

Original Article

Pediatric upper aero-digestive and respiratory tract burns

Adam Ofri¹, John G Harvey^{2,3}, Andrew J A Holland^{2,3}

¹Department of Paediatric Surgery, Sydney Children's Hospital at Randwick, New South Wales, Australia; ²The Children's Hospital at Westmead Burns Research Institute and Burns Unit, Westmead, New South Wales, Australia; ³Discipline of Paediatrics and Child Health, Sydney Medical School, The University of Sydney, New South Wales, Australia

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Abstract: Upper aero-digestive and respiratory tract burns may occur in isolation or in association with cutaneous burn injury. Major respiratory burns have been linked with a high mortality and morbidity. Despite the importance of these injuries there have been few studies in children. A retrospective case note review between December 2000 and March 2011 of all pediatric upper aero-digestive and respiratory tract burns referred to the New South Wales Statewide Burn Injury Service was performed. Data were collected on patient characteristics, injury details, requirement for intubation, length of stay (LOS), morbidity and mortality. There were 33 patients diagnosed, with a median age of 5.4 years and a male to female ratio of 1.2:1. Mechanism of injury was ingestion of a caustic material ($n=15$), flame ($n=11$) or scald ($n=7$). Overall 14 (42%) patients were intubated; the majority associated with burns to the face (79%) and oropharynx (64%). Median LOS was 6 days (range 3 to 23). Of those patients admitted to intensive care, 50% had a positive bacterial culture. The most common sites of infection were tracheal/endotracheal (80%) and burn sites (44%). There were 2 (6%) deaths in the series. Whilst the majority of children with upper airway and respiratory tract burns required intubation, the overall morbidity and mortality was low compared to adult series. This may reflect that a number of children suffered an upper aero digestive tract burn following ingestion of a caustic material or hot liquids, rather than a lower tract, inhalational flame burn.

Keywords: Pediatric, upper aerodigestive, respiratory, burns

Introduction

Inhalation injury represents a significant predictor of morbidity and mortality and is associated with an approximate mortality rate up to 30% for all cutaneous burns [1]. In children, concomitant inhalation injury reduces the lethal burn area from 73% Total Body Surface Area (TBSA) to 50% TBSA [2]. Adult studies focusing exclusively on victims of smoke inhalation report a 3% mortality risk [3]. Although there has been steady improvement in the management of cutaneous burns, the mortality rates of patients with inhalational injury has changed comparatively little over the last 20 years [4].

A higher frequency of inhalational injuries has been reported in children than adults, possibly due to differences in the mechanisms of injury and behavioural responses to burn injury [5].

Unfortunately there remains comparatively limited data regarding inhalation injury in children, with no study specifically evaluating this population in our region to date [6, 7].

A confounding factor has been the variety of inclusion criteria used to define this important group of patients, with some series based on clinical criteria alone whilst others have only included those with severe lower respiratory tract burns confirmed by bronchoscopy [4, 7, 8].

The aim of this study was to explore the etiology and outcomes of upper aero-digestive and/or respiratory tract burns at our institution over the last decade.

Methods

A retrospective database review was conducted using an ICD-10 search with primary diagno-

Pediatric aero-digestive and respiratory tract burns

Table 1. Patient details

	Flame (11)	Scald (7)	Ingestion (15)	Total (33)
Age (years)	12 (7-13)	1.3 (1.1-6)	2.5 (1.6-4)	3 (1.6-7)
Sex (M:F)	2.67:1	1:1.33	1:1.14	1.2:1
Intubated % (n)	90.9% (10)	28.6% (2)	13.3% (2)	42.4% (14)
Ventilator days	3 (2.5-25)	6.5 (4-9)	4.5 (3-6)	3.5 (2-6)
Hospital LOS (d)	6 (4-23.5)	6 (4-14)	6 (2-14)	6 (3-15)
Mortality % (n)	18.2%	0%	0%	0.06%

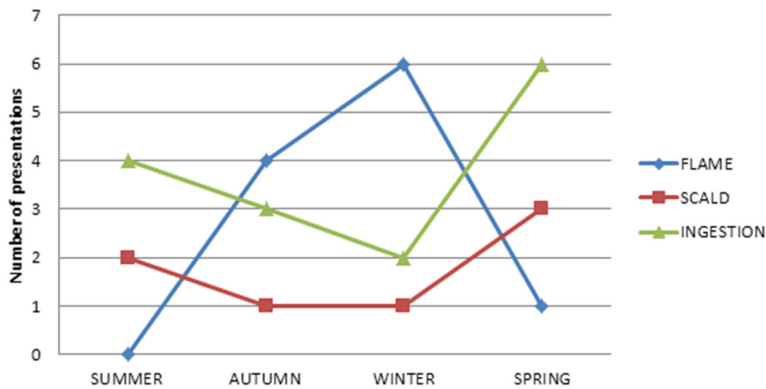


Figure 1. Presentations based on season.

sis of T27.x (Burn and corrosion of respiratory tract) and T28.x (Burn and corrosion of other internal organs) from December 2000 to March 2011 at The Children's Hospital at Westmead (CHW). Our Burn unit represents the Pediatric arm of the New South Wales (NSW) Statewide Burn Injury Service (SBIS) and the sole referral centre for pediatric burns in NSW and the Australian Capital Territory (ACT). Approval for the study was obtained from our institutions Ethics Committee. We reviewed all burns to the upper airway and/or respiratory tract. Diagnosis of airway involvement was based on the clinical assessment of the treating burns surgeon, the results of any plain radiographs, together with observations made at the time of intubation and/or the results of Laryngo-Broncho-Oesophagoscopy (LBO). Patients were categorised based on their mechanism of injury into flame, scald (secondary to heated fluid) or ingestion of caustic material.

