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# Review of children with severe trauma or thermal injury requiring intensive care in a Hong Kong hospital: retrospective study

## 香港醫院中患嚴重外傷或燙傷而需要深切治療的兒童：回顧性研究

**Objective.** To study the injury pattern of children admitted for management of severe trauma or thermal injury.

**Design.** Retrospective review.

**Setting.** Paediatric intensive care unit of a regional hospital, Hong Kong.

**Patients.** Twenty-eight children were admitted under this category from July 1996 to December 1999.

**Main outcome measures.** Mechanisms, severity, and circumstances of injury.

**Results.** Road traffic accident was the most common cause of admission, followed by thermal injury, accidental fall, and non-accidental injury. However, children with non-accidental injury were admitted in a significantly more severe condition, as measured by the paediatric risk of mortality score, than those admitted for the other three reasons. Non-accidental injury was also associated with significantly higher morbidity and mortality than the other causes of admission.

**Conclusions.** During the 42-month study period, trauma and thermal injury accounted for 7% of all admissions to the paediatric intensive care unit. Road traffic accident was the most common reason, while non-accidental injury accounted for the most serious injury. Detailed analysis of these cases identified certain preventable risk factors.

**目的：**研究因嚴重外傷或燙傷而入院兒童的受傷模式。

**設計：**回顧性研究。

**安排：**香港一所地區醫院的兒科深切治療部。

**患者：**1996年7月至1999年12月期間因嚴重外傷或燙傷而住院的28名兒童。

**主要結果測量：**受傷的機制，嚴重性和狀況。

**結果：**交通事故是入院的最常見原因，其次是燙傷、意外跌傷、和非意外受傷。然而，因非意外受傷的兒童住院時的狀況比其他三個原因住院時的狀況更嚴重，該狀況以兒童死亡率危險指標衡量。非意外受傷的併發病率和死亡率大大高於其他原因入院的患者。

**結論：**在42個月的研究期間，外傷和燙傷佔所有入住兒科深切治療部患者的7%。交通事故是最常見的原因，而非意外受傷是最嚴重的損傷。全部這些病例的詳細分析確定了某些可預防的危險因素。

### Key words:

Child;

Intensive care units, pediatric;

Wounds and injuries

### 關鍵詞：

兒童；

深切治療部，小兒科的；

創傷和傷害

HKMJ 2002;8:82-6

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### Introduction

Trauma is the leading cause of death after the first year of life in industrialised countries<sup>1</sup> and China.<sup>2</sup> A similar picture has been reported in Hong Kong, where in 1996, road traffic accidents (RTA), drowning/submersion, and accidental falls accounted for 30%, 20%, and 20%, respectively, of all deaths from accidental injury in children under the age of 15 years.<sup>3</sup> Kwong Wah Hospital is a public-funded regional hospital located in an urban area of Hong Kong with a lower socio-economic class population. The paediatric in-patient service consists of two wards with 100 beds provided and the paediatric intensive care unit (PICU),

which serves both paediatric and surgical departments, consists of one ward with five beds provided. This review aimed to identify the pattern of severe childhood trauma requiring admission to the PICU.

## Methods

A retrospective review was conducted for children admitted to the PICU in Kwong Wah Hospital between July 1996 and December 1999. This hospital has no standardised criteria for being admitted to the PICU, and admission was the result of a clinical decision made by the attending paediatric specialist. Thus, each admission was judged on its own merits. All discharge files were reviewed for diagnoses of trauma or thermal injuries (scalds or burns).

## Statistical analyses

Data collected from the patients' records was processed using the Statistical Package for Social Science (Windows 98; SPSS Inc., Chicago, US). Numerical data were expressed as mean or median values plus or minus the standard deviation (SD). The Mann-Whitney *U* test was used to assess differences between groups.

