ORIGINAL ARTICLE

Concussive head injury in children and adolescents related to sports and other leisure physical activities

G J Browne, L T Lam

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See end of article for authors' affiliations

Correspondence to: Dr Browne, The Children's Hospital at Westmead, CHISM, Sydney, NSW 2145, Australia; garyb@chw.edu.au

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Objective: To compare the characteristics of children and adolescents with concussive head injury (CHI) sustained during organised sports or other leisure physical activity.
Methods: This was a case series study reviewing the medical records retrospectively over a four year period of children 6–16 years presenting to the emergency department with a CHI after participating in sport and/or recreation activity.
Results: There were 592 cases of sport and recreation related concussion over the study period (2000–2003). Most of the patients (n = 424, 71.6%) were male, with half (n = 304, 51.4%) being older than 10 years of age. A total of 152 (25.7%) cases of CHI were related to playing sports. Most cases (71.2%) were mild concussion. The cause of injury was a fall (n = 322, 54.4%) or a collision. Nearly a quarter of the children (n = 143, 24.2%) were admitted to hospital, with imaging performed in 134 (22.7%). Most children were treated appropriately and no adverse events were reported.
Conclusions: A severe CHI in a child is six times more likely to have resulted from organised sport than from other leisure physical activities. Outcomes for CHI in children is excellent, although their management places a considerable burden on emergency services. The need for activity restriction and the benefits of this in reducing long term cognitive effects of CHI are uncertain.

A variety of injuries occur to children and adolescents while involved in different sports and leisure physical activities. One of the most commonly reported injuries in children 16 years and under who participate in such activity is concussion,[1–4] with as many as 180 per 100 000 per year suffering a head injury while participating in sports and other leisure physical activities, many of these being mild.[5] There is some evidence that even a mild head injury or concussion has a negative impact on cognitive function and can contribute to long term disability. Many sequelae of concussion have been reported in the literature, including poor attention span, headache, impaired memory, behavioural problems, and learning difficulties.[6–10]

Although injuries due to sports and other physical activity are often grouped together by authors when reporting injury data,[11 12] there are inherent differences between the two types of activity as can be seen in the circumstances that lead up to an injury. Children participating in leisure physical activities are often minimally supervised. In addition, children playing sports such as football in a recreational manner are unlikely to follow any official rules or regulations, such as wearing protective equipment. In contrast, in organised sports, rules are well defined and the activity takes place in a supervised environment. Most studies do not make this important distinction and therefore lack subtle information on the differences between these two types of activity, in terms of patient characteristics such as severity of concussion, treatment and clinical management, and outcomes of injury.[13–15]

The aim of this paper is to compare the injury characteristics of children who suffered concussive head injury (CHI) while participating in organised sports or recreation related activities.

METHODS

The medical records of children aged 6–16 who presented to the emergency department of The Children's Hospital at Westmead between 2000 and 2003 with a CHI related to sport or other leisure physical activity were reviewed retrospectively. The Children's Hospital at Westmead is the major paediatric trauma centre for New South Wales and serves most of the paediatric population of the western region of Sydney.

There is no standardised definition of concussion. It is generally accepted as a traumatically induced alteration in mental status that may or may not be associated with loss of consciousness. The presence or absence and duration of different markers of concussion such as loss of consciousness, amnesia, and disorientation/confusion have been used to stratify patients in different risk groups.[16–18] In this study, CHI is defined as a history of impact to the head, a Glasgow coma score above 14 at the initial examination, and no focal neurological deficits. Hence, these children were classified as having mild traumatic head injury according to the Glasgow coma score. They may have a history of loss of consciousness, seizure, vomiting, headache, amnesia, lethargy, or confusion following the head trauma. Evaluation of the severity of CHI in children acutely presenting to an emergency department can be difficult, and in many cases the diagnosis may be incorrect. A conservative approach to CHI is taken in our emergency department, with any loss of consciousness considered to be the most serious form of concussion a child can sustain. For this reason, the American Academy of Neurology criteria best characterise how we stratify children with concussion in daily clinical practice in our emergency department.[16–18] From the description in the medical notes, the severity of concussion or CHI was classified according to the American Academy of Neurology classification.[16] A brief change in mind set or confusion of less than 15 minutes is classified as grade 1, any change in mind set/confusion longer than 15 minutes is grade 2, and any loss of consciousness grade 3.

