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Smoke inhalation increases intensive care requirements and morbidity in paediatric burns

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ABSTRACT

Burn survival has improved with advancements in fluid resuscitation, surgical wound management, wound dressings, access to antibiotics and nutritional support for burn patients. Despite these advancements, the presence of smoke inhalation injury in addition to a cutaneous burn still significantly increases morbidity and mortality. The pathophysiology of smoke inhalation has been well studied in animal models. Translation of this knowledge into effectiveness of clinical management and correlation with patient outcomes including the paediatric population, is still limited. We retrospectively reviewed our experience of 13 years of paediatric burns admitted to a regional burn's intensive care unit. We compared critical care requirements and patient outcomes between those with cutaneous burns only and those with concurrent smoke inhalation injury. Smoke inhalation increases critical care requirements and mortality in the paediatric burn population. Therefore, early critical care input in the management of these patients is advised.

1. Introduction

Inhalation injury is present in approximately 30% of all cutaneous burn patients [1]. Localized pulmonary damage occurs as a result of both thermal injury and chemical irritation from contents of combustion. Systemic toxicity may occur with inhalation of significant amounts of hydrogen cyanide and carbon monoxide often found in smoke amongst many other products of combustion.

The presence of inhalation injury and its associated pulmonary complications increases cutaneous burn mortality and morbidity rates from 3–10% to 20–30% [2]. In the presence of small cutaneous burns (TBSA $\leq$ 10%), the influence of inhalation injury on mortality was found to be statistically significant with an odds ratio of an outcome of death of 9.988 [3]. In the paediatric population in the United States, the TBSA for cutaneous burns associated with a 10% mortality rate was higher when associated with inhalation injury versus no inhalation injury (73% vs 50%) [4]. The long-term complications associated with prolonged intubation are also more likely to occur in burn population with inhalation injury [5]. Resulting pulmonary dysfunction lasts for months even after patients appear to have recovered from initial insult [6].

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Management of paediatric burns in itself is challenging and can be further compounded with the presence of inhalation injuries. Literature describing patient outcomes following inhalation injury in paediatric population is available although limited. We reviewed 13 years of paediatric burns admitted to our burns intensive care unit (ICU) and in particular, the impact of inhalation injuries on the paediatric population outcome measures such as ITU stay, presence of other organ failure and inotropic requirements.

2. Methodology

We retrospectively analyzed case notes for all paediatric burn cases admitted to a regional burns intensive care unit who required mechanical ventilation between 1998 and 2011. Patients were included if they were aged 16 years or younger, had burn injuries and required ICU care. They were excluded from the study if they were admitted for reasons other than burn pathology. Patients were then grouped into those with inhalation injuries and those without for comparison of outcomes. We collected data on patient demographics, total burn surface area, presence of inhalation injury, duration of mechanical ventilation, presence of organ dysfunction, length of ITU stay, total length of hospital stay and mortality rates. We also reviewed the proportion of patients with inhalation injury who subsequently required tracheostomy. Indications for tracheostomy includes prolonged mechanical ventilation and the management of extensive full-thickness burns to the head and neck. The gold standard for diagnosis of inhalation injuries in our unit is bronchoscopy. All patients requiring mechanical ventilation received lung protective ventilation strategies and those with a diagnosis with smoke inhalation received nebulized acetylcysteine, heparin and salbutamol.

As data was not normally distributed, Mann-Whitney Rank Sum test was used to compare medians of continuous variables. Fisher's Exact Test was used for categorical variables. We adopted Spearman's Rank Correlation Coefficient to explore statistical associations between variables and multiple logistic regression analysis using presence or absence of ≥ 2 organ failures as the dependent variables. Backward and stepwise methods were used to eliminate variables with regression coefficients $P > 0.05$. Statistical analysis was carried out using MedCalc© Version 16.2 (Ostend, Belgium).

3. Results

Over 13 years, 86 paediatric patients with burn injuries required admission and mechanical ventilation to the burns ICU. Of these, 29% ($n = 26$) patients had inhalation injury as confirmed on bronchoscopy and 71% ($n = 60$) patients had cutaneous burns only (Table 1).

3.1. *Patient demographics*

(i) Inhalation injury group ($n = 26$)

Mean patient age was 7.08 years (± 5.17). Mean %TBSA in this group was 35.06 (± 27.78).

(ii) Non-inhalation injury group ($n = 60$)

Mean patient age was 4.98 years (± 5.13). Mean % TBSA in this group was 26.55 (± 16.82).

3.2. *Duration of mechanical ventilation*

Median number of days of mechanical ventilation required in the inhalation injury group was 2.2 times longer when compared to the non-inhalation injury group (8.25 vs 3.75). This was noted to be statistically significant ($p = 0.002$). The proportion of patients with inhalation injury who had tracheostomy was 3/26 (12%), compared to 2/60 (3.3%) in non-inhalation injury group. This difference was not found to be statistically significant ($p = 0.16$). Patients who had tracheostomy all had large TBSA burns of $\geq$ 80%.

3.3. *Inotropic Support*

The mean number of days in which the patient required inotropic support was noted to be statistically significantly longer in patients with inhalation injury (3.8 vs 1.19, $p = 0.0282$). There was a positive association between the

Table 1 – Comparison baseline variables for inhalation injury and non-inhalation injury.

Variable	No inhalation injury N = 60	Inhalation injury N = 26	P
Mean Age (±SD) (years)	4.98 ± 5.13	7.08 ± 5.17	**0.006**
Mean TBSA burn size % (SD) Median TBSA%	26.55 ± 16.82 21.5	35.06 ± 27.78 26.5	0.28
Days ventilation (range)	3.75 (2–6)	8.25 (4.8–15.4)	**0.002**
Oscillation	4/60 (67%)	2/26 (8%)	1.0
Reintubation	14/60 (23%)	11/26 (42%)	0.11
Tracheostomy	2/60 (3%)	3/26 (12%)	0.16
Inotrope days (range)	0	1.25 (0–3)	**0.02**
Sepsis lung	25/60 (42%)	14/26 (54%)	0.3
Sepsis line	11/60 (18%)	5/26 (19%)	1.0
Sepsis wound	47/60 (78%)	15/26 (58%)	0.09
Sepsis other	13/60 (22%)	5/26 (19%)	1.0
Sepsis GI	5/60 (8%)	2/26 (8%)	0.74
LOS/% burn (range)	1.11 (0.98–1.34)	1.48 (1.25–2.02)	**0.01**
Deaths	1/60 (2%)	5/26 (19%)	**0.009**