Forensic Sciences Research, 2024, Vol. 9, Issue 3
https://doi.org/10.1093/fsr/owae040
Case Report

Still waters run deep: a unique case of mummification under extreme conditions

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Abstract

In rural Crete, Greece, a mummified body was discovered inside a screw-top plastic barrel next to a dry riverbed. Local authorities conducted a field investigation along with a forensic pathologist, and the body was transferred inside the barrel to the Forensic Medicine Unit of the University of Crete for further investigation. Forensic examination included radiographs taken using a portable X-ray machine *in situ* followed by extraction of the remains, a full-body postmortem computed tomography scan, autopsy, DNA extraction, tissue and biofluid sampling, and histological and toxicological analyses. Two butane camping gases were recovered from inside the barrel. The remains were determined to belong to a middle-aged adult male. The postmortem interval was estimated to be over 4 months. DNA comparison revealed that the body belonged to a 58-year-old man who was reported missing 28 months prior to discovery. Examinations showed no evidence of skeletal or other trauma, and death was attributed to asphyxia due to oxygen deprivation. Careful examination of the barrel, which bore several peculiar modifications, in conjunction with contextual information pertaining to the deceased's personal life, led to successful case resolution.

Key points

- Advanced decomposition and taphonomic alterations present challenges for forensic practitioners.
- A case of a set of mummified remains discovered inside a plastic screw-top barrel is reported.
- A multidisciplinary approach, including examination of the barrel and contextual information regarding the deceased, led to case resolution.

Keywords: forensic sciences; forensic anthropology; forensic imaging; mummification; asphyxia

Introduction

Examination of highly decomposed bodies presents a challenge to the most experienced forensic pathologists and anthropologists. The condition of the remains, the degree of decomposition and fragmentation, and the effect of taphonomy are a few factors that can impede forensic analysis and identification. Contextual information can be helpful but misleading. This report presents a unique case of mummified remains recovered on the island of Crete, Greece. Identification of the deceased provided great leads to the investigating authorities, resulting in a successful case resolution.

The case

Death scene investigation

In late July 2021, a city worker conducting landscaping work in a rural area of Southern Crete discovered a plastic barrel containing human remains in advanced decomposition. The police arrived at the scene accompanied by a forensic pathologist to perform a field investigation. A blue plastic screw-top barrel was discovered ~20 m from a dried riverbed 15 m from the highway. The lid was also recovered near the barrel. A mummified human head was visible, protruding from the barrel's opening (Figure 1). The barrel was transported untouched to the Forensic Medicine Unit (FMU) of the

Figure 1 Scene of discovery.

Received: April 30, 2024. **Accepted:** July 23, 2024

University of Crete for further investigation. The identity of the remains was unknown at the time of discovery and initial examinations.

Postmortem imaging

X-rays

Twenty-six X-ray images were taken before extracting the remains from the barrel to gain insight on the interior and the condition of the remains. The body was in the foetal position: the arms and legs were folded towards the torso, and the head was positioned towards the barrel opening. No skeletal trauma or ballistic foreign bodies were found. At least two maxillary teeth contained fillings. Several metallic objects were identified: two keys, one wristwatch, several trouser buttons, one belt buckle, and a zipper. A cylindrical non-metallic foreign object resembling a pipe was captured, demonstrating one free edge near the head and another fixed on the barrel wall (Figure 2A and B). Finally, two camping gases were identified at the bottom of the barrel (Figure 2C).

Postmortem computed tomography (PMCT) examination

A full-body PMCT examination was conducted using a GE Lightspeed (Cincinnati, OH, USA), 64-slice volume CT, at the Medical Imaging Department of the University Hospital of Heraklion, Crete. The body was extracted from the barrel and laid anatomically to fit the scanner. The examination revealed several potential identity indicators but no signs of skeletal trauma or severe pathology (Table 1).

Dental examination

Dental examination revealed antemortem loss of teeth 38 and 46, the presence of dental amalgam fillings on teeth 25, 26, and 27, and evidence of root canal treatment on teeth 23 and 24. The aforementioned oral (buccal) exostoses of the maxilla and mandible [1, 2] were also noted. A dental professional evaluated the dental work, which was considered to be old and of poor quality. An odontogram was created for possible comparison with antemortem data if available.

Clothing and personal items

The clothing of the deceased was also examined for evidence collection and identification. A rainproof jacket was recovered from the bottom of the barrel. The body was dressed in a long-sleeved woollen sweater, a sleeveless undershirt, long blue jeans, a belt, underwear, woollen socks, and size 44 laced shoes. All clothing items were drenched in decomposition fluid but were otherwise intact. A wristwatch was also recovered from the deceased's left wrist, that was still operational. A set of house keys was also discovered inside the barrel.