Patients with a presenting diagnosis of CHI, with or without other injuries, were selected from the emergency department information system. Only the patients who complied with our working definition of concussion at presentation were entered into the study proper. As well as

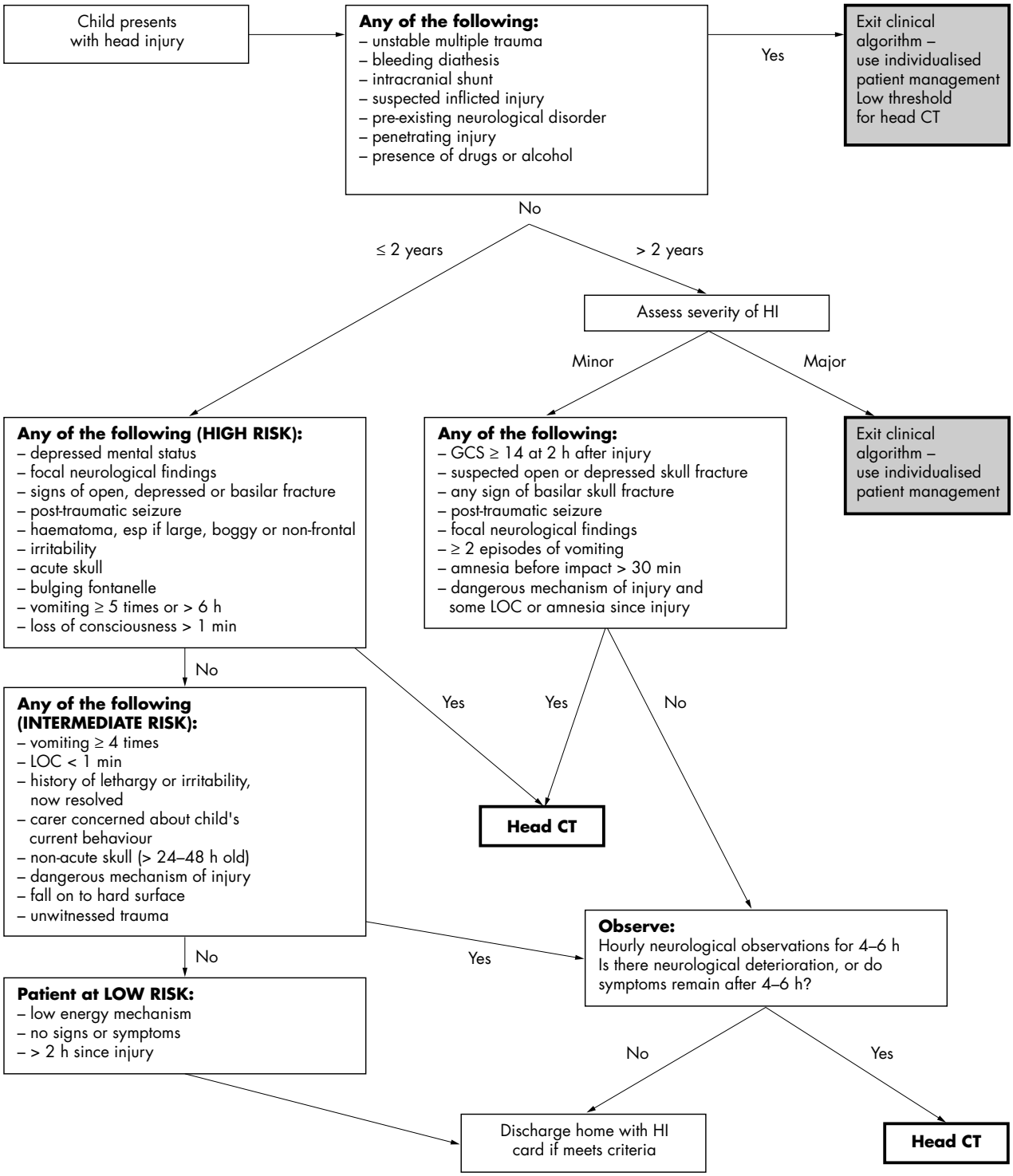

Figure 1 Emergency department head injury management algorithm (www.chw.edu.au/emergency/policies). CT, Computed tomography; HI, head injury; LOC, loss of consciousness.

patient age and sex, information was collected on mechanism of injury, type of activity, details of presenting symptoms, diagnostic investigations, and clinical treatment and management (operative, non-operative, and observation), and the definitive diagnosis was extracted from the information system. The activity involved when injury occurred was classified on the basis of the standard of the National minimum data set for injury data collection (NDS-IS version 2.1c January 1998).

The management of children with a concussion or CHI presenting to our emergency department follows a common procedure that is part of the routine care for all children presenting to our emergency department with such a head injury. This algorithm is an evidence based approach to head injury for use in our emergency department (fig 1).[19–27] Adherence to or deviation from the clinical algorithm was used to determine appropriateness of treatment for each patient.

Table 1 Basic characteristics, injury, treatment, and outcome for paediatric patients with concussive head injury (n = 592)

Characteristic	Number (%)
