

Case Report

Fatal Outcome Following Blunt Trauma Without Lethal Injuries: A Possible Reflex-Mediated Death

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Abstract

Background: Death following blunt force trauma in the absence of major internal injuries represents a significant forensic challenge. In such cases, reflex-mediated mechanisms leading to cardiac inhibition may be overlooked, particularly when multiple autonomic triggers act simultaneously. **Methods:** We report the case of a 78-year-old man who died after a violent assault involving repeated blunt force trauma, followed by a prolonged 16-day submersion in river water. A complete forensic investigation was performed, including postmortem computed tomography, autopsy, histological examination, toxicological analyses, and diatom testing to assess the possibility of drowning. **Results:** External and internal examination revealed multiple blunt force injuries involving the head, face, thorax, upper limbs, scrotal region, and back. Rib fractures, pulmonary contusions, and testicular hematomas were documented, but no internal lesion of sufficient severity to independently explain death was identified. No significant pre-existing cardiac disease or structural cardiac abnormality was found. Toxicological analysis showed a blood alcohol concentration of 0.7 g/L, with no lethal substances detected, although interpretation was limited by the prolonged 16-day submersion interval. Diatom testing performed on multiple tissue samples was negative, arguing against drowning. Overall, neither trauma, intoxication, nor submersion alone adequately explained the fatal outcome. **Conclusions:** This case supports the hypothesis that parasympathetic hyperactivation may have contributed to death. The combined effects of trauma to reflexogenic areas, cold water immersion, and alcohol-related autonomic modulation may have triggered a fatal cardioinhibitory response. Reflex-mediated death should be carefully considered in similar cases when conventional autopsy findings are inconclusive. In the present case, interpretation is limited by prolonged submersion and related postmortem changes, which may have affected the reliability of certain forensic findings.



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1. Introduction

Blunt force trauma is one of the most common causes of homicide. A Danish study identified three primary mechanisms responsible for death in these cases: bodily force, assault with blunt objects, and falling from heights [1]. In these scenarios, examination of injuries sustained by the victim plays a crucial role in determining the cause of death, which

may result from severe internal organ damage, hemorrhage, fracture, or a combination of these factors. Survival times can range from moments to several days, particularly when death occurs because of secondary complications, including sepsis. Analysis of injury distribution is essential, as it helps clarify the specific mechanism of death, especially in cases involving critical areas, such as the head. Therefore, postmortem computed tomography (PMCT) is increasingly used to complement autopsy, providing optimal detection of skeletal injuries, particularly when enhanced with 3D reconstruction [2].

In our case, despite the presence of multiple injuries and a documented history of physical aggression, autopsy, postmortem imaging, and toxicological findings did not identify any single lesion sufficient to independently explain death. Therefore, a reflex-mediated mechanism involving increased parasympathetic activation represents a plausible explanation for the fatal outcome. The distribution of trauma in reflexogenic areas, environmental stressors, including cold water exposure, and moderate alcohol levels may have acted synergistically, triggering a fatal autonomic response.

However, alternative mechanisms should also be considered in similar forensic scenarios. These include fatal cardiac arrhythmias, particularly in the presence of predisposing conditions such as channelopathies or long QT syndrome, hypothermia-related cardiac instability, and Takotsubo syndrome, all of which may present without specific macroscopic autopsy findings.

Although prolonged postmortem submersion complicates external and internal assessment owing to water-related decomposition and potential postmortem artifacts [3], the overall pattern of findings may be compatible with functional autonomic disturbances and may support the consideration of a reflex-mediated mechanism of death.

2. Detailed Case Description

A man in his late seventies with no known significant prior medical history was reportedly assaulted during an altercation near a riverbank. The assault initially consisted of punches to the face and kicks to the chest and abdomen, while the victim was still conscious. In a subsequent phase of the assault, stones collected from the riverbank were thrown against the victim's body, at a time when he was reportedly unconscious. The confrontation culminated in the victim being thrown into the river, where he was apparently rendered unconscious. The entire sequence of events occurred rapidly and was described in detail by an eyewitness, who promptly alerted the emergency services. Despite immediate search efforts, the victim was recovered from the river after 16 d by the body recovery dive team. The mean water temperature of the river during that time interval was estimated to range between 10 °C and 14 °C.

