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Sports-related Genitourinary Injuries Presenting to United States Emergency Departments

Herman S. Bagga, Patrick B. Fisher, Gregory E. Tasian, Sarah D. Blaschko, Charles E. McCulloch, Jack W. McAninch, and Benjamin N. Breyer

OBJECTIVE	To describe epidemiologic features of sports-related genitourinary (GU) injuries and determine patient cohorts and particular sporting activities associated with increased GU injury risk.
MATERIALS AND METHODS	The National Electronic Injury Surveillance System, a data set validated to provide a probability sample of injury-related US emergency department (ED) presentations, was analyzed to characterize GU injuries between 2002 and 2010. A total of 13,851 observations were analyzed to derive national estimates.
RESULTS	Between 2002 and 2010, an estimated 137,525 individuals (95% confidence interval, 104,490–170,620) presented to US EDs with GU injuries sustained during sporting activities. Nearly three-quarters of injuries occurred in the pediatric population. The most common product involved was a bicycle, representing approximately one-third of injuries in both adult and pediatric populations. Injuries related to team sports such as football, baseball or softball, basketball, and soccer were also common, particularly among boys where they represented a combined third of all injuries. Eighty-nine percent of all patients were evaluated and treated in the ED without inpatient admission. The large majority of injuries involved the external genitalia (60%), and significant injuries of paired GU organs (kidneys and testicles) requiring inpatient admission were rare (8.5%).
CONCLUSION	Sports-related GU injuries are most commonly sustained during the use of a bicycle. However, there are other associated activities with identifiable high-risk cohorts, products, and situations. Consumers, practitioners, and injury-prevention experts can use our epidemiologic data to prioritize and develop strategies aimed at the prevention and limitation of such injuries, particularly when counseling at-risk cohorts, such as those with solitary kidneys or testicles. UROLOGY 85: 239–245, 2015. © 2015 Published by Elsevier Inc.

Physical activity and participation in sporting activities is vital to maintaining health and is increasingly encouraged. Prior studies have noted that sporting injuries in particular are a common source of genitourinary (GU) injury, especially among pediatric and young adult cohorts.^{1,2} In particular, current investigations have provided some important insights into the nature and likelihood of such injuries by focusing on

specific sporting activities^{3–11} and isolated GU organs.^{12–21} However, the overall epidemiology of sporting GU injury remains unknown. This is largely due to a focus on the pediatric population with most data derived from institution-specific trauma cohorts and national trauma databases. Although such data are valuable, they tend to select patients who have sustained severe injuries requiring admission, which can overestimate the morbidity and underestimate the incidence of such injury.

To better describe the epidemiology of acute, sports-related GU injuries in the United States, we used a nationally representative sample of individuals who presented to US emergency departments (EDs) between 2002 and 2010. We hypothesized that the study of such ED presentations would allow for accurate description of the incidence of significant sporting GU injury, although also allowing for identification of populations, activities, and organs at high risk. Our aim is to inform both consumers and caregivers of risk characteristics associated with sporting GU injury with the hope that such

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information will influence safety counseling, sporting product design, and preparedness for treatment when injury occurs.

MATERIALS AND METHODS

Data Source

The National Electronic Injury Surveillance System (NEISS) is a stratified national probability sample of patients who present to US EDs with physical injury. Data are prospectively collected from approximately 100 representative US hospitals. Operated by the US Consumer Product Safety Commission, the data set is validated to produce national estimates of patients who present to US EDs with injury. Data on patient age, race, gender, type of injury, locale where injury occurred, body part affected, disposition, and product(s) involved are abstracted by professional NEISS coders. In addition, a brief narrative description of each injury (eg, mechanism and associated conditions) is recorded. Secondary and tertiary level review and quality control occurs after the data are sent to the US Consumer Product Safety Commission.²² The University of California, San Francisco Institutional Review Board gave this study exempt status.

Variables

The NEISS database was searched to identify all individuals who sustained GU injuries from 2002 to 2010. The narratives were reviewed, and data were extracted to identify products, situations associated with GU injury related to sporting activity.

Statistical Analysis

All analyses were performed with adjustments for sample weighting and the stratified survey design.²³ A total of 13,851 cases were analyzed to derive national estimates. All data are reported as national estimates along with 95% confidence intervals (CIs) unless specified as being actual unweighted case numbers. Linear regression was used to determine the changes in annual incidence rate. Analyses were performed using Stata 12 (Stata Corp., College Station, TX).

RESULTS

Demographic Features

Between 2002 and 2010, 130,726 individuals (95% CI, 103,184-158,269) presented to an ED with sports-related GU injuries. The annual incidence of injury was stable over the study interval. Sporting-related injuries represented 34.1% of all GU injury presentations, making sporting injury the most common cause of GU injuries for both adults and children.

