

Original Article

Golf cart-related neurosurgical injuries

Annelisse Torres-Urquia, Orlando De Jesus

Department of Surgery, Section of Neurosurgery, University of Puerto Rico, San Juan, Puerto Rico, United States.

E-mail: Annelisse Torres-Urquia - annelisse.torres@upr.edu; *Orlando De Jesus - drodejesus@aol.com

*Corresponding author:

Orlando De Jesus,
Department of Surgery, Section
of Neurosurgery, University of
Puerto Rico, San Juan, Puerto
Rico, United States.

drodejesus@aol.com

Received: 14 March 2024

Accepted: 06 June 2024

Published: 28 June 2024

DOI

10.25259/SNI_185_2024

Quick Response Code:



ABSTRACT

Background: Head and spine injuries sustained following golf cart accidents have been rarely analyzed. This study aimed to describe a series of patients sustaining golf cart injuries requiring neurosurgical management for head or spine injuries.

Methods: The University of Puerto Rico Neurosurgery database was used to retrospectively identify and investigate patients who sustained a golf cart-related injury requiring a neurosurgical evaluation during 15 years.

Results: The analysis identified 25 patients with golf cart-related injuries requiring neurosurgical management with a median age of 16 (interquartile range 13–34). Seventeen patients (68%) were female. The primary mechanism of injury was ejection from the cart in 84% of the patients ($n = 21$). The most frequent head injury was a skull fracture in 80% of patients ($n = 20$). Intracranial hemorrhage was present in 76% of patients ($n = 19$), with brain contusions ($n = 16$, 64%) being the most common. Eighteen patients (72%) were admitted for surgery or neurological monitoring. The median hospital length of stay among hospitalized patients was 5.5 days. Ten patients (40%) were admitted to the intensive care unit (ICU) with a median stay of 8.5 days. Four patients (16%) required surgery for their injuries. At discharge, 80% of patients ($n = 20$) had a good outcome.

Conclusion: This study showed that children and adolescents are at high risk for golf cart-related neurosurgical injuries. This form of transportation can produce considerable neurological injuries, the primary mechanism of injury being ejection from the cart. Approximately three-quarters of the patients need hospital admission, with half requiring an ICU stay.

Keywords: Golf cart, Neurosurgery, Pediatric, Traumatic brain injury

INTRODUCTION

The use of golf carts has expanded in the past decades from its classic use on golf courses to an everyday mode of transportation in resorts, gated communities, and even open roads. This augmented use has increased the incidence of golf cart-related injuries.^[8,11,12] Most patients involved in a golf cart-related accident experience mild traumatic bruises, lacerations, long bone fractures, and simple skull fractures; however, significant spinal and brain injuries can occur.^[3,4,7,8] Some patients with severe brain injury or spinal fractures require urgent surgical intervention. Injuries can result from cart ejection, a cart overturned, or being struck by a cart.^[3,12] It has been reported that approximately two-thirds of golf cart-related hospitalizations are secondary to head or neck injuries.^[3] Brain injuries are more prominent among children, who are more susceptible to developing traumatic brain injuries (TBIs) than adults.^[3] The presence of a TBI or an abdominal injury in a child is associated with prolonged hospitalization.^[3,5,12] This predisposition in children

establishes the importance of monitoring the prevalence of golf cart accidents in this population.^[3,5,12]

Head and spine injuries sustained by golf cart accidents are usually underreported, as only patients requiring management at an emergency department (ED) are included in the reports. This study aimed to describe and analyze a series of patients sustaining golf cart injuries requiring neurosurgical management for head or spine injuries.

MATERIALS AND METHODS

The University of Puerto Rico Neurosurgery database, which has been stored daily in Excel software since 2004, was used to identify patients who sustained a golf cart-related injury requiring a neurosurgical evaluation during 15 years from July 1, 2008, to June 30, 2023. The database was queried in August 2023 to retrieve information for the study. All patients who sustained a golf cart-related injury requiring a neurosurgical evaluation were included in the study. No patients were excluded from the study. For each identified patient, basic demographics were collected, including age and gender. In addition, the following variables were investigated: mechanism of injury (ejection, rollover, and pedestrian), injuries received, Glasgow coma scale (GCS) score at arrival, days of hospitalization, days at the intensive care unit (ICU), surgery performed, and outcome on discharge using the modified Rankin scale (mRS) score. A good outcome was defined as a mRS score of 0–3. Descriptive statistics were used to report frequency, median value, and interquartile range (IQR). This study was reviewed and approved by the Institutional Review Board of the participating institution (protocol 2308131225). Due to the study's retrospective nature, informed consent was not required.

