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Research article

Epidemiology and risk prediction of patients with severe burns admitted to a burn intensive care unit in a burn center in beijing: A 5-year retrospective study

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ABSTRACT

Objective: This study was performed to describe the epidemiology of patients with severe burns hospitalized in a burn intensive care unit (BICU), explore the risk factors associated with the patients' outcomes and evaluate the ability of prognostic scoring systems as risk prediction of mortality.

Methods: The data for this study were derived from patients with severe burns in the BICU of Beijing Jishuitan Hospital from 2015 to 2019. The following epidemiological information and outcomes were collected for retrospective analysis: sex, age, date of injury, etiology of burn, admission time after injury, extent of burn, inhalation injury, length of stay, and outcome. Abbreviated Burn Severity Index (ABSI), prognostic burn index (PBI), the burn index (BI), Belgian Outcome in Burn Injury (BOBI) scores and the revised Baux (rBaux) scores were calculated.

Results: Of the 243 patients included in this study, the median age was 41.00 (22.00) years and the male: female ratio was 4.28:1.00. Most of the burns had occurred from March to July. Flame was the main cause of the burns (77.37%), followed by electricity (14.40%). In total, 78.19% of all patients sustained third-degree burns, and the median burn area and third-degree burn area of patients were 40% (53%) and 15.0% (43.0%) of the total body surface area, respectively. The incidence of inhalation injury was 69.14%. Tracheotomy was performed in 53.89% of the patients with inhalation injuries, and the rate of tracheostomy showing a rising trend. The median length of stay was 37 (40) days, and the case fatality rate was 8.64%. Multivariable logistic regression model indicated that age and third-degree burn area were risk factors for death, and the area under the receiver operating characteristic curve for the full prediction model was 0.921 (95% CI = 0.874–0.967).

Conclusions: The majority of severe burns are flame-related accidents in middle-aged men. Risk prediction model combining age and third-degree burn area has better mortality predictive value.

1. Introduction

Burns are a global health issue. The World Health Organization indicates that burns account for an estimated 180,000 deaths annually [1]. Approximately 26 million people in China sustain burns of different degrees every year, accounting for 2% of the total population. Burns not only lead to physical injuries; they are also accompanied by psychological and mental damage. In addition, the sequelae of burns, such as limb dysfunction, cicatrix formation, and cosmetic disfigurement, have a great impact on patients' lives. Many patients require prolonged surgical rehabilitation, which placed a major economic burden on the patients and their families. Recent advances in burn care have resulted in significant reductions in the rates of burn-related death and disability. However, the mortality rate of severe burns remains high [2]. The treatment of patients with severe burns has always been the focus and clinically difficulty of burn therapy, and epidemiological studies describing severe burns are limited. Severe burns are a research hotspot because of their high mortality and unique difficulty of treatment.

Various scoring systems consisted of the most predictive variables have been applied to critical ill burn patients to predict the severity and risk of mortality. Since Baux originally described a prognostic score based on age and percentage total body surface area (%TBSA) burned which

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gained wide international recognition, numerous new mortality prediction models had been created and applied [3]. The scoring systems used worldwide concluded Abbreviated Burn Severity Index (ABSI) [4], the burn index (BI) [5], the prognostic burn index (PBI) [5], Belgian Outcome in Burn Injury (BOBI) score [6], and the revised Baux (rBaux) score [7]. With the improvement of burn care, survival rate has significantly increased, while these scoring systems have been used for decades. Comparison of the predictive value of these scoring systems was lacking due to the fact that various scoring systems are used in different countries, and it were still few researches on assessing risk prediction in our country. Accurate risk predictions for patients with severe burns facilitate an objective assessment of outcomes and rational resource allocation. It is necessary to explore a new risk-related model and re-evaluate the predictive value of scoring systems. The present study was conducted in a BICU in a burn center in Beijing with the aim to analyze the epidemiological characteristics and outcomes of inpatients with severe burns and evaluate the prognostic value of ABSI, BI, PBI, BOBI, and rBaux. This may provide useful information for the prevention and treatment of burns, thus contributing to clinical decision-making and research.

2. Methods

2.1. Patient selection

This study was approved by the ethics committee of Beijing Jishuitan Hospital and performed in the burn department of this hospital, which is a tertiary hospital in China. The hospital treats inpatients with burns from Beijing and surrounding areas; it also receives referral patients from throughout the country. It is a prominent burn center in China. This center has three general wards (including 120 inpatient beds) and one BICU (including 6 BICU beds).

This study involved patients with severe burns admitted to the BICU from 2015 to 2019. Severe burns admitted to BICU were defined as: 1) a total burn area >30%TBSA for adults and a total burn area >15%TBSA for children; 2) three-degree burn area >10%TBSA for adults and three-degree burn area >5%TBSA; 3) The burn area of patients does not meet the above criteria but the following conditions are present: inhalation injury; shock or other pre-existing disorders that could elevate mortality. The inclusion criteria for this study were hospitalization in the BICU from 1 January, 2015 to 31 December, 2019 and a diagnosis of burns, patients with severe burns of all ages and both sexes were included. The exclusion criteria were a diagnosis of traumatic cutaneous injuries and other non-burn-related issues, readmission, and duplicate patients.

