Pediatric Burn Outcome; Diagnostic Value of R-Baux and P-Baux Scores

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Research note

Keywords: Burn, Children, R-Baux, P-Baux

DOI: https://doi.org/10.21203/rs.3.rs-45955/v1

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Abstract

Objective: The purpose of this study was to determine the value of R-Baux and P-Baux indexes in predicting the pediatric burn outcome. Using prospective cross-sectional method, 213 children under 12 years old admitted with burn in burn referral hospital in Northwest of Iran were included in the study. Data were collected using goal-driven questionnaire including patients’ demographics and burn clinical data and outcome.

Results: About 59.6% of participants were male. The most common causes of burns was burning with boiling water (127; 69%). For outcome of death, the AUC for the scores of P.Baux and R.Baux were same with 0.959. The AUC for death were 982% and 992% for P.Baux and R.Baux respectively. Also, for the outcome of admission to ICU the AUC were same with 959%. A significant relation between R-Baux and P-Baux scores with patients need for intubation was determined based on logistic regression (p=0.01).

Conclusions: The R-Baux and P-Baux scores were related to the probability of intubation, ICU admission and mortality. Using these scores not only predicts mortality risk, but also provide the opportunity for health providers to prioritize patients and provide proper facilities and services to prevent child mortality due to burn.

Introduction:

Burns with nearly 180000 deaths every year, mostly in low and middle income countries (LMICs), are the most important and preventable public health problem that threaten human health by inflicting physical, psychological, socioeconomic damage to patients, families and society [1, 2]. Burn mortality rate is high (10-20%) even in high-income countries with high-tech burn centers [3]. Burn injuries, in general population, were 13th most frequent cause of the burden of disease and 7th in age group of 5-14, in Iran (2003) [4]. Moreover, burn injuries accounted for 18% of child mortality as second cause of child death in Iran [5]. However, as declared by World Health Organization (WHO) burns and its injuries are preventable [2]. During the past decade, due to the considerable prevention and treatment strategies, survival after burn has increased [6, 7]. Moreover, predictive models were developed to manage the inflicted patients based on mortality risk prediction [8-11]. Baux score has showed an acceptable credibility and efficacy in prediction of burned patients’ outcome [11]. Total burned surface area (TBSA) and age relation with death probability is focused in this score. To consider the inhalation injuries in this score, revised Baux score (R-Baux) was developed. Using this score helps service providers to effectively manage the treatment process [12].

Among age groups, children are a vulnerable group for burn injuries as child death due to burns, in LMICs, was reported 7 times more than high income countries [2, 6, 13]. Children health is in focus of global movements such as Sustainable Development Goals (SDGs) and Social Determinates of Health (SDH) [14, 15]. Regarding, it is important to provide timely and effective services for burned child to prevent their death. To achieve this, previous literature had introduced R-Baux score to be used to predict burn
mortality [16, 17]. R-Baux includes TBSA, age and inhalation injury in predicting the outcome. R-Baux usage in pediatric patients is not well-documented while child are more at risk of burn injuries. Karimi et al (2013) calculated mean R-Baux and P-Baux scores in a same ample of burned patients, as 73 and 55 for 95% probability of death. They reported a positive prognostic value for age and negative prognostic value for TBSA and inhalation in relation to under 15-year patients’ mortality [7]. Despite the commonality of R-Baux usage, P-Baux usage and sensitivity in predicting pediatric burn outcome, is not well documented. The aim of this was to determine and compare the prognostic value of R-Baux and P-Baux scores in predicting the pediatric burn outcome including need to intubation, Intensive care and death.

**Methods:**

**Study design and setting:**

This is a cross-sectional study was done in Sina Hospital in Tabriz in 2017. Sina Hospital is burn referral hospital in northwest of Iran with 280 active beds. It has 45 beds for hospitalized burn cases of which 17 are for child and 12 burn Intensive Care Unite (ICU) beds.

