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Injury pattern in lethal motorbikes-pedestrian collisions, in the area of Barcelona, Spain

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ABSTRACT

Introduction: There are several studies about M1 type vehicle-pedestrian collision injury pattern, and based on them, there has been several changes in automobiles for pedestrian protection. However, the lack of sufficient studies about injury pattern in motorbikes-pedestrian collisions leads to a lack of optimization design of these vehicles. The objective of this research is to study the injury pattern of pedestrians involved in collisions with motorized two-wheeled vehicles.
Methods: A retrospective descriptive study of pedestrian's deaths after collisions with motorcycles in an urban area, like Barcelona was performed. The cases were collected from the Forensic Pathology Service database of the Institute of Legal Medicine of Catalonia. The selected cases were categorized as pedestrian-motorcycle collision, between January 1st, 2005 and December 31st, 2014. Data were collected from the autopsy, medical, and police report. The collected information was then analyzed using Microsoft Excel statistical functions.
Results: Traumatic Brain Injury is the main cause of death in pedestrian hit by motorized two-wheeled vehicles (62.85%). The most frequent injury was the subarachnoid hemorrhage, in 71.4% of cases, followed by cerebral contusions and skull base fractures (65.7%). By contrast, pelvic fractures and tibia fractures only appeared in 28.6%.
Conclusions: The study characterizes the injury pattern of pedestrians involved in a collision with motorized two-wheeled vehicles in an urban area, like Barcelona, which has been found to be different from other vehicle-pedestrian collisions, with a higher incidence of brain injuries and minor frequency of lower extremities fractures in pelvis, tibia and fibula.

1. Introduction

Traffic accidents, including pedestrian-vehicle collisions, are one of the leading causes of death in developed and developing countries. In 2005 in the United States more than 64,000 of the injured people were pedestrians,[1] in Germany in 2008, a total of 695 pedestrians were killed and 33.733 were injured.[2] The magnitude of the epidemiologic problem takes even more importance in developing countries, for instance in Ghana 60% of people who died by traffic accidents were pedestrians.[3] Therefore, there are many initiatives undertaken by different institutions to reduce the number of accidents and fatalities involving pedestrians, as well as the severity of the sustained injuries.

In recent years there has been greater awareness in relation to the so-called vulnerable users on the road such as pedestrians, cyclists and two-wheeled motor users.[4,5] The highest incidence of motorcycle accidents are related to the characteristics of the vehicle, such as its high maneuverability or its great power in relation to its weight. Moreover, its high morbidity and mortality are due to both the driver and the passenger due to the lack of body structure and protection in comparison to other vehicles. Additionally, it particularly affects young people, leading to a great loss of labor capacity or loss in life years.[6]

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On the other hand, in relation to pedestrians, awareness is such that the European Union Directive 2003/102/EC of the European Parliament and of the Council from November 17th, 2003 related to the protection of pedestrians, amending Directive 70/156/EEC, has forced the automotive industry to redesign M1 vehicles for their design to be more friendly for the pedestrians in case of collision. This regulation is not intended to avoid any injury in case of impact, but to minimize its consequences in order to prevent unnecessary injuries. These adopted measures consist, inter alia, to increase the distance between the hood and the rigid structures, to include collapsible structures designed to absorb energy, to incorporate energy absorbing elements between the pedestrian and rigid structures, reducing the potential of area being impacted, etc.[7]

Most of the current research has been done on type M1 vehicles. Currently there is a lack of knowledge of the injury patterns in other vehicles such as motorcycles. Is there any difference between M1 injury pattern and motor vehicles with two wheels? Is vulnerability affected by geometric factors, stiffness, size, speed, momentum or a combination of all of them?.[8] It would seem common sense that stiffness, speed and mass are against the pedestrian, since in this type of collision pedestrians are injured in different levels of severity or, as we will discuss in this research, even death. However, there is not legislation for the design of motorcycles to try to minimize the consequences of a pedestrian impact.

It is not difficult to find literature on motorcycle accidents and injuries sustained by the drivers, or about the pedestrian injury pattern from vehicle collisions,[1,2] however it is challenging to find literature relative to collisions of pedestrians struck by motorcycles. The aim of this study is to describe the injury pattern of pedestrians who have been struck by motorcycles that resulted on death, in urban areas.