2.2. Burn care in the BICU

Basic treatment options for burns include individualized fluid resuscitation, airway patency, wound repair, nutritional support, sedative and analgesic treatment.

At the time of admission, patients are first assessed and treated urgently by a team of burn doctors. Patients with larger injuries involving intensive care and systematic support will be hospitalized at BICU. At shock stage, appropriate fluid resuscitation is performed according to the burn area and general conditions, the volume and speed of fluid replacement are timely adjusted according to clinical indicators. Injuries to the skin need to be repaired by wound dressings or some form of skin replacement. When the clinical hemodynamics is stabilized, tangential excision and skin grafting are performed at the earliest opportunities, and surgery is usually performed multiple times.

Patients with a history of burns in confined space and on the face, especially around the mouth and nose, with charred nose hair, carbonized sputum, hoarseness, irritable cough or dyspnea, are given a bronchoscopy and diagnosed as inhalation injuries, and the prevention and treatment are initiated. Prophylactic tracheostomy will be performed as soon as possible in patients assessed for potential airway obstruction. Timely establishment of artificial airway is one of the important measures for treatment. Mechanical ventilation is available when necessary.

2.3. Data collection

The patients' medical records were obtained using the electronic medical record system in the hospital. Two investigators independently made judgments and extracted valid information, and disagreements were resolved through consensus consultation. The following data were extracted from the medical records: age, sex, date of the injury, etiology, admission time after injury, the extent of the burn, inhalation injury, length of stay (LOS), and patient outcomes. The burn area was assessed according to the Chinese rule-of-nine and rule-of-palms method [8]. Burn scoring systems were calculated. ABSI was calculated by adding the scores of five variables: gender, age, inhalation injury, %TBSA and presence of full-thickness burn [4]. BI $= 1/2 \times$ %TBSA of second-degree burns + %TBSA of third-degree burns, PBI = BI + age [5]. BOBI was calculated by dividing patients according to age, %TBSA, and inhalation injury [6]. The rBaux scores = age +%TBSA burned + inhalation injury (yes = 17, no = 0) [7]. The patients were classified into three age groups: children (0–14 years old), adults (15–59 years old), and advanced-age adults (≥60 years old).

2.4. Statistical analysis

Microsoft Excel 2019 (Microsoft Corp., Redmond, WA, USA) and SPSS version 26 (IBM Corp., Armonk, NY, USA) were used to process and analyze the extracted data. Numerical variables with a normal distribution are presented as mean ± standard deviation, and group comparisons were performed using variance analysis. Numerical variables with a non-normal distribution are presented as median (interquartile range [IQR]) for statistical descriptions, and group comparison were performed using a non-parametric test (Mann–Whitney U test or Kruskal–Wallis rank sum test). For classified variables, frequency and percentage were used for statistical descriptions, and the $\chi 2$ test or Fisher's exact test was used for group comparisons. Further comparisons were corrected by the Bonferroni method. The Mantel–Haenszel test and the Pearson's correlation coefficient were used to determine relationships between variables. Multivariable logistic regression model was used to predict the risk factors for death, and receiver operating characteristics (ROC) curve were drawn to assess the discriminative power of the regression model, ABSI, BI, PBI, BOBI, and rBaux scores. The area under curve (AUC) was calculated. A P value of <0.05 was considered statistically significant.

3. Results

3.1. General characteristics

This investigation included 243 patients with burns admitted to the BICU of Beijing Jishuitan Hospital from 2015 to 2019. The median number of patients treated during each of the 5 years of the study period was 49 (range, 45–51). 42.80% of patients were admitted to the hospital ≤6 h. Among all hospitalized burn patients, the rate of tracheostomy increased from 21.6% to 60.4%, showing a rising trend, as is shown in Table 1.

The median age of the patients was 41.00 (IQR, 22.00) years, with a range of 3–91 years. Children (0–14 years old), adults (15–59 years old), and advanced-age adults (≥60 years old) represented 3.29%, 83.13%, and 13.58% of all patients, respectively. Among them, nearly half of all patients are between 30 and 50 years old (46.91%). Most of the patients were male (81.07%), with a male: female ratio of 4.28:1.00. This ratio in children, adults, and advanced-age adults was 1.0:1.0, 5.3:1.0 and 2.3:1.0, respectively (Table 2).

Table 1. Demographics of patient population from 2015 to 2019.

