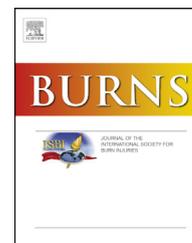


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Can systemic inflammatory response syndrome score at admission predict clinical outcome in patients with severe burns?

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ABSTRACT

Introduction: The use of SIRS score as a predictor of outcomes in patients with severe burns has not been fully evaluated. Here, we aimed to test that whether admission SIRS score, combining with other predictors, could be used in predicting outcomes in patients with severe burns. Additionally, we compared the prognostic accuracy of admission SIRS score with other score systems and newly developed models.

Methods: We performed a retrospective study of adult patients with $\geq 40\%$ total body surface area burns admitted to a burn center from 2005 to 2017. The primary outcome was in-hospital mortality, and the secondary outcomes were hospital and intensive care unit length of stay. SIRS score, rBaux score, ABSI and newly developed models were compared using area under the receiver operating characteristic curve analysis.

Results: Out of the total 144 patients, 128 (88.9%) met SIRS criteria on admission; with a predominant SIRS scores of 3. Patients with admission SIRS were more likely to have larger burns and have higher rBaux and ABSI scores when compared with non-SIRS patients. With the each increment of admission SIRS score, total and full-thickness burn areas, proportion of inhalation injury, tracheostomy and mortality increased significantly. However, SIRS score at admission was not increasingly predictive of deleterious outcomes when analyzed by multivariable regression analysis. Although the combination of SIRS score, age, and burn-specific variables showed better or equal prognostication of outcomes than that of other score systems, the contribution of the variable SIRS score was negligible.

Conclusions: The model with the variables age, percentage full-thickness burns, and inhalation injury provided excellent prediction of poor outcomes in patients with severe burns, while SIRS score has limited use for prognostic determinations.

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1. Introduction

Although great improvements have been made in the treatment of severe burns, the management of severely burned patients is time and resources consuming. Predicting an outcome in the initial hours or days after injury may be helpful to identify patients requiring specific interventions and make triage decisions. Several scoring systems and predictive models have evolved in recent decades, aiming to help physicians make decisions when managing burn patients. These scoring systems include abbreviated burn severity index (ABSI), Belgian outcome in burn injury (BOBI), Baux score, revised Baux (rBaux) score, simplified acute physiology score (SAPS), sequential organ failure assessment (SOFA) and acute physiology and chronic health evaluation (APACHE) and all have been proven feasible [1–5].

In 1992, the concept of systemic inflammatory response syndrome (SIRS) was precisely defined [6]. Since then, the SIRS score was widely used as a tool to predict outcomes in emergency patients, trauma patients, and critical care patients [7–9]. It was raised at the 2007 American Burn Association Consensus Conference that SIRS was not recommended in burns because those patients were in a state of chronic systemic inflammation [10]. However, thermal injury can also induce a marked systemic inflammatory response at early stage, the degree of which can partially reflect the severity of injury. To our best knowledge, no study has used SIRS score as a predictor of outcomes in patients with severe burns. The aims of this study is to (1) test that whether admission SIRS score, combining with other predictors, is a simple and rapid tool of predicting outcomes in patients with $\geq 40\%$ total body surface area (TBSA) burns and (2) to compare the prognostic accuracy of admission SIRS score with other score systems and newly developed models in our study.

2. Methods

2.1. Patient cohort and data collection

The current study was a retrospective study conducted at the burn center of Changhai hospital in Shanghai, China from January 2005 to December 2017. The inclusion criteria were as follow: adult; $\geq 40\%$ TBSA burn size; admit to our center less than 72h after injury; complete data record. Patients who received limitation of care strategy were also included in the study. Clinical data were obtained from the electronic patient record including age, gender, etiology of burn, burn size, depth of burn, inhalation injury status, length of hospitalization and intensive care unit (ICU) length of stay. Furthermore, daily body temperature, heart rate, respiratory rate or PaCO₂ and white blood cell (WBC) count were also extracted from the electronic patient record. The variables collected at the time of admission were used to calculate admission SIRS score. From the second day after admission, the data were collected at a fixed time of each day unless a worst event happened. This work was approved by the Committee on the Ethics of Medicine, Changhai hospital.

2.2. Treatment strategies

The patients with severe burns in our center were treated as previously reported [11]. The measures include appropriate fluid resuscitation during shock stage, rapid establishment of airway and ventilator support in those patients with potential airway obstruction or severe hypoxemia, extensive eschar-ectomy, debridement and skin grafting after shock period, effective infection control, management of complications, routine application of gastric mucosa protective agents, and early enteral nutrition.

