Injury, Int. J. Care Injured 48 (2017) 1093–1097

Contents lists available at ScienceDirect

Injury

journal homepage: www.elsevier.com/locate/injury

The impact of helmet use on outcomes after a motorcycle crash

Desmond Khor, Kenji Inaba*, Alberto Aiolfi, Samantha Delapena, Elizabeth Benjamin, Kazuhide Matsushima, Aaron M. Strumwasser, Demetrios Demetriades

Division of Acute Care Surgery and Surgical Critical Care, LAC+USC Medical Center, CA, USA

ARTICLE INFO

Keywords:
Helmet
Cervical spine
Motorcyclist
Motorcycle collisions
Trauma

ABSTRACT

Background: Helmet use in a motorcycle collision has been shown to reduce head injury and death. Its protective effect on the cervical spine (C-spine), however, remains unclear. The objective of this study was to explore the relationship between helmet use and C-spine injuries.

Method: Retrospective National Trauma Data Bank (NTDB) study. All motorcycle collisions between 2007 and 2014 involving either a driver or passenger were included. Data collected included demographics, vital signs, Abbreviated Injury Scale (AIS), Injury Severity Score (ISS) and specific injuries. The primary outcome was the prevalence of C-spine injuries. Secondary outcomes included were overall mortality, ventilation days, intensive care unit length of stay (LOS), total hospital LOS, and in-hospital complications.

Results: A total of 270,525 patients were included. Helmets were worn by 57.6% of motorcyclists. The non-helmeted group was found to have a higher incidence of head injury with head AIS > 2 (27.6% vs 14.8%, $p < 0.001$). Univariate analysis showed a higher prevalence of C-spine injuries in the non-helmeted group (10.4% vs 9.4%, $p < 0.001$), with a higher proportion of severe C-spine injuries with AIS > 2 (3.2% vs 2.6%, $p < 0.001$). Additionally, traumatic brain injury (TBI) was found to be two times higher in the non-helmeted group (20.7% vs 10.9%, $p < 0.001$). Multiple logistic regression showed helmet use to be an independent protective factor against mortality (OR = 0.832, 95% CI 0.781–0.887, $p < 0.001$). Although statistically significant in univariate analysis, helmet use was not associated with C-spine injuries after adjusting for relevant covariates. However, helmet use reduced the risk of severe head injuries by almost 50% (OR = 0.488, 95% CI 0.475–0.500, $p < 0.001$).

Conclusions: Helmet use reduces the risk of head injury and death among motorcyclists; however, no association with C-spine injuries could be detected.

Introduction

There were 8.4 million motorcyclists documented in the United States in 2014, with 13 percent of all motor vehicle crash fatalities involving motorcyclist riders [1]. The fatality rate for motorcycle or scooter riders is even more pronounced in developing countries. In Malaysia, for example, motorcycle-related fatalities accounted for greater than 50 percent of the total road traffic accident fatalities [2].

Helmet use has been shown in several studies to reduce the risk of head injury and death [3,4]. A reduction in traumatic brain injuries by 67% has also been estimated by the United States National Highway Traffic Safety Administration [5]. Despite this evidence, there are still a number of states without a mandatory helmet law. Only 19 states and the District of Columbia have a universal helmet law in place. In another 28 states, only certain motorcyclists are required to wear a helmet. There is no helmet law in three other states [6].

The data supporting the impact of helmet use on cervical spine injury remain controversial [7]. The Goldstein study, for example, showed an increased risk of neck injuries in helmeted motorcyclists [8]. A possible mechanism suggested for this is that helmets exert a significant mass effect on the head, further increasing flexion and extension of the neck upon collision, increasing the risk of neck injuries.

However, several studies have shown no increased risk or even a reduction in cervical spine injury with helmet use [9–13]. Therefore, the objective of this study was to address the conflicting data in the published literature and explore the relationship between helmet use and cervical spine injuries using the largest

* Corresponding author at: Division of Trauma and Surgical Critical Care, University of Southern California, LAC+USC Medical Center, 2051 Marengo Street, Inpatient Tower, C5L100, Los Angeles, CA 90033, USA.
E-mail address: kenji.inaba@med.usc.edu (K. Inaba).

http://dx.doi.org/10.1016/j.injury.2017.02.006
0020-1383/

available trauma database in the United States. We hypothesized that helmet use will not increase the risk of cervical spine injuries.

Methods

After Institutional Review Board approval, a retrospective American College of Surgeons National Trauma Data Bank (NTDB) study was conducted. The NTDB remains the full and exclusive copyrighted property of the American College of Surgeons. The American College of Surgeons is not responsible for any claims arising from works based on the original Data, Text, Tables, or Figures. It consists of trauma registry data voluntarily submitted by trauma centers throughout the United States. All cases between 2007 and 2014 involving a road traffic motorcycle collision with either a driver or passenger were included in the study (E-code 810-819, series 0.2 and 0.3). Non-traffic motorcycle collisions were excluded from the study. Injury to the cervical spine (C-spine) was identified using the Abbreviated Injury Scale (AIS) code, which included bony and non-bony injury, cord syndrome, nerve root injury, ligamentous injury, disc herniation, dislocation and strain.

The data collected included helmet use at the time of injury, demographics, vital signs upon arrival in the emergency department (ED), alcohol and illegal drug intoxication, regional AIS (head, spine, neck, thorax, and abdomen), Injury Severity Score (ISS), specific injuries, and procedures performed within 24 h. The primary outcome measure was the prevalence of C-spine injuries. Secondary outcomes included overall mortality, ventilation days, intensive care unit (ICU) length of stay (LOS), total hospital LOS, and in-hospital complications.