**Sampling and data collection:**

All the children admitted to the hospital during the study period (2017 March 20 to 2017 September 21) were included in the study. Inclusion criteria included patients less than 12 years of age admitted to the pediatric burn ward and parents willingness to participate in the study. Patients with incomplete records were excluded.

Before the beginning of the study, informed consent consisted of three aspects of information, full comprehension and voluntariness of the research was taken from parents. All information of patients was confidential and the relevant information was extracted in coding form and all ethical principles were observed.

Demographic information and burn clinical data including percentage and extent of burn, complications of patients during hospitalization, length of hospital stay (LOHS), burn cause, burn and other disease history, burned anatomic site and patients’ outcome including requiring intubation, admission to ICU and death were recorded in a researcher-made goal-driven form and the Baux score was calculated for all patients. The scores of R-Baux and P-Baux are used for adult and children patients, respectively. The calculation formula of these scores were defined as follow:

\[
\text{R-Baux score} = \text{TBSA} + \text{age} + (17 \times \text{R})
\]

\[
\text{P-Baux score} = \text{TBSA} + \text{age} + (18 \times \text{R}) \text{ If patient has inhalation injury } \text{R} = 1 \text{ If patient has not inhalation injury } \text{R} = 0
\]

Where; TBSA = Total Body Surface Area; R = Respiratory burn
Data analysis:

Data were analyzed through descriptive statistics (including Mean, Frequency) and inferential statistics including chi square test, Sensitivity and specificity, positive and negative predictive values and positive and negative Likelihood Ratio were calculated. The ROC curve was used to determine the diagnostic value of the Baux score and the Area under Curve (AUC) for diagnostic scores. Moreover, to investigate the effect of R-Baux and P-Baux scores on each of outcomes, Multivariate Logistic Regression was used. Initially uni-variable logistic regression was run and variables with p-value ≤ 0.2 were selected to be include in multivariable regression analysis through ENTER model [18].

Results:

Totally 213 children with burns were included of which 127 (59.60%) were male and 178 (% 83.60) were in pre-school age. Most of the admitted children with burns (69.50%) were urban residents and nearly 90% of the burns were occurred at home. The most common causes of burns were boiling water (Scold) (127; 69%), fire (23; 10.8%) and hot tea (20; 9.4%), respectively. In case of burn degree, (137; 64.3%) of children were in classified degree 2 and 3. The lower limbs were reported in 148 children (69.5%) with the highest incidence of burns. Only 24 (11.3%) child had previous history of the disease, and only 8 child (3.08%) used the medicine. There was only one child with burn history. Six children (2.80%) had respiratory burns.

The percentage of burns in 161 patients (75.60%) was less than 16.5%. Majority of the burned children (88.70%) were hospitalized in burn ward, and 24 children (11.30%) were transferred to the ICU, of which 13 died. The intubation rate was 10% and unfortunately all intubated patients were died.

The information about Area Under Curve (AUC), best cut point, sensitivity and specificity of two scores of R-Baux and P-Baux in related to outcomes of study are shown in table 1.
### Table 1: Area Under Curve Information Related to the outcomes of the Study

| Outcome                | Reference score | Area under curve | Best Cut Point | Sensitivity | Specialty |
|------------------------|-----------------|------------------|----------------|-------------|-----------|
| Admission to ICU       | TBSA            | 966              | 17.50%         | 92%         | 90%       |
|                        | R.Baux          | 959              | 20.50%         | 87%         | 82%       |
|                        | P.Baux          | 959              | 19.04%         | 87%         | 86%       |
| Need for intubation    | TBSA            | 967              | 23.50%         | 90%         | 90%       |
|                        | R.Baux          | 987              | 36.37%         | 90%         | 96%       |
|                        | P.Baux          | 982%             | 36.37%         | 90%         | 96%       |
| Death                  | TBSA            | 992%             | 37.25%         | 85%         | 70%       |
|                        | R.Baux          | 992%             | 37.75%         | 85%         | 70%       |
|                        | P.Baux          | 982%             | 22%            | 92%         | 91%       |

