Retrospective review of all-terrain vehicle accidents in Alberta

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Background: All-terrain vehicles (ATVs) are frequently associated with injuries and deaths. In spite of this, very few guidelines, let alone legal restrictions, exist to guide users of these machines.

Methods: We conducted a standardized review of prospectively collected data from the Alberta Trauma Registry. All patients who were involved in ATV-related traumas from 2003 to 2008 with an Injury Severity Score (ISS) greater than 12 were included. The variables studied were age, sex, type of vehicle, purpose of use, person injured (driver or passenger), ISS, distribution of injuries, length of hospital stay, helmet use and death.

Results: We evaluated 435 patients with ATV-related injuries and ISS greater than 12. The average ISS was 22.8, with an overall mortality of 4.6%; 55% of patients were not wearing helmets, and most of the deaths (85%) occurred among these individuals. Helmet use was associated with a lower risk of mechanical ventilation and of injury to the head and/or cervical spine. Children accounted for 18.9% of all patients and 15% of deaths; 57% of them were wearing helmets at the time of their accidents.

Conclusion: All-terrain vehicle use in Alberta carries a significant risk of injury and death, and there is an association between death and lack of helmet use. A minimum age for ATV use of at least 16 years and a legal requirement for helmet use may increase public awareness of these risks and decrease morbidity and mortality.

Contexte : Les véhicules tout-terrain (VTT) sont souvent associés à des traumatismes et à des décès. Malgré cela, il existe très peu de lignes directrices et encore moins de lois pour guider les utilisateurs de tels véhicules.

Méthodes : Nous avons effectué une revue standardisée des données recueillies de manière prospective auprès de l'Alberta Trauma Registry. On y a inclus tous les patients impliqués dans un accident de VTT entre 2003 et 2008 et présentant un indice de gravité de la blessure supérieur à 12. Les variables étudiées comprenaient l'âge, le sexe, le type de véhicule, le but de son utilisation, la personne blessée (conducteur ou passager), l'indice de gravité de la blessure, la distribution des blessures, la durée du séjour hospitalier, le port du casque et les décès.

Résultats : Nous avons évalué 435 patients victimes de traumatismes subis lors d'un accident de VTT et dont l'indice de gravité de la blessure excédait 12. L'indice de gravité de la blessure moyen était de 22,8, avec une mortalité globale de 4,6 %; 55 % des patients ne portaient pas de casques et la plupart des décès (85 %) sont survenus chez ces personnes. L'emploi du casque a été associé à un risque moindre de recours à la ventilation mécanique et de traumatisme crânien et(ou) cervical. Les enfants représentaient 18,9 % de tous les patients et 15 % de tous les décès; 57 % d'entre eux portaient des casques au moment de l'accident.

Conclusion : L'emploi de véhicules tout-terrain en Alberta comporte un risque significatif de traumatisme et de mortalité et il existe un lien entre la mortalité et le non-port du casque. Fixer l'âge minimum d'utilisation d'un VTT à 16 ans ou plus et rendre le port du casque obligatoire pourraient contribuer à sensibiliser le public à ces risques et à réduire la morbidité et la mortalité.

All-terrain vehicles (ATVs) were first introduced to the North American population in 1971 as a means of providing efficient transportation for those in the agricultural industry.[1] With their rising popularity, there was a corresponding increase in the incidence of injuries and deaths due to ATV accidents. Consequently, in 1988, the Consumers' Product Safety Commission and the ATV manufacturers initiated a consent decree: a voluntary agreement to improve the safety of ATVs over a 10-year period. Unfortunately, since the expiration of the decree in 1998, there have been numerous publications documenting an increase in the number of ATV-related injuries and deaths.[1–5]

Presently, legislation varies across provinces and states in North America. In Canada, there are only 3 provinces (Quebec, New Brunswick and Nova Scotia) that mandate driver safety training and helmet use, despite the fact that head and neck injuries are the most common injuries sustained by ATV users. Helmet use has been associated with a 64% reduction in head injury and a 42% reduction in deaths caused by ATV accidents.[6]

Whereas it is well known that the use of these vehicles has increased in our population, there are few publications examining the frequency and type of ATV-related injuries that occur, especially among Canadian adults. This in turn has led to more debate and reduced momentum for further legislation in the province of Alberta. We therefore studied the frequency, severity and nature of injuries sustained on ATVs in our province. We hypothesized that severe ATV injuries were common in Alberta and that helmet use could prevent the severity of brain and other traumatic injuries and decrease overall morbidity and mortality. By examining helmet use and substance abuse among patients with ATV-related trauma, we hoped to gain insight and influence future legislation in our province.