2. Method

A retrospective descriptive study of pedestrian's deaths after collisions with motorcycles in an urban area like Barcelona was conducted between January 1st, 2005 and December 31st, 2014. The cases were collected from the entire registry of the Forensic Pathology Service database of the Institute of Legal Medicine of Catalonia. The inclusion criterion was to be categorized as pedestrian-motorcycle collision. The data were collected from the autopsy report and complemented with the medical and police files. When the pedestrian was deceased in the site of the accident, a copy of the ambulance assistance report was investigated. In cases that required transfer to a hospital, data from the final medical report were also investigated.

The Pathology Service of the Institute of Legal Medicine of Catalonia performed a total of 12797 autopsies in the studied period of time, from those total cases 837 were categorized as motor vehicle accidents and 300 were pedestrians involved in collisions with any type of vehicle. A total of 38 pedestrians were categorized in the data base as pedestrian's deaths after collisions with motorcycles. After double checking the autopsy reports, medical and police reports three cases were excluded for not meeting the inclusion criteria, in two cases for inaccurate codification and one for fatality not related to the motorcycle collision. The total pedestrians analyzed in this study were n = 35.

Data were collected and analyzed with Microsoft Excel statistical functions. Victim's data collected were: age, sex, date of accident, date of death, hospital admission, cause of death; and injuries sustained on head, neck, upper and lower extremities, thorax, abdominal and back. For the interpretation of the injuries the *Abbreviated Injury Score* (AIS) was used for each reported injury, and from these scores the *Maximum Abbreviated Injury Score* (MAIS) of head, neck, upper extremities, lower extremities, thorax, abdomen, back and general was calculated. Additionally the *Injury Severity Score* (ISS) (sum of the squares of the highest AIS score in the three most severely injured body regions) and the *New Injury Severity Score* (NISS) (the sum of the squares of the highest AIS score regardless of the body region in which they occur) were calculated.

3. Results

A total of 35 pedestrian fatal cases were collected, 18 men and 17 women, with an average age of 67.4 ± 22.7 years for women and 72.3 ± 15.2 years for men.

From the 35 pedestrians, 91.4% ($n = 32$) of the cases received hospital treatment while the other three people died in the crash site. Those who received hospital care, 80% died the same day of the accident or the next day; and those who survived beyond two days had an average hospital stay of 4 days. The results are presented in Table 1.

The most important cause of death was Traumatic Brain Injury (TBI) in 62.9% of the cases, followed by hypovolemic shock in 20% of the cases, and a combined thoracic and brain trauma in 5.7% of the cases (Table 2).

When the cause of death reported in the autopsy was TBI, the MAIS was the punctuation of the head (except in two cases, cases 11 and 16, where the cause of death was the TBI but had an equal MAIS for head and thorax) whereas when the cause of death was the hemorrhage the MAIS was the one found in lower extremities, thorax and/or abdomen.

The pedestrians died from injuries sustained in the accident in all the cases, except in one of the cases, whose cause of death was pneumonia as a complication of injuries after a long hospital stay.

The 31.4% of patients sustained an AIS 5 on the head and 91.43% sustained severe injuries with AIS 3 + in this anatomical region. The next often anatomical regions injuries with an AIS 3 + were the thorax (45.7%) and the lower extremities (20%). According to the MAIS, 40% had a MAIS 5 + and 60% had a MAIS 4+, and only one case (2.85%) was coded as MAIS 6 due to a thoracic aortic rupture.

The average calculated ISS was 27.7 ± 13.4. The ISS median was 27, with data between 9 and 75. A significant variation was observed regarding the NISS, with an average of 36.2 ± 13.9 and a median of 34, with data also between 9 and 75 (Table 2). It should be noted that pedestrians with highest scoring both at ISS and NISS presented the most serious injuries in thoracic and abdominal areas.

Using additionally the AIS categories 9–15 for moderately injured patients, 16–24 for severely injured patients and 25–75 for critically injured patients, a total of 5 pedestrians were included in the 9–15 (14%), 9 included in the 16–24 (26%) and 21 pedestrians in the category of critically injured patients 25–75 (60%).

The main injuries grouped by anatomic region can be observed in Table 3.

The most frequent injuries found (Table 3) were derived from TBI, specifically subarachnoid hemorrhage in 71.4% of cases, followed by cerebral contusions and skull base fractures (65.7%) and

Table 1
Time lapsed from the accident to the death. Note: the fatalities during the same day include the 3 fatalities at scene.

Fatality event	n	%
Immediately/at scene	3	8,6
During the same day	18	51,4
Next day	10	28,6
≤7 days	6	17,1
≤30 days	1	2.9
Total	35	100