2.3. Score measurements

SIRS was diagnosed as presence of 2 or more following criteria: temperature below 36°C or above 38°C, heart rate >90 /min, respiratory rate >20 /min or maintenance of PaCO₂ <32 mmHg, WBC count $<4,000/\text{mm}^3$ or $>12,000/\text{mm}^3$, or left shift defined as $>10\%$ bands. Routine SIRS scores were calculated for first 7 days post burn based on the rule as one point for each component above. rBaux score and ABSI were also calculated because both of them were widely used in assessing burn injury prognoses and showed some accuracy [4,12].

2.4. Definitions

The primary outcome was mortality, and the secondary outcomes were hospital length of stay (LOS) and ICU-LOS. Longer stay was defined as LOS $>$ median or ICU-LOS $>$ median where appropriate in the statistical analysis because LOS and ICU-LOS were non-normally distributed data. Inhalation injury was defined based on the presence of symptoms and signs: carbonaceous deposits, erythema, edema, bronchorrhea or obstruction observed with or without bronchoscopy examination, similar to previous study [13]. The extension and depth of the burn was assessed by two senior doctors, depending on the simple guides of ISBI/WHO [14].

2.5. Statistical analysis

Analyses were performed using SPSS 12 and MedCalc statistical software. Student t test, Chi-squared test and Mann-Whitney test were conducted in group comparisons, when appropriate. Multivariable regression models for outcomes were established using stepwise selection after assessing clinical and biological plausibility. Receiver operating characteristic curve (ROC) analysis was used to assess the predictive ability of score systems and models. Discriminatory power for each score system or model was analyzed by calculating the area under ROC (AUROC). Hanley-McNeil method was used to assess the differences between AUROC [15]. A p value of less than 0.05 was considered significant.

3. Results

During the study period, there were 308 patients admitted to our center with 40% TBSA burns or more. One hundred and fifty-eight patients presented at our center more than 72h after injury were excluded from this study. Among the remaining

150 patients, five under 18 years old and one with incomplete data were also excluded. Finally, a cohort of 144 patients remained (Fig. 1). The mean age of the cohort was 40.8 years, and the median burn size was 65 (Inter-quartile range (IQR): 45, 85)% TBSA. Most of the patients were male (71.5%). The most common mechanism of burn was flame. One hundred and seven (74.3%) patients were diagnosed as inhalation injury. Fifty-five (38.2%) patients transferred to our center from another hospital. No patients underwent surgery such as tangential excision, escharectomy and skin grafting at early stage (0–72h post burn) except limbs or chest-wall incision for reduction of tension. The median rBaux score was 121(IQR: 95.25, 143), with a median ABSI of 11.5(IQR: 9, 14). The observed mortality for this cohort during their inpatient hospitalization was 19.4%. The median LOS and ICU-LOS of the total survivors was 53.5 (IQR: 37.25, 82.75) days and 29 (IQR: 12, 47.75) days, respectively.

Of the 144 patients, 128 (88.9%) met SIRS criteria on admission. The demographics and the comparison of patients with admission SIRS and without admission SIRS are displayed in Table 1. The age was relatively similar in both group with admission SIRS and the group without SIRS. Patients with admission SIRS had larger burns compared with patients without SIRS. Furthermore, more SIRS patients experienced tracheostomy than patients without SIRS. And rBaux score and

ABSI differed significantly between patients with admission SIRS and without SIRS. Between the two groups, there were no significance in full-thickness burn size, occurrence of inhalation injury, LOS, ICU-LOS, and mortality.

The time course of SIRS score during first 7 days post injury was shown in Fig. 2. The distribution of patients with SIRS score 4 increased with LOS; with a slight decrease from day 3 to day 5. The proportion of patients with SIRS score 3 stayed at a stable level during the first week with a peak at day 5. Conversely, the distribution of patients with SIRS score 2 decreased from day 1 to day 7 in this cohort with a sharp rise on day 4.

The characteristics of patients according to admission SIRS scores were presented in Table 2. The number of SIRS score of 3 was the highest among the study population, followed by 2, 4, and 1. The median of overall and full-thickness burn areas were found to significantly increase with higher admission SIRS score. Moreover, with the increase of admission SIRS score, a significantly increased proportion of inhalation injury and tracheostomy were also noted. And increasing SIRS scores were associated with statistically significant increases in mortality at each increment from 1 to 4. However, the LOS and ICU-LOS were not significantly increased with increasing score.