## Results

In the 42-month period from July 1996 to December 1999, a total of 21 619 childhood emergency admissions into different departments of Kwong Wah Hospital were recorded, of which 391 (1.8%) were admitted to the PICU. Twenty-eight children, with a mean (SD) age of 5.25 (3.35) years, were admitted to the PICU because of trauma or thermal injury, accounting for 7.2% of all PICU admissions. Road traffic accidents were the most common cause of admission to the PICU, followed by thermal injuries, accidental falls, and non-accidental injury (NAI) [Table 1]. The paediatric risk of mortality (PRISM) score reflects the severity of the trauma or thermal injury on admission to the PICU. Children admitted with NAI had significantly higher PRISM scores than those admitted for the other three reasons ( $P < 0.05$ ) [Table 1]. In fact, children sustaining thermal injuries, accidental falls, or RTA had similar PRISM scores (Table 1).

## Road traffic accidents

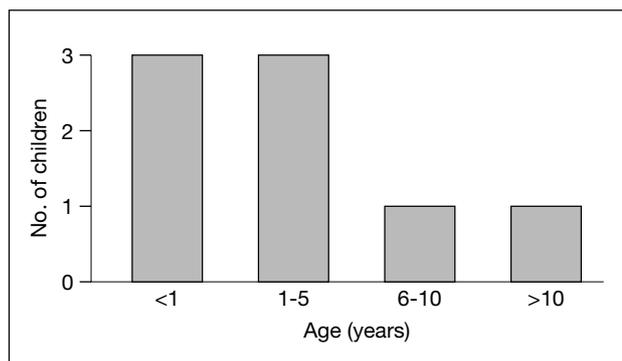
Ten (35.7%) children (six boys and four girls) were admitted to the PICU for RTA. Their records showed that all were pedestrians at the time of the incident, which, with one exception, occurred in the afternoon or evening. The mean (SD) age of this group of patients was 7.5 (1.8) years.

**Table 1. Details of the cases**

	Patients No. (%)	Death	PRISM* score Mean (SD)
Road traffic accident	10 (35.7)	0	5.3 (4.67)
Thermal injury	8 (28.5)	0	1.87 (3.18)
Accidental fall	7 (25)	0	3.57 (8.20)
Non-accidental injury	3 (10.7)	1	15.33 (5.03) <sup>†</sup>

\* PRISM = paediatric risk of mortality

<sup>†</sup>  $P = 0.0112$



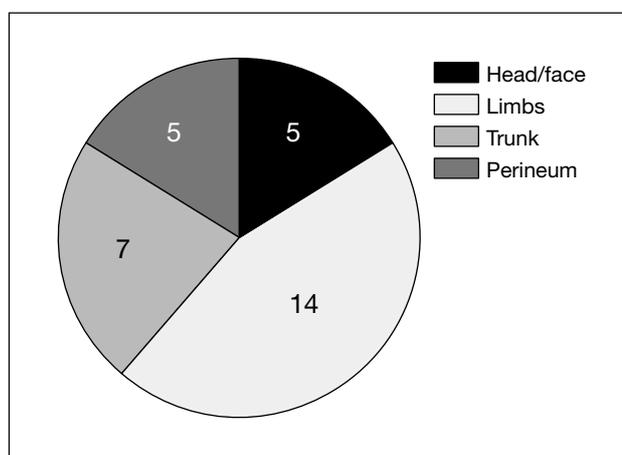
**Fig 1. Age distribution of children suffering from thermal injuries**

Seven children were found to have intracranial bleeding, of whom six required burr hole (craniotomy) for cerebral oedema or extradural haemorrhage. Two had ruptured/lacerated spleens and both required laparotomy. Splenectomy was required in one child. One child had multiple fractures of the facial bones, but did not require surgery. All 10 children survived the trauma, with two suffering from sequelae: one with surgical asplenia; the other with right optic nerve avulsion leading to loss of vision affecting the right eye.

## Thermal injury

Eight (28.6%) children (five boys and three girls) were admitted for thermal injury. Seven presented with scalding injuries and one with burn injuries. The majority of these patients were under the age of 5 years (Fig 1). Four children sustained moderate injury, ie 5% to 15% of their body surface area was involved. The remaining four sustained severe injury, ie more than 15% of their body surface area was involved. Fig 2 summarises the body parts that were affected by the thermal injuries.

As regards the actual causes of the thermal injuries, one episode involved a substandard old electric fan and two were due to careless caregivers' mistakes, such as leaving hot soup on the floor of a corridor and pouring hot water into a bath tub before adding the cold water. Multifactorial incidents involved rice cookers (three) and thermoflasks (two).



