Epidemiology and factors associated with all-terrain vehicle accidents in children: A retrospective cross-sectional study of a trauma registry in Saudi Arabia

Mohammed Al Mutari1,2, Bushra Alasmari2,3, Lama Aldosari2,3, Rahaf Alluhaidan2,3, Reham Aljohani2,3, Shahd Omar Hijazi2,3, Fatmah Othman2,4

1Department of Pediatric Emergency, King Abdullah Specialist Children Hospital, 2King Abdullah International Medical Research Center, 3College of Medicine, King Saud Bin Abdulaziz University for Health Sciences, 4Department of Research, College of Applied Medical Sciences, King Saud Bin Abdulaziz University for Health Sciences, Riyadh, Saudi Arabia

ABSTRACT

Background: All-terrain vehicle (ATV) accidents have a substantial impact on the pediatric population in Saudi Arabia; however, few local studies are available. An in-depth study of this issue and adequate implementation of regulations are required to prevent additional casualties. The aim of this study was to describe the epidemiology of ATV injuries in the pediatric population and the outcomes associated with the injuries.

Methods: We conducted a retrospective chart review at a Level 1 trauma center in Riyadh. All patients, aged ≤14 years and admitted due to an ATV accident, from 2004 to 2018 were included in this study. Demographic information, hospital course, and injury outcomes were extracted from the King Abdulaziz Medical City trauma registry. Each medical record was reviewed for short-term complications and the mechanism of injury. The primary outcome measure was the type of injury associated with ATV accidents; the secondary outcomes were injury site and mechanism of injury, and the association between the impact of injury and the clinical and demographic variable.

Results: In total, 165 patients were involved in ATV accidents and met our inclusion criteria. The mean age was 8 ± 4 years, and 79% (131/165) were boys. Over 50% (84/165) of the sample had lower limb injuries. The majority of patients had fracture injuries (37%, 61/165), followed by amputations (30%, 50/165). Of the amputation group, the majority (86%, 43/50) was from 1 to 5 years compared to the no amputation group ($P < 0.001$). For the amputation group, 67% (33/50) had a limb trapped in the chain of the vehicle as to the mechanism of injury.

Conclusion: The majority of patients had lower-extremity injuries, specifically fractured (37%) or amputated (30%) with children from age 1–5 years having a significantly higher proportion of hospital admission compared to the rest of the study population. Despite the existing legislation for ATV use in children, they are not enforced. The finding of this study recommends urgent implementation of these regulations for both ATV retailers and users and promotes public awareness about the severity of such injuries.

Key Words: Off road motor vehicles, Pediatric, wounds and injuries

INTRODUCTION

All-terrain vehicles (ATVs) contribute to childhood injuries and hospital admissions.[1] ATVs are defined as
Children have incompletely developed physical and cognitive skills that put them at risk of injuries, which may be considered preventable in adults. In addition, their small physical build makes them more prone to accidents. Literature reports a substantial increase in the incidence of ATV-related injuries in children compared to adults, and the children had a higher injury severity score (ISS) and a higher risk of isolated head injuries and fractures compared to adults. Several studies show that children age <17 years accounted for almost half of the entire ATV-related injury admissions. Two other studies, one of which was done in Canada and the other in Georgia, show that children account for a significant number of the total ATV-related injuries.

In the Kingdom of Saudi Arabia, ATVs are commonly used for recreational purposes in families and young adults, especially during the winter season. They are easily accessible to everyone, as there are neither license requirements nor age restrictions. In addition, unsafe riding behavior such as multiple passengers, not using protective gear (i.e., helmet, knee, and elbow pads), and wearing open shoes (i.e., sandals) is prevalent. Although several directives have been issued by the Saudi Standard, Metrology, and Quality Organization (SASO) in terms of safety measures for ATV bike use, none are implemented mainly because of the unavailability of penalties for nonadherence.

A case series study conducted in a single hospital in Riyadh and focusing on traumatic foot amputation secondary to ATV injuries in children aged <16 years identified 21 cases in 2 years. This case series was followed by another study indicating that 16% of their sample had a complete amputation and 83.6% had a partial amputation. These findings emphasize the urgent need for intervention to prevent such preventable and devastating incidents, which have a significant impact on the child’s future. This research aimed to highlight this issue by estimating the prevalence and identifying the factors associated with ATV-related injuries of children to enforce the implementation of safety measures at a national level.