A full-body PMCT was performed prior to autopsy using a 16-slice CT scanner (Somatom Scope, Siemens Healthineers, Forchheim, Germany). Scanning was performed in supine position without contrast administration. Acquisition parameters included a tube voltage of 130 kV and a tube current of 71 mA. Images were reconstructed with a slice thickness of 1.5 mm using a H31s reconstruction kernel. Axial volumetric acquisitions were obtained with multiplanar reconstructions. Image analysis was carried out by a radiologist with expertise in forensic imaging.

Histological examination was performed on formalin-fixed, paraffin-embedded tissue samples collected from representative areas of all organs examined during autopsy, including the liver, trachea, testis, prostate, pancreas, spleen, heart, brain, lung, and kidney, as well as contused soft tissues. Sections were stained with hematoxylin and eosin. Microscopic evaluation was carried out using light microscopy at magnifications ranging from 40× to 400×.

The diatom test was performed on lung, kidney, liver, and brain samples. A water sample from the recovery site was also analysed for comparative diatom analysis and yielded negative results. Tissue samples were digested using 37% hydrochloric acid and incubated for 48 h. The resulting material was diluted, washed with distilled water, and centrifuged at 1500 rpm for 30 min. Hydrogen peroxide was then added for further cleaning, followed by additional washing and centrifugation cycles until a neutral pH was obtained. The final sediment was mounted on slides, air-dried at 100 °C, and examined under a Zeiss light microscope using 40× and 100× magnification. No diatoms were detected in any sample.

PMCT revealed no fractures of the skull, face, arms, spine, or pelvis. Marked putrefactive gas was present at all examined levels, together with a variable amount of fluid within the trachea and main bronchi. Due to advanced postmortem gas formation, evaluation of lung parenchyma was partially limited; however, no evidence of pulmonary hyperinflation, pleural effusion, fluid in the paranasal sinuses, or intracranial haemorrhage related to head trauma was identified. Gastric contents were not clearly demonstrated at PMCT. Multiple bilateral non-displaced rib fractures (5th–7th ribs) were detected. Overall, PMCT findings were consistent with the gross examination, except for gastric content, which was likely not visualized due to extensive putrefactive gas within the abdominal cavity.

An external examination revealed signs of prolonged submersion, including skin maceration. Blunt force injuries were noted on the forehead, above the right eyebrow (Figure 1), and in the right parietal region (Figure 2). Multiple ecchymoses were observed on the head and face, with the largest contusions located in the right zygomatic, right frontal, and left parieto-occipital regions. Additional ecchymosis was identified in the right hemithorax, right arm, inguinoscrotal region, and back. Upon internal examination, a hemorrhage was observed in the soft tissues of the skull, with no evidence of subdural or subarachnoid involvement. Examination of the brain parenchyma revealed no contusional or hemorrhagic foci in the cortical or subcortical areas or white matter. The heart did not exhibit any pathological lesions. Additionally, multiple bilateral rib fractures involving the fifth to seventh ribs were identified, associated with haemorrhagic infiltration of the intercostal muscles at the corresponding fracture sites, consistent with vital reaction (Figure 3). These findings were accompanied by pulmonary contusions of corresponding distribution, involving the underlying lung parenchyma at the same anatomical levels (Figure 4).

Hemorrhages in the posterior thoracic wall muscles and testicular hematomas were also observed. Widespread signs of putrefaction were observed, including reduction in the consistency of the brain, liver, and lungs.



Figure 1. A 1.3 cm linear laceration is present above the right eyebrow, with irregular margins and fibrous bridging. The absence of histological evidence of vital reaction suggests that the lesion is more likely postmortem.



Figure 2. Right parietal scalp laceration (F–O orientation), measuring 3.6 cm. The lesion shows irregular margins, skin detachment, and fibrous bridging, consistent with blunt trauma. No associated intracranial lesions were identified. The absence of histological evidence of vital reaction suggests that the lesion is more likely postmortem.

