original article

The role of seating position in determining the injury pattern among unrestrained children involved in motor vehicle collisions presenting to a level I trauma center

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BACKGROUND AND OBJECTIVES: Seating position in motor vehicle collisions (MVC) plays a major role in determining the injury pattern in mainly restrained children. However, compliance with child seating and restraint laws is still suboptimal. The role of seating position in predicting injury patterns among unrestrained children has not been previously studied.

DESIGN AND SETTING: Retrospective review based on the trauma registry of a level I trauma center in Riyadh, Saudi Arabia. Data collection was restricted to unrestrained children involved in MVC.

PATIENTS AND METHODS: Between July 2001 and March 2010, 274 records were identified. Detailed information about the collision, child seating position and the use of restraints was cross-verified using parental phone interviews.

RESULTS: Of the 274 identified records, cross-verification was possible for 89 (32.4%) unrestrained children, 64 boys and 25 girls, with a mean (SD) age of 83 (40) months. Of these children, 41 (46.1%) were front seated (FS), and 48 (53.9%) were back seated (BS). There were higher rates of rollover (52.1% vs 24.4%, *P*=.02), ejection (41.7% vs 22%, *P*=.05), and occupant death ratio (14.8 vs 4, *P*=.04) among BS children. However, the two groups did not differ in pediatric trauma scores, Glascow coma scale score, or age distribution. FS children were more likely to present with isolated head, neck or facial injuries (HNFI) (51.2% vs 25%, *P*=.01), whereas BS children were more likely to suffer long bone or pelvic fractures (LPF) (60.4% vs 36.6%, *P*=.025).

CONCLUSION: Injury pattern can vary according to seating position among unrestrained children presenting at trauma centers after MVC. While FS children are more likely to present with HNFI, BS children more often sustain LPF. BS children had similar trauma severity compared with FS children despite the higher-impact nature of their MVCs. While highlighting the value of proper restraints use and seating position, these results can be valuable in the initial assessment of traumatized children involved in MVC.

Guidelines and legislation for child restraint systems and child seating position have significantly minimized the incidence of injuries among children involved in motor vehicle collisions (MVC).[1-3] Current worldwide standards recommend rear seating for all children younger than 13 years, regardless of the child restraint system used.[1] However, compliance remains suboptimal in many developing countries where such legislation does not exist or is weakly implemented.[4-6] Even in developed traffic systems, compliance with these recommendations can vary widely across different ages[7] and ethnic groups.[8]

The nonuse of restraints is very common among those who are referred to a trauma center and those who die or are badly injured in MVCs. In 2008, the US National Highway Traffic Safety Administration reported that 23% of all children younger than 14 years involved in MVCs were unrestrained. And of those

who died, 46% were unrestrained.[9] Similarly, compared with back-seated (BS) children, front-seated (FS) children are at a higher risk of injury[10,11], which tends to be more severe[12] and leads to higher fatality.[13] Despite the advances in automotive safety features, seating position continues to play an important role in determining the risk of injury to children.[10] Moreover, the introduction of the passenger airbag toward the end of the last century had a significant impact on the variations in injury patterns between FS and BS passengers,[14] particularly for younger children who are susceptible to indirect trauma caused by rapid airbag deployment.[15-17] While there is sufficient evidence supporting the protective effect of rear seating for both adults and children, the difference in injury patterns for children involved in MVC based on their seating position has not been previously studied, particularly among unrestrained children who are at the highest risk of injury and are therefore more likely to present to trauma centers.

PATIENTS AND METHODS

After obtaining the necessary institutional review board approval, data for all unrestrained children younger than 13 years of age involved in MVCs between 2001 and 2010 were retrospectively collected from a level I trauma center registry. The registry is a prospectively recorded database of all trauma patients admitted to the center and has an internal auditing process to ensure data integrity. The selected ages represent the recommended group for rear seating.[9] Detailed information about the nature of the collisions, the child seating position and the use of restraints was cross-verified using standardized parental phone interviews. The interview included questions about the nature of the MVC, whether it involved rollover or child ejection, the child seating position, restraint use, total number of occupants, and the number of deaths among occupants. Only those children whose information could be cross-verified by phone interview were included. Children were assigned to either the FS or BS group based on their seating position during the MVC. Trauma was grouped into two main patterns: a pattern of isolated head, neck or facial injuries (HNFIs), which included children with documented injury that was confined to the brain, cervical spine injury or facial fractures, and a pattern of pelvic or long bone injury (LPF), which included patients with documented fractures of the pelvis, upper or lower extremities with or without HNFIs. The severity of the MVC impact was indirectly predicted by crash features, such as vehicle rollover, patient ejection, and the occupant death rate (ODR). ODR is the percentage of deaths among the total number of occupants at the time of the MVC. A chi-square test was used to analyze categorical data, and a *t* test was used for continuous variable analysis. *P* values <.05 were considered significant.