**METHODS**

**Study design and settings**

This was a cross-sectional retrospective study using data obtained from the trauma registry database related to children, presenting at the ED at King Abdulaziz Medical City (KAMC) from 2004 to 2018, due to ATV-related injuries. KAMC is one of the largest trauma centers in the country, with a bed capacity of 1501 and a well-established emergency care center. It ranks 4th outside of the United States to provide prehospital trauma and life support programs, in addition to various other emergency services. For this study, we used the KAMC trauma registry database, which records data of all patients admitted to the hospital following traumatic injuries. The KAMC trauma registry has been established in 2001 by the Department of Surgery for the purpose of monitoring the frequency of injuries as well as establishing preventative measures in which many studies have been published trauma-related studies using this data. The study was approved by the local institutional review board. As the study was a retrospective chart review, no informed consent from the patients was required. The manuscript adheres to the STROBE guidelines for observational studies.

**Study participants**

Children aged <4 years presented at the ED due to an ATV accident and incorporated in KAMC trauma registry database from 2004 to 2018 were included. In the registry data, the mechanism of injury is classified into 12 categories, one of which relates to motor bike-related accidents. Patients who were involved in motor bike-related accidents and presented at the ED at KAMC with a minor injury (i.e., not requiring hospitalization or intensive care unit [ICU] admission) were excluded from this study. In addition, children who died on the scene were excluded.

**Study variables**

Variables retrieved included age, gender, mechanism of injury, type of injury, injury site, ISS, Glasgow Coma Scale (GCS), diagnosis, surgical procedure, ED length of stay, ED disposition, ICU length of stay, hospital length of stay, and hospital disposition. For the purpose of investigating the short-term complications of the sample, additional information was extracted from the electronic medical record department. Each patient file was manually reviewed for the following: re-admission (defined as any subsequent hospital admission related to a trauma complication), infection, rehabilitation, referral, and details of the complications during or after the hospital stay. To minimize the effect
of information bias, we had rechecked the data in the medical file to be consistent with the mechanism of injury that was recorded in the database.

Statistics
We estimated that we need at least 125 patients in our sample based on the expected prevalence of 3% from previous studies, 0.03 effect size, and 95% as the level of confidence. We expected to reach this sample size as an estimated number from the trauma registry data showed that there were 138 patients met our eligibility criteria. Descriptive analysis was done for continuous variables and was expressed as mean and standard deviation for normally distributed variables, and as median and interquartile ranges, if otherwise. For categorical variables, we used frequency and percentage. We categorized the sample into two categories based on the type of injury in an amputation group following ATV trauma and a no amputation group. Similarly, we categorized the sample in patients with and without a fracture following ATV trauma, based on the most frequent type of injury. We used the information from the medical records to enhance the validity of amputation and fracture. A Chi-square and the t-tests (and Mann-Whitney U-test for skewed data) were used for measurements of association between the impact of injury and the clinical variables. P < 0.05 was set as a cutoff for statistical significance. Missing values in were handled using separate categories. All analyses were done with the Stata 12 software system (StataCorp L. P., College Station, TX, USA).

RESULTS

Demographic and clinical characteristics
In total, the sample size was realized as 165 participants who met the inclusion criteria. The mean age was 8 ± 4 years, and 79% (131/165) were boys. Table 1 displays the clinical characteristics of the sample. The majority (81%, 133/165) arrived at the ED with a private vehicle, and half (50%, 84/165) of the sample had lower limb injuries. The mean ISS score at presentation was 6 ± 7, and the mean Glasgow Coma Score was 13.8 ± 2. The mortality rate was 3% (5/165) on arrival or postadmission. A fall was the most prevalent cause of injury (28%, 46/165), followed by a collision and being hit by another vehicle (24%, 40/165) and trapped in the metallic chain of the ATV (22%, 36/165). Figure 1 displays the surgical procedures received by the sample. For the group transferred directly to the operation room (OR) after ED admission, the most prevalent type of procedure was fixation/reduction, followed by amputation.