Supplementary Tables 1–3 described the potential prognostic factors of poor outcomes. After adjusting confounding factors, age, percentage full-thickness burns (FTB%) and inhalation injury were found to independently increase the risk of death, but admission SIRS score could not impact the risk. Additionally, the coefficients of LOS and ICU-LOS were evaluated with univariate and multivariable regression analyses in survivors. Only FTB% and presence of inhalation injury were significantly predictive of LOS. Similarly, the results showed that FTB% and presence of inhalation injury also independently remained predictive of ICU-LOS. However, SIRS score at admission did not change ICU-LOS significantly in the presence of other variables.

To test the utility of SIRS score in predicting outcomes in patients with severe burns, we developed alternative models by adding demographic characteristics and “burns-specific” variables. FTB% was chosen as a component of our models based on the multivariable regression analysis. Model I contained only age and SIRS score; Model II added in the FTB%, and Model III the inhalation injury. In addition, we developed Model IV with variables age, FTB% and inhalation injury. The estimated coefficients for each variable of these models were shown in Supplementary Table 4. As shown in Table 3, AUROC was used to evaluate the discrimination performance of a given score system or model. Based on the Hosmer-Lemeshow statistics, only Models II–IV in predicting LOS were judged to be “less calibrated”. In predicting mortality, LOS and ICU-LOS, SIRS score alone had low predictive with an AUROC of 0.66, 0.531 and 0.539, respectively. However, the combined models (Model II–IV) provide excellent prediction of poor outcomes.

Next, we compared the differences in prediction under each two score systems or models. As shown in Table 4 and Fig. 3, the curves and AUROC indicated that SIRS score was not a better predictor of mortality than rBaux Score and ABSI (difference between areas: SIRS vs rBaux, 0.233 [0.125–0.339], $p < 0.01$; SIRS

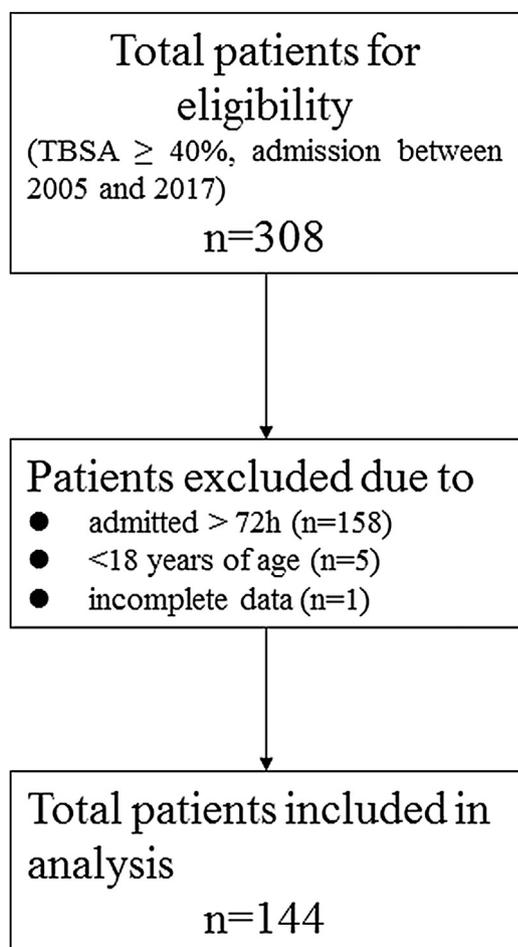


Fig. 1 – Flow diagram of patient inclusion in this study. (TBSA, total body surface area).

Table 1 – Characteristics of study population of patients with severe burns.

