INTRODUCTION

Burn injuries are one of the most devastating traumas affecting the integumentary and renal, cardiovascular, respiratory, neurological, and musculoskeletal systems. According to the World Health Organization (WHO), around 200,000 people die each year worldwide because of burn- and thermal-based injuries. The mortality rate of burns is greater in low-and middle-income countries than in high-income countries.[11] In 2004, a study showed that the incidence of burns in North America was 19,000 compared to 243,000 in South East Asia. Note that burn injuries often result from residential fires, cooking accidents, and industrial accidents. In Saudi Arabia, burn injuries are a significant public health problem, and there is a need for better understanding the epidemiology of burn injuries and the factors associated with mortality.
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This is a retrospective cohort analysis of patients admitted to the burn unit at King Fahd Hospital of the University (KFHU), Al Khobar, Saudi Arabia, between March 2014 and February 2020. KFHU is a major burn center in the Eastern Province, and along with two other burn centers in the region, it serves >6 million people.

Inclusion and exclusion criteria

All patients admitted to the burn unit during the study period were included. These included patients admitted through the emergency department or emergency referral. Patients discharged against medical advice and those with minimal burn injuries managed in dressing clinics or with old burn scars were excluded from the study.

Variables, definitions, and outcomes

Data regarding patients’ age, length of hospital stay, and revised Baux scores were collected from the electronic medical records at KFHU. In addition, data were also collected for factors that contribute to mortality such as degree of burn, total affected surface area, inhalation injury, comorbidity, and endotracheal intubation. Inhalational injury was defined as any involvement to the orofacial area with a history of burn in closed space; when the case was equivocal, and laryngoscope was done to evaluate for a sign of injury. The primary outcome assessed in the study was the rate of mortality and its predictors. The secondary outcome was assessing the effectiveness of the Baux score in predicting mortality.

Statistical analysis

Data were analyzed using the Statistical Package for Social Sciences (SPSS IBM, version 20). All variables were expressed as frequencies and percentages. The predisposing factors of interest were analyzed using a simple logistic regression. P value < 0.05 was considered statistically significant.

RESULTS

From March 2014 to February 2020, 106 patients were admitted to the burn unit at KFHU. Of these, four were excluded from the study because they left the hospital against medical advice, and thus no data were available regarding their recovery. The mean age of the final included sample was 24.2 years (range: 9 months to 78 years). Those aged 15–44 years (60; 58.8%), accounted for the highest proportion of patients followed by those aged 0–14 years (29; 28.4%) [Figure 1].

The mean TBSA of the total patients was 26.4%, and it ranged from 5% to 95% [Figure 2]. Flame injury was the most common cause of burn, affecting 88 patients (86.3%). Full-thickness burn was noted in 27 patients (26.5%), with a mean TBSA of 54.5%. A total

Methods

Study design, setting, and patients

This is a retrospective cohort analysis of patients admitted to the burn unit at King Fahd Hospital of the

Asia.[7] Yet, in the United States, it is estimated that there is a burn-related death every 2 hours and a burn-related injury every 23 minutes.[7] According to the American Burn Association, there are 1.1 million burn-related injuries annually that need medical care, of which about 50,000 require hospitalization, 20,000 involve at least 25% of the total body surface area (TBSA), and about 4500 die.[8] In addition to the mortality rates, burns cause substantial morbidity that can be cureless in both physical and psychological domains.[4]

In Saudi Arabia, a systematic review found that burns tend to affect males more than females (58.6% vs. 41.4%, respectively).[8] The same study also revealed that 25% of the sample were <2 years old, and 50% were aged ≥16 years, indicating that most burn injuries occur in the pediatric population. The overall weighted percentage of mortality from multiple burns in Saudi Arabia has been reported as 5.9%, while in a burn unit from the Jizan region, it has been reported to be 16.7%.[4]