The outcome of all-terrain vehicle trauma
Figure 2 shows the type of injuries for the sample, by age group. The highest proportion had fracture injuries (37%, 61/165), followed by amputations (30%, 50/165). During the follow-up period, 16 patients (10%) were readmitted, 38 patients (23%) were referred, primarily for physiotherapy, and a small proportion (2%, 4/165) had an infection at the injury site. Table 2 compares the characteristics of the amputation and no amputation groups. The majority (86%, 43/50) of the amputation group were aged from 1 to 5 years compared to the no amputation group (P < 0.001). The mean GCS was 13 ± 0.2 for the no amputation group compared to 15 ± 0.2 for the amputation group, the difference was statistically significant (P < 0.05).

The majority (67%, 33/50) of the amputation group had the limb trapped in the metallic chain of the ATV as the mechanism of injury. Table 3 presents the comparison between the groups with and without a fracture. In terms of a fracture injury following an ATV collision, the 10 years and older age group had a higher proportion (37%) than the younger age groups (30%). There was no difference between gender and fracture injury following ATV collisions.
DISCUSSION

The current study presents a single-center overview of the epidemiology of ATV-related accidents in Riyadh in the pediatric population. The findings report that fracture injuries, followed by amputations, were the most prevalent type of injury resulting from ATV accidents. Young children had a high proportion of limb amputations, compared to the older age groups. The most prevalent mechanism of injury for the younger age group was a limb trapped in the metallic chain of the ATV. Traumatic limb amputation in a pediatric age group would have physical and psychological sequelae, which is challenging to manage, especially in this young population.\cite{16,22,23}

Accounting for 39% of all the admitted patients, 1–5-year age group had the highest proportion in the current study. In contrast, international literature reports a low percentage in this age group.\cite{13,24-29} This finding can be explained behavior that may increase the risk of serious injuries in children. From our observation, lack of parental awareness about the danger of an ATV appears to contribute significantly to children riding ATVs as passengers. Similarly, other studies reporting that unsupervised children, under the age of 5 years, who are double riding ATVs, have a greater risk of sustaining major injuries.\cite{7,12,30} These factors are modifiable and preventable but are instrumental in exposing children to extreme danger.\cite{33}

Similar to literature, the most prevalent anatomical site of injury is the lower extremities (50%), followed by head injuries (35%) of the total injuries.\cite{7,32} The SASO emphasizes current legislation, such as wearing a helmet and riding under adult supervision, as an intervention to decrease ATV-related injuries in youth and children.\cite{14} Unfortunately, this important legislation is not implemented. Not wearing a helmet contribute significantly to head injuries;\cite{13,24,33,34} ATV retailers are willing to rent adult-size ATVs to children without providing any safety equipment. Parents are also involved as they do not pay attention to the size of an ATV suitable for the child. Small children riding adult-size ATVs have less control over the ATV, and they are more prone to roll over and get trapped under the vehicle, resulting in a higher rate of lower extremity injuries.\cite{7,8}

In the current study, limb amputation (30%), mostly involving the foot, was the second most prevalent type of injury after fractures (37%). We reported that children in the 1–5-year age group had a significantly higher rate of limb amputations compared to the older age groups.

| Variables                                      | Number of patients involved total number (n=165), n (%) |
|------------------------------------------------|--------------------------------------------------------|
| **Age categories (years)**                      |                                                        |
| 1–5                                           | 64 (39)                                                |
| 6–10                                          | 47 (28)                                                |
| >10                                           | 54 (33)                                                |
| **Gender**                                     |                                                        |
| Male                                           | 131 (79)                                               |
| Female                                         | 34 (21)                                                |
| **Transportation to the emergency department**  |                                                        |
| Ambulance                                      | 32 (19)                                                |
| Private car                                    | 133 (81)                                               |
| **ISS score categories**                       |                                                        |
| 1–8                                           | 120 (73)                                               |
| 9–15                                          | 36 (22)                                                |
| >15                                           | 9 (5)                                                  |
| **Glasgow coma score (mean±SD)**               |                                                        |
|                                                | 13.9±2.7                                               |
| **Length of stay in the emergency department in hours (median, IQR)** | 6.4 (4-11) |
| **Emergency department disposition**           |                                                        |
| ICU                                            | 22 (13)                                                |
| Operation room                                 | 74 (45)                                                |
| Ward                                           | 68 (41)                                                |
| Mortality                                      | 5 (3)                                                  |
| **Type of impact**                             |                                                        |
| Fall                                           | 46 (28)                                                |
| Stuck/trapped in the metallic chains           | 36 (22)                                                |
| Collision/being hit by another vehicle         | 40 (24)                                                |
| Rollover                                       | 34 (21)                                                |
| Missing                                        | 9 (5)                                                  |
| **Anatomical site of injury**                  |                                                        |
| Head and neck                                  | 59 (35)                                                |
| Thoracoabdominal                               | 13 (8)                                                 |
| Upper limb                                     | 9 (5)                                                  |
| Lower limb                                     | 84 (50)                                                |