	Patients (n)	Age (median (IQR),y)	Sex (male/female, %)	admission time after injury (≤6h/others, %)	Etiology (flame/others, %)	Burn area (median (IQR), (% TBSA))	Inhalation injury (n (%))	Tracheotomy (n (%))	Length of stay (median (IQR), d)	Death (n (%))
2015	51	42 (23)	78.4/21.6	31.4/68.6	76.5/23.5	35 (45)	31 (60.8)	11 (21.6)	31 (31)	7 (13.7)
2016	50	37.5 (23)	86.0/14.0	42.0/58.0	64.0/36.0	42.5 (55)	33 (66.0)	15 (30.0)	38 (43)	2 (4.0)
2017	45	47 (23)	77.8/22.2	55.6/44.4	82.2/17.8	35 (46)	29 (64.4)	16 (35.6)	49 (49)	2 (4.4)
2018	49	40 (25)	79.6/20.4	36.7/63.3	73.5/26.5	50 (60)	37 (75.5)	24 (49.0)	38 (45)	6 (12.2)
2019	48	41 (22)	83.3/16.7	50.0/50.0	91.7/8.3	45 (55)	38 (79.2)	29 (60.4)	35 (38)	4 (8.3)
Total	243	41 (22)	81.1/18.9	42.8/57.2	77.4/22.6	40 (53)	168 (69.1)	95 (39.1)	37 (40)	21 (8.6)
p value	-	0.818	0.848	0.147	0.020	0.236	0.235	<0.001	0.794	0.824

Table 2. Epidemiological characteristics of patients in different age groups.

Patient characteristics	All patients (n = 243)	0–14years (n = 8)	15–59years (n = 202)	≥60 years (n = 33)	*p* value
Sex, n (%)					0.012
Male	197 (81.07)	4 (50)	170 (84.20)	23 (69.70)	
Female	46 (18.93)	4 (50)	32 (15.80)	10 (30.30)	
Etiology, n (%)					0.149
Flame	188 (77.37)	6 (75)	153 (75.74)	29 (87.88)	
Electricity	35 (14.40)	0 (0)	33 (16.34)	2 (6.06)	
Scald	11 (4.53)	2 (25)	8 (3.96)	1 (3.03)	
Chemical	9 (3.70)	0 (0)	8 (3.96)	1 (3.03)	
Admission time after injury, n (%)					0.746
≤6h	104 (42.80)	3 (37.50)	86 (42.57)	15 (45.45)	
>6h and ≤24h	50 (20.58)	3 (37.60)	42 (20.79)	5 (15.15)	
>24h	89 (36.63)	2 (25)	74 (36.63)	13 (39.39)	
Total burn area, median (IQR) (% TBSA)	40 (53)	30 (18)	40 (55)	40 (50)	0.529
Third-degree area, median (IQR)	15 (43)	0 (5)	15 (48)	19 (35)	0.019
Inhalation injury, n (%)					0.727
With	168 (69.14)	6 (75)	141 (69.80)	21 (63.64)	
Without	75 (30.86)	2 (25)	61 (30.20)	12 (36.36)	
Outcome, n (%)					0.119
Survived	217 (89.30)	8 (100)	183 (90.59)	26 (78.79)	
Died	21 (8.64)	0 (0)	14 (6.93)	7 (21.21)	
Others	5 (2.06)	0 (0)	5 (2.48)	0 (0)	

3.2. Distribution by month

Burns occurred during every month of the year and more frequently from March to July. As shown in Figure 1, this trend was much more prominent in male patients, but no significant trend was observed among female patients in the distribution of patients by month.

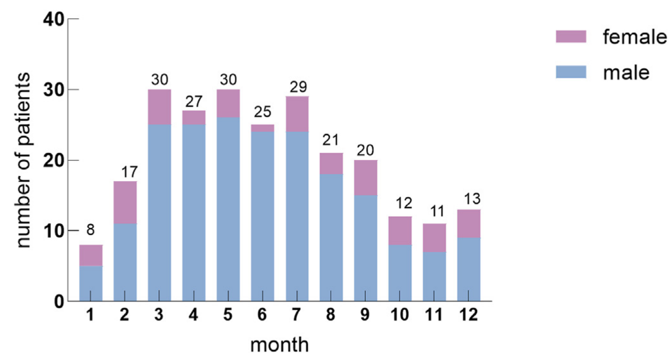

Figure 1. Distribution of patients by month.

3.3. Etiology

Flame was the predominant cause of burns in this study, accounting for 77.37% (188/243) of all burns, and chemical burns accounted for the least of all burns. Advanced-age adults has the highest proportion of flame-induced burns. In addition, 35 patients with electrical burns were male, including 3 patients injured by electrical arcs and 32 patients injured by electric currents.

3.4. Extent of burns

Figure 2 shows the distribution of the total burn areas and third-degree burn areas among all patients. The total burn area ranged from 2% to 100% TBSA, and the median TBSA was 40% (IQR, 53%). The highest were 35.39% (86/243) of patients with a total burn area of ≤20% TBSA. While 46.91% of patients had a total burn area >40% and patients with a total burn area of >80% TBSA accounted for 13.99% (34/243). A total of 190 patients sustained third-degree burns, accounting for 78.19% of all patients, and their median TBSA was 15% (IQR, 43%). The third-degree burn area was significantly lower in children than in the other age groups.

