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Hear Hoofbeats? Think Head and Neck Trauma: A 10-year NTDB Review of Equestrian Related Trauma in the United States

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ABSTRACT

Objectives

Equestrian related injuries account for 45% of sports related traumatic brain injuries in the United States. Equestrian related trauma causes more injuries than motorcycle or auto racing. Stratification of the injuries sustained in horseback riding accidents has only been described in papers detailing EMR review of single Level I trauma centers or a few regional hospitals. The aim of this study was to stratify the different types and severity of equestrian injuries on a national level.

Methods

A 10-year review (2007-2016) of the National Trauma Data Bank (NTDB) was conducted to identify injuries due to horseback riding. Injuries were separated into head and neck injuries (HNI), extremity injuries (EXTI), thoracic injuries (THORI) and abdominal injuries (ABDI). Data points examined included: ethnicity, intensive care unit (ICU) length of stay (LOS), hospital LOS, ED disposition and ventilator days. Logistical regression, chi-squared and Kruskal-Wallis tests were used to analyze the data.

Results

Nationally, 24,791 adults were injured in equestrian related trauma. In descending order, THORI accounted for 9,189 (37.07%) injuries, 6,560 (26.47%) suffered EXTI, 5,689 (22.95%) sustained HNI, and 3,353 (13.52%) experienced ABDI. HNI caused 237 (74.83%) deaths while 59 (18.03%) were caused by THORI. Riders were more likely to die from HNI compared to EXTI (OR, 55.93; 24.08-129.89 95% CI; $p<0.001$), or from THORI (OR, 7.18; 3.00-17.18 95% CI; $p<0.001$). HNI had the highest ICU LOS (mean,4.66;SD,6.18).

Conclusion

Annually, over 2,000 equestrian related injuries resulted in presentation to a trauma center in the United States. While THORI were most commonly identified, HNI resulted in the highest mortality and ICU LOS. These results support the focus on prevention of HNI in equestrian sports.

MANUSCRIPT

Introduction

Humans have been domesticating horses for at least 5500 years. [1] They revolutionized human society and were instrumental in the advancement of fields such as agriculture and transportation. Our relationship with horses has continued to evolve over the years, and they are now commonly used for both work and recreational activities. However, although domesticated, horses remain unpredictable. Their large size and strength can lead to significant morbidity and mortality when things go wrong. According to Center for Disease Control and Prevention (CDC) data, each year in the United States (U.S.), more than 30 million people ride horses. [2] Although accurate estimations are made difficult by the unidentified injuries that do not make it to hospitals, equestrian accidents are beginning to be recognized as a large contributory source of injuries, especially with respect to traumatic brain injuries (TBI). This fact is made worse when you consider that more experienced riders, although most at risk for injuries requiring hospitalization or causing permanent disability, were less likely to use a helmet. [3] There is a paucity of evidence focused on traumatic injuries sustained due to equestrian injuries on a national level. Most have focused on injuries sustained in a small geographic region and lack generalizability to a national population. Furthermore, there has been few studies that provide insight into the sequelae of equestrian related trauma. This study aims to uncover national level data in relation to equestrian related trauma using the National Trauma Data Bank (NTDB). The NTDB is the largest aggregation of U.S. trauma registry data and is the national standard for the exchange of trauma registry data. Using this data bank, a 10-year review (2007-2016) was conducted to identify injuries sustained while horseback riding in the adult population. This study aims to delineate the injuries sustained through this type of trauma mechanism. This retrospective analysis looked to characterize mortality rates, hospital length of stay (LOS), intensive care unit (ICU) LOS, ventilator days, and emergency department (ED) disposition. This study reveals the demographic and epidemiological data that will allow for the development of prevention strategies.

Methods

Data source and Study Population

Our study collected data from the NTDB over a 10-year period between 2007 and 2016. The NTDB collects data from patients that present to all Level I and Level II trauma centers. Level III and IV trauma centers are able to participate in the data bank on a voluntary basis. All patient data is deidentified and aggregated. Therefore, this study was categorized as exempt from institutional review board review by the University of Texas Rio Grande Valley. Patients 18 years of age and older involved in equestrian injuries were analyzed. Equestrian related injuries mechanisms were uncovered from the NTDB using the appropriate external cause of injury code or E-code. From this data set, we then stratified equestrian-related injuries using the appropriate International Classification of Diseases-9th Rev./10th Rev. codes (ICD-9/ICD-10) corresponding to the insult sustained. Injuries were aggregated into categories based on the location of the injury. Patient results with missing or incomplete data were excluded from the analysis.

