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Short Communication

Comparison of the injury severity and medical history of disease-related versus trauma-related bicyclist fatalities

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ABSTRACT

The objective of this study was to clarify the relationship between injury severity and mechanism of death in bicycle fatalities resulting from trauma compared with those resulting from disease, to propose effective measures to prevent fatal bicyclist accidents.

Autopsy and accident records were reviewed for bicyclist fatalities who had undergone forensic autopsy at the Dokkyo Medical University School of Medicine between September 1999 and March 2014. Victims' health histories, blood alcohol levels, causes of death, mechanisms of injury, Abbreviated Injury Scale (AIS) scores and Injury Severity Scores (ISSs) were determined.

Fifty-five bicyclists (43 male and 12 female) with a mean age of 62.5 ± 17.3 years were included in this study. Sixteen victims had driven under the influence of alcohol (mean blood concentration of 1.8 ± 0.7 mg/ml). Mean ISS was 32.4 and the chest had the highest mean AIS score (2.6), followed by the head (2.1) and the neck (1.8). Thirty-nine victims (70.9%) had died of trauma and 16 had died of disease. The disease-death victims had significantly higher prevalence of having diabetes mellitus, hyperlipidemia, hypertension, heart disease or cerebrovascular diseases (50.0% vs. 22.2%, $p = 0.03$) and a lower rate of drunk driving (6.3% vs. 41.0%, $p = 0.01$) than the trauma-death group. All victims who were affected by disease, and 33.3% of trauma-death victims, had fallen on the road without a vehicle collision ($p < 0.001$). The mean ISS of the trauma-death group was significantly higher than that of the disease-death group (44.0 vs. 4.2, $p < 0.001$). Except for facial injuries, the AIS scores were significantly higher in trauma-death victims than in the disease-death group ($p < 0.005$).

To effectively reduce bicyclist fatalities, the authors strongly advocate efforts that will increase compliance with drunk driving prohibitions. For victims of fatal bicycle accidents with a medical history of diseases, a forensic autopsy should be performed to establish a disease-related death while bicycle riding. We must also put into effect preventative safety measures, which take into consideration the physical condition of bicyclists, to reduce the incidence of these types of accidents.

1. Introduction

Road traffic injury is a major public health issue. According to the World Health Organization, 1.3 million people die annually in road collisions worldwide [1]. An overwhelming majority of traffic deaths and injuries involve vulnerable road users, such as pedestrians and bicyclists. In Japan, the number of bicyclist injuries and fatalities in 2014 was 108,538, accounting for 15.2% of persons injured or killed in traffic-related accidents [2]. In addition, bicyclist fatalities accounted for 13.7% of all road traffic fatalities in 2014, an increase from 10.9% in 2000. Based on these trends, the Japanese government emphasized bicyclist safety as one of three strategic objectives of the Ninth Fundamental Traffic Safety Program, which sets up road safety strategies for 2011–2020 in Japan.

In motor vehicle drivers, sudden onset of signs and symptoms of diseases while driving is one of the causes of vehicle collisions [3,4]. In Finland, incapacity of the driver caused by sudden illness was the immediate cause of the accident in 10.3% of fatal motor vehicle accidents [5]. When bicyclists unexpectedly suffer from acute illness, they, as well as other vulnerable road users, may be injured or killed. As the age of bicyclists increases, disease-related accidents may increase in the future. Therefore, detailed analysis of disease-related bicycle accidents is needed to maintain road traffic safety.

In disease-related bicycle fatalities, the accident is not caused by driver error such as delayed recognition, errors in judgment, or mishandling of the vehicle. Therefore, specific preventive

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measures are required for these types of accidents. Furthermore, because forensic autopsies have not been performed for most bicyclist fatalities in Japan, some of sudden deaths while bicycle riding might have been underestimated. To provide a better estimation of disease-related bicycle fatalities, we have clarified the descriptions of accidents, medical statuses and concomitant injuries of the bicyclists suffering from illness while riding. Our study may provide useful information for forensic pathologists who examine bicyclist fatalities and lead to effective interventions that will improve bicyclist safety.

2. Materials and methods

2.1. Data collection

Between September 1999 and March 2014, the Department of Legal Medicine at the Dokkyo Medical University School of Medicine conducted 295 forensic autopsies on traffic accident-related fatalities occurring in Tochigi Prefecture. From these 295 autopsies, bicyclist cases were selected. Cases were excluded from analysis if the victim had obviously not taken a ride and walked with a bicycle or information regarding the object with which the bicyclist collided was unknown. We also excluded cases in which the victim died of a disease that occurred after the accident, because the contribution of the accident to disease onset was undetermined in these cases. In total, 55 bicyclists (43 male and 12 female) were included in this study.