Trends of injury across age ranges are noted in Figure 1. The smallest proportions of injury were experienced by those aged <3 years (3.3%) and those aged >45 years (5.6%). In general, as individuals aged, fewer presented to EDs with sporting-related GU injury (Fig. 1A). The majority of patients were managed in the ED without the need for inpatient admission; however, there was higher prevalence of admission with increasing age (Fig. 1B). When stratified by sex, females sustained the majority of sporting GU injuries until the age of 7 years. After this age, males sustained the most injuries (Fig. 1C). Injuries

Figure 1. Trends of genitourinary sporting injury presenting to US emergency departments, across age ranges. (A) Total number of presentations, (B) presentations requiring admission, and (C) by gender. GU, genitourinary. (Color version available online.)

occurred more commonly during the months of May through August (48% of all injuries).

GU Injury by Type of Sport

The most common sport associated with GU injury presenting to US EDs was bicycling, noted as the etiology for one-third of all presentations (national annual estimate 4799; 95% CI, 4016-5584). Bicycle injuries were the most common etiology for all cohorts aged ≥ 2 years with the exception of those aged 16-18 years. Nearly half of these injuries occurred due to collision with the "top tube" or the handlebars, and nearly a quarter of injuries

Table 1. Sports-related genitourinary injuries presenting to US emergency departments from 2002 to 2010, stratified by age range

	%	National Estimate (Persons)	95% CI (Persons)	Average Annual Incidence (Persons)	95% CI (Persons)	% Male	% Discharged from ED
Total		130,726	103,184-158,269	14,525	11,465-17,585	70.1	88.4
Adult	32.9	42,987	33,217-52,757	4776	3691-5862	83.1	85.1
Pediatric	67.1	87,739	69,967-105,512	9749	7774-11,724	63.8	90.0
Age, y							
0-1	0.01	13	0-33	1	0-4	49.4	91.6
2-3	3.3	4332	2750-5913	481	306-657	31.2	94.6
4-7	19.5	25,507	18,609-32,404	2834	2068-3600	33.6	92.8
8-11	19.1	24,996	19,972-30,019	2777	2219-3335	63.1	91.6
12-15	15.5	20,261	16,251-24,270	2251	1806-2697	84.0	80.6
16-18	9.7	12,632	10,179-15,084	1404	1131-1676	91.2	86.2
19-28	16.2	21,162	16,210-26,114	2351	1801-2902	83.2	87.6
29-45	11.1	14,526	11,683-17,370	1614	1298-1930	84.2	83.2
46-65	4.8	6250	3975-8525	694	442-947	79.6	75.0
≥66	0.8	1049	313-1785	117	35-198	85.1	61.2

CI, confidence interval; ED, emergency department; US, United States.

from collision with the handlebars. For individuals aged 16-18 years, in which 1404 sporting GU injuries (95% CI, 1131-1676) occur annually, football was the most common cause of GU injury (18.4%) followed by basketball (12.8%) and bicycling (12.6%). Across patients of all other age ranges, the second most common source of sporting injury was baseball and softball injuries (9.3%), followed by football injuries (6.5%), injuries related to exercise equipment such as treadmills and exercise bicycles (6.3%), sports vehicle injuries (6.2%), and basketball injuries (5.4%). A number of other etiologies of sporting GU injury were also identified, including soccer, skiing, rock climbing, gymnastics, golf, horseback riding, hockey, lacrosse, roller skating, skateboarding, wrestling, and tennis. Each of these named activities was estimated to be <5% of ED presentations. Bowling, ice skating, boxing, and volleyball injuries were also identified, but their numbers were too low to be significant as CIs extended past 0. Of GU injuries caused by sports vehicles, over two-thirds were due to the use of all terrain vehicles and one-fifth due to use of dirt bikes. The most common sporting injuries stratified by sex and age range are summarized in [Tables 1](#) and [2](#).

The majority of all sporting injuries were of the external genitalia, with penoscrotal injuries representing half. Female external genitalia were involved one-fifth of the time, and kidney injury occurred in 10%. Bladder, urethral, and ureteral injuries were rare (<1% of injuries). A national annual estimate of 7081 (95% CI, 5508-8653) sporting injuries involved the kidneys or scrotum. Such injuries put paired GU organs (kidneys and testicles) at risk. [Table 3](#) lists the sports most commonly involved in these injuries.

