



Case Report

Severe starvation and restraint in a 47-year-old woman: Clinical, autopsy and histopathological evidence of abuse and neglect

Giorgia Franchetti^{a,*}, Clara Cestonaro^{a,1}, Renzo Giordano^a, Enrica Callegari^a, Chiara Giraud^b, Guido Viel^a, Giovanni Cecchetto^a

^a Unit of Legal Medicine and Toxicology, Department of Cardiac, Thoracic, Vascular Sciences and Public Health, University of Padova, Via Falloppio 50, 35100 Padova, Italy

^b Unit of Advanced Clinical and Translational Imaging, Department of Medicine - DIMED, Via Giustiniani 2, 35121 Padova, Italy

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ABSTRACT

The recognition of abuse and/or neglect still represents a challenge for both clinicians and forensic pathologists. Whereas abusive behaviors have been largely described among pediatric and elderly populations, adults' abuse and neglect is less frequently encountered, and therefore investigated. We report a case of a middle-aged woman without any known organic or psychiatric disorders who died of a multiple organ failure (MOF) due to extreme cachexia and bed-resting syndrome. The integration of all clinical, autopsy and histopathological data highlighted a picture of severe malnutrition, restraint, and widespread traumatic injuries related to abuse and neglect. We believe that the case here presented could be useful for both clinicians and forensic pathologists as it underlines once again the importance of collecting and integrating all medical evidence (both in the ante- and post-mortem settings) for reconstructing the most probable pathophysiology of disorders and injuries, comparing that reconstruction with the allegations of the caregivers, and thus identifying any potential abuse and/or neglect behaviors.

1. Introduction

The recognition of abuse and/or neglect behaviors without the victim's disclosure often embodies a challenge for the clinicians and/or the forensic pathologists facing the case in the ante- or post-mortem setting.

When an organic disease is present, mild or moderate clinical signs may be considered as part of the medical disorder and only the most serious signs (e.g., fractures or severe malnutrition) might lead to suspect an abusive conduct [1]. Medical evidence conflicting with allegations, unusual delay in seeking for medical help, uncommon weight loss and malnourishment may underlie an abuse/neglect and therefore should raise a red flag in the mind of the examiner [2]. Potential markers of abuse and neglect have already been described in the forensic literature; they include, as for example, multiple lacerations and abrasions, bruises at different stages of healing, head, spine and trunk fractures, wounds related to restraint, preventable pressure ulcers, inadequate nutrition and hydration [3,4]. Unfortunately, sometimes both abuse and neglect may remain misunderstood during life: in such cases, the

autopsy represents the last chance for the diagnosis [5], which should be based on radiological, autopsy, histology and laboratory data.

We present the case of a 47-year-old woman with no known organic or psychiatric disorders admitted to hospital in a comatose state dying after 3 days of hospitalization. Given the severe malnutrition, not explained by any medical reasons, and the contradictory allegations of the relatives of the victim, the clinicians contacted the judicial authority, which requested a forensic autopsy.

2. Case history

After the emergency number was called by her relatives, a 47-year-old woman was rescued at home by the emergency staff. As she was found unconscious, she was conducted to the Emergency Department, where the physicians described her as 'comatose and not contactable', with an edema of the left half-face. Health professionals identified also cachexia, poor general conditions, several infected ulcers and multiple traumatic lesions. Blood tests were indicative of dehydration

* Corresponding author.

E-mail address: giorgia.franchetti@studenti.unipd.it (G. Franchetti).

¹ These authors contributed equally and should be considered co-first authors.