External body examination

External examination of the remains revealed extensive drying of the skin, which displayed a darkened, leathery appearance consistent with mummification, most prominently on the facial and neck region, arms, and legs with sites of skin detachment and bone exposure. Epidermal detachment at the extremities and digits made fingerprints unobtainable. Dark

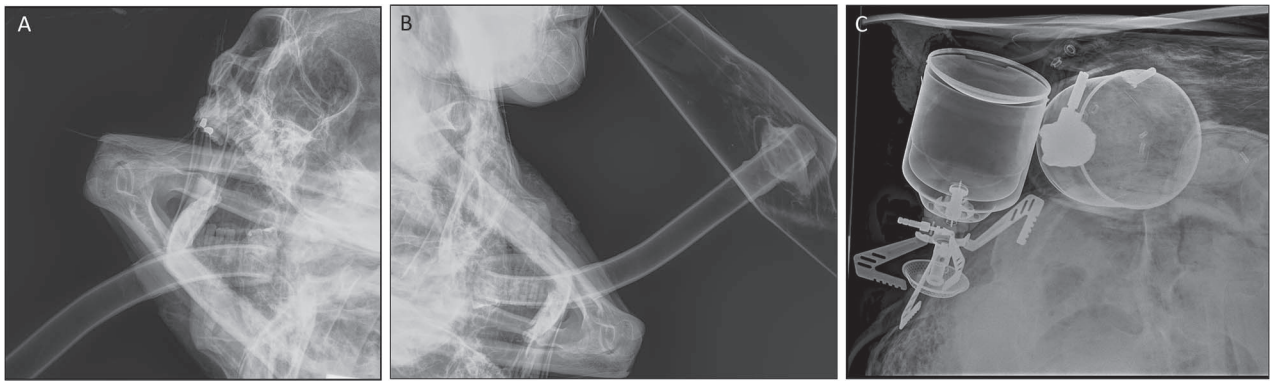

Figure 2 X-ray images. (A, B) A non-metallic cylindrical object and the spatial relationship to the deceased's head. (C) Camping gases at the bottom of the barrel.

Table 1. Major findings on the postmortem computed tomography (PMCT) examination.

Type	Finding
Trauma	Absence of recent skeletal trauma Absence of healed skeletal trauma Absence of soft tissue or organ disruption
Pathology	Low bone density Osteophytic activity Absence of metallic objects embedded in the body (e.g. bullets)
Potential ID indicators	Presence of dental fillings in the maxilla Upper and lower dentition available for comparison Antemortem loss of teeth 38 and 46 Presence of mandibular and maxillary oral exostoses Presence of left inguinal hernia Presence of frontal sinus Metallic objects (keys, wristwatch, belt buckle, buttons, zipper) on the body Absence of prosthetics objects in the body (e.g. orthopaedics devices)

brown curly hair was preserved with some white streaks. Short, irregular facial hair of a few millimetres was also noted. Heavy hair growth was observed, mostly on the chest region. No evidence of trauma was recorded.

Autopsy

A full autopsy showed no evidence of trauma or foreign objects in the body. A left inguinal hernia and degenerative changes on the skeleton were noted on the CT scan and grossly confirmed. All remaining organs were severely decomposed, and both their gross and microscopic examinations offered no valuable information.

Additional analyses

Organ and muscle tissue samples were collected for toxicological analysis, but the results came back negative for alcohol, pharmaceuticals, and narcotics. Dental and bone samples were kept for possible isotopic analysis. Femoral bone (10 cm) was sampled according to the instructions of the National DNA Laboratory of the Hellenic Police, and all fingernails were collected to detect biological material.

Biological profiling

The sex of the individual was easily determined as male based on the preserved external genitalia and secondary male sex characteristics, such as facial hair and extensive hair growth. The stature was measured to be 170–175 cm, a range provided to account for the soft tissue loss and dehydration due to decomposition. Population affinity was assessed as European, based on the gross morphology of the cranial features [3]. Skin colour could not be assessed owing to the advanced decomposition of the remains and extensive tissue mummification. Several parameters were assessed to estimate the age: dental root translucency [4, 5], which has been shown to perform well in the Greek population [6], metamorphosis of the sternal end of the fourth rib through PMCT [7, 8], the reduced bone density, the presence of vertebral osteophytic activity [3, 9, 10], dental morphology and quality, and the presence of white hairs. Table 2 illustrates a probable combined age range with the possibility of age at death being more likely to fall towards or over the upper limit.