Study Variables

Individuals were classified based on demographic data such as age, sex, race, and payer status. Variables extracted from the NTDB also included Injury Severity Score (ISS), hospital and ICU LOS, admission

Glasgow Coma Scale (GCS) and ISS. Other variables that were obtained from the NTDB were hospital and ED discharge disposition. ED systolic blood pressure (SBP) was also analyzed with <90 mm Hg being considered the threshold for shock. Mortality data was obtained from ED and hospitalized patient data and analyzed by injury type.

Statistical Analysis

Continuous variables were reported as mean with SD while continuous variables were reported as frequencies with percentages. Statistical analysis was performed via Chi-squared test (for categorical variables) or Fisher exact test. ANOVA or Kruskal-Wallis test (for continuous variables) were among statistical procedures used in this analysis. The use of the ANOVA test was dictated by the Shapiro Wilk test of Normality. The Fisher exact test was used instead of the Chi-squared test where a cell count was less than five. In order to assess the association between death and injury type, a multivariable logistic regression was utilized and the analysis was adjusted for race, payer status, age group, severity of the injury. Odds ratios (OR), confidence intervals (CI), p-values, means, standard deviations (SD), proportions (p), sample sizes (n) were reported. A p-value less than 0.05 corresponds to results that were considered to be statistically significant at 95% confidence level. Also, when 1.96 times SD is less the corresponding mean, the finding was considered statistically significant at 5% level of significance. Data processing and analysis were performed using Stata/MP 16.1 StataCorp LLC College Station, Texas 77845 USA.

Results

Demographics and Injury Distribution

During the 10-year study period from 2007-2016, 45,671 patients were retrieved from the NTDB using the E-codes related to equestrian injuries. A total of 20,880 patients were omitted due to missing or incomplete information leaving 24,791 for analysis. Of the patients that were admitted for equestrian injuries, 9,189 (37.07%) had thoracic injuries. This accounted for the most common injuries recorded (Table 1). Extremity injuries occurred in 6,560 (26.46%) patients while 5,689 (22.95%) sustained head injuries. Abdominal injuries were least common with only 3,353 (13.53%) experiencing this type of injury. Patient's mean age (±SD) of the studied population was 46.85(±15.33) with the slight majority being male (50.53) and Caucasian (61.62%). Most patients were insured (69.94%) with a small portion of patients (13.53%) being uninsured. A majority of patients, 23,619 (95.27%), presented to the ED with a SBP≥90 mm Hg. Only 347 (1.40%) of patients presented with a SBP<90 mm Hg, our threshold for hemodynamic shock.

Most patients presented with mild TBI with a Glasgow coma score (GCS) of 13—15 (88.41%) due to equestrian injuries. Severe TBI (GCS 3-8) accounted for the 2nd most common presentation in patients (3.58%) overall. As expected, head and neck injuries were the most likely to lead to severe TBI, occurring in 706 patients or 79.5% of patients with severe TBI (Table 2). Moderate TBI (GCS 9-12) occurred in the least number of patients (1.04%). Patient injury severity score values were ranked mostly in the minor or moderate ISS subgroups (33.28% and 43.59% respectively). It is important to note that most patients seen in the ED were admitted to the hospital (88.19%). Half of admitted patients were sent to a floor bed (50.05%), with the 28.32% being sent to the ICU. The operating theatre (9.82%) was the third most likely destination for patients with equestrian injuries being evaluated in the ED. Equestrian injuries that presented to the ED had a low likelihood (5.15%) of being discharged home from the emergency department.

Table 1: Statistical Summary of Variables for Equestrian Related Injuries in Adults.