Disposition After Presentation

A total of 1,691 (95% CI, 1166-1883) patients required inpatient admission for treatment. Admission occurred in <1 of every 8 presentations. The most common sporting GU injury associated with inpatient admission

among adults involved sports vehicles (31%), followed by baseball or softball (24.3%), and horseback riding (10.6%). Among children, the sports most often associated with inpatient admission were bicycling (24.1%), football (11.9%), baseball or softball (10%), and sports vehicles (10%). A total of 57.3% of all patients who presented with kidney injury were admitted to the hospital. Only 7.3% of patients who presented with any scrotal injuries required inpatient admission for treatment. However, when the testicle was specifically noted to be involved, 15.8% of men and 19.4% of boys were admitted. Penile injuries rarely required admission (3%). Injury of female external genitalia was associated with a 16.4% admission rate among girls and a 2.6% rate among women (aged >18 years).

COMMENT

We observed a yearly incidence of >14,500 sporting-related GU injuries, approximately two-thirds of which were within the pediatric population. The use of NEISS, a national data set validated to provide accurate estimations of injury, allowed us to identify populations at particular risk for these types of injuries.

We noted that males were injured more often than females. This was particularly notable in the adult population, where >80% of presentations were male. Within the pediatric population, the difference was less striking, with 64% of injuries among boys. With regard to age, the incidence of injury seemed to be highest among those between the age of 4 and 7 years and then decreased with increasing age. This is perhaps due to the experience of older individuals promoting increased caution during play; however, it could also represent less concern or bother by injury.

Among children, the highest rate of admission was for those aged 12-15 years, where nearly one-fifth were admitted compared with less than one-tenth in all other pediatric cohorts. This suggests that the acuity of injury may have been higher for this cohort, perhaps due to

Table 2. Most common sports-related genitourinary injuries presenting to US emergency departments between 2002 and 2010, stratified by age range

Rank	Age, 2-3 Y			Age, 4-7 Y			Age, 8-11 Y			Age, 12-15 Y			Age, 16-18 Y		
1	Bicycle	1345	31.0%	Bicycle	12,596	49.4%	Bicycle	10,426	41.7%	Bicycle	6296	31.1%	Football	2321	18.4%
2	Exercise equipment	285	6.6%	Exercise equipment	1805	7.1%	Football	1655	6.6%	Football	2600	12.8%	Basketball	1622	12.8%
3	Horseback riding	145	3.3%	Gymnastics	654	2.6%	Baseball	1496	6.0%	Baseball	2029	10.0%	Bicycle	1597	12.6%
4	Gymnastics	83	1.9%	Soccer	484	1.9%	Soccer	1009	4.0%	Sport vehicles	1572	7.8%	Baseball	1438	11.4%
5				Baseball	410	1.6%	Exercise equipment	920	3.7%	Basketball	1483	7.3%	Soccer	1150	9.1%
6				Basketball	407	1.6%	Sport vehicles	487	1.9%	Exercise equipment	1172	0.0%	Sport vehicles	828	6.6%
Total (95% CI)	4332 (2750-5913)			25,507 (18,609-32,404)			24,996 (19,972-30,019)			20,261 (16,251-24,270)			12,632 (10,179-15,084)		
Rank	Age, 19-28 Y			Age, 29-45 Y			Age, 46-65 Y			Age, ≥66 Y			Overall		
1	Bicycle	4478	21.2%	Bicycle	3701	25.5%	Bicycle	2287	36.6%	Bicycle	349	33.3%	Bicycle	43,194	33.0%
2	Baseball	2660	12.6%	Baseball	2986	20.6%	Horseback riding	795	12.7%	Baseball	215	20.5%	Baseball	12,197	9.3%
3	Sport vehicles	2265	10.7%	Sport vehicles	1952	13.4%	Baseball	696	11.1%	Sport vehicles	215	20.5%	Football	8435	6.5%
4	Basketball	1867	8.8%	Exercise equipment	1086	7.5%	Exercise equipment	612	9.8%	Exercise equipment	167	15.9%	Exercise equipment	8205	6.3%
5	Exercise equipment	1729	8.2%	Basketball	863	5.9%	Sport vehicles	394	6.3%	Horseback riding	140	13.3%	Sport vehicles	8097	6.2%
6	Football	1345	6.4%	Horseback riding	829	5.7%	Golf	203	3.2%	Skiing	86	8.2%	Basketball	7057	5.4%
Total (95% CI)	21,162 (16,210-26,114)			14,526 (11,683-17,370)			6250 (3975-8525)			1049 (313-1785)			130,726 (103,184-158,269)		

Abbreviations as in [Table 1](#).

Numbers represent projected estimates during the study period. Percentages are the proportion of injuries within respective age groups.