	Total (n=144)	No admission SIRS (n=16)	With admission SIRS (n=128)	p
Age (yrs), mean (SD)	40.8 (14.5)	42.1 (18.3)	40.6 (14.0)	0.1
Gender				
Male (%)	103 (71.5%)	9 (56.3%)	94 (73.4%)	0.156
Female (%)	41 (28.5%)	7 (43.8%)	34 (26.6%)	–
Total TBSA%, median (IQR)	65 (45, 85)	43.5 (40, 57.75)	70 (50, 86.5)	0.001
FTB%, median (IQR)	27 (10, 55)	20 (6.75, 29.25)	27.5 (10, 59.75)	0.097
Etiology, n (%)				
Flame	130 (90.3%)	13 (81.3%)	117 (91.4%)	0.19
Scald	8 (5.6%)	1 (6.3%)	7 (5.5%)	1.0
Other	6 (4.2%)	2 (12.5%)	4 (3.1%)	0.133
Inhalation injury, n (%)	107 (74.3%)	10 (62.5%)	97 (75.8%)	0.361
Tracheostomy, n (%)	76 (52.8%)	4 (25%)	72 (56.3%)	0.031
Incision to reduce tension, n (%)	49 (34%)	3 (18.8%)	46 (40%)	0.263
Transfer, n (%)				
Non	89 (61.8%)	8 (50%)	81 (63.3%)	0.414
<24h	19 (13.2%)	3 (18.8%)	16 (12.5%)	0.445
24-48h	15 (10.4%)	3 (18.8%)	12 (9.4%)	0.376
48-72h	21 (14.6%)	2 (12.5%)	19 (14.8%)	1.0
rBaux score, median (IQR)	121 (95.25, 143)	99.5 (91, 115.25)	125.5 (99, 144.75)	0.011
ABSI, median (IQR)	11.5 (9, 14)	10 (8.25, 11)	12 (9, 14)	0.009
Mortality, n (%)	28 (19.4%)	1 (6.3%)	27 (21.1%)	0.280
Hospital length of stay ^a (days), median (IQR)	53.5 (37.25, 82.75)	43 (27, 60)	54 (40.5, 89)	0.057
ICU length of stay ^a (days), median (IQR)	29 (12, 47.75)	30 (7, 45)	29 (12.5, 49)	0.378

Abbreviations: SIRS indicates systemic inflammatory response syndrome; SD, standard deviation; TBSA, total body surface area; FTB, full-thickness burns; IQR: inter-quartile range; rBaux, revised Baux; ABSI, abbreviated burn severity index; ICU, intensive care unit.

rBaux Score: Age+Percent Burn +17* (Inhalation Injury, 1=yes, 0=no); ABSI was calculated based on previous study [12].

A p value of less than 0.05 was presented in bold.

^a Only data of survivors were analyzed.

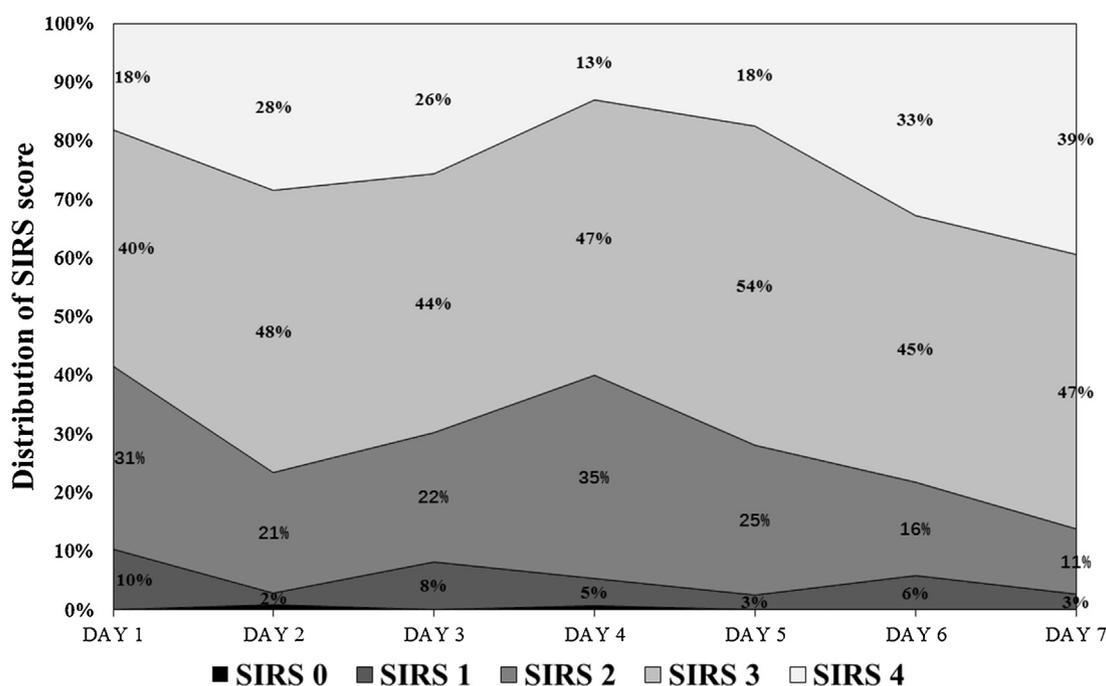


Fig. 2 – The observed SIRS scores for the total cohort of severe burns over 7 days. Day1-7 represent the initial 7 days post injury.

vs ABSI, 0.209 [0.099-0.318], $p < 0.01$). Discrimination of LOS and ICU-LOS was better using ABSI than either rBaux score or SIRS score. Similarly, rBaux score outperformed SIRS score for discrimination of ICU-LOS. Models II-IV had considerably

higher discriminatory power than rBaux score in predicting LOS and were comparable with rBaux score in predicting mortality as well as ICU-LOS. Superior predictive power of Model III and Model IV over ABSI was found when considering

Table 2 – Patient characteristics by admission SIRS scores.

