ED Utilization Trends in Sports-Related Traumatic Brain Injury

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KEY WORDS

traumatic brain injury, sports, pediatrics, admission, severity

ABBREVIATIONS

CCHMC—Cincinnati Children's Hospital Medical Center

CDC—Centers for Disease Control and Prevention

ED—emergency department

ICD-9—International Classification of Diseases, Ninth Revision

ISS—injury severity score

LOS—length of stay

TBI—traumatic brain injury

Dr Hanson conceptualized and designed the study and drafted the initial manuscript; Dr Pomerantz was involved in the initial study designs, was responsible for the data analysis, and reviewed and revised the manuscript; Dr Gittelman was involved in the initial study design and critically reviewed and revised the manuscript; and all authors approved the final manuscript as submitted.

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WHAT'S KNOWN ON THIS SUBJECT: Traumatic brain injury (TBI) in children causes significant morbidity and mortality. Parental and coach awareness about brain injury due to sports has recently increased. Since 2001, pediatric emergency departments have seen a significant increase in sports-related TBI.

WHAT THIS STUDY ADDS: Pediatric, sports-related TBIs cared for in the emergency department and admitted to the hospital have both increased, resulting in no change in the percentage being admitted. However, patients admitted have had a significant reduction in injury severity.

abstract

BACKGROUND: Emergency department (ED) visits for sports-related traumatic brain injuries (TBIs) have risen. This study evaluated how the number and severity of admissions have changed as ED visits for sports-related TBIs have increased.

METHODS: A retrospective study of children aged 0 to 19 years at a level 1 trauma center was performed. Patients from 2002 to 2011 with a primary or secondary diagnosis of TBI were identified from the hospital's inpatient and outpatient trauma registries. Frequencies were used to characterize the population, χ^2 analysis was performed to determine differences between groups, and regression analysis looked at relationship between year and injury severity score or length of stay.

RESULTS: Sport was responsible for injury in 3878 (15.4%) cases during the study period; 3506 (90.4%) were discharged from the hospital, and 372 (9.6%) were admitted. Seventy-three percent were male patients and 78% Caucasian; mean age was 13 ± 3.5 years. ED visits for sports-related TBIs increased 92% over the study period, yet there was no significant change ($\chi^2 = 9.8$, $df = 9$, $P = .37$) in the percentage of children admitted. Mean injury severity score for those admitted decreased from 7.8 to 4.8 ($\beta = -0.46$; $P = .006$); length of stay trended downward ($\beta = -0.05$; $P = .05$).

CONCLUSIONS: The percentage of children being admitted from the ED with sports-related TBI has not changed over the past 10 years. The severity of admitted sports-related TBI is decreasing. Additional research is needed to correlate these trends with other TBI mechanisms. *Pediatrics* 2013;132:e859–e864

Traumatic brain injury (TBI) is an epidemic that gained national recognition and funding for research by the Centers for Disease Control and Prevention (CDC) after a series of hospital-based clinical cases and epidemiologic studies demonstrated its potential for significant morbidity and mortality.¹ TBI is responsible for ~630 000 emergency department (ED) visits, 67 700 hospitalizations, and 6100 deaths annually in children 0 to 19 years of age.² Although many mechanisms can cause TBI, medical evaluations for children and adolescents in US EDs increased 62% between 2001 and 2009 as a result of sports-related TBI.^{3,4}

It is unclear why ED visits for sports-related TBI have been increasing. It is possible that the increase is from greater sports participation because of children joining competitive sports at younger ages and more girls participating in sports.⁵ During the 2011–2012 school year, the National Federation of State High School Associations reported that >7 million high school students participated in organized sports in the United States, 24 000 more than the previous year. This organization also reported that female involvement in sports has grown each year for the past 23 consecutive years.⁵ It is also possible that media attention regarding brain injury in sports has created an awareness that is resulting in more ED visits. In the past 10 years, many landmark studies and initiatives have been reported across mass media including the CDC's Head's Up campaign, articles from the University of North Carolina on the adverse long-term effects of TBI, and the passing of the Zachary Lystedt law that initiated state laws regarding sports-related TBI and return to play.^{6–9} Another potential reason for the increase in ED visits is that children today are stronger and bigger than ever.¹⁰ In fact, one-third of US children currently fall in the obese

category, creating greater force if collisions occur between athletes and resulting in the potential for more significant injuries, such as TBI.¹¹

Regardless of etiology, ED visits for sports-related TBI continue to increase, and to date no study has assessed whether hospital admissions and/or the severity of TBIs cared for has similarly increased. The objectives of this study were (1) to determine if the number and proportion of admissions to the hospital due to sport-related TBI has increased compared with ED visits for sports-related TBI and (2) to assess if the TBI severity and length of admission has changed over the past 10 years.