Age group (years)	
0–4	18 (3.0)
5–9	270 (45.6)
⩾10	304 (51.4)
Sex	
M	424 (71.6)
F	166 (28.4)
Mechanism	
Fall	322 (54.4)
Collision	270 (45.6)
Activity involved	
Organised sports	152 (25.7)
Other physical activity	440 (74.3)
Place of injury	
Home	149 (25.2)
School	123 (20.8)
Others	320 (54.1)
Concussion severity	
Severe	19 (3.2)
Moderate	148 (25.1)
Mild	422 (71.2)
Multiple injury	
Yes	108 (18.2)
No	484 (81.8)
Imaging	
Yes	134 (22.7)
No	457 (77.3)
Observation	
Yes	579 (99.8)
No	1 (0.2)
Vital sign	
Yes	532 (90.5)
No	56 (9.5)
Neurological assessment	
Yes	308 (52.2)
No	282 (47.8)
Appropriate treatment	
Yes	585 (99.2)
No	5 (0.8)
Admission to hospital	
Yes	143 (24.2)
No	449 (75.8)
Re-presentation	
Yes	11 (1.9)
No	580 (98.1)
Deterioration	
Yes	3 (0.5)
No	580 (98.1)
Instruction	
Yes	571 (96.6)
No	20 (3.4)
Education	
Yes	402 (68.7)
No	183 (31.3)
Return to activity instruction	
Yes	217 (38.1)
No	353 (61.9)

The focus of the study was a comparison of the characteristics of patients injured in organised sports and other leisure physical activities. Data on the study variables were analysed descriptively and presented as numbers and percentages. Logistic regression analysis was also applied to calculate the odds ratio (OR) and corresponding 95% confidence interval (CI) for determining the associations between activity types and patient characteristics, such as severity of concussion, treatment, and outcomes.

RESULTS

A total of 592 children and adolescents aged 6–16 years presented to the emergency department of the Children's Hospital at Westmead with CHI between 2000 and 2003.