Methods

Data collection

This study is a retrospective review of data on major trauma injury owing to ATV use that we obtained from the Alberta Trauma Registry (ATR). The ATR is housed at the Alberta Centre for Injury Control and Research (ACICR) and prospectively collects information on all major trauma patients (Injury Severity Score [ISS] ≥ 12) treated at a level 1–3 trauma centre in Alberta. We included all patients (adult or pediatric) injured using an ATV who were treated at an Alberta level 1–3 trauma centre, had an ISS of 12 or greater, were included in the ATR, were injured between May 2004 and August 2009 and whose helmet use at the time of injury was known. Ethical, administrative and operational approval was obtained from the University of Alberta Health Research Ethics Board and Alberta Health Services.

Research design

Data obtained from the ATR included age; sex; place of injury; person injured (driver or passenger); blood alcohol concentration (BAC) levels; mechanism of injury; helmet use; length of stay (LOS) in hospital; ISS; Glasgow Coma Scale scores; the need for and number of days of mechanical ventilation; discharge status; Abbreviated Injury Scale (AIS) scores for the head, face, chest, abdomen and extremities; and external injury.

Statistical analysis

Statistical analysis was completed in SPSS software, version 18. We removed the mechanism-of-injury variable from the study as there was limited variation in injury (1 penetrating and 400 blunt injuries). In cases where multiple BAC readings were recorded per patient, the highest BAC level recorded was used for the statistical calculation.

We compared clinical and demographic variables between helmet users and those not using helmets; we performed

Table 1. Mann–Whitney *U* and *t* test results comparing helmet use to no helmet use

Characteristic	No.	Mean (SD) [mean rank]*	F†	*p* value†	*t* (95% CI)	*p* value*
Loss of consciousness	400	10.36 (11.14)	—	—	—	0.86
Helmet	182	[201.58]				
No helmet	218	[199.60]				
Mechanical ventilation	401	1.69 (4.79)	—	—	—	0.021
Helmet	182	[189.38]				
No helmet	219	[210.66]				
Age	401		0.328	0.57	2.46 (0.793–7.079)	0.014
Helmet	182	30.05 (15.52)				
No helmet	219	33.99 (16.29)				
Blood alcohol content	269		25.946	< 0.001	4.14 (4.106–11.539)	< 0.001
Helmet	114	5.45 (13.49)				
No helmet	155	13.27 (17.45)				
Injury Severity Score	401		0.628	0.43	1.61 (–0.320 to 3.244)	0.11
Helmet	182	22.05 (9.47)				
No helmet	219	23.51 (8.67)				

CI = confidence interval; SD = standard deviation.
*Mann–Whitney *U* test.
†For those *t* tests that demonstrated a significant Levene statistic, unequal variance was reported.

Student t tests to compare age, BAC and ISS, the Mann–Whitey U test to compare LOS and mechanical ventilation days and the χ^2 test to compare sex, discharge status, need for mechanical ventilation, major head injury (AIS ≥ 3), major chest injury (AIS ≥ 3) and major extremity injury (AIS ≥ 3).

Continuous variables were screened for normality. One patient had missing data regarding LOS, and 132 had missing BAC data. Based on the values of skewness and kurtosis, age (mean 32.20 [standard deviation; SD 16.04] yr), BAC (mean 9.96 [SD 16.34] mg/g) and ISS (mean 22.85 [SD 9.06]) were all normally distributed, with skewness ranging from 0.45 to 1.55 and kurtosis ranging from –0.42 to 1.29. Length of stay (median 6.00 [interquartile range; IQR 8.75] d) and mechanical ventilation days (median 0.00 [IQR 1.00] d) did not meet assumptions for normality, with skewness ranging from 2.5 to 5.3 and kurtosis ranging from 7.9 to 37.8.

