

Prediction of Mortality in Pediatric Burn Injuries: R-Baux Score to Be Applied in Children (Pediatrics-Baux Score)

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Abstract

Objective: R-Baux score has obtained an acceptable validity and accuracy in predicting burn-related mortality. However, its usage and efficacy among pediatric burn patients has not been well documented. The aim of this study was to employ Pediatrics-Baux (P-Buax) score as modified version of R-Baux score in these patients to determine how it could be applicable in this population.

Methods: Through a prospective study, 870 pediatric burn patients were enrolled. P-Baux and R-Baux scores were calculated for each patient and they were categorized to different groups according to these scores. Mortality and further death probability were measured for each subject and then analyzed by logistic regression model to reveal how they change in relation with age in pediatric burn patients.

Findings: R-Baux score for 95% probability of death revealed a mean of 73 among patients of this study. Also P-Baux score was measured in these patients with inhalation injury which showed to be 55 for 95% probability of death. Results showed that age had a positive prognostic value in contrast to the negative prognostic value of Total Body Surface Area (TBSA) and inhalation injury.

Conclusion: Our analysis showed that in children under the age of 15 years, age has a positive prognostic value while TBSA and inhalation injuries had negative prognostic values in relation to mortality. Hence, in contrast to the adult population, burn injury related mortality may be predicted by modified R-Baux score as (TBSA - age + [18×R]) which could be named as P-Baux score.

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Key Words: Burns; Thermal Injury; Inhalation Burns; Children; Baux Score

Introduction

Survival after occurrence of a burn injury has dramatically increased over the past decades^[1-3]. However, burn is still causing a considerable morbidity and mortality for its victims^[4,5]. Several predicting models have been developed to estimate the risk of mortality in these patients^[6-10] among which Baux score points to the important

relationship of total burned surface area (TBSA) and age with the overall probability of death^[11]. However, with increasing incidence of inhalation injuries among victims of burn, the concerns has been raised about the necessity of including such critical determinant in these models; hence, the revised Baux score (R-Baux score) has been developed to resolve the mentioned issue. In fact, the purpose of developing such scoring model was

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the need to recalibrate the original Baux score after introduction of newer treatment options for burn patients. Therefore the outcome of modern burn care could be predicted while the primary simplicity of the formula is maintained^[12]. Despite universal acceptance of modified Baux score (R-Baux score) in prediction of burn mortality, this score has not been well studied among pediatric population. It seems that in this group of patients, based on R-Baux score, mortality rate raises as the age increases. However, the probability of death may be greater in younger children especially neonates as is seen in critical circumstances.

Hence, we aimed to investigate the applicability of this scoring model discretely in children with burn injuries to determine how P (Pediatric)-Baux score can predict prognosis in this population.

Subjects and Methods

Patient selection

We enrolled pediatric cases of burn injuries which were admitted to emergency department of Motahari Burn hospital in Tehran (the most great referral center in Iran) during 2005 to 2009. Patients were evaluated physically to determine the extent and severity of burn injuries, general conditions, and vital signs. Then they were stabilized and admitted to the pediatric ward of the hospital for further management. Inclusion criteria were age of less than 15 years and need to be admitted due to the severity of their burn injuries.

Data collection

The following data was recorded for each patient: demographics, epidemiologic characteristics, clinical features of their injuries, mechanism of injury and cause of burn, total body surface area (TBSA by the Lund and Browder method calculated by two independent physicians on admission), presence of inhalation injury (defined on the basis of exposure to smoke, burn injury in a closed space, presence of carbonaceous sputum, signs of airway obstruction, deterioration of PO₂ in serial Arterial Blood Gas (ABG) tests and/or positive findings in bronchoscopy).

Scoring model for prediction of mortality

According to TBSA, patients were divided into 4 categories: 0-10%, 10-20%, 20-40%, and >40%. Also, children were categorized into five age groups of infants (0-1 year), toddlers (1-2 years), early childhood (2-6 years), primary school (6-10 years), and secondary school (10-15 years).

R-Baux score to predict the probability of death after burn injury was calculated for each patient by following formula: R-Baux score = (TBSA + age + [17×R]). {R=1 if patient has inhalation injury and R=0 if not}. The measurement of this score in our patients revealed that in contrast to adults, increasing age in children may have inverse relationship with the score bearing a positive prognostic value. In addition, presence of inhalation injuries seems to add an additional 18 to the score leading to more probability of death according to our analysis. Hence, P-Baux score for the 95% probability of death in our population was calculated as follows:

P (Pediatric)-Baux score = (TBSA-age + [18×R]). {R=1 if patient has inhalation injury and R=0 if not}.

Patients were then categorized based on the calculated P-Baux score to reveal the relationship between percentages of death occurrence with calculated score.

Statistical analysis

Data were analyzed by Statistical Package for Social Sciences (SPSS version 16, Washington, Inc.). The logistic regression model was performed to reveal the effects of age, TBSA, and inhalation injury on mortality. We then developed a modified Revised Baux score (as Pediatric Baux score) by a second logistic regression model to estimate the probability of death.

