficiency, an ischemic ventricular septal defect, or hemodynamically relevant aortic valve insufficiency

AMI acute myocardial infarction, *ECG* electrocardiography, *CS* cardiogenic shock

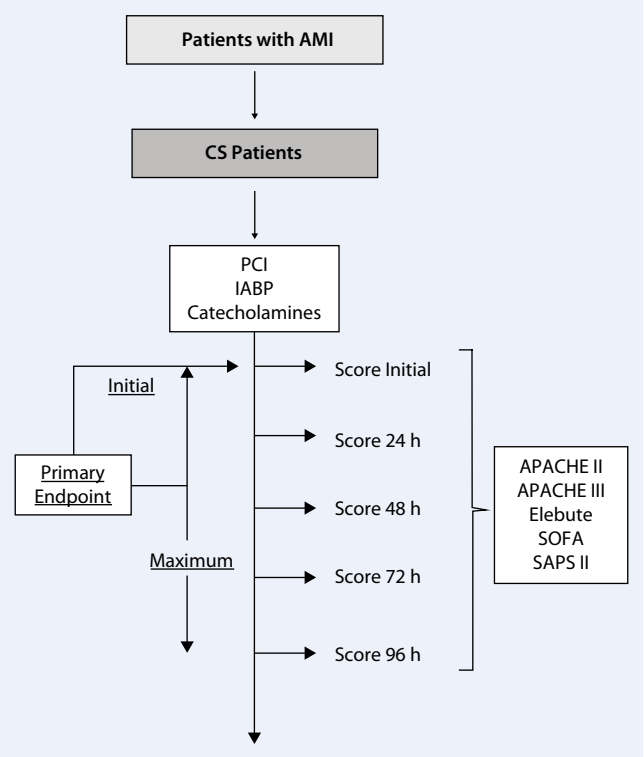

Fig. 1 ◀ Flowchart of the study. *AMI* acute myocardial infarction, *CS* cardiogenic shock, *PCI* percutaneous coronary intervention, *IABP* intra-aortic balloon pump

culation is more complex and laborious. However, a scoring system is only valid for a special group of patients when it has been validated on this group. The objective of the present study was to evaluate the predictive value of the APACHE II, APACHE III, Elebute–Stoner, SOFA, and SAPS II scores on mortality, determined on the day of diagnosis/admission of infarction-related CS patients and at the point of maximum value.

Methods

Inclusion and exclusion criteria

Patients treated with primary PCI for CS secondary to AMI, who required inotropic and/or vasopressor support despite appropriate volume filling, were included in the study. For the diagnosis of CS, the definitions of Hochman et al. [16] and Reynolds et al. [36] were used. The inclusion and exclusion criteria are shown in **Tab. 1**.

Study design

In this prospective observational study, carried out in a medical intensive care unit of a university hospital from 2004 to 2005, we consecutively enrolled 45 patients in CS. Patients underwent regular clinical assessment, complete invasive monitoring, and frequent blood sampling for laboratory markers. Datasets for the APACHE II, APACHE III, Elebute–Stoner, SOFA, and SAPS II scores and for the patient parameters were calculated. Written informed consent was obtained from all patients or their relatives. The trial was approved by the local ethics committee.

Primary endpoints

The primary endpoint was the value of the initial and the maximum value of the APACHE II, APACHE III, Elebute–Stoner, SOFA, and SAPS II scores in predicting mortality. Scores were collected at enrollment and then daily for 4 days. Demographic data, admission diagnosis, mechanical ventilation, IABP use, hemodynamic parameters, survivors, and nonsurvivors were recorded. The APACHE II, APACHE III, Elebute–Stoner, SOFA, and SAPS II scores were determined by the worst value found during the initial 24 h after ICU admission and also by the maximum value during the following 96 h.

A flowchart of the study is shown in **Fig. 1**.

Coronary angiography and PCI

Coronary angiography and PCI were performed using standard techniques immediately after admission. At the commencement of PCI, all patients were given acetylsalicylic acid (250 mg i.v.), glycoprotein-IIb-/IIIa-receptor blocker (weight adjusted, i.v. abciximab or tirofiban) for 12–24 h, and heparin, 5,000–10,000 U i.v. bolus, followed by continuous infusion to maintain an activated partial thromboplastin time of two to three times the normal value.

Intra-aortic balloon pump

A 40-cc balloon IABP (IABP System 97, Datacope; Fairfield, NJ, USA,) was inserted when necessary (cardiologist's discretion) via the femoral artery using an 8-French sheath immediately after PCI. Aortic counterpulsation was continued for a minimum of 48 h.