Table 3. Most common sporting injuries presenting to US emergency departments between 2002 and 2010 placing paired genitourinary organs (testicles and kidneys) at risk

	Scrotal Injuries				
	Incidence Over Study Interval	95% CI	Average Annual Incidence	95% CI	% of Scrotal Injuries
Bicycle	12,536	9437-15,635	1393	1049-1737	24.7
Baseball/softball	6844	4693-8990	760	521-999	13.5
Basketball	4079	2904-5253	453	323-584	8.0
Football	3975	2383-5568	442	265-619	7.8
Exercise equipment	3174	1852-4296	353	206-477	6.3
Soccer	3088	1608-4567	343	179-507	6.1
Sport vehicles	2702	1400-4006	300	156-445	5.3
Total	50,722	40,328-61,116	5636	4481-6791	

	Kidney Injuries				
	Incidence Over Study Interval	95% CI	Average Annual Incidence	95% CI	% of Kidney Injuries
Sport vehicles	3406	1620-5191	378	180-577	26.2
Baseball/softball	2318	845-3792	258	94-421	17.8
Bicycle	2158	1360-2956	240	151-328	16.6
Football	2018	1384-2653	224	154-295	15.5
Skiing	1534	153-2915	170	17-324	11.8
Horseback riding	951	787-1516	106	87-168	7.3
Soccer	642	266-1019	71	30-113	4.9
Total	13,006	9246-16,765	1445	1027-1863	

Abbreviations as in Table 1.

more risk-taking behavior at this age range. Among adults, the highest rate of admission was among those aged >65 years, which may reflect increased fragility or co-morbidities of older individuals. Overall, the need for inpatient admission was low, at <12%. It is important to note, however, that all patients (including those ultimately discharged from the ED) experienced enough morbidity to justify their presentation and triage to a provider in the ED. This is not only reflective of a significant medical morbidity, but also of increased financial cost to the medical system.

Team sports placing individuals at risk for collision or contact injury (eg, football, baseball or softball, basketball, and soccer) were common causes of injury, particularly in the pediatric male population, where they represented a third of GU sporting injuries. The concern for GU injury during team sports in boys has prompted several studies to determine guidelines for play, particularly in those with solitary paired GU organs such a single kidney or testicle.^{12-14,16,18,24} Although these studies are based on retrospective reviews of inpatient data sets and observational cohort, they consistently report that such injuries are rare during sporting activity.

Our validated analysis of national ED presentations supports the idea that kidneys and testicles are at very low risk for significant injury during sports as we noted annual incidences of only approximately 5600 scrotal injuries (only 7% of which required admission) and 1500 kidney injuries (with a 57% admission rate) within our study. With specific regard to kidney injury, our previous studies at the San Francisco General Hospital have noted that <6% of blunt renal injuries require operative exploration, and <2% of patients admitted for renal trauma

ultimately undergo nephrectomy, further supporting the idea that kidney injury during sports would rarely result in serious consequences.²⁵

Guidelines provided by the American Academy of Pediatrics do not restrict any sporting activity for those with a solitary kidney or testicle. Instead, protective equipment is encouraged for these patients, and individual assessment is recommended for athletes with a solitary kidney participating in contact or collision sports.²⁴ Despite these data and recommendations, however, there is evidence that many practitioners tend to restrict sporting activity in these patients. In interviews of members of the American Society of Pediatric Nephrology, Grinsell et al¹⁴ noted that 62% would not allow patients with solitary kidneys to participate in any contact or collision sports, 86% would bar participation in football, and only 5% would bar bicycling. This last finding is additionally surprising as multiple reports have noted bicycling as a potential source of kidney injury perhaps beyond that of contact sports.^{4,7,12,14,26} In other studies, 68% of pediatric urologists²⁷ and 46% of members of American Medical Society for Sports Medicine²⁸ have similarly noted they would limit contact sports for those with solitary kidneys. This overly restrictive counseling by practitioners may be due to the vague and limited guidelines currently available on the topic, and major organizations such as the American Urological Association should consider issuing guidelines with a more permissive attitude toward this issue.

Despite the comprehensive nature, reliability, and generalizability of NEISS, there are limitations of the data set and thus our study. Although NEISS captures the majority of acute GU injury in the United States, it does miss some presentations, such as high acuity injury noted

in the operating room after polytrauma, as well as low-acuity injury presented to primary care providers and urgent care facilities. We speculate that addition of these data would likely increase the incidence and decrease the overall morbidity of reported sporting GU injury. Although we were able to identify product associations with GU injury, we were unable to determine if products were misused or defective. Furthermore, it was not documented what preventive measures (such as safety gear) were used by persons sustaining injury. Such information is important when considering preventive interventions. Inpatient and long-term follow-up data are also lacking, which limits the ability to assess the full morbidity of GU injuries.

