Helmet use is associated with a decrease in intracranial hemorrhage following all-terrain vehicle crashes

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BACKGROUND: With the recent increase in size and horsepower of all-terrain vehicles (ATVs), it is imperative that preventable injuries be identified to protect the large population using ATVs. Currently, many states have no laws regulating ATV or helmet use. By identifying preventable injuries, the legislature can design appropriate laws to protect both children and adults.

METHODS: A retrospective review of all patients with ATV injuries presenting between the years 2005 and 2010 was conducted. The data were grouped in several ways for analysis. This included age less than 9 years, weight less than 30 kg, crash at night, substance abuse, and presence of a helmet.

RESULTS: There were 481 patients included in the study. Only 28 (8%) were using a helmet at the time of the crash. Helmet use was associated with less intracranial hemorrhage (3% vs. 22%, $p = 0.01$) and a decreased incidence of loss of consciousness (14% vs. 35%, $p = 0.01$). Patients testing positive for alcohol intoxication with or without drugs were significantly more likely to have intracranial hemorrhage, to crash at night, to have facial fracture, to have rib fracture, to arrive intubated, and to have a higher Injury Severity Score (ISS) ($p < 0.01$ for all).

CONCLUSION: With the recent increase in size and horsepower of ATVs, it is imperative that preventable injuries be identified to help protect a growing population of ATV operators. This study reveals a high rate of intracranial hemorrhage following an ATV crash in operators who do not use a helmet. Legislative efforts to implement strict helmet laws for ATV operators may be warranted. (*J Trauma Acute Care Surg*. 2014;76: 201–204. Copyright © 2014 by Lippincott Williams & Wilkins)

LEVEL OF EVIDENCE: Prognostic study, level III.

KEY WORDS: ATV; traumatic brain injury; helmet; prevention.

The all-terrain vehicle (ATV) was introduced in the United States in 1971. The Consumer and Product Safety Committee reported that during the period from 1982 to 2009, there were more than 130,000 serious injuries each year and 10,281 mortalities related to ATV use.[1] During the past decade, children younger than 16 years accounted for up to 33% of deaths associated with the use of an ATV.[1] In recent years, the popularity of these vehicles has increased, with 2009 estimates of 10.5 million ATVs in use.[1] Moreover, these vehicles have become larger and more powerful, with some ATV models capable of traveling at speeds greater than 80 mph.[1,2]

It is generally accepted that helmet use reduces injuries in both bicycle and motorcycle crashes; however, the benefit of helmet use during ATV crashes has not been determined.[3] Helmet use with ATVs remains as low as 8% in some regions.[4–8] Furthermore, there are currently no federal regulations governing ATV use, with 26 states requiring children to wear helmets and 13 states requiring helmet use in both adults and children. Although many states have implemented ATV safety education, it has been reported that safety education without implementation of strict safety laws will likely have a minimal effect.[9–12] The primary objective of this study was to determine injury patterns associated with helmet use during ATV crashes.

PATIENTS AND METHODS

This study is a retrospective review of all injured ATV crash patients who presented to the University of Mississippi Medical Center Emergency Department between the years 2005 and 2010. Patients were identified with the trauma registry, followed by a chart review. An attempt to contact all patients via telephone was done to gather missing data. Data collected from chart review and telephone patient interviews included demographics, injuries, treatment, and helmet use.

All patients involved in an ATV crash during the study period were included. The study population was grouped in the following ways for subgroup analysis: presence of helmet, alcohol use, drug use, intracranial hemorrhage (ICH), patient's weight less than 20 kg, and age of 8 years or younger. The following injuries were extracted by chart review and recorded as a categorical variable: ICH, skull fracture, facial fracture, loss of consciousness, cervical spine fracture, thoracic spine fracture, lumbar spine fracture, rib fracture, patient orotracheal intubation on emergency department arrival, pulmonary contusion, liver injury, spleen injury, and extremity fractures.

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An ATV was considered to be "an off-road, motorized vehicle having four low pressure tires, a straddle seat for the operator, and handlebars for steering control."[1] ICH was defined as evidence of blood within the cranial cavity on computed tomography scan. Loss of consciousness (LOC) was defined by a witnessed state of unconsciousness or amnesia following the incident. Any blood alcohol concentration greater than 50 mg/dL was considered positive. Any abnormal value on the urine toxicology screen was considered positive, with the exclusion of opiates and benzodiazepines, if drugs from these classifications were administered in the emergency department before urine specimen collection. The time of injury was considered at "night" if between the hours 8:00 PM to 6:00 AM. Univariate analysis was performed using Student's *t* test for continuous variables and χ^2 analysis for categorical variables. Values were considered statistically significant with $p < 0.05$. This study was approved by the University of Mississippi Medical Center Institutional Review Board.