We used a purposeful selection modelling approach to assess the association between helmet use and dependent variables of interest (i.e., relevant clinical outcomes). A univariate analysis was performed where independent variables were included in the final model if they were deemed to have clinical relevance or had a $p < 0.20$. We performed a multivariate logistical regression analysis to assess the relation between helmet use and the dependent variables, accounting for any additional variables that were found to be significant in the univariate analysis.

Univariate analysis revealed 2 variables of interest for the statistical model when compared with helmet use: age ($p = 0.015$) and ethanol ($p < 0.001$). Sex ($p = 0.50$) was retained in the model owing to its clinical relevance. To improve the precision of our estimates given the number of predictor variables, we used 80 or greater for the dependent clinical variables of interest as a minimum (i.e., the minimum number of outcomes required for us to look at this in the analysis). This eliminated major facial injury ($n = 47$) and major abdominal injury ($n = 59$).

Results

Sample

There were 401 patients who met the inclusion criteria for the study (34 patients could not be included because their helmet use was unknown). Of the 401 patients included in the study 327 (81.5%) were male and 74 (18.5%) were female, ranging in age from 2 to 82 (mean 32.20 [SD 16.04]) years.

Pattern of injuries

The majority of patients sustained injuries to the head, cervical spine and thorax, and most injuries were not in isolation:

- 240 (59.9%) patients had injuries to the head and/or cervical spine, with 179 (74.6%) of those injuries classified as a major injury (AIS ≥ 3);
- 235 (58.4%) patients sustained injuries to the thorax, with 207 (88.1%) of those injuries classified as a major injury;
- 194 (48.4%) patients had extremity injuries, with 93 (47.9%) classified as a major extremity injury;
- 127 (31.6%) patients had injuries to the abdomen;
- 94 (23.4%) patients sustained facial injuries; and
- of the patients who sustained an abdominal or facial injury, 68 (53.5%) and 47 (50%), respectively, sustained a major injury.

Comparisons between helmeted and helmetless groups

Results of the comparison are summarized in Table 1 and Table 2. The need for and number of days of mechanical ventilation, age, BAC, discharge status and head injury were all statistically significant between the helmeted and helmetless groups, with more favourable clinical outcomes among patients who used a helmet. When controlling for age, sex and BAC (Table 3), there was no significant difference

Table 2. Injury patterns and outcomes in patients wearing helmets versus patients without helmets

Characteristic; helmet use	No.	p value
Sex, male:female		0.50
Helmet	151:31	
No helmet	176:43	
Discharge status, alive:dead		0.005
Helmet	179:3	
No helmet	202:17	
Mechanical ventilation, yes:no		0.014
Helmet	29:153	
No helmet	57:162	
Major head injury, yes:no		0.025
Helmet	54:28	
No helmet	125:33	
Major chest injury, yes:no		0.89
Helmet	108:15	
No helmet	99:13	
Major extremity injury, yes:no		0.26
Helmet	49:45	
No helmet	44:56	

Table 3. Odds ratios for various clinical outcomes from injuries related to all-terrain vehicles based on helmet use, controlling for age, sex and blood alcohol level

Clinical outcome	β	SE	p value	Odds ratio (95% CI)
Major head injury	0.832	0.408	0.041	2.297 (1.033–5.109)
Major chest injury	0.121	0.482	0.80	1.128 (0.439–2.899)
Major extremity injury	–0.245	0.379	0.52	0.783 (0.373–1.644)
Discharge status, death	1.884	0.779	0.016	6.577 (1.428–30.300)
Mechanical ventilation	–0.619	0.321	0.05	0.539 (2.87–1.010)

CI = confidence interval; SE = standard error.

between helmet use and no helmet use in patients who had sustained a major chest or extremity injury (AIS ≥ 3). However, when controlling for age, sex and BAC, those who did not wear a helmet were almost 2.3 times ($p = 0.041$) more likely to sustain a major head injury (AIS ≥ 3) and were nearly 6.6 times ($p = 0.016$) more likely to die (based on reported discharge status). Interestingly, we found that patients who did not wear a helmet were less likely to need mechanical ventilation than those who wore a helmet (odds ratio 0.5, $p = 0.05$).

