

An Unusual Autopsy Case of Incomplete Decapitation of a Motorcyclist With Herniation of Thoracic Organs Through a Helmet-Related Neck Wound

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Abstract: The authors report an unusual autopsy case of a motorcyclist who wore a full-face type helmet and had incomplete decapitation and herniation of the heart and a portion of the right lung through an extensive lacerate wound on the front of the neck after his motorcycle crashed.

The authors identified 2 main offensive dynamics that occurred simultaneously: First, partial decapitation with a extensive gaping wound on the neck caused by the chin strap after a violent angular movement of the head; second, the translocation of the abdominal organs into the thorax and the herniation of the thoracic organs through the neck wound generated by a compressive trauma of the thorax and abdomen.

This singular case, like few others in forensic literature, shows the possibility of helmet chin strap-related traumas and highlights the limitations of modern protective helmets. If the postulated mechanism is confirmed despite the massive benefits derived from the compulsory use of protective helmets, the properties of the helmet chin strap would need to be reassessed to improve the protection of the soft tissue and bones in the neck.

Key Words: incomplete decapitation, helmet-related injuries, motorcycle crashes, neck wounds, herniation of thoracic organs

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Head and neck injuries are the principal cause of fatalities in motorcycle and moped crashes.¹

To reduce these kinds of traumatic injury, the use of a protective helmet has become compulsory throughout the Western World.

In Italy, the use of such a device for motorcyclists and their passengers became legal on December 7, 1999 (law no. 472, article 33).

In actual fact, it has been proven that the use of a protective helmet while riding these vehicles is very effective in protecting the head and brain^{2–5} by preventing possible cranial lesions or reducing their seriousness.⁶

Crash helmets are lined with expanded polystyrene, also known as styrofoam, a padding made of tiny air cells that compress and dilate when submitted to pressure, thus partially absorbing the impact energy.⁷

In Italy, according to a recent Italian National Institute of Statistics survey concerning road injuries in 2010 and published

in September 2011, there were 211,404 crashes with casualties and 4090 human deaths. Of the vehicles involved, 18.8% were motorcycles and were responsible for 32.9% of all deaths.⁸

Crash helmets reduce the risk of serious head injury even if they cannot guarantee complete safety.

Many authors have stated that among the various types of legal helmets available, the full-face type provides better protection than the legal half-shell helmets.^{9,10}

In any case, the efficiency of such equipment is limited in high-speed impacts and, in particular, in cases of violent flexoextension or rotation and inclination of the head on the neck due to lack of protection of the cervical vertebrae.

Moreover, despite the success in reducing the number and seriousness of cranial, encephalic, and neck injuries achieved by the use of the helmet, there are also documented cases in which lesions were caused by the use of this device.^{11–14}

It is also possible that while reducing risks for the head, the helmet may actually cause injury to parts of the neck because it adds mass to the head itself.

We report a autopsy case of a motorcyclist wearing a full-face-type helmet who had an incomplete decapitation and herniation of his heart and a portion of his right lung through a wide lacerate wound in the front part of his neck after his motorcycle crashed.

CASE REPORT

On September 2, 2009, at approximately 8 AM, a 29-year-old man wearing a full-face helmet was riding on his 600 Ducati Monster on the highway. At the end of a bend, the motorcyclist who was traveling at full speed hit a Fiat Iveco van, which was coming from the opposite direction and had suddenly turned left. The victim's body collided with the right side of the van and fell to the ground, where it was further crushed by the right rear wheel of the van. He died instantly. In the police report, the impact speed was estimated to be approximately 100 to 110 km/h (62–68 mph). Forensic autopsy was performed 48 hours after death.

The patient's body was wearing a black motorcycle jacket, a T-shirt, a pair of motorcycle gloves, blue jeans, a pair of sneakers, and a perfectly set black full-face helmet (Fig. 1).

External analysis of the body allowed the following traumatic findings to be identified:

- Wide and deeply lacerated wound affecting the neck, except for a small portion of intact skin on the left posterior surface, presenting herniation of a large part of the heart and upper and medium lobe of the right lung;
- Extensive contusions and excoriations on the face, trunk, and superior limbs;
- Abnormal right superior limb mobility, as in shoulder fracture;
- Mangling of the entire lower left limb with diffused flaying and multiple exposed fractures of the femur, tibia, and fibula.