Table 2 Details of injury mechanisms and activity when injury occurred

	Number (%)
Mechanism	
Falls (total)	322 (54.4)
Stumbling on same level	17 (2.9)
Slipping, tripping	126 (21.3)
On/from stairs	14 (2.4)
<1 m	37 (6.3)
>1 m	78 (13.2)
Other specific fall	26 (4.4)
Other unspecific fall	24 (4.1)
Collisions (total)	270 (45.6)
With moving object	55 (9.3)
With static object	62 (10.5)
With person	130 (22.0)
With animal	2 (0.3)
Other specific contact	16 (2.7)
Other unspecific contact	5 (0.8)
Activity	
Organised sports (total)	152 (25.7)
Baseball	6 (1.0)
Basketball	9 (1.5)
Cricket	8 (1.4)
Football Australian	3 (0.5)
Football rugby	34 (5.7)
Football soccer	29 (4.9)
Football unspecific	49 (8.3)
Hockey	2 (0.3)
Netball	9 (1.5)
Tennis	1 (0.2)
Gymnastics	2 (0.3)
Other physical activities (total)	440 (74.3)
Horse riding	9 (1.5)
Trampolining	6 (1.0)
Roller blade	3 (0.5)
Roller skating	1 (0.2)
Skateboarding	13 (2.2)
Ice skating	13 (2.2)
Diving/swimming	13 (2.2)
Scootering	14 (2.4)
Other leisure activities	215 (36.3)
Playing	153 (25.5)

Most were male (n = 424, 71.6%), and about half (n = 304, 51.4%) were older than 10 years (table 1) . About a quarter (n = 152, 25.7%) were sustained during organised sport. Falls constituted slightly more than half of the mechanism of injury (n = 322, 54.4%), with the rest being contact with a person or an object. Table 2 gives details of the injury mechanisms and activities involved. About one quarter of these injuries occurred at home (n = 149, 25.2%), one fifth (n = 123, 20.8%) in schools, and more than half at other places such as parks and playgrounds. Most were classified as mild (n = 422, 71.2%), 148 (25.1%) were moderate, and 19 (3.2%) were severe; in most cases, concussion was the only injury (n = 484, 81.8%). In terms of the treatment at the emergency department, 134 (22.7%) patients had further radiological imaging, and about half were assessed neurologically at presentation (n = 308, 52.2%). Nearly all of these patients were under observation, with vital signs monitored as normal in 90.5%. Retrospective assessment of the clinical management of these patients found that most were treated appropriately, with only five (0.8%) patients whose treatments could be improved. In total, 143 (24.2%) of these patients were admitted to hospital. In terms of the outcome, 11 patients (1.9%) re-presented to the hospital after initial discharge, three with deterioration of their head injury. Information about the symptoms and after effects of head injury was given to most of the parents and patients (n = 571, 96.6%) before discharge. However, only 38.1% (n = 217) were provided with ''return to activity'' instruction.

Table 3 Unadjusted associations between patients' characteristics and organised sports

	Organised sports (n = 152)	Other activities (n = 440)	Significance
Age group			
⩾10	133 (87.5)	219 (49.8)	χ^2_1 = 66.71, p<0.0001
<10	19 (12.5)	221 (50.2)	
Sex			
M	134 (88.2)	290 (65.9)	χ^2_1 = 27.51, p<0.0001
F	18 (11.8)	150 (34.1)	
Mechanism			
Contact	131 (86.2)	139 (31.6)	χ^2_1 = 135.73, p<0.0001
Fall	21 (13.8)	301 (68.4)	
Place of injury			
Home	2 (1.3)	147 (33.4)	χ^2_2 = 80.15, p<0.0001
School	24 (15.8)	99 (22.5)	
Others	126 (82.9)	194 (44.1)	
Concussion severity			
Severe	9 (6.0)	10 (2.3)	χ^2_2 = 22.38, p<0.0001
Moderate	56 (37.0)	92 (21.0)	
Mild	86 (57.0)	336 (76.7)	
Multiple injury			
Yes	39 (25.7)	72 (16.4)	χ^2_1 = 6.41, p = 0.01
No	113 (74.3)	368 (83.6)	
Imaging			
Yes	45 (29.6)	89 (20.3)	χ^2_1 = 5.61, p = 0.02
No	107 (70.4)	350 (79.7)	
Vital sign			
Yes	137 (91.9)	395 (90.0)	χ^2_1 = 0.51, p = 0.48
No	12 (8.9)	44 (10.0)	
Assess cognitive dysfunction			
Yes	50 (32.9)	258 (58.9)	χ^2_1 = 30.59, p<0.0001
No	102 (67.1)	180 (41.1)	
Admission to hospital			
Yes	59 (38.8)	84 (19.1)	χ^2_1 = 23.99, p<0.0001
No	93 (61.2)	356 (80.9)	
Re-presentation			
Yes	1 (0.7)	10 (2.3)	χ^2_1 = 1.62, p = 0.20
No	152 (99.3)	429 (97.7)	
Instruction			
Yes	148 (97.4)	423 (96.4)	χ^2_1 = 0.35, p = 0.55
No	4 (2.6)	16 (3.6)	
Education			
Yes	119 (79.3)	283 (65.1)	χ^2_1 = 10.58, p = 0.001
No	31 (20.7)	152 (34.9)	
Return to activity instruction			
Yes	37 (24.7)	180 (42.9)	χ^2_1 = 15.51, p<0.0001
No	113 (75.3)	240 (57.1)	

