Youth Ice Hockey Injuries Over 16 Years at a Pediatric Trauma Center

AUTHORS: Stephanie F. Polites, MD,[a] Arjun S. Sebastian, MD,[b] Elizabeth B. Habermann, PhD,[c] Corey W. Iqbal, MD,[d] Michael J. Stuart, MD,[b] and Michael B. Ishitani, MD[e]

Departments of [a]Surgery, [b]Orthopedic Surgery, [c]Robert D. and Patricia E. Kern Center for the Science of Health Care Delivery, Mayo Clinic, Rochester, Minnesota and [e]Pediatric Surgery, Mayo Clinic, Rochester, Minnesota; and [d]Department of Surgery, The Children's Mercy Hospital, Kansas City, Missouri

KEY WORDS
injury, pediatric, ice hockey, trauma, traumatic brain injury

ABBREVIATIONS
CI—confidence interval
CT—computed tomography
DDQB—Data Discovery and Query Builder
OR—odds ratio
TBI—traumatic brain injury

Dr Polites designed the study, performed data collection, carried out data analysis and interpretation, and drafted the initial manuscript; Dr Sebastian assisted with data analysis and interpretation and revised the manuscript; Dr Habermann carried out and supervised data analysis and revised the manuscript; Dr Iqbal conceptualized the study and revised the manuscript; Dr Stuart critically reviewed the manuscript; Dr. Ishitani supervised design of the study, supervised data collection, and revised the manuscript; and all authors approved the final manuscript as submitted.

www.pediatrics.org/cgi/doi/10.1542/peds.2013-3628

doi:10.1542/peds.2013-3628

Accepted for publication Mar 4, 2014

Address correspondence to Michael B. Ishitani, MD, Division of Pediatric Surgery, Mayo Clinic College of Medicine, 200 1st Street SW, Rochester, MN 55901. E-mail: ishitani.michael@mayo.edu

PEDIATRICS (ISSN Numbers: Print, 0031-4005; Online, 1098-4275).

FINANCIAL DISCLOSURE: The authors have indicated they have no financial relationships relevant to this article to disclose.

FUNDING: No external funding.

POTENTIAL CONFLICT OF INTEREST: The authors have indicated they have no potential conflicts of interest to disclose.

WHAT'S KNOWN ON THIS SUBJECT: Participation in youth ice hockey is increasing. Players are prone to injury because of the nature of the game. Injury patterns vary based on age, gender, and degree of contact permitted.

WHAT THIS STUDY ADDS: This study adds an updated description of injuries sustained by youth ice hockey players and associated demographic patterns, with emphasis on seriously injured children. It also evaluates health care utilization and outcomes related to youth ice hockey injuries.

abstract

FREE

BACKGROUND: Youth ice hockey is an exciting sport with growing participation in the United States. Updated assessment of injury patterns is needed to determine risk factors for severe injury and develop preventive efforts. The purpose of this study was to evaluate our experience as a level 1 pediatric trauma center in Minnesota treating injured youth ice hockey players.

METHODS: Children ≤18 years old who presented to our institution from July 1997 to July 2013 with an injury sustained while participating in ice hockey were identified. Patient demographic information, injury characteristics, and outcomes including use of computed tomography, hospital admission, and procedures were obtained. Age- and gender-specific patterns were determined for injuries and outcomes.

RESULTS: Over 16 years, 168 injuries in 155 children occurred, including 26 (15.5%) injuries in girls. Extremity injuries were most common, followed by traumatic brain injury. Injuries to the spine, face, and trunk were less common. Traumatic brain injury and injuries to the spine were most common in younger children (≤14 years old) and girls, whereas injuries to the face were most common in older players (≥15 years old). Most injuries resulted from intentional contact. Admission to the hospital was needed in 65 patients, including 14 (8.3%) who needed intensive care. A major procedure was needed by 23.2% of patients because of their injuries.

CONCLUSIONS: Youth ice hockey trauma can be severe, necessitating a thorough evaluation of injured children. Injury patterns are influenced by age and gender, providing an opportunity for targeted preventive efforts. *Pediatrics* 2014;133:e1601–e1607

Ice hockey is a fast-paced, exciting sport that is rapidly growing in popularity in the United States. In the 2011–2012 season, >4500 new youth players were registered, adding to the total of >350 000 registered players in the USA Hockey organization.[1] Female participation has increased dramatically from 10 000 players nationally in 1993 to 65 000 in 2011.[2] Unfortunately, many of these children sustain injuries because the game features high-speed collisions with other players, the ice, boards, and equipment. Ice hockey–related injuries result in >18 000 emergency department visits annually.[3] The most recent national investigations of youth ice hockey injuries indicate that upper extremity injuries are most common in players ages 9 to 18.[4] Furthermore, ice hockey is second only to football in rates of fractures and head injuries in high school athletes.[5,6] Given the growth in participation and risk of injury in youth ice hockey, current information on the most common injuries is needed.