A significant relation between R-Baux and P-Baux scores with patients need for intubation was determined based on logistic regression (p=0.01). As reported in Table 2, one unit increase in R-Baux and P-Baux scores will increase the intubation chance by 22 and 21%, respectively.
Table 2-
The relationship between R-Baux and P-Baux scores and patients’ intubation need

| Score | Variables   | B   | SE  | Sig.  | Exp (B)  | 95% C.I. for EXP(B) |
|-------|-------------|-----|-----|-------|----------|---------------------|
|       |             |     |     |       |          | Lower   | Upper   |
| R-Baux| Age         | -.038 | .027 | .162  | .963     | .913  | 1.015  |
|       | Burn cause  | -.049 | .256 | .848  | .952     | .577  | 1.573  |
|       | TBSA        | -.064 | .090 | .475  | .938     | .786  | 1.119  |
|       | LOHS*       | -.069 | .065 | .288  | .933     | .821  | 1.060  |
|       | R-Baux      | .204  | .083 | .014  | 1.226    | 1.042 | 1.443  |
| P-Baux| Age         | -.040  | .028 | .160  | .961     | .909  | 1.016  |
|       | Burn cause  | -.046  | .253 | .856  | .955     | .582  | 1.568  |
|       | TBSA        | -.052  | .085 | .538  | .949     | .803  | 1.121  |
|       | LOHS        | -.065  | .066 | .322  | .937     | .823  | 1.066  |
|       | P-Baux      | .190  | .078 | .014  | 1.209    | 1.039 | 1.408  |

*Length of Hospital Stay

Logistic regression did not revealed a significant relation between patients admission to ICU and death with R-Baux and P-Baux scores (p>0.05) (Table 3, 4).
### Table 3-
The relationship between R-Baux and P-Baux scores and patients' admission to ICU

| Score | Variables | B     | SE    | Sig.  | Exp (B) | 95% C.I. for EXP(B) |
|-------|-----------|-------|-------|-------|---------|---------------------|
|       |           |       |       |       |         | Lower | Upper          |
| R-Baux| Age       | -0.063| 0.029 | 0.026 | 0.939   | 0.887 | 0.993          |
|       | Burn cause| 0.152 | 0.174 | 0.380 | 1.165   | 0.829 | 1.637          |
|       | TBSA      | 0.105 | 0.125 | 0.399 | 1.111   | 0.870 | 1.418          |
|       | LOHS      | 0.052 | 0.060 | 0.386 | 1.053   | 0.937 | 1.185          |
|       | R-Baux    | 0.095 | 0.106 | 0.369 | 1.100   | 0.894 | 1.352          |
| P-Baux| Age       | -0.063| 0.029 | 0.027 | 0.938   | 0.887 | 0.993          |
|       | Burn cause| 0.151 | 0.174 | 0.384 | 1.163   | 0.827 | 1.636          |
|       | TBSA      | 0.103 | 0.120 | 0.390 | 1.109   | 0.876 | 1.403          |
|       | LOHS      | 0.054 | 0.060 | 0.374 | 1.055   | 0.938 | 1.187          |
|       | P-Baux    | 0.095 | 0.101 | 0.344 | 1.100   | 0.903 | 1.341          |

