

# Incidence of Pediatric Cervical Spine Injuries in Iraq and Afghanistan

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**Objective:** Military providers frequently treat civilians, including pediatric patients. Cervical spine injuries in pediatric trauma patients occur infrequently, with limited data on the incidence. The aim of this study was to describe the incidence of cervical spine injuries in pediatric patients in Iraq and Afghanistan.

**Methods:** We queried the Department of Defense Trauma Registry for all pediatric encounters from January 2007 to January 2016. We searched within that dataset for all cervical spine fractures.

**Results:** From January 2007 through January 2016 there were 3439 pediatric encounters. There were 36 subjects identified (1.0%) with a cervical spine fracture. Of those with a cervical spine fracture, 6 (17%) had a prehospital cervical collar placed, which did not improve survival to hospital discharge (collar, 66.7% vs no collar, 83.3%,  $P = 0.573$ ). Of those with a cervical spine fracture, 6 (17%) had a documented spinal cord injury. The median age of subjects with a cervical spine fracture was 9.5 years and the majority (63.9%) were male. Most were injured by explosion (41.7%). The median composite injury score was higher in subjects with a cervical spine fracture compared with those without one (16.5 vs 10,  $P < 0.001$ ). Subjects with a cervical spine fracture had longer lengths of stay in the intensive care unit (median 3 days vs 1,  $P = 0.012$ ) and a trend toward worse survival to hospital discharge (80.6%,  $n = 29$ , vs 90.3%,  $n = 3074$ ,  $P = 0.079$ ).

**Conclusions:** Cervical spine injuries occurred infrequently in pediatric patients in Iraq and Afghanistan. When a fracture was present, almost

one in five patients had spinal cord involvement. The pediatric prehospital literature would benefit from the development of a clinical decision tool to guide prehospital personnel as to when a cervical collar is indicated. Moreover, appropriate size equipment should be available when caring for host national civilians.

**Key Words:** cervical, fracture, pediatric, spine, trauma

Military medical providers frequently are required to treat children in Iraq and Afghanistan based on the medical rules of eligibility.<sup>1</sup> The medical rules of eligibility throughout the theaters of war varied both in time frame of conflict and location, with Afghanistan generally featuring a more liberal use of US resources. Children made up 5% to 15% of all admissions to combat support hospitals. When admitted, their lengths of stay are frequently longer and more complicated.<sup>2</sup> The longer stays often are the result of challenges in transferring children to their local health systems, which is in contrast to the US and Coalition service members, who are rapidly transported out of the combat theater.

The pediatric population has a combination of anatomic, physiologic, metabolic, and psychological differences that require different approaches to treatment compared with adults with similar injuries. In addition, pediatric patients may experience different responses to treatment than do their adult counterparts.<sup>3</sup> Because of the smaller size of a child, the force of a trauma is more widely dispersed throughout his or her body.<sup>4,5</sup> The larger surface area of the child's body relative to his or her weight gives him or her a predilection toward substantial heat loss and other potential adverse effects.<sup>4</sup> In addition, pediatric treatment can be challenging because of a child's ability to metabolize some medications differently than do adults.<sup>6,7</sup>

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## Key Points

- Children made up 5% to 15% of all admissions to combat support hospitals, with their lengths of stay frequently being longer and more complicated than those of adults.
- Spinal cord injury exists in only 1% to 2% of pediatric trauma patients, with cervical spine injuries representing 60% to 80% of all pediatric vertebral injuries.
- Identifying the incidence of pediatric cervical spine injuries in theater could direct further training for medical care providers.