Most literature on youth ice hockey injuries in the United States is based on small cohorts[7] or national databases,[3,4] which provide a large sample size but cannot follow patients longitudinally. This has resulted in a dearth of information on outcomes of youth ice hockey injuries. Detailed information about hospital admissions, surgical procedures, and the length and nature of recovery periods is needed to determine risk factors for severe injuries. The recovery period and natural history of traumatic brain injuries (TBIs) are particularly important because these injuries are common in youth ice hockey players and have long-term physical and cognitive consequences.[8] Because the demographics of youth ice hockey are changing and injury patterns are known to vary based on age and gender,[3,4,9] updated assessment of these patterns is needed. Our institution is a level 1 pediatric trauma center in Minnesota, the state where the largest number of youth ice hockey players in the United States are registered.[10] The purpose of this study was to describe our experience treating injured youth ice hockey players over a 16-year period, focusing on age- and gender-specific injury patterns and risk factors for injuries necessitating extensive health care utilization and recovery periods.

METHODS

Patient Identification

After institutional review board approval was obtained, patients ages ≤18 years who were treated at our institution for an ice hockey injury from July 1997 to July 2013 were identified from 2 sources: the trauma registry and the institutional patient database. Our institution has level 1 adult verification, and our pediatric trauma center received pediatric level 1 verification in 2006[11] after introduction of pediatric verification by the American College of Surgeons. As a result, the trauma registry is used for state and national reporting, with standardized inclusion criteria meeting the requirements of the National Trauma Data Bank. The trauma registry is maintained by trained nurse abstractors using the TraumaBase (Clinical Data Management, Inc, Conifer, CO) software and is validated at multiple points, including formal chart review of 10% of entries on a monthly basis. Additional patients were identified from a data repository containing billing data for our institution since 1997 and clinical patient records since 1994. The data repository was accessed by investigators using the Data Discovery and Query Builder (DDQB) web-based software, which is maintained collaboratively with IBM (International Business Machines Corp., Armonk, NY) by dedicated information technologists, regularly audited, and validated in the literature as accurate for both *International Classification of Diseases, Ninth Revision* and free text search.[12,13] The DDQB was queried for both *International Classification of Diseases, Ninth Revision* E003.1 and free text terms *hockey* and *ice hockey* in patient diagnoses. Although coding practices at our institution have not changed over the study period, addition of a free text query helped ensure that injured patients were not missed. Additionally, formal review of all identified patients' clinical charts was conducted to verify the presence of a documented injury resulting directly from participation in ice hockey.

Inclusion and Exclusion Criteria

Patients who presented to the emergency department, direct admissions to the hospital, and patients treated in an outpatient clinic setting at our institution were included. Injuries sustained during participation in any organized or recreational ice hockey, including organized USA Hockey league play and school extracurricular organized ice hockey, were included because injuries occur in all settings,[14] and youth players often participate in multiple settings. Patients injured by hockey-related equipment during unrelated activities (eg, fighting with a hockey stick or throwing a hockey puck) and those with chronic sports-related conditions not attributable to a specific incident were excluded.

Data Collection

All patient data were collected from patients' clinical records by one of the physician authors using a standard data collection instrument for all patients. Players were categorized into age groups corresponding with current male youth hockey divisions for additional analysis, because each division has different regulations for play, including degree of contact permitted.[15]

These age divisions were ≤12, 13 to 14, and 15 to 18. Information about presentation, including setting, time since injury event, and level 1 trauma activation, was collected. A level 1 trauma activation at our institution is triggered by physiologic and mechanism of injury criteria, based on current guidelines and evidence.[16] No standard level 1 criteria between institutions have been developed. Cause of injury was classified as fall, unintentional contact, intentional contact, or equipment (skate, hockey stick, or puck). Unintentional contact included unintentional collisions with other players or the boards, and intentional contact included body checking or fighting while participating in ice hockey. Cause of injury was captured from the clinical record and relied solely on patient report. Injuries were broken down into the following categories based on documentation in patients' clinical charts: TBI, face, extremity, spine, and trunk. TBI was separated into concussion and intracranial hemorrhage. For TBI patients with one year of follow-up in the medical record, it was noted whether they had persistence of symptoms at or beyond the one-year point. Trunk injuries were defined as injuries to the chest and abdomen. Injury severity score was taken from the trauma registry calculations. Because of the cost and predicted increased risk of cancer associated with computed tomography (CT) in children,[17] use of CT to evaluate injuries was recorded. Although MRI is often used to evaluate sports injuries, this is infrequently done in the acute setting and was not recorded in this study. Procedures were classified as major or minor, with major procedures including open surgical interventions and interventional angiography and minor procedures including superficial laceration repair, closed reduction of fractures, and splinting or casting of injuries. Information about admission to the hospital, need for intensive care, and length of stay was also collected.