(hypernatremia and hypokalemia) and revealed hypoglycemia, anemia, and low creatinine levels. Toxicological screening tested negative. At thoraco-abdominal CT, multiple left rib fractures with osteo-repairing signs and a reduction in bone density were observed. The patient's sister and mother told the physicians that up to ten days prior to hospitalization she fed and walked autonomously; they alleged also that in the past ten days the woman complained 'fatigue' and leg pain, which hindered her walking capability. The two relatives reported also that the woman suffered unspecified circulation disorders that could have caused the leg ulcers. During hospitalization, the health conditions of the patient worsened progressively till her death, which occurred three days after admittance because of multi-organ failure. The Public Prosecutor, who was informed by the physicians about the physical conditions of the woman and the contradictory allegations of her relatives, asked for a forensic autopsy. The inspection of the victim's home, carried out by the Police several days after the death of the victim, revealed that she used to live together with her mother and sister in very precarious living conditions; no evidence of physical restraint was found. The whole previous documentation was analyzed: no recent hospitalizations were found, and the family physician lastly examined the woman 2 years earlier, making a generic diagnosis of 'single ulcer of the right lower limb'. The woman suffered no known pathologies and had no cognitive delay; she worked as a teacher until she was 42 years old. The doctor reported a complicated relationship between the woman, her mother and her sister, but situations of physical and/or psychological violence had never previously emerged. The neighbors said they did not see the victim leaving the house during the last year. The Public Prosecutor therefore decided to inquire the woman's mother and sister for physical abuse (art. 572 of the Italian criminal code). The criminal trial ended two years after the death of the victim due to the death of both her mother and sister.

3. Materials and methods

3.1. Forensic autopsy

Complete post-mortem examination was performed 2 days after the death.

3.2. Histopathology

Tissue samples of brain, heart, lungs, spleen, liver, kidneys, thyroid gland, and suprarenal glands were fixed in 4 % buffered formalin for 24 h, embedded in paraffin, cut by microtome in 7- μ m sections, and stained with hematoxylin and eosin (H&E). All the sections were examined with a Leica DM4000B optical microscope (Leica, Cambridge, UK).

Furthermore, the following comparative analysis was conducted. Tissue sections of the heart and liver of the reported case and of one control sample with a normal BMI (coupled by age and gender) were analyzed with the same optical microscope. For each liver tissue section, 10 noncontinuous and not overlapping zones at magnification 400x were analyzed: the cell diameter of all hepatocytes was measured, and the average values were calculated for both the case and control. Heart sections were divided into subepicardial adipose tissue and myocardium; for each region, 10 noncontinuous and not overlapping zones at magnification 400x were analyzed: cell diameters of all adipocytes and myocytes were measured, and the average values were calculated and compared.

4. Results

4.1. Forensic autopsy – external examination

Vertex to heel 176 cm and weight of approximately 35 kg. The corpse laid on an obligatory left side decubitus, with severe scoliosis (right dorsal hump) and bilateral flexed ankylosis of the hips and knees. She

had atrophic muscular masses, anasarca, no adipose panniculus, and costal bones-iliac-knee protrusions (knobby knees). The corpse displayed multiple traumatic injuries with polymorphic characteristics and a polytopic distribution.

Abrasions were small sized, isolated and located on the face, the right shoulder, the right parasternal region and the left knee. Ecchymoses were mostly localized on the upper extremities, extended along the medial and distal surfaces, purplish colored.

Ulcerative areas were localized both on the dorsal surface of the body (i.e., back, sacrum, coccyx and right trochanteric region on the bony prominences) and the distal region of the lower extremities with a circumferential extension (Fig. 1). These latter ulcerations were bilateral, extended to the distal region of the legs and ankle, associated to other smaller ulcerated areas on the feet.

4.1.1. Forensic autopsy - internal examination

Weight and morphology of the main organs are reported in Fig. 2. The most relevant internal findings were a marked reduction of both subcutaneous and visceral adipose tissue, with gelatinous fat transformation, and a comprehensive atrophy of all organs, except for the brain. Abundant serous effusions were observed in the pleural, pericardial and peritoneal cavities. Multiple well-healed fractures were observed in the rib cage, with varying degrees of callus bulging. One rib fracture appeared to be recent as evidenced by the partially healing of the bone. Almost all the ribs were involved, at multiple sites in single ribs, bilaterally along the midclavicular lines, anterior and posterior axillary lines and scapular lines (Fig. 3A-B). A severe deformity of the rib cage was also observed (Fig. 3C). No pathologies affecting the vessels or neoplasms were detected.