Data were collected on patient details (age, gender, time of injury), injury characteristics (clinical signs and symptoms) and requirement for intubation, Pediatric Intensive Care Unit (PICU) admission (duration mechanical ventilation, length of stay) and hospital course (overall duration, mortality). Statistical analysis was

performed using SPSS Version 18 (IBM, Armonk, NY, USA). Due to the size of the data set, continuous variables were compared using median and ranges with percentages used for categorical variables. A *P* value of < 0.05 was considered statistically significant.

Results

Patient details, mechanism of injury and outcomes

A total of 33 patients were identified with an upper aero-digestive and/or respiratory tract burn, with an overall male to female ratio of 1.2:1 and mean age of 5.4 years (**Table 1**). The most common mechanism of injury was ingestion (*n*=15), followed by flame (*n*=11) and scald (*n*=7). Of the flame injured patients,

7 occurred as a result of open fires and 4 in the setting of an enclosed house fire. Ingestion injuries resulted from alkali cleaning agents (*n*=11), acidic cleaning agents (*n*=3) and copper sulphate (*n*=1). The median total burn surface area (TBSA) of 33 burn patients was 2% (0-90%); within each group - ingestion 0% (0-5%), flame 5% (0-90%) and scald 6.5% (0-18%). The median age of presentation was significantly different between the three mechanisms: flame 12 years, scald 1.3 years and ingestion 3 years of age (*P* < 0.012), although there was no evidence of seasonal variation (**Figure 1**, *P*=0.09) [9]. There were two deaths (mortality rate 6% overall, 18% of flame burns), both in patients with respiratory tract and cutaneous burns of greater than 80% TBSA.

Injury characteristics and requirement for intubation

Of the 33 burn patients with evidence of an inhalational injury, 14 were intubated (42%): flame (*n*=10), scald (*n*=2) and ingestion (*n*=2).

Of patients who were intubated, the most common signs and symptoms indicative of the need for intubation were burns to the face (79%) and oropharynx (64%). Statistical analysis revealed

Pediatric aero-digestive and respiratory tract burns

Table 2. Number of positive cultures per group's testing

Tests	Number of patients positive in each group (Number patients tested per group)			
	Flame	Scald	Ingestion	Total
Blood	1 (7)	1 (2)	0 (0)	2 (9)
Trachea/endotracheal	6 (8)	2 (2)	0 (0)	8 (10)
Burn	3 (6)	1 (2)	0 (1)	4 (9)
Urine	1 (6)	1 (2)	0 (0)	2 (8)

that patients with inhalational injury in conjunction with limb burns were more likely to be intubated than cases without limb burns (61% versus 19%, $P < 0.001$). Patients with facial burns were also more likely to be intubated than those without facial burns (61% versus 20%, $P=0.02$). Based on mechanism of injury, flame patients were noted to have the highest risk of intubation: flame (91%), scald (29%) and ingestion (13%).

Two of the intubated flame patients had significant evidence of upper aero-digestive tract and respiratory tract involvement with extensive neck and chest burns (TBSA > 80%) and subsequently died. The two scald patients who were intubated did not have significantly different characteristics to their non-intubated counterparts, but were referred from a rural hospital to our institution and may have been intubated to ensure a definitive airway during transfer. Two patients with caustic ingestion injury had significant laryngeal injury on LBO as well as extensive burns. They both had burns covering the face and perioral region, extending to the anterior chest and upper limbs.

Pediatric Intensive Care Unit and hospital admission

Overall 42% of burn patients diagnosed with inhalational injury required intubation and PICU admission. The median length of intubation was 3.5 days (1-8) and of PICU admission 5 days (1-9). There was no statistical evidence indicating that burn type affected either the duration of mechanical ventilation or PICU admission.

During PICU admission infections were investigated by performing cultures on tracheal/endotracheal aspirates, urine, blood and cutaneous wound burn swabs (**Table 2**). Cultures were not performed routinely for all patients but upon the clinical discretion of the treating clinician,

thus rates were calculated only from patients whom were tested. Overall 6 out of 12 patients had cultures that grew non-contaminant bacteria (defined as a positive culture). Positive cultures were obtained from: tracheal/endotracheal region (80%, $n=8/10$), burn sites (44%, $n=4/9$), urine (25%, $n=2/8$) and blood (22%, $n=2/9$). The most common bacteria grown were

Staphylococcal sp. (33%), *Streptococcal sp.* (25%), *Moraxella* and *Haemophilus sp.* (13% each). The two scald patients had positive cultures overall in 5 out of 8 cultures, whereas the two caustic ingestion patients only had one negative burn culture performed.