RESULTS

A total of 481 patients presented to the emergency department at the University of Mississippi Medical Center between 2005 and 2010 who were involved in an ATV crash. The mean age was 23.4 years (range, 1–89 years). Sixty-three patients (13%) were 8 years or younger. There were 104 females (21.6%) and 377 males (78.4%) in the study population. The mean Injury Severity Score (ISS) was 11.3 (range, 1–43), with two mortalities (<1%). The characteristics of the study population are outlined in Table 1.

Prevalence of injuries for the entire study population were as follows: ICH, 88 (18%); skull fracture, 66 (14%); cervical spine fracture, 27 (6%); facial fractures, 75 (16%); liver laceration, 29 (6%); spleen laceration, 16 (3%); pelvic fracture, 27 (6%); upper-extremity fracture, 132 (27%); and lower-extremity fracture, 99 (21%). Eight patients (2%) underwent exploratory laparotomy. (Table 2)

There were 28 patients (7%) wearing a helmet at the time of the crash. Helmet use was associated with a statistically significant decrease in prevalence of ICH (3.6% vs. 22.0%, $p = 0.02$) and LOC (14.3% vs. 35.4% $p = 0.02$). (Table 3) There was a 7.6-fold (95% confidence interval, 1.02–56.8) increase in the odds of an ICH among nonhelmet users and a 3.3-fold (95% confidence interval, 1.1–9.6) increase in the odds of LOC among nonhelmet users. Helmet use did not prevent significant facial fractures, with no difference in the incidence of mandible, temporal bone, orbital, or zygoma fractures. Nasal fractures occurred with greater frequency in patients wearing helmets (4% vs. 8%, $p < 0.05$). There were 88 patients (18%) with an ICH. Patients with ICH were more likely to have LOC (65% vs. 22%, $p < 0.05$), to have skull fracture (53% vs. 5%, $p < 0.05$), to have facial fracture (34% vs. 12%, $p < 0.05$), to arrive intubated (26% vs. 5%, $p < 0.05$), and to have a longer hospital stay (8 days vs. 4.5 days, $p < 0.05$) (Table 4). Patients testing positive for alcohol intoxication (with or without drugs) had an increased incidence of ICH (28% vs. 16%, $p < 0.05$), night crashes (46% vs. 22%, $p < 0.05$), facial fractures (28% vs. 13%, $p < 0.05$), rib fractures (20% vs. 10%, $p < 0.05$), and prehospital intubations (18% vs. 7%, $p < 0.05$) and had higher ISS (14.8 vs. 10.5, $p < 0.05$) (Table 5).

More than half of the study population was classified as children (13%, ≤8 years; 58%, ≤16 years). Helmet use in patients younger than 8 years was similar to older ATV operators (8% vs. 6%, respectively); however, the prevalence of most injuries was higher in patients older than 8 years (Table 6).

TABLE 1. Description of Study Population

Description	n	Percentage
n	481	—
Male	372	77
Age ≤ 8 y	63	13
Alcohol and/or drugs	127	26
Drugs	14	6
Crash at night	59	27
Helmet use	28	7

TABLE 2. Prevalence of Injuries for the Entire Study Population

Injuries	n	Percentage
ICH	88	18
Skull fracture	66	14
Cervical spine fracture	27	6
Facial fracture	75	16
Intubated on arrival	43	9
LOC	143	30

DISCUSSION

In 1988, the Consumer Product Safety Commission negotiated a decree with leading ATV producers banning three-wheeled ATVs and the sale of large engine ATVs to children younger than 16 years. The decree also required ATV manufacturers to add warning labels and launch a safety awareness campaign. Since 1998, this action plan has become voluntary and self-regulated. Following expiration of the decree, ATV injuries have increased by 56%.[13] This has also been true for the pediatric population, with a reported 150% increase in pediatric hospitalizations caused by ATV-related injuries following expiration of the decree.[14] Current guidelines of the

TABLE 3. Description of Neurologic Injuries Related to Helmet Use

Description	With Helmet (n = 28)	No Helmet (n = 364)	*p*
ICH	1 (4%)	80 (22%)	<0.05
Skull fracture	3 (11%)	60 (16%)	0.40
C-spine fracture	1 (4%)	26 (7%)	0.47
Arrived intubated	1 (4%)	40 (11%)	0.21
LOC	4 (14%)	129 (35%)	<0.05
Glasgow Coma Scale (GCS) score on arrival, mean	14.5	13.6	0.90
Facial fracture	4 (14%)	68 (19%)	0.56

C-spine, cervical spine.

