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Traumatic fatal aortic rupture in motorcycle drivers

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ABSTRACT

Traumatic fatal aortic rupture (FAR) is a common finding in victims of motor vehicle crashes (MVC), but its aetiology and mechanisms of production remain an issue of major concern, above all in motorcyclists. This study reports a series of cases obtained from a retrospective analysis of traumatic FARs occurring in motorcycle drivers, with the aim of defining the injury patterns and correlating them with the mechanisms of FAR production.

Circumstantial, autopsy and histology data were collected through a retrospective analysis of post mortem examinations performed at the Institute of Legal Medicine of the University of Padova between 2014 and 2016. Among 151 traffic related victims, 8 were motorcycle drivers and displayed traumatic FAR and were thus included in the study.

In 7 cases, the presence of abdominal/thoracic injuries suggested that the external compression due to the accident was at least a concurrent cause of FAR, being the predominant mechanism of aortic injury in 4 cases, through the "osseous pinch" or the "waterhammer effect" mechanisms. Our study highlights the well-known role of "preventative forensic pathology", which has become routinary in traffic medicine since many years, also for defining the points of impact and the injury patterns of motorcyclists sustaining traumatic FAR, thereby facilitating the development of new prevention strategies and devices. Further studies, however, are needed in order to widen the investigated population and to estimate the real number of victims for which traumatic FAR might hypothetically be prevented with specific countermeasures.

1. Introduction

Motorcyclists exhibit a higher risk of motor vehicle crashes (MVC) compared to other drivers, and fatal accidents occur most frequently as a consequence of severe head and/or thoracic trauma with multiple visceral injuries [1–4].

Beside brain injuries and trauma to the brainstem and upper cervical spinal cord, fatal aortic rupture (FAR) is a common cause of rapid death, whose incidence and mechanisms of production have been fully investigated in car driver fatalities, but less studied in motorcyclists [5–8]. The significance of the problem has also been underlined in a specific session dedicated to Thorax Injuries at the 2016 International Research Council on Biomechanics [9], where Otte et al. [10], in a series of 142 FAR occurred in MVC victims, reported that the majority of aortic lacerations involved car occupants (53,3%), followed by pedestrians (19,0%), motorcyclists (16,9%), cyclists (7,8%) and truck occupants (2,8%). In 2002, Kraus et al. [11] reported a frequency of FAR of 15,4% calculated on 548 fatal motorcycle crashes, while Teixeira et al. [12], in a population of 24 dead motorcyclists, reported a frequency of thoracic FAR of 29%. Ankarath et al. [13], in 2002, given the high mortality at the site of the accident, observed a FAR frequency of only 2,8% in motorcyclists admitted to the hospital. These data highlight that FAR is still an issue of major concern in motorbike accidents, and that a high percentage of victims die at the scene [4]. Although reported in previous studies, the aetiology of traumatic FAR in motorcyclists has been investigated less than those in car occupants, and effective strategies aimed at preventing FAR or at least at extending the survival time, allowing the victims to reach the emergency service, are urgently needed [13,14].

The concept of forensic pathology intended as "preventative forensic pathology", has become routine, especially in traffic medicine, since forensic autopsies allow the documentation of all

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external and internal injuries with their mechanisms of production, the identification of the cause of death, as well as the reconstruction of the points of impact and the most probable dynamics of the fatal event, hopefully useful for developing new prevention strategies and devices [15–18].

In this paper we report a case series obtained from a retrospective analysis of traumatic FARs concerning motorcycle drivers, with the aim of defining external/internal injury patterns and correlating them with the mechanism of production of FAR in order to improve the knowledge, implementation and development of focused prevention strategies.

2. Methods

A retrospective analysis of post-mortem examinations, searching for traffic related deaths with "aortic laceration" or "traumatic aortic rupture", was carried out at the Institute of Legal Medicine of the University of Padova between January 2014 and December 2016. Eight (8) out of the 151 traffic related victims were motorcycle drivers and displayed traumatic FAR and were therefore included in the study.

For each case the following data were assessed: age of the driver; vehicle; type of collision according to the classification used by Peek-Asa and Kraus [19] (Approach turn, Single vehicle, Same direction, Different direction, Head on[1]); speed of the motorcycle at the time of the collision estimated by the police through the analysis of the length of skid marks and the amount of damage received by the vehicle(s); parts of vehicle(s) damaged in the collision; protection devices used by the motorcyclist; presence and localization of external/internal fractures and injuries; localization of aortic rupture/s; type of the traumatic aortic rupture/s according to the classification proposed by Prijon and Ermenc [16]; signs of vital reactions (haemorrhagic infiltration of the vascular wall and soft tissues near to the aortic injury); presence and quantification of any hemothorax and hemoperitoneum; previous pathologic alterations of the aorta; cause and timing of death.