### Table 4-
The relationship between R-Baux and P-Baux scores and patients' death

| Score | Variables | B     | SE    | Sig.  | Exp (B) | 95% C.I. for EXP(B) |
|-------|-----------|-------|-------|-------|---------|---------------------|
|       |           |       |       |       |         | Lower | Upper          |
| R-Baux| Age       | -0.128| 0.107 | 0.232 | 0.880   | 0.714 | 1.085          |
|       | Burn cause| -0.448| 0.591 | 0.449 | 0.639   | 0.201 | 2.036          |
|       | TBSA      | 0.162 | 0.341 | 0.635 | 1.176   | 0.602 | 2.296          |
|       | LOHS      | -0.594| 0.415 | 0.153 | 0.552   | 0.245 | 1.247          |
|       | R-Baux    | 0.507 | 0.415 | 0.221 | 1.661   | 0.737 | 3.744          |
| P-Baux| Age       | -0.125| 0.107 | 0.239 | 0.882   | 0.716 | 1.087          |
|       | Burn cause| -0.432| 0.591 | 0.464 | 0.649   | 0.204 | 2.066          |
|       | TBSA      | 0.177 | 0.346 | 0.610 | 1.193   | 0.605 | 2.352          |
|       | LOHS      | -0.583| 0.413 | 0.158 | 0.558   | 0.249 | 1.253          |
|       | P-Baux    | 0.482 | 0.407 | 0.236 | 1.620   | 0.729 | 3.600          |
R-Baux and P-Baux scores more than 60 was associated with 0.90 mean of probability for patients need for intubation and increase in the score resulted in a higher probability of the outcomes (Table 5).

| R-Baux | Mean of Probability | P-Baux | Mean of Probability |
|--------|---------------------|--------|---------------------|
| 0-10   | 0.001               | 0-10   | 0.001               |
| 011-20 | 0.005               | 011-20 | 0.006               |
| 21-30  | 0.014               | 21-30  | 0.022               |
| 31-40  | 0.089               | 31-40  | 0.097               |
| 41-50  | 0.33                | 41-50  | 0.32                |
| 51-60  | 0.62                | 51-60  | 0.63                |
| 61-70  | 0.93                | 61-70  | 0.9                 |
| 71-80  | 0.9                 | 71-80  | 0.97                |
| 81-90  | 0.92                | 81-90  | 0.99                |
| 91-100 | -                   | 91-100 | -                   |
| 101-110| -                   | 101-110| -                   |
| 111-120| -                   | 111-120| -                   |

Mean of probability for admission to ICU ward and death were calculated more than 0.90 with an R-Baux and P-Baux score higher than 50 (Table 6, 7).
### Table 6.
Mean of Probability of admission to ICU calculated by R-Baux and P-Baux

| R-Baux | Mean of Probability | P-Baux | Mean of Probability |
|--------|---------------------|--------|---------------------|
| 0-10   | 0.004               | 0-10   | 0.005               |
| 011-20 | 0.024               | 011-20 | 0.027               |
| 21-30  | 0.13                | 21-30  | 0.13                |
| 31-40  | 0.49                | 31-40  | 0.499               |
| 41-50  | 0.498               | 41-50  | 0.865               |
| 51-60  | 0.97                | 51-60  | 0.97                |
| 61-70  | 0.995               | 61-70  | 0.996               |
| 71-80  | 0.999               | 71-80  | 0.999               |
| 81-90  | 0.999               | 81-90  | 0.999               |
| 91-100 | -                   | 91-100 | -                   |
| 101-110| -                   | 101-110| -                   |
| 111-120| -                   | 111-120| -                   |
Table 7. Mean of Probability of death calculated by R-Baux and P-Baux

| R-Baux | Mean of Probability | P-Baux | Mean of Probability |
|--------|---------------------|--------|---------------------|
| 0-10   | 0.001               | 0-10   | 0.0001              |
| 011-20 | 0.001               | 011-20 | 0.001               |
| 21-30  | 0.01                | 21-30  | 0.01                |
| 31-40  | 0.13                | 31-40  | 0.13                |
| 41-50  | 0.62                | 41-50  | 0.62                |
| 51-60  | 0.94                | 51-60  | 0.93                |
| 61-70  | 0.995               | 61-70  | 0.99                |
| 71-80  | 0.999               | 71-80  | 0.994               |
| 81-90  | 0.999               | 81-90  | 0.999               |
| 91-100 | -                   | 91-100 | -                   |
| 101-110| -                   | 101-110| -                   |
| 111-120| -                   | 111-120| -                   |

**Discussion:**

The aim of this study was to investigate the prognostic value of R-Baux and P-Baux scores in predicting the pediatric burn outcome including need to intubation, Intensive Care Unit and death.