The following data were obtained from each victim's record:

(1) *Physical data:* Age, sex, height and body weight of the victim as measured at autopsy were examined. Past medical history, including a history of medication, was given by relatives and/or police when known.

(2) *Accident details:* We surveyed how and when each traffic accident occurred. Then, we clarified whether the bicyclist collided to a vehicle, or not. The latter cases mean that the victim had lost control of the bicycle and fell without coming into contact with other vehicles.

(3) *Involvement of alcohol:* Blood alcohol level was measured by gas-chromatography. For victims who were pronounced dead at the scene or prior to arrival at the hospital, blood taken at the autopsy was used for analysis. For victims who were admitted to the hospital, blood taken at the emergency room immediately after the arrival was used.

(4) *Injury characteristics:* The cause of death, the anatomical region injured and the type of injury were examined. Cause of death (trauma vs. disease) was used to categorize the victims into two independent groups. Anatomical injury severity was assessed for all victims. The Injury Severity Score (ISS) and the 1990 revision of the Abbreviated Injury Scale (AIS) were calculated for each victim [6,7]. The AIS was used to categorize 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 the squares of the highest AIS score in each of the three most severely injured body regions.

This study was performed under the approval of the Ethics Committee, Shiga University of Medical Science (No. 26-10)

2.2. Statistical analysis

An unpaired *t*-test was used to compare the age, body height and weight of the victims between trauma deaths and disease deaths. A chi-square test was used to compare the rates of male to female, drunk driving and falling on the road between the two groups. A Mann–Whitney test was used to compare the AIS and ISS values with the two groups of victims. The analyses were performed with Stacel 3 for Windows (CMS, Saitama). Differences with a p-value <0.05 were considered statistically significant.

3. Results

3.1. Overview

Continuous variables were summarized by mean ± standard deviation (SD). The victims' ages ranged from 13 to 88 years, with a mean of 62.5 ± 17.3 years. The mean height of the victims was 159.8 ± 10.0 cm, and their mean weight was 58.1 ± 9.9 kg. Twenty-seven victims had medical histories; 25 victims had no previous illnesses, and medical histories were unknown for 3 victims. Among the 27 victims with a known medical history, fourteen victims suffered from lifestyle diseases; hypertension was the most common condition (8 persons), followed by heart disease (5 persons) and diabetes mellitus (4 persons).

3.2. Collision scene

Two victims were wearing a helmet at the time of the collision. Twenty-nine victims had fallen on the road without colliding with a vehicle, and 26 had collided with a passenger or a heavy vehicle. Upon arrival of the emergency crew, 14 victims were pronounced dead and not transported to the hospital; 41 victims (including 36 cardiopulmonary arrests) were transported to the hospital and subsequently died.

3.3. Drunk driving

Ethanol was detected in the blood of 16 victims. The blood alcohol concentrations ranged from 0.8 to 2.8 mg/ml with a mean of 1.8 ± 0.7 mg/ml.

3.4. Cause of death

Thirty-nine victims (70.9%) died of accident-related trauma. Of these trauma cases, brain or cervical spinal injuries were the most common injury (19 victims), followed by thoracic or abdominal injuries (11 victims), drowning (4 victims), hemorrhagic shock (3 victims), and whole body destruction (2 victims). Sixteen victims total died from disease, including heart disease (14 victims) and epilepsy (2 victims). Both helmeted persons died because of heart disease.

3.5. Injury severity

The ISS in all victims ranged from 1 to 75 (average, 32.4 ± 27.0). Sixteen victims (29.1%) had an ISS of less than 10. In comparing injured body regions, the chest had the highest AIS score (2.6 ± 2.2), followed by the head (2.1 ± 2.1), neck (1.8 ± 2.2), abdomen (1.4 ± 1.8), lower extremities (1.4 ± 1.3), face (0.9 ± 0.7) and upper extremities (0.9 ± 0.7).

3.6. Comparison by cause of death

We compared the victim's background, the mechanism of the accident and injury severity between the trauma deaths and disease deaths. First, we compared the physical characteristics of the victims between the trauma and disease groups (Table 1). No significant difference was found between the groups ($p > 0.05$) for sex, age, body height and weight. Using past medical histories, we calculated the prevalence of having diabetes mellitus, hyperlipidemia, hypertension, heart disease or cerebrovascular diseases,