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CASE REPORT

PATHOLOGY/BIOLOGY: ENGINEERING SCIENCES

Francesco Brandimarti,[1] *M.D.; Ilenia Giacomini,*[1] *M.D.; Barbara Fraternale,*[1] *M.D.; Raffaele Giorgetti,*[1] *M.D.; and Adriano Tagliabracci,*[1] *M.D.*

Massive Lesions Owing to Motorcyclist Impact Against Guardrail Posts: Analysis of Two Cases and Safety Considerations*

ABSTRACT: Two motorcycle riders lost control of their vehicle, fell, and hit a guardrail, which acted as a blade and led to a rapid, fatal outcome. In one case, the high velocity of the body at the time of the impact resulted in complete detachment of the trunk. Reconstruction of the accident dynamics enabled the guardrail post to be identified as the means of injury in both cases. The two accidents occurred over a short period of time, highlighting a dangerous phenomenon that in less severe cases is presumably associated with different degrees of survivor disability. The accidents deserve mention, because a different design of the impact surface of the guardrail post might have prevented the lethal outcome. There is an urgent need for legislators to pass regulations that modify crash barrier homologation criteria, which have been devised primarily for the safety of car passengers but fail to protect motorcyclists.

KEYWORDS: forensic science, forensic pathology, guardrail, road safety, traffic accidents, motorcycles, motorcyclists

Road accidents are among the most significant causes of disability and mortality in industrialized as well as in developing countries. Motorcycles, though accounting for a fraction of the vehicle fleet, are vastly over-represented in road accidents. Mileage being equal, the risk of death for motorcyclists in Europe is 18 times that of other road users (1).

It is common for motorcyclists to sustain accidents because of loss of control of the vehicle, which may be followed by a collision with other vehicles, trees, lampposts, kerbs, traffic signals, and concrete barriers or guardrails. The latter are the second most frequent collision objects (2). In France and Austria, 4.7% of motorcycle accidents involving injury or death entail guardrail impacts, with mortality rates ranging from 9.75 to 15% (3).

Guardrails are roadside barriers installed to contain errant vehicles and reduce the severity of off-path collisions. Different models are mounted on different roads, but most consist of one or two parallel, continuous metal beams having a W-shaped section, designed to absorb the kinetic energy of impacts. The beams are screwed to vertical metal posts, directly or through distancers. There are several types of posts. Some have a □-shaped section, with the long limb facing the road (Fig. 1). Posts have been recognized as the most dangerous portion of the guardrail system for motorcyclists (2). Their small surface and narrow edges mean that the kinetic energy of a body striking a post is concentrated on a small area, inevitably resulting in severe injury.

In 2008, there were about 5,900,000 registered motorcycles in Italy (>50 cc), accounting for 12.2% of a ca. 48 million-strong vehicle fleet (4). It has been estimated that in the United States, where motorcycles are a mere 3% of the vehicle fleet, motorcyclists account for 42% of fatalities because of guardrail impacts (5). It is therefore reasonable to assume that the proportion is much higher in most of the other countries, Italy included. Analysis of the data regarding the risk of death owing to guardrail impacts yields very different figures for motorcyclists and car occupants, with one fatality in every eight riders sustaining a guardrail impact compared with ca. 1/650 for car occupants, representing an 80-fold higher risk (5). There are several reasons for the difference, first of all the structural cage and the restraints fitted on cars. In addition, guardrails designed and installed in Europe must meet the EN 1317 standard (6), which has been developed to protect car and truck/van occupants and does not even mention motorcyclists (2): consequently, motorcycle accidents with guardrail impacts have a much higher fatality risk than motorcycle crashes in general (5).

We report on two nearly simultaneous fatalities characterized by distinctive, massive lesions because of impact against a guardrail post.

Case Reports

Case 1

A 30-year-old man on a motorcycle was hit by the van he was overtaking as the latter changed lane to overtake another vehicle. The motorcyclist was thrown off the bike and skidded into the opposite guardrail. Although promptly reached by an ambulance

[1]Sezione di Medicina Legale, Dipartimento di Neuroscienze, Università Politecnica delle Marche, via Conca 71, 60126 Torrette di Ancona (AN), Italy.

