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Factors influencing the length of the emergency room and hospital stay in non-fatal bicycle accidents: A retrospective analysis

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A B S T R A C T

Purpose: Lengthy hospitalization places a burden on patients and healthcare resources. However, the factors affecting the length of hospital stay (LHoS) and length of emergency room stay (LERS) in non-fatal bicycle accidents are currently unclear. We investigated these factors to inform efforts to minimize hospitalization.

Methods: We performed a retrospective analysis of data from non-fatal injured bicyclists admitted to the Emergency and Critical Care Center at Kyoto Medical Center between January 2012 and December 2016. We measured LHoS, LERS, mechanism of injury, head injury prevalence, polytrauma, operations performed, injury severity score (ISS), abbreviated injury scale (AIS) score, maximum AIS score, and trauma and injury severity score probability of survival. We conducted multiple regression analysis to determine predictors of LHoS and LERS.

Results: Within the study period, 82 victims met the inclusion and exclusion criteria and were included. Mean age was (46.0 ± 24.7) years. Overall mean LHoS was (16.8 ± 25.2) days, mean LERS was (10.6 ± 14.7) days, median ISS was 9 (interquartile range (IQR): 3−16), median maximum AIS was 3 (IQR: 1−4), and median trauma and injury severity score probability of survival was 98.0% (IQR: 95.5%−99.6%). Age, maximum AIS, ISS, and prevalence of surgery were significantly greater in long LHoS and LERS groups compared with short LHoS and LERS group ($p < 0.05$). Performance of surgery independently explained LHoS ($p = 0.0003$) and ISS independently explained LERS ($p = 0.0009$).

Conclusions: Surgery was associated with long hospital stays and ISS was associated with long emergency room stays. To improve the quality life of the bicyclists, preventive measures for reducing injury severity or avoiding injuries needing operation are required.

Introduction

As the reduction of CO_2 emissions becomes a widespread goal worldwide, cycling is an increasingly common alternative means of transportation. Furthermore, in Japan, the bicycle has become a more popular means of transport since the catastrophic earthquake in the eastern part of the country in March 2011 and represents a viable alternative to motor vehicles in many commuters. However, bicyclists are exposed to a higher risk of injury and fatality in road traffic injuries. According to a survey in Australia, the incidence of cycling injuries over 1 year was 27%, of which 49% were minor injuries.[1] According to a study in the Netherland, 31% of the lethal traffic accident victims treated in the emergency room (ER) were cyclists.[2] In Japan, in 2017 there were 480 and 88,888 fatal and non-fatal bicycle accidents involving injury, accounting for 13.0% and 15.3% of all fatal and non-fatal traffic accidents involving injury, respectively. These data have been consistent for 14 years.[3] Based on these trends, the Japanese government has emphasised improvement of the safety of vulnerable road users, including bicyclists, in the 10th Fundamental Traffic Safety Program, which outlines road safety strategies for 2016−2020 in Japan.

According to an analysis of fatal or injured bicyclists between 2012 and 2016 by the National Police Agency Japan, the rate of casualties was substantially higher in teenagers (up to 16 years old, 470.6/million).[4] Long hospital stays or disability can strongly influence the development of young people. Furthermore, prolonged

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hospitalization is associated with an unacceptable burden on healthcare resources, and undermines the productive capacity of the population through time lost during hospitalization and disability. Therefore, minimising the duration of hospital stays is important for improving the quality of life by enabling patients to resume daily activities. Although the patterns of injuries of bicyclists involved in vehicle collisions have been examined previously, to our knowledge, no English-language studies have examined the factors influencing the length of hospital stay (LHoS) among injured bicyclists.[5−11]

We retrospectively analysed bicyclists' backgrounds, injuries and LHoS, and the descriptions of the collisions in which they were involved. We sought to clarify the factors influencing LHoS among non-fatally injured bicyclists and to inform the development of effective measures for shortening the duration required to resume daily life for injured bicyclists.

Methods

This was a retrospective hospital-based study, approved by the Ethics Committee of Kyoto Medical Center.