RESULTS

Of the 274 identified unrestrainted children, cross-verification was possible in 89 of the cases. The group included 64 boys and 25 girls, with a mean (SD) age of 83 (40) months. Of these children, 41 (46.1%) were FS and 48 (53.9%) were BS. Boys were more likely to be FS than girls (54.7% vs. 24%, *P*=.009). There were higher rates of rollover 25 (52.1%) vs. 10 (24.4%) (*P*=.02), ejection 17 (41.7%) vs. 10 (21%), P=.05, and ODR (14.8% vs. 4%, *P*=.04) among BS children. However, FS and BS children did not differ in their mean pediatric trauma scores, 9.9 (2.3) vs. 10.1 (1.9), *P*=.7, Glascow coma scale scores, 13 (3.4) vs. 13 (3.4), *P*=.9, or age distribution 74.2 (41.7) vs. 90.4 (37.8) months, *P*=.06. Although the list of injuries did not show a major difference (**Table 1**), analysis of the injury pattern groups revealed a significant difference (**Table 2**). After a relatively lower-impact MVC, FS children were more likely to sustain injuries limited to the head, neck or face without other associated injuries 21 (51.2%) vs. 12 (25%), *P*=.01, whereas BS children were likely to present with multiple injuries that included LPF, 29 (60.4%) vs 15 (36.6%) (*P*=.025).

DISCUSSION

According to a WHO report published in 2004, road traffic injury is the second leading cause of death among children worldwide and is responsible for more than 130 000 deaths per year for children aged 5-14

Table 1. Injury distribution based on seating position.

Injury list	Back seat (n=48)	Front seat (n=41)
Traumatic brain injury	23 (47.9)	24 (58.5)
Pelvic fracture	6 (12.5)	1 (2.4)
Facial fracture	8 (16.7)	2 (4.9)
Chest trauma	8 (16.7)	4 (9.8)
Abdominal trauma	6 (12.5)	8 (19.5)
Upper extremities fracture	12 (25)	8 (19.5)
Lower extremities fracture	13 (27.1)	7 (17.1)
C-spine injury	3 (6.3)	3 (7.3)

Values are n (%).

Table 2. Crash characteristics and injury pattern.

	Back seat (n=48)	Front seat (n=41)	*P*
Crash Characteristics			
Rollover	25 (52.1)	10 (24.4)	.02
Ejection	17 (41.5)	10 (21)	.05
Occupant death ratio	14.8%	4%	.04
Injury pattern			
Isolated HNFI	12 (25)	21 (51.2)	.01
LPF	29 (60.4)	15 (36.6)	.025

Values are n (%).

HNFI: head, neck or facial injuries), LPF: long bones or pelvic fractures) with or without HNFI.

years.[18] In developed countries, injury is the principal cause of death among children, and transport-related injuries account for almost 41% of these deaths.[19] Unrestrained children are the most vulnerable to injury and death, and both front seating and the nonuse of child restraints are very frequent among those killed in MVCs.[9,20] Furthermore, FS and unrestrained children are at higher risk of more severe injuries, longer hospitalization and higher costs of trauma care compared to properly seated and restrained children.[21]

Unfortunately, restraint use among children still varies worldwide. In the United States, between 84% and 87% of children use proper restraint systems.[22] The reported rate of restraint use is significantly lower in less-developed countries, such as Oman (3.7%),[23] Nigeria (0.7%)[6] and Malaysia (0.6%).[5] Compliance with seating position guidelines is another persistent problem. In 2008, 94% of children under the age of 8 years and 99% of those under the age of 1 year sat in the rear seat in the US.[22] However, in a recent US survey, Greenspan et al[24] estimated that more than one million children rode in the front seat some of the time during the previous 30 days. In other countries, a larger proportion, up to 34.6% of children under 5 years old, were seated in the front.[23] Among our group of injured patients, nearly half (46.1%) were seated in the front. Considering the relatively large number of unrestrained children and persistent variations in seating position worldwide, particularly among injured children, analyzing injury patterns for this population based on seating position could be of a significant value to trauma care providers.