**Fig 2. Body parts affected by thermal injury (n=8)**

Fluid therapy followed the modified Parkland's formula, ie 4 mL/kg/% burn plus maintenance fluid for the first 24 hours. Subsequent management was to maintain the urine output at 1 mL/kg/h. The actual mean (SD) fluid intake of 2901 (1988) mL/day, as dictated by urine output and circulation, was very close to the 2451 mL/day predicted by the modified Parkland formula (P=0.26). Blood cultures for all eight patients were negative and none were given prophylactic systemic antibiotics in the PICU. However, one child did receive systemic antibiotics for ventilator-associated pneumonia. There was no mortality in this group of children. After exiting the PICU, all eight required pressure garment treatment. Three patients defaulted during follow-up. One required reconstructive surgery and one had functional disability.

**Accidental falls**

Seven (25%) children (four boys and three girls) were admitted for accidental falls, all suffering from epidural/subdural haematoma with or without skull fracture. All required craniotomy with clot evacuation. The mean (SD) age of this group of patients was 6.2 (2.5) years.

All except one of the falls occurred at home indoors. The most common episode was accidental fall from a double-decker bunkbed, typically from a height of around 1.5 m (four cases). All children experiencing such a fall were unaccompanied or unsupervised at the time of the incident, which was always in the evening (6pm-9pm). All four recovered fully on follow-up.

One boy fell from a height of around 20 m from his fifth-floor home. Briefly, the circumstances surrounding his accident were as follows: left alone at home asleep, while his mother went shopping, he awoke (unexpectedly early) and tried to climb out through a living room window which had no protective bars. He suffered extradural and subdural haemorrhage, skull fracture, and splenic rupture. Emergency craniotomy with clot evacuation and laparotomy with splenectomy were performed. The resultant sequelae

included profound neurosensory deafness from laceration of the left auditory nerve secondary to fracture of the left petrous temporal bone, and surgical asplenia.

**Non-accidental injury**

Three (10.7%) children (two boys and one girl) were admitted because of acute or subacute encephalopathy with sudden collapse or depressed conscious state. All had experienced seizures and two of them had status epilepticus on admission or shortly thereafter (Table 2). These patients were subsequently diagnosed to have 'shaken baby syndrome' based on the following widely accepted diagnostic descriptions<sup>4</sup>:

- All three were under the age of 2 years;
- All three presented in a serious condition (ie high PRISM score);
- All three had acute or subacute encephalopathy with seizure;
- All three had retinal haemorrhage;
- All three had severe subdural and/or interhemispheric haemorrhages, with or without cerebral oedema, on computed tomography (CT) brain scan; and
- Two developed status epilepticus before or shortly after admission.

Two of the children had no signs of external injury, while one had a minor 2 cm long forehead abrasion. Obtaining their histories from their respective caregivers provided no helpful clues as to the cause of the intracranial catastrophes. When questioned, all three caregivers denied inflicting any form of injury preceding the onset of symptoms, although one did report that her charge had sustained a "very trivial" fall from a height of greater than 0.5 m from her arm onto a bed. In two cases, there was a delay in seeking medical attention after the incident. One caregiver did not inform the child's parents or seek medical attention until 1 day after the onset of lethargy and repeated vomiting.

Coagulopathy was excluded by normal clotting profile and platelet count. Two of the three patients were previously

**Table 2. Features of non-accidental injury children**

	Case 1	Case 2	Case 3
Age (months)	23	2	13
Sex	Female	Male	Male
Presentation	Sudden collapse, seizure	Lethargy, vomiting, seizure	Seizure, coma
PRISM* score on admission	10	20	16
Mean modified GCS†	7	9	3
History of injury	None	Fall from 0.5 m	None
Injury	Right subdural and interhemispheric haemorrhage, cerebral oedema	Bilateral subdural haemorrhage, cerebral oedema	Right subdural and subarachnoid haemorrhage, cerebral oedema
Retinal haemorrhage	Yes	Yes	Yes
Peripheral injuries	2 cm forehead abrasion	None	None
Skeletal fracture	None	None	None
Abuser (suspected or confirmed)	Domestic helper	Child minder	Unidentified
Ventilator support	Yes	Yes	Yes
Outcome	Spastic hemiplegia, cortical blindness, moderate mental retardation	Spastic triplegia, cortical blindness, severe developmental delay	Death

