

Patterns of Injuries in Newer Mechanisms of Pediatric Injuries (ATVs, Snowmobiles, Trampolines, Flat Screen TVs)

Deidre Wyrick · R. Todd Maxson

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Abstract Injury is a leading cause of mortality and long-term disability for children of all ages, with intentional injuries predominating in the less than 1 year age group and unintentional injuries posing the greatest threat to life in children older than 1 year of age. Recreational vehicles are gaining in popularity and availability making their use by children a more common mode of injury. The explosion of popularity and prevalence of flat screen televisions has also changed the landscape of pediatric injuries and provided new challenges to providers of pediatric trauma care. This chapter will provide an in-depth examination of these new modes of pediatric injury and provide insight into injury control efforts that should be incorporated into every primary care provider's anticipatory teaching.

Keywords Pediatric trauma · All-terrain vehicles · ATV · Snowmobiles · Trampolines · Flat screen televisions

Introduction

Unintentional injury poses the greatest threat to life and causes the greatest morbidity in children 1–14 years of age [1, 2]. Injury is a leading cause of mortality and long-term disability for children of all ages, with intentional injuries

predominating in the less than one-year age group and unintentional injuries posing the greatest threat to life in children older than 1 year of age. Historically falls have been the leading cause of injury and motor vehicular crashes the leading cause of injury related mortality, with burns and firearm injuries having the highest lethality [1–3] (Tables 1, 2). As technology advances and the falling price of new technologies make them more widely affordable, there are new injury threats to children. Recreational vehicles are gaining in popularity, and availability making their use by children a more common mode of injury. The explosion of popularity and prevalence of flat screen televisions has also changed the landscape of pediatric injuries and provided new challenges to providers of pediatric trauma care. This chapter provides an in-depth examination of these new modes of pediatric injury, describes the injury patterns seen, discusses the treatment paradigms and most importantly, provides insight into injury control efforts that should be incorporated into every primary care provider's anticipatory teaching.

ATVs

All-terrain vehicles (ATVs) were introduced in the United States in the early 1970s and in 2008 it was estimated that there were nine million ATVs in use the US [4]. These vehicles can weigh over 500 pounds, travel up to 100 miles per hour and have 70 horsepower engines [5]. The stated intent of these vehicles was for operation in an off road environment and they were intended for single passenger use. There are specific skills of navigation, depth perception, distribution of weight and balance, and general "rules of the road" that make their operation complicated and often beyond the skill level of a pediatric patient. The successful operation of such a vehicle requires skills that are additive to, and surpass the skill

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D. Wyrick (✉) · R. T. Maxson
Department of Pediatric Surgery, Arkansas Children's Hospital,
University of Arkansas for Medical Sciences, 1 Children's Way,
Slot 837, Little Rock, AR 72202, USA
e-mail: dlwyrick@uams.edu

R. T. Maxson
e-mail: rmaxson@uams.edu

Table 1 Unintentional fatal injuries by age, 2000–2005

Rank	Age group in years			
	<1	1–4	5–9	10–14
1	Suffocation 66 %	Motor vehicle traffic 31 %	Motor vehicle traffic 53 %	Motor vehicle traffic 58 %
2	Motor vehicle traffic 14 %	Drowning 27 %	Other ^a 15 %	Other ^a 18 %
3	Drowning 7 %	Other ^a 15 %	Fire/burn 13 %	Drowning 10 %
4	Other ^a 6 %	Fire/burn 14 %	Drowning 13 %	Fire/burn 6 %
5	Fire/burn 4 %	Suffocation 8 %	Suffocation 4 %	Suffocation 4 %

* Includes ATV accidents

Table 2 Unintentional nonfatal injuries by age, 2001–2006

Rank	Age group in years			
	<1	1–4	5–9	10–14
1	Falls 52 %	Falls 43 %	Falls 37 %	Falls 28 %
2	Struck by or against object 14 %	Struck by or against object 19 %	Struck by or against object 23 %	Struck by or against object 25 %
3	Bite/sting 6 %	Bite/sting 9 %	Bite/sting 8 %	Overexertion 12 %
4	Fire/burn 5 %	Foreign body 6 %	Cut/pierce 7 %	Cut/PIERCE 7 %
5	Foreign body 4 %	Cut/pierce 4 %	Bicycle 6 %	Bicycle 6 %

necessary to operate a bicycle and many other motorized vehicles. The paradox is that many of the injuries seen are in children who do not yet possess competency in the operation of a bicycle, let alone a motorized vehicle.

