ORIGINAL ARTICLE

Significant preservation of the heart in human body extremely destroyed by the fire

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SUMMARY
Fire-related fatalities often result in extensive thermal destruction of human remains, posing significant challenges for forensic analysis. Although soft tissues are generally destroyed during exposure to high temperatures, rare cases may reveal selective internal organ preservation. This case report describes two individuals recovered from a recreational cabin fire in northern Slovakia, where most bodily structures were extensively carbonized and fragmented. Remarkably, the heart exhibited an intact internal morphology despite external carbonization. Macroscopic examination revealed preserved myocardium, distinguishable valve structures and voluminous cooked blood within the cardiac chambers. The pericardial sac and epicardial layer including coronary vasculature were thermally destroyed and thus non-evaluable. The preserved state of this organ, amid widespread anatomical destruction, suggests a thermal buffering mechanism mediated by retained blood and the histomorphological structure of the heart. This case underscores the importance of thoroughly examining severely burned remains, as preserved internal tissues may yield critical insights, contributing to the accurate reconstruction of death circumstances in fire-related fatalities.

Keywords: carbonization – fire-related death – thermal injury – heart – autopsy

Signifikantné uchovanie srdca pri extrémnej termickej deštrukcii ľudského tela

SOUHRN
Úmrtia v dôsledku požiarov často vedú k rozsiahlej termickej deštrukcii ľudských pozostatkov, čo predstavuje výzvu pre forenznú antropologickú analýzu. Vysoké teploty zvyčajne spôsobujú úplnú karbonizáciu mäkkých tkanív a výrazne degradujú aj kostné tkanivo, čím sťažujú aplikáciu štandardných identifikačných a vyšetrovacích postupov. Napriek tomu, že mäkké tkanivá sú pri vystavení vysokým teplotám spravidla veľmi ťažko morfologicky hodnotiteľné, v špecifických prípadoch a podmienkach môže dôjsť k selektívnemu zachovaniu vnútorných orgánov. Táto kazuistika popisuje dvoch jedincov nájdených po požiari rekreačnej chaty na severe Slovenska, kde bola väčšina telesných pozostatkov zuhoľnatená a fragmentovaná. Pozoruhodné však je, že srdce si napriek vonkajšej karbonizácii zachovalo pôvodnú anatomickú celistvosť a morfológiu. Pri makroskopickom vyšetrení bol zreteľne zachovaný myokard (kompaktná aj trabekulárna časť vrátane papilárnych svalov), endokard a chlopňový aparát vrátane cípov chlopní a ich úponov. V srdcových dutinách sa nachádzalo objemné množstvo termicky modifikovanej krvi. Perikard a epikard vrátane koronárnych tepien bol termicky deštruovaný a nehodnotiteľný. Zachovanie vnútorných štruktúr srdca, napriek rozsiahlej termickej deštrukcii tela vrátane celého skeletu, poukazuje na pôsobenie termoprotektívneho efektu, súvisiaceho s prítomnosťou tekutiny (krvi) v srdcových dutinách a histologickou stavbou srdcového tkaniva. Tento prípad zdôrazňuje význam dôkladného post-mortem vyšetrenia zuhoľnateného ľudského telo následkom požiaru, pretože zachované vnútorné štruktúry môžu poskytovať kľúčové informácie prispievajúce k presnej rekonštrukcii okolností úmrtia pri požiaroch.

Kľúčové slová: zuhoľnatenie tela – úmrtie pri požiari – termické poškodenie – srdce – pitva

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Fatalities resulting from fire are a frequent finding in forensic casework, however, the investigation of such deaths presents a range of forensic complexities and interdisciplinary investigative demands. Human bodies exposed to fire often suffer extensive thermal injury and post-mortem environmental interference, both of which hinder the preservation of forensic evidence and complicate the accurate interpretation of peri-mortem events (1-3).

Although fire has the capacity to destroy both soft tissue and the underlying skeletal structures, complete incineration of a human body is rare and typically achievable only under highly specific and controlled conditions. These include scenarios such as cremation, prolonged exposure to high-temperature fires or open-air pyres maintained over extended durations (4,5). These limitations can create confusion among law enforcement officers, fire investigators and forensic practitioners when encountering cases where a body appears almost entirely consumed by fire.