Data Analysis

Continuous variables are presented as mean (95% confidence interval [CI]) or median (interquartile range). Differences in injuries and health care utilization between age groups and gender were evaluated by the χ^2 test or the Fisher's exact test for frequencies <5. Odds ratios (ORs) were reported with 95% CIs. The catchment area of our institution is large and does not coincide with district divisions of Minnesota Hockey, the governing affiliate of USA Hockey in Minnesota. Therefore, a population of youth ice hockey players to serve as a denominator for calculating injury incidence was not available.[18] To evaluate the change in injury trends over time, we compared the relative frequency of injuries between the first and second half of the study (July 1997 to June 2005 and July 2005 to July 2013) using the Cochran–Armitage test of trend. We performed data analysis using JMP software (version 9.0.1; SAS Institute, Inc, Cary, NC), and significance was acknowledged when $P < .05$.

Overview of Youth Ice Hockey Rules of Play

USA Hockey rules of play for youth ice hockey are reviewed and revised every 4 years; therefore, regulations have changed over the course of our study. Briefly, helmets and full facial protection have been required in all players <20 years of age since 1978.[19] The most recent change affected the minimum age for body checking. Body checking, or purposeful contact aimed at separating the opponent from the puck, has never been allowed in female youth ice hockey. In male youth ice hockey, the age at which body checking is allowed was increased from age 11 to age 13 in 2011. The rule change was enacted to decrease injury risk and promote acquisition of other hockey skills.[20] Because this rule change was in effect for only 1 year of this study, injury patterns for 11- and 12-year-old male players reported in this study may not reflect current rules of play.

RESULTS

Demographics

From July 1997 through July 2012, 155 youth ice hockey players with 168 distinct injuries were identified. The trauma registry provided 64 (38%) injuries, and the remaining injured players were identified from the DDQB. The cohort's demographics are outlined in Table 1. Most injuries occurred in older youth players, ages 15 to 18 (54.8%); no injured players <7 years old were identified, and 15.5% of injuries occurred in girls. Most players presented to the emergency department (91.1%), and most presented within 24 hours of injury (86.3%). There were no fatal injuries. The oldest players appeared to be the most severely injured, because all players needing level 1 trauma activation were

TABLE 1 Characteristics of Injured Youth Ice Hockey Players (N = 168)

Characteristic	*n* (%)
Age group	
≤12[a]	30 (17.9)
13–14	46 (27.4)
15–18	92 (54.8)
Gender	
Male	142 (84.5)
Female	26 (15.5)
Presentation	
≤24 h	145 (86.3)
>24 h	23 (13.7)
Emergency department	153 (91.1)
Non–emergency department[b]	15 (8.9)
Disposition	
Not admitted	102 (60.7)
General care	51 (31.0)
Intensive care	14 (8.3)
CT	
Yes	55 (32.7)
No	113 (67.3)
Procedure	
None	93 (55.4)
Minor[c]	36 (21.4)
Major[d]	39 (23.2)

[a] No injuries in players <7 y of age were identified.
[b] Non–emergency department settings included outpatient clinic and direct admissions to the hospital.
[c] Minor procedures included superficial laceration repair, closed reduction of fractures, and splinting or casting.
[d] Major procedures included open surgical intervention and interventional angiography.

15 to 18 years old. The mean (95% CI) injury severity score was 6.1 (5.1–7.1). Hospital admission was needed in 39.3% of injuries. Youth ice hockey–related injuries increased in frequency at our institution over time, with 68.4% of injuries occurring in the latter period (Fig 1).

Injuries

Extremity injuries were the most common, at 44.6% (Table 2). Notably, most extremity injuries were fractures, including 9 femur fractures. TBI, including intracranial hemorrhage and concussion, was the next most common injury, occurring in 22.6% of patients. A previous concussion was reported by 15 (39.5%) patients with TBI. Of 23 (60.5%) patients with TBI who had follow-up information available, 8 had symptoms for ≥1 year after their injury, and 9 were advised not to return to ice hockey or other contact sports. Injuries to the face and spine were equivalent at 11.9% each. Most spine injuries were sprains or strains without neurologic deficit. However, 1 patient had a ligamentous injury of the cervical spine, resulting in tetraplegia. Injuries to the trunk were least common (9.0%), and none were identified before 2005. One patient sustained a renal artery injury leading to loss of function in 1 kidney. The distribution of injuries did not change significantly over the course of the study (Fig 2) ($P = .42$).