METHODS

Data Source

We performed a retrospective study of children from birth through age 19 years who presented for sports-related TBI to a large, pediatric level 1 trauma center, with an annual patient volume of 92 000 (15% admission rate), between January 1, 2002, and December 31, 2011. Patients were identified electronically through the Cincinnati Children's Hospital Medical Center (CCHMC) Trauma Registry, a hospital-based injury surveillance system that contains information about all patients sustaining injuries. Information in the CCHMC Trauma Registry is obtained by abstracting medical charts of all patients who were treated in the ED and released, were admitted to the hospital, or who died in the ED as a result of injury (International Classification of Diseases, Ninth Revision [ICD-9] E-codes 800.00–995.09, and 10th Revision codes T36–T65 and X60–X69). Checks are performed monthly by the Trauma Information Coordinator on a random sample of 10% of the charts in the trauma registry to ensure internal consistency and reliability

within the database. The hospital's institutional review board approved this study (Study ID 2012-1935).

Study Population

Charts were extracted from the CCHMC Trauma Registry if the individual was <20 years of age, had a primary or secondary diagnosis of TBI based on ICD-9 code (800.0–801.9, 803.0–804.9, 850.0–854.1, 950.1–950.3, 995.55, and 959.01), and had sport as the mechanism of injury. Patients were excluded if they had no mechanism of injury recorded. Any patient seen more than once within 7 days for the same injury had only their initial ED visit counted. If the patient was admitted at a subsequent visit (>7 days later), however, that admission was retained in the data for analysis. The age range 0 to 19 years was selected to maintain consistency with statistics on this topic previously published by the CDC. The ICD-9 codes were selected to maintain the definition of TBI in accordance with the CDC definition of an “occurrence of injury to the head (arising from blunt or penetrating trauma or from acceleration-deceleration forces) that is associated with symptoms or signs attributable to the injury—decreased level of consciousness, amnesia, other neurologic or neuropsychologic abnormalities, skull fracture, diagnosed intracranial lesions—or death.”¹

The data set included medical record number, demographics (age at the time of the injury, gender, race, type of insurance coverage), type of head injury, sport, disposition from ED (discharged, admitted to the floor/ICU, death), outcome (lived or died), and ICD-9 code. For admitted patients, length of stay (LOS) and injury severity score (ISS) were also obtained. Medical record numbers were initially retained in the data and used to identify any person who presented to the ED for the same injury more than once. Sport included

football, basketball, soccer, baseball/softball, skateboarding/roller blading, skiing, swimming, sledding, and hockey; all other types of sports such as gymnastics and volleyball were categorized as "other." Sport excluded bicycle activities (whether organized or not), near drowning not related to the sport of swimming, and any playground activities.

Statistical Analysis

All charts meeting inclusion criteria were deidentified and entered into a Statistical Package for the Social Sciences (Release 19.0.0, 2010, IBM SPSS Statistics, IBM Corporation) database. Frequencies were used to define the study population for descriptive variables. χ^2 analysis was used to determine differences between those admitted and those discharged from the hospital for categorical variables; Student's *t* test was used for continuous variables. Regression analysis was used to fit a trend line to evaluate the relationship between year and ISS or LOS for admitted patients. A *P* value <.05 was considered statistically significant.

RESULTS

During the study period, 25 410 patients presented to the ED with a primary or secondary diagnosis of TBI. Of those, 20 637 (81.2%) patients were excluded because a nonsport mechanism was responsible for the TBI, and 746 (3%) patients were excluded because there was no mechanism of injury recorded. One hundred forty-nine patients with a sports-related TBI presented to the ED more than once within 7 days, so only the initial visit was included in the analysis. After all exclusions, a sports mechanism was documented for 3878 (15.4%) cases, and 372 (9.6%) of those children were admitted to the hospital. There were no deaths due to sports-related TBI.

The mean age of the patients was 13.0 ± 3.5 years. There was no difference in age or gender between those children seen in the ED and discharged from the hospital (outpatient) and those admitted to the hospital (inpatient); however, a statistically significant difference was found between these 2 groups with regard to race and insurance type (Table 1). According to ICD-9 code, those children admitted to the hospital were more likely to have brain bleeds, skull fractures, and brain contusions than those children seen in the ED and discharged from the hospital. The ICD-9 code for concussion was seen in similar percentages in the ED and hospital admission categories, 46.9% and 49.7%, respectively.

For patients seen in the ED and discharged from the hospital, football (29.1%), soccer (16.5%), and basketball (15.4%) were the most common sports responsible for TBI. For admitted patients, the most common sports seen were football (24.7%), skateboarding/roller blading (16.1%), and baseball/softball (12.9%). However, as Table 2 demonstrates, skateboarding/roller blading, sledding, and skiing had the highest admission rates per patients seen in the ED for TBI. Similar percentages of TBI were seen in boys and girls by sport with the exception of football and soccer. There was a larger percentage of football-related TBI in boys and a larger percentage of soccer-related TBI in girls.

