Penetrating head injuries in children presenting to the emergency department in Australia and New Zealand. A PREDICT prospective study.

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ABSTRACT

Aim: Penetrating head injuries (pHIs) are associated with high morbidity and mortality. Data on pHIs in children outside North America are limited. We describe the mechanism of injuries, neuroimaging findings, neurosurgery and mortality for pHIs in Australia and New Zealand.

Methods: This was a planned secondary analysis of a prospective observational study of children <18 years who presented with a head injury of any severity at any of 10 predominantly paediatric Australian/New Zealand emergency departments (EDs) between 2011 and 2014. We reviewed all cases where clinicians had clinically suspected pHI as well as all cases of clinically important traumatic brain injuries (death, neurosurgery, intubation >24 h, admission >2 days and abnormal computed tomography).

Results: Of 20 137 evaluable patients with a head injury, 21 (0.1%) were identified to have sustained a pHI. All injuries were of non-intentional nature, and there were no gunshot wounds. The mechanisms of injuries varied from falls, animal attack, motor vehicle crashes and impact with objects. Mean Glasgow Coma Scale on ED arrival was 10; 10 (48%) had a history of loss of consciousness, and 7 (33%) children were intubated pre-hospital or in the ED. Fourteen (67%) children underwent neurosurgery, two (10%) craniofacial surgery, and five (24%) were treated conservatively; four (19%) patients died.

Conclusions: Paediatric pHIs are very rare in EDs in Australia and New Zealand but are associated with high morbidity and mortality. The absence of firearm-related injuries compared to North America is striking and may reflect Australian and New Zealand firearm regulations.

INTRODUCTION

Information on penetrating head injuries (pHI) in children is limited. In several recent, large, observational studies deriving clinical decision rules for imaging in children with a head injury (HI) from North America, penetrating injuries were excluded a priori, and case numbers were not listed.1–3 While not excluded a priori in a dataset of 20 000 children with HI from the UK, pHIs were not differentiated from blunt injuries caused by high-speed objects.4 Reports of pHI in children usually come from settings where interpersonal violence is high. Examples include paediatric reports on pHI from the USA with a focus on gunshot wounds,5 from South Africa where stab wounds predominate6 and from battle zones in Iraq and Afghanistan where blast injuries dominate.7 Most reports do not relate pHIs to HIs in general, and often, the focus is on fatalities not emergency department (ED) presentations.

Based on single-centre reports, pHIs in children in Australia and New Zealand are infrequent.8,9 A comparison of gun fatalities in children, most of which were HIs, between South Australia and San Diego County in the USA showed a much higher rate of gun fatalities and a high rate of hand gun use in the USA, whereas in Australia, long guns were more often used in fatalities. 9 In Australia, the reduction of gun violence has been a focus of much regulatory and legislative change over the last 20 years,10,11 with gun ownership and gun-related deaths in Australia and New Zealand generally at low levels.12

Based on a lack of information on the cause and rate of ED presentations of pHI in Australia and New Zealand, we set out to identify and analyse cases of pHI from within a large prospective dataset of head-injured children to describe their frequency of presentation to the ED, their characteristics, management and outcome.

METHODS

Study design, setting and patients

This was a planned secondary analysis of a prospective multicentre observational study, which enrolled children presenting with HIs of any severity to 10 paediatric EDs in Australia and New Zealand over a 44-month period between April 2011 and November 2014. All EDs are members of the Paediatric Research in Emergency Departments International Collaborative (PREDICT) research network.13 Of the 10 study EDs, 8 were located at tertiary children’s hospitals, and 7 of the 10 sites were regional paediatric trauma centres. The parent study was conducted to assess the accuracy of three HI clinical decision rules with details described elsewhere.14,15

In this study, we extracted patients with possible pHIs in terms of epidemiology and outcome.

The study was approved by the institutional ethics committees at each participating site. We obtained informed verbal consent from parents/guardians apart from instances of significant life threatening or fatal injuries where participating ethics committees granted a waiver of consent.

The study was registered with the Australian New Zealand Clinical Trials Registry ACTRN12614000463673 and followed the Standards for Reporting Diagnostic Accuracy Studies guidelines.16

Study procedures

Patients were enrolled by the treating ED clinician who collected clinical data, including positive, negative or unknown suspicion of penetrating injury prior to any neuroimaging. The research assistant recorded ED and hospital management data after the visit and conducted a telephone follow-up for patients who had not undergone neuroimaging. Site investigators, research assistants and participating ED clinicians received formal training prior to and during the study.