3.5. Inhalation injuries

A total of 168 patients sustained inhalation injuries, accounting for 69.14% of all patients. Two hundred patients had facial burns, and the rate of inhalation injury among these patients with facial burns was 79.5% (159 patients). Patients with facial burns were more prone to inhalation injury, with an odds ratio (OR) of 3.915 (95% confidence interval [CI], 1.473–10.403). The risk of inhalation injury in patients

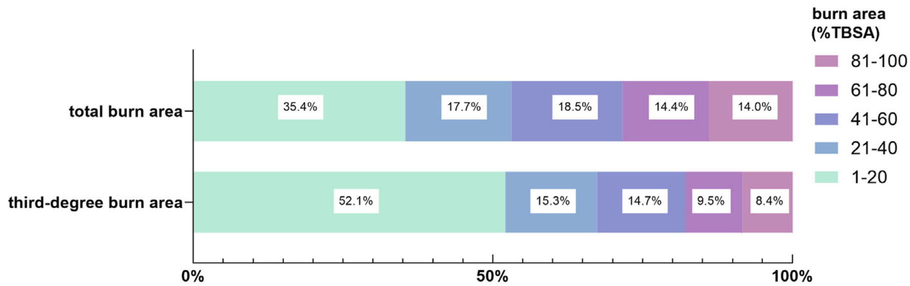

Figure 2. Distribution of total burn area and third-degree burn area.

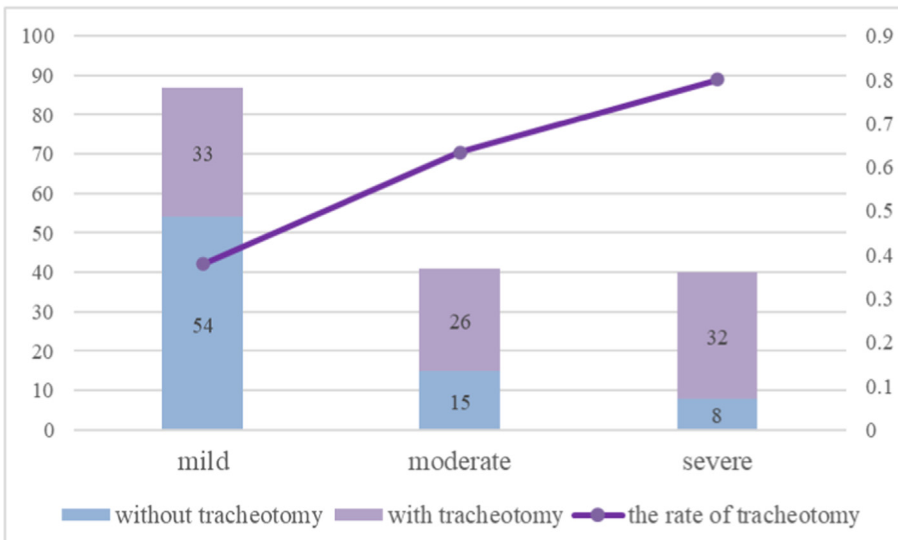

Figure 3. The rate of tracheotomy in patients with different degrees of inhalation injuries.

with facial burns was 2.924 times higher than that in patients without facial burns (95% CI, 1.254–6.816).

Among patients with inhalation injuries, 87 (35.80%), 41 (16.87%), and 40 (16.46%) had mild, moderate, and severe inhalation injuries, respectively. Tracheotomy was performed in 53.89% of patients with inhalation injuries. As shown in Figure 3, the rate of tracheostomy in patients with mild, moderate and severe inhalation injuries were 37.93%, 63.41% and 80.00%, respectively. The Mantel–Haenszel test for

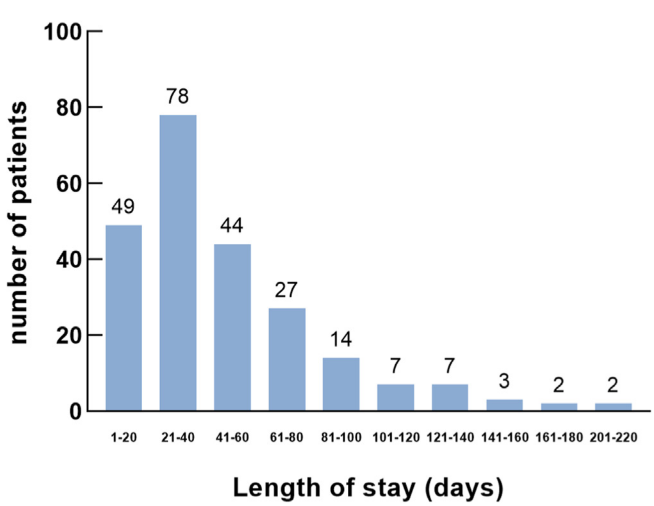

Figure 4. Distribution of length of stay.

linear trend revealed a linear relationship between the severity of inhalation injury and the rate of tracheotomy ($P < 0.001$), and Pearson's correlation showed that the rate of tracheotomy was positively correlated with the severity of inhalation injury ($r = 0.547$, $P < 0.001$).