This size and speed poses a unique risk to children who operate these vehicles because they often do not have the size, weight, manual dexterity or cognitive ability to properly handle them [6]. In fact, children younger than 16 years only make up 14 % of ATV riders nationally but account for 37 % of ATV-related injuries and 28 % of ATV-related fatalities [7]. This discrepancy in ridership to injury and mortality, when compared to adult riders emphasizes the relative risk to young riders. Due to

increased numbers of ATV injuries in the 1980s the United States Consumer Product Safety Commission filed a lawsuit against ATV manufacturers that resulted in the “consent decrees”. These consent decrees set forth rules for manufacturers of ATVs and included: (1) provisions to terminate the production and retail of the unstable three wheel ATV for the “safer” four wheel version, (2) recommend ATVs not carry passengers, (3) offer free safety courses to drivers, (4) recommend age to engine size compatibility, (5) recommend ATVs not be used for roadway travel, (6) require children younger than 16 years have adult supervision and (7) require helmet use at all times. These decrees were mandatory, went into effect in 1988 and lasted for 10 years, during which time failure to comply with the consent decrees could result in loss of the franchise and/or fines [8]. After the 10-year period manufacturers agreed to voluntarily follow “ATV Action Plans” which were less restrictive than the consent decrees [9]. Despite this good faith effort on behalf of the Consumer Product Safety Commission, failure to further regulate the use of these vehicles by children has contributed to a steady increase in the numbers of injuries, fatalities and children with permanent disability [10–12]. In 2007, Helmkamp et al. [13] estimated that the annual cost of caring for ATV related injuries exceeded \$750 million dollars.

Many factors contribute to injuries related to ATVs. Campbell et al., conducted a survey of children to assess attitudes toward ATV use. They found that not only does riding begin at a young age (9.2+/- 3.2 years) but 60 % admit to riding without adult supervision. Furthermore, very few children reported using appropriately sized engines, almost half reported riding without helmets and 70 % rode with passengers. Finally, they found that more than 95 % riders did not receive any formal safety instruction on appropriate use of ATVs [14]. The lack of safety training, helmet use and riding inappropriately sized vehicles has been corroborated by several other studies [15–19]. Additionally, legislation on appropriate use and sale of ATVs is variable from state and enforcement is difficult. In 2012, only 31 states had a helmet requirement and only 33 states had minimum age requirements for operating ATVs [20]. Many of those states that have language that limits ridership by age have waivers for operation on private land, rendering the statutes ineffective.

ATV accidents are frequently high-energy injuries and riders have little protection which results in frequent hospitalization when injury does occur. Shults et al., found that, when compared to all emergency department visits related to injury, ATV injuries were seven times more likely to be hospitalized. When compared to motor vehicle collisions, ATV injuries were twice as likely to require hospitalization [21]. In accordance with trends in other mechanisms of injury, boys are more often injured and

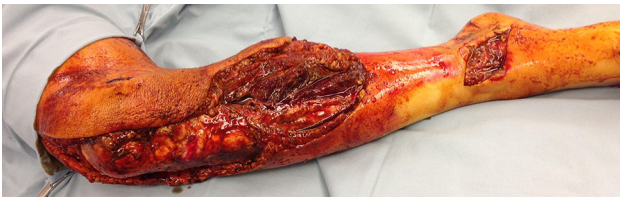


Fig. 1 Right lower extremity soft tissue injury



Fig. 2 Left lateral thigh/hip degloving injury

more often hospitalized when compared to girls [11, 15–18, 21, 10, 22, 23]. Head injuries are the most commonly documented injuries [10, 16, 21, 23, 24]. Orthopedic fractures and spine injuries are also common injury patterns in ATV accidents [21, 22, 24]. When spine fractures are found, 45 % are multiple and in children <16 years old lumbar spine fracture predominate [22]. Multi-system injury is reported in 40–55 % of injuries and evaluation for a second injury should be undertaken in this patient population [10, 22, 25]. It seems that in older riders drivers are more commonly injured but in younger riders passengers are more commonly injured [17, 18]. The most common mechanism of injury related to ATV accidents was ejection from the vehicle, followed by crush injury when the vehicle rolls or flips [16, 18, 25].

Because ATV riders are relatively unprotected when accidents do occur they can have extensive soft tissue injuries (Figs. 1, 2, 3). These injuries are often contaminated and require thorough irrigation and multiple debridements prior to extensive reconstruction. When associated with open fractures a multidisciplinary approach must be taken to achieve adequate recovery.