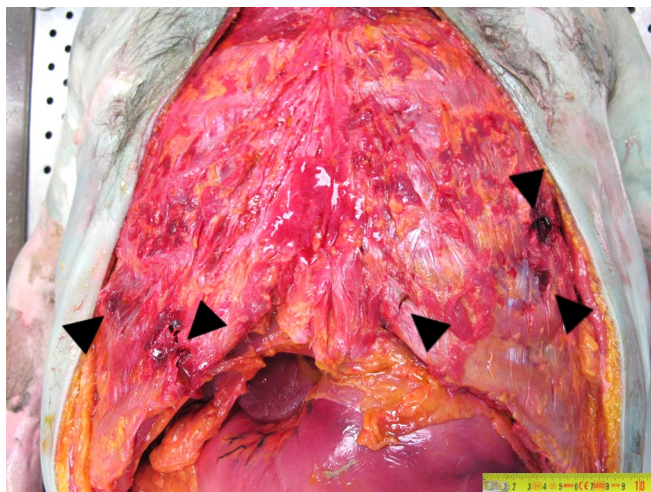


Figure 3. Multiple bilateral rib fractures (5th–7th ribs) were identified. The arrows indicate the fracture sites. Findings are consistent with blunt thoracic trauma, likely sustained in vivo.



Figure 4. Pulmonary contusions underlying rib fractures. The arrow tip and dissection line indicate the extent of parenchymal involvement, consistent with blunt chest trauma.

Upon opening the stomach, a large amount of brownish liquid material was observed. Histological examination confirmed the presence of pulmonary edema and congestion, with mild intra-alveolar hemorrhagic extravasation. Skin examination at the level of multiple ecchymoses demonstrated vital reaction, characterized by inflammatory and haemorrhagic infiltrates, limited to the right zygomatic and left parieto-occipital regions.

Toxicological analysis revealed no diatoms in the lungs, kidneys, liver, or brain tissues. The blood alcohol concentration was measured at 0.7 g/L.

3. Discussion

In our case, it was essential to distinguish the cause of death from homicidal drowning [4], acute intoxication, physical injuries sustained during the altercation, or other potential causes, including functional autonomic disturbances. The available findings did not allow a single definitive explanation of death, requiring a comprehensive forensic evaluation of competing hypotheses.

A study by Lee et al. investigated decomposition changes in bodies recovered from water, both in deaths due to drowning and in deaths resulting from other causes [5]. The authors identified several findings suggestive of drowning—such as fluid in the sphenoid sinus, drowning fluid in the stomach or duodenum, and petromastoid hemorrhage—that may remain detectable despite ongoing decomposition. In the present case, gastric fluid was the only finding potentially compatible with drowning, whereas the other classical indicators were absent. However, this finding is non-specific and cannot be uniquely attributed to drowning, as it may also result from pre-existing gastric contents, postmortem redistribution, putrefaction, or prolonged submersion effects.

Moreover, the absence of additional features commonly associated with drowning—including expanded and emphysematous lungs, fluid-filled sinuses, and airway foam [6,7]—on both autopsy and postmortem CT supported the exclusion of drowning as the cause of death.

The diatom test was performed to assess whether diatoms, which are unicellular algae naturally present in fresh and salt water, had been aspirated during the agonal phase. If detected in an appropriate distribution, their presence may support water inhalation and may help distinguish drowning from postmortem immersion. One proposed approach is to compare the diatom concentration in lung tissue with that in a water sample collected from the site where the body was recovered [8]. However, the diagnostic value of the diatom test remains debated. False-positive results may occur because of postmortem contamination during sampling or laboratory processing [9]. In addition, diatoms may derive from exogenous non-drowning sources, including food intake and possible passage through the gastrointestinal barrier [10].

In agreement with the forensic literature, diatom analysis in our case was performed on multiple tissue samples [11]. In this context, the uniformly negative results across all tested organs strengthen the argument against drowning.

The assessment of acute ethanol intoxication in bodies recovered from water is affected by major interpretative limitations, with a risk of both overestimating and underestimating the measured blood alcohol concentration (BAC). On the one hand, BAC may be artificially increased by postmortem microbial ethanol production. On the other hand, ethanol levels may be lowered by dilutional effects involving postmortem body fluids and water exposure [12]. These problems are particularly relevant in submerged bodies, in which decomposition and prolonged immersion can make toxicological interpretation more difficult. Warmer environmental conditions are generally considered to favor postmortem ethanol formation, whereas lower temperatures may reduce, but do not eliminate, this possibility [13]. In the present case, the measured BAC was 0.7 g/L. Although this

value would indicate alcohol exposure, and likely some degree of impairment in a living subject [14], it could not be interpreted with certainty as evidence of fatal acute ethanol intoxication in the postmortem setting. Indeed, while the moderate water temperature at the time of recovery may have partly limited postmortem ethanol production, we believe that the unusually prolonged 16-day submersion interval may still have contributed to an increase in the measured BAC. For these reasons, acute ethanol intoxication was not considered the primary cause of death.