Values in parentheses are percentages.

Table 3 summarises the unadjusted associations between patients' characteristics and organised sports related concussion. Characteristics identified as significantly related to organised sports were included in the logistic regression analyses. The results obtained from the logistic regression suggested that, after adjustment for each other (table 4), some patients' characteristics remained significantly associated with organised sports. In comparison with other leisure physical activities, children and adolescents who suffered a CHI while playing in organised sports were more likely to be male and older than 10 years. In terms of the severity of the injury, children and adolescents involved in organised sports were nearly six times more likely to suffer a severe concussion (OR 5.57, 95% CI 1.30 to 23.81) than those involved in other physical activities, with injuries more likely to occur in schools or other places than at home. In terms of clinical management, patients with CHI related to organised sport were significantly less likely to receive assessment for cognitive dysfunction before discharge from the emergency department (OR 0.47, 95% CI 0.27 to 0.83) and also less likely to be given return to activity instructions (OR 0.36, 95% CI 0.18 to 0.70). However, they were more likely to have received information about head injury symptoms and their after effects.

DISCUSSION

This study reports on the nature and characteristics of CHI in a large cohort of paediatric emergency department patients and the key differences between children injured while participating in organised sports compared with other leisure physical activities.

Most (71.6%) CHIs in this study occurred in boys, and this is consistent with other reports in which boys were three times more likely to present to an emergency department with such an injury.[28] The most severe CHIs in our study occurred predominantly in boys 10 years of age and older involved in sport. This is also in keeping with other reports in which boys aged 10–14 years who participated in sport were found to have the highest rates of presentation and suffered the most severe types of injury.[28]

In terms of the severity, children and adolescents involved in organised sports were nearly six times more likely to suffer a severe concussion than those involved in leisure physical activities. The results further suggest that severe concussion is associated with collision rather than a fall. Collisions occur more often in organised sports than leisure physical activities. The main question arising from this result is why are children involved in organised sport more at risk of CHI. One possible explanation involves the human factor. Many studies have

Table 4 Adjusted associations between patients' characteristics and organised sports

	OR (95% CI)
Age group	
10+	4.54 (2.30 to 8.94)
<10	1.00
Sex	
M	2.84 (1.42 to 5.67)
F	1.00
Mechanism	
Contact	12.08 (6.60 to 22.11)
Fall	1.00
Place of injury	
School	12.02 (2.40 to 60.31)
Others	34.67 (7.40 to 162.30)
Home	1.00
Concussion severity	
Severe	5.57 (1.30 to 23.81)
Moderate	1.75 (0.84 to 3.64)
Mild	1.00
Multiple injury	
Yes	1.98 (0.95 to 4.11)
No	1.00
Imaging	
Yes	1.07 (0.54 to 2.13)
No	1.00
Assess cognitive dysfunction	
Yes	0.47 (0.27 to 0.83)
No	1.00
Admission	
Yes	0.76 (0.35 to 1.67)
No	1.00
Education	
Yes	3.66 (1.87 to 7.91)
No	1.00
Return to activity instruction	
Yes	0.36 (0.18 to 0.70)
No	1.00