SIRS Score	n	Age	Total TBSA%	FTB%	Inhalation injury	Tracheostomy	LOS ^a	ICU-LOS ^a	Mortality
0	0	–	–	–	–	–	–	–	–
1	16	42.1 (18.3)	43.5 (40, 57.75)	20 (6.75, 29.25)	10 (62.5%)	4 (25%)	43 (27, 60)	30 (7, 45)	1 (6.3%)
2	43	40.2 (11.2)	65 (44, 80)	27 (10, 39)	31 (72.1%)	20 (46.5%)	52.5 (34.75, 90)	23 (12, 42)	5 (11.6%)
3	60	41.3 (15.9)	67.5 (50, 85)	25 (7.25, 50)	41 (68.3%)	30 (50%)	55 (42, 83)	31 (11, 54)	13 (21.7%)
4	25	39.9 (14.0)	85 (52.5, 92.5)	60 (12.5, 80.5)	25 (100%)	22 (88%)	50.5 (31.25, 133.75)	33.5 (17.25, 84.25)	9 (36.0%)
p	–	0.947	0.001	0.029	0.011	<0.001	0.287	0.14	0.046

Abbreviations: SIRS indicates systemic inflammatory response syndrome; TBSA, total body surface area; FTB, full-thickness burns; LOS, length of stay; ICU, intensive care unit.

Age was presented as mean (standard deviation), TBSA%, FTB%, LOS and ICU-LOS were presented as median (inter-quartile range).

A p value of less than 0.05 was presented in bold.

^a Only data of survivors were analyzed.

Table 3 – AUROC for discrimination characteristics of rBaux score, ABSI, SIRS score, and new models on poor outcomes (in-hospital mortality, LOS over median^a, ICU-LOS over median^a) among patients with severe burns.

	rBaux score	ABSI	SIRS score	Model I	Model II	Model III	Model IV
Mortality							
AUROC (95%CI)	0.892 (0.83-0.938)	0.869 (0.803-0.919)	0.660 (0.577-0.737)	0.744 (0.665-0.813)	0.921 (0.865-0.96)	0.935 (0.882-0.97)	0.934 (0.88-0.969)
Hosmer-Lemeshow χ^2	–	–	–	$\chi^2=6.303$ P=0.613	$\chi^2=3.313$ P=0.913	$\chi^2=4.896$ P=0.769	$\chi^2=2.621$ P=0.956
LOS > median							
AUROC (95%CI)	0.647 (0.553-0.734)	0.709 (0.618-0.790)	0.531 (0.436-0.624)	0.568 (0.473-0.659)	0.802 (0.718-0.87)	0.831 (0.75-0.894)	0.826 (0.744-0.89)
Hosmer-Lemeshow χ^2	–	–	–	$\chi^2=13.359$ P=0.1	$\chi^2=17.941$ P=0.022	$\chi^2=25.36$ P<0.001	$\chi^2=33.19$ P<0.001
ICU stay > median							
AUROC (95%CI)	0.710 (0.619-0.791)	0.747 (0.658-0.824)	0.539 (0.444-0.632)	0.570 (0.475-0.662)	0.774 (0.687-0.847)	0.802 (0.718-0.87)	0.793 (0.708-0.863)
Hosmer-Lemeshow χ^2	–	–	–	$\chi^2=8.078$ P=0.426	$\chi^2=9.72$ P=0.285	$\chi^2=13.702$ P=0.09	$\chi^2=14.307$ P=0.074

Abbreviations: AUROC indicates areas under the receiver operating characteristic curves; LOS, length of stay; ICU, intensive care unit; rBaux, revised Baux; ABSI, abbreviated burn severity index; SIRS, systemic inflammatory response syndrome.

the mortality and LOS. Notably, Model IV including age, FTB% and inhalation injury provided excellent prediction of poor outcomes, and adding SIRS score to the multivariable model did not further improve the predictive ability.