4.1.2. Histopathology

Histopathological findings of the main organs are shown in Fig. 2. Histology confirmed the organ atrophy. Significant cellular shrinkage was demonstrated in the heart and liver (Fig. 4). The average diameter of myocytes was 18.015 μ m in the control and 10.929 μ m in the reported case. The average diameter of the subepicardial adipocytes was 77.373 μ m in the control and 13.718 μ m in the reported case. The average diameter of the hepatocytes was 17.170 μ m in the control and 10.715 μ m in the reported case. Mucoid interstitial alteration was found in the myocardium and subepicardial adipose tissue. Both lungs showed capillary congestion and atrophic emphysema. Other histopathological findings were colloidal condensation and collapse of the follicles of the thyroid gland and vacuolar degeneration of the adrenal medullary cells. Histological examination of intestine and pancreas excluded diseases causing malabsorption (e.g. celiac disease, Chron's disease, chronic pancreatitis, etc.).

Histological examination of the skin lesions showed the coexistence of ulcerated and necrotic areas, located on the lower limbs and sacrum, and areas with reparative fibrosis of the dermis and epidermal hyperplasia, located on the back.

5. Discussion

Abuse and neglect are issues often addressed referring to children, elderly, disabled and psychiatric patients, rather than to middle-aged adults without known organic disorders. Child abuse manifests when the caregiver 'fails to provide for the youth's health and well-being either by causing an injury or, as in neglect, by not meeting a basic need' [6]; the World Health Organization defines elder abuse as 'a single or repeated act, or lack of appropriate action, occurring within any relationship where there is an expectation of trust, which causes harm or distress to an older person' [7]; risk factors consist in functional dependency, cognitive impairment, poverty, poor or conflictual relationships, low social support [8,9]. Bruises, wounds, burns, of different age of healing and/or pattern, and restraint marks on wrists or ankles have been considered indicators of physical abuse in the elderly. On the other

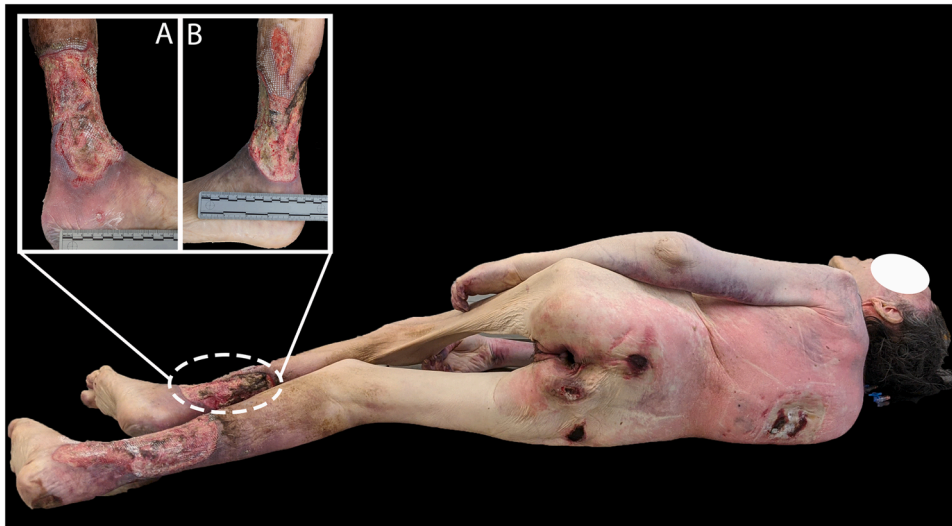


Fig. 1. Dorsal surface of the body. Ulcerative areas on the bony prominences of the back, sacrum, coccyx, right trochanteric region and lower limbs. Particularly, the ankles and the distal parts of the calves showed ulcerated areas characterized by circumferential extension.

side, dehydration, malnutrition, extensive pressure ulcers and poor hygiene are indicators of neglect [10], which consists in lacking proper care and may occur through failure to provide sufficient food, medical care, and cleanliness [11,12].

The case here reported is emblematic because of the simultaneous presence of cachexia, prolonged bed-resting consequences and multiple lesions in a middle-aged woman without any known organic or psychiatric diseases, with the exception of a single leg's ulcer of unspecified etiology reported by the family physician two years earlier.

