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Pediatric all-terrain vehicle (ATV) injuries: An epidemic of cost and grief

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ABSTRACT

Objective: Evaluate cost of care of all-terrain vehicle (ATV) related injuries sustained by riders 16 years and younger in Pennsylvania.
Methods: Population-based retrospective cohort design reviewing costs of care of 78 patients (≤16 years), admitted (01/01/2007–12/31/2009) to our institution for injuries sustained during an ATV accident.
Results: Cost of care varied from $322 to $310,435. Mean and median costs for all patients were $25,760 and $8,066, respectively. Average costs increased with increasing age. Patients wearing helmets or driving the ATV had lower mean costs, but these trends were not statistically significant. Crashes with stationary objects not involving rollover or ejection had significantly lower mean costs than other crash types ($p = 0.01$). Patients involved in rollover accidents were significantly more likely to require an overnight hospital stay (OR = 3.45, $p = 0.02$). Patients wearing helmets were marginally less likely to require an overnight admission (OR = 0.34, $p = 0.07$).
Conclusion: ATV crashes involving unhelmeted riders and rollover accidents result in significant medical costs. Interventions to increase helmet use and measures to improve stability are likely to reduce these costs and shorten hospital stays.
Level of evidence: Level IV, Economic study.

Introduction

Designed for single riders, all-terrain vehicles (ATVs) are three- or four-wheeled motorized vehicles with large, soft tires that have been dubbed the "nearly unbreakable toy" since their introduction in the 1970's.[1–3] ATVs are used in all climates, various terrains, and are considered by some to be the most versatile vehicle in operation. In recent decades, the popularity of ATVs has increased for use in hunting, farming, and recreation, by people of all ages. In 2010 there were an estimated 10.6 million 4-wheel ATVs in operation in the United States.[4]

With their increased popularity, ATVs have been involved in an alarming number of injuries and deaths.[5–7] ATVs in general are difficult machines to operate, as the high center of gravity requires a high degree of coordination, muscle strength, mature judgment and experience for safe operation.[8] Like their three-wheel predecessors, four-wheel ATVs have some of the same design features: a high center of gravity, short wheel base, short turning radius, weight in excess of 1000 pounds, and high-powered engines capable of speeds up to 70 mph.[1,2,5] By design, four-wheel ATVs are somewhat less likely to rollover than the three-wheeled versions.

Waiver of patient consent granted by IRB for Retrospective chart review.

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However, uneven surfaces can cause them to turn over, largely due to the high center of gravity. When used on hills, they are capable of flipping over from front to back, as the rear wheels can lift the front wheels off the ground when excessive power is applied. Studies have shown that almost 60% of accidents involving four-wheeled ATVs result from tipping and overturning. Drivers and passengers can be thrown from these ATVs or can be crushed beneath them. As such, ATVs are known to be associated with significant injuries. Spine, neurologic, and orthopaedic injuries have been documented.

Pediatric trauma constitutes 30–40% of all ATV-related deaths and approximately 11% of injured ATV operators seen in the emergency department require admission to the hospital.[3,5,9,10] Despite statements from government agencies and medical societies including the American Academy of Orthopaedic Surgeons (AAOS) and the American Academy of Pediatrics against the use of ATVs by children, one third of all ATV-related fatalities and emergency department visits involve patients younger than 16 years.[3,5,11] The Consumer Product Safety Commission (CPSC) Annual Report of ATV-Related Deaths and Injuries recorded 2865 fatalities (25% of total) in children younger than 16 years of age between 1982 and 2011, with 1226 fatalities (43%) of those among children 12 years and younger.[4]

In 1998, the CPSC reached an agreement with ATV manufacturers that they would not market adult-sized ATVs for use by children younger than 16, would not market three-wheeled ATVs, and would provide information and safety and education.[1]

The number of ATV accidents has risen in recent years across all states.[1] As of December 2011, the CPSC received reports of 327 ATV-related fatalities occurring in 2011, 590 in 2010, 684 in 2009 and 741 in 2008.[4] In the CPSC 2011 Annual Report of ATV-Related Deaths and Injuries, Pennsylvania is ranked third with 459 reported deaths related to ATVs from 1982 to 2007, and from 1989 to 2002 children accounted for 32% of the total deaths in PA.[2,5] There is a significant economic cost associated with these injuries: hospital admitted ATV-related injuries to youth under 17 years cost over $5.2 million annually.