Data collection

Hospital records were reviewed for all non-fatally injured patients who had been involved in a road traffic collision while riding a bicycle and subsequently transferred to the Emergency and Critical Care Center at Kyoto Medical Center from January 2012 to December 2016. This hospital is located in an urban area in the southern part of Kyoto prefecture, near the Fushimi-Inari shrine, and serves as the emergency medical centre for approximately 1.5 million people living in and surrounding Kyoto city. In the Emergency and Critical Care Center in Kyoto Medical Center, approximately 13,000 emergency patients are received annually. Of these, 600−700 are trauma patients. Approximately 300 patients visit our center with road traffic injuries annually. The ER at Kyoto Medical Center has 30 beds specifically designated for critical care, and the hospital has a total of 580 beds. Cases were excluded from the analysis if information regarding the collision or detailed medical data were missing. Besides, patients with certain pre-existing diseases, such as severe heart disease, paralysis, advanced cancer, Alzheimer's disease, depression, or psychosis were excluded from the study.

Length of hospital and ER stay, mechanism of injury, injury severity and specific injury, in addition to general information (e.g., age, gender and past medical history), were obtained from each patient record.

Length of hospital and ER stay We investigated the number of days between admission and discharge from the ER and hospital. After hospital discharge, most patients returned to their residence, while some were transferred to a rehabilitation facility to perform specific rehabilitation. After admission, patients were taken to the ER where the initial management and acute surgery were performed.

Criteria for entering the ER in our hospital including high-energy trauma, trauma-related injury, the trauma of unknown origin, and multiple injuries. When the vital signs of patients were stable and required no further intensive care, patients left the ER and treatment proceeds at the hospital.

Mechanism of injury We surveyed how and when each collision occurred and determined the other objects involved in the collision with the bicyclist: single-vehicle collision (i.e., the bicyclist fell to the road surface or hit an object without contacting other vehicles), bicycle, motorcycle, or four-wheeled vehicle.

Injury severity The part of the body injured and the type of injury was examined, and the injury severity was assessed for all patients. The injury severity score (ISS) and the 1990 revised version of the abbreviated injury scale (AIS) score were calculated for each patient.[12,13] The AIS score is used to categorise the injury type and severity in each body region on a scale from 1 (minor) to 6 (clinically untreatable). The ISS, which is useful for assessing the severity of multiple injuries, is the sum of squares of the highest AIS score in each of the 3 most severely injured body regions. The maximum AIS (MAIS) score denotes the most severe injury in each of 6 body regions.

The revised trauma score (RTS) is a physiologically-based triage score. The RTS consists of 3 variables: respiratory rate, systolic blood pressure, and Glasgow coma scale. The RTS is the sum of each variable multiplied by a weighted coefficient. The trauma and injury severity score (TRISS) calculates the predicted survival rate (Ps: the probability of survival) by adding physiological severity, anatomical severity and age factors. When calculating the Ps for fatal cases, death is considered to be avoided if the Ps is 0.5 or more, as preventable if the Ps is 0.25 or more, and as non-preventable if the Ps is less than 0.25.

Specific injury We examined whether patients suffered from head injury or polytrauma. In this study, head injury was defined as having injuries with AIS of 1 or more in the head region and polytrauma was defined as suffering from injuries with AIS of 1 or more in two or more body regions. We also examined whether the patient received an operation.

Statistical analysis

Data were summarized in the form of values with proportions or frequency for categorical variables. Means with SD for the values that followed the normal distribution and median with the interquartile range (IQR) for values that did not follow the normal distribution were used to summarise continuous variables. Chi-square tests were used to compare the prevalence of the two groups. The Mann-Whitney test was conducted to examine differences in values between the two groups.

Multiple regression analysis with a forced input method was performed withLHoS or length of ER stay (LERS) as target variables, and age, AIS score, ISS, mechanisms of injury, head injury, polytrauma and operation as descriptive variables. Furthermore, analysis of variance was used to discern the significance of the relationship obtained by multiple regression analysis. Significance was assessed at the 5% level.

Results

Overview

During the research period, 3054 patients were admitted to the ER. A total of 903 trauma patients remained after exclusion of 2151 patients due to disease. Of these 903 trauma patients, 393 were injured in road traffic collisions. Finally, a total of 82 bicyclists (59 male and 23 female patients) were included in this study. The ages ranged from 3 to 89 years, with a mean of (46.0 ± 24.7) years. The most common age group among patients was 10−19 years, accounting for 18.3% of all bicyclists. None of the patients had worn a helmet or other protective device at the time of collision. Regarding the mechanism of injury, collision with a vehicle was the most common (43.9%, 36 cases), followed by single collision (32.9%, 27 cases) and collision with motorcycles (9.8%, 8 cases) and bicycles (9.8%, 8 cases). Three (3.7%) patients had fallen onto the road without collision with a vehicle. The overall LHoS ranged from 1 to

160 days with a mean duration of (16.8 ± 25.2) days. The LERS ranged from 1 to 67 days with a mean duration of (10.6 ± 14.7) days.