At forensic post-mortem examination, findings such as extreme emaciation, markedly reduced body weight, generalized edema, severe rarefaction and gelatinous transformation of adipose tissues, atrophy of skeletal muscles, and atrophy and weight loss of the internal organs, indicated a state of starvation [13,14]. Starvation is the most extreme form of malnutrition, which has been defined as “cellular imbalance between the supply of nutrients and the body's demand for them to ensure growth, maintenance, and specific functions” [15]. During the first 24 h of starvation, hepatic glycogen provides to maintain blood glucose concentrations. After this period, the body responds to insufficient glucose levels with proteolysis and gluconeogenesis, which can persist for weeks. Lipolysis with accompanying ketogenesis also occurs in this phase, which slows down the breakdown of proteins from muscle tissues. However, when starvation is prolonged, fat stores are depleted and, as a result, catastrophic protein catabolism very quickly sets in. Therefore, chronic starvation usually results in rarefaction of adipose tissues and atrophy and weight loss of muscles and organs, depending on the duration of caloric deficiency, and, consequently, in a reduction of Body Mass Index (BMI) [14]. Rarefaction of adipose tissues involves both subcutaneous and visceral adipose tissues, most notably the greater omentum, the mesentery and the adipose capsule of the kidneys, and, in some cases, fat gelatinous transformation can occur [14]. Shrinking of the adipocytes can microscopically be observed, particularly in the subepicardial adipose tissue. It has been reported that, in emaciated people, the fat cells have a diameter of less than 70 μm , in proportion to the nutritional state [16]. A loss of about 35–50 % of body weight may cause death [13].

In the presented case, the woman's BMI was extremely lower (more than 50 %) than the one expected for a healthy woman of the same age and height. Moreover, the subcutaneous and visceral adipose tissues were rarefied with greater omentum completely absent, and the gelatinous transformation was markedly evident, particularly in the subepicardial adipose tissue. These findings were confirmed by the histological observation of a markedly reduced diameter of adipocytes

and a degeneration of the epicardial collagen with mucoid deposition. In addition, the loss of organ weight was more than 50 % in relation to the reference values of a healthy adult woman of height between 166 and 180 cm [17], as shown in Table 1. Consistently with the literature [18], the most significant weight loss occurred in the spleen and liver. The weight of the brain was as expected increased due to the massive edema. Atrophy of the heart and liver was histologically confirmed by the marked cell shrinkage, observing a significant reduction of the cell diameters in the myocardium and liver parenchyma.

We also observed generalized edema with abundant fluid in tissues and body cavities, which could be related to protein deficiency usually occurring in advanced stages of starvation (i.e., nutritional edema) [14].

Other common findings in case of fatal starvation are a distended and filled gallbladder because of the absence of food as stimulant of bile excretion, an empty stomach and a small bowel, along with the presence of dry stool in the colon [18]. All the above-reported findings were observed in the case here presented, with the exception of the stool in the colon, which was empty. Interestingly, the histological examination of endocrine organs showed degenerative changes, suggesting a hormonal reaction to chronic stress.

The aforementioned morphological findings can develop in various conditions, including morbid impairment of digestion with a sufficient supply of food (maldigestion), inadequate resorption of a properly degraded and sufficient food supply (malabsorption), and external food shortage, which is termed exogenous inanition [16].

In our case, the medical history of the victim, along with the autopsy finding have excluded organic etiologies of cachexia (e.g. maldigestion/malabsorption, neoplasms, systemic diseases, etc.), suggesting that the extreme emaciation of the woman was due to a prolonged deprivation of food.

It has been reported that victims of fatal starvation can survive for a long time before death, depending on several factors such as body weight prior to the starvation period, total or partial lack of food, deprivation of fluids and pre-existing conditions [14,18]. Survival periods of about 50–60 days for total lack of food and of about 10 days for combined nutrition and fluid deprivation have been reported in the literature [19–21]. Altun et al. [22] reported three fatal cases of hunger strike who survived for a longer period than expected, 170, 173 and 189 days, respectively, as a result of taking thiamine during the first 103 days of hunger strike. In our case, we were not able to be informed about the premorbid body weight of the woman and the severity of the nutritional and/or fluids deprivation. However, the post-mortem examination allowed to graduate the severity of the cachexia excluding any