Definitions

Clinically important traumatic brain injury

We defined clinically important traumatic brain injury (ciTBI) as death from traumatic brain injury, need for neurosurgery, intubation >24 h for traumatic brain injury or hospital admission >2 nights for traumatic brain injury in association with traumatic brain injury on computed tomography (CT).1 We used the Glasgow Coma Scale (GCS) as assigned by the ED clinician on initial assessment in the analysis. We used senior radiologist reports to determine the results of CT and magnetic resonance imaging scans and operative reports for patients who underwent neurosurgery.

Penetrating head injuries

Multiple strategies were undertaken to identify pHIs among the 20 137 patients with HIs. We reviewed: (i) all cases in which the ED clinician at time of presentation indicated a clinical suspicion of pHIs in the clinical report form; (ii) all ciTBI cases with unknown and no suspicion of pHIs to ensure complete case identification; and (iii) cases with no ciTBI but with unknown suspicion of pHIs and skull fracture findings on CT scan. Patients were classified as having a true positive pHI if they had sustained any traumatic fracture of the skull where the dura mater was breached by either a foreign object or by comminuted bone fragments.

Statistical analysis

Patients with pHIs are presented using descriptive statistics. Data were entered into Epidata (The Epidata Association, Odense, Denmark) and, later, REDCap17 and analysed using Stata 14 (Statacorp, College Station, TX, USA).

RESULTS

At the 10 study hospitals, we identified 20 137 patients with His whose follow-up data were available after excluding representation for the same injury. In total, 21 patients with pHIs were identified: 8 of 28 patients with a suspicion of pHI and 13 of 271 patients with ciTBI with unknown or no suspicion for pHI.

The 21 patients (8 females, 38%) had a mean age at injury of 7.1 years (SD = 5.2) (Table 1). All injuries were non-intentional; none of the injuries were purposefully self-inflicted or the result of violence. There were no firearm (shotgun, handgun, rifle) or stabbing, arrow or dart injuries. Table 1 provides details on clinical symptoms and signs. In summary, six injuries were caused by impacts with objects, five were pedestrians struck by motorised vehicles, four were patients involved in motor vehicle crashes, three injuries were the result of falls and three were due to other transorbital or transcranial punctures. Mean GCS assigned by the ED clinician was 10 (SD = 5.4). Two thirds of patients were intubated, and two thirds underwent neurosurgery, which was mainly craniotomy, monitoring of intracranial pressure and elevation of a depressed skull fracture. Four patients (19%) died (Table 2).

DISCUSSION

Paediatric pHIs are very infrequent in Australia and New Zealand EDs and make up only 0.1% of HIs of all severities and causes. While the small number of pHIs was caused by a range of mechanisms, it is striking that none of them involved gunshots or stabbings.

The few pHIs that did occur had severe injury, a high frequency of loss of consciousness, low GCS on presentation, a high rate of intubation and neurosurgery and high mortality. In comparison, for the overall cohort of 20 137 children, only 1.1% had a GCS of ≤12, 0.4% required neurosurgery, and 0.1% died.14 For ED clinicians, an important finding is that the clinical suspicion of a pHI is rare but likely correlated with the true finding of a Phi on investigation and should accordingly trigger urgent CT scanning and early neurosurgical involvement.

The absence of gunshot injuries to the head in this study may reflect the relatively low level of gun ownership and gun violence across Australia and New Zealand compared with other countries. Gun ownership in Australia and New Zealand is reported at 13.7 (2016) and 29.5 (2016) guns per 100 people, respectively. Gun-associated deaths of any cause in Australia in New Zealand are reported at 0.93/100 000 (2015) and 1.20/100 000 (2010), respectively.12 This compares to the USA whose rates of gun ownership is 3.4–7.3 times higher (101.05 guns per 100 people) and gun deaths is 8.8–11.3 times higher (10.54/100 000 (2014)).12 In Australia in particular, following the Port Arthur gun massacre at a tourist location in 1996, multiple legislative and regulatory processes were put in place across the country to restrict gun ownership as part of the National Firearms Agreement. 11 In addition, a national tax payer-funded gun buy-back programme led to the destruction of some 600 000 weapons.10,11 A recent analysis of the gun law reforms and intentional firearm deaths in Australia has shown an accelerated reduction in firearm deaths following the reforms.10 Similar to Australia, a mass shooting in New Zealand in 1990 triggered legislative change that restricted firearm sales, tightened restrictions for firearm licences and required secure storage of firearms.18 While causality between firearm policy and gun violence is difficult to determine, our observational study supports the current status quo regarding firearm policy in both countries.