Postmortem interval (PMI) estimation

The PMI was estimated considering three parameters. First, the condition of the body relative to the closed airtight environment in which it was enclosed (a sealed barrel) made it impossible to establish an upper limit to the PMI. Second, the clothes on the individual were warm, winter clothes, and third, the wristwatch recovered was set to the winter time zone (therefore likely set before March 31st). Because those parameters and the peculiar and highly specific circumstances of the body enclosure did not allow for a more precise estimation, death was determined to have occurred during the winter. Therefore, the time of death was set at a minimum of 4 months prior to discovery (possibly February or earlier). The upper PMI limit was unclear and thus not proposed considering the varying ranges in the literature (e.g. [11] mentions a range of 18–217 days, whereas [12] describes a case of mummified remains preserved in similar settings for over 30 years).

Table 2. Age estimation methods and provided age assessments.

Method	Age assessment (years)	Reference
Dental root translucency	28.8–38.8	[5]
	34.6–51.4	[4]
Condition of dentition	Middle age	
Sternal rib end metamorphosis	41–67	[7]
(CT assessment)		[8]
Mean osteophyte score	32–58	[10]
(CT assessment)		[9]
Clear presence of osteophytes	>40	[3]
Broad estimate	28.8–67	
Probable age range	40–60	

Barrel examination

The barrel and its contents were examined to provide contextual information regarding the cause and possible manner of death. The main inquiries of the investigation revolved around the way and reason the body was found inside the barrel and whether it happened antemortem, perimortem, or postmortem.

The cylindrical pipe-like object apparent on the X-rays was a plastic water hose, whose rear end penetrated the barrel wall. This construction corresponds to a makeshift fertilizing tool used by farmers in the rural regions of Crete. Its purpose is to be filled with a mixture of fertilizer dissolved in water that slowly leaks into the soil through the water hose. In this case, soil blocked the penetrating end of the hose, and the free end inside of the barrel was taped to a plastic bag found at the *in situ* examination of the remains near the head of the deceased (Figure 3A). A roll of duct tape corresponding to the one used to tape the plastic bag was also recovered from inside the barrel. The two camping gases previously identified *via* X-rays were empty but switched on. Careful examination of the barrel's rim showed residue of a white-coloured, dried adhesive material, similar to that used for construction, placed both on the interior and exterior rim surfaces. Residue of the same material was also identified on the lid, further strengthening the hypothesis that the barrel was sealed for a period of time prior to discovery. Another interesting finding was the existence of four fabric straps glued on the interior lid surface (Figure 3B).

Identification

The remains likely belonged to a European male, aged 40–60 years, with no evidence of old injuries or skeletal pathology and several identity indicators, personal items, and clothing. The remains were finally identified through DNA comparison with the closest match from the missing persons' list. The deceased's son provided a sample for comparison, which confirmed that the body belonged to a 58-year-old Greek male who disappeared 28 months prior to discovery and was reported missing by family members in early March 2019. The circumstances of the individual's disappearance were unclear at the time; however, his car was discovered several months prior to the discovery of his remains, a few kilometres away, but within walking distance from the site. Personal items and official documents (e.g. ID card and driver's licence) were discovered inside the vehicle at the time of its discovery.

Mechanism, cause, and manner of death

Forensic investigation of the remains, considering the police investigation and all available evidence, defined the most probable cause of death as asphyxia due to oxygen deprivation in an enclosed, sealed space. The presence of the switched-on camping gases was likely relevant to the mechanism of

Figure 3 (A) Water hose (arrows) penetrating the barrel wall and the plastic bag attached to its free end, relative to the deceased's head. Presence of a dried adhesive material is noted along the barrel's rim (arrowheads). (B) Interior aspect of the barrel's lid and four fabric straps attached to it (arrows), as photographed at the scene. The same adhesive material is noted (arrowheads).

death, as inhalation of butane gas is sometimes used recreationally and can lead to direct and indirect toxicity [13–16]. However, this was impossible to test at the point of examination, especially considering the volatile nature of butane gas and the long PMI. The peculiar circumstances of the death ruled out the possibility of an accident. With no evidence of criminal activity, as determined by both forensic practitioners and the police, the manner of death was classified as suicide.