The Baux score (TBSA burn + age), originally developed in the 1960s, can provide an estimate of the likeliness of mortality in patients with burn injuries. The initial scoring lacked accuracy; however, Osler et al. modified the score to include inhalation injury to the calculation, as it was alone found to add 17 years to the patient's age or 17% of the TBSA.[4] Since this revision, several studies have investigated the prognostic power of the score and found it to demonstrate a higher level of accuracy compared with other prediction models. For example, Pantet et al. examined different scores models on 492 patients admitted to a burn ICU and found that the revised Baux score had the best mortality prediction compared with other scores (AUC: 0.919).[9] In addition, multiple studies have demonstrated the simple and reliable use of the revised Baux score in developing countries.[8,9]

With the advances in medical care and increasing awareness and safety measures, burn injuries, in general, have decreased worldwide. However, epidemiological data on burn injury and mortality rate in Saudi Arabia is lacking. Such data can represent a reference for guideline implantation and future quality control in burn centers. Accordingly, the current study was conducted to provide updated data regarding the survival rates in patients with burn injury at a major tertiary care hospital in the Eastern Province of Saudi Arabia using the revised Baux score.
of 18 (17.6%) patients died: all these patients had flame burns, 13 (72.2%) had evidence of inhalational injury, and 15 (83.3%) had full-thickness burns. Table 1 demonstrates the distribution of mortality in relation to age, TBSA percentage, and burn type.

Patients with patent airway and no inhalation injury were found to be 19 times more likely to survive than those with a compromised airway \( (P < 0.001) \). The depth of burn was also found to play a major role in survival: partial thickness increased the likeliness of survival by 10 times compared with full thickness \( (P < 0.003) \).

Table 2 demonstrates the percentage of death in relation to the revised Baux score. A directly proportional relationship was noted: as the score increased, the mortality rate also increased. Mortality rate was 100\% for the modified Baux scores \( \geq 110 \) [Figure 3]. In contrast, there was no mortality at scores <36.

**DISCUSSION**

The overall mortality rate in the current study was 17.6\%, which is lower than those reported in Cameroon (23.4\%)\(^{[10]}\) and Iran (21.4\%)\(^{[11]}\) but higher than those reported from other developing countries such as Malaysia (12.2\%) and Iraq (13.3\%).\(^{[12,13]}\) In fact, the rate is significantly higher than those reported in large-scale studies from developing countries such as Turkey (0.9\%)\(^ { [14]} \) and China (0.7\%).\(^ { [15]} \)

These discrepancies in mortality rates could be owing to various factors, such as some countries having achieved a high level of safety measures in case of dealing with inflammable materials either in work, home, or public places. Heterogeneity in the inclusion criteria could also be another factor; for example, in the study from Turkey, the mean TBSA was 7.5\% (±8.2\%); however, the mortality rates substantially rose from the 0.9\% to 57.9\% among those with TBSA >40. In addition, mortality rates in burns also depend on various presentation and clinical factors, such as in-hospital complications and subsequent operative procedures.\(^ { [16]} \) Accordingly, the lack of a burn ICU and dedicated burn intensivists and specialists at our hospital, in addition to logistics problems, may have contributed to the relatively higher mortality rates in this study.

Osler et al. described a useful equation for predicting the mortality rate in burn injury (revised Baux score): age added to the percentage of TBSA plus a factor 17, if the patients have inhalational injury.\(^ { [6]} \) An interesting modification to this calculation was discussed in a study considering a pediatric population, which showed that the inhalational injury had a more negative effect on managing pediatric patients with burn trauma than adults. Therefore, 18 points rather than 17 should be added if the patient’s age is <15 years.\(^ { [17]} \) Baux score has shown to have a high reliability in predicting the outcome of thermal injury. Using a multivariate analysis, Baux score was the most significant predictive tool in comparison to other mortality indices.\(^ { [18]} \)

Our study showed that age, TBSA, and inhalational injury are predictive for mortality and morbidities. In terms of age, this is mostly because the weak immune response and poor physiological compensation in elderly patients increases the likelihood of death secondary to infections or organ collapse during the resuscitation phase.\(^ { [19,20]} \) Furthermore, respiratory and inhalational lesions have previously been shown to be an independent factor in predicting mortality.\(^ { [21,22]} \)