RESULTS

The retrospective analysis identified 25 patients with golf cart-related injuries requiring neurosurgical management during the 15 years from July 1, 2008, to June 30, 2023. Their ages ranged from 4 to 69, with a median age of 16 (IQR = 13–34) [Table 1]. Seventeen patients (68%) were female. The primary mechanism of injury was ejection from the cart in 84% of the patients ($n = 21$), followed by a rollover in 8% ($n = 2$), and being hit by a cart as a pedestrian in 8% ($n = 2$). Forty percent ($n = 10$) of the accidents occurred in the 11–20 age group [Figure 1]. The most frequent injury was a skull fracture in 80% of patients ($n = 20$) [Table 2]. An intracranial hemorrhage occurred in 76% of patients ($n = 19$). Brain contusions (64%, $n = 16$) were the most frequent finding among intracranial hemorrhages. One patient had a contusion at the cerebellar hemisphere. An acute subdural hematoma occurred in 44% of the patients ($n = 11$). At the initial neurosurgical evaluation, the GCS

Table 1: Patient demographics and characteristics ($n=25$).

Variable	<i>n</i> (%)
Gender	
Female	17 (68)
Male	8 (32)
Age	
0–18	14 (56)
>18	11 (44)
Mechanism of injury	
Ejection	21 (84)
Rollover	2 (8)
Pedestrian	2 (8)

Table 2: Distribution of all golf cart-related neurosurgical injuries, with most patients presenting multiple injuries.

Type of injury	%
Skull fracture	80
Brain contusion	64
Acute subdural hematoma	44
Subarachnoid hemorrhage	20
Otorrhea	20
Epidural hematoma	12
Vertebral fracture	4
Pneumocephalus	4
Scalp hematoma	4

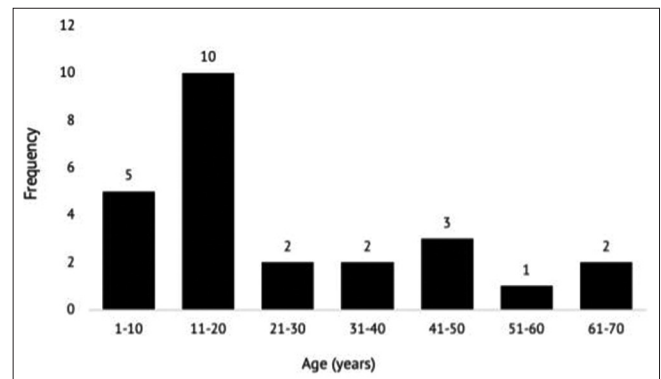


Figure 1: Age distribution among patients sustaining golf cart neurosurgical injuries.

score varied from 4 to 15 with a median of 14 (IQR 12–15). Eight percentages of the patients had a GCS of 3–8, 24% had a GCS of 9–12, and 68% had a GCS of 13–15.

Eighteen patients (72%) were admitted for surgery or neurological monitoring, while 7 (28%) were discharged from the ED after being observed for 1 day. The median hospital length of stay among admitted patients was 5.5 days (IQR 3–16; range 2–40). Ten patients (40%) were admitted to the ICU with a median stay of 8.5 days (IQR 4–14; range 1–23). Four patients (16%) required surgery for their

injuries. Among them, two had a decompressive craniectomy and were readmitted a few months later for a cranioplasty. At discharge, 80% of patients ($n = 20$) had a good outcome. Among the patients with poor outcomes, one died. Surgery was not performed on this patient due to the catastrophic nature of the injuries on arrival.

Three patients (12%) returned to the ED for reevaluation. One patient showed worsening symptoms and required surgery for an expanding subacute subdural hematoma. The other two patients developed post-traumatic seizures that were controlled with oral medications at the ED and did not require admission. One of the patients experienced seizures 1 week after discharge, while the other experienced them 3 months later.