\* PRISM paediatric risk of mortality  
 † GCS Glasgow coma score

normal in terms of their health and development. One child, however, had two risk factors suggestive of NAI: pre-existing significant neurological impairment and unstable family environment.<sup>4</sup> One child did not survive the incident and the remaining two had serious neurological sequelae including spastic cerebral palsy, blindness, and moderate-to-severe developmental delay. In the fatal case, no abuser has thus far been identified. In the two surviving cases, however, the suspected culprits were identified, and one of them, an accused child minder, was subsequently found guilty after police prosecution. The other suspected culprit (a domestic helper) was dismissed by her employer.

## Discussion

The findings of this study suggest that the pattern of severe injuries requiring intensive care differs in different paediatric age-groups. In children under the age of 2 years, for example, shaken baby syndrome and thermal injury were more likely to occur. Thermal injuries were also common among children between the ages of 2 and 5 years, while accidental falls were common in those between the ages of 4 and 6 years. Road traffic accidents tended to involve children between the age of 7 and 10 years.

### *Road traffic accidents*

At home,<sup>3</sup> as abroad,<sup>5</sup> RTA are the most common cause of death for children aged between 1 and 14 years. Hence, it came as no surprise that RTA were the most common reason for trauma admission to the PICU in our hospital. All of these victims of RTA were pedestrians and the incident almost always occurred in the afternoon or evening. This finding was similar to that of another Hong Kong survey, which reported a peak period for RTA in children at approximately 1pm and from 4pm to 6pm, and that the majority of paediatric victims of RTA were pedestrians.<sup>2</sup> In 1999, there were a total of 499 380 registered vehicles in Hong Kong, an increase of 40% compared with 1990.<sup>6</sup> Fortunately, the number of fatalities related to RTA decreased from 321 to 217 in the same year. This trend probably reflects the improvements in medical care and the effectiveness of preventive measures, such as education, publicity, legislation, and engineering. Pedestrians accounted for 51% of the overall fatal casualties.<sup>7</sup> Happily, this rate was not reflected in our series of 10 paediatric victims of RTA, all of whom were pedestrians, but all of whom survived.

### *Thermal injury*

Similar to a previous report,<sup>3</sup> most thermal injuries in this study were due to scalding and occurred in children under the age of 4 years. Overcrowding and inattentive caregivers were common factors in the majority of cases. Public education should specifically target the hazards of rice-cookers and thermoflasks, which were involved in five (62.5%) out of eight of our cases. Legislation against sub-standard electrical appliances has been passed, and strict enforcement should be employed. In this study, the actual

fluid requirement was quite similar to that predicted by the modified Parkland formula, ie 4 mL/kg/% burn and daily maintenance. It was encouraging to note that bacteraemia was not found in any of our patients. This result validated the hospital's policy of no prophylactic systemic antibiotics for children presenting with thermal injuries.

### *Accidental falls*

Like those described in another local report,<sup>3</sup> children who were involved in accidental falls in this study were young (mean age, 5.8 years). Four (57%) out of the seven cases involved double-decker bunkbeds, a much higher incidence than the 10.6% reported in another local regional hospital.<sup>8</sup> In the highly cramped living environment of Hong Kong, double-decker bunkbeds act as essential space savers and are often used as work/play areas for children. The accidental fall most commonly occurred when an unaccompanied young child was playing on the bed after dinner at a time when adult family members were otherwise occupied. Public education designed to discourage dangerous behaviour by children on double-decker bunkbeds, and improved adult supervision of children at night, would be helpful in reducing the frequency of these preventable accidents.