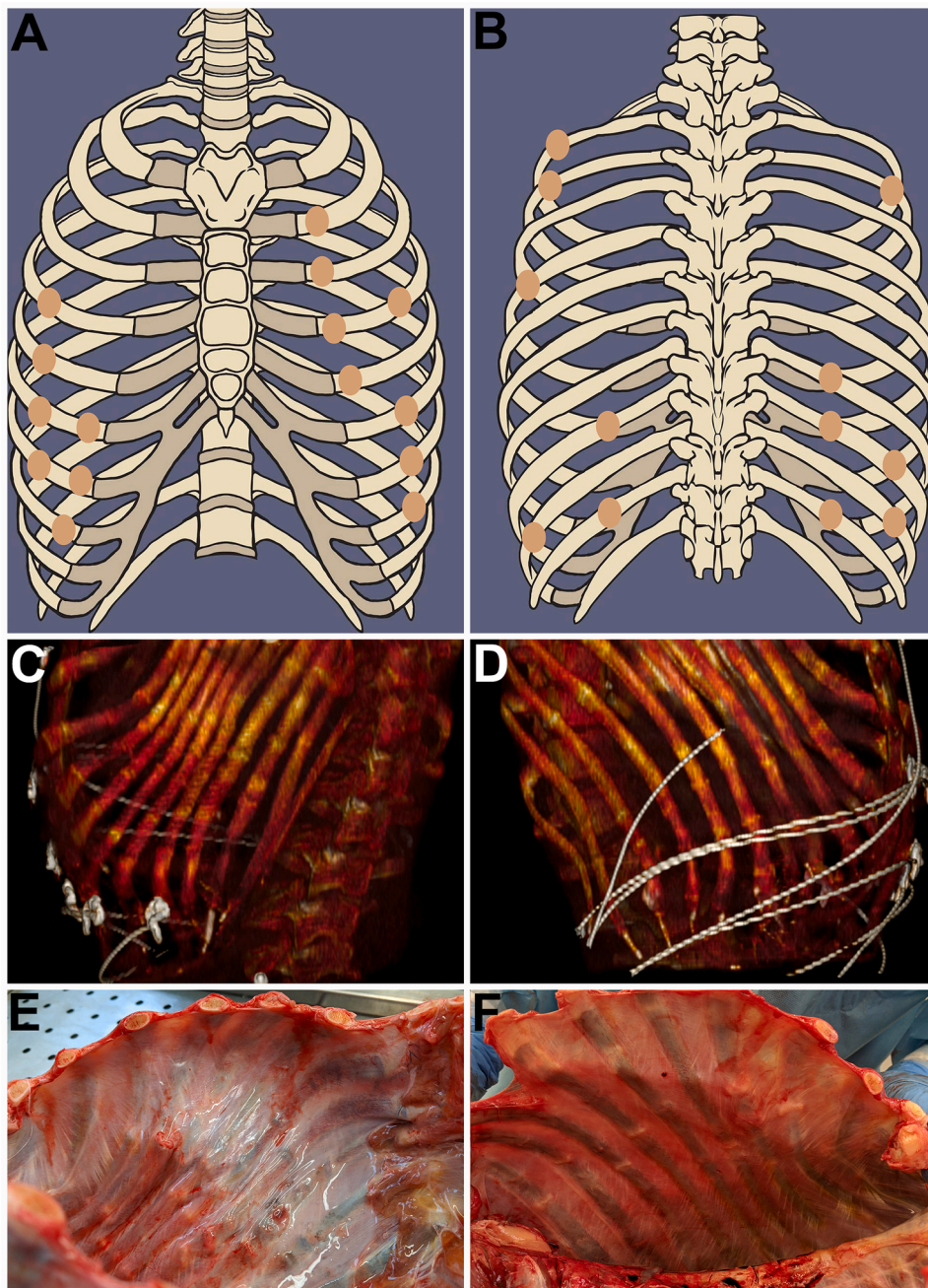


Fig. 2. Weight, macroscopic and histopathological findings of the main organs. Brain: volume increase, edema and congestion, Purkinje cell degeneration in the cerebellum (red arrow). Lungs: volume reduction, dry parenchyma, atrophic emphysema and capillary congestion. Heart: volume reduction, absence of subepicardial adipose tissue, myocardiocytes shrinkage, mucoid interstitial alteration in the myocardium. Liver: volume reduction, dry capsule and parenchyma, hepatocytes shrinkage, intracellular deposits of pigment granules. Spleen: volume reduction, dry capsule and parenchyma, follicles hypotrophia. Kidney: volume reduction, glomerulosclerosis, interstitial fibrosis. Thyroid (black arrows): volume reduction, colloidal condensation, collapsed follicles.

pre-existing pathological conditions that could have worsened the state of starvation. On these bases, we concluded that the nutritional deprivation lasted for at least several months.