3.6. LOS

The median LOS was 37 (IQR, 40) days, ranging from 1 to 213 days. Figure 4 shows the distribution of the LOS in this study. The LOS for most patients ranged from 20 to 40 days, accounting for 32.10% (78/243) of all patients. Among the various age groups, the LOS of advanced-aged adults was significantly longer than that of adults ($P = 0.014$). LOS was positively correlated with burn index and ABSI scores, whereas it showed no significant correlation with PBI, BOBI and rBaux scores (Figure 5, a-e).

3.7. Outcomes and logistic regression

Among the 243 patients hospitalized in the BICU, 21 (8.64%) patients died. Five patients were transferred to other hospitals or stopped treatment for various personal reasons. No patients with a total burn area of <40% TBSA died, and the mortality rate of patients with 40%–59%TBSA, 60% to 79%TBSA, and 80%–100% TBSA were 14.29% (n = 3), 28.57% (n = 6), and 57.14% (n = 12), respectively.

Table 3 showed the characteristics of patients with severe burn admitted to BICU comparing survivors with non-survivors. Compared with the survival group, the non-survival group had older age, a higher proportion of flame burns, a larger total burn area and three-degree burn

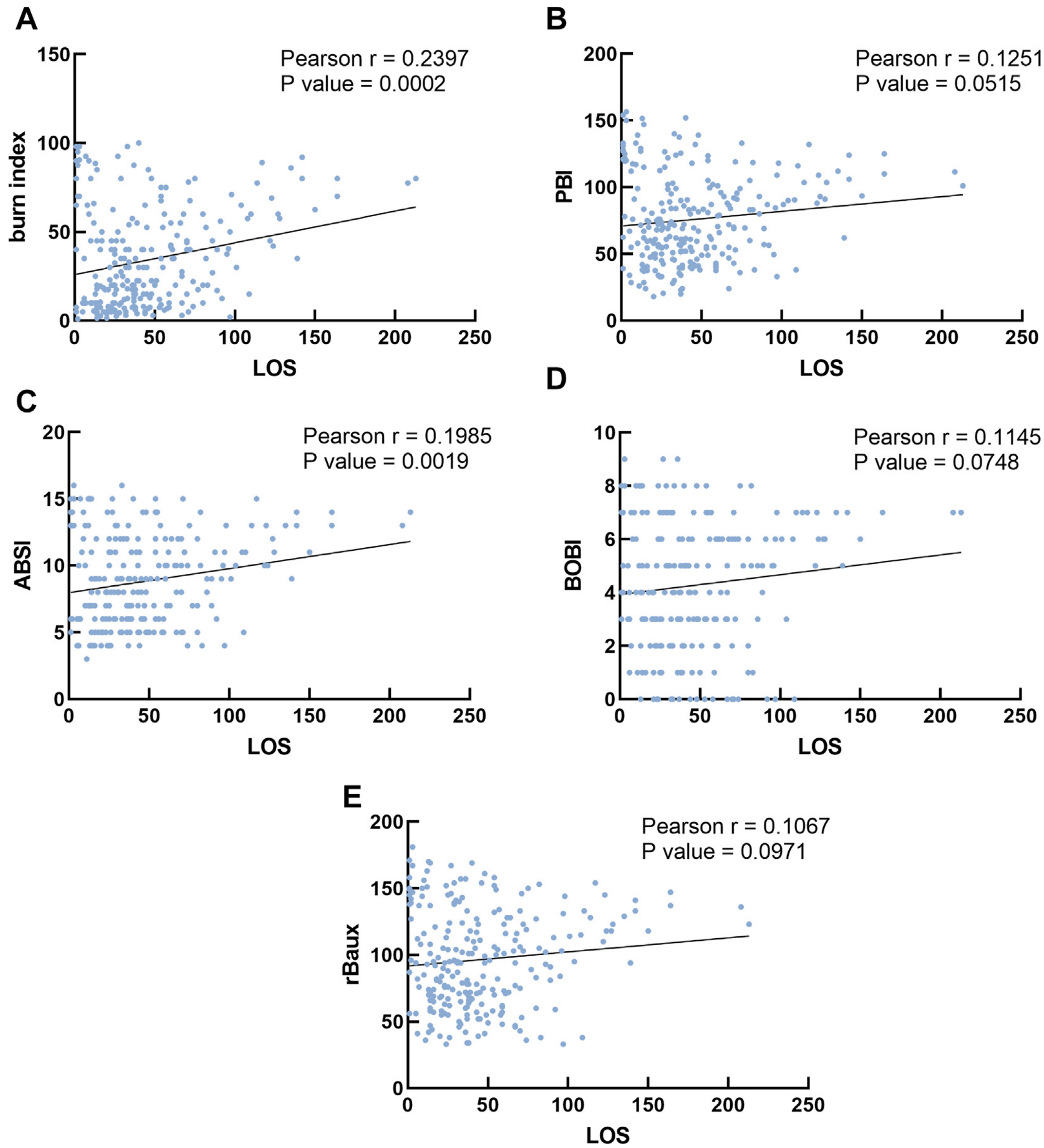

Figure 5. A. Pearson correlation analysis between LOS and BI. B. Pearson correlation analysis between LOS and PBI. C. Pearson correlation analysis between LOS and ABSI. D. Pearson correlation analysis between LOS and BOBI. E. Pearson correlation analysis between LOS and rBaux.