Findings

Age, TBSA, number of patients with inhalation injury, and number of deaths are presented in Table 1. 10.6% of patients died and 9.5% of the patients (82 cases) had complications requiring ICU admission. Overall 60 (6.9%) patients had inhalation injury. 31 cases of inhalation injuries

Table 1: Demographics, TBSA, and outcomes of the patients with burn injuries

Features		
Age		4.19± (years)
Gender	Male	550 (63.3%)
	Female	320 (36.7%)
TBSA		21 ± (%)
Number of patients with inhalation injury		60 (6.8%)
Hospital stay		11.44 ±
Number of deaths		89

TBSA: Total Body Surface Area

were due to gas explosion. Among patients who had inhalation injury, 18 (33.3%) patients died; however, in patients without inhalation injury (810 cases), 71 (8.7%) patients died with a statistically significant difference ($P<0.01$). Sex and age distribution of burn injury is depicted in Table 2.

Among inhalation injury cases (total=60), 49 (81.7%) patients were in a closed space during the accident compared to 11 (18.3%) patients in an open space.

Flame related burn injuries accounted for 57% of the deaths and 43% were due to scalds. 8 cases of death were due to multiple organ failure compared to 7 deaths due to infection and sepsis (Table 3). Inhalation injury increased the risk of death for 5.1 folds ($P<0.0001$). Fifteen patients (25%) with inhalation injury developed severe respiratory failure and were admitted to intensive care unit (ICU) for intensive respiratory care. Patients diagnosed with sepsis had 11% mortality compared to those without sepsis (9.4%) which did not reveal a statistically significant difference ($P>0.05$).

In the four year period of our study, there were 89 (10.6%) in-hospital deaths due to burn of which 64 (72%) cases occurred in patients with a burned area of more than 40%.

Table 2: Comparison of sex in different age groups in Pediatric Burn Injuries

Age groups (years)	Male	Female	Total
0-1	78	42	120 (13.8%)
1-2	148	82	230 (26.4%)
2-6	199	131	330 (37.9%)
6-10	70	43	113 (13%)
10-15	55	22	77 (8.9%)
Total	550 (63.3%)	320 (36.7%)	870 (100%)

Seventy seven patients (8.8%) aged between 10 and 15 years old. In this group, 14.2% patients died due to severe morbidities which was the highest amount of mortality rate among these five groups. Odds ratio (OR) was 2.74 for female sex, 0.758 for an additional year of age, 1.27 for an additional percent of TBSA. OR for inhalation injury among flame burn victims was 255.5. Comparison between age and TBSA is depicted in Table 4.

Patients were categorized into 12 groups according to R-Baux score to compare the percentage of death (Table 5). P-Baux score was calculated for each patient and then compared with the occurrence of death; the probability of death was then calculated by percentages of the patients who died compared to total number of patients which received similar score in a unique category. It is obvious that "P-Baux score" has a direct relationship with mortality rate of patients and had a relatively higher predictive value ($r=0.57$). Fig. 1 shows the direct and sigmoid relationship of "P-Baux" to patients' death. Scores less than 50 were associated with no probable mortality while the likelihood of death increased from the score of 50 to 100 and stayed at a 100% probability from 100 to the highest score which was 130 (Table 5).

Table 3: Comparison of the causes of burns in the different age groups

Age (years)	Scalds	Flame	Hot material	Electricity	Acid	Total
0-1	104	4	6	6	0	120
1-2	204	20	3	3	0	230
2-6	233	80	6	18	3	330
6-10	59	45	0	9	0	113
10-15	3	64	4	6	0	77
Total number	593 (68.2%)	213 (24.5%)	19 (2.2%)	42 (4.8%)	3 (0.3%)	870 (100%)

Table 4: Comparison of age and TBSA

Variable	B	P-value	95% CI	
			Lower	Upper
Age	-0.184	0.004	0.733	0.944
TBSA	0.167	0.000	1.144	1.220

TBSA: Total Body Surface Area

Discussion

A limited number of risk factors have been certainly linked to increased probability of death after burn injuries; these include age greater than 60 years, TBSA more than 40%, and the presence of inhalation injury and also burn depth^[13]. Osler et al had noted in their study to calibrate the Baux score to the R-Baux score, the calibrated features of their models, so it could not easily be applied to all of the burn care centers^[12]. Baux score (which is calculated as: age + TBSA) is no more used for mortality prediction of burn patients^[14].