Methods

This study was a population-based retrospective cohort design. Approval was obtained from the Institutional Review Board. Using the External Cause of Injury and Poisoning codes (E-codes) for off-road motor vehicle accidents, we identified children ages 2–16 years injured during a four-wheeled ATV accident admitted or transferred to our Level I and Level II trauma centers from January 1, 2007 to December 31, 2009. Data was obtained using our institutional trauma registry (Geisinger Medical Center, Danville, PA) which includes all orthopaedic trauma patients aged $\geq$1 year treated at one level I trauma center (Geisinger Medical Center, Danville, PA) and one level II trauma center (Geisinger Wyoming Valley, Wilkes-Barre, PA) associated with the system.

The E-codes used in this study for case selection included E821.0 through E821.9, which are specific for ATV accidents. Then, via manual chart review, accident-related data including age, gender, BMI, environment descriptors (i.e. rural highway, wooded area, personal property), length of hospital stay, whether the patient was a driver or passenger, and helmet use where noted was collected. Where possible, each crash was categorized into one of four categories, in decreasing order of severity: ejection, rollover, crash with a moving object, or crash with a stationary object. If more than one category applied, the most severe category was chosen. Total hospital costs related to the initial hospital stay for ATV-related trauma patients were determined for patients, including both direct and indirect costs of nursing, laboratory, diagnostic, surgical, surgical supplies, medications, and support staff. Costs associated with subsequent hospital readmissions or clinic visits after hospital discharge were not assessed.

The two main outcomes of interest were the total cost of care, and whether or not the injury required an overnight hospital stay (length of stay >1 day). Because cost data follow a log-normal distribution rather than a normal distribution, generalized linear regression (GLM) with a log-link function was used to test for significant risk factors associated with higher costs, and logistic regression was used to test for risk factors associated with overnight hospital stays. Finally, to examine whether there was a time trend, we compared both outcomes among the 3 years of the study using ANOVA or chi-square testing. All statistical analyses were performed using SAS statistical software (SAS 9.3, Cary, NC), with a p-value of <0.05 considered statistically significant.

Results

A total of 78 patients met inclusion criteria for the study. Sixty-one of the patients (78%) were male, and the mean age was 12.2 years (median 13 years, range 2–16 years). Table 1 describes the details of the crash circumstances. Rollovers (41%) were the primary mechanism of injury followed by ejections, collisions with stationary objects, and collisions with a moving object. Over half of the patients (54%) were reported as wearing a helmet at the time of the accident, 23% were not wearing a helmet, and helmet status was undocumented for 23% of patients. The majority (74%) were reported to be the driver with 15% reported as being passengers, and the remaining 10% did not have their role recorded. Only one fatality was reported.

Total cost of care ranged from $322 to $310,435 with a mean cost of $25,760 (median $8066). Length of stay ranged from 0 to 19 days with a mean value of 1.8 days, and 37 of 78 patients (47%) required an overnight stay. Table 2 shows the results of the cost analysis where each potential risk factor was assessed. Results are expressed as a Cost Ratio (CR), which is a multiplication factor by which the risk factor affected the log-cost of care, with ratios greater than 1.0 indicating higher cost and less than 1.0 indicating lower costs. Crashing into a stationary object (as opposed to the other three crash types of rollovers, ejections, or crashes with moving objects) had a cost ratio of 0.40 ($p = 0.01$), indicating it had significantly lower costs than other crash types. Age and rollover crashes were associated with cost ratios slightly greater than 1.0, but did not reach statistical significance. Likewise, helmet use was associated with a favorable cost ratio of 0.64, but this was not statistically significant ($p = 0.69$).

