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## Deaths from Motorcycle Accidents: An Autopsy Study from Turkey

الوفيات الناجمة عن حوادث الدراجات النارية: دراسة تشريحية من تركيا

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Original Article

### Abstract

Motorcyclists and pillion passengers in road traffic accidents have an increased risk of morbidity and mortality because of lack of adequate safety systems. The purpose of this study was to analyze the injuries sustained by motorcycle riders and pillion passengers in fatal motorcycle accidents.

A total of 56 cases autopsied in the Istanbul Morgue Department of the Council of Forensic Medicine were included in this study.

The majority of the cases were young males. Fifty (89.3%) cases were riders and six (10.7%) were pillion passengers. The vast majority (78.6%) of the cases died at the scene or on the same day in hospital. Most of the cases had multiple traumas, and the most common trauma was head trauma ( $n = 45$ ). The most common injury was intracranial hemorrhage ( $n = 40$ ). Fifteen (26.8%) cases tested positive for drug and/or alcohol intake.

These autopsy findings can be helpful for medicolegal examinations to diagnose possible injuries and also for the automotive industry to improve better protective safety devices for motorcycle riders.

### المستخلص

يزداد خطر حدوث الإصابات والوفيات في حوادث الدراجات النارية عند السائقين والمرافقين بسبب افتقارها إلى نظم السلامة الملائمة. وكان الغرض من هذه الدراسة تحليل الإصابات التي لحقت بسائقين الدراجات النارية ومرافقيهم في حوادث الدراجات النارية القاتلة.

أدرج في هذه الدراسة ما مجموعه 56 حالة تم تشريحها في إدارة مورغ اسطنبول التابعة لمجلس الطب الشرعي. وكانت غالبية الحالات من الذكور الشباب. وكانت خمسين حالة من السائقين وستة من الركاب في المقعد الخلفي. توفيت الغالبية العظمى (78.6%) من الحالات في مكان الحادث أو في نفس اليوم في المستشفى. معظم الحالات عانت من صدمات متعددة، ولكن الصدمة الأكثر شيوعاً كانت صدمة الرأس (45 حالة)، وكانت الإصابة الأكثر شيوعاً نزيفاً داخل الجمجمة (40 حالة). وأعطت 15 حالة (26.8%) نتائج إيجابية لفحص المخدرات و/ أو تناول الكحول.

يمكن أن تكون نتائج التشريح هذه مفيدة لفحوص الطب الشرعي لتشخيص الإصابات المحتملة وأيضاً لصناعة الدراجات النارية بهدف تحسين أجهزة السلامة الوقائية.

**Keywords:** Forensic Sciences, Forensic Medicine, Motorcycle Accident, Autopsy, Injury.

الكلمات المفتاحية: علوم الأدلة الجنائية، الطب الشرعي، حادث دراجة نارية، تشريح الجثة، الإصابات.



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## 1. Introduction

Compared to car drivers, motorcycle riders and pillion passengers have an increased risk of serious injury and death [1-3]. Despite this fact, the number of motorcycles is increasing all over the world, especially in developing countries [4]. The low price of motorcycles, low fuel costs, possibility of faster transportation, increase in socio-economic levels, and using heavy motorcycles for leisure could be factors responsible for the increasing number of motorcycles [2,4]. Increase in motorcycle numbers raises the number of accidents. A study from Brazil reported that the proportion of deaths from motorcycle accidents increased by 820% between 1996 and 2007 [5]. Another study also showed that there was a significant increase in the number of deaths of motorcycle riders over time, increasing from 7.3% in 1995 to 31.5% in 2010 [6].

The 2007 Traffic Legislation of Turkey makes it mandatory for motorcycle riders to wear helmets and protective glasses and pillion passengers to wear helmets [7]. Since helmets and protective garments are the only protective measures for motorcycle riders and pillion passengers, they have an increased risk of mortality and morbidity in the event of an accident than car drivers and passengers [8]. Although the use of helmets and safety equipment is mandatory in Turkey and in several other countries, these rules are frequently ignored by motorcycle riders [4].

Accident mechanisms and sociodemographic features of individuals killed in fatal motorcycle accidents have been reported in the literature; however, there are not many studies from Turkey [9].

The aims of this study were to analyze the epidemiologic features of the individuals killed in motorcycle accidents, to define the causes of death, to determine the frequency of injuries in order, to be a guide for clinicians and to draw attention to this subject to reduce the number of fatal motorcycle accidents.