The analysis of burned human remains presents multiple challenges in both the recovery and laboratory stages. High-intensity heat causes significant physical alterations. These changes can impede both macroscopic and microscopic evaluations, complicating standard procedures for biological profiling, such as sex estimation, age assessment and stature reconstruction, as well as DNA and toxicological analysis (6). Recovery at the scene is further hindered by the morphological resemblance of burned biological and inorganic remnants, increasing the likelihood of overlooking or misidentifying critical evidence. Such difficulties can ultimately obscure determinations regarding peri-mortem trauma, delay victim identification and undermine efforts to accurately establish the cause and manner of death (7,8). Therefore, meticulous collection and safeguarding of every fragment and every piece of evidence, no matter how

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Fig. 1. Scene photograph showing the aftermath of a structural fire that completely consumed the wooden building, leaving only the chimney intact amid scattered debris and extensively burned material.

minor, is imperative. Each may carry essential information that contributes to a reliable and scientifically valid forensic conclusion.

While soft tissues are typically destroyed in high-temperature fires, leaving only thermally altered bone, rare exceptions exist. The present report examines a rare and unusual finding: a heart that was externally carbonized yet preserved internally, including myocardium and coagulated blood, recovered in the context of near-total body destruction. This case offers a unique opportunity to explore the biophysical principles that may allow partial organ preservation in extreme thermal environments and to assess the implications of such findings for forensic interpretation and death investigation.

CASE REPORT

Two unidentified bodies were discovered following a building fire incident in a recreational cabin located in northern Slovakia. The blaze, presumed to have been accidental, completely consumed the wooden building (Fig. 1). Human remains were recovered from two separate clusters within the debris, each spatially and anatomically corresponding to a distinct individual. At the time of recovery, both sets of remains exhibited extensive thermal alteration, including advanced charring and skeletal disintegration.

Forensic pathologists performed autopsies with the aim of assessing thermal injuries and establishing the cause and manner of death. The pattern and extent of fire-induced modifications suggested that death likely occurred shortly before or during the early stages of the fire. The X-ray examination of body remains, conducted prior to autopsy, revealed no metallic artifacts or other features useful for identification purposes.

Both individuals displayed advanced combustion-related changes, consistent with prolonged exposure to high temperatures (Fig. 2). Recovered cranial fragments included the supraorbital region, occipital bone, mandible and maxilla, along with displaced but thermally preserved teeth. Sex estimation was based on morphological traits of the mandible, mastoid processes and external occipital protuberance, indicating male biological sex in both cases. This assessment was further corroborated by analysis of the postcranial skeleton, particularly pelvic morphology and other sexually dimorphic features (9). Fragments of femur, humerus, scapula, ribs, vertebrae and long bones, were calcined, brittle and displayed thermal fractures and warping characteristic of post-mortem exposure to extreme heat. Bone shrinkage was noted and considered during interpretation.

Fig. 2. Extensively carbonized and calcined vertebrae (a) and skull elements (b), showing advanced fragmentation, charring and warping, indicative of prolonged exposure to high-temperature combustion. Calcined bone fragments appear white to gray, while more carbonized elements remain darkened.

Residual soft tissues were present, but showed advanced thermal destruction. In the first individual, only calcined remains of pelvic and thigh musculature, a thermally altered liver and charred remnants of the urinary bladder and prostate were identifiable. In the second individual, remnants of pelvic tissue and a single charred lung lobe were recovered. These structures were highly carbonized and provided minimal anatomical detail. Notably, among all organs, only the heart demonstrated exceptional preservation.