Statistical analysis

Quantitative values such as age or body mass index (BMI) and the different scoring systems were tested on normal distribution with the Kolomogrov–Smirnov test and the Shapiro–Wilk test. Differences in parametric values were tested with Student's t test. Categorical variables were compared by the chi-squared test. Some continuous variables (APACHE II, SOFA) were categorized into classes by selecting the best cut-offs (receiver operating characteristic analysis, ROC). Discrimination was tested using the ROC curves and by evaluating areas under the curve (AUC) [14]. According to Hosmer and Lemeshow, AUCs between 0.7 and 0.8 were classified as"acceptable" and between 0.8 and 0.9 as"excellent" [18].

For the different scoring systems and time-points tested, the sensitivity and specificity values were calculated and cut-off points giving the best sensitivity and specificity for mortality were determined. Each variable that was found to be significant at $p<0.05$ by univariate analyses was entered into a backward stepwise logistic regression model. Logistic regression analysis was performed to estimate the predictive ability of the APACHE II,

Abstract · Zusammenfassung

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Predictive value of outcome scores in patients suffering from cardiogenic shock complicating AMI. APACHE II, APACHE III, Elebute–Stoner, SOFA, and SAPS II

Abstract

Background. Scoring systems in critical care patients are essential for prediction of outcome and for evaluation of therapy. In this study we determined the value of the APACHE II, APACHE III, Elebute–Stoner, SOFA, and SAPS II scoring systems in the prediction of mortality in patients with cardiogenic shock (CS) complicating acute myocardial infarction (AMI).

Material and methods. In this prospective, observational study, patients who were admitted to the ICU with CS complicating AMI were consecutively included. Data for the APACHE II, APACHE III, Elebute–Stoner, SOFA, and SAPS II scores were recorded on admission and during the following 96 h. Receiver operating characteristic curve analyses and the area under the curve (AUC) were used to estimate the predictive ability (mortality) of the scoring systems on admission and the maximum value.

Results. Mortality among the 41 patients included in this study was 44%. On admission, the mean APACHE II (p=0.035), APACHE III (p=0.003), SAPS II (p=0.001), and SOFA (p=0.042) scores were significantly higher in nonsurvivors than in survivors. At maximum score, APACHE II (p=0.009), APACHE III (p<0.001), and SAPS II (p<0.001) appeared to have higher significance. On admission, the discrimination for APACHE III was 0.786, for SAPS II 0.790, and for APACHE II 0.691. The maximum-score AUC for APACHE II was 0.726, for APACHE III 0.827, and for SAPS II 0.832. Elebute–Stoner and SOFA did not yield valuable results at maximum score or, in the case of Elebute–Stoner, on admission.

Conclusion. These results suggest that at the time of diagnosis and at maximum value, the SAPS II, APACHE III, and APACHE II scores may be useful in predicting a high probability of survival of patients with CS complicating AMI.

Keywords

Cardiogenic shock · Scoring · APACHE II · APACHE III · Sepsis score according to Elebute and Stoner · SAPS II · SOFA

Prädiktiver Wert von Risikoscores bei Patienten im kardiogenen Schock nach akutem Myokardinfarkt. APACHE II, APACHE III, Elebute–Stoner, SOFA und SAPS II

Zusammenfassung

Hintergrund. Scoring bei Intensivpatienten ist für eine Outcome-Abschätzung und Therapieevaluation essentiell. In dieser Studie untersuchten wir den prädiktiven Wert des APACHE II, APACHE III, Elebute-Stoner, SOFA und SAPS II im Rahmen der Mortalitätsabschätzung bei Patienten im kardiogenen Schock (CS) infolge eines akuten Myokardinfarkts (AMI).

Material und Methoden. In diese prospektive Observationsstudie wurden Patienten mit CS infolge eines AMI konsekutive eingeschlossen. Die Daten zur Erhebung des APACHE-II-, APACHE-III-, Elebute-Stoner-, SOFA- und SAPS-II-Score wurden zum Zeitpunkt der Aufnahme und während der folgenden 96 h erhoben. Um die prädiktive Wertigkeit (Mortalität) der Scoringsysteme zum Zeitpunkt der Aufnahme und des Maximalwerts abzuschätzen, wurden diese durch eine „Receiver-Operating-Characteristic"-(ROC-)Analyse und den AUC-Wert („area under the curve"; Fläche unter der Kurve) evaluiert.

Ergebnisse. Die Mortalität betrug bei den 41 eingeschlossenen Patienten 44%. Die Mittelwerte des APACHE II (p=0,035), des APACHE III (p=0,003), SAPS II (p=0,001) und SOFA (p=0,042) waren zum Aufnahmezeitpunkt in verstorbenen signifikant höher als in überlebenden Patienten. Bei Betrachtung der Maximalwerte zeigte sich ein gleiches Bild (APACHE II, p=0,009; APACHE III, p<0,001; SAPS II, p<0,001). Die Unterscheidung (AUC) betrug bei Aufnahme für den APACHE II 0,786, für den SAPS II 0,790 und für den APACHE III 0,691. Die Analyse der Maximalwerte erbrachte folgende Ergebnisse: APACHE II 0,726, APACHE III 0,827 und SAPS II 0,832. Der SOFA und Elebute-Stoner waren beim Maximalwert und der Elebute-Stoner auch bei Aufnahme nicht in der Lage eine aussagekräftige Unterscheidung zu treffen.