4. Discussion

Previous studies have been published using SIRS score to predict outcomes in several populations of patients, but little has been done to examine the applicability of SIRS score in severe burns [16–21]. To our best knowledge, this is the first study that test the potential role of SIRS score as a tool to predict outcomes in patients with burn areas 40% TBSA or more. Meanwhile, this study also assessed the discriminatory capacities of each score system (or model) and made a systematic comparison of the different score systems (or models) in predicting outcomes. Our work presented five major findings: (1) A large proportion of patients with severe burns met SIRS criteria on admission, with SIRS scores of 3 as

the predominant one. (2) Mortality rose for each increment of SIRS score in our cohort. (3) ABSI was superior to SIRS and rBaux scores in predicting LOS and ICU-LOS in patients with severe burns. (4) In comparison with using SIRS score alone, SIRS score combining “burns-specific” variables and age demonstrated better prognostic accuracy for outcomes. (5) The multivariable model with the variables age, FTB%, and inhalation injury provided excellent prediction of poor outcomes, and the contribution of the variable SIRS score was negligible when it was added to this model.

In a previous study with a cohort of 2300 surgical ICU patients, Talmor et al. [9] reported that SIRS score on day 2, not day 1, correlated well with several outcomes because 24h of ICU resuscitation could affect SIRS score. In the present study, we did not analyze the relationship of day 2 SIRS score to outcomes because of missing data. In another prospective study including 4887 trauma admissions, Napolitano et al. reported that a SIRS score of 2 at admission could independently affect LOS and mortality [20,21]. Furthermore, an admission SIRS score of 2 or more was an independent

Table 4 – Difference between AUROCs for discriminating poor outcomes (in-hospital mortality, LOS over median^a, ICU stay over median^a) among patients with severe burns.

	rBaux score	ABSI	Model I	Model II	Model III	Model IV
Mortality						
SIRS score	0.233 (0.125–0.339) P<0.0001	0.209 (0.099–0.318) P=0.0002	0.0839 (–0.021 to 0.189) P=0.1172	0.261 (0.154–0.369) P<0.0001	0.275 (0.169–0.382) P<0.0001	0.274 (0.163–0.385) P<0.0001
rBaux score	–	–0.0234 (–0.02 to 0.0668) P=0.2909	–0.148 (0.0436–0.253) P=0.0055	0.0292 (–0.022 to 0.0801) P=0.2599	0.0431 (–0.004 to 0.09) P=0.0742	0.0419 (–0.006 to 0.09) P=0.087
ABSI	–	–	–0.125 (0.0411–0.249) P=0.0492	0.0526 (–0.0119 to 0.117) P=0.1099	0.0665 (0.007–0.126) P=0.029	0.0653 (0.005–0.125) P=0.0335
Model I	–	–	–	0.177 (0.0791–0.276) P=0.0004	0.191 (0.089–0.294) P=0.0002	0.190 (0.084–0.296) P=0.0004
Model II	–	–	–	–	0.0139 (–0.012 to 0.0393) P=0.2861	0.0126 (–0.015 to 0.0402) P=0.3703
Model III	–	–	–	–	–	0.00123 (–0.007 to 0.01) P=0.7729
LOS> median						
SIRS score	0.116 (–0.021 to 0.354) P=0.0964	0.179 (0.043–0.314) P=0.0098	0.037 (–0.0768 to 0.151) P=0.524	0.272 (0.143–0.4) P<0.0001	0.3 (0.171–0.428) P<0.0001	0.295 (0.175–0.415) P<0.0001
rBaux score	–	0.062 (0.014–0.11) P=0.011	–0.0794 (–0.033 to 0.192) P=0.166	0.155 (0.035–0.275) P=0.0112	0.183 (0.077–0.29) P=0.0007	0.179 (0.074–0.283) P=0.0008
ABSI	–	–	–0.141 (0.013–0.27) P=0.0312	0.093 (–0.016 to 0.202) P=0.0945	0.121 (0.029–0.214) P=0.01	0.116 (0.024–0.209) P=0.0134
Model I	–	–	–	0.235 (0.116–0.353) P=0.0001	0.263 (0.141–0.385) P<0.0001	0.258 (0.138–0.378) P<0.0001
Model II	–	–	–	–	0.0282 (–0.03 to 0.087) P=0.3453	0.0233 (–0.036 to 0.082) P=0.4384
Model III	–	–	–	–	–	0.0049 (–0.013 to 0.023) P=0.5976
ICU stay> median						
SIRS score	0.172 (0.041–0.303) P=0.0103	0.209 (0.079–0.339) P=0.0016	0.0315 (–0.069 to 0.132) P=0.5398	0.238 (0.113–0.363) P=0.0002	0.258 (0.135–0.38) P<0.0001	0.255 (0.132–0.378) P<0.0001
rBaux score	–	0.0371 (–0.007 to 0.081) P=0.0995	–0.14 (0.027–0.254) P=0.0156	0.0661 (–0.047 to 0.179) P=0.2526	0.086 (–0.013 to 0.185) P=0.0876	0.083 (–0.015 to 0.181) P=0.0792
ABSI	–	–	–0.177 (0.05–0.304) P=0.0062	0.029 (–0.073 to 0.131) P=0.5765	0.049 (–0.037 to 0.135) P=0.2645	0.046 (–0.04 to 0.132) P=0.2953
Model I	–	–	–	0.206 (0.085–0.328) P=0.0009	0.226 (0.102–0.351) P=0.0004	0.233 (0.102–0.344) P=0.0003
Model II	–	–	–	–	0.0199 (–0.03 to 0.069) P=0.4289	0.017 (–0.033 to 0.07) P=0.5052
Model III	–	–	–	–	–	0.00298 (–0.012 to 0.018) P=0.7022