## 2. Materials and Methods

Cases of motorcycle and all-terrain vehicle (ATV) (which can be used with a motorcycle license in Turkey) crashes autopsied in the Istanbul Morgue Department of

the Council of Forensic Medicine from December 1st 2013 to August 1st 2014 were included in this study. Data regarding the riders and/or pillion passengers involved in the crashes were collected, while occupants from other vehicles that might have also been involved in the same crash were excluded. A total of 56 cases were included in this study.

Istanbul is the most crowded and cosmopolitan city in Turkey. All medicolegal autopsies are performed in the Istanbul Morgue Department of the Council of Forensic Medicine. Starting from December 1st 2013, data were collected; age, sex, time and place of accident, time and cause of death, medical data, type of injuries, blood alcohol and drug levels were recorded from the autopsy reports. The recorded injuries were grouped into head/face/neck injuries, chest and abdominal injuries, bone fractures, and peripheral artery injuries.

## 3. Results

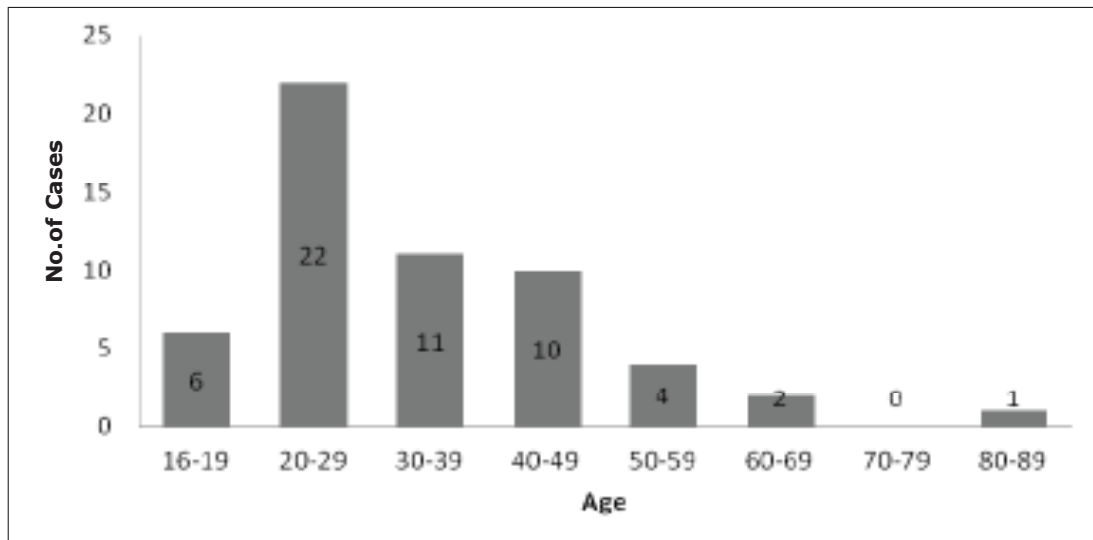
During the 9-month period between December 2013 and August 2014, a total of 56 autopsies were performed. There were 54 males (96.4%) and 2 females (3.6%). Both the female cases were pillion passengers. In total, 6 cases were pillion passengers and 50 were riders. Three cases died as a result of ATV accidents. The mean age was 33.4 years, with a range of 16–80 years, and 39.2% ( $n = 22$ ) of the cases were aged 20–29 years. Distribution of age groups is shown in Figure-1.

Of the 56 cases, 29 (51.8%) occurred during weekends and on official holidays while 27 (48.2%) occurred on weekdays. Time of the accident was not recorded in the legal documents for 13 cases, while 20 accidents occurred between 08:00 am and 04:00 pm, 15 occurred between 04:00 pm and 12:00 midnight and 8 occurred between midnight and 08:00 am.

Excluding 17 cases, for which the accident type was not recorded, the most common cause of accidents was a collision with a different vehicle ( $n = 23$ ). Another 16 cases were accidents caused by the motorcycle rider, such as hitting a parked car, hitting a tree, and rollover.

Regarding the number of deaths, 27 (48.2%) died at the





**Figure 1-** Distribution of cases according to their age groups (Years).

scene, 17 (30.4%) died in hospital on the same day, and 12 (21.4%) died in hospital after a certain period of hospitalization (2 days to 2 months). The overall proportion of cases that died at the scene and the cases that died at the hospital on the same day was 78.6%.