Age and gender variation in injury patterns was identified. All truncal injuries occurred in male players ages 13 to 18.

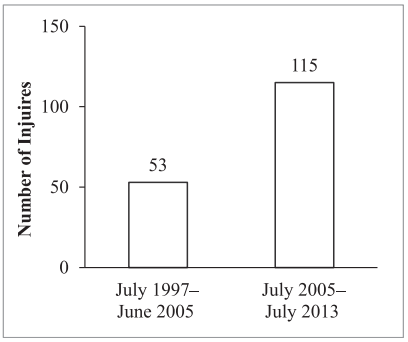

FIGURE 1
Youth ice hockey injury frequency over time.

TABLE 2 Distribution of Youth Ice Hockey Injuries ($N = 168$)

	n	Percentage
Extremity	75	44.6%
Clavicle fracture	12	7.1%
Extremity contusion	6	3.6%
Extremity laceration	6	3.6%
Femur fracture	9	5.3%
Knee injury	4	2.4%
Shoulder injury	7	4.2%
Tibia, fibula, or ankle fracture	13	7.7%
Upper extremity fracture	18	10.7%
TBI	38	22.6%
Anoxic injury	1	0.6%
Concussion	35	20.8%
Intracranial hemorrhage	2	1.2%
Face	20	11.9%
Fracture	6	3.6%
Laceration	11	6.5%
Other	3	1.8%
Spine	20	11.9%
Fracture	1	0.6%
Sprain or strain	18	10.7%
Tetraplegia	1	0.6%
Trunk	15	9.0%
Abdominal contusion	2	1.2%
Cardiac or pulmonary contusion	5	3.0%
Kidney laceration	2	1.2%
Splenic laceration	4	2.4%
Rib fracture	2	1.2%

Furthermore, older youth players were more likely to sustain facial injuries ($P = .004$; OR = 5.52; 95% CI, 1.55–19.62), and male players were more likely to sustain extremity injuries ($P < .001$; OR = 7.89; 95% CI, 2.27–27.45) (Table 3). Female gender was associated with TBI ($P < .001$; OR = 5.46; 95% CI, 2.26–12.21) and spine injuries ($P = .010$; OR = 3.66; 95% CI, 1.30–10.32). Older youth players were less likely to sustain a TBI than players ages ≤12 and 13 to 14 ($P = .020$; OR = 0.42; 95% CI, 0.23–0.88), and the youngest players (age ≤12) were most likely to have spine injuries ($P = .033$; OR = 2.93; 95% CI, 1.05–8.12).

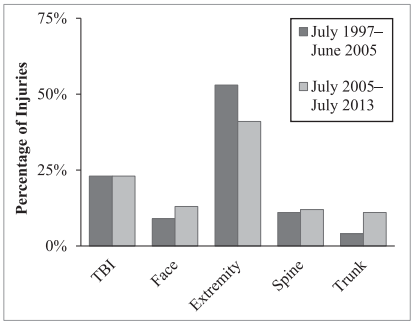

FIGURE 2
Youth ice hockey injury distribution over time. The relative decrease in extremity injuries and increase in facial and trunk injuries was not significant ($P = .42$).

Intentional contact was the most commonly reported cause of injury (38.1%), followed by unintentional contact (26.2%), equipment (16.1%), and falls (13.1%). The cause of injury could not be determined for 6.5% of patients. When evaluated by type of injury, intentional contact and unintentional contact were the first and second most common causes, respectively, of TBI, extremity, spine, and trunk injuries. Ice hockey equipment was the most common cause of facial injuries. Intentional contact was the most common cause of injury to players 13 to 14 (54.4%) and 15 to 18 (34.8%) years old. Falls and unintentional contact were the most common causes of injuries in younger players, each resulting in 26.7% of injuries to players aged ≤12 years. Male players were most commonly injured by intentional contact (40.9%) and female players by unintentional contact (42.3%). Although body checking is prohibited in girls' ice hockey, 23.1% of female players reported injuries due to intentional contact.

Health Care Utilization and Outcomes

Many patients required advanced imaging, hospital admission, and invasive procedures (Table 1). CT was needed in 32.7% of patients, and 39.3% were admitted to the hospital, including 14 (8.3%) patients who needed intensive care. The median (interquartile range) length of stay was 2 (1–3) days. Almost half (44.6%) of patients needed a procedure, including 23.2% who underwent a major procedure. Minor procedures were needed in 21.4% of patients.