All variables were compared between the helmeted (HM) and non-helmeted (NHM) group. Categorical data were reported as percentages, and continuous data were reported as medians with interquartile ranges (IQR). Continuous variables were also dichotomized using clinically relevant cutoff points. Pearson's chi squared test or Fisher's exact test were used to compare proportions for categorical variables while Mann-Whitney U test was used to compare medians for continuous variables. A direct fitting logistic regression model was used to identify independent risk factors for mortality and C-spine injuries. Each result was presented as an odds ratio (OR) with 95% confidence interval (CI). Multicollinearity testing was performed to identify any correlation between covariates. The accuracy of the test was calculated using the area under the curve with 95% CI. Variables with p-value < 0.05 were considered significant. All analyses were performed using SPSS for windows version 20.0 (SPSS Inc. Chicago, IL).

Results

A total of 270,525 patients were identified during the study period. Helmets worn at the time of injury were documented in 155,877 (57.6%) motorcyclists. Overall, the trend of helmet use among motorcyclists remain constant from 2007 to 2014 (Fig. 1). Median age was 41 (IQR 27-52), 6946 (2.6%) patients were less than 16 years, 234,360 (87.0%) were male, and 252,180 (93.2%) were drivers. Alcohol screening was positive in 48,376 (21.3%) while illegal drugs were found to be positive in 32,794 (16.1%) patients. Overall, 84,776 (31.4%) patients had an ISS > 15, and C-spine injuries were seen in 9.8% of the population (26,557 patients).

Demographic and injury characteristics for HM and NHM motorcyclists are shown in Table 1. NHM motorcyclists were more likely to be less than 16 years old (3.3% vs 2.1%, $p < 0.001$), have a GCS less than 9 (13.9% vs 7.6%, $p < 0.001$), be hypotensive (4.4% vs 3.8%, $p < 0.001$), be tachycardic (7.9% vs 6.4%, $p < 0.001$), and test positive for alcohol use (28.8% vs 15.8%, $p < 0.001$) and illegal drugs (17.2% vs 15.3%, $p < 0.001$). The age, gender, race, number of riders, and ISS did not differ between groups.

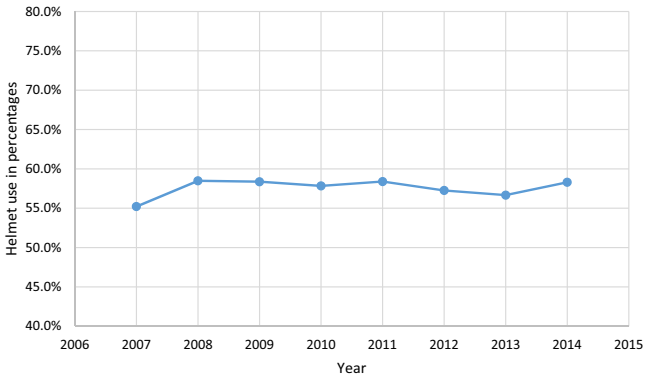

Fig. 1. Trend of helmet use at the time of injury over the years 2007–2014.

The NHM group was found to have more motorcyclists with a head AIS > 2 (27.6% vs 14.8%, $p < 0.001$). The unadjusted analysis also showed a higher prevalence of C-spine injuries in the NHM group compared to the HM group (10.4% vs 9.4%, $p < 0.001$). They had a higher proportion of severe C-spine injuries with AIS > 2 (3.2% vs 2.6%, $p < 0.001$). C-spine fractures were also more common in the NHM group (7.6% vs 6.2%, $p < 0.001$). There were no differences in other C-spine injury types between HM and NHM groups. Additionally, traumatic brain injury (TBI) was found to be two times higher in the NHM group (20.7% vs 10.9%, $p < 0.001$). The NHM group was more likely to undergo craniectomy and intracranial pressure monitoring within 24 h (1.6% vs 0.4%, $p < 0.001$, and 1.0% vs 0.4%, $p < 0.001$, respectively).

Hospital outcomes comparing HM and NHM groups are presented in Table 2. There were no differences in ventilation days, ICU LOS, or hospital LOS between groups. Overall mortality was higher in the NHM group (3.9% vs 2.5%, $p < 0.001$). The HM group was less likely to develop a complication compared to the NHM group (8.8% vs 10.6%, $p < 0.001$). An unadjusted comparison of mortality, overall complications, C-spine injury, and TBI between HM and NHM groups is shown in Fig. 2.

After including significant covariates into a logistic regression model, helmet use was found to be an independent protective factor against mortality (OR = 0.832, 95% CI 0.781–0.887, $p < 0.001$). Male gender, age ≥ 65, hypotension, GCS < 9, and AIS > 2 (head, neck, abdomen, and thorax) were all associated with a significant increase in the risk for mortality (Table 3). Our analysis demonstrated no association between helmet use and C-spine injuries (Table 4); however, helmet use was shown to reduce the risk of severe head injuries (head AIS > 2) by almost 50% (OR = 0.488, 95% CI 0.475–0.500, $p < 0.001$) after adjusting for gender, age, vital signs upon arrival, alcohol use, illegal drug use, and other body region injuries (Table 5).

Discussion

Riding a motorcycle places the rider at high risk for sustaining injuries and death compared to being within an enclosed vehicle [1]. Helmet use was introduced as a passive protection measure, designed to protect the head during collision. In most countries, the use of helmets has been made compulsory [14].

In the United States, however, there is no universal helmet law. Helmet laws are regulated by the state government. Only 19 states and the District of Columbia have a mandatory helmet law in place. States with selective helmet laws may require minor riders, for example, to use a helmet, while leaving adults to decide whether or not to wear a helmet. One of the concerns expressed by opponents of a mandatory helmet law is that the use of a helmet will increase the risk of a C-spine injury.