Because fewer than half of the patients were admitted overnight, we tested for associations between risk factors and an

Table 1
Crash circumstances.

Types of crash, N (%)	
Rollover	32 (41%)
Ejection	23 (29%)
Collision with stationary object	18 (23%)
Collision with moving object	1 (1%)
Other	1 (1%)
Not documented	3 (4%)
Helmet use, N (%)	
Helmet	42 (54%)
No Helmet	18 (23%)
Not documented	18 (23%)
Patient's role in crash, N (%)	
Driver	58 (74%)
Passenger	12 (15%)
Not documented	8 (10%)
Fatalities, N (%)	1 (1%)

Table 2
Regression model calculating cost ratios for potential cost determinants.

Potential risk factor	Cost ratio, OR [95% confidence interval]	p-value
Age (per year)	1.02 [0.94–1.10]	0.70
Rollover (Y vs. N)	1.12 [0.61–2.07]	0.71
Ejection (Y vs. N)	0.86 [0.45–1.66]	0.65
Crash with stationary object (Y vs. N)	0.40 [0.20–0.79]	0.01
Helmet (Y vs. N)	0.64 [0.31–1.34]	0.24
Driver (Y vs. N)	0.85 [0.38–1.88]	0.69

overnight stay rather than length of stay as a continuous variable. Table 3 shows the results of this admissions analysis. Patients who were in rollover crashes had a significantly higher odds of requiring an overnight stay (odds ratio = 3.58, p = 0.01) compared to patients who were in other types of crashes. Patients wearing helmets were less likely to require an overnight stay (odds ratio = 0.34, p = 0.07), which was a marginally significant finding.

Finally, to see if these outcomes changed over time, a year by year comparison was performed. Results are summarized in Table 4. The mean total cost of care was much higher in 2008 ($30,865) and 2009 ($33,381) than in 2007 ($10,160), but this difference was not statistically significant (p = 0.24) and these numbers were highly influenced by 3 out of 78 patients who had hospital stays of 18–19 days and incurred extraordinarily high costs (>$100,000). The median and log-mean costs were much more consistent among the three years since they are less influenced by extreme observations ($5162-8037 and 8.4–9.3, respectively) The mean length of stay was similarly much higher in 2008 (1.92) and 2009 (2.6) than in 2007 (0.65). These values were also highly influenced by the three previously-mentioned patients, but we note that the percentage of patients requiring overnight hospital stays was lower in 2007 (30%) than in the other two years as well (54–55%). None of these yearly comparisons reached statistical significance (p > 0.07).

Table 3
Regression model calculating odds ratios of requiring a stay of ≥1 day for potential risk factors.

Potential risk factor	Odds ratio, OR [95% confidence interval]	p-value
Age (per year)	1.03 [0.91–1.17]	0.62
Rollover (Y vs. N)	3.58 [1.39–9.25]	0.01
Ejection (Y vs. N)	0.48 [0.17–1.31]	0.15
Crash with stationary object (Y vs. N)	0.64 [0.22–1.86]	0.41
Helmet (Y vs. N)	0.34 [0.11–1.08]	0.07
Driver (Y vs. N)	0.62 [0.18–2.19]	0.46

Table 4
Year by year comparison of cost of care and length of stay.

	2007 (n = 23)	2008 (n = 24)	2009 (n = 31)	p-value
Mean (SD) cost of care ($)	10,160 (15,639)	30,865 (53,107)	33,381 (68,047)	0.24
Median (IQR) cost of care ($)	5162 (1532–11,191)	11,184 (3213–26,907)	8037 (3401–30, 742)	0.14
Mean (SD) log-cost of care (log $)	8.4 (1.4)	9.3 (1.5)	9.2 (1.5)	0.07
Mean (SD) length of stay, days	0.65 (1.6)	1.92 (3.6)	2.6 (4.8)	0.10
Patients requiring hospital stay ≥1 day	30%	54%	55%	0.15

Discussion

Injuries in children resulting from ATV-related crashes result in significant medical costs, especially when they involve unhelmeted riders and rollover accidents. In our cohort, children who wore helmets had lower costs on average and shorter hospital stays than those not wearing helmets. Additionally children involved in rollover crashes had slightly higher costs on average than patients in other types of ATV crashes.