Injury, gender, and age patterns of health care utilization were identified.

TABLE 3 Age and Gender Variation in Youth Ice Hockey Injuries

Location of Injury (N = 168)	Gender			Age Group			
	Male (n = 142)	Female (n = 26)	P	≤12[a] (n = 30)	13–14 (n = 46)	15–18 (n = 92)	P
TBI	16.9%	53.9%	<.001	30.0%	32.6%	15.2%	.020
Face	12.7%	7.7%	.742	3.3%	4.3%	18.5%	.004
Extremity	50.7%	11.5%	<.001	43.3%	41.3%	46.7%	.822
Spine	9.2%	26.9%	.010	23.3%	10.9%	8.7%	.033
Trunk	10.6%	—[b]	—[b]	—[b]	10.9%	10.9%	—[b]

[a] No injuries in players <7 y of age were identified.

[b] No female youth ice hockey players or players ages 7–12 y sustained injuries to the trunk; thus, no P values were calculated.

Extremity injuries resulted in 22.7% of hospitalizations, although none necessitated intensive care. Extremity injuries were also responsible for 76.9% of major procedures. TBIs resulted in 22.7% of hospitalizations, including 3 patients who required intensive care. CT was needed in 63.2% of patients with TBI. Truncal injuries led to considerable health care utilization, as 86.7% underwent CT and 60.0% needed intensive care, more than any other injury. No patients with truncal injuries needed operative intervention. Male players were more frequently admitted than female players, although this difference was not significant (42.3% vs. 23.1%; P = .058; OR = 2.44; 95% CI, 0.92–6.44). Major procedures were more likely in older players (ages 15–18 [32.6%] vs ages ≤12 and 13–14 [11.8%]; P = .002; OR = 3.60; 95% CI, 1.59–8.19) and in boys (26.1% vs 7.7% in girls; P = .041; OR = 4.23; 95% CI, 0.95–18.77). This was likely due to the high proportion of extremity injuries in these patients.

DISCUSSION

The results of this study show that, although it is unlikely to result in life-threatening injury, youth ice hockey players sustain injuries during organized and recreational play that necessitate hospitalization, advanced imaging, surgical intervention, and, rarely, critical care. Extremity injuries were the most common ice hockey-related injuries, followed by TBI. Player age, gender, and cause of injury influenced both location and severity of injury, with male and older players most likely to experience injuries necessitating hospital admission and major procedures. Although girls and young players are a minority of youth hockey players, they were the players most susceptible to head injuries in our study.

Determining the true incidence of TBI in youth ice hockey players is difficult because population-based data are needed, and these injuries are known to be underreported by players. However, head injuries were unacceptably common in our study, making up 22% of injuries. Consistent with existing literature,[9,21] players who were younger and female had the highest likelihood of sustaining a TBI in our cohort, and older male players were at risk for head injuries necessitating admission to the hospital. Specific preventive efforts targeted at these populations are needed. Furthermore, 40% of players who sustained TBI reported a previous concussion, and 35% of players who followed up at our institution had symptoms for >1 year. Studies have shown that a previous concussion places patients at risk for repeat head injury and prolonged recovery.[22] Multiple concussions place patients at risk for mental illness, motor disorders, and even encephalopathy.[8,23] Treatment of concussions includes physical and mental rest until symptoms resolve, followed by a gradual return to play process, measures supported by the fourth International Conference on Concussion in Sport.[8] Players should also return to baseline on neurocognitive testing.[24] Additional research is needed to determine whether more stringent guidelines on returning to play after a TBI are needed. Youth athletes and parents must be educated about the risk of TBI in ice hockey and the possible long-term outcomes of repeated injuries.

Although trunk injuries were uncommon, they were most likely to result in CT use and ICU admission. Little has been written on these injuries, because they are uncommon. As in other studies of blunt trauma to the abdomen, the spleen was most commonly affected.[25,26] Although no surgical treatment was needed in our small cohort, loss of the spleen or kidney in a pediatric patient has long-term ramifications, including risk of overwhelming post-splenectomy infection, hypertension, and renal insufficiency.[27,28] The presence of these injuries highlights the importance of systematic pediatric trauma evaluation in injured players. Additionally, the tendency for children with truncal injuries to undergo CT in this study and elsewhere in the literature[29] is concerning, because the radiation associated with CT is predicted to increase the risk of cancer for exposed children.[17,30] Prevention of abdominal trauma in ice hockey would reduce this exposure risk. Furthermore, providers should be aware of evidence on the management of pediatric abdominal visceral injuries[31,32] to avoid unnecessary CT use.