Schlussfolgerung. Die Ergebnisse legen nahe, dass der SAPS II, APACHE III und APACHE II zum Zeitpunkt der Aufnahme und des Maximalwerts bei Patienten mit CS nach AMI hilfreich in der Outcome-Abschätzung sein können.

Schlüsselwörter

Kardiogener Schock · Scoring · APACHE II · APACHE III · Sepsis-Score nach Elebute und Stoner · SAPS II · SOFA

APACHE III, Elebute–Stoner, SOFA, and SAPS II scoring systems in assessing CS-related mortality. The dependent variable was the mortality and the potential independent variables were age, APACHE II, APACHE III, Elebute–Stoner, SOFA, and SAPS II, and cardiogenic shock. All analyses were performed using SPSS software version 16.

Results

Baseline characteristics

Of the 45 patients in the study, 4 were excluded, because of acute heart failure due to other reasons. The overall mortality rate was 44% in this study population. Percutaneous coronary intervention (i.e., PCI, PTCA, or stents) or IABP was performed on most patients (about 70–75%), but did not differ between treatment groups. The sole significant difference between survivors and nonsurvivors was CPR, which was most often performed before PCI was carried out. The baseline characteristics and inflammatory parameters on admission are given in **Tab. 2**.

Scores and survival

APACHE II score

Mean APACHE II scores on admission were 33.3±8.4 for nonsurvivors and 27.1±9.1 for survivors, determined at the time of CS diagnosis, and were signifi-

Tab. 2 Demographics, diagnosis, and other characteristics of cardiogenic shock patients

Characteristics	Total (n=41)	Nonsurvivors (n=18)	Survivors (n=23)	Significance among groups
Gender, (male/female)	26 (63%)/15 (37%)	12 (66.6%)/6 (33.3%)	14 (61%)/9 (39%)	NS
Age, years, mean (range)	67.5 (43–85)	70.8 (46–85)	64.9 (43–84)	NS
BMI, mean (range) Kg/m^2	29.7 (20.7–46.9)	30.4 (20.7–46.9)	29.2 (21–44.3)	NS
Smoker, n (%)	9 (22)	3 (16.7)	6 (26.1)	NS
Hypertension, n (%)	26 (63.4)	9 (50.0)	17 (73.9)	NS
Dyslipidemia, n (%)	8 (19.5)	2 (11.1)	6 (26.1)	NS
Diabetes mellitus, n (%)	24 (58.5)	10 (55.6)	14 (60.9)	NS
Previous AMI, n (%)	10 (24.4)	3 (16.7)	7 (30.4)	NS
Known heart failure, n (%)	17 (41.5)	8 (44.4)	9 (39.1)	NS
Cardiac risk factors, one and more, n (%)	38 (92.7)	17 (94.4)	21 (91.3)	NS
PTCA, n (%)	29 (70.7)	13 (72.2)	16 (69.6)	NS
Hemodialysis, n (%)	8 (24.2)	4 (23.5)	4 (25)	NS
CPR, n (%)	16 (39)	14 (77.8)	2 (8.7)	p<0.05
Before PTCA, n (%)	14 (34.1)	7 (38.9)	7 (30.4)	NS
IABP, n (%)	31 (75.6)	13 (72.2)	18 (78.3)	NS
Ventilation, n (%)	31 (75.6)	15 (83.3)	16 (69.6)	NS
Leukocytes on admission, mean (range) Gpt/l	14.75 (5.00–26.90)	14.48 (5.00–25.60)	14.97 (6.55–26.90)	NS
CRP on admission, mean (range) mg/l	66.37 (5.00–318.80)	67.10 (5.10–318.80)	65.78 (5.00–258.60)	NS
PCT on admission, mean (range) ng/ml	3.08 (20.92–0.10)	3.14 (16.92–0.10)	3.02 (20.92–0.10)	NS

BMI body mass index, *AMI* acute myocardial infarction, *PTCA* percutaneous transluminal coronary angioplasty, *CPR* cardiopulmonary resuscitation, *IABP* intra-aortic balloon pump, *CRP* C-reactive protein, *PCT* procalcitonin, *NS* not significant

Tab. 3 Comparison of ***initial*** APACHE II, APACHE III, Elebute–Stoner, SOFA, and SAPS II scores among patients with cardiogenic shock secondary to myocardial infarction

Death	Initial score	Mean	SEM	Min.	Max.	p Value
No	Apache II	27.09	9.09	12	39	0.035
Yes		33.24	8.36	18	46	
No	Apache III	96.35	33.99	29	167	0.003
Yes		127.94	26.83	84	172	
No	Elebute-Stoner	10.65	4.13	4	18	NS
Yes		11.06	4.14	6	21	
No	SOFA	9.78	3.19	2	16	0.042
Yes		11.82	2.81	7	16	
No	SAPS II	57.00	16.70	18	84	0.001
Yes		74.76	14.36	52	94	

