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The impact of inhalation injury in patients with small and moderate burns

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ABSTRACT

Background: Inhalation injury is an independent risk factor of mortality in burn patients. The burn index (BI), which includes burn depth and size, also plays a role in predicting mortality. We aimed to establish a relationship between survival rate, inhalation injury, and BI.

Methods: From 1997 to 2010, 21,791 burn patients from 44 hospitals were retrospectively reviewed. Kaplan–Meier and log-rank assessments were used for survival curve analysis. Chi-square, Fishers-exact test and odds ratio evaluations were used to assess the relationship between mortality rate, inhalation injury, BI. Two population proportion Z test was used to analyze the causes of death and morbidity. The significance level was set at 0.01.

Results: The overall mortality rate was 2.1%. Inhalation injuries were found in 7.9% of the patients. The mortality rate of inhalation and non-inhalation injury group was 17.9% and 0.7%, respectively. The survival rate of the inhalation injury group was significantly lower than that of the non-inhalation injury group at BI 0–50. The patients with both inhalation injury and BI less than 50 had significant higher rate to die of pneumonia, respiratory failure, sepsis and wound infection. There was no significant difference when BI was larger than 50.

Conclusions: Inhalation injuries significantly reduced the survival rate, especially when the BI was less than 50. The possibility of pulmonary dysfunction and complications arising from inhalation injury should be considered even in patients who have small cutaneous burns associated with inhalation injuries.

1. Background

Burns are a common cause of traumatic injury, resulting in major morbidity and mortality. Sepsis and ventilator dependency (indicating severe respiratory complications) are the principal causes of morbidity and mortality following traumatic thermal injury [1,2]. Because of advances in clinical care, including the use of fluid resuscitation formulas, antimicrobials, early enteral feeding, early debridement and surgery, and artificial skin or wound dressing products, the survival rate following acute burn has improved in recent decades [3].

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The incidence of burn wound sepsis has also markedly decreased because of improved wound management [4]. However, even with advances in respiratory management, respiratory complications have become an increasingly important cause of morbidity and mortality in burn patients. Pulmonary complications are more common in patients with inhalation injury than in patients without these injuries (38% vs. 8%) [5]. Although patients may show acute pulmonary damage due to chemical material irritation and/or high temperature steam, pneumonia was more common in subjects with inhalation injuries, especially in combination with old age (>60 years) or/and large cutaneous burn size (>20%) [7]. Currently, inhalation injury is known as an independent risk factor of mortality in burn patients, and is thought to influence survival in all patients except those with small burns [5,6].

Burn depth, another risk factor of mortality in burn patients, is under increasing attention. In 1956, Schwartz et al. developed the burn index (BI) on the basis of burn depth and burn size [8]. In our previous study, age, inhalation injury and BI were the independent risk factors under multivariable logistic regression model. In this model, BI has proved to be a stronger indicator than body surface area of burn to predict mortality [9]. However, the impact of inhalation injury in burn patients with different BI, especially in the minor burn group, has not been fully studied. In this study, we used the database from the Childhood Burn Foundation (CBF) of Republic of China (Taiwan) to establish a relationship between survival rate, inhalation injury, and BI.

2. Methods

This multi-center retrospective observational study was conducted to analyze the relationships between age, total body surface area (TBSA), burn depth, BI, inhalation injury, survival time, and mortality rate. We accessed the database maintained by the CBF of Republic of China (Taiwan). CBF is an institution co-founded by Mackay Memorial Hospital and Ali Shan Oasis Shrine Club of Taipei in November 1988. In 1997, CBF established a burn epidemiology online registration system that stores the data of burn cases; these data can be used for medical research. Currently there are 44 hospitals contracted with the CBF across Taiwan. From 1997 to 2010, 23,147 patients were registered in CBF's database. We excluded 1356 patients because of incomplete data and hospital stay longer than 500 days. Finally, 21,791 patients were included in this study. The options of causes of death and morbidity were advised in 2004. The data analysis about cause of death and morbidity were based as the 11,562 patients from 2004 to 2010.

The well-trained nurses of burn unit were responsible for recording the database. The burn extent, burn depth and inhalation injury were determined by doctors of burn unit according to wound condition and history of patients. The burn extent was recorded by the rule of nine: hand and each arm, 9%; back and chest, each 18%; each leg, 18% and perineum, 1%. The skin features of partial-thickness burn (second-degree) are skin blebs, blisters, pink or mottled pin skin with variable painful sensation. Features of full-thickness burn (third-degree) are dry mixed white waxy, dark, or charred skin with leathery eschar, with little or no pain sensation.

BI was calculated as half of % burn surface area (BSA) of second-degree burns plus %BSA of third-degree burns. BI values ranged from 0 to 100, and the patients were separated into 10 groups by intervals of 10 according to their BI. Survival was defined as discharge from the hospital, either to home or to another facility. The presence or absence of inhalation injury was based on the records provided in the registry data. Inhalation injuries were diagnosed on the basis of clinical history and symptoms, including smoke inhalation or impaired level of consciousness in an enclosed space, the presence of facial flame burns or productive sputum containing soot, the requirement of mechanical ventilation when the patient initially arrived at the hospital, and bronchoscopic findings of respiratory tract injury.

Pneumonia event was defined by the fact that patients had purulent sputum, dyspnea or desaturation with pulmonary infiltration on chest X-ray and the presence of pathogenic bacteria in Gram-stain or culture of sputum. Sepsis was defined as the presence of both pathogenic bacteria in blood culture and severe inflammatory response syndrome. When there were purulent discharge from wounds, increased area or depth of wounds and pathogenic bacteria in wound culture, patients were diagnosed to have wound infection.

Kaplan–Meier method was used for survival analysis. The log-rank test was used to compare the difference of survival curves between inhalation and non-inhalation injury groups. The Chi-square test was used to analyze the influence of age and BI on the mortality rates in the inhalation and non-inhalation injury groups. When the patient numbers in any sub-group (mortality or survival, non-inhalation injury or inhalation injury event) were less than 5% of those in the other group in the same BI or age range, Chi-square test was not suitable to analyze the data. In such cases, analyses were performed using Fisher's exact test. Two population proportion Z test was used to analyze the influence of inhalation injury and BI on the causes of death and morbidity. The significance level was set to be 0.01. Data are presented as the mean $\pm$ standard deviation.

3. Results

In this study, we included a total of 21,791 patients (65% males; mean age, 30.9 ± 22.6 years). Second-degree burn area was 8.9 ± 10.7% TBSA, and third-degree burn area was 3.3 ± 10.9% TBSA. BI was 7.8 ± 12.0. Inhalation injury was diagnosed in 7.9% patients. Overall mortality rate was 2.1%. The mortality rate in the inhalation injury group was 17.9%, and that in the non-inhalation injury group was 0.7%.

Eighty percent of patients had BI less than 10. The incidence of inhalation injury was 4% when BI was less than 10. When BI was higher, the incidence of inhalation injury was increased. The incidence was progressively increased to 46.9% when BI was at the range 40–50, and further increased to 92.9% when BI was more than 90 (Fig. 1).

The mortality rate also increased with increasing BI. Chi-square analysis and odds ratios were used to show the difference in the mortality rates between the inhalation and