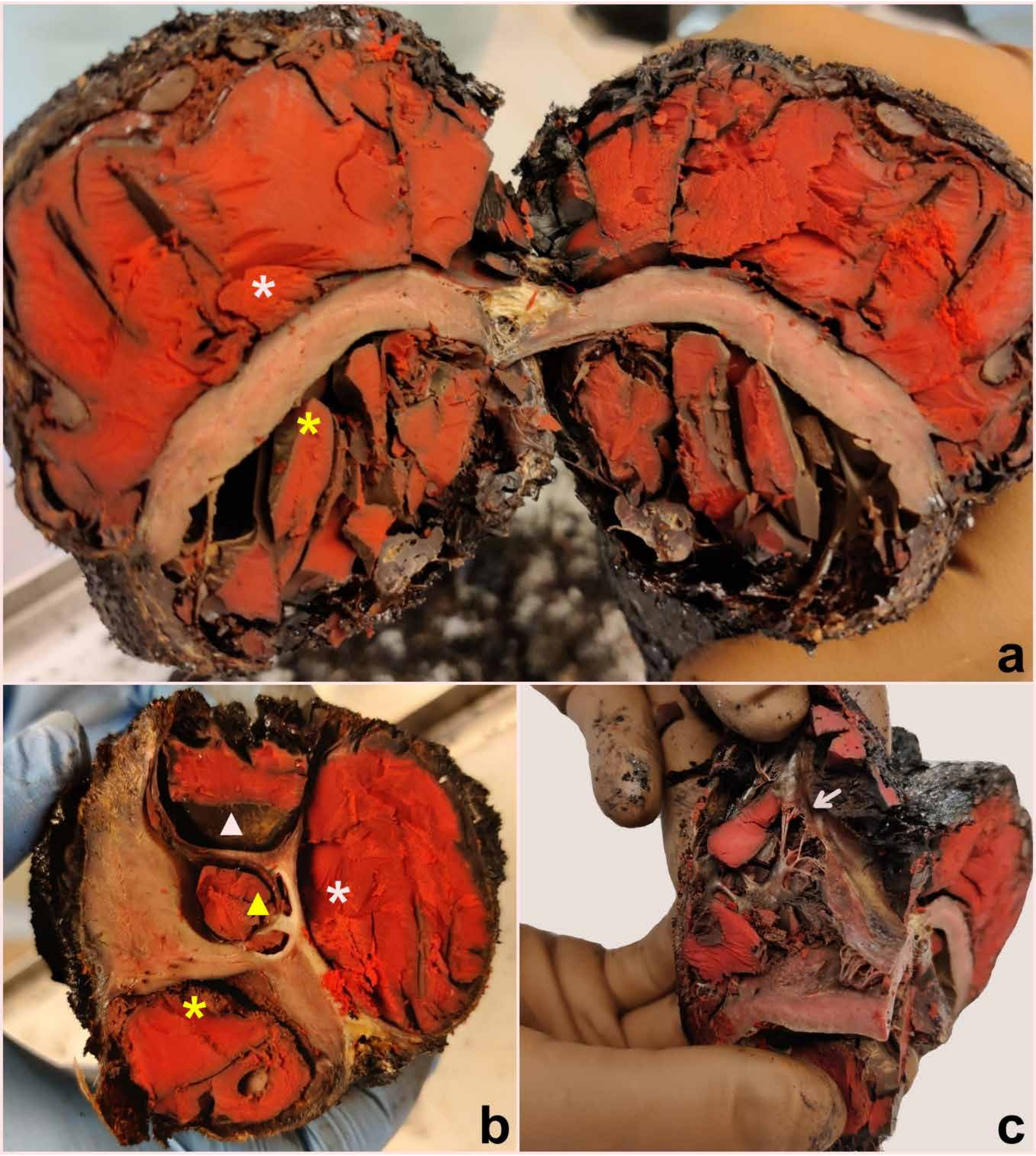

Fig. 3. A carbonized heart reveals a charred epicardial surface with partially preserved internal myocardial architecture and coagulated, thermally altered blood: (a) – longitudinal section of the heart with visible septum dividing left (yellow asterisk) and right (white asterisk) ventricles; (b) – transverse section of the heart with visible left ventricle (yellow asterisk) and right ventricle (white asterisk), aorta (yellow triangle) and pulmonary trunk (white triangle); (c) – interior of the left ventricle with visible cusp of the aortic valve (white arrow).

Against the background of widespread combustion-related damage, the preservation of the heart was particularly striking (Fig. 3). Macroscopic examination revealed that while the epicardium was completely carbonized, forming a rigid outer shell, the internal anatomy was basically intact. Upon sectioning, the myocardium remained pliable, with discernible muscular striations. The endocardial surface was intact and both the atrioventricular and semilunar valves were identifiable, including well-preserved leaflet morphology and visible anchoring structures at the annuli. The anatomical architecture of all four chambers, the left and right atria and ventricles, was distinguishable, allowing accurate anatomical orientation. Notably, both ventricular cavities contained coagulated and boiled blood, displaying stratification consistent with *in situ* thermal coagulation rather than post-mortem pooling. This degree of preservation is highly unusual given the surrounding level of thermal damage and suggests that the internal cardiac tissues were protected by localized thermal buffering, likely mediated by retained intracardiac blood and the anatomical position of the heart within the thorax. No vital pathological or traumatic changes has been noted on the preserved parts of the heart.

According to information provided by the police, both individuals had entered the cabin the day prior to the incident. At the time of discovery, the remains were still warm, supporting the inference that death had occurred during the night preceding the fire. Based on the investigated circumstances, the deceased were identified as two males, aged 22 and 24 years. Owing to the extensive thermal destruction of both bodies, the exact cause of death remained unknown. The police concluded the manner of death to be accidental.