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FIGURE 1. Macroscopic view of traumatic incomplete decapitation with herniation of the heart and of a portion of the right lung through the neck wound.

The subsequent internal analysis of the body allowed the following traumatic findings to be identified:

- Wide fracture of the cranial base, with complete craniocervical disjunction, cervical spine cord section, and copious hemorrhagic contusion of the medulla oblongata;
- Multiple cervical and dorsal vertebrae fractures;
- Fracture of the thyroid cartilage with diffused hemorrhage of the neck soft tissue;
- Ample thorax injury with multiple and bilateral costal fractures with hemorrhage of adjacent soft tissues;
- Multiple contusions and lacerations of the heart and the lungs;
- Diffused lacerations of the diaphragm with thoracic translocation of the spleen, the stomach, the duodenum, and part of the liver;
- Multiple contusions and lacerations of the abdominal organs.

Organ and body fluid samples were taken for further histological and toxicological analyses.

Toxicological examinations were carried out on central and peripheral blood, which tested negative for narcotics and positive for alcohol, with a level of 1.5 g/L (0.5-g/L maximum level allowed by Italian Law to drive vehicles). These investigations were completed with a histological examination of the organs. Specimens were embedded in paraffin, and 4- μ m-thick sections were cut and stained with hematoxylin-eosin. Preparations of samples from the organs only revealed visceral hematic congestion; histological examination did not reveal any other significant findings. In conclusion, the cause of death was posttraumatic neurogenic shock due to cervical spinal cord section.

DISCUSSION

Head and neck injuries are the leading cause of death in motorcycle and moped crashes, but a significant percentage of them can also produce severe or fatal injuries to the chest and the abdomen. Several studies have shown that 7% to 23% of all motorcyclists dying in accidents, besides having head and neck injuries, suffer severe chest and abdominal injuries.^{15–17}

Regarding cranioencephalic lesions, it is possible to find descriptions in forensic literature of both complete^{18–20} and incomplete²¹ traumatic decapitation of motorcyclists involved in motor vehicle crashes, such as the case taken into consideration.

In forensic literature, it is reported that the atlanto-occipital dislocation after motor vehicle crashes is not related to the speed impact: it has been proven that almost the same percentage of this injury occur in highways and roads.²² It is also reported that the force needed for the complete decapitation is very high, reaching approximately 3923 Newton to 7846 Newton.²³

The dynamics of damage caused by complete and incomplete decapitation are the following: hyperextension, anterior flexion, rotation, and inclination of the neck. Moreover, there is a reported case of a motorcyclist wearing a full-face helmet with semidecapitation due to the detrimental effect of the helmet chin strap that caused an incised wound to the neck.²⁴

However, cases of semidecapitation with herniation of internal organs have never before been documented in forensic literature.

In the reported case, 2 fundamental offensive dynamics can be identified: first, the partial decapitation with ample gaping wound on the neck determined by the chin strap after the violent angular acceleration of the head on the neck; second, the translocation of the abdominal organs into the thorax and the herniation of the thoracic organs through the neck wound generated by compressive trauma of the thorax and abdomen.

The 2 actions occurred simultaneously when the body of the victim was crushed by the wheel of the van running over the thoracoabdominal area.

CONCLUSIONS

The compulsory use of the protective helmet has drastically reduced the risk of cranioencephalic lesions in motor vehicle crashes; however, there are reported cases of helmet-induced traumas.

We report an unusual case of death by semidecapitation with evisceration of part of the heart and the right lung through the neck wound after a violent vehicle crash.

The injuries found in the postmortem examination were produced by the combination of 2 forces, one compressive and one rotational, which, in addition to the lacerating effect of the helmet chin strap, still fastened at the beginning of the forensic examination, have affected the body of the patient.

Although it may be implausible that the chin strap itself may have been the only cause of decease, this case can be classified within the forensic studies of helmet-related traumas.

This singular circumstance underlines the limitations of modern protective devices, especially regarding the protection of cervical vertebrae and the soft tissues of the neck.

If the postulated mechanism is confirmed, despite the massive benefits derived from the compulsory use of protective helmets, the function of the helmet chin strap should be reassessed and redesigned. It is necessary to study alternative fixation devices to protect the soft tissues and bones of the neck.