According to the previous data, there are three important factors predicting the mortality of burned patients with a rather simple pattern as the following:

R-Baux score: (TBSA+age+[17×R])

{R =1 if patient has inhalation injury and R=0 if not}

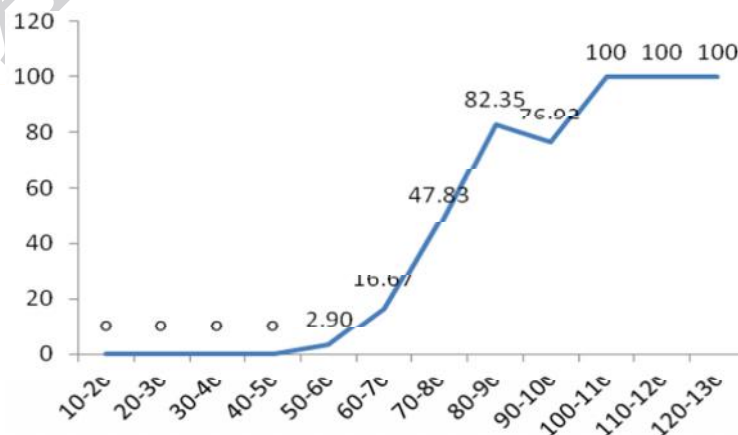
We calculated the original Baux score in our patients and then by employing a logistic regression analysis, an additional 18 was added to revise the predicting model to the P-Baux score. In fact, as we used such a score in children, we found that an additional 18 in case of inhalation injuries would predict burn related mortalities with more probability.

Table 5: Percentage of death calculated by R-Baux formula in patients with inhalation injury

	R-baux	Death (%)
1	10-20	0
2	20-30	0
3	30-40	0
4	40-50	0
5	50-60	2.90
6	60-70	16.67
7	70-80	47.83
8	80-90	82.35
9	90-100	76.92
10	100-110	100
11	110-120	100
12	120-130	100
Total mortality		10.6

Although there are statements on the young age as risk factors of burn-related mortality^[15], a few studies have expressed that age does not interfere with mortality in children^[2,16]. The controversy indeed stands as a result of the differences in treatment options, type, severity, and extent of burns in the studied groups of pediatric patients. However, mortality due to burn injuries has been shown to be lower in children and it has been stated that pediatric cases survive even severe incidents of burn^[4,15]. Children younger than 4 years have been shown to experience shallower burns, smaller TBSA, and lower incidence of inhalation injuries; so these conventional risk factors of mortality need to be considered before interpreting any results.

As it has been shown in previous studies, greater TBSA and larger extent and severity of burns and presence of wound infections and

**Fig. 1:** Relationship of "R-baux" with patients' death

inhalation injuries have all been related with more probability of death^[4,9,13,17].

Mortality rate was 10.6% in our study. This is considerably higher than in other similar studies which have included children in their investigations^[15]. However, we should notice that this rate is reflective of the overall factors which influence mortality including age, type and severity of burn, well care providing, and psychosocial supports. These factors absolutely differ between different studies which have been carried out in various settings and on varying populations.

P-Baux score was directly related to the probability of death except for the 90-100 score which is related to decreased mortality (Fig 1). Other studies have also proposed predicting models for burn mortality^[12,13,16]. However, few ones have validated such models in a large data set. Our study is somehow similar to Osler et al. They have proposed R-Baux score and have used it to predict the probability of mortality after burn injuries^[12]. However, they have not paid sufficient attention to explicit children from other age groups of patients. Our study indeed went the same way as they did, but in children aging less than 15 years rather than inclusion of all age population. Such model although gives a rough estimation of the death probability, but it is obvious that many other factors may impact on end outcomes; these include but are not limited to the external supports, sufficient resuscitation, complications after burn such as acute respiratory distress syndrome, ventilator associated pneumonia, wound infection, sepsis, and multi organ failure syndrome. But, these complications are predictable by the extent and severity of injuries which is remarked by TBSA in the formula; in addition, the mentioned complications are late onset and the aim of the current model is to predict mortality prediction in the early hours of burn injuries.

P-Baux score is easy to use and simply calculated and hence would award easy benchmarking in emergent settings. In addition, other models of prediction for burn related mortality employ the proved risk factors of death due to burn which are unique among different systems and they are age, TBSA, and the presence or absence of inhalation injury^[18]. But despite these facts, validation and previous experience in

application of these models are essential before recommending them as a routine method in estimation of death probability. In our model, probability of death was 0% when the score was assumed to be less than 50, while mortality tended to increase when the score rose up and got constant at 100% for scores greater than 100 (Table 5; Fig. 1). This simple calculation of mortality prediction has been shown to outweigh the rough estimation of the mentioned percentage^[18].

There were limitations to this study which need to be taken into account before certain interpretation of our study results. The most important issue is the number of patients; we should expand the sample size of our study to be able to improve the validity of our model. Using a data set available from burn care centers has been shown to be much beneficial in this regard; however, before using such sources, precautions must be taken into account in terms of accuracy and validity of the extracted data and if not assured, a new data registry should be established. Another consideration for this study is the need to the close collaboration of different burn care centers to reveal the unique differences of participants which may remain hidden between such a wide spectrums of patients.

Conclusion

P-Baux score can be useful for predicting the probability of survival in pediatric burn injuries. Our study showed that P-Baux score is directly correlated with probability of death after burn injuries in pediatric patients.

Conflict of Interest: None

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