Discussion

The ATR data that we collected confirmed that serious injuries occur as a result of ATV accidents. Most patients sustained injuries to the head and cervical spine, which is consistent with previously reported injury patterns.[4,7–10] In keeping with our study hypothesis, our results showed that patients not wearing helmets were more likely to sustain significant brain injuries (with an odds nearly 2.3 times greater) or die (with an odds nearly 6.6 times greater) than those who did wear helmets.

Our results are in keeping with those reported in a study by Bowman and colleagues,[8] who retrospectively reviewed the impact of helmets on injuries to riders of ATVs. Their study found that helmetless patients were more likely to undergo a neurosurgical procedure as a result of the severity of their brain injuries, require admission to the intensive care unit, have a longer LOS and be discharged to a post–acute care rehabilitation facility versus home.[8]

Interestingly, we found that individuals who wore helmets were more likely to need mechanical ventilation than those who did not wear helmets. Mechanical ventilation in helmeted patients was likely owing to the presence of other injuries affecting physiologic status rather than a primary head injury. Helmeted individuals were probably alive as a result of the protective mechanism of the helmet, whereas helmetless individuals would have died from a severe head injury and therefore would not have been included in this study, especially if they had died at the scene of the accident.

Lord and colleagues[11] demonstrated that 58.1% of patients admitted owing to ATV accidents had head injuries and that 63.3% of all those who died did not wear helmets. The National Electronic Injury Surveillance System estimates that helmet use for all ATV users might decrease the risk of death by 42% and the risk of nonfatal head injuries by 64%.[10] Despite evidence demonstrating that helmets decrease the incidence and potentially the severity of brain injuries, the compliance rates still remain low and may be partially related to the lack of consistent regulation mentioned previously. Only 45% of patients in our study used helmets and, although these numbers are suboptimal, they are much higher than those reported in other Canadian studies.[4,5] It may be that since the publication of these studies, there has been an increase in awareness and education targeting users of ATVs.

In Alberta, there are no mandatory helmet laws or laws mandating ATV training. Whereas previous studies have shown less than ideal compliance rates in areas where helmets are mandated,[4,9] states with mandatory helmet laws have been shown to have a decreased mortality.[10] Decreases in head injuries and deaths have been associated with helmet use, as demonstrated by the results of our study; therefore, it is imperative that legislators send appropriate messages to the public by mandating helmet use. All-terrain vehicles have become heavier and faster (dry weights range from 200 to 1000 lbs). Speeds up to 70 miles per hour can be achieved depending on the model, increasing the risk for serious injuries, including major trauma.[2] The use of helmets, in addition to the application of safe driving practices, can reduce injury severity and mortality.[12]

Safe driving practices include the limitation of ethanol use. In Alberta, at the time of our study, there was no law limiting the use of alcohol during ATV operation on private property. Our data demonstrated that a large number of trauma patients (67%) had consumed alcohol. During the study period, it was not mandatory to collect alcohol levels on trauma patients, and consequently the proportion may be even higher than those reported. Ethanol can substantially impair judgment and can promote reckless and irresponsible behaviour.[13] Thepyasuwan and colleagues[9] performed a retrospective review of ATV injuries and found that 21% of their patients had detectable alcohol levels and that, of these patients, 66% had alcohol levels that were equal to or higher than the legal driving limit. The authors found a higher degree of noncompliance with the use of helmets and protective gear among individuals who used alcohol.[9]

Regulating alcohol and helmet use poses challenges owing to the off-road nature of ATV activity. It is not impossible, however, and solutions, such as monetary fines or driver license penalties, have previously been suggested.[14] Additional policies mandating ATV training should also be in place: demonstration of rider competency via formalized driving tests, license restrictions based on age, penalties for those who do not complete an ATV safety training course, restriction of sales of ATVs to drivers who have a certificate of safety and competency.[13] Changing the behaviour and attitudes of ATV purchasers and drivers is integral to instituting safe driving practices, which may in turn lead to fewer fatal accidents.