A 92% increase was observed in ED visits for sports-related TBI from 2002 to 2011, and an 85% increase was seen in admissions across the same time period. Despite an increase in number of both ED visits and admissions, there was no significant change ($\chi^2 = 9.8$, *df* = 9, *P* = .37) in the percentage of children admitted from the ED (average 9.6%; Table 3). Of those patients who were admitted, the mean ISS decreased significantly ($\beta = -0.46$, *P* = .006) across the 10 years. There was a trend toward decreased LOS, which approached statistical significance ($\beta = -0.05$, *P* = .05) as shown in Fig 1.

DISCUSSION

TBI, regardless of mechanism, is known to be associated with significant morbidity and mortality, and studies have shown that the more severe the TBI, the more debilitating the sequelae.^{12,13} It has been well studied and demonstrated that ED visits for sports-related TBI are increasing.^{4,14,15} This study has established that despite the increase seen in the ED, the percentage of children requiring admission for sports-related TBI has remained near 10% annually over the past 10 years. However, of those patients requiring hospital admission, the ISS has significantly decreased over this same period, indicating that more patients are being admitted with milder injury.

TABLE 1 Demographic Characteristics of Children With a TBI Secondary to a Sports Injury

	All Patients (<i>n</i> = 3878)	Outpatient (<i>n</i> = 3506)	Inpatient (<i>n</i> = 372)	<i>P</i> : Inpatient Versus Outpatient
Age, mean (SD)	13.0 (3.5)	12.9 (3.5)	13.2 (3.4)	.11
Male gender	2820 (72.2%)	2538 (72.4%)	282 (75.8%)	.16
Race				.02
Caucasian	3029 (78.1%)	2723 (77.7%)	306 (82.3%)	
African American	607 (15.7%)	568 (16.2%)	39 (10.5%)	
Other	242 (6.2%)	215 (6.1%)	27 (7.3%)	
Insurance				<.001
Private	3272 (84.4%)	2980 (85.0%)	292 (78.5%)	
Medicare/Medicaid	429 (11.1%)	359 (10.2%)	70 (18.8%)	
Self-pay	68 (1.8%)	66 (1.9%)	2 (0.5%)	
Unknown	109 (2.8%)	101 (2.9%)	8 (2.2%)	

TABLE 2 Sports Responsible for TBI

Sport	Overall (n = 3878)	Outpatient (n = 3506)	Inpatient (n = 372)	% Admitted by Sport
Skate/roller blading	222 (5.7%)	162 (4.6%)	60 (16.1%)	27.0
Sledding	140 (3.6%)	110 (3.1%)	30 (8.1%)	21.4
Skiing	92 (2.4%)	73 (2.1%)	19 (5.1%)	20.7
Baseball/softball	344 (8.9%)	296 (8.4%)	48 (12.9%)	14.0
Football	1113 (28.7%)	1021 (29.1%)	92 (24.7%)	8.3
Basketball	586 (15.1%)	541 (15.4%)	45 (12.1%)	7.7
Hockey	69 (1.8%)	64 (1.8%)	5 (1.3%)	7.2
Swimming	130 (3.4%)	122 (3.5%)	8 (2.2%)	6.2
Other ^a	574 (14.8)	539 (15.4%)	35 (9.4%)	6.1
Soccer	608 (15.7%)	578 (16.5%)	30 (8.1%)	4.9

Percentages seen in outpatient and inpatient columns represent the percentage of TBI for that sport compared with all other sports seen in the same setting.

^a Other includes boxing, cheerleading, golf, karate, lacrosse, rugby, track, gymnastics, wrestling, and volleyball.

TABLE 3 Number of Outpatient and Inpatient Visits per Year for TBIs

Year	Outpatient ^a	Inpatient ^a	% Admitted
2002	228	26	10.2
2003	229 (0.4%)	28 (7.7%)	10.9
2004	245 (7.5%)	27 (3.8%)	9.9
2005	297 (30.3%)	31 (19.2%)	9.5
2006	293 (28.5%)	30 (15.4%)	9.3
2007	337 (47.8%)	42 (61.5%)	11.1
2008	325 (42.5%)	37 (42.3%)	10.2
2009	583 (155.0%)	40 (53.8%)	6.4
2010	531 (133.0%)	63 (142.0%)	10.6
2011	438 (92.1%)	48 (85.0%)	9.9
Total	3506	372	9.6

^a Percentages in outpatient and inpatient columns represent the percent increase in number since 2002 for that setting (outpatient or inpatient).