Injury severity

ISS in all patients ranged from 1 to 34 (median: 9, IQR: 3–16). Specifically, 48.7% of patients had a head injury and 47.6% of patients had polytrauma. There were 62.2% of patients had an ISS of less than 10, and more than half of the patients had an ISS of less than 8 (Fig. 1). MAIS ranged from 1 to 5 (median : 3, IQR: 1–4). In comparing injured body regions, the head had the highest AIS score (median: 3.5, IQR: 3–4), followed by the extremities (median: 3, IQR of 1–5), chest (median: 3, IQR: 2.75–3.25), abdomen (median: 3, IQR: 2–3), and face (median: 2, IQR: 1–2). The TRISS Ps ranged from 13.6% to 99.7% (median: 98.0%, IQR: 95.5%–99.6%).

Comparison between short and long hospital and ER stays

We compared patients' basic information, ISS and MAIS, mechanisms of injury, the prevalence of head injury, polytrauma, and operation between two groups (Table 1). First, patients were divided into two groups based on LHoS (14 days or less, and more than 14 days). When comparing these two groups, age, MAIS, ISS and the prevalence of undergoing an operation were significantly higher in the long LHoS compared with the short LHoS group. Next, we performed a comparison between short LERS (7 days or less) and long LERS (more than 7 days). The results were similar to the comparison of LHoS.

Factors influencing hospital or ER stay duration

Multiple regression analysis using a forced input method revealed that undergoing an operation explained LHoS independently with a p value of 0.0003 and that ISS explained the LERS independently with a p value of 0.0009. According to the analysis of variance, multiple regression equations were significant ($F = 4.25$, $p < 0.001$ in LHoS; $F = 5.39$, $p < 0.001$ in LERS). Tables 2 and 3 show the results of multiple regression analysis for LHoS or LERS.

MAIS: maximum abbreviated injury scale, ISS: injury severity score.

Discussion

Regarding traffic accidents, a reduction in premature mortality is well understood as an important goal of health practice. However, research on measures to minimize hospital stay and resume daily activities among traffic injured bicyclists is rare.

LHoS for injured patients has been examined in several previous studies and has been suggested to be related to gender, age, and type of victim, as well as the location and nature of injuries.[14,15] However, few reports have investigated the factors influencing LHoS and LERS separately in the same patients, as in the current study.

Multiple regression analyses revealed that undergoing an operation was a significant factor for LHoS, whereas ISS was the only significant factor for LERS. A previous study examined the injury characteristics of road traffic crash victims and hospital duration, revealing that patients with severe trauma stayed longer in hospital.[9] Another study of chest injury patients revealed that ISS of the patients was significantly associated with LHoS.[16] Therefore, the severity of injuries is traditionally considered a significant factor for LHoS. However, in the current study, injury severity was found to be a significant factor for LERS, but not LHoS. We propose that this difference may have been caused by differences in the patients' characteristics compared with previous studies. The patients in the current study were all injured non-fatally, and suffered from relatively low-severity injuries, with median ISS of 9 and median TRISS Ps of 98.0%. Patients with low-severity injuries are more likely to leave the ER quickly, whereas severely injured patients are more likely to stay in the ER. Therefore, the current results confirmed that injury severity significantly influenced ER stay duration, but no hospital stay duration.

Besides, a previous report suggested road traffic crash victims with long bone fractures stayed longer in hospital.[9] Because most long bone fractures in adults require surgery, the current finding that undergoing an operation influenced LHoS was in accord with this previous result.

Although age significantly affected the results of simple comparisons between the long and short hospital or ER stay, multiple regression analysis revealed no significant effects for LHoS or LERS. A previous study of hospitalised bicyclists conducted by Pai et al.[17] revealed that older people exhibited a greater likelihood of