CONCLUSION

Sports-related GU injuries are most commonly sustained during the use of a bicycle. However, there are other associated activities with identifiable high-risk cohorts, products, and situations. Consumers, practitioners, and injury prevention experts can use our epidemiologic data to prioritize and develop strategies aimed at the prevention and limitation of such injuries; particularly when counseling at-risk cohorts, such as those with solitary paired GU organs.

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EDITORIAL COMMENT

The authors in this study used the National Electronic Injury Surveillance System (NEISS) to evaluate sporting activities and the incidence of genitourinary (GU) injury. The NEISS is maintained by the US Consumer Product Safety Commission and links those injuries presenting to emergency departments with consumer products. Prior work has used this data set to evaluate injuries associated with a wide variety of consumer products ranging from batteries to trampolines. The authors of this study are to be congratulated on recognizing that the NEISS could be used more extensively to estimate the demographics of GU injury related to sporting activities.

Prior literature on the epidemiology of GU trauma is either based on hospital admission^{1,2} or specific GU injuries and, thus, cumulative incidence remains unknown. Other studies, which include data about overall injury rates, are restricted by mechanism, such as GU trauma related to motor vehicle accidents.³ This present study is important because it is not limited to patients requiring hospital admission, and although it is limited to sports activities, the mechanism of injury ranged from contact to motorized sports.

The most important finding of the study was the rarity of injury to the kidneys and scrotum. The reason this finding is important is that clinicians often recommend limiting contact sports when patients have a solitary kidney or testicle. In this study, kidney

injury from sports activities was estimated to occur in 1500 patients nationally and only 855 were serious enough to require admission. The authors aptly point out that because the rate of intervention is so low for blunt renal trauma, recommendations to avoid sports that may put the kidneys in jeopardy are probably not warranted. Scrotal injuries occurred more frequently in the study (5600 injuries), but there was no way to determine the rate of testicular rupture in these injuries. There is a low rate of testicular rupture among men presenting with scrotal trauma to the emergency department, therefore restricting sporting activities out of fear of rupture to a solitary testicle is likewise not needed.

In fact, this study showed that bicycling is the leading mechanism of injury across age ranges, other than between the ages of 16 and 18 years. Bicycling accounted for approximately one-third of all GU injuries related to sporting activities, and if sporting activities were to be restricted in those patients with a solitary kidney or testicle, it would make most sense to restrict bicycle use rather than contact sports.

It is important to continue to study GU trauma because injury is the leading cause of death from the ages of 1 to 45 years.⁴ Although much of urology focuses on oncology, the cumulative burden of injury to patients in this age range is much greater from trauma than cancer. The authors' study is significant and provides insight into the basic facts underlying GU injury.

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REPLY

Thank you for your comments. Sporting injuries are indeed a significant source of genitourinary (GU) trauma resulting in US emergency department (ED) presentation. In fact, we found

them the most common etiology of such GU injury over virtually every age range. It is important to note, however, that the very young (aged <3 years) and the elderly (aged >65 years) were notable exceptions. In both of these cohorts, GU injury was more common in the bathroom, often due to trauma with bathroom fixtures, and in infants, due to hot water burns or irritation due to soaps.^{1,2}

Also important to note is that play-related GU injury in children was not limited to just sports. Playground-related injuries were not included in our investigation, but our unpublished data show that 10% of all pediatric GU injury-related ED presentations were attributed to use of playground equipment. Children aged 4-11 years experienced the majority of this injury (86%), and nearly half of the injuries were falls from climbing equipment such as climbing gyms. Interestingly, girls were far more likely to be injured on playground equipment than boys, sustaining 82% of such injury! Fortunately, most injuries were minor with 95% of the patients being discharged from the ED without need for inpatient admission.

Regarding bicycle-related GU injuries, we have done further analysis that can help promote injury prevention. Nearly half of these injuries were associated with contact with the "top tube," which is the long horizontal bar of the bicycle located close to the rider's perineum. Furthermore, we found children nearly 10 times more likely than adults to sustain GU injuries due to bicycle use. Perhaps modifications such as soft "top tube" covers can be considered on bicycles, particularly in the pediatric population.³

Sporting injuries resulting in GU trauma are often minor enough to not require inpatient admission. However, they remain a significant cause of morbidity, resulting in a substantial number of US ED presentations every year. Further study of the etiologies, mechanisms, and circumstances of such injury will be important to go to the next step and promote injury prevention, as well as injury anticipation and treatment.

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