Previous studies report that spinal cord injury occurs in only 1% to 2% of pediatric trauma patients, with cervical spine injuries representing 60% to 80% of all pediatric vertebral injuries.<sup>8,9</sup> Children are predisposed to injuries of the bones and soft tissues of the cervical spine because of incomplete ossification, vertebral configuration, and laxity of the ligaments.<sup>5,8,10</sup> Younger children tend to have a propensity for cervical spine injuries at the upper level potentially as a result of their immature pediatric cervical spine, while older children tend to have a lower incidence of injury.<sup>10,11</sup> Studies have demonstrated that there is a high incidence of neurologic deficits in pediatric patients with cervical spine injuries, with the overall mortality rate being high and often related to associated head injuries.<sup>8,10-12</sup>

The published studies on cervical spine injuries in the pediatric population are limited because most major trauma centers treat one to two patients with this injury per year.<sup>6,13,14</sup> Universal consensus as to whether cervical spine immobilization in the pediatric population is beneficial or detrimental following a trauma is lacking.<sup>11,15,16</sup> No data exist describing the incidence of pediatric cervical spine injuries during combat operations in Iraq and Afghanistan. We sought to describe the incidence of pediatric cervical spine injuries during combat operations in Iraq and Afghanistan with the anticipation that it will reflect the low incidence of the civilian population.

## Methods

### Data Acquisition

We identified subjects as part of a study seeking to evaluate prehospital and emergency department interventions for pediatric trauma patients.<sup>17,18</sup> The US Army Institute of Surgical Research regulatory office reviewed protocol H-16-014 and determined it was exempt from institutional review board oversight. We obtained only deidentified data.

### Subjects and Setting

We queried the Department of Defense Trauma Registry (DODTR) for all pediatric (17 years or younger) encounters from January 2007 and January 2016 in Iraq and Afghanistan. This is a retrospective review of prospectively collected data within the registry. We included subjects with missing data provided there was a documented age or estimated age within the records. We retrieved all of the available documentation of prehospital care and fixed-facility-based care. Within that dataset, we searched for all subjects with a documented cervical spine fracture.

The DODTR, formerly known as the Joint Theater Trauma Registry, is the data repository for DOD trauma-related injuries.<sup>19,20</sup> The DODTR includes documentation regarding demographics, injury-producing incidents, diagnoses, treatments, and outcomes of injuries sustained by US/non-US military and US/non-US civilian personnel in wartime and peacetime from the point of injury to final disposition. Subjects are enrolled in the DODTR if they are admitted to a Role 3 (fixed facility) or

forward surgical team (FST) with an injury diagnosis using the *International Classification of Diseases, Ninth Edition (ICD-9)* between 800 and 959.9, near-drowning/drowning with associated injury (*ICD-9* 994.1), or inhalational injury (*ICD-9* 987.9), and if the trauma occurred within 72 hours of presentation.

### Data Analysis

We performed a statistical analysis using Microsoft Excel version 10 (Microsoft, Redmond, WA) and JMP Statistical Discovery version 13 (SAS Institute, Cary, NC). Study variables were compared using a Student *t* test for continuous variables, a Wilcoxon rank sum test for ordinal variables, and a  $\chi^2$  test for nominal variables.

## Results

From January 2007 through January 2016 there were 42,790 encounters in the DODTR. Of those, 3439 (8.0%) were pediatric by documented or estimated age. Of the 3439, 36 subjects were identified (1.0%) with a cervical spine fracture. Of those with a cervical spine fracture, 6 (17%) had a prehospital cervical collar placed. Prehospital cervical collar placement did not improve survival to hospital discharge (collar placed, 66.7%,  $n = 4$  vs no collar placed, 83.3%,  $n = 25$ ,  $P = 0.573$ ). Of those with a cervical spine fracture, 6 (17%) had a documented spinal cord injury. Within that group with a cord injury, 5 (83%) survived to hospital discharge. The median age of subjects with a cervical spine fracture was 9.5 years and the majority (63.9%,  $n = 23$ ) were male.

The most frequent mechanism of injury was explosion (41.7%,  $n = 15$ ). The median composite injury score was higher in subjects with a cervical spine fracture compared with those without one (16.5 vs 10,  $P < 0.001$ ). Abbreviated Injury Scale (AIS) measurements were worse in subjects with a cervical spine injury for the head/neck (median 3/interquartile range 3–4.75 vs median 0/interquartile range 0–2,  $P < 0.001$ ), face (0/0–1.75 vs 0/0–0,  $P = 0.035$ ), and thorax (0/0–2 vs 0/0–0,  $P = 0.002$ ). AIS was lower for the skin/superficial (0.5/0–1 vs 1/0–1,  $P = 0.013$ ). Subjects with a cervical spine fracture had longer lengths of stay in the intensive care unit (median 3 days vs 1,  $P = 0.012$ ) and a trend toward worse survival to hospital discharge (80.6%,  $n = 29$  vs 90.3%,  $n = 3403$ ,  $P = 0.079$ ; Table 1). When using a dichotomized AIS of  $\geq 3$  to delineate serious injuries by body region, those with a cervical spine fracture had higher rates of serious injuries to the head/neck (77.8%,  $n = 28$  vs 23.4%,  $n = 797$ ,  $P < 0.001$ ) and a trend toward lower rates of serious injuries for the superficial/skin (0%,  $n = 0$  vs 8.1%,  $n = 275$ ,  $P = 0.075$ ; Table 2).