Limitations

Some limitations of our study include the fact that most of the data were collected from the ATR, limiting the number of ATV accident patients included in the study. Not only were patients with minor ATV trauma excluded, there may also have been an underestimation of ATV-related deaths, given that patients who died at the scene of the accident were not included in the ATR. Furthermore, our study was a retrospective review using an existing database. This means there is a limit to the number and types of variables that could be analyzed and that other potentially important risk factors that might have impacted our estimates (e.g., whether the patient was the driver or passenger, the type of ATV, whether the size of the ATV was age-appropriate) could not be analyzed. Also, there were several variables with missing data, namely alcohol use, reducing the accuracy of some of our data points. Despite analysis of 5 years of data, we were limited with the number of pediatric patients available for analysis.

Conclusion

All-terrain vehicles are a major source of morbidity and mortality in the province of Alberta, and morbidity and mortality are likely underestimated in our study. The lack of mandatory legislation is problematic, and is definitely a barrier to the promotion of ATV safety. There is ample evidence in the literature, local information from the ATR and data from the Alberta Centre for Injury Control & Research indicating that ATV users are involved in serious accidents that lead to detrimental injuries and deaths. Several studies have also demonstrated the benefits of helmet use in decreasing neurologic injuries and of mandatory helmet laws in decreasing rates of noncompliance. With this study, we hope to lend further evidence to the benefit of helmet use and influence legislators to mandate helmet use among all ATV users.

Competing interests: None declared.

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References

1. Fonseca AH, Ochsner MG, Bromberg WJ, et al. All terrain vehicle injuries: Are they dangerous? A 6-year experience at a level 1 trauma centre after legislative regulations expired. *Am Surg* 2005;71:937-40.
2. Axelband J, Stronski C, McQuay N, et al. Are all-terrain vehicle injuries becoming more severe? *Accid Anal Prev* 2007;39:213-5.
3. Bansal V, Fortlage D, Lee J, et al. A 21-year history of all-terrain vehicle injuries: Has anything changed? *Am J Surg* 2008;195:789-92.
4. Su W, Hui T, Shaw K. All-terrain vehicle injury patterns: Are current regulations effective? *J Pediatr Surg* 2006;41:931-4.
5. Sibley AK, Tallon JM. Major injury associated with all-terrain vehicle use in Nova Scotia: a 5-year review. *CJEM* 2002;4:263-7.
6. Rodgers GB. The effectiveness of helmets in reducing all-terrain vehicle injuries and deaths. *Accid Anal Prev* 1990;22:47-8.
7. Stolz U, McKenzie LB, Mehan TJ, et al. Assessing public opinion regarding potential ATV-related policies. *J Safety Res* 2009;40:149-55.
8. Bowman SM, Aitken ME, Helmkamp JC, et al. Impact of helmets on injuries to riders of all-terrain vehicles. *Inj Prev* 2009;15:3-7.
9. Thepyasuwan N, Wan XT, Davis VJ. All-terrain vehicle injuries at Arrowhead Regional Medical Center (level ii): epidemiology, risks and outcome. *Am Surg* 2009;75:1004-8.
10. Keenan HT, Bratton SL. All-terrain vehicle legislation for children: a comparison of a state with and a state without a helmet law. *Pediatrics* 2004;113:e330-4.
11. Lord S, Tator CH, Wells S. Examining Ontario deaths due to all-terrain vehicles and targets for prevention. *Can J Neurol Sci* 2010; 37:343-9.
12. Alberta Centre for Injury Control & Research. *All terrain vehicle (ATV) injuries in Alberta*. Edmonton: Alberta Centre for Injury Control & Research; 2009. Available: http://acicr.ca/Upload/documents-reports/data-reports/ATV_Letterstyle2008Deaths.pdf (accessed 2010 July 15).
13. O'Connor T, Hanks H, Steinhardt D. All-terrain vehicle crashes and associated injuries in North Queensland: findings from the rural and remote road safety study. *Aust J Rural Health* 2009;17:251-6.
14. Warda L, Klassen TP, Buchan N, et al. All terrain vehicle ownership, use and self reported safety behaviors in rural children. *Inj Prev* 1998;4:44-9.