REFERENCES

1. Branas CC, Knudson MM. Helmet laws and motorcycle rider death rates. *Accid Anal Prev.* 2001;33:641–648.
2. Houston DJ, Richardson LE. Motorcyclist fatality rates and mandatory helmet use laws. *Accid Anal Prev.* 2008;40:200–208.
3. Coben JH, Steiner CA, Miller TR. Characteristics of motorcycle-related hospitalizations: comparing states with different helmet laws. *Accid Anal Prev.* 2007;39:190–196.
4. Bachulis LB, Sangster W, Gorrell GW. Pattern of injury in helmeted and non-helmeted motorcyclist. *Am J Surg.* 1988;155:708–711.

5. Norvell DC, Cummings P. Association of helmet use with death in motorcycle crashes: a matched pair cohort study. *Am J Epidemiol.* 2002;156:483–487.
6. Houston DJ, Richardson LE Jr. Motorcycle safety and the repeal of universal helmet laws. *Am J Public Health.* 2007;97(11):2063–2069.
7. Spitz WU. Road traffic victim. In: Spitz WU, ed. *Medicolegal Investigation of Death. Guidelines for the Application of Pathology to Crime Investigation.* 4th ed. Springfield, IL: Charles C. Thomas Publisher Ltd; 2006:956–959.
8. ISTAT [database online]. Italian Institute of Statistics; updated November 9, 2010.
9. Liu BC, Ivers R, Norton R, et al. Helmets for preventing injury in motorcycle riders. *Cochrane Database Syst Rev.* 2008;23(1):CD004333.
10. Amirjamshidi A, Ardalan A, Nainei KH, et al. Comparison of standard and nonstandard helmets and variants influencing the choice of helmets: a preliminary report of cross-sectional prospective analysis of 100 cases. *Surg Neurol Int.* 2011;2:49.
11. Kuo LC, Lin HL, Chen CW, et al. Traumatic hyoid bone fracture in patient wearing a helmet: a case report. *Am J Emerg Med.* 2008;26(2):251–252.
12. Hoekstra HJ, Kingma LM. Bilateral first rib fractures induced by integral crash helmets. *J Trauma.* 1985;25(6):566–567.
13. Doi A, Deguchi J, Yamada M, et al. Traumatic internal carotid artery dissection due to compression by a helmet strap. *No Shinkei Geka.* 2004;32(12):1279–1282.
14. Cooter RD, David DJ, McLean AJ, et al. Helmet-induced skull base fracture in a motorcyclist. *Lancet.* 1988;1(8577):84–85.
15. Chiu WT, Kuo CY, Hung CC, et al. The effect of the Taiwan motorcycle helmet use laws on head injuries. *Am J Public Health.* 2000;90(5):793–796.
16. Wick M, Muller E, Ekkernkamp A, et al. The motorcyclist, easy rider or easy victim? An analysis of motorcycle accidents in Germany. *Am J Emerg Med.* 1998;16:320–323.
17. Matsh T, Karlsson B. Moped and motorcycle accidents: similarities and discrepancies. *J trauma.* 1986;26:583–543.
18. Doichinov ID, Spasov SS, Dobrev TS, et al. Complete decapitation of a motorcyclist in a road accident, a case report. *Folia Med.* 2007;49(3–4):80–83.
19. Ihama Y, Miyazaki T, Fuke C, et al. Complete decapitation of a motorcycle due to a roadblock chain. *Int J Legal Med.* 2008;122(6):511–515.
20. Zoia R, Gentile G, Giovannetti GF, et al. Death by complete decapitation of motorcyclist wearing full face helmet: case report. *Forensic Sci Int.* 2011;207:e48–e50.
21. Hitosugi M, Fukui K, Takatsu A. Incomplete decapitation of a motorcyclist from hyperextension by inertia: a case report. *Med Sci Law.* 2001;41(2):174–177.
22. Zivot U, Di Maio VJ. Motor vehicle-pedestrian accidents in adults. Relationship between impact speed, injuries, and distance thrown. *Am J Forensic Med Pathol.* 1993;14(3):185–186.
23. Doichinov ID, Spasov SS, Dobrev TS, et al. Complete decapitation of a motorcyclist in a road accident. A case report. *Folia Med (Plovdiv).* 2007;49(3–4):80–83.
24. Oliva A, Vernoooy K, Cooter R, et al. Helmet-induced neck degloving in a motorcyclist. *J Trauma.* 2005;58(2):370–371.