No underlying cardiac disease or anatomical alteration sufficient to explain death was identified. In the differential diagnosis of potential cardiac-related mechanisms of death, Takotsubo syndrome should also be considered. This condition is an acute and usually reversible form of heart failure characterized by transient regional left ventricular dysfunction in the absence of obstructive coronary artery disease [15]. It is also known as stress-induced cardiomyopathy, as it is typically triggered by intense emotional or physical stress mediated by excessive activation of the sympathetic nervous system and catecholamine surge. The literature reports cases of near-drowning associated with electrocardiographic changes and clinical features compatible with Takotsubo syndrome [16]. Therefore, this condition should be regarded as a potential contributory mechanism in similar forensic scenarios, although it remains a diagnosis of exclusion that cannot be confirmed postmortem with current standard autopsy techniques.

Although multiple traumatic injuries were present, including rib fractures, pulmonary contusions, head injuries, and testicular hematomas, a comprehensive evaluation of their severity did not indicate a lethal injury burden. The rib fractures were limited in number and morphology and were not associated with a flail chest or significant thoracic instability. Pulmonary contusions were focal and not extensive enough to account for respiratory failure. Cranial trauma, located in the left parieto-occipital region based on the distribution of cutaneous vital reaction, was not associated with intracranial haemorrhage or other structural brain lesions. Similarly, no evidence of major internal organ injury or catastrophic haemorrhage was identified. Taken together, these findings indicate that, although the injuries were consistent with blunt force trauma and were multiple in distribution, they were individually and collectively insufficient to explain death.

Other potential mechanisms involved in the pathophysiology of death include fatal hypothermia and the cold shock response (CSR) [17]. Hypothermia is defined as a core body temperature below 35 °C and typically develops after a prolonged period of heat loss [18]. In the present case, the estimated river water temperature of 10–14 °C would not necessarily induce immediate hypothermia but is sufficient to trigger a CSR, which is characterized by increased heart rate, cardiac output, and blood pressure [19]. This acute autonomic cardiovascular response has been proposed as a potential arrhythmogenic substrate in immersion-related deaths [20].

In parallel, attention was directed to the distribution of injuries, which predominantly involved reflexogenic areas, such as the face, including the periocular region (Figure 1), epigastrium, testicles, and lungs.

The arterial baroreflex, oculocardiac reflex [21,22], and diving reflex are well-known vagal mechanisms that reduce heart rate through parasympathetic activation [23,24]. Alcohol-induced vasodilation may amplify these effects [25].

The arterial baroreflex relies on a baroreceptive pathway in which arterial baroreceptors located in the carotid sinus and aortic arch serve as afferent sensors. Afferent signals from the carotid sinus are transmitted via the carotid sinus nerve, a branch of the glossopharyngeal nerve, while those arising from the aortic arch are conveyed through the vagus nerve. Both pathways project to the nucleus tractus solitarius in the medulla oblongata. In

response to increased arterial pressure, the efferent limb of the reflex promotes sympathetic inhibition and parasympathetic activation [26].

The oculocardiac reflex operates via an arc involving the ophthalmic division of the trigeminal nerve, with the efferent pathway mediated by vagus nerve fibers. Some authors have suggested that this reflex can also be triggered by stimuli in areas adjacent to the orbits, proposing the broader terms trigeminocardiac reflex [27] or blepharocardiac reflex [28]. Complications related to hyperactivation of the trigeminocardiac reflex have been reported mainly in the surgical setting. Zhang et al. described a case of cardiac arrest occurring during percutaneous balloon compression for the treatment of trigeminal neuralgia [29]. Of particular interest, sinus rhythm did not recover after removal of the device and cessation of the compressive stimulus, making cardiopulmonary resuscitation necessary. This report is particularly relevant to our case, as the dynamics of the event and the violent intent underlying the assault likely precluded any possibility of prompt rescue.

The diving reflex, particularly studied in the context of sudden infant death syndrome [30], is triggered by contact with cold water and leads to bradycardia. Although usually benign, it can be lethal when combined with other cardioinhibitory triggers [31]. Additionally, pressure applied to reflexogenic areas, including the thorax and inguinoscrotal region, as well as intense physical or emotional stress, such as that experienced during violent altercations preceding the victim's fall, can significantly influence autonomic responses [32].

