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Original Article

Autopsy findings and identification process in severely burned bodies: A four-year retrospective case series

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Abstract

Aim: The identification and forensic evaluation of severely burned bodies can be challenging because fire may destroy both anatomical features and critical evidence. This study aimed to evaluate the autopsy findings, vitality indicators, toxicological results, and identification-related challenges in fire-related deaths.

Materials and Methods: This retrospective case series included nine fire-related deaths autopsied at the Council of Forensic Medicine, Van Branch, between 2018 and 2021. Autopsy reports and forensic investigation records were reviewed for demographic characteristics, incident circumstances, burn severity, vitality indicators, toxicological findings, cause and manner of death, and the feasibility of visual identification.

Results: Six victims were male and three were female, with all female victims being children. Six cases (66.7%) involved foreign nationals, and all deaths were classified as accidental. Soot was detected in the airways of all cases. carboxyhemoglobin (COHb) levels could be measured in three pediatric cases and ranged from 32% to 43%. Carbon monoxide poisoning was reported as the cause of death in two cases and as a contributing factor together with burn injuries in one case. Six adult victims had advanced fourth-degree burns, making visual identification impossible. Alcohol, illicit drugs, and fire accelerants were not detected in any case.

Conclusion: Vitality indicators, particularly airway soot and COHb levels, should be evaluated together in fire-related deaths. DNA analysis and dental examination are particularly important when visual identification is impossible. Heat-related artifacts should also be carefully distinguished from true traumatic injuries.

Keywords: Fire-related deaths, carbonization, victim identification, carbon monoxide poisoning, forensic autopsy, vitality markers

INTRODUCTION

Fire-related deaths constitute a significant public health concern and represent a common category of forensic cases. It is estimated that approximately 10% of such cases result from intentionally set fires. Therefore, all fire-related fatalities should be treated as suspicious, and in bodies recovered from fire scenes, the possibility that the manner of death may be suicide or homicide must be thoroughly investigated [1]. Although fire-related deaths are not uncommon in forensic practice, their investigation is considered among the most challenging due to the potential destruction of both the body and critical crime scene evidence by the fire [2].

Another frequent challenge in fire-related fatalities is determining whether the individual was already deceased prior to the onset of the fire. For instance, an elderly individual may collapse and die due to a fatal cardiac arrhythmia, after which a toppled heater could ignite a fire. Conversely, setting fire to a residence after placing a body inside to conceal a homicide is also a well-documented method. In light of such scenarios, meticulous evaluation of vitality indicators is essential in every fire-related death [1].

The most important indicators of vitality in burned bodies, demonstrating that the individual was alive during the fire, are the presence of soot deposition in the airways and elevated levels

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of carboxyhemoglobin (COHb) in the blood [3]. In assessing whether a person was alive at the time of exposure to flames in a fire environment, a COHb level exceeding 10% is generally considered a significant finding [4]. However, if COHb levels are low and the body is found in a burned state, the possibility that the individual was alive at the time of the fire cannot be entirely excluded. Conditions such as laryngeal spasm, exposure to toxic gases produced in the fire environment (e.g., cyanide, nitrogen oxides, phosgene), or injuries resulting from an explosion may lead to death during the fire despite low blood CO levels [4].

Deaths related to fires most commonly occur as a direct consequence of burn injuries. However, carbon monoxide poisoning or inhalation of other toxic gases may also constitute the cause of death [5]. Particularly in residential fires, when household items burn at a low intensity for a period of time, dense smoke accumulates in the environment, and victims may lose their lives due to the toxic effects of smoke rather than direct exposure to flames. In such cases, although carbon monoxide poisoning is the most common cause of death, burning synthetic materials may also release other lethal gases, such as cyanide [6].

In more intense and prolonged fires, advanced carbonization develops in the bodies; findings may range from the classical flexion posture known as the "pugilistic attitude" to completely charred bones and ash remains. In mass fire disasters involving multiple fatalities, where remains may become commingled, both the identification of burned bodies and the determination of the cause of death become extremely challenging [7]. In such situations, since soft tissues are often completely destroyed, preserved skeletal structures—particularly teeth—play a critical role in identification [8]. Furthermore, certain heat-related artifacts observed in severely burned bodies (e.g., heat fractures or heat hematomas within the skull) may mimic true traumatic lesions, posing a significant challenge in forensic evaluation [2].

The aim of this study was to retrospectively evaluate the demographic characteristics, autopsy and toxicological findings, vitality indicators, and identification-related findings of fire-related fatalities examined at the Council of Forensic Medicine, Van Branch, between 2018 and 2021.

