

Case report

Acute vertical deceleration injury: A case of cranial impalement

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ABSTRACT

In forensic science and in modern times, impalement is a rare event. When this occurrence involves the head, it is even more unusual since this region is very small compared to the rest of the body. Although impalements are rare, they represent scenarios that must be treated with great care by forensic pathologists. They may involve a mixture of blunt and penetrating wounds, and the injuries observed at autopsy must be interpreted correctly. For this reason, if possible, the interconnection between the body and the impaling object should be maintained until the autopsy table. In this report, it is presented a case of cranial penetrating trauma that occurred after a suicidal fall from a great height with impact on the railing below, by reporting both the on-site scene inspection and autopsy data. The critical forensic issues that may arise in the practical management of such cases are discussed, starting from the fact that there is still no clear and unambiguous definition of impalement.

1. Case report

A 19-year-old girl suffering from anorexia and depression (not pharmacologically treated) had experienced further exacerbation of her symptoms during the COVID-19 lockdown. The body of the young woman was discovered impaled with her head and right forearm on the spikes of the apartment building's railing, suspended in midair (Fig. 1A and B). Shortly after the discovery, police officers, firefighters, and medical personnel reached the courtyard of the apartment building along with the mother of the victim, returning home from work. Inspection of the apartment, located at the sixth floor of the flat complex, did not reveal any sign of forced entry, rooms appeared tidy. The bedroom window was discovered wide open and it was located at a height of 15 m above the highest part of the railing. The girl's body could be noted in perpendicular correspondence with the open window, at a distance of 50 cm from the building wall (Fig. 1C). No farewell notes were found in the house, but there were several messages to friends on the victim's cell phone, revealing deep inner suffering due to the social isolation and distance learning caused by the pandemic. A passerby stated that shortly before the discovery of the corpse, he had seen a girl standing at the window, turning around and then falling into the void with her arms outstretched. Based on these reports and the position of the hands and arms, the hypothesis that the penetrating head injury

could have resulted from an unsuccessful attempt to climb over the railing, during which she slipped, could be ruled out almost immediately. The parts of the fence connected to the body were cut off by the fire department officers, and the entire block was taken as a unicum to the Forensic Institute. The autopsy was performed three days after the event.

1.1. Autopsy findings

The corpse appeared in good condition of preservation (weight kg 35; height cm 156; body mass index = 14.68 kg/m²). The external examination revealed a connection of the head and the right forearm with metal elements of the railing, which was confirmed by the radiographic examinations performed before autopsy (Fig. 2A). The railing consisted of a bar to which three other metal elements (identified as nos. 1, 2, and 3) were welded vertically, curved, and with sharpened cusps (Fig. 2B). Lateral elements, nos. 1 and 3, had a completely extracorporeal course, whereas the central element, identified as no. 2, was characterized by an intracranial course with a right retro-mastoid origin (Fig. 3A) that extended into the left frontal region, from which the pointed end protruded (Fig. 3B). Several abrasions were observed in the areas of contact of the grid with the body, especially to the back and the posterior surface of the neck. There was no evidence of defense lesions or aggression

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Fig. 1. Images of the judicial on-site inspection. Rear exterior of the house with, in 1A and 1B, the iron fence on which the girl's body was found impaled through the head (arrow) and the right forearm (circle). In 1C, evidence of the window of the apartment where the girl lived and detail of the body in perpendicular correspondence (both indicated with arrows).

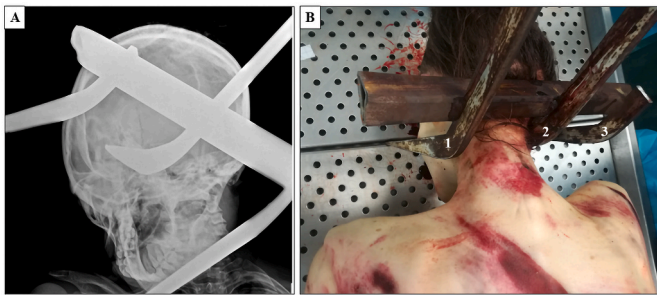


Fig. 2. In 2A, RX image of the skull, with insertion of one of the sharpened ends of the fence; in 2B, portion of the railing still in situ, with all the interconnections with the body preserved.

injuries by third parties.