Due to the threat of injury to children who ride ATVs, the American Academy of Pediatrics, American College of Surgeons, American Pediatric Surgical Association, and Canadian Association of Pediatric Surgeons have put forth guidelines for the safe use these vehicles. Although there are minor variations between each set of guidelines, all



Fig. 3 Left anterior thigh soft tissue injury

agree that children <16 years of age should not operate ATVs. At a minimum, those >16 should have an automobile driver's license, and preferably some additional certification for ATV use. ATVs are designed for a single rider, and no passenger should ever be on board. Finally, government approved helmets should be worn while operating these vehicles although the injury patterns are such that use of helmets will not routinely prevent death or significant disability. [13, 26–29]. Anticipatory teaching should stress that ATVs are not toys, but are motorized vehicles that children do not have the strength, cognition or motor skills to operate safely.

Snowmobiles

Similarly to all-terrain vehicles, snowmobiles are large vehicles, weighing up to 600 pounds, and can travel up to 110 miles per hour [30]. In 2013, 48,536 snowmobiles were sold in the United States and there were 1.4 million registered snowmobiles [31, 32]. There are currently over 225,000 miles of dedicated snowmobile trails in North America [33] and this does not include the numerous trails on private property.

As with ATVs, there are several factors contributing to the injury patterns seen in children who drive and ride on snowmobiles. The first being that children often do not have the strength, manual dexterity or cognition needed to operate large motorized vehicles [34]. Legislation related to operation of snowmobiles is less restrictive than for

other types of motor vehicles [34]. The Snowmobiling Hazards Committee on Injury and Poison Prevention examined legislation in the 18 states with the highest snowmobile ownership and found that 61 % had no helmet requirements. Of the states that did have helmet legislation the laws only applied to those <18 years old and do not comment on passengers. Many states do not have age restrictions and for those that do, there is great variability in minimum age requirements. In some states, children as young as 8 years old can operate snowmobiles provided they have attended a state course. In a similar fashion, children as young as 14 years old can act as “adult supervision” if they have attended safety classes. It is important to note that state laws are applicable only on public land and do not govern operation on private property [34].

As with other reported motorized vehicles, males were more frequently injured than females. Orthopedic and head injuries are the two most common injury patterns seen in snowmobile accidents. Although, not the main cause of injury, head injuries account for the majority of fatalities. The most common causes of injury included collision with a stationary object, rollover, and fall from the vehicle. The mechanism that was attributed to the highest mortality was collision with a stationary object [30, 35, 36]. An interesting mechanism of injury seen is related to children being towed behind the snowmobile [34, 35]. Potentially unique injury patterns of near drowning and frostbite are rarely reported in the adult or pediatric literature [34]. In 2001, Skokan et al., reported on hospital charges for taking care of snowmobile injuries in the state of Utah. Over the 2 year study period the median cumulative charge in Utah was \$266,283 for emergency department treatment and \$1.3 million for inpatient treatment of snowmobile injuries [37].

In 2000 the American Academy of Pediatrics published guidelines concerning the safe operation of snowmobiles. They state the following: (1) children younger than 16 years should not operate snowmobiles, (2) children younger than 6 years do not have the strength or stamina to be transported safely as passengers on snowmobiles, (3) advertisements that promote snowmobiling should not be directed toward young adolescents, and advertisements should not depict young adolescents driving snowmobiles, (4) for drivers >16 years old graduated licensing is recommended, (5) snowmobilers should travel at safe speeds, (6) snowmobilers should avoid the use alcohol or other drugs before or during the operation of a snowmobile, (7) all drivers and passengers should wear helmets, (8) snowmobilers should avoid snowmobiling on ice if they are uncertain about its thickness or condition, (9) snowmobilers should not carry more than one passenger, and (10) use of a saucer, tube, tire, sled, or skis to pull someone behind a snowmobile is not recommended [34].

Similarly to ATVs, primary care physicians should stress that snowmobiles are motorized vehicles, not toys, and similar care should be taken during the operation of these vehicles; including limiting use to those >16 years old. It should be noted that young children do not have the strength to safely ride as passengers and that a passenger should never be pulled behind a snowmobile.

Trampolines

The trampoline was first introduced to the United States by acrobat George Nissen in 1936 and was used to train fighter pilots during World War II [38]. The trampoline gained popularity as a recreational device in the 1950s and 1960s [38], which not surprisingly corresponded to the first documented reports of injuries due to trampoline use [39, 40]. Between the years 1990–1995 there were approximately 250,000 trampoline injuries in the United States [38].