Variable	Value
Mean age in years (SD)	46.85 (15.33)
M/F ratio (%)	12,501 (50.53%):12,238 (49.47%)
Injury Type	
Thoracic	9,189 (37.07%)
Extremity	6,560 (26.46%)
Head and Neck	5,689 (22.95%)
Abdominal	3,353 (13.53%)
Race	
White	15,009 (60.54%)
Black	361 (1.46%)
Hispanic	2,097 (8.46%)
Other	7,324 (29.54%)
Health Insurance	
Commercial	12,476 (50.32%)
Government	4,723 (19.05%)
Uninsured	3,657 (14.75%)
Other	1,059 (4.27%)
Missing	2,876 (11.61%)
ED SBP	
<90	347 (1.40%)
≥90	23,619 (95.27%)
Unknown	825 (3.33%)
ED GCS Score	
Severe (3-8(	888 (3.58%)
Moderate (9-12)	258 (1.04%)
Mild (13-15)	21,917 (88.41%)
Unknown	1,728 (6.97%)
ISS	
Minor (0-8)	8,250 (33.28%)
Moderate (9-15)	10,807 (43.59%)
Severe (16-24)	3,625 (14.62%)
Very Severe (25+)	1,542 (6.22%)
Missing	567 (2.29%)
ED Disposition	
Home	1,277 (5.15%)
Floor Bed	12,407 (50.05%)
Operating Room	2,435 (9.82%)
Intensive Care Unit	7,022 (28.32%)
Expired/Deceased	51 (0.21%)
Other	1,320 (5.32%
Unknown	279 (1.13%)

Table 2: Summary of GCS Scores by Injury Type

	Injury Type				
	Abdominal	Thoracic	Extremity	Head and Neck	Total
GCS					
Mild	3,104	8,428	5,877	4,508	21,917
Moderate	8	47	13	190	258
Severe	17	145	20	706	888
Unknown	224	569	650	285	1,728
Total	3,353	9,189	6,60	5,689	24,791

Inpatient Characteristics and Mortality

The mean hospital LOS was 4.46 SD 5.27 **(**Table 3**)**. Patients also spent an average of 3.96 SD 5.17 in the ICU and a mean of 5.80 SD 7.06 on a ventilator. Patients with head and neck injuries required more days on the ventilator and spent more time in the ICU when compared to patients without TBI. However, the difference days on the ventilator between head and neck injuries and thoracic injuries did not achieve statistical significance (Table 4). For the patients that survived their hospital stay, 14,096 (56.86%) patients were discharged to home without additional services and 1,747 (7.05%) were discharged/transferred to a rehabilitation or skilled nursing facility. The 50-59 age group was found to most likely group to present to trauma centers accounting for 5,939 (26.58%) injuries. Older riders, those belonging to the 60+ age group, came in second with 4,883 (21.85%) incidents in the period analyzed. The 40-49 age group came in the third with 4,568 (20.44%) reported events. Patients in the youngest category, the 18-29 age group, accounted for 4,009 (19.94%) injuries. Finally, the 30-39 age group was the least likely age group to be reported in equestrian injuries accounting for 2,946 (13.18%) patients.

Table 3: Statistical Distribution of Variables For Adult-Equestrian By Injury Type

	Injury						
variables	Abdominal		Thoracic	Extremity	Head and Neck	Total	p-value
Hospital LOS: mean, SD	5.00 (4.59)	4.57 (4.73)		3.57(3.88)	4.99 (7.32)	4.46 (5.27)	NA
ICU LOS: mean, SD	3.02 (3.00)	3.65 (4.56)		2.88(4.03)	4.69 (6.2)	3.96 (5.17)	NA
Days on Ventilator: mean, SD	4.69 (6.24)	5.60 (7.34)		3.18(6.81)	6.23 (6.97)	5.80 (7.06)	NA
Age group: n; p							<0.001
18-29	537; 13.39%	834; 20.80%		1384; 34.52%	1254; 31.28%	4,009; 100%	NA
30-39	404;13.71%	722;24.51%		1,090;37.00%	730;24.78%	2,946; 100%	NA

40-49	580;12.7%	1,630;35.68%		1,345;29.44%	1,013;22.18%	4,568; 100%	NA
50-59	865;14.56%	2,589;43.59%		1,309;22.04%	1,176;19.81%	5,939; 100%	NA
60+	666; 13.64%	2425; 49.66%		786;16.10%%	1006; 20.6%	4883; 100%	NA

Our analysis revealed that there were 320 deaths caused by equestrian related injuries over the study period. Head and neck injuries were the leading cause of mortality leading to 237 (74.83%) of the deaths recorded (Fig. 1). Thoracic injuries were second with 59 (18.44%) and abdominal injuries causing the third highest amount of deaths with 17 (5.31%). Finally, extremity injuries led to the least amount of deaths with 7 (2.19%) patients succumbing to their injuries. Patients were more likely to pass away due to head and neck trauma (OR 44.07, p-value<0.001, 95% CI 21.30-91.19) than from any other injury type (Table 5).Unsurprisingly, as ISS increased, so did the likelihood of death. Moderate injuries on the ISS scale led to a doubling of death risk (OR 2.64, p-value 0.003, 95% CI 1.38-5.05) when compared to minor injuries. Severe injuries led to an eight fold increase in risk of death (OR 8.21, p-value <0.001, 95% CI 4.28-15.74) when compared to minor ISS injuries.