Proper helmet use is estimated to reduce the risk of head injury by 64% and the risk of death by 42%.[12–16] Helkamp in 2001 showed a two-fold increase in ATV-related mortalities in states without helmet laws.[17] Despite this evidence in support of helmet use, lack of acceptance and highly variable, poorly enforced policy intervention still results in low helmet use among ATV riders.[12] Dietz et al (2012), reported that the percentage of riders under age 18 in West Virginia wearing helmets actually decreased from 67% to 55% after the enactment of a helmet law there.[15] Our findings further support previous studies reporting abysmally low helmet use rates among ATV riders ranging from 5% to 50%.[8,9,12–14,17–30]

Similar to previous reports most of the injuries reported in our cohort were not life threatening and patients were treated in the ED and released; however, more seriously injured patients required hospitalization and more advanced treatment.[13,26,28,31,32] Lynch et al (1998) reported an average hospital length of stay of 8 days (range 1–51) for a similar series of 51 patients, and Bowman, Aitken et al (2009) observed in a series of 11,589 pediatric and adult patients that average length of stay was longer for unhelmeted patients (4.8 vs 4.2 days, $p < 0.001$).[12,33]

Rollover or "flipping" was the most common mechanism of injury in our cohort, similar to previous published reports.[3,13,15,19,26,28,32,34–38] Brandenburg, Brown, Archer et al (2007) reported that ATV rollover crashes were significantly more likely to involve more than one rider, and most occurred when the ATV was traveling on flat or uneven terrain as opposed to a slope.[13] A child's inability to maneuver an ATV due to low body mass and/or strength in combination with lack of experience and vehicle-related factors (i.e. weight) may prevent a child from being able to correct or prevent a rollover once it has begun.[37] In our study age and rollover crashes were associated with slightly greater cost ratios but did not reach statistical significance and patients involved in rollover crashes had significantly higher odds of requiring an overnight stay as compared to patients who were involved in other types of crashes.

The primary limitation of our study is that it only included cases seen at our institution, therefore under representing the actual number of injuries within our region. Our institution is the only level I trauma center in its region; however, several additional hospitals with emergency departments are present. A secondary limitation is that the study was a retrospective review and therefore relies on the accuracy of existing records; however, a retrospective study is the most appropriate design for examine risk factors such as helmet use or rollover crashes, since it would not be ethical to randomize children to such interventions. Identifying crash victims in medical records is typically accomplished by use of E-codes that "record events, circumstances, or conditions that cause or contributed to the occurrence of any injury. As noted in previous studies, ATV-related injuries and hospitalizations may be under-reported because the same E-code 821 can be used to identify accidents including ATVs, golf carts, go-carts and others. In this study, manual chart reviews were performed to verify all ATV cases. Because it was a retrospective review, however, crash details such as number of riders, and whether not protective gear was used was not always collected at the time of injury and therefore could not be used.

Conclusion

Injuries resulting from ATV crashes result in significant medical costs, especially when they involve unhelmeted riders and rollover accidents. Our data suggests that interventions to increase helmet use among ATV riders and measures to improve ATV stability seem warranted.

Conflicts of interest and source of funding

KAS and TRB's institution received funding from Synthes for research fellow support. WRS is on the speaker's bureau for Stryker, a paid consultant for Synthes and Stryker, receives royalties, financial or material support from Mcgraw Hill, is on the editorial board for Journal of Patient Safety in Surgery and holds a board member/committee appointment for the American College of Surgeons. For the remaining authors none were declared.

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