area, a higher rate of inhalation injury and tracheotomy. Therefore, we incorporated potential variables including age, etiology, total burn area, three-degree burn area, extent of inhalation injury and tracheotomy into multivariable regression model. Table 4 shows the results of multivariable logistic regression model. The new predictive model for the probability of death risk was as follows: $p = e^{logit(p)}/1 + e^{logit(p)}$, logit(p) = -7.676 + 0.059*age+0.057* third-degree burn area (%TBSA), which indicated that the significant independent risk factors for death were age and third-degree burn area. Inhalation injuries, total burn area and etiology were excluded from the results of multivariable analysis.

3.8. ROC analysis

ROC curves for the full model and other predictive score systems were performed to further assess mortality prediction power (Figure 6). Table 5 showed that the area under the curve (AUC) of the full model was 0.921 (95% CI = 0.874–0.967), Youden's index was a maximum of 0.781, with a sensitivity and specificity of 0.952 and 0.829, respectively. Table 6 demonstrated the results of NRI (Net Reclassification Index) of this model compared with other predictive score systems. All NRIs>0, its predictive power has improved statistically compared to BI, ABSI and BOBI ($p < 0.05$), but there was no significant difference compared with PBI, and rBaux scores.

4. Discussion

This study summarized the epidemiological characteristics and risk prediction of patients with severe burns admitted to the BICU in Beijing Jishuitan Hospital during a 5-year period. This hospital is one of the most highly representative burn clinics in China and receives a large number of critically ill patients. Therefore, analysis of the patients at this hospital can accurately reflect the epidemiological characteristics of patients with severe burns in China and provide broad, reliable and representative reference data for the prevention, diagnosis, and treatment of patients with severe burns.

This study shows that the majority of patients with severe burns are male, and the main population comprises middle-aged patients; these findings are similar to previously reported conclusions [9]. The male: female ratio of patients admitted to the BICU in this study was 4.28:1.00, and this proportion is significantly higher than that of patients in the

Table 3. Baseline characteristics of patients comparing survival and non-survival groups.

Characteristics	All patients (n = 238)	Survival (n = 217)	Died (n = 21)	*p* value
Sex, n (%)				0.746
Male	192 (80.7)	174 (80.2)	18 (85.7)	
Female	46 (19.3)	43 (19.8)	3 (14.3)	
Age, median (IQR)	42 (23)	40 (22)	52 (26)	0.005
Etiology, n (%)				0.020
Flame	184 (77.3)	163 (75.1)	21 (100)	
Others	54 (22.7)	54 (24.9)	0 (0)	
Admission time after injury, n (%)				1.000
≤6h	102 (42.9)	93 (42.9)	9 (42.9)	
>6h	136 (57.1)	124 (57.1)	12 (57.1)	
Total burn area, median (IQR) (%TBSA)	40 (52)	35 (45)	85 (42)	<0.001
Second-degree area, mean (IQR)	10 (21)	10 (25)	10 (16)	0.086
Third-degree area, median (IQR)	15 (39)	10 (36)	65 (41)	<0.001
Inhalation injury, n (%)				0.002
Without	75 (31.5)	74 (34.1)	1 (4.8)	
Mild	86 (36.1)	80 (36.9)	6 (28.6)	
Moderate	38 (16.0)	30 (13.8)	8 (38.1)	
Severe	39 (16.4)	33 (15.2)	6 (28.6)	
Tracheotomy				<0.001
With	91 (38.2)	75 (34.6)	16 (76.2)	
Without	147 (61.8)	142 (65.4)	5 (23.8)	
LOS, median (IQR)	37 (41)	39 (43)	10 (22)	0.119
ABSI, median (IQR)	8 (6)	8 (5)	13 (3)	<0.001
BI, median (IQR)	25.00 (43.13)	20 (33)	70 (33.25)	<0.001
PBI, median (IQR)	70.25 (49.00)	68 (41.5)	126.5 (19.25)	<0.001
BOBI, median (IQR)	4 (3)	4 (4)	7 (1)	<0.001
rBaux, median (IQR)	94 (60.25)	89 (53.5)	149 (20.5)	<0.001

Table 4. Multivariable logistic regression model of risk factors for death of patients in BICU.