The absence of gunshot wounds to the head may also reflect the possibility that children injured in this way do not present to EDs. Gunshot wounds in general, and those to the head in particular, are often fatal and may only be captured in a coronial dataset. 9,19 National data from New Zealand reported only three unintentional firearm deaths in children aged younger than 15 years from 2002 to 2014,20–22 confirming that not only injury but death from gunshots is rare in New Zealand. There likely are intentional firearm injuries, but they are not reported. A report from the Australian National Coronial Information System reported 47 closed cases of deaths in children aged 15 or younger due to projectile-related fatalities from 2002 to 2014,23 of which 35 were related to long gun use and 9 handgun use. Nineteen of these were due to intentional self-harm, 17 assault, 10 unintentional and 1 legal intervention.

pHI in general and gunshot wounds to the head in particular carry a high mortality, and it is possible that victims died on scene and did not present to the ED. These patients would only be captured in a linked coronial database. Our study was focussed on their frequency of presentation to the ED, their clinical characteristics and outcome.

CONCLUSIONS

In a prospectively collected Australian and New Zealand multicentre dataset, childhood pHIs were very rare in EDs and generally presented as seriously injured. No firearm-related HIs were identified in this large ED dataset.

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Table 1. Demographics and presentations of penetrating head injuries in children

	Penetrating head injury n=21	
	n	%
DEMOGRAPHICS		
Median age (years, (SD))	6.5	2.9-10.7
Patients < 2 years	4	19
Female	8	38
Current GCS (clinician assigned), median (IQR)	12	3-15
3-8	8	38
9-12	3	14
13	0	0
14	2	10
15	8	38
PATIENT HISTORY		
Known or suspected LOC	10	48
Witnessed disorientation	6	29
History of vomiting	2	10
History of amnesia	4	19
Seizure since injury	1	5
GENERAL EXAMINATION		
Intubated and ventilated on arrival	7	33
Headache*	7	50
Focal neurology present*	2	29
Patient irritated or agitated*	6	86
Patient abnormally drowsy/difficult to wake*	4	57
Patient slow to respond to speech*	3	43
Patient has altered mental status*	5	71
Head laceration	14	67
Head haematoma	15	71
Obvious palpable skull fracture	10	48
Possible skull fracture on palpation	10	48
Suspicion of depressed skull fracture	13	62
Clinical open skull fracture	9	43
Serious facial injury	9	43
Signs of basal skull fracture	4	19

*Percentage based on patients not intubated on arrival (n=7)
GCS = Glasgow Coma Scale; LOC = loss of consciousness

Table 2. Management and outcome of penetrating head injuries

	Current study n=21	
	n	%
Patient intubated or ventilated due to the head injury	13	62
Length of intubation (hours, mean; SD)	63.5	70
NEUROIMAGING*		
Neuroimaging	21	100
CT	21	100
MRI	7	33
Abnormal neuroimaging	21	100
Intracranial haemorrhage/contusion	15	71
Extra-axial bleeding	11	52
Parenchyma bleeding	8	38
Sub-arachnoid bleeding	5	24
Cerebral oedema	9	43
Diffuse axonal injury	1	5
Midline shift or brain herniation	6	29
Diastasis of skull	4	19
Pneumocephalus	11	52
Skull fracture*	20	90
Depressed	15	70
Non-depressed	8	14
Basal Skull	5	33
Unknown	1	5
NEUROSURGICAL INTERVENTION		
Neurosurgery *	14	67
Monitoring of intracranial pressure	9	43
Elevation of depressed skull fracture	9	43
Craniotomy	10	48
Haematoma Evacuation	3	14
Lobectomy	1	5
Tissue debridement	2	9
Dura repair	10	48
DEATH		
Died	4	19

*More than one type of skull fracture/neuroimaging possible

CT= computed tomography; ED = Emergency Department; MRI = magnetic resonance imaging