In our population, ~15% of all TBIs were secondary to a sports mechanism, a figure that is comparatively lower than the 20% reported by Sosin and colleagues in 1996 and the 30% reported by Meehan and colleagues in

2010.^{14,16} We also observed a 92% increase in ED visits for sports-related TBI over the 10-year study period, and this is higher than the national increase of 62%.⁴ Interestingly, a large spike in the volume of sports-related TBI was seen beginning in 2009. The reason for this increase is not clear. Possible explanations include an increase in recognition of sports-related TBI, more coaches educating athletes and parents, or more media attention to this topic.⁶⁻⁹ It should be noted that Ohio did not enact any laws regarding sports-related TBI management until April 2013. Kentucky and Indiana, also part of the region using Cincinnati Children's Hospital as their "home" hospital, enacted sports-related TBI laws in April 2012 and May 2011, respectively. Therefore, changes in laws

surrounding sports-related TBI management and return-to-play are not likely to have affected our study.

In our population, boys were ~3 times more likely than girls to have a TBI secondary to sports. This is a trend that has been seen in multiple studies, including the CDC's report in 2011 that stated 71% of sports and recreation injuries were among male participants.^{4,14,17,18} This is likely in part because more boys participate in sports than girls. In fact, 60% of high school athletes nationally in 2011–2012 were boys.¹⁹ Interestingly, soccer, a sport played by both boys and girls showed that girls tend to suffer from TBI more than their male counterparts. Various sports, mechanisms of injury, and gender need to be investigated in the context of TBI.

In our study, the proportion of children admitted from the ED for a sports-related TBI remained on average 9.6% across all 10 years. Despite no change in the proportion of hospital admissions, the ISS significantly decreased, suggesting that more patients were being admitted with less severe injuries. Interestingly, LOS changed little in the 10 years studied but was low (<2 days). The admission of children with a lower ISS could be related to emphasis on an approach to head injury with less imaging and more observation of patients.²⁰ It may also be that ED physicians are better at recognizing TBI now, and it therefore takes less severe injury to trigger a need for observation in the hospital. There have been no studies that have looked at this phenomenon directly, but several studies have looked at the severity of patients with all causes of TBI who are admitted to a hospital. The first study, which included data from 1980 to 1995, included data for persons of all ages and showed that admission rates for TBI were decreasing overall, but there was a notable increase in the admissions

FIGURE 1

ISS and LOS for admissions by year.

for severe TBIs.²¹ A follow-up study by Bowman and colleagues from 1991 through 2005 showed a continued decrease in the overall admission rate for children <19 years of age who suffered TBI, whereas admissions for moderate and severe TBI were noted to be stable.²² Our study does not seem to correlate with these trends.

When differentiating which sports were most responsible for ED visits versus hospital admission, it was seen that common, competitive sports such as soccer, basketball, and football had the highest numbers of sports-related TBI in the ED. Bakhos and colleagues demonstrated a similar finding in the ED with competitive, organized sports making up more than twice as many TBIs than in nonorganized sports.¹⁵ This may be related to the high volume of children who play these particular sports.⁵ Interestingly, those sports that tend to be nonorganized, such as sledding, skiing, and skateboarding, had the greatest percentage of ED visits for TBI requiring admission. This discrepancy may be secondary to education about the morbidity

and mortality of TBI among players in organized sports or because of lesser regulation in sports equipment among participants in nonorganized sports. This, however, was not assessed in our study and would require further investigation to confirm.

There are some limitations to this study. First, this is a retrospective study and data came from 1 children's hospital trauma registry. As a result, the findings may not be generalizable to other populations. Also, being an urban children's hospital, older children and adolescents may present to other community hospitals for emergency care. Additionally, the observations made in this study included only 1 city; thus, there may be a bias in demographics, the sports available in this part of the country, and specific safety equipment regulations. For instance, skiing is not as readily available as it may be in colder, higher-altitude climates. Another limitation is that we only looked at volume of ED visits and hospital admissions, not rates. An increase in number of ED visits or admissions in a particular sport may

be secondary to increased participation in that sport and not an increased rate of injury. Lastly, children seen at an outside ED or urgent care would have been missed from inclusion in this study.

CONCLUSIONS

The number of pediatric, sports-related TBIs presenting to the ED and being admitted to the hospital is increasing; however, this has not translated into any change in the percentage of children being admitted over the past 10 years at 1 children's hospital. Additionally, the ISS of those children being admitted is decreasing whereas the length of inpatient stay has remained unchanged. Skiing, sledding, and roller blading or skateboarding were shown to be responsible for the greatest ratio of admissions for sports-related TBIs. Future studies should include national data and compare how the trends seen in sports-related TBI compare with other mechanisms for TBI with regard to admissions.

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