SEM standard error of the mean, *Min.* minimum, *Max.* maximum, *NS* not significant

Tab. 4 Comparison of ***maximum*** APACHE II, APACHE III, Elebute–Stoner, SOFA, and SAPS II scores among patients with cardiogenic shock secondary to myocardial infarction

Death	Maximum score	Mean	SEM	Min.	Max.	p Value
No	Apache II	29.09	8.36	14	42	0.009
Yes		36.00	7.25	21	48	
No	Apache III	104.35	29.87	63	167	<0.001
Yes		139.24	23.04	87	172	
No	Elebute	13.00	3.79	6	22	NS
Yes		14.06	4.47	7	23	
No	SOFA	12.43	7.08	6	42	NS
Yes		13.35	4.06	7	23	
No	SAPS II	60.09	15.63	32	88	<0.001
Yes		79.82	13.36	52	104	

SEM standard error of the mean, *Min* minimum, *Max* maximum, *NS* non-significant

cantly higher in nonsurvivors than in survivors (p=0.035) (**Tab. 3**).

The maximum value of the APACHE II score was also significantly higher (p=0.009) for nonsurvivors (36.0±7.3) than for survivors (29.1±8.4; **Tab. 4**).

APACHE III score

Among the survivors, the initial APACHE III score was 96.4±34.0. The APACHE III score on admission was significantly higher in nonsurvivors (127.9±26.8, p=0.003; **Tab. 3**).

The maximum APACHE III scores of survivors (104.4±29.9) and nonsurvivors (139.2±23.0) also differed significantly (p<0.001; **Tab. 4**).

Elebute–Stoner score

The mean Elebute–Stoner scores were 11.1±4.1 for nonsurvivors and 10.7±4.1 for survivors, determined at the time of CS diagnosis (p=NS; **Tab. 3**).

The maximum value of the Elebute–Stoner score showed similar results: The Elebute–Stoner score in survivors was 13.0±3.8 and in nonsurvivors it was 14.1±4.5 (p=NS; **Tab. 4**).