Table 4. Comparison of mean ventilation day between Head Injury and other injury type

Injury	**mean difference (95% CI)**	**p-value**
Extremity	1.54 (0.13,2.96)	0.033
Thoracic	0.63 (-0.23, 1.50)	0.1503
Abdominal	3.05 (1.53, 4.58)	0.0001

Table 5: Multivariable Analysis of Predictors of Death After Adult Equestrian Injuries

Parameter	Odds ratio (95% CI)	p-value
Injury Type		
Extremity	Reference	NA
Head/Neck	44.07 (21.3, 91.19)	<0.001
Abdominal	5.8 (2.45,13.72)	<0.001
Thoracic	5.87 (2.75,12.52)	<0.001
Injury Severity Score (ISS)		
Minor	Reference	NA
Moderate	2.64 (1.38, 5.05)	0.003
Severe	8.21 (4.28,15.74)	<0.001
Very Severe	141.71 (78.62,255.42)	<0.001
Unknown	19 (8.6,42)	<0.001
ED SBP		
SBP>=90	Reference	NA
SBP<90	23.37 (16.95,32.23)	<0.001
Unknown	2.31 (1.35,3.93)	0.002

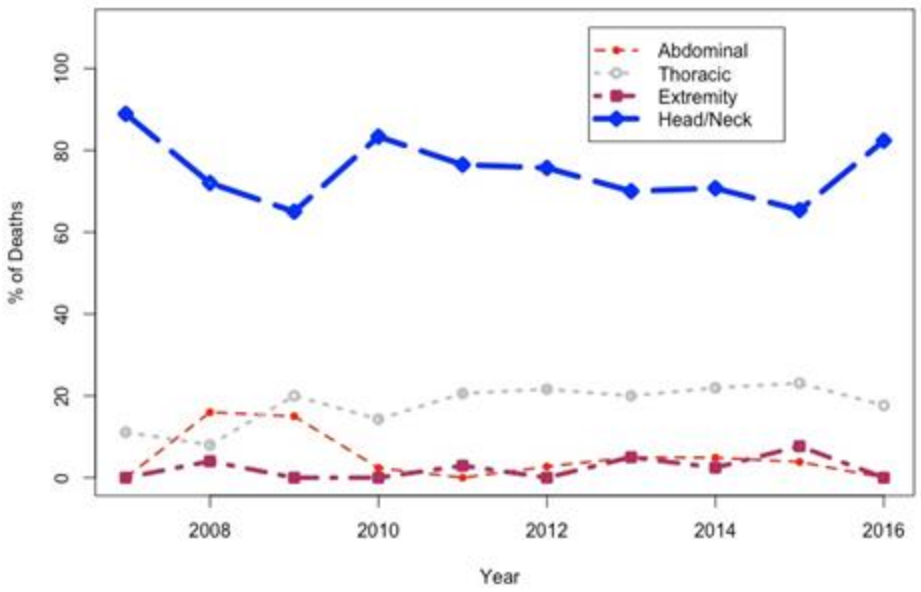

Figure 1. Comparison of percentage deaths of equestrian related injuries by injury type from 2007 to 2016. There were 320 deaths recorded during this time period. Head and neck injuries accounted for the highest percentage of deaths for each year surveyed during a 10-year period.

Discussion

Equestrian related injuries are an often-ignored public health issue due to the lack of a national survey. Previous studies have characterized the mechanisms of injury or injury patterns of these types of injuries. [4-5] however, these studies were local retrospective studies. Furthermore, these studies did not include any inpatient data that would allow for an assessment of inpatient and acute outcome data such as ICU LOS ventilator days and mortality rates after equestrian injuries. In our present study of a 10-year review of the NTDB data set, we characterized the demographics, hospital and ICU characteristics and mortality rates of patients injured in equestrian injuries. To our knowledge, this study is the first to characterize the inpatient characteristics and outcomes of adults involved in equestrian injuries that present to Level I and Level II trauma centers in the US.
Our study of equestrian injuries seen at Level I and Level II trauma centers found that over 88% of patients presented with a mild TBI with a GCS of 13-15. Severe TBI were second but accounted for only 3% of total admissions. Of all patients that presented to the hospital, 88% were admitted. This mirrors research findings showing the proportion of admissions from equestrian injuries was 3.5x higher than data reported for motorcycle riding [6]. When taken together, these data suggest that the dangers of equestrian activities have been severely understated. Horseback riding, when controlled for hours of activity resulted in a higher proportion of hospital admission than other higher risk activities like skiing. [7]