Variables	B	Std. Error	OR	95% CI	*p* value
Age	0.059	0.018	1.061	1.023–1.100	0.001
Three-degree burn area, % TBSA	0.057	0.011	1.059	1.037–1.081	<0.001
Constant	-7.676	1.326	-	-	-

Hosmer–Lemeshow C statistic $\chi^2 = 3.793$, p value = 0.875.

general ward of this hospital [2]. A systematic review showed that about one-third of severe burns in adults were work-related [10], and work-related burn injuries have been found to affect a greater proportion of men [11]. Young and middle-aged men represent the main labor force of production industries in China, and they are therefore more prone to work-related flame-induced burns. Male patients may more commonly have severe burns than ordinary burns. Therefore, the safety protection of workplaces to adults should be strenghtened. The proportion of advanced-age men in this study was lower than that of other ages. This might be because most advanced-age men have retired and are thus at low risk of workplace injuries. However, with the decline in physiological function and the weakening of resistance in advanced-age patients, most of these patients have chronic diseases and a poorer prognosis after burn injuries.

Burns in this study were more likely to occur between March and July, which is the warmer period of the year in China. This trend among male patients is obviously due to work-related injuries. However, the seasonal distribution trend of female patients was not significant; this may be related to women having a greater risk of burns at home and during household work. Serious burns in females are mostly caused by explosions of gas tanks, so the maintenance of gas pipelines and safety education to citizens are of great importance. Flames are still the main cause of inpatient burns, which is consistent with multiple studies from both China [12, 13]and abroad [14, 15, 16]. However, the incidence of electrical burns has significantly increased, which is a key factor for burn prevention that cannot be ignored. Studies in Canada [17] and the United States [18] have shown higher proportions of electrical burns than those found in the present study (approximately 32% and 20%, respectively). Notably, a previous study showed that the proportion of electrical burns sustained in the workplace was seven times greater for work-related burns than for non-work-related burns [11]. Therefore, efforts to prevent electrical burns cannot be slackened. The key to prevention of severe burns are the establishment of complete protection and safety measures based on etiology, and the popularization of safety awareness.

This hospital received a great number of patients with large-area burns. Nearly half of patients had a burn area >40% and approximately 14% of patients had a burn area >80%. In total, 78.19% of patients had third-degree burns, and the LOS of patients with severe burns was always long. LOS has the highest correlation with BI, indicating that LOS is mainly related to burn area and burn depth. Most of the patients in the BICU are seriously ill. Third-degree burns were the main risk factor for mortality and should be the focus of treatment and research. The third-degree burns in children were less severe than in other age groups. This may be because scalding was the main cause of pediatric burns [19], whereas the proportion of burns caused by flames increased as the severity of burns increased [9].

The rate of inhalation injury in patients with severe burns admitted to the BICU was up at 69.14%. Additionally, a hospital in Shanghai reported a 71.8% incidence of inhalation injury in patients with a total burn area of ≥70% TBSA [13]; however, most hospitals in China have reported a 19.09%–32.38% incidence of inhalation injury in patients with severe burns [20, 21]. In the present study, nearly 80% of patients had facial burns; therefore, a high proportion of patients had inhalation injuries. The present study also showed that mild inhalation injuries accounted for the majority, similar to a previous study [22]. The rate of the tracheotomy among this patients was 53.89%, which was positively correlated with the severity of inhalation injury and higher than the rate in a previous study in this hospital [22], and the rate of tracheotomy increased gradually from 2015 to 2019. At present, early tracheotomy is an important treatment measure for inhalation injury; it has gradually gained attention in the treatment of patients with severe burns and has greatly decreased the case fatality rate. According to the experience and guidelines for the treatment of inhalation injury that has been formed in China, tracheotomy is advocated to be performed in a non-emergency state rather than intubation. Early prophylactic tracheotomy is advocated and should not be limited to traditional indicators such as blood gas analysis and oxygen saturation. However, prophylactic tracheotomy is controversial and is not recommended by Western countries [23]. Some countries prefer intubation for airway management. Tracheotomy has many advantages, including reducing upper airway obstruction, preventing laryngeal and upper respiratory tract injuries due to prolonged endotracheal intubation, and being easier to care for the airway than endotracheal intubation [24]. Most mild to moderate inhalation injuries only exist in the respiratory tract, which does not damage the lung parenchyma and affect its gas exchange function. Therefore, it is possible to cure most of the patients with inhalation injury when the respiratory tract is kept unobstructed, and the respiratory mucosa and the functions of anatomical structures are restored.