## Discussion

We describe the incidence of cervical spine injuries in pediatric trauma patients in the joint combat theaters in Iraq and Afghanistan. To our knowledge, no prior studies have examined this injury type in this specific population. We found that the subjects with a cervical spine fracture had a median age of

**Table 1. Demographics and outcome data of subjects with a cervical spine fracture**

|                                      | Subjects with cervical spine fracture (n = 36) | Subjects without cervical spine fracture (n = 3403) | P      |
|--------------------------------------|--|---|--------|
| Demographics                         |  |   |        |
| Age, y, median (IQR)                 | 9.5 (5–12.75)                                  | 9 (5–12)  | 0.920  |
| Male, %                              | 63.9 (23)                                      | 77.3 (2631)   | 0.159  |
| Mechanism of injury, %               |  |   |        |
| Explosion                            | 41.7 (15)                                      | 43.1 (1466)   | 0.187  |
| GSW                                  | 27.8 (10)                                      | 22.0 (750)  |        |
| MVC                                  | 19.4 (7)                                       | 11.5 (391)  |        |
| Other                                | 11.1 (4)                                       | 23.4 (796)  |        |
| Injury severity scores, median (IQR) |  |   |        |
| Composite                            | 16.5 (13–25)                                   | 10 (4–17)   | <0.001 |
| AIS                                  |  |   |        |
| Head/neck                            | 3 (3–4.75)                                     | 0 (0–2)   | <0.001 |
| Face                                 | 0 (0–1.75)                                     | 0 (0–0)   | 0.035  |
| Thorax                               | 0 (0–2)  | 0 (0–0)   | 0.002  |
| Abdomen                              | 0 (0–0)  | 0 (0–0)   | 0.664  |
| Extremities                          | 0 (0–0.75)                                     | 0 (0–2)   | 0.145  |
| Superficial, skin                    | 0.5 (0–1)                                      | 1 (0–1)   | 0.013  |
| Outcome data, median (IQR)           |  |   |        |
| ICU LOS                              | 3 (0.25–5)                                     | 1 (0–3)   | 0.012  |
| Hospital LOS                         | 5 (2–6)  | 3 (1–8)   | 0.375  |
| Discharge alive, % <sup>a</sup>      | 80.6 (29)                                      | 90.3 (3074)   | 0.079  |

AIS, Abbreviated Injury Scale; GSW, gunshot wound; ICU, intensive care unit; IQR, interquartile range; LOS, length of stay; MVC, motor vehicle crash.

<sup>a</sup>Fisher exact test.

9.5 years, were male, and were most frequently injured by explosion. There was a total of 36 pediatric patients with a cervical spine fracture, 6 of whom had a documented spinal cord injury. Of that group, 83% survived to hospital discharge. Our data mirror previous reports that cervical spine fractures occur more frequently in young children than in adolescents.<sup>21</sup>

According to the data collected by the Pediatric Emergency Care Applied Research Network, the most common mechanism of cervical spine injury in the civilian pediatric population if younger than 2 years or 2 to 7 years of age was a motor vehicle crash. For patients between the ages of 8 and 15 years, the most common causes of injury were sports injuries and motor vehicle

crashes.<sup>22</sup> In contrast, we found our population to be most frequently injured by mechanisms related to war, including explosions and gunshot wounds, and the average age being 9.5 years. Our data are congruent with that of Mohseni et al, who found that the incidence of pediatric cervical spine injury increases sharply after 9 years of age.<sup>23</sup>