Most of the admitted children in our study were boys and under 5 years age. In a study on 11 year patients' records in Zurich, it was revealed that children under 5 years were the age-group with highest risk. Moreover, boys were at more risk of burn than girls [19]. These findings were in line with previous studies results [7, 13, 20-22]. Boys were four times more at risk of burn injuries than girls[23]. This might be due to boys more risk taking behaviors during their daily activities and play. Moreover, Skogli et al (2013) have declared that attention deficit hyperactivity disorder (ADHD) affect boys more than girls and this increases the risk of accidents in boys [24]. Meanwhile, ADHD was introduced as a risk predictor for pediatric burn injuries in Iran [25].

Mortality rate was 10% in our study which was consistent with Karimis et al (2013) study results [7]. However, there was a vast diversity in literature in mortality rate which was reported 7.1 % in East Africa [26] to 31.3% in India [27]. It should be noticed that mortality rate is related with burn severity, patients' age and gender distribution, access to care facilities, care quality and also psychological services. In addition, cultural environment were introduced as an affecting factor on mortality [22].
Previous studies had reported age, burn size and inhalation injury as the main predictors of mortality due to burn injuries. To simply predict the burn outcome, revised Baux score was introduced by Osler et al. (2010)[16]. Its efficacy in predicting burn outcome in pediatric was studied in limited studies. We investigated R-Baux and P-Baux prediction value on pediatric patients. Results showed that R-Baux and P-Baux scores were related to predicting burned pediatric outcome. P-Baux was reported, in previous studies to be correlated with death probability in pediatric burn patients which was consistency with our results [7, 28, 29]. Osler in study of 39888 burn patients concluded that R-Baux could be used by surgeons and nurses to precisely predict mortality[16].

R-Baux and P-Baux scores were used for predicting the death probability in previous literature [7, 16, 17, 28] but our study results revealed that they could be also used to predict patients need to intubation and admission to ICU. R-Baux and P-Baux have shown almost equal AUC in predicting patients need to intubation, ICU admission and death. It may be due to low number of patients with respiratory injuries. However, based on logistic regression a significant relation was revealed between these scores and patient need to intubation ad one unit increase in R-Baux and P-Baux scores increase the intubation chance by 22 and 21%, respectively. This not only help physicians and nurses to provide more timely health services to avoid death but also facilitates patients triage in burn wards. In emergent situations, P-Baux score provides simple way for decision making about patients. However, this must be taken into account that this score usage is in early stages of burn injuries and in late stages health services quality, wound infection, disease history and other factors impact on patients' outcome.

**Limitations:**

The study was done based on patients' records in Sina Hospital as the burn referral hospital in Northwest of Iran and this might be considered in interpretations.

**Conclusions:**

The R.Baux and PBaux scores were related to the probability of intubation, ICU admission and mortality. Our results showed that these scores could be used to predict patients' needs in early stages of burn. Using these scores not only predicts mortality risk, but also provide the opportunity for health providers to prioritize patients and provide proper facilities and services to prevent child mortality due to burn.

**Abbreviation:**

WHO: World Health Organization

TBSA: Total burned surface area

LMICs: Low and Middle income countries

SDGs: Sustainable Development Goals
Declarations:

Ethics approval and consent to participate:

This study was approved by ethical committee of Tabriz University of Medical Sciences (ethical code: 94/1-3/12).

Consent for publication:

Not applicable.

Availability of data and materials:

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

Competing interests:

None.

Funding:

None.

Authors' contributions:

KSH, FR and HS has contributed in study conceptualization, design and supervision. KSH and AKH and FR contributed in data gathering. KSH and AR and MS contributed in data analysis and interpretation. AR and MS developed the manuscript draft. All the authors reviewed and approved the final manuscript.

Acknowledgements:

We are thankful of all child's family and also Sina Hospital authorities and staff for their contribution in the study.

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