The most serious injury in this group in this survey involved a child falling around 20 m from his fifth-floor home. A significant number of children are still left unattended at home despite continuing public education in child safety. These unattended children are thereby placed at risk of various physical injuries at home. There are 230 occasional childcare units in Hong Kong, each providing relatively inexpensive temporary childcare services at a cost of HK\$32 for each half-day session. Thus far, however, this service has not been widely utilised,<sup>3</sup> a situation that should be improved through wider publicity of its availability. Public education, especially for our large and ever-growing (currently at the rate of approximately 50 000 per year) new immigrant population, who are less familiar with the local environment and the community resources available, should be enhanced. Legislation against children left unattended at home should be reconsidered, as the last consultation was conducted, but turned down, in 1991.<sup>9</sup>

### *Non-accidental injury*

The mean age of children presenting with NAI in this study was much lower than that of the children in the other three groups: all three were under the age of 2 years compared with a mean age of 5 years for those admitted for RTA, thermal injuries, or accidental falls. In addition, patients with NAI were in a more serious condition on admission to the PICU, as evidenced by significantly higher PRISM scores, than those in the other three groups (Table 1). This could be related to a multitude of factors including the intrinsically more damaging effect of shaking on the brain, delay in seeking medical attention by the caregiver, and delay in recognition of the seriousness of the child's condition by medical personnel due to the lack of external

injuries. The comparatively high mortality and morbidity rate observed in this group relative to the other three groups could be accounted for by their poorer state on admission to the PICU.

Shaken baby syndrome is a condition little recognised among medical practitioners. It describes a combination of signs and symptoms that result from violent shaking of a young child with resultant diffuse axonal injury and subdural haemorrhage. Typical CT brain scan findings consist of thin and extensive subdural and/or subarachnoid haemorrhage (especially in the interhemispheric fissure), diffuse loss of grey and white matter differentiation, and cerebral oedema. Retinal haemorrhage is seen in 65% to 95% of victims, although it is not specific for this diagnosis. Signs of external injuries may not be present. Suggestive features include incompatible or inadequate history and delay in seeking medical attention.

Although, as in the case of the three children in this study, caregivers may not admit to inflicting injuries on their charges, this does not, of course, rule out the possibility that they are lying and the diagnosis is indeed shaken baby syndrome—especially as the suspected abuser(s) may not be identified in all cases.<sup>10,11</sup> In a study of missed cases of abusive head trauma, 31.2% of children with abusive head injury had been seen by physicians and the diagnosis was not recognised.<sup>12</sup> Medical practitioners thus need to have it drawn to their attention that abusive head trauma is not that uncommon and a high index of suspicion is necessary.

Similar to another report,<sup>10</sup> a child minder and (perhaps also) a domestic helper were responsible in two out of the three cases of shaken baby syndrome in our series. Child minders and domestic helpers play an important role in Hong Kong families. Currently, child minders are not required to receive any formal training in childcare. In April 2001, there were approximately 240 000 foreign domestic helpers working in Hong Kong, some of whom are inevitably inexperienced in childcare. They themselves may also be subjected to a large amount of stress, working as they do in a foreign environment with communication problems due to language barriers and cultural differences. Thus, it is important for both potential employers and employment agencies for child minders and foreign domestic helpers to realise that appropriate training, avoidance of excessive workload, and suitable supervision are all important for avoiding these tragedies.

## Conclusions

From July 1996 to December 1999, trauma and thermal injuries accounted for 7% of admissions to the PICU in Kwong Wah Hospital. Road traffic accidents were the most common cause of admission, whereas NAI accounted for the most serious injury. Indeed, NAI was associated with the single instanced mortality in this series. Detailed analysis of all these cases identified certain preventable factors, such as inappropriate use of double-decker bunkbeds, which were involved in four out of seven cases of accidental falls. Regularly reviewing the circumstances of incidents that lead to admission to the PICU would provide essential data for the 'Childhood Injury Information System' advocated by Chow.<sup>3</sup> This information system is meant to collect and analyse data relating to childhood injuries, with the aim of disseminating information to relevant authorities and agencies for appropriate actions, for example, public education programmes and school education programmes. This series, however, has limitations in that not only is the study sample small, but it is drawn from a single hospital with a biased case mix (ie lower socio-economic class). A multicentre survey to cover all Hong Kong PICUs at regular intervals is needed in order to give the big picture of paediatric trauma in Hong Kong.

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