Previous studies have suggested that the simultaneous activation of two opposing reflex responses may lead to autonomic nervous system dysfunction and increase the risk of fatal cardiac arrhythmias. In this context, the diving reflex, discussed above, acts mainly through parasympathetic activation and promotes bradycardia, whereas the CSR stimulates the sympathetic nervous system and results in tachycardia. The concurrent activation of these two antagonistic pathways may generate an "autonomic conflict", which has been proposed as a possible mechanism underlying potentially lethal cardiac events [33]. In cases such as the present one, determination of the cause of death requires careful exclusion of other plausible medical conditions, such as cardiac arrhythmias, electrolyte imbalances, intoxication, and drug overdose [34].

The forensic literature addressing fatal events potentially attributable to a cardiac inhibitory reflex emphasizes three criteria for considering this mechanism: a well-founded hypothesis of cardiac arrest based on the circumstances of death, the documented presence of a reflexogenic trigger, and a complete autopsy unable to rule out cardiac inhibitory reflex as a cause of death [35]. In the present case, the prolonged postsubmersion interval limited the definitive exclusion of loss of consciousness followed by drowning.

Within this context, the distribution of blunt force injuries involving potential reflexogenic areas, together with contributing factors such as cold water exposure, abdominal trauma during the fall, and alcohol-related vasodilation, may have plausibly contributed to an imbalance of autonomic regulation. Considering the patient's age (78 years), it is also plausible that additional individual factors related to age-associated physiological decline and reduced functional reserve may have further increased vulnerability and contributed to the fatal outcome [36].

Interpretation is limited by several factors. Direct physiological confirmation of reflex-mediated death was not possible, and the prolonged 16-d submersion complicated the assessment of injury severity, timing, and the evaluation of tissue vitality. In addition, it is well recognized that, as decomposition progresses in bodies recovered from water, the postmortem evaluation of drowning signs becomes increasingly unreliable [37]. Putrefactive changes may alter, obscure, or completely mask several classical findings of drowning,

thereby reducing their diagnostic value and making the differential diagnosis between drowning and postmortem immersion more challenging.

Additional limitations include the absence of specialized histological sectioning of the cardiac conduction system, including the sinoatrial and atrioventricular nodes; therefore, structural abnormalities of the conduction system cannot be definitively excluded. Immunohistochemical markers such as connexin43 [38] have been described in the literature as potential tools for investigating early or subtle functional cardiac changes in experimental and research settings. However, these analyses were not performed in the present case and therefore such subtle alterations could not be assessed.

In addition, no postmortem genetic testing was performed [39]; consequently, underlying cardiac channelopathies cannot be definitively excluded.

Finally, postmortem endogenous alcohol production may have confounded the toxicological findings [40]. Complementary toxicological markers, such as urine alcohol concentration (UAC) and vitreous alcohol concentration (VAC), as well as ethanol metabolites, could have provided additional data for a more robust evaluation of the case [41]. In addition, alcohol consumption is a recognized risk factor for fatal river drowning and may have acted as a contributory factor in the overall forensic assessment [42].

4. Conclusions

In conclusion, a reflex-mediated mechanism remains a possible explanation among several competing hypotheses; however, no definitive causal relationship can be established based on the available postmortem findings.

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Institutional Review Board Statement: Since only normal clinical practice is described in this case report, formal ethical approval by the Independent Review Board was not required in accordance with the policy of our institution. The individual examined in the current study underwent a forensic autopsy. The collection of data, sampling, and subsequent forensic analyses were conducted with authorization from the Public Prosecutor. In Italy, forensic autopsies and related post-mortem investigations that are performed within the framework of a judicial proceeding (either upon prosecutorial order or under the authority of the judiciary) is exempted from the approval by an Institutional Review Board (IRB) or Ethics Committee. Such procedures are conducted under the provisions of the Italian Code of Criminal Procedure (Articles 359–360, 116, 224 et seq.), which govern medico-legal examinations performed for judicial purposes.

Informed Consent Statement: The report does not contain personal data. The authorization to use the judicial material was obtained from the Prosecutor's Office. All data are covered by Italian Law—Data Protection Authority (Official Gazette no. 72 of 26 March 2012)—for scientific research purposes. The study complies with the principles of the Helsinki Declaration and with the requirements of European Union GDPR regarding consent.

Data Availability Statement: No new data were created or analyzed in this study. Data sharing is not applicable to this article.

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