DISCUSSION

Most golf cart accidents occur on golf courses; however, some occur in resorts, residential areas, or farms.^[2-4,12] Our study focused on neurosurgical injuries following golf cart accidents. We found that ejection from the cart was the primary mechanism of injury among the 25 patients. More than half of the accidents involved children and adolescents, with predominance in the 11–20 age groups. Golf cart-related injuries after being ejected from a golf cart have been reported to occur in 38–80% of the patients.^[2,3,12] National studies have demonstrated that ejection from a golf cart is the most frequent cause of injury in adults and children.^[3,12] Our cohort's most frequent mechanism of injury in our sample was consistent with these prior studies. Researchers have thought that the increased rate of ejections is secondary to the vehicle's design.^[5] Golf carts lack seatbelts, and the hip restraints are not large enough to prevent passengers from falling off. In addition, hip restraints can increase head injuries by acting as a pivot, causing the head to crash first into the ground when the passenger is ejected over the hip restraint. Moreover, most children sit forward while riding as a passenger, and the hip restraints do not provide any protection. Children are almost 1½ times more likely to be injured after being ejected than patients of all other ages.^[3] It has been noted that ejected patients are more likely to sustain an injury to the head or neck than patients injured by all other mechanisms.^[3] Compared to adults, golf cart-related head and neck injuries involving children occur more frequently at homes, farms, or on the road.^[3,5,10,12] Adults are more likely to be injured at a sports or recreational facility.^[3,12]

Recently, Horvath *et al.* documented an increase in head and neck injuries after a golf cart accident, demonstrating that they were the most frequent body location for injuries.^[3] This increase in head and neck injuries could be explained by the development of faster carts and the augmented use by the pediatric population, factors associated with accidents secondary to ejection from the cart.^[5] It has been shown that

in several pediatric cases, the accident occurred while the child was driving the golf cart.^[5]

Simpson *et al.* found that most patients with a golf cart-related injury sustained mild TBIs with good outcomes, which they ascribe to the low speed of the cart.^[8] In our study, skull fractures (80%) were the most frequent type of injury, closely followed by intracranial hematomas (subdural, contusions, subarachnoid, and epidural hemorrhages). Our results are consistent with previous studies, which have shown that the most frequent intracranial injuries include skull fractures, contusions, subdural hematomas, and subarachnoid hemorrhages.^[4,8] Golf cart-related TBIs in children are 2–3 times more frequent than in adults.^[3,5] In the pediatric population, slightly over half of the injuries occurred while riding as a passenger.^[10,11] Tracy *et al.* demonstrate that skull fractures were more frequent in younger children, while orthopedic injuries were more frequent in older children.^[11] Compared to adults, head-and-neck injuries in children are more frequent after being ejected from the cart.^[3,5,12] Leg and foot injuries are more common in adults while getting out of the cart or after being struck by the cart compared to those injuries in children.^[3,12] Passaro *et al.* found that in a non-golf course setting, more than half of the injured individuals were ejected from a golf cart.^[6] They also noted that 40% of injured adults were known to have been drinking alcohol before the accident.^[6] The influence of alcohol could not be analyzed for our study as most adult patients did not have laboratory values for alcohol levels.

In their analysis, Simpson *et al.* reported that 87% of patients had a good outcome at discharge.^[8] In our investigation, 80% of patients had a good outcome. In the study by Simpson *et al.*, the mean presenting GCS score was 13, with only one patient (4%) developing a seizure disorder.^[8] Our patient's initial median GCS score was 14. Two patients (8%) in our cohort developed post-traumatic seizures. One patient experienced early seizures, while the other experienced late seizures.

The incidence of golf cart accidents in Puerto Rico is unknown as no investigations have been previously done. These accidents do not have to be reported to the police or the transportation department. Contrasting the results of golf-cart accidents noted in our cohort with comparable accident-type scenarios in which a cabin does not protect, the occupant may provide helpful information. However, few reports exist in Puerto Rico of comparable transport such as an all-terrain vehicle (ATV), motorcycle, or bicycle. In the study by Acosta and Rodriguez, motorcycle accidents occurred twice as frequently as ATV accidents.^[11] They found that the number of patients younger than 17 years involved in ATV accidents was significantly higher than in motorcycle accidents. The percentage of patients with head injuries after ATV accidents was significantly higher compared to

motorcycles. For ATV accidents, half of the injuries involved the head region. The 20% mortality secondary to ATV accidents was slightly higher than for motorcycle accidents; however, there was no statistical significance.^[1] Although golf cart accidents may resemble ATV accidents because they involve a younger population and have an elevated frequency of head injuries, they are much rare, with less morbidity.