SD: Standard deviation; IQR: Interquartile range; ICU: Intensive care unit; ISS: Injury severity score
In contrast, Kellum et al. reported limb amputation as a rare finding, only 0.3% of all injury types in the children in their study. \cite{13} Supported by a previous case series, 82% of the amputation group in the current study were not wearing appropriate protective footwear (barefoot, socks only, or sandals), compared to 8% who were wearing shoes. \cite{14} The majority of the amputation group who had a foot amputated had their foot stuck in the exposed chain of the ATV as a mechanism of injury. An amputation is a grievous injury, which requires extensive rehabilitation. The child is affected in several ways: a lengthy hospital stay, morbid disability, and psychological implications. \cite{22,23}

**Strengths and limitations of the study**

This study has several limitations due to its retrospective nature and the use of the trauma registry. Thus we don’t have information on minor injuries and patients who treated and discharged from the ED as the data were limited to injuries resulting in hospitalization. Another limitation is that some important injury predictors during the ATV accident and outcomes after discharge are not

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### Table 2: Comparison of the clinical characteristics of the pediatric population involved in all-terrain vehicle accidents of patients with and without limb amputations following all-terrain vehicle trauma in the trauma registry data during the study period

| Variables                                      | No limb amputations following ATV trauma total number (n = 115), n (%) | Limb amputations following ATV trauma total number (n = 50), n (%) | P*  |
|------------------------------------------------|--------------------------------------------------------------------|-----------------------------------------------------------------|-----|
| Age categories (years)                          |                                                                    |                                                                |     |
| 1-5                                            | 21 (18)                                                            | 43 (86)                                                        | <0.001* |
| 6-10                                           | 42 (36)                                                            | 5 (10)                                                         |     |
| > 10                                           | 52 (45)                                                            | 2 (4)                                                          |     |
| Gender                                         |                                                                    |                                                                |     |
| Male                                           | 94 (81)                                                            | 37 (74)                                                        | 0.259 |
| Female                                         | 21 (18)                                                            | 13 (26)                                                        |     |
| Transportation to the emergency department      |                                                                    |                                                                |     |
| Ambulance                                      | 24 (21)                                                            | 8 (16)                                                         | 0.467 |
| Private car                                    | 91 (79)                                                            | 42 (84)                                                        |     |
| ISS score categories                            |                                                                    |                                                                |     |
| 1-8                                            | 82 (71)                                                            | 38 (76)                                                        | 0.116 |
| 9-15                                           | 24 (21)                                                            | 12 (24)                                                        |     |
| > 15                                           | 9 (8)                                                              | 0                                                              |     |
| Glasgow coma score                             | 13 (0.3)                                                           | 15 (0.2)                                                       | 0.002* |
| Length of stay in the emergency department (h)  | 7 (4-13)                                                           | 5 (3-8)                                                        | 0.027* |
| Mechanism of injury                            |                                                                    |                                                                |     |
| Fall                                           | 41 (38)                                                            | 5 (10)                                                         | <0.001* |
| Stuck/trapped in the metallic chains            | 3 (2)                                                              | 33 (67)                                                        |     |
| Collision/being hit by another vehicle         | 30 (28)                                                            | 10 (21)                                                        |     |
| Rollover                                       | 33 (28)                                                            | 1 (2)                                                          |     |
| Missing/unknown                                | 8 (7)                                                              | 1 (2)                                                          |     |

*significant P values (<0.05). The p-value were obtained using Chi square tests or Fisher’s exact tests (for numbers less than five in each group). For continuous variable P value were obtained using y-test or The Mann Whitney U-test