Abbreviations: AUROC indicates areas under the receiver operating characteristic curves; LOS, length of stay; ICU, intensive care unit; rBaux, revised Baux; ABSI, abbreviated burn severity index; SIRS, systemic inflammatory response syndrome.

Model I: Age and SIRS score; Model II: Age, percentage full-thickness burns (FTB%) and SIRS score; Model III: Age FTB%, SIRS score and inhalation injury; Model IV: Age, FTB% and inhalation injury.

A p value of less than 0.05 was presented in bold.

^a Only data of survivors were analyzed.

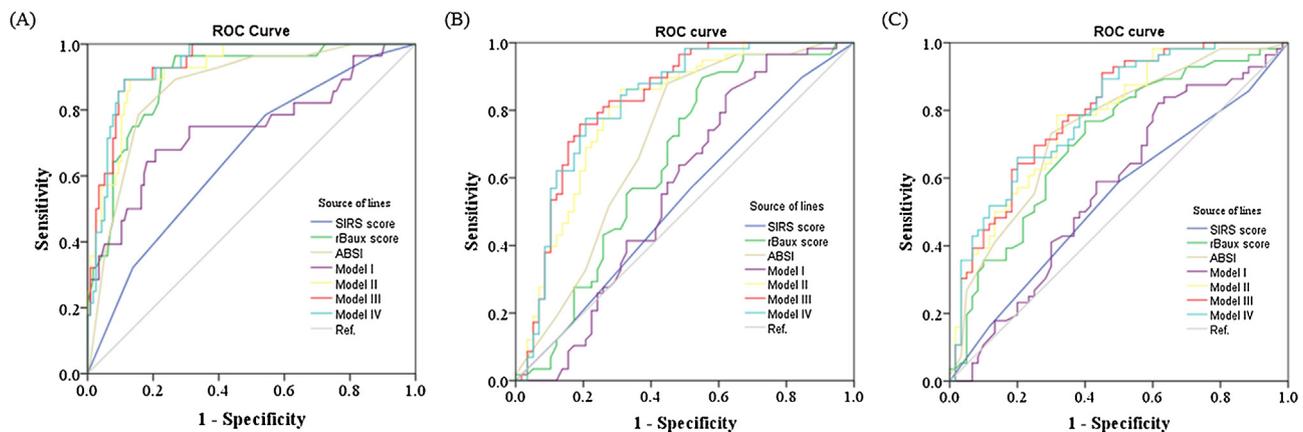


Fig. 3 – Area under the receiver operating characteristic curves (AUROCs) for discriminatory capacity for outcomes in patients with severe burns. (A) Mortality; (B) Hospital length of stay; (C) Intensive care unit length of stay. (ROC, receiver-operating characteristic; rBaux, revised Baux; ABSI, abbreviated burn severity index; Model I: Age and SIRS score; Model II: Age, percentage full-thickness burns (FTB%) and SIRS score; Model III: Age FTB%, SIRS score and inhalation injury; Model IV: Age, FTB % and inhalation injury.).

predictor of posttraumatic infection. Baek et al. [22] retrospectively reviewed 229 patients with multiple trauma and also found SIRS score independently predicted higher mortality. In a newly published study, Jacome and Tatum [18] reported a 15.2% of 330 patients with isolated traumatic brain injury met SIRS criteria upon admission. They also showed SIRS at admission could be an independent predictor of deleterious outcomes. In Kaukonen et al.'s [19] epidemiologic study including patients with infection and organ failure from 172 ICUs, 87.9% met SIRS criteria within twenty-four hours after admitting to ICU. However, Kaukonen et al. reported that SIRS was not a perfect predictor of ICU mortality. In our series, the proportion of patients with severe burns met SIRS criteria at admission was 88.9%. Considering that almost all patients with large burns usually met SIRS criteria, the phenomenon that the 11.1% patients in our study did not meet criteria for SIRS could partially be explained by the delayed assessment of admission scores in some patients (transferred to our center 24–72h post-burn). Another explanation may be that some patients were in a normal stress status or a mild inflammatory response at the time of admission. And according to statistical results, admission SIRS score was not an independent predictor of mortality, LOS and ICU-LOS.