Discussion

The discovery of human remains inside enclosed spaces such as a barrel or suitcase is naturally deemed suspicious by authorities and forensic practitioners. The most obvious conclusion is that the barrel was used to dispose and conceal the body of a homicide victim. This practice, referred to as a "barrel murder", was adopted by early American mafiosi in the 1870s, in which victims who had been shot or stabbed to death were enclosed inside barrels and dropped on the streets or posted to a different city [17]. Cases involving concealment of human remains are common in the literature [18–21] and are most commonly associated with homicides. Catanese and Bloom [12] reported a case of a victim of blunt force trauma homicide discovered in a state of mummification inside a sealed 55-gallon drum over 30 years after death, further highlighting the limitations of setting an upper limit to PMI estimations. Such discoveries can, however, result from third parties failing to report an individual's death to "not be parted" from their loved one or to protect others involved in illegal activity (e.g. drug use) [18, 19, 22].

Body confinement in sealed spaces includes suitcases, barrels, bricked spaces, freezers, and bodies set in concrete. The anaerobic environment of the enclosed space affects the decomposition process and obstructs scavenging activity by insects and animals [11], which can lead to long-term preservation of the remains, complicating the PMI estimation and identification of the deceased. The contribution of forensic anthropology to assess age and sex early in the investigation is of the utmost importance to provide authorities with a robust, preliminary biological profile and allow initiating investigations into the possible identity of the deceased. Furthermore, forensic anthropology expertize allows searching for and discovering traits that can be used for identification purposes (e.g. frontal sinus and anatomical variants) and to comprehensively evaluate skeletal trauma.

The body in our case was revealed after the barrel was accidentally knocked over by an excavator machine operated by a landscaping city employee, and the lid was ejected, revealing the body inside. The barrel was constructed to leak fertilizer into the soil through a cylindrical plastic water hose whose rear end penetrated the barrel wall. The penetrating end of the hose was blocked by soil, and the free end inside of the barrel was taped with a plastic bag near the head of the deceased. This initially created the impression that the plastic bag was taped around the head, which raised questions on the role of this setting in the individual's circumstances of death. Body confinement and suffocation are long-documented forms of torture as methods of gaining information, punishment, or intimidation [23]. In addition, torture victims are disposed of immediately after death and may not be discovered for a while, thus making identification and forensic investigation challenging [24] since suffocation leaves no signs on a decomposed body. In view of this evidence, the authorities considered the possibility of this being criminal activity of the sort of "settling scores" amongst criminals.

Meticulous investigation of the physical evidence revealed the peculiar adjustments made on the barrel itself. The fabric straps placed on the interior aspect of the lid enabled sealing the lid from inside the barrel. This means that the plastic bag was wrapped around the rear end of the hose and not the head of the deceased to seal the opening of the hose from the inside. All evidence together pointed towards a self-executed confinement, indicating that the manner of death was suicide. To our knowledge, no cases of suicide by self-containment have been published to date.

After the remains were positively identified, new contextual information came to light through a police search of the deceased's residence and through interviews with his family and social circle. The investigation revealed that the deceased had no enemies, debts, or involvement in criminal activities. He had expressed to family members his will to "leave" and "never to be found again". In addition, he was infatuated with a well-known Greek philosophical figure (DL). DL was a University Professor of Philosophy and Education who disappeared after leaving a letter stating his plan to take his own life. His skeletonized remains were discovered inside a remote cave several years later. His burial location was indicated to his wife by a family member who was instructed to do so 7 years after his disappearance. His death was considered a suicide.

This case exemplifies how positive identification of the deceased along with meticulous documentation and interpretation of physical evidence can lead to safely ruling out criminal activity. Because of the advanced state of decomposition of the remains, the exact cause of death could not be ascertained; however, the most probable scenario was determined in the absence of disputing evidence. This case highlights the importance of a multidisciplinary approach and continuous interagency communication; a forensic investigation cannot and should not be conducted within a "circumstantial void".

Acknowledgements

The authors thank the Radiology Department of the University Hospital of Heraklion for their invaluable contribution to the forensic casework handled by the FMU.

Authors' contributions

Despoina E. Flouri drafted the manuscript. Despoina E. Flouri, Efstratios Kougios, Elena F. Kranioti, and Antonios Papadomanolakis contributed to the forensic analysis and interpretation. Efthimios Fasoulakis and Konstantinos Spanakis analyzed and interpreted imaging data. All authors edited the manuscript and have read and agreed to the published version of the manuscript.

Compliance with ethical standards

The authors declare that they have complied with ethical standards. This case is part of an ongoing research protocol approved by the Research and Ethics Committee of University General Hospital of Heraklion, Crete, Greece (N. 1388/2016). All data used were anonymized. The case is no longer a subject of a forensic investigation as it is considered closed thus no legal approval needs to be obtained.

Disclosure statement

None declared.

Funding

None declared.

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