As in other contemporary studies, extremity injuries were the most common.[3,25] These injuries were also most likely to result in admission to the hospital and surgical intervention. Players with serious extremity injuries, such as femur fractures, should receive formal trauma evaluation, because these painful injuries could distract from head, spine, or trunk injuries. Older age and male gender were risk factors for extremity injury, fracture, and the need for a major procedure. Additional

investigation is needed to develop prevention strategies for extremity injuries.

Helmets and facial protection have been required in amateur ice hockey players <20 years old in the United States since 1978[19] and have decreased the rates of face and eye injuries.[33,34] There was concern that protective gear would result in more aggressive head contact and subsequently more spine injuries.[35] We found both face and spine injuries to be uncommon. Because facial protection was required for the duration of the study period, these results support the conclusion of a previous study of elite amateur players that facial protection reduces facial injuries without increasing head and neck injuries.[34] Improvement in neck injuries is probably due, in part, to the effectiveness of the "Heads Up, Don't Duck" campaign, started in 1996 to prevent cervical spine injuries.[36] This initiative should be emphasized to female players and young players, because we found these populations to be most likely to sustain spine injuries. Nonetheless, 2 patients presented with serious cervical spine injuries, highlighting the importance of maintaining cervical spine precautions when injury is suspected.

Contact, both intentional and unintentional, was the most common cause of overall injury and most likely to result in TBI and extremity injuries. There is extensive discussion of body checking in the literature. When body checking is allowed, rates of contact-related injuries increase.[37–39] On the other hand, Donaldson et al[40] demonstrated no reduction in concussion after head contact regulations were put in place. Whether earlier introduction of body checking increases injuries or is protective against future injuries is controversial.[41–44] In 2011, USA Hockey, the national governing body for ice hockey, approved a program to encourage progressive body contact in the pre–body checking age groups.[45] The age at which legal body checking is permitted was also increased from 11 to 13 years. Ongoing research is needed to monitor the success of these initiatives. In girls, unintentional contact resulted in most injuries. Young players were most likely to be injured by falls. This finding suggests that injury prevention for these groups should focus on improving skating abilities.

This was a retrospective study with associated limitations. Population-based data were not used; therefore, incidence of injuries and injury rates could not be determined.[46] Injured players in the catchment of our pediatric trauma center may have been missed if ice hockey was not noted in the medical record or if the child did not seek medical attention beyond a team physician or on-site athletic trainer. This probably explains the low number of extremity strains, sprains, and contusions in our study. Age classification was based on current male youth ice hockey regulations. These have changed over the period of the study, including recent prohibition of checking in players ages 11 and 12. Female youth ice hockey age classification is slightly different. We believe that this difference has minimal impact on the results of this study, however, because body checking is not allowed in any female players. Although helmets and facial protection were required for the entire study period, information on enforcement of this regulation and other regulations related to protective gear and contact was not collected in this study. Thus, it is possible that injuries described in this study were sustained while players were failing to follow regulations enacted to protect them. Lastly, players who were initially evaluated at our institution may have sought additional treatment elsewhere, resulting in potential underreporting of CT use, procedures, and outcomes of TBI.

CONCLUSIONS

Youth ice hockey players experience serious injuries including extremity fractures, TBI, and blunt abdominal trauma. Many injuries result in hospitalization and surgery. Systemic evaluation of injured players is needed to rule out life-threatening injuries, especially in the presence of distracting injuries. Additional studies of youth ice hockey players using population-based data are needed to determine whether the incidence of injuries among youth ice hockey players is increasing. Age and gender are important modifiers of injury patterns and opportunities for targeted intervention. Furthermore, prevention and treatment of TBI and extremity fractures emerged as specific areas that warrant attention. Hockey organizations have implemented initiatives to improve player safety, and ongoing investigation is needed to evaluate their effectiveness and develop new programs.

REFERENCES

1. USA Hockey. 2011–2012 annual report. 2012. USA Hockey web site. Available at: www.usahockey.com/page/show/836948-annual-report. Accessed October 31, 2013
2. USA Hockey. Girls & women's hockey. USA Hockey web site. Available at: http://www.usahockey.com/players/girls_women.aspx. Accessed October 31, 2013
3. Hostetler SG, Xiang H, Smith GA. Characteristics of ice hockey-related injuries treated in US emergency departments, 2001–2002. *Pediatrics*. 2004;114(6). Available at: www.pediatrics.org/cgi/content/full/114/6/e661
4. Deits J, Yard EE, Collins CL, Fields SK, Comstock RD. Patients with ice hockey injuries presenting to US emergency departments, 1990–2006. *J Athl Train*. 2010;45(5):467–474