Alcohol and substance use assessment via blood investigations was not performed at the Morgue Department for 8 cases that died in hospital after more than 5 days of hospitalization. Out of 48 cases, blood alcohol was positive for 11 cases, and the blood alcohol levels were 50–100 mg/dl ( $n = 2$ ), 100–200 mg/dl ( $n = 5$ ), 200–300 mg/dl ( $n = 3$ ), and >300 mg/dl for one case. Two of the eleven positive cases were also positive for substance use. In addition, there were four cases positive for drugs but negative for blood alcohol. Six cases were positive for drugs, and the substances found in the blood included Tetrahydrocannabinol Carboxylic Acid (THC-COOH) in three cases, 1-pentyl-3-(1-naphthoyl)indole (JWH 018) in one case, morphine in one case, and 3,4-Methylenedioxyamphetamine (MDMA) in one case.

Unfortunately, information regarding wearing a helmet and protective garments was not recorded in most of the scene reports. It was found that only eight cases were wearing protective garments and five were wearing a helmet.

The most common injury was head and neck trauma, comprising 45 of the 56 cases. Bone fractures were also common; 34 of the 56 cases had extremity bone fractures.

Details regarding the injuries of the cases are shown in Table-1.

#### **Head/Face/Neck Injuries**

Head, neck, and/or facial injuries are shown in Table-1. Skull fracture, brain injury, and intracranial hemorrhage occurred together in 27 cases, of which 7 did not have any other injuries. Of the 27 cases, 8 had a fracture of cervical spine in addition to a skull fracture, brain injury, and intracranial hemorrhage.

#### **Chest Injuries**

Twenty-five cases had thoracic organ or vessel injury. Two cases had rupture of superior vena cava and rupture of the thoracic aorta (Table-1).

#### **Bone Fractures**

Thirty-four cases had fracture of pelvis and/or extremity bones. In addition to pelvic bone fractures, the most common was the fracture of the femur (Table-1).

The cause of death in 53 cases was found after the autopsy and the pathological and chemical investigations. In order to determine the cause of death for the other three cases, they were sent to the 1st Specialization of the Council of Forensic Medicine, which has specialists of Forensic Medicine, General Surgery, Pathology, Pediatrics, Internal Medicine, Cardiology, Neurosurgery, Anesthesiology and Reanimation, and Obstetrics and Gynecology. The cause of death according to body parts is shown in Table-2.

**Table 1-** Types of injuries in the observed cases \*

Injury Type	n
<b>Head/Face/Neck Injuries</b>	<b>45</b>
Intracranial haemorrhage	40
Cerebral injury	30
Fracture of skull	35
Fracture of cervical spine	15
Fracture of facial bones	14
<b>Chest Injuries</b>	<b>25</b>
Fracture of ribs	23
Lung injury	22
Haemothorax	20
Fracture of sternum	15
Rupture of thoracic aorta	10
Myocardial injury	9
Pneumothorax	6
Pericardial tear	6
Fracture of Thoracic spine	3
Tear of superior Vena cava	2
<b>Abdominal Injuries</b>	<b>20</b>
Liver injury	14
Splenic rupture	7
Renal injury	3
Diaphragmatic tear	2
Fracture of lumbar spine	2
Superior mesenteric artery tear	1
Bladder rupture	1
Pancreatic injury	1
<b>Bone Fractures</b>	<b>34</b>
Pelvic fracture	14
Femur	12
Tibia	9
Humerus	9
Radius-Ulna	8
Clavicle	6
Scapula	3
Hands	3
Fibula	2
<b>Peripheral Artery Injuries</b>	<b>1</b>
Subclavian artery	1
External carotid	1

\*Many patients had more than one injury so the total number of injuries are more than the total number of cases.

#### 4. Discussion

While motorcycles are used for leisure activities in developed countries, they also offer an inexpensive and a fast mode of transportation. These are the major reasons for motorcycle use in developing countries [10]. The use of

**Table 2-** Cause of death due to injuries on different body parts.

Part of the body	n (%)
Head-neck	19 (33.9)
Head-neck+Thorax	10 (17.8)
Head-neck+Thorax+Abdomen	9 (16.1)
Head-neck+Abdomen	6 (10.7)
Thorax+Abdomen	6 (10.7)
Abdomen	3 (5.4)
Thorax	3 (5.4)
<b>Total</b>	<b>56</b>

motorcycles is increasing gradually in Turkey, as in other parts of the world [9]. Due to the increase in motorcycles, the number of motorcycle accidents and deaths due to accidents is also increasing [11]. Motorcycle riders are 34 times more at risk of death than people using other forms of transport [12].

Motorcyclists can be divided into two groups; the first group comprises people who ride smaller motorcycles as an easy and inexpensive mode of transport and the second group comprises people who use larger (bigger engine size) motorcycles for leisure activities. It has been noted that the second group of riders are generally middle-aged, wealthier, have driving licenses and motorcycle driving education, and take care to use protective garments and helmets all the time [13-15].