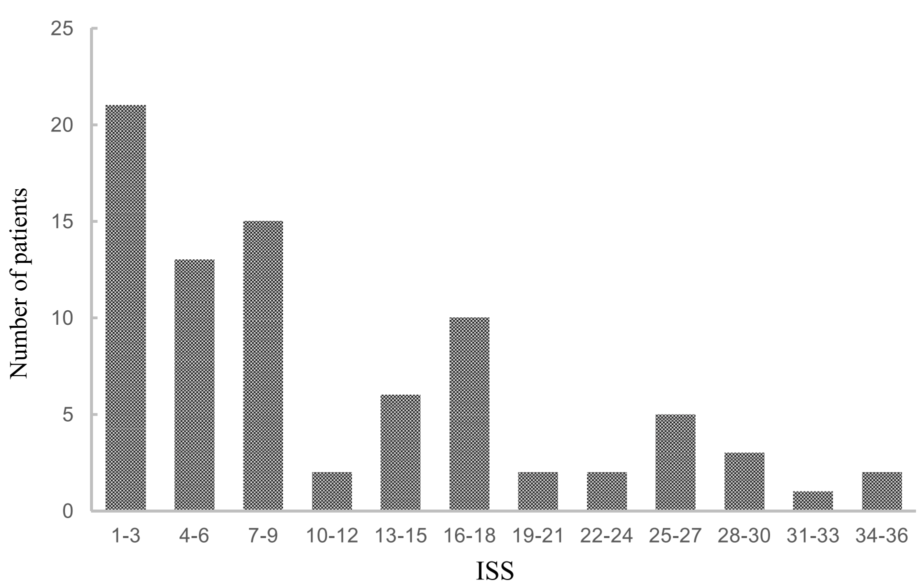

Fig. 1. Distribution of 82 patients based on injury severity score (ISS).

Table 1
Comparison of patients' basic information, ISS and MAIS, mechanism of injury, the prevalence of head injury, polytrauma and operation between long and short hospital and the emergency room stays.

Variables	Overall	Hospital stay (day)			ER stay (day)		
		≤14 (n = 57)	≥14 (n = 25)	p value	≤7(n = 49)	≥7(n = 33)	p value
Age (year), median (IQR)	52 (21–69)	35 (18.5–64)	65 (49–76)	<0.01	39 (19–65)	62 (25–71)	0.04
Female, n (%)	23 (28.0)	17 (29.8)	6 (24.0)	0.59	14 (28.6)	9(27.3)	0.90
MAIS, median (IQR)	3(1–4)	2 (1–3)	3 (3–4)	<0.01	2 (1–3)	3(2.5–4)	<0.01
ISS, median (IQR)	9 (3–16)	5 (1–14)	17 (9–27)	<0.01	5 (1–10)	16 (9–25)	<0.01
Mechanism of injury, n (%)							0.05
Unknown	3 (3.7)	1 (1.8)	2 (8.0)		2 (4.1)	1 (3.0)	
Single collision	27 (32.9)	23 (40.4)	4 (16.0)		20 (40.8)	7 (21.2)	
Collision to bicycle	8 (9.8)	7 (12.3)	1 (4.0)		7 (14.3)	1 (3.0)	
Collision to motorcycle	8 (9.8)	5 (8.8)	3 (12.0)		3 (6.1)	5 (15.2)	
Collision to vehicle	36 (43.9)	21 (36.8)	15 (60.0)		17 (34.7)	19 (57.6)	
Head injury, n (%)	40 (49)	28 (49.1)	12 (48.0)	0.93	23 (46.9)	17 (51.5)	0.07
Polytrauma, n (%)	29 (48)	25 (43.9)	14 (56.0)	0.31	20 (40.8)	19 (57.6)	0.14
Operation, n (%)	13 (16)	0	13 (52.0)	<0.01	4 (8.2)	9 (27.3)	0.02
Length of hospital stay, median (IQR)	5.5 (2–21)						
Length of ER stay, median (IQR)	4.5 (2–12)						

ER: emergency room, IQR: interquartile range, MAIS: maximum abbreviated injury scale, ISS: injury severity score.

Table 2
Results of multiple regression analysis for long hospital stays (>14 days).

Variables	Parameter estimates	F value	p value
Age	0.193	0.059	3.680
Female gender	0.426	0.885	0.021
MAIS	2.976	0.525	0.409
ISS	0.370	0.581	0.307
Mechanism of injury			1.037
Unknown	0.282	0.979	
Single	0.768	0.876	
Bicycle	−8.652	0.204	
Motorcycle	−0.222	0.975	
Car	Control		
Head injury	0.455	0.67	0.028
Polytrauma	−3.199	0.269	1.244
Operation	13.47	0.000	14.276

MAIS: maximum abbreviated injury scale, ISS: injury severity score.

Table 3
Results of the multiple regression analysis for long emergency room stays (>7 days).