MATERIAL AND METHOD

This study included all cases (n = 9) autopsied at the Council of Forensic Medicine – Van Branch between January 1, 2018 and December 31, 2021, with a history of being recovered from a fire scene. Autopsy reports and forensic investigation files were reviewed to obtain demographic data (age, sex, nationality), incident characteristics (type of fire, scene location, date), external examination findings (degree of burns, extent of carbonization, clothing and personal belongings, integrity of the body), and internal/toxicological findings (organ burns, presence of soot in the airways, COHb levels, alcohol and drug analyses).

Identification-related data, including the feasibility of visual identification and the use of DNA comparison, dental records, personal belongings, or other investigative evidence, were also obtained from the autopsy reports and forensic investigation files.

All data were recorded in Microsoft Excel and subjected to descriptive analysis. The findings are presented in tables and percentages with respect to the victims' sociodemographic characteristics and forensic examination results.

The study was conducted in accordance with the principles of the Declaration of Helsinki. Institutional approval was obtained from the Education and Scientific Research Commission of the Council of Forensic Medicine, Ministry of Justice of the Republic of Türkiye (approval date: February 22, 2023; approval no.: 21589509/2023/114). All data were anonymized, and identifying information was kept confidential.

RESULTS

Of the nine cases included in the study, six were male and three were female; all female cases were in the pediatric age group (one was a 13-month-old infant, and the other two were aged 3 and 5 years). The ages of the male cases could not be determined; however, all were adults and recorded as migrant workers. A total of 66.7% of the cases (n = 6) were of foreign nationality (presumably undocumented immigrants from abroad), while the remaining three cases were Turkish citizens.

In all nine cases examined, the manner of death was assessed as accidental; no evidence of homicide or suicide was identified in the forensic investigation records. Regarding the scene, three cases died in indoor residential fires, whereas the remaining six cases lost their lives in outdoor fire settings (workplaces, vehicles, or open areas). The demographic distribution of the cases and scene-related data are summarized in Table 1.

Table 1. Sociodemographic characteristics and scene of incident (n = 9)

Characteristic	No of cases (%)
Sex – Male	6 (66.7%)
Sex – Female	3 (33.3%)
Age Group – Child (<18 years)	3 (33.3%) – (5 y, 3 y, 13 mo)
Age Group – Adult	6 (66.7%) – (ages unspecified)
Nationality – Foreign	6 (66.7%)
Nationality – Turkish	3 (33.3%)
Scene of Incident – Home/Residence	3 (33.3%)
Scene of Incident – Other (Non-residential)	6 (66.7%)
Manner of Death – Accident	9 (100%)

Key findings from the autopsy and toxicological analyses of the cases are presented in Table 2. Soot was detected in the airways of all nine cases. In six cases, there were advanced burns (fourth-degree) with complete carbonization of the body, whereas in three cases (the pediatric cases), burns were limited to second- and third-degree. In six of the adult cases, visual identification of the bodies was not possible due to complete destruction of the face and distinguishing features by fire. In contrast, the pediatric

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cases demonstrated largely preserved body integrity, with facial and anatomical features partially recognizable.

Table 2. Identification and autopsy findings

Finding / observation	No. of cases (%)
Soot in respiratory tract	9 (100%)
COHb measured	3 (33.3%)
High COHb (> 10%)	3 (33.3%)
COHb not measured (sample unavailable)	6 (66.7%)
Visual identification possible by appearance	3 (33.3%)
Visual identification impossible (extensive burns)	6 (66.7%)
Advanced burn (4th-degree)	6 (66.7%)
Partial burn (2nd–3rd degree)	3 (33.3%)
Pugilistic posture (heat flexion)	5 (55.6%)
Body cavity opening (heat artifact)	3 (33.3%)
Limb loss (heat artifact)	4 (44.4%)
Heat-induced bone fractures	6 (66.7%)
Accelerant detected (fire accelerant)	0
Toxicology positive for alcohol/drugs	0
Cause of death – burn complications	6 (66.7%)
Cause of death – CO poisoning	2 (22.2%)
Cause of death – combined burns + CO	1 (11.1%)

Depending on the severity of the burns, the typical "pugilistic attitude" (heat-induced flexion posture) was observed in five cases. Due to exposure to high temperatures, spontaneous opening of body cavities (such as the skull or thorax) was identified in three cases, while in four cases, extremities (such as arms or legs) were found to be detached or missing. In six cases, multiple heat-related fractures were observed in the skeletal system. Notably, in the skeletal examination of two cases (severely burned adult cases), extensive fragmentation and fractures of multiple long bones due to advanced burning were identified (e.g., bilateral fractures of the right forearm, multiple fractures in the wrists and lower leg bones). According to the forensic investigation records, the identities of the severely burned adult cases were established primarily through comparison with familial DNA samples, supported by personal belongings recovered from the scene.