In Turkey and also in some different countries, motorcycles are commonly used for quick and inexpensive transportation purposes, and young and inexperienced people are being employed to ride them [11,13,16]. Like most of the studies about motorcycle accidents, this study also showed that those who were killed in motorcycle accidents were young males [4-11, 17-19]. Being inexperienced and riding motorcycles fast increases the risk of accidents [20]. Riding a motorcycle needs physical coordination, balance, and instantaneous deflection, and gaining these skills needs



experience [14, 21]. A study from New Zealand reported a strong relationship between increased driver age and decreased risk of moderate to fatal injury and noted that experience and familiarity with a specific motorcycle offers added preventive benefits [22]. A study from Malaysia also showed that most motorcycle accident victims have no license or have had a license for less than 5 years, are inexperienced and learn to ride a motorcycle by themselves [18]. Different studies have revealed that young and inexperienced motorcycle drivers lack appropriate riding skills, exhibit dangerous and risky behaviors, and disobey traffic rules when riding a motorcycle [18, 20, 21, 23, 24].

Two (3.6%) cases in this study involved women, and both were pillion passengers. Two studies from Iran noted that the male-to-female ratio of fatal motorcycle accidents was 28 and the male-to-female ratio of hospitalized victims of accidents was 16 [19, 25]. Sexual diversity among traffic accident victims is higher in developing countries. Generally, women follow traffic rules more than men, they take all the necessary measures such as wearing a helmet or protective garments, and they usually ride the motorcycle for shorter distances. It can also be assumed that men ride a motorcycle more carefully when they have a pillion passenger.

It has also been noted that the economic status of riders affects accidents and riders with a lower socioeconomic status have an injury risk 2.5 times more than that of people with a higher socioeconomic level [13, 15].

Another factor responsible for motorcycle accidents is alcohol use and high speed. Studies show that one of the major factors responsible for fatal motorcycle accidents is an intake of alcohol [1, 4, 12]. Alcohol consumption can cause distraction, loss of concentration, and can also induce behaviors that reduce safety, such as riding a motorcycle without wearing a helmet or excessive speeding [10, 15, 26, 27]. Moreover, it was shown that alcohol use is the strongest determinant of a severe outcome of accidents; balancing and coordination on a motorcycle are more important than on other motor vehicles, and hence motorcycle drivers must be alcohol-free. A study from Brazil showed that 42.2% of people killed in a motorcycle

accident tested positive for blood alcohol, with the mean level being 0.62 mg/dl [4]. In China, this ratio was 12.8% [10]. In the present study, blood alcohol and/or drugs were positive in 15 (26.8%) cases. It is obvious that the use of drugs and alcohol makes motorcyclists vulnerable to fatal accidents, and more than a quarter of cases were under the influence of alcohol and/or a drug.

Motorcycle riders and pillion passengers are disadvantaged by the lack of safety equipment such as seat belts and airbags [28]. That is why in most of the accidents, the riders or passengers suffer various injuries, from mild to severe, and these injuries are often seen in multiple parts of the body [4]. Categorizing the most serious and fatal injuries is not simple in these types of accidents, and hence in such case the most fatal injuries as the cause of death can be acceptable [3]. In this study, it was found that only nine cases had major injuries on an isolated body part along with mild injuries on the other parts of the body as well. Most victims of fatal accidents cannot reach a hospital in time and thus die at the scene [4, 19, 29]. Consistent with this, in the present study also, nearly 78.6% of the deaths occurred at the scene and in hospital on the same day. The longest hospitalization period recorded in the present study was 2 months.

Head trauma was found to be the most common injury in most of the studies (4, 12, 19, 30-32). A proper helmet is the most important piece of safety equipment for riders and passengers during an accident. It has been reported that helmet use decreases morbidity by 70% and mortality by 40% (28). Brain injury, intracranial hemorrhage, face and skull fractures, and cervical spine fractures are the most common in those who do not use proper helmets (30, 33). Serious injuries are inevitable if the crash is severe, irrespective of whether the helmet absorbs it, and this can be explained by the severity of trauma dynamics (4). Helmets change the applied force to the head, but high forces still cause skin, muscle, and brain injuries (30). Although helmet use is mandatory, head trauma has been found to be the most common injury in different countries (4, 12, 30). Intracranial hemorrhage was a major indicator of mortality in some studies (29, 31). In the present study, out of the



56 cases, 45 cases were with head/face and neck injuries and the most common injury was an intracranial hemorrhage. The majority of the cases with cranial trauma died at the scene, which implies that taking precautions is more important than improving treatment (31). Helmets must be standardized for optimal protection; however, a proper helmet can itself be the cause of death, as shown in a case report in which the chin strap, after a violent movement of the head, caused partial decapitation (34). In this study, there was limited information about helmet use in the pre-autopsy legal documentation. Helmet use was recorded in five cases and was unknown in others. Of these five cases, two were alcohol-positive and one was positive for drugs. Two of them died of head and thorax trauma; another two died of head, thorax, and abdominal trauma; and one case died of head trauma.