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### Table 3: Comparison of the clinical characteristics of the pediatric population involved in all-terrain vehicle accidents between patients with and without fractures following all-terrain vehicle trauma in the trauma registry data during the study period

| Variables                                      | Patients without fractures following ATV trauma total number (n = 115), n (%) | Patients with fractures following ATV trauma total number (n = 61), n (%) | P*  |
|------------------------------------------------|-----------------------------------------------------------------------------|-------------------------------------------------------------------------|-----|
| Age categories (years)                          |                                                                            |                                                                         |     |
| 1-5                                            | 44 (42)                                                                    | 20 (32)                                                                | 0.441 |
| 6-10                                           | 29 (28)                                                                    | 18 (29)                                                                |     |
| > 10                                           | 31 (30)                                                                    | 23 (37)                                                                |     |
| Gender                                         |                                                                            |                                                                         |     |
| Male                                           | 82 (79)                                                                    | 49 (80)                                                                | 0.820 |
| Female                                         | 22 (21)                                                                    | 12 (20)                                                                |     |
| Transportation to the emergency department      |                                                                            |                                                                         |     |
| Ambulance                                      | 22 (21)                                                                    | 10 (16)                                                                | 0.455 |
| Private car                                    | 82 (78)                                                                    | 51 (83)                                                                |     |
| ISS score categories                            |                                                                            |                                                                         |     |
| 1-8                                            | 70 (67)                                                                    | 50 (82)                                                                | 0.019* |
| 9-15                                           | 25 (24)                                                                    | 11 (18)                                                                |     |
| > 15                                           | 9 (10)                                                                     | 0                                                                      |     |
| Glasgow coma score                             | 13 (3.3)                                                                   | 14 (1.4)                                                               | 0.024* |
| Length of stay in emergency department (h)     | 5 (3-10)                                                                   | 7 (6-12)                                                               | 0.067 |
| Mechanism of injury                            |                                                                            |                                                                         |     |
| Fall                                           | 28 (17)                                                                    | 18 (29)                                                                | 0.001* |
| Stuck/trapped in the metallic chains            | 22 (21)                                                                    | 14 (23)                                                                |     |
| Collision/being hit by another vehicle         | 31 (29)                                                                    | 18 (30)                                                                |     |
| Rollover                                       | 23 (22)                                                                    | 11 (18)                                                                |     |

*P values were obtained using Chi-square tests or Fisher’s exact tests (for numbers less than five in each group). For continuous variable P value were obtained using y-test or The Mann-Whitney U-test. P < 0.05 was considered as significant. ISS: Injury severity score.
reported in the trauma registry. To overcome the limitation, the medical records were reviewed to obtain additional data. However, data related to injury prevention, such as wearing a helmet and being a passenger or driver, could not be obtained as it is not documented in the trauma registry or the medical records. Finally, some recent data may have been missed due to the transfer of the pediatric ED to a separate institution. The trauma registry did not capture a number of pediatric trauma admissions during the transfer. Despite the limitations, the study provides evidence regarding the adverse outcomes resulting from ATV accidents. Public governance should enforce the regulations related to the presence of ATV activity in many leisure areas in Saudi Arabia.

CONCLUSION

As the popularity of ATVs increases, the prevalence of injuries and death increases. Children, as young operators or passengers of ATVs, frequently sustain more severe injuries compared to adults. In our study, lower extremities were frequently injured, specifically fractured (37%) or amputated (30%). A noteworthy finding in the current study is that 86% of the amputations occurred in the 1–5-year age group. Despite the existing SASO legislation for ATV use in children and adults, they are not implemented or enforced. There is a need for a strict review of the situation and the urgent implementation of these regulations for both ATV retailers and users. It is pivotal to increase public awareness regarding the engagement in high-risk riding behavior and encourage the use of safety equipment. The current study provides a baseline for additional research to highlight the risk and lifelong consequences to the pediatric population.

Research quality and ethics statement

This study was approved by the Institutional Review Board / Ethics Committee at King Abdullah International Medical Research Center (Approval # RYD-19-419812-73246; Approval date May 6, 2019). The authors followed the applicable EQUATOR Network (http://www.equator-network.org/) guidelines, specifically the Strobe Guidelines, during the conduct of this research project.

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Conflicts of interest

There are no conflicts of interest.

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