5. Swenson DM, Henke NM, Collins CL, Fields SK, Comstock RD. Epidemiology of United States high school sports-related fractures, 2008–09 to 2010–11. *Am J Sports Med*. 2012;40(9):2078–2084
6. Marar M, McIlvain NM, Fields SK, Comstock RD. Epidemiology of concussions among United States high school athletes in 20 sports. *Am J Sports Med*. 2012;40(4):747–755
7. Stuart MJ, Smith AM, Nieva JJ, Rock MG. Injuries in youth ice hockey: a pilot surveillance strategy. *Mayo Clin Proc*. 1995;70(4):350–356
8. McCrory P, Meeuwisse WH, Aubry M, et al. Consensus statement on concussion in sport: the 4th International Conference on Concussion in Sport held in Zurich, November 2012. *Br J Sports Med*. 2013;47(5):250–258
9. Keightley M, Reed N, Green S, Taha T. Age and competition level on injuries in female ice hockey. *Int J Sports Med*. 2013;34(8):756–759
10. USA Hockey. 2011–2012 season final registration reports. USA Hockey web site. Available at: http://assets.ngin.com/attachments/document/0043/6195/11-12_Final_Reports.pdf. Accessed October 31, 2013
11. American College of Surgeons. Verified trauma centers. American College of Surgeons web site. Available at: www.facs.org/trauma/verified.html
12. Alsara A, Warner DO, Li G, Herasevich V, Gajic O, Kor DJ. Derivation and validation of automated electronic search strategies to identify pertinent risk factors for postoperative acute lung injury. *Mayo Clin Proc*. 2011;86(5):382–388
13. Singh B, Singh A, Ahmed A, et al. Derivation and validation of automated electronic search strategies to extract Charlson comorbidities from electronic medical records. *Mayo Clin Proc*. 2012;87(9):817–824
14. Stuart MJ, Smith A. Injuries in Junior A ice hockey. A three-year prospective study. *Am J Sports Med*. 1995;23(4):458–461
15. Minnesota Hockey. Minnesota Hockey youth classifications. Age charts and participation levels. Minnesota Hockey web site. Available at: www.minnesotahockey.org/page/show/85059-age-charts-and-participation-levels. Accessed October 31, 2013
16. The EAST Practice Management Guidelines Work Group. Triage of the trauma patient. 2010. Available at: www.east.org/resources/treatment-guidelines/triage-of-the-trauma-patient. Accessed December 13, 2013
17. Miglioretti DL, Johnson E, Williams A, et al. The use of computed tomography in pediatrics and the associated radiation exposure and estimated cancer risk. *JAMA Pediatr*. 2013;167(8):700–707
18. Minnesota Hockey. Registration numbers. Minnesota Hockey web site. www.minnesotahockey.org/page/show/101127-registration-numbers. Accessed December 13, 2013
19. Reynen PD, Clancy WG Jr. Cervical spine injury, hockey helmets, and face masks. *Am J Sports Med*. 1994;22(2):167–170
20. USA Hockey. Body Checking Rule Proposal Background. USA Hockey web site. Available at: http://assets.ngin.com/attachments/document/0042/6381/QandABodyCheckingProposal2.pdf. Accessed December 13, 2013
21. Harmon KG, Drezner JA, Gammons M, et al. American Medical Society for Sports Medicine position statement: concussion in sport. *Br J Sports Med*. 2013;47(1):15–26
22. Eisenberg MA, Andrea J, Meehan W, Mannix R. Time interval between concussions and symptom duration. *Pediatrics*. 2013;132(1):8–17
23. Bazarian JJ, Blyth B, Cimpello L. Bench to bedside: evidence for brain injury after concussion—looking beyond the computed tomography scan. *Acad Emerg Med*. 2006;13(2):199–214
24. Reddy CC, Collins MW. Sports concussion: management and predictors of outcome. *Curr Sports Med Rep*. 2009;8(1):10–15
25. Gaines BA, Ford HR. Abdominal and pelvic trauma in children. *Crit Care Med*. 2002;30(11 Suppl):S416–S423
26. Nance ML, Holmes JH IV, Wiebe DJ. Timeline to operative intervention for solid organ injuries in children. *J Trauma*. 2006;61(6):1389–1392
27. Diamond LK. Splenectomy in childhood and the hazard of overwhelming infection. *Pediatrics*. 1969;43(5):886–889
28. Ein SH, Shandling B, Simpson JS, et al. The morbidity and mortality of splenectomy in childhood. *Ann Surg*. 1977;185(3):307–310