After careful removal of the railing block (Fig. 3C), internal examination of the head revealed a full-thickness fracture of the skull base in the right cerebellar fossa and of the cranial vault in the left frontal area. In both cases, the fracture section was clearly quadrangular in shape (Fig. 4A and B). At brain examination, a quadrangular cross-section of disintegrated parenchyma was observed from the right occipital region to the left frontal one (Fig. 5). Further findings included the presence of blood in the cerebral ventricles and atlo-occipital diastasis. All blunt force injuries were macroscopically infiltrated with blood. No fractures were found on examination of the neck, which was consistent with the radiological evidence. No major findings were noted at dissection of the chest and abdomen. Finally, the lungs showed no signs of blood



Fig. 3. In 3A, entry point of the metal segment no. 2 in the right retro-mastoid area, in 3B, exit wound with sharpened end protrusion in the left frontal area, in 3C, metal portion of the railing after removal with curvature detail of segment no. 2 on which the impalement occurred; at the bottom right, fragment of the fence on which the impalement of the right forearm took place, with fragment of the dress worn by the victim.

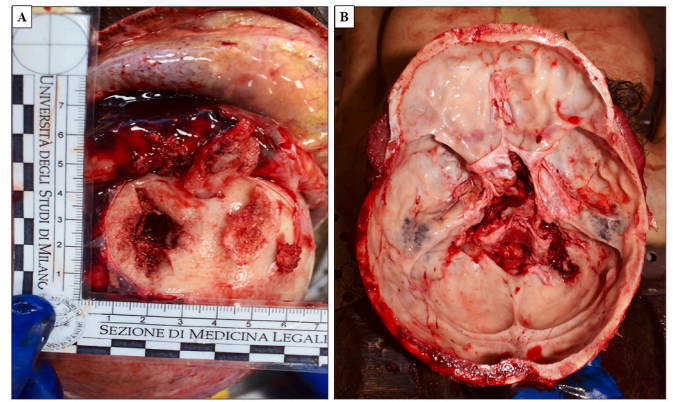


Fig. 4. Macroscopic views in 4A, of exit lesion in the left frontal area with quadrangular section and presence of autonomized bone fragments; in 4B, cranial base with evidence of the entry wound in the right cerebellar fossa and multiple fractures of the middle cranial fossa.

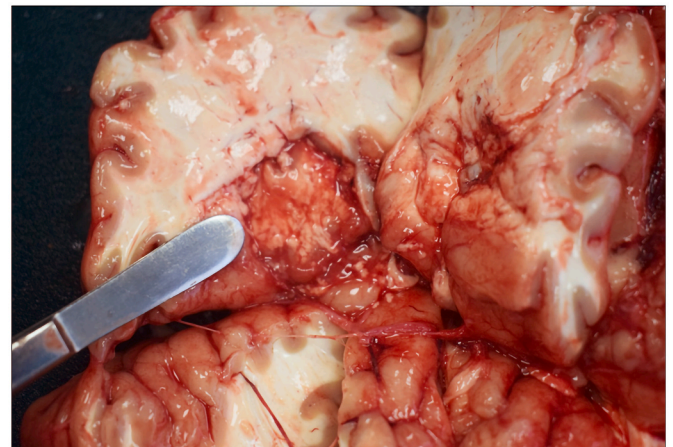


Fig. 5. Macroscopic view of the brain with detail of the quadrangular section of disintegrated parenchyma.

aspiration.

Toxicological analyses were negative for molecules of toxicological interest and routine histological examinations on the cutaneous margins of the injuries (head and forearm) showed hemorrhagic extravasations with features of vitality.

At the conclusion of all investigations, the consistency and concordance of the circumstantial evidence and the autopsy and laboratory findings allowed to identify the cause of death as cranial penetrating

trauma by impalement following suicidal falling from height.