DISCUSSION

In fire-related fatalities, it is common that only skeletal remains are recovered, as soft tissues are often completely destroyed or rendered unsuitable for analysis due to the extreme thermal conditions. Thermal effects on bone follow predictable and well-documented patterns. With increasing heat exposure, bone undergoes progressive alterations: dehydration, collagen loss, charring and ultimately calcination, accompanied by a characteristic color transition from black to gray to white (10-12). Fully calcined bone becomes highly brittle and fragmented, which significantly complicates both its recovery at the scene and its subsequent forensic evaluation. Given these challenges, it is crucial to assess all remaining biological remnants, including any preserved soft tissues, as such structures may retain valuable diagnostic or investigative information that skeletal remains alone cannot provide.

In the present case, most internal organs and soft tissues were either entirely destroyed or reduced to heavily charred remnants. While the heart's external surface was also completely carbonized, its internal structures remained remarkably intact. The myocardium retained its flexibility and the chambers of the heart contained a high volume of boiled blood. This finding suggests that the internal temperature reached the boiling point, yet did not rise to levels that would cause full protein denaturation or complete anatomical breakdown.

This finding mirrors the case presentation reported by Handlos et al., in which two individuals were recovered after a structural fire with extensive external thermal alteration. In both cases, a significant accumulation of blood in the pleural cavity, a hemothorax, was observed. It appeared that intrathoracic fluid acted as a shield to intrathoracic organs, such as the lungs and pericardial structures, protecting them from thermal destruction and even preserving indicators of stab wounds. The authors emphasized that this was the first documented instance of a hemothorax acting as a thermal insulator, protecting deeply located tissues despite high external heat (13). In our case, although no pleural fluid was present, the considerable volume of blood retained within the chambers of the heart likely functioned by a similar mechanism: attenuating conductive heat transfer, delaying heat-induced degradation and allowing internal cardiac structures to remain intact while other tissues including skeletal components, lungs or great thoracic vessels were extensively carbonized or destroyed.

From a thermophysical perspective, water-rich biological fluids such as blood possess both high specific heat capacity and significant latent heat of vaporization, allowing them to absorb substantial thermal energy before undergoing temperature elevation or phase transition (14,15). In this instance, the blood within the cardiac chambers likely acted as a localized thermal buffer. The process of boiling may have created a thermal plateau, maintaining the heart's internal temperature near 100 °C and thus preventing deeper tissue destruction. In contrast, the epicardium, lacking this internal protection and directly exposed to flames, underwent complete carbonization and hardening. It is also plausible that the outer carbonized layers acted as a secondary insulative barrier, further delaying conductive heat transfer. The presence of boiled, coagulated blood within the chambers strongly supports this thermal gradient and reinforces the concept of fluid-mediated preservation in high-heat post-mortem contexts.

Additionally, in our case, the preserved heart displayed not only intact internal architecture but also areas of visibly thickened myocardial and vascular tissue, which at first glance, could be interpreted as indicative of underlying pathology such as myocardial hypertrophy or vascular disease (16). In a routine autopsy setting, such macroscopic features might suggest chronic cardiovascular conditions or physiological adaptation to increased physical activity (17). However, this interpretation requires caution. Thermal effects on soft tissues, particularly vascular structures, can mimic pathological thickening. This phenomenon was demonstrated in the study by Živković et al., in which coronary artery segments were exposed to a temperature of 70 °C for a short period. Their analysis revealed substantial heat-induced morphological changes, including significant wall thickening, most notably within the *tunica intima* and *adventitia*, as well as partial or complete disruption of the internal elastic lamina. These findings occurred in otherwise healthy vessels and were not related to any underlying disease (18). Therefore, while the preserved state of the heart in our case is unusual and noteworthy, any apparent thickening or structural changes must be interpreted within the context of post-mortem thermal exposure.

From a forensic standpoint, the coexistence of internal tissue preservation and coagulated blood within a thermally devastated corpse provides valuable insight into the thermal environment and the sequence of events during burning. Internal tissues that retain structure may still be suitable for histological or toxicological analyses, even when external surfaces appear destroyed. Even in cases of near-total external incineration, internal organs may remain partially intact and forensically informative.

CONCLUSION

This case demonstrates a rare but significant phenomenon: the internal preservation of the human heart amid near-complete body destruction in a high-temperature fire. Despite advanced carbonization and fragmentation affecting all other anatomical structures, the heart retained identifiable internal features, including soft myocardium, intact valves and thermally coagulated blood. This finding supports the theory that endogenous fluids can serve a thermoprotective function by creating a localized heat buffer, thereby delaying or mitigating the extent of internal tissue degradation. Furthermore, the presence of myocardial thickening requires cautious interpretation, as heat-induced morphological changes can mimic pathological findings. Ultimately, this case reinforces the need for comprehensive forensic evaluation, even in cases of extreme thermal damage. Internal organ preservation, though infrequent, may offer critical insights into the circumstances surrounding death and expand our understanding of fire-related fatalities.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this paper.

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