3. Results

All the victims died at the scene without any attempts at cardiopulmonary resuscitation. For each case, the age of the driver, the type of motorcycle involved, the type collision, the estimated speed of the motorcycle at the time of the collision, the protection devices used, the parts of vehicle(s) damaged, the localisation and characteristics of external/internal injuries and/or bone fractures, the presence and magnitude of hemothorax/hemoperitoneum, the localisation and type of traumatic aortic rupture and the cause of death are reported in Table 1. Moreover, the type of collision and the parts of vehicles involved in the accident are reported in Fig. 1. The sites of all external/internal injuries, bone fractures and FARs, along with a picture of the aortic lacerations are depicted in Fig. 2. In all cases histological examination excluded any previous alterations of the aorta, and identified haemorrhagic infiltration of the lacerated vascular walls in the absence of inflammatory reaction. A summary of each case study is provided below.

3.1. Case A

A 35-year-old man riding a scooter (150 CC) and wearing the helmet and a protective jacket (spine, shoulder and elbow protectors), collided with a small family car which was travelling in the opposite direction and turned left into the lane of the motorcycle (Fig. 1A). After the collision, which involved the front of the scooter and the right anterior side of the car (fender), the body of the victim struck the anterior pillar and was then thrown to the ground. The main autopsy findings were skull and rib fractures; lung, spleen and left kidney injuries; a type IIA laceration of the supravalvular ascending aorta (Fig. 2A and a); hemothorax (1,5 l) and hemoperitoneum (0,5 l). The estimated speed of the scooter was 60–80 km/h.

3.2. Case B

A 50-year-old man riding a moped (50 CC) and wearing a helmet, after travelling through a red light at a cross-road, collided with the left side of a small family car (anterior door, body side molding; Fig. 1B). After the collision, the motorcyclist was thrown over the hood and did not come into contact with the car involved in the crash. The main autopsy findings were skull, rib, left arm, forearm and leg fractures; lung, liver and spleen injuries; a type IIA rupture of the supravalvular ascending aorta (Fig. 2B and b); hemothorax (1,5 l) and hemoperitoneum (0,2 l). The estimated speed of the moped was 60–70 km/h.

3.3. Case C

A 54-year-old man riding a motorbike (500 CC) and wearing a helmet and a protective jacket (spine, shoulder and elbow protectors), was involved in a frontal collision with a city car, which had changed its lane while passing another vehicle (Fig. 1C). The collision involved the front of both vehicles. After crashing with the bumper of the car with the front of the vehicle, the body of the victim collided with the hood and the windshield of the car and was then thrown to the ground. The main autopsy findings were skull, rib and left forearm fractures; lung, liver and spleen injuries; a type IIA rupture of the supravalvular ascending aorta (Fig. 2C and c); hemothorax (1,5 l) and hemoperitoneum (0,4 l). The estimated speed of the motorbike was 90–140 km/h.

3.4. Case D

A 50-year-old man riding a scooter (150 CC) and wearing a helmet collided with a station wagon, which was travelling in the opposite direction and turned left into the lane of the motorcyclist (Fig. 1D). The collision involved the front of the scooter and the right side of the car (fender, anterior pillar and anterior door). The back of the victim struck the anterior pillar of the car, after a rotation motion, and then was thrown to the ground. The main autopsy findings were rib and vertebral fractures; lung and liver injures; a type IIIB rupture of the distal descending aorta (Fig. 2D and d); hemothorax (1,5 l) and hemoperitoneum (1 l). The estimated speed of the scooter was 40–60 km/h.

3.5. Case E

A 51-year-old motorcyclist riding a scooter (400 CC) and wearing the helmet lost control of his vehicle a few meters before arriving at a crossroad and fell to the ground, continuing his forward motion (Fig. 1E). Both the scooter and the motorcyclist collided with the right anterior wheel of a refrigerated truck. The main autopsy findings were mandible, rib and left forearm fractures (Fig. 1E and e); liver and kidney injuries; a type IIB

[1] Approach turn: collision that occurs when one vehicle proceeding straight collides with a vehicle travelling in the opposite direction turning into the path of the first vehicle; Single vehicle: the motorcycle is the only moving vehicle; Same direction: two vehicles travelling in the same direction collide, includes rear-end and sideswipe crashes; Different direction: two vehicles travelling in the same direction collide at angle.