29. Fenton SJ, Hansen KW, Meyers RL, et al. CT scan and the pediatric trauma patient: are we overdoing it? *J Pediatr Surg*. 2004;39(12):1877–1881
30. Mathews JD, Forsythe AV, Brady Z, et al. Cancer risk in 680,000 people exposed to computed tomography scans in childhood or adolescence: data linkage study of 11 million Australians. *BMJ*. 2013;346:f2360
31. Stylianos S; The APSA Trauma Committee. Evidence-based guidelines for resource utilization in children with isolated spleen or liver injury. *J Pediatr Surg*. 2000;35(2):164–167, discussion 167–169
32. Streck CJ Jr, Jewett BM, Wahlquist AH, Gutierrez PS, Russell WS. Evaluation for intra-abdominal injury in children after blunt torso trauma: can we reduce unnecessary abdominal computed tomography by utilizing a clinical prediction model? *J Trauma Acute Care Surg*. 2012;73(2):371–376
33. LaPrade RF, Burnett QM, Zarzour R, Moss R. The effect of the mandatory use of face masks on facial lacerations and head and neck injuries in ice hockey. A prospective study. *Am J Sports Med*. 1995;23(6):773–775
34. Stuart MJ, Smith AM, Malo-Ortiguera SA, Fischer TL, Larson DR. A comparison of facial protection and the incidence of head, neck, and facial injuries in Junior A hockey players. A function of individual playing time. *Am J Sports Med*. 2002;30(1):39–44
35. Daly PJ, Sim FH, Simonet WT. Ice hockey injuries. A review. *Sports Med*. 1990;10(2):122–131
36. USA Hockey. Heads Up, Don't Duck. USA Hockey web site. 2012. Available at: www.usahockey.com/page/show/1011484-heads-up-hockey. Accessed October 31, 2013
37. Blake T, Hagel BE, Emery CA. Does intentional or unintentional contact in youth ice hockey result in more injuries? *Clin J Sport Med*. 2012;22(4):377–378
38. Emery CA, Hagel B, Decloe M, Carly M. Risk factors for injury and severe injury in youth ice hockey: a systematic review of the literature. *Inj Prev*. 2010;16(2):113–118
39. Darling SR, Schaubel DE, Baker JG, Leddy JJ, Bisson LJ, Willer B. Intentional versus unintentional contact as a mechanism of injury in youth ice hockey. *Br J Sports Med*. 2011;45(6):492–497
40. Donaldson L, Asbridge M, Cusimano MD. Bodychecking rules and concussion in elite hockey. *PLoS ONE*. 2013;8(7):e69122
41. Harris AW, Voaklander DC, Drul C. Hockey-related emergency department visits after a change in minor hockey age groups. *Clin J Sport Med*. 2012;22(6):455–461
42. Cusimano MD, Taback NA, McFaull SR, Hodgins R, Bekele TM, Elfeki N; Canadian Research Team in Traumatic Brain Injury and Violence. Effect of bodychecking on rate of injuries among minor hockey players. *Open Med*. 2011;5(1):e57–e64
43. Kukaswadia A, Warsh J, Mihalik JP, Pickett W. Effects of changing body-checking rules on rates of injury in minor hockey. *Pediatrics*. 2010;125(4):735–741
44. Emery C, Kang J, Shrier I, et al. Risk of injury associated with bodychecking experience among youth hockey players. *CMAJ*. 2011;183(11):1249–1256
45. USA Hockey. Board of Directors approves all points of Progressive Checking Skill Development Program. 2011. USA Hockey web site. Available at: www.usahockey.com/news_article/show/275876?referrer_id=908033. Accessed October 31, 2013
46. Stuart MJ, Smith AM. Principles of ice hockey injury research. In: Ashare AB, ed. *Safety in Ice Hockey*. West Conshohocken, PA: American Society for Testing and Materials; 2000

Youth Ice Hockey Injuries Over 16 Years at a Pediatric Trauma Center

Stephanie F. Polites, Arjun S. Sebastian, Elizabeth B. Habermann, Corey W. Iqbal, Michael J. Stuart and Michael B. Ishitani

Pediatrics 2014;133;e1601
DOI: 10.1542/peds.2013-3628 originally published online May 26, 2014;

PEDIATRICS®
OFFICIAL JOURNAL OF THE AMERICAN ACADEMY OF PEDIATRICS

Youth Ice Hockey Injuries Over 16 Years at a Pediatric Trauma Center

Stephanie F. Polites, Arjun S. Sebastian, Elizabeth B. Habermann, Corey W. Iqbal, Michael J. Stuart and Michael B. Ishitani

Pediatrics 2014;133;e1601
DOI: 10.1542/peds.2013-3628 originally published online May 26, 2014;