Across the injury types analyzed, several important trends were noted. First, head and neck injuries were the largest contributor to mortality in equestrian injuries. In the 10-year period surveyed, head and neck injuries came in first every year. Not surprisingly, head and neck injuries were also significantly associated with longer ICU LOS and more ventilator days. Head and neck injuries were also associated

with a 9-fold increase in the risk of death (Table 5). This finding coincides with previous data indicating greater mortality from head and neck injuries in equestrian related accidents. [8] Our study adds to the evidence demonstrating a clear need for helmet use in equestrian activities. Helmet use has not been widely adopted in the horse-riding community, given the lack of public health campaigns that specifically target casual riders and people who use horses for work. Studies have shown that a large fraction of riders involved in equestrian injuries were not wearing helmets at the time of their accident [9]. It stands to reason that raising awareness of the possible injuries and increasing preventive measures to protect against equestrian injuries would significantly reduce mortality. Furthermore, little work has been done to quantify the real costs of equestrian injuries. Although overall death numbers are low [10], previous work has shown that the long-term rehabilitation costs to treat these injuries may be high [11-13]. Further work looking into the epidemiology and true financial burden of these injuries is warranted.

Our study also uncovered demographic data that revealed that men and women were injured at the same rate. There was no statistical difference between the rates of injury between genders. This goes against several studies that have claimed that women are injured more often in equestrian related injuries[14-17]. This finding would suggest that both sexes are susceptible to injuries and that the current prevention efforts should be focused on both sexes. Some studies have suggested targeting safety efforts on female [14] and young riders [18]. However, improved safety outcomes may occur if prevention efforts are made to be more general.

This study is not without limitation. The retrospective analysis included only patients that were injured in equestrian related accidents that presented to US trauma centers that report data to the NTDB, which may exclude rural hospitals who do not contribute to trauma databases. We did not have access to unreported equestrian related injuries or injuries that were not coded appropriately for inclusion into the NTDB database. Therefore, our analysis may have underestimated the true prevalence of equestrian related injuries in the US. This amount may be higher than the number of injuries we reported here. Although much care was used in selecting the appropriate ICD 9 and ICD 10 D-codes and E-codes to query the NTDB, it must be noted that inaccurate or missing data from incorrectly coded patients may have caused the underestimation of different types of injuries in our analysis. Despite these limitations, the NTDB remains a powerful tool in uncovering patterns and prevalence in different traumatic presentations and remains the most extensive wide scale trauma databank available for US trauma centers.

Conclusion

Horseback riding is very popular among Americans. It is estimated that 1 in 63 US persons come into contact with horses each year. [19] Although they are used for both leisure and work, the true impact of equestrian related injuries can often be ignored [11,20]. As traumatic brain injuries have become more apparent in the mainstream media due to reports of chronic traumatic encephalopathy in football players[21], it is imperative to discuss the dangers of equestrian related activities while underscoring the importance of safe riding. Many public health initiatives have focused on making sure that participants wear helmets during bike and motorcycle riding [22-23]. Furthermore, research funding has mirrored lay public interest as the NFL pledged millions of dollars in grant funding to launch the Head Health campaign [24]. They are hoping to define the brain injuries that occur during play [25] and create new helmet prototypes that will protect the brains of athletes [26-27]. Interestingly, the risk of hospital admission from horseback riding is higher than football, car and motorcycle racing and skiing. [28] Recently, some attention has been paid by equestrian sporting agencies to the use of protective

equipment to prevent injuries, especially as it relates to concussion and brain injuries[29-30] However, very few public health campaigns have focused on preventing injuries in riders using horses for leisure and work. This is in stark contrast to the popularity of riding these animals. As such, these factors indicate that preventive measures and campaigns should be instituted to highlight safety practices and personal protective equipment that should be implemented such as helmets and vests attempting to protect all riders while on horseback. It is also imperative that medical professionals examine patients injured during horseback riding for head and neck injuries as these contribute to the highest mortality. Together, as Americans, we can continue to enjoy this popular sport while simultaneously reducing the amount of severe injuries.

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