Thermal burn, including scald, flame, and contact burns, were the most common type of burn injury in this study, and all mortality cases had flame burns. Such burns have...
been reported to be disproportionately higher in pediatric populations and women such as housewives.\textsuperscript{[23]} Flame burn particularly has been linked with the highest mortality rates and longest in-patient hospital stay periods.\textsuperscript{[24,25]} The mean percentage of TBSA in this study was about 26%, which is similar to that reported from Europe in a systematic review (11%–24%), although there was a decreasing trend in the recent decades.\textsuperscript{[26]}

**Limitations**

The study has the inherent limitations of a retrospective study. In addition, this study reports data from a single center, and thus has limited representativeness. In addition, the microbiological profile was not analyzed because the wound swabs or tissue cultures were not collected for all patients. Nonetheless, the findings of this study provide crucial insight regarding the current medical care for burn injuries and provide an opportunity for improvement through the use of an objective measure, such as the revised Baux score.

**CONCLUSION**

The mortality rate was 17.6%, with all patients having flame burns. No patient with a revised Baux score ≥110 survived. Inhalational injury and burn size were found to be the most prognostic factors of burn injury in this study. As the most common cause of mortality in burns was flame burns, regulation on flammable materials and safety measures should be promoted to the public.

**Ethical considerations**

This study was approved by the Institutional Review Board (IRB) of Imam Abdulrahman Bin Faisal University, Dammam, Saudi Arabia (Ref. no.: IRB-2020-01-251), on September 7, 2020. The study adhered to the principles of Declaration of Helsinki, 2013.

**Data availability statement**

The datasets generated during and/or analyzed during the current study are not publicly available but are available from the corresponding author on reasonable request.

**Table 1:** Mortality rates according to age, total body surface area, and burn type

| Parameters | n (%) | Survivors, n (%) | Nonsurvivors, n (%) |
|------------|-------|-----------------|---------------------|
| Age (years) |       |                 |                     |
| 0–14       | 29 (28.4) | 28 (27.5) | 1 (1) |
| 15–44      | 60 (58.8) | 46 (45.1) | 14 (13.7) |
| 45–59      | 8 (7.8) | 6 (5.9) | 2 (2) |
| ≥60        | 5 (4.9) | 4 (3.9) | 1 (1) |
| Total body surface area |       |                 |                     |
| 0–9        | 24 (23.5) | 24 (23.5) | 0 |
| 10–19      | 34 (33.3) | 33 (32.4) | 1 (1) |
| 20–29      | 16 (15.7) | 16 (15.7) | 0 |
| 30–39      | 6 (5.9) | 5 (4.9) | 1 (1) |
| 40–49      | 4 (3.9) | 4 (3.9) | 0 |
| ≥50        | 18 (17.6) | 2 (2) | 16 (15.7) |
| Etiology   |       |                 |                     |
| Flame      | 88 (86.3) | 70 (68.6) | 18 (17.6) |
| Chemical   | 11 (10.8) | 11 (10.8) | 0 |
| Electrical | 2 (2) | 2 (2) | 0 |
| Mechanical | 1 (1) | 1 (1) | 0 |
| Burn degree |       |                 |                     |
| Full thickness | 27 (26.5) | 12 (11.8) | 15 (14.7) |
| Partial thickness | 75 (73.5) | 72 (70.6) | 3 (2.9) |

**Table 2:** Mortality rates according to the revised Baux score

| Revised Baux Score | Mortality, n (%) |
|--------------------|------------------|
| 0–19               | 0                |
| 20–29              | 0                |
| 30–39              | 1 (6.6)          |
| 40–49              | 0                |
| 50–59              | 0                |
| 60–69              | 0                |
| 70–79              | 1 (16.6)         |
| 80–89              | 0                |
| 90–99              | 0                |
| 100–109            | 2 (40)           |
| 110–119            | 4 (100)          |
| 120–129            | 3 (100)          |
| 130–139            | 5 (100)          |
| ≥140               | 2 (100)          |

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Conflicts of interest
There are no conflicts of interest.

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