reported the benefits of protective equipment in reducing injury. Unfortunately, attitudes among children and adolescents towards the use of protective equipment during physical activities are variable. A number of reports have shown low usage rates of protective equipment in youth sport across a range of sports. The implication is that poor acceptance and low compliance with the use of protective equipment has led to an increased risk of CHI, particularly severe head injury. Rules and regulations need to be enforced by parents and coaches if we are to see the benefits of such protective equipment in reducing CHI. This will require further efforts to understand the barriers to compliance in children and adolescents, as well as to investigate more effective ways to educate parents, coaches, and players on the potential benefits of injury reduction through appropriate use of protective equipment.

Force with 2–3-fold greater impact is required to produce clinical symptoms in a child than in an adult who has suffered a head injury. A child who exhibits symptoms after a head injury is therefore likely to cause considerable concern to both parents and doctor. We can take some consolation from the results of our study, which show the outcome of CHI in children participating in sport and leisure activity to be excellent, with no adverse outcomes reported.

Our study confirms that injuries caused by sport and leisure activities use large amounts of emergency department and hospital resources.[29] As nearly a quarter of the cases in our study were sports related and as there was a higher risk of severe CHI, it is not surprising that the children exhibiting symptoms after a CHI were more likely to be admitted to hospital. What is surprising is the large number of children with CHI who had further radiological investigation in the emergency department that was unwarranted. Current guidelines in the literature on the management of mild traumatic brain injury are somewhat confusing. To avoid unnecessary imaging, evidence based management guidelines for caring for children with CHI must be developed. Otherwise healthcare resources will continue to be overused for CHI in children, and children will continue to undergo potentially unnecessary investigation.

Follow up in most children discharged after suffering a CHI was adequate, but few parents were given clear instructions about when their child should return to activity. Parents may become unnecessarily anxious when told about activity restrictions, particularly when the reasons for their application are explained. Activity restriction may also place an unnecessary burden on parents, as it may be difficult for some parents to impose restrictions on their children. Opinion therefore remains divided over the need for activity restriction in children. Some authors believe that a previous CHI may increase the risk of subsequent CHI.[30] Others believe that a child's activities should not be unnecessarily restricted after suffering CHI.[31] The importance of symptomatic treatment, rest breaks, and reassurance is emphasised by these authors as adequate discharge advice.[32] There have been very few reports on the effect of activity restriction on the cognitive sequelae of a CHI in children. Much work remains to be carried out on the nature of cognitive effects of CHI in children and the benefits, if any, of activity restriction in children after a CHI.[33 34]

This study has some limitations. An intrinsic limitation to all hospital based studies is that the patients are not representative of the general paediatric population. Furthermore, because of the hospital data collection system, which is very specific for emergency department patients, we did not collect comprehensive information on variables that are crucial for furthering our understanding of the circumstances of injury such as whether protective equipment was worn. We therefore cannot extrapolate our findings to the general paediatric population. To achieve that, a well designed case-control study is necessary to provide much more accurate risk estimates.

What is already known on this topic

- Concussion is a common reason for presentation to emergency departments, and is predominantly the result of a sporting or leisure activity, although little distinction has been made between these two entities
- Clinical outcome for these patients is usually good

What this study adds

- Compared with leisure physical activities, sporting activities more often involve collisions, which may result in more severe injuries
- The management of concussion places a considerable burden on emergency department resources, and guidelines need to be produced to keep this to a minimum

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Authors' affiliations

G J Browne, The Children's Hospital at Westmead, Sydney, NSW, Australia
L T Lam, Royal Alexandra Hospital for Children, Sydney

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