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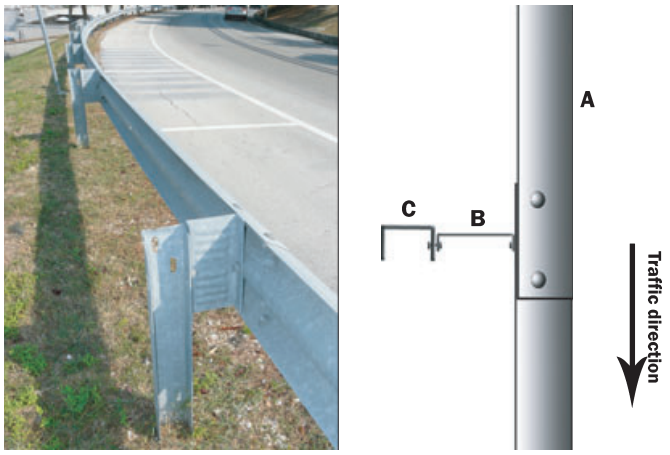

FIG. 1—*Guardrail: photograph and schematic view from above. A = beam; B = distancer; C = ⊏-shaped post.*

and flown by helicopter to the Regional Hospital, he died soon after arriving there.

The physical examination demonstrated a broad, transverse, abraded, and contused band-like lesion involving the right lumbar area and hip. Two long, parallel tracks separated by ca. 8 cm deeply marked the skin, which exhibited a severe, extensive laceration with irregular and ragged margins that exposed the underlying soft tissues and bones (Fig. 2). The pelvis and left leg were fractured. The cause of death was attributed to severe, irreversible hemorrhagic shock because of massive bleeding from a large, open fracture wound involving the pelvis and adjacent soft tissues.

Case 2

A 29-year-old man had an alcoholic drink in a bar and rode his replica racing motorcycle into a four-lane highway devoid of a median barrier (speed limit 70 km/h). He lost control of the bike, fell to the ground, and slid across both opposite lanes for ca. 80 m and into the guardrail. The body was torn roughly in two halves, which were retrieved ca. 8 m one from the other, close to the drain running beyond the guardrail. Some abdominal viscera were found in the vicinity of the lower half-body. Examination of the body demonstrated an extensive skin laceration at the level of the iliac crests posteriorly and of the inguinal ligament anteriorly. The spine,

FIG. 3—*Case 2. Note the exposed whole lumbar spine, still attached to the lower half-body.*

paravertebral muscles, and perispinal soft tissues were resected at a more cranial level (T12); therefore, the whole lumbar spine was still attached to the lower half-body and was exposed (Fig. 3). In particular, vertebra L5 was normally joined to the pelvic bones. Some of the abdominal organs were still attached to the lower half-body. A distinctive patterned lesion was noted at the level of the postero-inferior portion of the chest, which consisted of two transverse, parallel, band-like abraded contused lesions 3 cm in thickness, running at a distance of ca. 12 cm across the width of the chest (Fig. 4). The lower lesion coursed at the level of T12 and of the spinal resection.

The toxicology report disclosed a blood alcohol concentration of 1.84 g/L. It was established that the man's license had been suspended for driving under the influence of alcohol.

Analysis of the first victim's lesions allowed the accident dynamics to be reconstructed as follows: after falling off the bike, the man slid on the asphalt at a 40–45° angle and hit the guardrail post face with the right hip. The lesion characteristics were consistent with the width of the post. The high-energy impact produced the abraded contused lesion and the soft tissue laceration between its tracks (Fig. 5).