Many score systems and prediction models have been developed for outcome prediction amongst burn patients. In 1961, Baux [23] developed a simple score based on age and TBSA burned. In 2010, Osler et al. [4] modified Baux score by adding 17 points when a patient suffered an inhalation injury. Before Osler, other studies have proposed models based on the same three predictors [24–26]. However, these models contained the three main burn-specific variables that only reflecting the severity of the initial injury but ignoring the pathological condition of individuals after burn. In 1982, Tobiasen et al. [12] described the score system ABSI based on analysis of more than 1300 patient clinical data. They demonstrated that ABSI was accurate at predicting risk of death. We confirmed in our study that both rBaux score and

ABSI were useful predictors of mortality, LOS and ICU-LOS in patients with severe burns. And both rBaux score and ABSI provided better prediction of outcomes when compared with SIRS score alone. Furthermore, ABSI was superior to rBaux score for prognostication of LOS and ICU-LOS. However, ABSI is hard to remember and inconvenient to use at bedside because the five variables included were subdivided into several ranges. Recently, APACHE III was proved to be significantly associated with burns mortality and be accurate at estimating risk of death [3]. And combining full-thickness burn areas with APACHE III is more accurate than either variable alone. Obviously, APACHE III is complex to calculate and mainly useful for critical patients who need to stay in ICU. In our work, we developed a model including variables age, FTB% and inhalation injury. Similar to Moore et al. [3], our results showed FTB% was associated with statistically significant increased risk of poor outcomes, so we preferentially used FTB% as a component of our models. As would be expected, the above mentioned multivariable model showed similar discrimination to other score systems or even better predictive value.

In the consensus conference held in 2007 in Tucson, the experts proposed that SIRS should not be applied to burn population as a diagnostic tool of infection or sepsis. In our work, we just used the SIRS score to reflect the relative degrees of individual response to injury at early stage. As previously reported, the addition of anatomic injury data to scoring systems could improve the predictive accuracy [27–32]. Finally, in the current study, the combined models indeed showed better predictive value than SIRS score alone. In addition, some models were equal or superior to other score systems for prognostication of outcome. However, adding SIRS score did not further improve the predictive ability beyond that achieved by multivariable model with variables age, FTB% and inhalation injury. Notably, this conclusion is based on statistical results. We speculated that it seemed clinically reasonable to add SIRS score (calculated

based on physiologic variables) to burn-specific variables, which could reflect burn severity and physiological response at the same time.

Some limitations cannot be ignored in our study, and the findings should be interpreted in the context of limitations mentioned below. First, this is a single center study with a relatively small number of patients with severe burns. However, to our best knowledge, this may be the one with the biggest sample size among its kind of research. Second, the difficulties in collecting the clinical data of those transferred-in patients at early stage (0–24h post injury) and the impact of treatment intervention on the components and reliability of SIRS diagnosis can lead to diagnostic bias. Third, we would like to highlight that we just developed a model with moderate to high discriminatory power for outcomes in patients with severe burns. We cannot comment on its validity on all burn patients so far, but it can be used as a guidance in clinical practice. Additionally, future prospective multicenter studies are warranted to confirm its validation.

5. Conclusions

Although major burns are likely to meet SIRS criteria, admission SIRS score was not an independent predictor of deleterious outcomes in this study. The model with the variables age, FTB%, and inhalation injury provided excellent prediction of poor outcomes in patients with severe burns, while SIRS score has limited use for prognostic determinations.

Conflict of interest

The authors declare no conflicts of interest.

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Author contribution

Substantial contributions to the design of the work: GSW, MZZ, YJ.

Acquisition, analysis and interpretation of data for the work: GSW, MZZ, YJ, JHF, YFS, ZYZ, ZFX and YS.

Drafting the work: GSW, MZZ, YJ.

Revising the work critically for important intellectual content: GSW, MZZ, YJ, ZFX, YS.

Final approval of the version submitted for publication: ZFX and YS.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at <https://doi.org/10.1016/j.burns.2018.11.011>.

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