Individuals must develop more awareness of the injuries that can be sustained while riding golf carts. Community safety guidelines must be implemented to reduce the incidence of these injuries. Several authors have suggested rigorous safety regulations during golf cart driving, including a stricter minimum legal age for adolescents or children operating the cart to reduce the number of inexperienced operators.^[3-5,7]

⁰¹ In our study, a substantial number of injuries occurred in children; for this reason, we agree with the previous authors' recommendations. Golf carts are not prepared for the secure transportation of children, and their use for transporting children should be dissuaded. Children and adolescents without a driver's license should not operate a golf cart. Adult drivers transporting children should operate golf carts at low speeds, braking slowly and avoiding sharp turns to reduce the risk of passenger ejection. The use of rear-facing cart seats should be banned in children and adolescents as they are associated with high rates of passenger ejection. Golf carts used for transportation in resorts, gated communities, and open roads should include seat belt safety equipment as they effectively reduce ejection from the cart.

Limitations

This study contains several limitations. First, the study design was retrospective and observational, which may be subject to bias or errors. Second, the institution where the study was performed is a trauma level I hospital; therefore, only those cases with major trauma involving a golf cart accident were referred to. Finally, the study involved the population of Puerto Rico, which may limit the generalizability of the findings to other populations or countries where golf cart use varies and may impact the incidence of golf cart accidents.

CONCLUSION

This study showed that children and adolescents in our population are at high risk for golf cart-related neurosurgical injuries. This form of transportation can produce considerable neurological injuries, the primary mechanism of injury being ejection from the cart. Approximately three-quarters of the patients need hospital admission, with half requiring an ICU stay. However, the outcome in most patients is good.

Ethical approval

The research/study was approved by the Institutional Review Board at the University of Puerto Rico Medical Sciences Campus, number 2308131225, dated August 31, 2023.

Declaration of patient consent

Patients' consent not required as patients' identities were not disclosed or compromised.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

Use of artificial intelligence (AI)-assisted technology for manuscript preparation

The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

REFERENCES

1. Acosta JA, Rodríguez P. Morbidity associated with four-wheel all-terrain vehicles and comparison with that of motorcycles. *J Trauma* 2003;55:282-4.
2. Gibson K, Stevens TJ, Krause MA. Adult golf cart injuries: A rising hazard off the course. *Traffic Inj Prev* 2023;24:352-5.
3. Horvath KZ, McAdams RJ, Roberts KJ, Zhu M, McKenzie LB. Fun ride or risky transport: Golf cart-related injuries treated in U.S. emergency departments from 2007 through 2017. *J Safety Res* 2020;75:1-7.
4. McGwin G Jr., Zoghby JT, Griffin R, Rue LW 3rd. Incidence of golf cart-related injury in the United States. *J Trauma* 2008;64:1562-6.
5. Miller B, Yelverton E, Monico J, Replogle W, Jordan JR. Pediatric head and neck injuries due to golf cart trauma. *Int J Pediatr Otorhinolaryngol* 2016;88:38-41.
6. Passaro KT, Cole TB, Morris PD, Matthews DL Jr., MacKenzie WR. Golf cart related injuries in a North Carolina island community, 1992-4. *Inj Prev* 1996;2:124-5.
7. Rahimi SY, Singh H, Yeh DJ, Shaver EG, Flannery AM, Lee MR. Golf-associated head injury in the pediatric population: A common sports injury. *J Neurosurg* 2005;102:163-6.
8. Simpson B, Shepard S, Kitagawa R. Golf cart associated traumatic brain injury. *Brain Inj* 2019;33:1476-8.
9. Smith RA, Ling S, Alexander FW. Golf related head injuries in children. *BMJ* 1991;302:1505-6.
10. Starnes JR, Unni P, Fathy CA, Harms KA, Payne SR, Chung

- DH. Characterization of pediatric golf cart injuries to guide injury prevention efforts. *Am J Emerg Med* 2018;36:1049-52.
11. Tracy BM, Miller K, Thompson A, Cooke-Barber J, Bloodworth P, Clayton E, *et al.* Pediatric golf cart trauma: Not par for the course. *J Pediatr Surg* 2020;55:451-5.
12. Watson DS, Mehan TJ, Smith GA, McKenzie LB. Golf cart-related injuries in the U.S. *Am J Prev Med* 2008;35:55-9.

How to cite this article: Torres-Urquia A, De Jesus O. Golf cart-related neurosurgical injuries. *Surg Neurol Int.* 2024;15:222. doi: 10.25259/SNI_185_2024

Disclaimer

The views and opinions expressed in this article are those of the authors and do not necessarily reflect the official policy or position of the Journal or its management. The information contained in this article should not be considered to be medical advice; patients should consult their own physicians for advice as to their specific medical needs.