Another important determinant of injury rate, severity and fatality is the type of crash impact. Ejection and occupant death are among the high-risk auto crash criteria published by the Center for Disease Control (CDC) in their field triage decision scheme to assess injury severity during prehospital triage.[25] In a mainly restrained child population, ejection and rollover are rare. However, fatalities are frequent among those who are ejected (29%) or are involved in rollovers (28%).[26] While rollover can be considered as another crash criterion that is associated with increased injury severity,[27] it is not clear whether the increased injury severity is an independent factor or is related to rollover.[25] Unlike the findings of most published studies, our cohort of BS children sustained injury severities similar to FS children, despite the higher-impact nature of their crashes, as evidenced by the high rates of ejection, rollover, and ODR. This finding can be explained by the variation in data sources. While most reports of the role of seating position in MVC injuries are more like a population-based analysis, data based on a trauma center registry tend to be selective and follow the center's preset referral criteria for injured children. We expect that, unlike BS children, FS children who sustained higher impact MVC might have either died at the scene or been referred to the nearest non-trauma center with severe brain injury. In both cases they are less likely to be good candidates for further management at level I trauma centers. In 1995, a CDC report described 8 deaths of child occupants involving airbag deployment that were of special concern because they involved low-speed crashes, in which the children otherwise should have survived.[28] Due to the protective nature of back seating, unrestrained BS children involved in higher-impact MVC are likely to survive[13] and because they are less likely to sustain severe TBI relative to other injuries, they are considered better candidates for trauma center transfer and are therefore likely to be included in the center's trauma registry.

This phenomenon can also partially explain the variation in injury patterns. However, this difference can be better attributed to the presence of passenger airbags. It is known that rapid airbag deployment is very traumatic and can be lethal for young children, even at minor impact force. This fact explains the similar pediatric trauma and Glascow coma scales scores between the two groups despite the relatively higher MVC impact among BS children. Prior to the wide implementation of airbags, Mucci et al[29] reported similar injury patterns between FS and BS individuals. However, the introduction of airbags caused a major shift in the pattern and rate of injuries among FS occupants, particularly younger children. In 1997, Braver et al[30] demonstrated that airbags were generally protective for FS, unrestrained passengers, leading to a 23% fatality reduction. However, among FS children

younger than 10 years, airbags were responsible for a 34% increase in the risk of death in frontal crashes. Similarly, in their study of FS children, Quinones-Hinojosa et al[31] reported that head injuries were the most frequent injury associated with airbag deployment, followed by spinal injuries. Similarly, a higher incidence of facial and C-spine injuries among front-seated and inappropriately restrained children has been reported by others.[16,17]

Despite the improvement in implementing seating position and child restraints system guidelines, limiting the study to unrestrained children population is relevant particularly from a specialized trauma center perspective as unrestrained children represent the larger proportion of referred children. In 2007, Rangel et al[32] reported that in a group of 1268 patients who presented at a level I trauma center, 44.8% were restrained, and only 20.3% were properly restrained. Moreover, the identification of possible injury patterns based on seating position could help trauma care providers to perform the necessary radiological evaluation that would minimize the rate of missed injuries. Soundappan et al[33] estimated that missed injuries, particularly skeletal injuries, in children occur in up to 16% of patients admitted to trauma centers, mainly after MVC.

Although there are controversies concerning the validity of self reported injury data,[34,35] cross verification of some MVC data particularly seating patterns and occupants death of restraints use via phone interview is often necessary.[11] These data, unlike the injuries, are not always clearly documented in registries. Another limitation is the relatively small sample size which is a consequence of our very specific inclusion criteria. Although larger sample size is preferable, our *P* values in the difference in injury patterns are remarkably smaller than .05 making type II errors less likely.

In conclusion, among the unrestrained population presenting at trauma centers, FS children may sustain significant injuries to the head, face and neck after a relatively minor impact MVC. However, because of the protective role of back seating, BS children are more likely to present to trauma centers after a relatively higher impact MVC with widely distributed injuries that frequently involve the long bones and pelvis. These results can be utilized in identifying the possible injuries based on the seating pattern among unrestrained children presenting to trauma centers.

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