Variables	Parameter estimates	p value	F value
Age	0.088	0.119	2.495
Female gender	−0.381	0.815	0.055
MAIS	−2.360	0.364	0.834
ISS	1.279	0.001	11.926
Mechanism of injury			2.262
Unknown	−6.683	0.253	
Single	0.373	0.891	
Bicycle	−4.184	0.268	
Motorcycle	2.873	0.470	
Car	Control		
Head injury	−2.111	0.165	1.972
Polytrauma	−1.052	0.511	0.437
Operation	−1.501	0.463	0.544

hospitalization. Another study examining the factors affecting hospital stays of 7 or more days among injured pedestrians revealed that being 65 or older was a significant risk factor.[18] In the current study, the average age of patients was relatively low (46 years old). Importantly, patients with paralysis, advanced cancer or Alzheimer's disease were excluded from the current study. These factors may have caused the difference between previous reports and the current findings.

The results of simple comparisons between the long and short hospital or ER stay revealed that the mechanisms of injuries tended to influence the duration of hospital and ER stays with p values of 0.06 and 0.05, respectively. The rates of bicyclists involved in collisions with a four-wheeled vehicle were greater in both comparisons (37% *vs.* 60%, 35% *vs.* 58%, respectively). However, in the multiple regression analysis, this factor was not found to be significant. In a previous study of chest injuries, the mechanism of injury was not significantly associated with LHoS.[16] In contrast, according to an analysis of hospitalised bicyclists and motorcyclists by Pai et al.,[18] the prevalence of hospitalization resulting from single-vehicle crashes was higher than the prevalence of collisions with other vehicles. To clarify the relationship between mechanisms of injuries and LHoS/LERS, further analyses with larger sample sizes will be required.

In the present study, we found that approximately half of the bicyclists suffered from head trauma or polytrauma. Bicyclists are at greater risk of injury compared with people in vehicles because the bicyclist's body is fully exposed without the protection of a vehicle's frame and body. Bicyclists often sustain injuries in multiple anatomical regions.[6] A previous study in the ER with both fatal and non-fatal bicyclists showed that 41% of bicyclists had suffered from multiple trauma, similar to our results.[5] Our results are also consistent with previous observations that the head is the most frequently injured body region.[7–9,19] In the current study, because the cases we examined were non-fatal, with higher values of TRISS Ps (median: 98.0%) and a median AIS of the head of 3.5 (IQR: 3–4), the prevalence of head injury and polytrauma did not influence LHoS or LERS.

The current study involved several limitations that should be considered. First, our data were obtained in the Kyoto prefecture, which has the 13th largest population of all prefectures in Japan. In Kyoto Prefecture, vehicle travel velocities are relatively low due to the prevalence of roads with speed limits of 50 km/h or less, and roads within zone 30 (i.e., roads for which the maximum travel velocity is 30 km/h in residential areas). Thus, vehicle travel velocity in rural areas is likely to be higher than that in the Kyoto area. It may be valuable for future studies to examine the characteristics of hospitalization of bicyclists both in rural and urban areas. Second, in this study, we did not examine the status of comorbidity in each patient. Pre-existing diseases are generally associated with longer hospital stays after injury.[20] According to one previous study of the effect of comorbidity on LHoS among unintentionally injured patients, Alzheimer's disease, paralysis, depression and psychosis significantly affect LHoS.[14] As patients with these diseases were excluded from the current study, we believe that our results have higher reliability. Third, the contribution of alcohol or drugs was not examined in this study. These substances can influence the incidence of collisions and may affect the severity of injuries. One previous study suggested that a blood alcohol concentration greater than 0.03% in bicyclists was not a significant risk for hospitalization.[18] Although another study revealed that alcohol abuse affected LHoS, alcohol abuse was not reported in any of the patients in the current study.[14] Thus, we believe this issue did not influence the current results. However, further research may reveal an influence of alcohol or drugs on LHoS of injured bicyclists.

Our findings were based on a retrospective analysis of patient records from one ER in an urban area in Japan. Multiple regression analysis revealed that undergoing an operation significantly influenced LHoS, while ISS significantly influenced LERS. To improve the quality life of the bicyclists, preventive measures for reducing injury severity or avoiding injuries needing operation are required.

Funding

Nil.

Ethical statement

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee (Kyoto Medical Center ethics committee, approval number: 18−052, approval date: Sep 18, 2018) and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Declaration of competing interests

The authors declare that they have no competing interests.

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