One of the most consistently documented contributors to injury was having more than one person on the trampoline at a time [41–46, 47•]. When an injury does occur with multiple jumpers, the lightest jumper, often the child, is the most frequently injured person [41, 42]. The industry, and probably intuition suggest that safety devices such as mats and nets as well as strict adult supervision make this activity less risky for children. Interestingly, approximately 50 % of injuries occurred with direct adult supervision [41, 42]. Additionally, 44–56 % of injuries occurred with safety nets and/or mats in place [43, 46].

Although the numbers vary slightly between studies, the injuries are essentially evenly split between males and females [38, 43, 44]. Reported injury patterns remain stable across all studies with extremity injuries occurring as the dominant injury type [38, 43–46, 47•]. Gary Smith and colleagues noted that 64 % of upper extremity injuries were fracture/dislocation injuries and 69 % of lower extremity injuries were soft tissue injuries [38]. The majority of these injuries were seen and then discharged from the emergency department, with 3–20 % of children requiring admission for their injury. The most common reason for admission was fracture/dislocation repair under anesthesia [38, 41, 45, 46]. It is important to note that while cervical spine injuries account for a small number of injuries, 10–17 %, spine injuries are the major cause of morbidity and mortality in trampoline injuries [44, 47•, 48].

The role of the American Academy of Pediatrics Council on Sports Medicine and Fitness is to support and encourage safe physical activity in the pediatric population and to provide pediatric providers with guidance on appropriate participation of their patients. In this role, they have published guidelines and recommendations for many sports and physical activities. The council recently released

guidelines on the safe and appropriate use of trampolines. In summary, they recommend that pediatricians should counsel their patients and families against recreational trampoline use. For those families that insist on using trampolines, they recommend the following: (1) insuring homeowners insurance policies cover trampoline related claims, (2) trampoline use should be restricted to a single jumper at any given time, (3) trampolines should have adequate padding in place, (4) trampolines should be set at ground level in an area clear of any surround hazards, 5) frequent inspection and appropriate replacement of protective padding, net enclosure, and any other damaged parts should occur, (6) trampolines should be discarded if replacement parts are unavailable and the product is worn or damaged, (7) somersaults and flips should not be performed in the recreational setting, (8) active supervision by adults familiar with the above recommendations should occur at all times, and (9) parents should confirm these guidelines are in place anytime their child is likely to use a trampoline [47•].

Flat Screen Televisions

Many studies have documented the injury patterns seen with large cathode ray televisions, which usually were pulled over onto a child, often toddlers cruising, leading to significant head injury [49]. Data is lacking on injuries related to flat screen televisions. Many studies within the last several years report a combination of cathode ray and flat screen television data making conclusions in regards to flat screen televisions difficult to interpret. Of particular importance are “tip-over” injuries. In 2007 the Consumer Product Safety Commission released the top five hidden hazards of home and tip-over injuries, such as large television screens, which were ranked as the third leading cause of morbidity and mortality [50] (Table 3). These injuries occur when the large flat screen televisions are mounted on a stand on a piece of furniture or hung on the wall within grasp of a child.

It appears that boys are more commonly injured in television accidents when compared to girls [51–53]. Multiple studies agree that the vast majority of these injuries occur in the home [51–54] and that most injuries are unwitnessed events [51, 53]. The most commonly reportedly injured area of the body was the head [51–54]. When compared to injuries to the body, injuries to the head often resulted in the more severe injuries and required more intensive care with longer hospital stays [52]. There is speculation that lighter weights coupled with a less bulky design may make flat screen televisions more easily tipped than cathode ray televisions and may be contributing to the observed increase in the rate of injuries associated with

Table 3 Top 5 hidden hazards of the home

1	Magnets
2	Recalled products
3	Tip-overs
4	Window and window coverings
5	Pool and spa drains

falling television [51, 53]; however, there is little data to support or refute this claim.

Conclusion

Injury control and prevention is a dynamic science and must adapt to changing threats posed to children. While we welcome change that brings new products to market, these technological advances and the introduction of readily available recreational vehicles and equipment must be examined for the potential threat that they create for naturally curious children who may be exposed. This chapter provides insight into a few of these newer threats and hopefully provides the pediatric practitioner information that is useful in anticipatory discussions with families and caregivers.

Compliance with Ethics Guidelines

Conflict of Interest R. Todd Maxson has served as a consultant for the American College of Surgeons and the Arkansas Department of Health. Deidre Wyrick declares that she has no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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