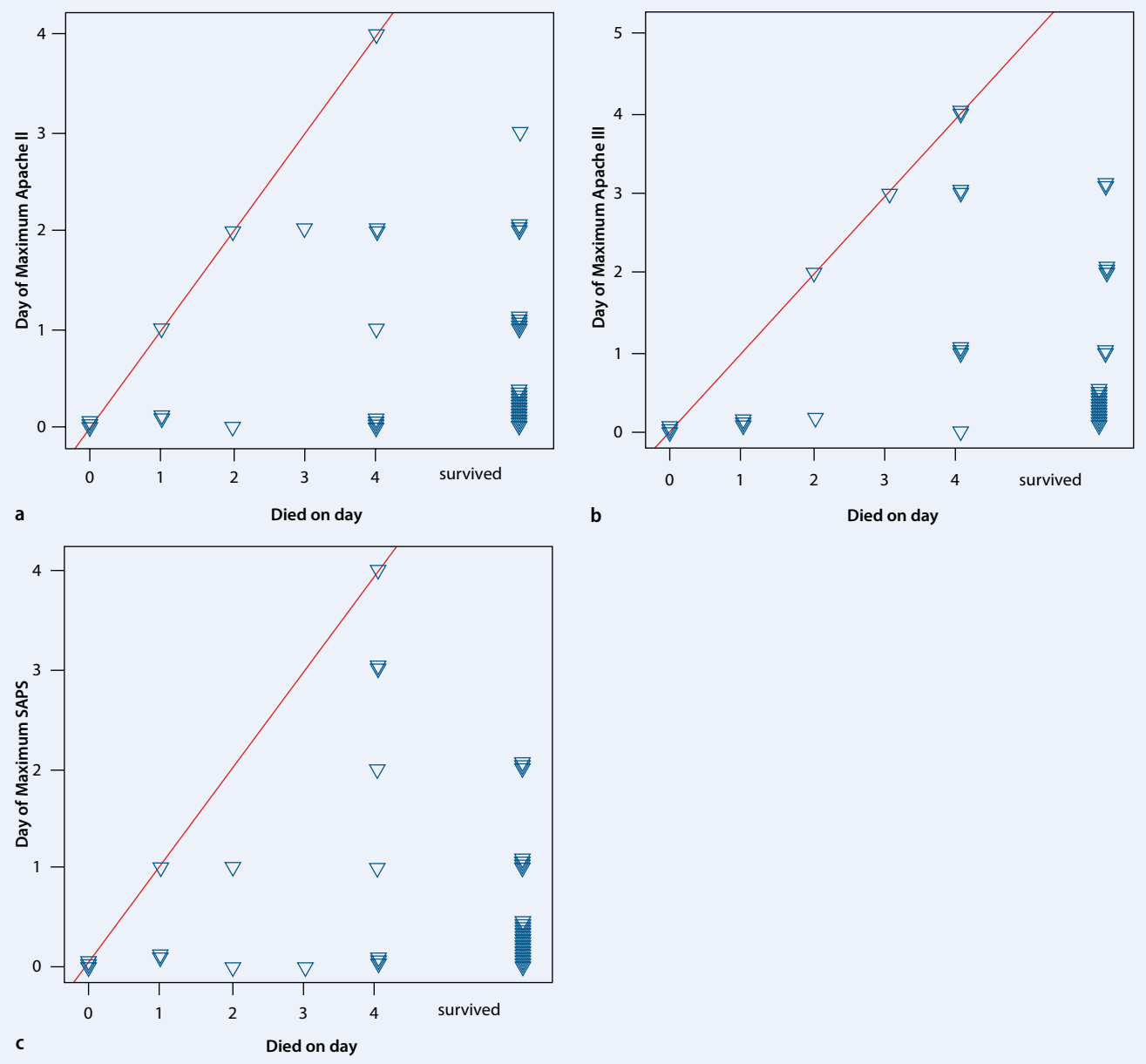

Fig. 2 ▲ Coherency of maximum value and death for the meaningful scores of APACHE II, APACHE III, and SAPS II. **a** Relationship between maximum value of APACHE II and day of death. **b** Relationship between maximum value of APACHE III and day of death. **c** Relationship between maximum value of SAPS II and day of death. *Blue triangle* indicates the day of death and day of maximum value of scoring, and day of maximum value of scoring in survivors. *Red line* indicates potential ideal coherency of the day of death and day of maximum value of scoring

SOFA score

The SOFA score was 9.8±3.2 in survivors at admission and 11.8±2.8 in nonsurvivors (p=0.042). There was no significant difference in the maximum SOFA scores (**Tab. 3, 4**).

SAPS II score

The SAPS II score was 57.0±16.7 among survivors and was significantly higher in nonsurvivors (74.8±14.4, p=0.001; **Tab. 3**). The maximum values were similar (60.1±15.6 and 79.8±13.4, respectively, p<0.001; **Tab. 4**).

Maximum value and survival

No correlation between maximum value and death was determined for the meaningful scores of APACHE II, APACHE III, and SAPS II. However, most survivors had their maximum score on admission (**Fig. 2**).

ROC and discrimination

ROC curves were calculated for the initial scores demonstrating a relative accuracy of the variables in predicting survival and are depicted in **Fig. 3**. ROC curves for maximum score values were illustrated in **Fig. 4**. Accuracy data derived from area under the curve analysis are shown in **Tab. 5** and confirms the greater numerical accuracy of SAPS II > APACHE III >

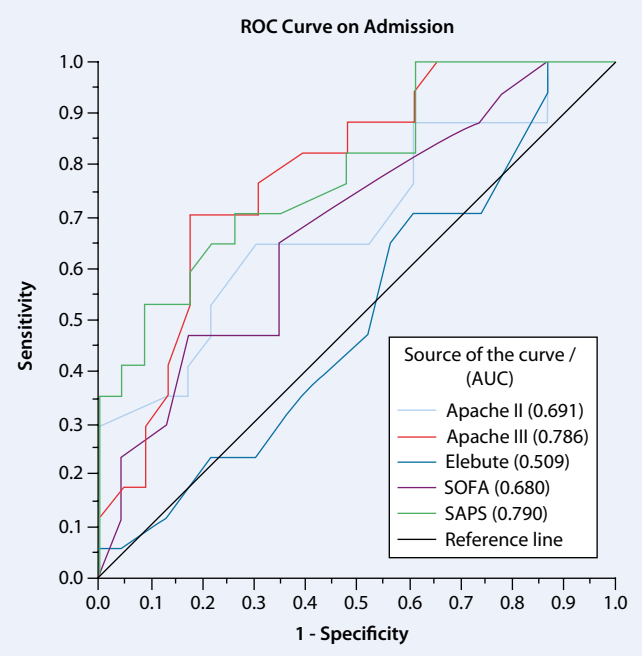

Fig. 3 ▲ Receiver operating characteristic curves (ROC) for mortality calculated from *initial* APACHE II, APACHE III, Elebute–Stoner, SOFA, and SAPS II scores among patients with cardiogenic shock secondary to myocardial infarction. Predictive utility was identified for APACHE II, APACHE III, and SAPS II but not for Elebute–Stoner and SOFA scores. *AUC* area under the curve