TABLE 4. Characteristics Associated With ICH

Variable	Yes, ICH	No, ICH	*p*
n	88 (18%)	393 (82%)	—
Helmet	1 (3%)	80 (22%)	<0.05
LOC	57 (65%)	86 (22%)	<0.05
Skull fracture	47 (53%)	19 (5%)	<0.05
Facial fracture	30 (34%)	45 (12%)	<0.05
Intubated	23 (26%)	20 (5%)	<0.05
C-spine fracture	8 (9%)	19 (5%)	0.12
ETOH	18 (20%)	45 (11%)	0.07
LOS, d	8	4.5	<0.05

C-spine, cervical spine; LOS, hospital length of stay.

American Academy of Pediatrics discourages children younger than 16 years from riding or operating ATVs because children younger than 16 years may be particularly vulnerable to serious injuries.[15] Fifty-eight percent of pediatric ATV injuries involve patients younger than 16 years.[15]

In this retrospective review of ATV crashes, helmet use was associated with a decrease in the incidence of ICH and hospital length of stay. These results demonstrate a low use of helmets while riding ATVs, with only 7% of the entire population wearing helmets and 8% of children younger than 8 years wearing helmets. A recent review of the National Trauma Data Bank revealed similar results. Nonhelmeted riders were more likely to experience severe traumatic brain injuries, more likely to experience neck injuries, and more likely to die of injuries.[6] Another similar study noted that helmet use reduced the risk of death by 42% and head injuries by 64%.[16]

More than one fifth of hospital admissions from ATV injuries are related to a head injury, and ATV patients experience more head injuries than motorcycle patients,[17] possibly related to helmet laws for motorcycles. Previous data obtained from the Healthcare Cost and Utilization Project in 2004 estimated $1.1 billion in total hospital charges from ATV accidents.[18] Cost associated with ATV accidents represents a substantial public financial burden as well as an avenue for health care savings.[11] The state of Pennsylvania has enacted strict helmet laws and age restrictions for ATV operation, which has resulted in a higher percentage of helmet use and an older mean age of patients with injury when compared with states without regulations[15] In addition, substance abuse associated with ATV operation is a public safety issue as reflected by the prevalence of substance abuse in our cohort (26%). This may represent the recreational nature of ATVs as well as alcohol and substance abuse. There are strict laws that prohibit the use of these substances when driving automobiles and motorcycles as well as when operating heavy machinery; however, these laws do not currently exist for operating ATVs.

TABLE 5. Description of Injuries Related to the Use of Alcohol and/or Drugs

Description	ETOH or Drugs	No ETOH/Drugs	*p*
n	83	398	—
Helmet	3 (4%)	25 (6%)	0.34
Facial fracture	23 (28%)	52 (13%)	<0.05
ICH	23 (28%)	65 (16%)	<0.05
Skull fracture	16 (19%)	50 (13%)	0.10
C-spine fracture	8 (10%)	19 (5%)	0.08
Arrived intubated	15 (18%)	28 (7%)	<0.05
LOC	39 (47%)	104 (26%)	<0.05
GCS score on arrival, mean	12.2	14.1	<0.05
Occurred at night*	38 (46%)	89 (22%)	<0.05
Rib fracture	17 (20%)	39 (10%)	<0.05
Pulmonary contusion	15 (18%)	40 (10%)	<0.05

*Fifty-eight patients were excluded due to unknown time of crash.
C-spine, cervical spine.

TABLE 6. Description of Injuries Related to Age

Variable	≤8 y	>8 y	*p*
n	63 (13%)	418 (87%)	—
ICH	6 (10%)	82 (20%)	<0.05
Helmet	5 (8%)	23 (6%)	0.76
LOC	9 (15%)	134 (32%)	<0.05
Skull fracture	10 (16%)	56 (33%)	<0.05
Facial fracture	3 (5%)	72 (17%)	<0.05
Intubated	1 (2%)	42 (10%)	<0.05
Upper-extremity fracture	20 (32%)	112 (27%)	0.45

CONCLUSION

With the recent increase in size and horsepower of ATVs, it is imperative that preventable injuries be identified to help protect a growing population of ATV operators. This study reveals a high rate of ICH following an ATV crash in operators who do not use a helmet. Legislative efforts to implement helmet laws for ATV operators may be warranted.

AUTHORSHIP

J.D.S. is the principle investigator and was responsible for the study design, data collection, and manuscript development. J.W.R. was involved in the manuscript development. K.A.D. was involved in the study design, data collection, and manuscript development. E.A.R. was involved in the data collection and manuscript revisions. J.S.: was involved in the data collection and manuscript revisions. J.M.P. was involved in the study design and manuscript revisions. N.A. was involved in the study design and manuscript revisions. W.H.R. performed the statistical analysis. R.P.G. and S.B.B. were involved in the manuscript revision and data analysis.

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DISCLOSURE

The authors declare no conflicts of interest.

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