2. Discussions

In impalement events, one of the first difficulties for the forensic pathologist is identifying the case clearly, as the definition is not univocal.¹ Indeed, the term "impalement" not only means that the body is pierced with an object that fixes it in a certain position, but it has also taken on another nuance, simply indicating being pierced with something sharp.² The body site affected also appears to be important for the diagnosis: the torso is the typical site, although cases of other body regions involved have been documented.^{2,3} The dynamics of impalement require a special force to overcome the resistance of the body structures⁴ and can result from two different mechanisms: either the moving human body collides with a stationary object,⁵ or it is the moving object that perforates the stationary body.^{6,7} In this broad and confusing scenario, cases classified as impalement have been reported in literature in traffic accidents^{8–11} (including self-impalement by an exposed long bone fragment penetrating the body²), as well as in falls,^{12–15} climbing over a fence,² and in some sports activities.² Less frequently, it has been documented in homicides,^{4,7,16–21} where it may be associated with a torturing component, reflecting in this sense its most ancient origins as an extreme torture method.²² Finally, suicides^{1,23} caused by self-inflicted oropharyngeal and thoracic impalements have been reported.^{24,25}

From a forensic perspective, impalement is a rarely observed event,² and the mechanism of the injury and how it occurred are important for its interpretation. Since wounds can have both contusive and penetrating aspects, diagnosis can be challenging, especially in cases with an unclear history or when the detrimental mean is not found in the body.⁴

Similarly, penetrating wounds, even if unremarkable, may prove fatal at autopsy examination.¹³ For these reasons, it is important that at the site of body discovery, the impaling object is not pulled out. Indeed, when the involved object is not present and, its size, shape, and consistency are not known, and its correspondence to the injuries observed on the body cannot be fully assessed. This is even more important if the impalements involve different districts of the body or occurred on articulated structures. Furthermore, the removal of the impaling object must be done in a suitable environment, by trained professionals, and without haste, so as not to cause further injury to the victim's body.

In the presented case, a moving body impacted against a stationary object and was impaled on it, remaining suspended from the ground. Therefore, it can be claimed that not only an impalement occurred, but also that this finding may be the closest to what should be considered the definition of a true impalement. Indeed, it can be argued that the most recent definition of impalement, meaning the simple event of being pierced by a sharp object should be avoided in the forensic field. In this sense, Byard's rightful assertion that, with these premises, even superficial knife wounds would be considered impalements,² is to be emphatically supported. Thus, although it can be stated that "impalement is the penetration of a body by a sharp object", it is essential that the body is also transfixed and immobilized in an "inescapable or helpless position".² This is exactly what happened in the presented specific case. Providing clarity on the correct definition of impalement would be beneficial for forensic investigations, as it is crucial for forensic pathologists to properly characterize cases with penetrating wounds that might be mistaken as impalements. In this sense, it would be desirable for the forensic community to agree as much as possible on the definition of impalement as penetration with complete perforation of a body district by a rigid, blunt object embedded therein.²⁶

In the presented case, moreover, as the impalement involved the skull following a suicidal fall from a great height, it is to be considered an even more peculiar and rare event given the small surface area of the head in relation to the rest of the body.²⁶ Regardless of how intentional the fall was, the subsequent cranial blunt penetrating trauma could of course have been an accident. However, such finding has not yet been

described in the literature. Indeed, there are only two reports of atypical skull impalement, one involving a bolt and a falling weight that forced the penetration of the object through the head and another describing the compression of the head with a hydraulic press.^{1,23}

This case of cranial impalement has raised critical questions and pathological-forensic considerations that are not usually asked in daily practice activity because of the rarity of such events. However, as these are occurrences that can happen according to the literature, it is crucial for forensic pathologists to be able to make the proper assessments and draw the right conclusions in order to address these challenging cases in the best possible way from all points of view.

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Conflicts of interest/Competing interests

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Ethics approval

This study was performed from data from human cadaveric tissues. This article does not contain any studies with (living) human participants or animals performed by any of the Authors. The subject involved in this study underwent a judicial autopsy at the Institute of Legal Medicine of Milan in order to identify the cause of death. Data collecting, sampling and subsequent forensic analysis were authorized by the public prosecutor. Therefore data were acquired as part of a forensic judicial investigation and in accordance to Italian Police Mortuary Regulation. Consequently, in accordance with Italian law, ethical approval is not required in these cases. Publication of data is allowed when the case has been closed, but the anonymity of the subject must be guaranteed.

Consent to participate

The authors declared that all the investigations were carried out accordingly to the Italian Law.

Consent for publication

All the authors agree for publication.

Availability of data and material

All the data have been reported in the manuscript.

Code availability

(software application or custom code) Not applicable.

Authors' contributions

TS and GG equally contributed to this work: writing – original draft, writing – review & editing, conceptualization, investigation, methodology, data curation. BM contributed to investigation and methodology, literature research and editing. RZ guarantor of the project and directed the study, devised the main conceptual idea of the article.

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