No evidence of gunshot wounds or sharp/penetrating injuries was detected in any of the cases (pre-autopsy radiographic screening examinations were also negative).

COHb levels could be measured in only three of the nine cases (the pediatric cases), from whom blood samples were obtained. In these three cases, COHb levels were determined to be 40%, 43%, and 32%, respectively. In the remaining six cases, CO levels could not be assessed due to the inability to obtain blood and internal organ samples as a result of advanced burning.

As the cause of death, six cases were attributed to burn injuries at the level of carbonization and burn-related complications (such as burn shock and fluid–electrolyte imbalance), whereas in two pediatric cases, the cause of death was reported as carbon monoxide poisoning. In one case (a 13-month-old infant), both burn injuries and carbon monoxide inhalation contributed to death.

No alcohol, illicit drugs, or other toxic substances were detected in any of the cases. Additionally, forensic laboratory analyses did not identify any fire accelerant residues (e.g., gasoline, thinner) in any of the cases.

DISCUSSION

This study presents the characteristics and identification process of nine fatal cases recovered from fire scenes over a four-year period in Van province. Although the number of cases is limited, evaluation of the findings in light of the literature reveals several parallels and noteworthy points. All nine deaths included in the present series were classified as accidental.

Although all deaths in our series were classified as accidental, this finding should be interpreted cautiously because of the small sample size. In a five-year Istanbul series, 98 of 133 fire-related deaths (73.7%) were accidental, 12 (9.0%) were homicidal, and 23 (17.2%) were undetermined, with no suicidal cases [1]. Another Turkish autopsy series classified 119 of 158 deaths (75.3%) as accidental, 9 (5.7%) as homicidal, 5 (3.2%) as suicidal, and 25 (15.8%) as undetermined [9]. Similarly, an Italian study reported 25 accidental, eight suicidal, three homicidal, and three undetermined deaths among 39 cases [10]. Therefore, the absence of homicide or suicide in the present series likely reflects the limited sample size and regional case characteristics rather than a general pattern of fire-related deaths.

In all nine cases in our study, the presence of vitality indicators (soot in the airways and/or carbon monoxide inhalation) is noteworthy. This finding demonstrates that the victims were alive at the time of the fire. In particular, COHb levels exceeding 30% in the three pediatric cases suggest that carbon monoxide poisoning played a primary role in death. According to the literature, the detection of COHb levels above 10% is considered a strong indicator that the individual was alive during the fire [3,4]. Carbon monoxide intoxication was reported to contribute to death, either alone or in combination with burns or smoke inhalation, in 74 of 158 cases (46.8%) in a Turkish autopsy series [9]. In the present series, carbon monoxide poisoning had a direct or contributory role in three of nine cases (33.3%). However, COHb levels could not be measured in six cases because suitable biological samples were unavailable due to advanced carbonization; therefore, a direct numerical comparison should be interpreted cautiously.

Nevertheless, low COHb levels may be measured in some fire-related deaths; in such cases, the presence of soot in the airways and other forensic findings must be evaluated collectively. For example, in our series, CO levels could not be determined in any of the adult migrant cases; however, the presence of soot in the trachea and bronchi indicated that these individuals were breathing in the fire environment. As reported by Byard, even

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an apparently "straightforward" fire-related death should be examined in depth, as the absence of soot in the body or low COHb levels may indicate that death occurred prior to the fire and may substantially alter the course of the forensic investigation [2]. The presence of at least one vitality indicator (and in most cases, both) in all of our cases constitutes an important finding confirming that death was fire-related.

The identification process represents one of the most challenging aspects of forensic practice, particularly in severely burned bodies. Destruction of both superficial and deep tissues due to burning eliminates the possibility of using fingerprints, facial recognition, and distinguishing features such as scars or marks for identification [7]. Carbonization of the facial tissues and thermocoagulation-related restriction of mouth opening may significantly complicate the collection and interpretation of dental findings in severely burned bodies. In a series of severely burned victims, final identification was achieved using DNA findings [11]. An examination of skeletal samples from 23 fire victims demonstrated an inverse relationship between thermal exposure and both DNA yield and STR profile quality. Nevertheless, optimized extraction methods produced full or partial STR profiles from severely burned remains [12]. These findings support the combined use of dental examination and DNA analysis, particularly from preserved teeth and skeletal tissues, when visual identification is impossible.