The median duration of hospitalisation was 6 days (2-36). Patients that required intubation were noted to have an almost three fold increase to median length of stay, 14 days (3-36) when compared to non-intubated length of stay 5 day (2-36; $P=0.02$).

Discussion

Though scalds account for approximately 60% of burn injury in Australian children, it is rarely considered a cause of upper aero-digestive and respiratory burns [10]. Whilst flame burns remain the most important cause of serious inhalation injury, our study revealed that the most common cause of upper aero-digestive and respiratory tract burn was caustic ingestion [5, 8]. The severity of upper aero-digestive and respiratory tract burns, however, was far greater following flame injury, as evidenced by the increased proportion requiring intubation. In addition, the two mortalities in our study were associated with flame burns with a TBSA > 80%, although such high TBSAs are strongly associated with mortality irrespective of associated inhalation injury. There were no deaths in the more common caustic ingestion group, reflecting the less severe nature of this mechanism of injury.

Although only 33 patients were treated at our institution with an upper airway or respiratory burn over the last decade, this is likely to represent an underestimate of the incidence of this condition in NSW and the ACT. Unfortunately it seems likely, based on contact with our retrieval organisation and review of newspaper reports, that at least several children died at

Pediatric aero-digestive and respiratory tract burns

the scene as result of house fires over the same time period [5].

The median age of 3 years and a male to female ratio of 1.2:1 identified in our study reflects previous reports. Flame burn injuries were commoner in males (male to female ratio of 2.67) and flame burns commoner in the older child (median age of 12 years) [5, 6, 8, 11-13]. Typically flame injuries take place predominantly in two peaks: late afternoon when older children are usually unsupervised after finishing school and late at night secondary to accidental house fires [14]. In contrast, scald injuries appeared more likely to occur when family members were in the kitchen during meal times, boiling water for cooking or preparing hot beverages [15]. Ingestion injuries occurred during normal waking hours, with the ingestion either secondary to thirst or children's inquisitive nature [16].

Approximately 50% of the patients in this study were referred to our unit following initial management at another hospital (rural or metropolitan). The need to intubate the patients in this study was therefore not always based purely on the risk of airway loss secondary to inhalational injury. In some cases the patient was deemed at low risk, but was intubated to establish a definitive airway prior to travel. These borderline patients would perhaps have been less likely to have been intubated had they been reviewed initially at our institution.

Scald burns caused localised damage but only rarely appeared to extend beyond the oropharyngeal region to cause lower respiratory tract burns. The diagnosis of associated upper airway injury was confirmed in all ingestion cases after LBO. It remains possible that children with more minor respiratory tract injuries were missed when this injury was not suspected following a typical scald burn.

Whilst there remain several signs and symptoms to indicate inhalational injury, there has been no widely accepted scoring system to determine the extent of airway injury, nor the risk of airway loss [4, 5, 7]. Our sole non-intubated flame patient had evidence of airway involvement, however did not have extensive TBSA involvement or evidence of facial, oropharyngeal or neck burns. Whether the presence of these signs can indicate an increased severity of inhalational injury and increased risk of air-

way loss has yet to be proven. In our series there was significant statistical evidence that flame injury patients with evidence of inhalation injury were intubated at a higher rate than the other two groups.

Mechanical ventilation, one of the mainstays of supportive therapy for patients with lower respiratory tract burns, was the primary indication for PICU admission and was necessary in 42% (n=14) of all study patients [17, 18]. Infection remains a well-documented risk for burn patients [8, 19, 20]. During PICU admission, infections were investigated for in most patients, but there was no routine screening in the absence of clinical signs. It was noted that scald injury patients had a significantly higher proportion of positive cultures. Ingestion patients had no positive cultures but were tested far less. The most common growths of *Staphylococcal* and *Streptococcal sp.* were consistent with other studies reviewing general and burn related infections; however *Pseudomonas* was grown less frequently than stated in those studies [21, 22]. The higher risk of infection in scald injury patients raises the question of whether scald injury patients being mechanically ventilated have a higher risk of infection.

Perhaps surprisingly, the overall duration of PICU admission was not statistically different between patients with different mechanisms of injury. In part this may reflect our unit's comparatively small number of patients with these injuries.

Conclusion

A caustic ingestion injury was the most common etiology for an upper aero-digestive or respiratory burn in our center. There was a significantly higher rate of intubation for flame injured patients, whilst scald patients had a higher risk of infection. The application of an appropriate grading system could potentially result in a decreased number of intubated patients, with a consequent decrease in LOS and associated costs.

Disclosure of conflict of interest

None.

Address correspondence to: Dr. Andrew J A Holland, Douglas Cohen Department of Paediatric Surgery,

Pediatric aero-digestive and respiratory tract burns

The Children's Hospital at Westmead, Locked Bag 4001, Westmead, New South Wales 2145, Australia. E-mail: andrew.holland@health.nsw.gov.au; Adam Ofri, Department of Paediatric Surgery, Sydney Children's Hospital at Randwick, New South Wales, Australia. E-mail: adamofri@gmail.com

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