Trauma to the neck is also common. Kasantikul et al. reported that occult neck injuries, such as hemorrhages in the carotid sheath or surrounding the vertebral arteries, phrenic nerve, or brachial plexus, and sometimes more serious injuries to the cervical vertebrae or spinal cord were found in both helmeted and unhelmeted motorcyclists (35). They also found serious tissue injuries even in the absence of external trauma on the neck (35). This finding indicates that clinicians should be careful regarding neck injuries.

The thorax and abdomen are also associated with a high risk of fatal injuries (10, 36). Thoracic and abdominal organs must be protected, in addition to wearing a helmet and protective garments, while riding a motorcycle so as to reduce the risk of injury to the thoracic and abdominal organs. However, according to a study from Turkey, protective garments (jackets, pants, shoes, and gloves) were not found to be protective for organ injuries or extremity fractures, with the exception of soft tissue injuries (33). De Rome et al. also noted that wearing protective garments reduces hospitalization and occurrence of open wounds but does not affect the occurrence of extremity fractures (2). Similar to helmet use, information regarding wearing protective garments was not recorded in the legal documentation. Nevertheless, there were eight cases wearing protective garments, and seven of them had fractures of sternum,

rib, or vertebrae.

Early diagnosis of thoracic and abdominal traumatic injuries is important to reduce mortality (31). According to Doyle et al. lower extremity, upper extremity, and head and thorax are the most affected regions in the accidents, and head and thorax injuries are fatal (37). Rib fractures may not be fatal, but they were the most common injuries after head injuries in the present study. This is in agreement with other studies that also reported that rib injuries were the most common injuries among motorcycle riders (27, 38).

Falling from a motorcycle while riding fast can cause rib fractures, visceral damage, and liver and spleen injuries (3). Liver injuries were the most common injury of abdominal traumas. Ankarath et al. observed that only a quarter of the liver injuries were fatal, and bleeding was found to be the major cause of death for abdominal traumas (31). Abdominal and pelvic region injuries were seen less frequently than head injuries, but they may be difficult to diagnose. Because of the structure of the abdominal wall, blunt traumas can cause serious internal injuries without any external evidence of injury; hence, it is important to make an accurate and early diagnosis.

Long bone fractures along with pelvic fractures are still among the most devastating musculoskeletal injuries being associated with high mortality and morbidity, despite head, thorax, or abdominal injuries (31). In the present study, there was a case with iliac crest and acetabulum fracture who died 2 months after the accident because of the complications due to this fracture. Lower extremity fractures increase morbidity and hospitalization (39). Crash bars can be useful for protecting the legs; however, in a crash, they can trap the legs (3). In two different studies, one of them reported that crash bars can be effective for lower extremity injuries, and the other one claimed that crash bars are not effective [39-40].

## 5. Conclusion

Motorcycle accidents mostly affect young men and cause very severe injuries. Although helmet use is mandatory, head injuries are the most common injuries. There must be a standard for the helmets and their appropriate



use. Traffic controls must be increased and fines must be deterrent. Thoracic and abdominal traumas can also be very serious. Long bone fractures with pelvic injuries increase morbidity, and early diagnosis of injuries in these regions can influence the results. Therefore, the pelvic region must be examined very carefully after the accident. Most of the cases died at the scene, which shows the severity of the injuries.

Motorcycle accidents can cause serious morbidity and economic loss. Motorcycle riders and also pillion riders must be trained carefully in preventive measures. In addition, like bicycle lanes, special roads for motorcycles can reduce the number of accidents. Motorcycling is a high-risk activity, and the person involved in this activity for any reason should be careful and take all preventive measures.

### Limitations

When a fatal motorcycle or motor vehicle accident occurs, the police first arrive at the scene, and they inform the prosecutor and doctor. The doctor examines the body and the prosecutor talks to the witnesses. Then they prepare a pre-report for autopsy and the report is sent to the Council of Forensic Medicine along with the body. In the present study, unfortunately, there was not sufficient information about the helmets or the garments of the motorcyclists. As a result, the relationship between protective garments and injuries could not be determined for all cases.

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### Conflict of interest

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