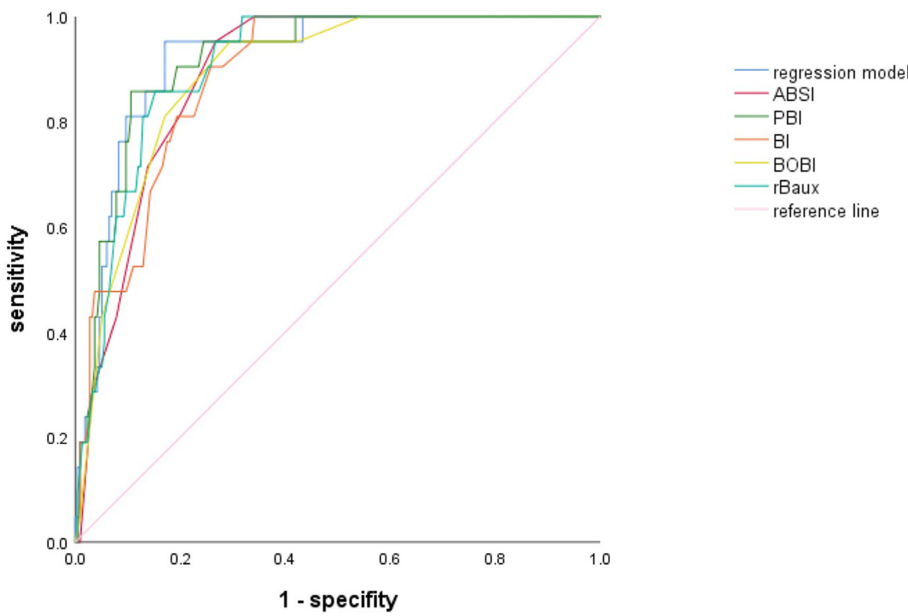

Figure 6. Receiver operating characteristics curve of predictive models.

Table 5. ROC analysis results of the full model and other score systems.

Prediction models	AUC	95%CI	threshold	sensitivity	specificity	Youden index
Logistic regression model	0.921	0.874–0.967	-	0.952	0.829	0.781
ABSI	0.892	0.845–0.938	10	0.952	0.747	0.699
BI	0.888	0.835–0.940	36.25	1	0.659	0.659
PBI	0.917	0.870–0.965	112.25	0.857	0.894	0.751
BOBI	0.880	0.822–0.937	5	0.905	0.724	0.628
rBaux score	0.908	0.863–0.952	132	0.857	0.857	0.714

Table 6. NRI of the full model and other score systems.

Models	NRI	z	P value
New model vs PBI	3.00%	0.432	0.666
New model vs rBaux	7.60%	1.119	0.263
New model vs BI	12.20%	2.202	0.028
New model vs ABSI	8.20%	4.208	<0.001
New model vs BOBI	15.20%	2.913	0.004

The fatality rate of patients with severe burns in this study was 8.64%, which is lower than in some other areas in China [9, 13, 20] and abroad [16, 25, 26]. None of the patients with a burn area of <40% died, suggesting that the current level of treatment of severe burns has been significantly improved. Some reports [9, 27] have indicated that the admission time after injury and the presence of inhalation injury are also risk factors for death, which was different in this study. Our results excluded the effect of inhalation injury, and demonstrated that risk prediction model combining age and third-degree burn area had better mortality prediction value. Partial thickness burns and inhalation injury were not associated with mortality in the multivariable analysis. This was confirmed by the high accuracy of PBI in risk prediction compared to other scoring tools. PBI is widely used in Japan and takes into account the effects of age and different burn thickness. With the improvement of the airway care in burn treatment in recent decades, actively tracheotomy, promoted in our country, has greatly reduced the impact of inhalation injuries on mortality. At present, the most predictable independent factors of death were age and third-degree burns in this study.

The tool for the disease risk prediction applied in clinical should be simple and practical. The main components of several previous used prediction tools are sex, age, burn area, burn depth, and inhalation injury, and the differences among these scoring systems were the variables included and the weights assigned. The risk prediction model combining age and third-degree burn area in this study could also provide an accurate estimate of mortality, the predictive ability was similar to PBI, but higher than other scores. PBI is a useful tool for clinical mortality prediction, it is simple to apply and widely used in Japan to assess the severity of disease. A nationwide retrospective study of the validation of PBI showed that a PBI above a threshold of 85 was significantly associated with mortality [5], which was 112.25 in our study. Some studies also suggested that laboratory indicators such as the acute physiology and chronic health evaluation (APACHE) III score could be used as another alternative efficient predictor of mortality in burn patients [28], but it is complex and need further verification.

This study has several limitations. One limitation is that this study was only conducted at a single burn treatment center, and therefore the sample size of patients with severe burns was not large enough. Another limitation is that we could not compare and validate other scoring systems such as APACHE III score due to the difficulty of obtaining laboratory indicators. In addition, we were unable to obtain follow-up data for a few individual patients because of referral or abandonment of treatment. Although the number of these patients was small, this may have resulted in some missing data. Nevertheless, this study provides important information on the epidemiology and outcomes of patients with severe burns in the BICU in recent years, and the data can thus serve as a reference for the development of severe burn prevention strategies.

Declarations

Author contribution statement

Cheng Wang: Conceived and designed the experiments; Performed the experiments.

Zhe Dou: Conceived and designed the experiments; Analyzed and interpreted the data; Wrote the paper.

Fengjun Qin: Performed the experiments; Contributed reagents, materials, analysis tools or data.

Guo-An Zhang: Performed the experiments; Wrote the paper.

Hui Chen, Yuming Shen: Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data.

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Data availability statement

Data will be made available on request.

Declaration of interest's statement

The authors declare no competing interests.

Additional information

No additional information is available for this paper.

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