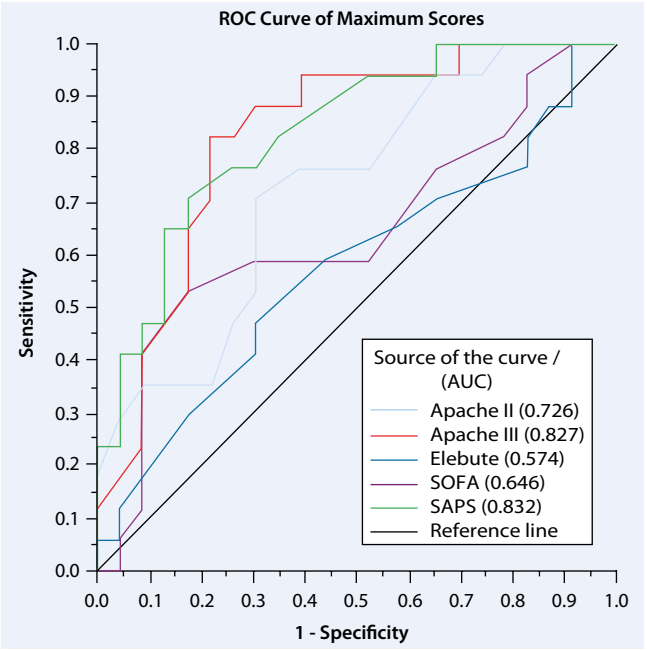

Fig. 4 ▲ Receiver operating characteristic curves (ROC) for mortality calculated from *maximum* APACHE II, APACHE III, Elebute–Stoner, SOFA, and SAPS II scores among patients with cardiogenic shock secondary to myocardial infarction. Predictive utility was identified for APACHE II, APACHE III, and SAPS II but not for Elebute–Stoner and SOFA scores. *AUC* area under the curve

APACHE II over the other parameters in predicting mortality of CS patients.

Discrimination was valuable for risk stratification for the admission values of the SAPS II (AUC: 0.790), APACHE III (AUC: 0.786), and APACHE II (AUC: 0.691) scores, but not for the Elebute–Stoner and SOFA scores (**Tab. 5**).

Analysis of the maximum values showed similar results. Discrimination was considered excellent for the SAPS II (AUC: 0.832) and the APACHE III (AUC: 0.827) scores and acceptable for the APACHE II (AUC: 0.726) score. Scores that rate inflammatory conditions, such as the Elebute–Stoner and SOFA scores, could not confirm these results.

At the time of CS diagnosis, the cut-off value for APACHE III was >122.5, for SAPS II >66, and for APACHE II >31.5. The sensitivity and specificity of the SOFA and Elebute–Stoner scores were not comparable with the general scoring systems.

At the maximum values, the cut-off point for APACHE III was >122.5, for APACHE II >32.5, and for SAPS II >74, which demonstrates more valid results than the SOFA and Elebute–Stoner systems. The cut-off points at admission and maximum value are almost the same for the APACHE II, APACHE III, and SOFA systems, with a higher sensitivity and specificity at the maximum score (**Tab. 5**).

Discussion

Urgent reperfusion of the infarct-related artery (IRA) is essential in the management of patients with AMI and CS [16, 20]. Despite reperfusion, mortality remains at almost 50% [2] due to low cardiac output, poor coronary perfusion, and worsening cardiac contractility, even though inotropic and vasopressor support is given [17]. Recently, it has been shown that this initiates a systemic inflammatory process characterized by SIRS and subsequently MODS or sepsis, leading to decreased myocardial contractility [21]. The inflammatory stimulation on the endothelium of the blood vessels generates inducible nitric oxide synthase and hence nitric oxide [15], which also depresses cardiac function [3]. We believe mortality from AMI-related CS results from a progression from initial hemodynamic instability followed by SIRS, sepsis, MODS, and finally death due to multiple organ failure. For this reason, we also decided to include the Elebute–Stoner and SOFA scores, besides APACHE II, APACHE III, and SAPS II.

The majority of scoring systems focus on mortality as the main outcome in a homogeneous population—not for an individual patient. Several authors have addressed the performance of mortality prediction models in subgroups of patients, defined by the same underlying disease or the same cause for intensive care admission [7, 11]. The aim of this study was to assess whether the APACHE II/III, Elebute–Stoner, SOFA, or SAPS II scores, determined on the day of diagnosis and at their maximum value, can predict mortality in patients with infarction-related CS.

Scoring in cardiogenic shock

We found that survivors of AMI-related CS had significantly lower initial APACHE II/III, SAPS II, and SOFA scores. In contrast, nonsurvivors had significantly higher initial scores. When examining the maximum value, only the APACHE II/III and SAPS II scores showed significant differences in survivors and nonsurvivors.