Overall, our results showed that the incidence of cervical spine injuries was relatively low, with only 1.0% incidence within the dataset. The results were similar to those of civilian studies, which demonstrated the infrequent occurrence of cervical spine injuries in pediatric populations.<sup>8,10–12</sup> In our study, cervical spine injuries were more common in males than females, which also is

**Table 2. Serious injuries (AIS ≥3) by body region**

| Body region AIS      | Subjects with cervical spine fracture (n = 36) | Subjects without cervical spine fracture (n = 3403) | P                  |
|----------------------|--|---|--------------------|
| Head/neck, %         | 77.8 (28)                                      | 23.4 (797)  | <0.001             |
| Face, %              | 0 (0)  | 0.3 (9)   | 0.757              |
| Thorax, %            | 19.4 (7)                                       | 11.9 (405)  | 0.190 <sup>a</sup> |
| Abdomen, %           | 8.3 (3)  | 10.1 (343)  | 1.000              |
| Extremities, %       | 13.9 (5)                                       | 19.1 (649)  | 0.527              |
| Superficial, skin, % | 0 (0)  | 8.1 (275)   | 0.075              |

AIS, Abbreviated Injury Scale.

<sup>a</sup>Fisher exact test.

consistent with previous reports.<sup>8,12,24</sup> Eleraky et al reported that of the cases with cervical spine injuries, 40% of the injuries were associated with head trauma.<sup>25</sup> Our findings indicated a higher rate of serious injuries to the head/neck region in those with a cervical spine injury (77.8% vs 23.4%). As expected with the nature of polytraumatic injuries, subjects with a cervical spine fracture had a higher median composite injury score (16.5) compared with those without a cervical spine fracture (10) and associated longer intensive care courses. These data are consistent with the findings of Chan et al, who found that patients with cervical spine injuries had higher injury severity scores and longer pediatric intensive care unit and hospital stays.<sup>26</sup>

The use of cervical collars is a prioritized procedure in the Advanced Trauma Life Support and the Prehospital Trauma Life Support guidelines from the National Association of Emergency Medical Technicians.<sup>27–29</sup> In our study we found that 17% of patients with a cervical spine fracture had a cervical collar placed before arrival at the hospital. The lack of cervical collar placement is likely the result of most units not carrying pediatric-sized equipment in the prehospital setting. In addition, the use of cervical collars is not universally recommended within the Tactical Combat Casualty Care guidelines, and most military medics do not have pediatric-specific training, which may add to challenges in identifying children at higher risk for cervical spine injury. Independent of injury severity markers, it has been found that following a trauma, spinal immobilization is associated with increased pain, increased use of cervical spine imaging studies, and admission to a hospital.<sup>16</sup> The risks of immobilization may outweigh the benefits, because we found that the AIS of regions other than the head/neck was not associated with cervical fracture. In addition, our data suggest that cervical spine injury is low in children without evidence of head/neck trauma. Our data also suggest there may be inadequate evidence to support the use of uniform immobilization; the development of a clinical decision tool for children would be beneficial.<sup>30,31</sup>

There are several limitations of this study. First, the observational nature of our investigation means that we can only demonstrate correlation and not causation. Second, for an encounter to be generated within the DODTR, subjects must arrive at the FST or fixed facility alive or with ongoing interventions for an encounter to be generated. Because our database excludes all subjects not surviving to the FST or fixed facility unless they are receiving ongoing interventions, we are unable to characterize subjects who died before arriving at the hospital. Third, we do not have data on transport times for each encounter, which may have had an effect on outcomes. A final limitation of note is that we included data even if they were incomplete in the DODTR.<sup>17</sup>

## Conclusions

Cervical spine injuries occurred infrequently in pediatric patients in Iraq and Afghanistan. When a fracture was present, almost one in five patients had spinal cord involvement. The expert recommendations for spinal immobilization remain a point of contention that need to be further examined to determine whether spinal

immobilization is detrimental or useful. The pediatric prehospital literature would benefit from the development of a clinical decision tool to guide prehospital personnel as to when a cervical collar is indicated. Moreover, appropriate size equipment should be available when caring for host national civilians.

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