In such circumstances, dental records and DNA analyses constitute the most reliable methods for identification [8]. Teeth provide highly valuable data in the identification of fire victims, as they are more resistant to high temperatures than most skeletal structures [8]. If dental records (e.g., panoramic radiographs, treatment records) are available, identification can be achieved through forensic odontology examinations. However, this method is often not applicable in foreign nationals or undocumented individuals.

In such cases, DNA analysis becomes the most effective option. Well-preserved skeletal tissues (e.g., long bone shafts or dental pulp) are the most suitable sources for obtaining DNA from severely burned bodies. The literature reports that even in the 2009 Victoria bushfire disaster, identification of burned victims was successfully achieved through DNA analysis [7]. On the other hand, in remains exposed to extremely high temperatures for prolonged periods, DNA retrieval may become impossible; in such situations, the identification process must rely entirely on case-specific evidence (e.g., jewelry, prostheses, clothing fragments, personal belongings).

There are also certain challenges in the interpretation of autopsy findings in fire-related cases. Findings known as heat artifacts represent changes induced in the body by the burning process and must be distinguished from true traumatic lesions. For example, in bodies exposed to high temperatures, false accumulations of blood such as dural or epidural collections (heat hematomas) may occur due to increased intracranial pressure; these should be differentiated from true intracranial hemorrhage [2].

Similarly, cracking or fracturing of bones due to sudden exposure to heat is a common finding, and such heat-induced fractures were identified in many cases in our study. These fractures are postmortem artifacts and cannot always be easily distinguished macroscopically from fractures resulting from traumatic impact. Although several cases in our series exhibited multiple fractures in the extremities, forensic investigation and radiological evaluation concluded that all of these findings were postmortem changes related to the fire. An experimental study involving 30 human forearm bones found that several morphological features overlapped between mechanically induced and heat-induced fractures. Nevertheless, differences in fracture-surface morphology and discoloration patterns could assist differentiation [13]. These findings support the cautious interpretation of the multiple fractures observed in our cases and demonstrate that macroscopic findings should be evaluated together with radiological and, when necessary, microscopic examinations.

Our study has several important limitations. The number of cases is extremely small and reflects only the regional data of a single forensic medicine unit. Therefore, our findings are not generalizable, and statistical inference could not be performed. However, detailed evaluation of each case indicates that the findings are consistent with the literature and include representative examples, particularly with regard to vitality during the fire and identification processes. In the future, larger multicenter studies may allow for a more comprehensive analysis of the common characteristics and differences among fire-related deaths across the country.

CONCLUSION

In forensic practice, encountering bodies recovered from fire scenes is not uncommon. Successful investigation and identification of such cases require a meticulous and multidisciplinary approach. In particular, the scene investigation must be conducted thoroughly; the origin of the fire, factors contributing to its spread, and any potentially suspicious circumstances should be carefully examined.

Pre-autopsy radiological screening of the body may facilitate the detection of foreign objects such as bullets or knife fragments, thereby revealing possible evidence of homicide. During the autopsy, appropriate sampling must be performed to identify vitality indicators in burned bodies (e.g., soot and COHb), and toxicological analyses should be conducted in all cases. Determination of COHb levels, in particular, should be specifically requested in addition to routine toxicological examinations, and blood samples should be properly collected and submitted to the laboratory.

In the external examination, all personal characteristics of the body (e.g., clothing fragments, jewelry, prostheses, scars, implants) should be carefully documented and photographed. In severely burned and unrecognizable cases, biological samples (especially suitable bone or dental specimens for DNA analysis) must be

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collected for identification purposes. Dental examination should be performed, dental features recorded, and consultation with a forensic odontologist should be requested when appropriate.

Furthermore, detailed pathological and radiological evaluations are recommended to distinguish heat-related artifacts from true traumatic lesions in suspicious findings. In conclusion, in forensic cases involving fire-related deaths, adopting an integrated approach encompassing scene investigation, autopsy, and laboratory analyses, evaluating all findings holistically, and supporting the identification process with modern forensic techniques are of paramount importance for the administration of justice.

Conflict of Interests
The authors declare that there is no conflict of interest in the study.

Financial Disclosure
The authors declare that they have received no financial support for the study.

Ethical Approval
The study was conducted in accordance with the principles of the Declaration of Helsinki. Institutional approval was obtained from the Education and Scientific Research Commission of the Council of Forensic Medicine, Ministry of Justice of the Republic of Türkiye (approval date: February 22, 2023; approval no.: 21589509/2023/114).

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