Tab. 5 ROC curve analysis

Initial score	Cut-off	Sensitivity (%)	Specificity (%)	AUC	95% CI (AUC)
APACHE II	31.5	64.71	69.57	0.691	0.52–0.86
APACHE III	122.5	70.59	82.61	0.786	0.64–0.92
Elebute–Stoner	–	–	–	0.509	0.32–0.69
SOFA	7.5 13.5	94.12 29.41	21.74 86.96	0.680	0.51–0.84
SAPS II	66.0	70.59	73.91	0.790	0.65–0.93
Maximum score					
APACHE II	32.5	70.59	69.57	0.726	0.57–0.88
APACHE III	122.5	82.35	78.26	0.827	0.70–0.96
Elebute–Stoner	14.5	47.06	69.57	0.574	0.39–0.76
SOFA	13.5	52.94	82.61	0.646	0.47–0.83
SAPS II	74.0	70.59	82.61	0.832	0.71–0.96

ROC receiver operating characteristic, *CI* confidence interval, *AUC* area under the curve

With regard to risk stratification, the initial scores reflect the possibility of death after admission to hospital. By contrast, the maximum score value indicates the worst point, which could be the angular point of disease or the last scoring value before death, and is influenced by therapy. As demonstrated, there was no significant coherence between the maximum value and death. Within the group of survivors, the maximum value was found on admission, which could be interpreted to be the result of the effectiveness of therapies.

The AMI with CS population appears to be more heterogeneous and shows a great spectrum of morbidity at presentation (and hence in initial and maximum scores). This spectrum can be used to predict mortality even at the time of admission to hospital. In simple terms, our data suggest that patients who have an initial APACHE III score threshold of 122.5 (SAPS II score >66 and APACHE II score >31.5) are at a substantially higher risk of death. This is also true for the analysis of the maximum values of APACHE III, SAPS II, and APACHE II. This heterogeneity of organ dysfunction in patients with CS is also reflected in the various subgroups identified in the SHOCK trial registry [27, 28]. Our study showed promising results for the SAPS II > APACHE III > APACHE II scores, with an excellent discrimination power. The discrimination between survivors and nonsurvivors appeared to be superior for the SAPS II and the APACHE III systems and acceptable for the APACHE II system. The Elebute–Stoner and SOFA scores were not able to determine the prognosis of CS patients since there was no significant difference between survivors and nonsurvivors. Some scores are accurate in assessing the risk of morbidity and mortality in shock patients, among which the APACHE III is the most accurate. However, it is more time-consuming and expensive than the APACHE II [41]. Knaus et al. [23] studied 17,740 patients and showed an AUC of 0.90 on admission and an average admission score of 50 points for the APACHE III. In a study by Reina et al. [35] of 1,711 patients with AMI, the AUC was 0.84 with a sensitivity of 75.80 and a specificity of 75.90. In 2001, Markgraf and coworkers [26] showed an AUC of 0.846 for APACHE III in 1,772 interdisciplinary ICU patients. In contrast to all other studies, we only included patients with CS, which could explain the slightly lower results.

The SAPS II score showed excellent results for both admission and maximum value, while cardiologic patients were excluded from the validation of this scoring system [24]. Schuster et al. [38] showed good results for these patients in 1997: In the subgroup of patients with AMI, the in-hospital mortality was 15.6%, AUC was 0.905, and the average score was 28.3. Our results demonstrate much higher values on admission, for maximum score, and also in mortality, probably because the patients were suffering from CS complicating AMI. Mentnitz and colleagues [29] demonstrated that the SAPS II score was of good assistance in mortality evaluation in cardiac patients. An interesting evaluation of APACHE III and SAPS II in patients with AMI found results similar to ours. In contrast to our study, Reina et al. [35] showed much lower mean values on admission for SAPS II in survivors and nonsurvivors (33.3 and 49.2, respectively). This demonstrates the difference between AMI and AMI leading to CS and also the high mortality of CS.

The APACHE II score is probably the most extensively used and recognized scoring system, which was primarily designed to predict mortality of patients in ICUs. In the study of Goel et al. [12], the APACHE II score was found to be useful in predicting long-term mortality for COPD patients admitted outside the ICU. Riberio and Kowalsky found APACHE II useful in predicting perioperative complications in patients with oropharyngeal cancer [8]. In the original paper of Knaus et al. [22], the APACHE II showed a higher AUC at admission (0.86) in the subgroup of patients with CS and a mortality of 33%. Reasons for these differences could be the small sample size of our study and that all the patients in our investigation only developed CS after AMI.

The SOFA and Elebute–Stoner scores were designed for detecting and scoring inflammation, SIRS, sepsis, and MODS [9, 40], also an important factor of mortality in CS [15, 21]. Several studies have shown that there are significant differences in the value of the SOFA and Elebute–Stoner score for differentiation of mortality or MODS. Oda et al. [31] had similar cut-off values at admission with ours, with a higher sensitivity and specificity (71.3 and 76.9%, respectively); however, they focused on MODS. Another study by Moreno et al. [30] that included 1,449 interdisciplinary ICU patients, found an AUC of 0.847 and 0.772 for the for the maximum SOFA score on admission. In comparison to our study, a trial by Janssens et al. [19] showed that the AUC of 303 cardiac and pneumology patients was 0.86 for the maximum SOFA score.