Examination of the injuries sustained by the second victim suggested that the body, after skidding toward the margin of the road across the two lanes, roughly at a 30° angle, as determined onsite, impacted the open profile of the guardrail post with the back (Fig. 5). The characteristics of the back lesion, consisting of two identical parallel tracks running 12 cm from one another, were

FIG. 2—*Case 1. Note the two long, parallel tracks and the extensive laceration.*

FIG. 4—*Case 2. Note the two transverse, parallel, band-like, abraded contused lesions.*

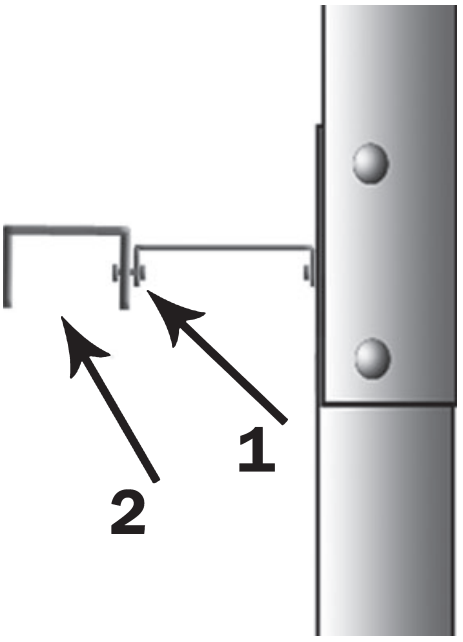

FIG. 5—*Case 1 and case 2: impact angle and direction.*

FIG. 6—*Guardrail manufactured in France. Source: AMI, Associazione Motociclisti Incolumi.*

consistent with the □ shape of the guardrail post. The high-energy impact resulted in resection of the spine at the level of T12 and tearing of the soft tissues at the sites of least resistance, owing to the high kinetic force and the absence of retaining osseous structures. The body was cut roughly into two halves at the boundary between the abdomen and the lower limbs.

Discussion

The fatalities described here share some distinctive features that are related to the harmful effect of the same object. The two very similar accidents occurred in the same area over a short period of time, suggesting that they should not be interpreted as isolated cases, but as examples of a wider phenomenon that involves not only fatal outcomes but also severe survivor lesions and mutilation. The uncommon severity of these injuries is associated with enormous family and community distress in fatal cases. Survivors need to cope with disabilities that are often extremely severe. In Italy, very little is being done to address this problem. In the substantial absence of EU action, some countries have passed ad hoc regulations. In Spain, the country with the most receptive attitude, new guardrail homologation criteria that take into account motorcyclist safety have been devised and new barriers installed, some fitted with a deformable under-run that reaches down to the road surface (Fig. 6), shielding the posts (2,3). Initiatives have also been taken by Portugal, France, the Netherlands, and Germany (2). Because Italian regulations merely require guardrails to meet EN 1317 criteria, the adoption of barriers of different types in some areas depends on the sensitivity of the bodies responsible for the maintenance of the various roads. Motorcyclist-friendly guardrails currently account for a negligible fraction in Italy.

It is conceivable that such guardrails would have prevented the fatalities described earlier. In case 1, even though the angle of the impact was fairly wide (40–45°), the kinetic force was not very high. The high energy of the impact of case 2 was associated with an angle of only 30°. A guardrail beam reaching down to the road surface would have prevented the impacts with the posts, which were responsible for the fatal lesions.

These two cases demonstrate the urgent need for appropriate regulations amending guardrail homologation criteria. They also confirm the role of Forensic Medicine in analyzing the injuries related to road accidents in terms of mortality, disability, and social cost. It needs to be stressed that most road accidents are foreseeable and thus avoidable. Our discipline therefore has a critical role not only in identifying irresponsible behavior (such as driving under the influence of alcohol or drugs), but also in analyzing the causes of injury and promoting the adoption of measures that enhance the safety of vehicle and road users.

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Additional information and reprint requests:
Francesco Brandimarti, M.D.
Sezione di Medicina Legale, Dipartimento di Neuroscienze
Università Politecnica delle Marche
via Conca 71, 60126 Torrette di Ancona (AN)
Italy
E-mail: francesco.brandimarti@gmail.com