The Elebute–Stoner score was not able to display differences in the admission and maximum values of CS patients. In contrast to our results, the original paper of Elebute and Stoner showed a significant distinction between survivors and nonsurvivors at a cut-off of 20 points for

septic patients [9]. A study by Pilz et al. [32] on 110 cardiac surgery patients illustrated that an Elebute–Stoner score over 12 points is associated with a higher probability of septic complications. We could not confirm these results in our study, possibly because of the group size and the items used to calculate the SOFA and Elebute–Stoner scores. The factors investigated were possibly not sufficient to show the inflammatory role of CS pathogenesis. In addition, as shown in **Tab. 2**, there were no significant differences in the inflammatory parameters of survivors and nonsurvivors. Another remarkable point is the interrater variability in the Elebute–Stoner score, which could be responsible for the unsatisfactory results of this scoring system.

Our results suggest, in accordance with the results found for APACHE II of the IABP SHOCK Trial, that it might possible to use these scoring systems to predict mortality in patients with infarction-related CS [33]. The APACHE II/III or SAPS II scores were recorded on the day of CS diagnosis and at their maximum value; it is, however, possible that some of the nonsurvivors developed sepsis and MODS after diagnosis and therefore led to increased scores in the course of the illness. The role of inflammation in CS is becoming more known, but it seems that the influence of the inflammatory reaction on these scoring systems is not high enough. Although the SOFA score was higher in nonsurvivors than in survivors at the time of CS diagnosis, at its maximum value it was not an independent predictor of mortality. While the Elebute–Stoner and SOFA scores were slightly higher in nonsurvivors, the calibration sensitivity and specificity of these scores were poor. The characteristics of patients treated in different ICUs are not the same. Different patient groups may develop different patterns of organ dysfunction and scores during CS. Little is known about the distribution and time course of organ failure in CS patients. With this study, we were able to show the effectiveness of the APACHE II/III and SAPS II scores in CS patients.

It is also important to consider serial scoring, which looks at the effectiveness of therapies and the trend during hospitalization [42, 43]. This aspect and the analysis of score-specific subscores, especially the question on the role of inflammation and organ dysfunction, are very interesting, and we are currently analyzing these data to publish them soon.

Limitations

There are several limitations in our study. The small sample size is the most important limitation, since it may influence the evaluation of the calibration and discrimination of the scores. Further, this study was performed within a single ICU. Since the severity of underlying disease, the age of the patients, and therapy protocols are different among ICUs, each ICU needs to determine its own cut-off points for each score even for different patient groups. Moreover, a higher lead time bias between the onset of illness or the most severe period of disease and the calculation of scores may also contribute to the performance of the scoring systems.

Conclusion

The present study suggests scoring systems can play a role in the prognosis assessment of patients with AMI complicated by CS. In this single-center registry, we were able to demonstrate the reliable discrimination of the APACHE III, SAPS II, and APACHE II scoring systems. In order to better evaluate these scoring systems in patients with CS, large-scale multicenter clinical studies should follow.

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Conflict of interest. On behalf of all authors, the corresponding author states that there are no conflicts of interest.

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Buchbesprechungen

H. W.Striebel

Anaesthesie, Intensivmedizin, Notfallmedizin

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Der in Lehre und Ausbildung sehr erfahrene Hans Walter Striebel legt nach knapp vier Jahren mit der 8. Auflage eine aktualisierte Überarbeitung seines für den Zielbereich Studium und Ausbildung gedachten Basiswerks zur Thematik vor.

Klar strukturiert, knapp formuliert und auf den Leser ohne wesentliche Vorkenntnisse zugeschnitten werden die Themenkomplexe abgehandelt. Wesentlicher Schwerpunkt des Buches liegt auf dem Bereich der Anaesthesie, während die Intensivmedizin und insbesondere die Notfallmedizin und das angefügte Kapitel chronische Tumorschmerzen nur relativ kurz behandelt werden.

Hier würde die nächste Auflage des für die Einführung in die Anaesthesie sicher gut geeigneten Werkes zweifellos gewinnen, wenn mindestens die sehr kurz abgehandelten Bereiche Notfallmedizin und chronische Tumorschmerzen aus dem Werk ausgegliedert würden. Auch das Kapitel Intensivmedizin wird in manchen Bereichen so oberflächlich und knapp behandelt, dass einige Abschnitte (z.B. nicht-invasive Beatmung) auch inhaltlich nicht mehr ganz dem aktuellen Wissensstand entsprechend dargestellt werden.

Der den überwiegenden Teil des Buches einnehmende Bereich der Anaesthesie kann sicher gut als erste Orientierung dem Studenten oder dem in der Anaesthesiepflege Auszubildenden als einführendes Werk empfohlen werden. Negativ schlagen hier allenfalls die relativ wenigen schematischen Darstellungen und die Tatsache des ausschließlichen Vorhandenseins von Schwarz-Weiß-Abbildungen zu Buche. Für den Umfang von über 600 Seiten erscheint der Preis von 36,95 Euro als günstig und dem Adressatenkreis angemessen.

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