Other autopsy findings such as poor skin turgor, sunken eyes, dry galea and dry organ surfaces indicated a state of hypertonic dehydration, which might accompany starvation [14].

Additionally, the postmortem examination of the body highlighted a forced decubitus with muscle atrophy and ankylosis in flexion of the lower limbs suggesting a prolonged state of immobilization, which resulted in muscle atrophy and weakness, joint contractures and pressure ulcers, as a consequence of a bed-resting syndrome [23]. The complete absence of range of motion of the major joints was indicative

of an immobilization protracted for several months [24] contrasting with the allegations of the relatives and caregivers, who claimed that the woman had walked up to ten days before hospitalization. The prolonged immobilization was also confirmed by the multiple ulcers localized on the back, sacrum, coccyx and right trochanteric region on bony prominences, which indicated a prolonged compression and were therefore defined as decubitus ulcers [25,26].

Furthermore, the distal region of the lower limbs showed ulcerated areas characterized by circumferential extension, location far away from the bone prominences and histopathological observation of a chronic and repetitive ulcerative process. These characteristics, together with the absence of underlying pathologies of the vessels of the lower limbs,


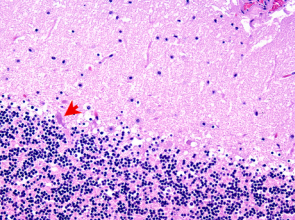
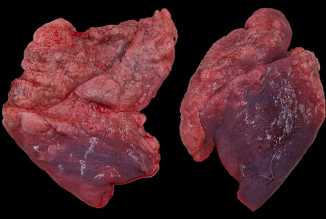
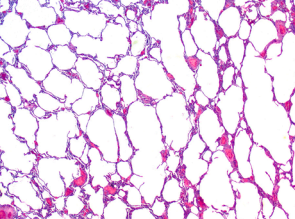

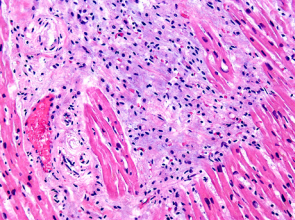

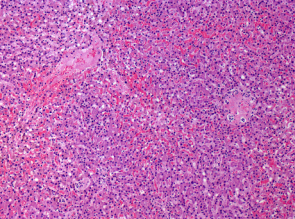

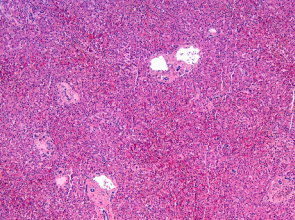

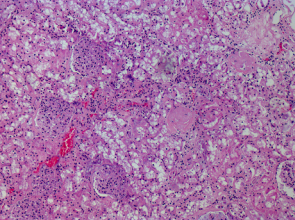
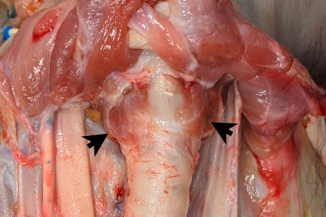
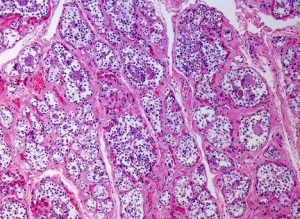
ORGAN (weight)	MACROSCOPIC	HISTOLOGY
Brain (1480 g)		
Lungs (dx 230 g - sn 300 g)		
Heart (155 g)		
Liver (670 g)		
Spleen (35 g)		
Kidneys (left 70 g - right 60 g)		
Thyroid (8 g)		

Fig. 3. Schematic representation of the rib cage (A: anterior surface; B: posterior surface) with fractures of different healing ages indicated by orange circles. Thoracic computed tomography performed *intra vitam* showing healing rib fractures with callus formation (C: left hemithorax; D: right hemithorax). Macroscopic appearance of rib fractures at different healing ages associated with severe deformity of both hemithoraxes (E: left hemithorax; F: right hemithorax).

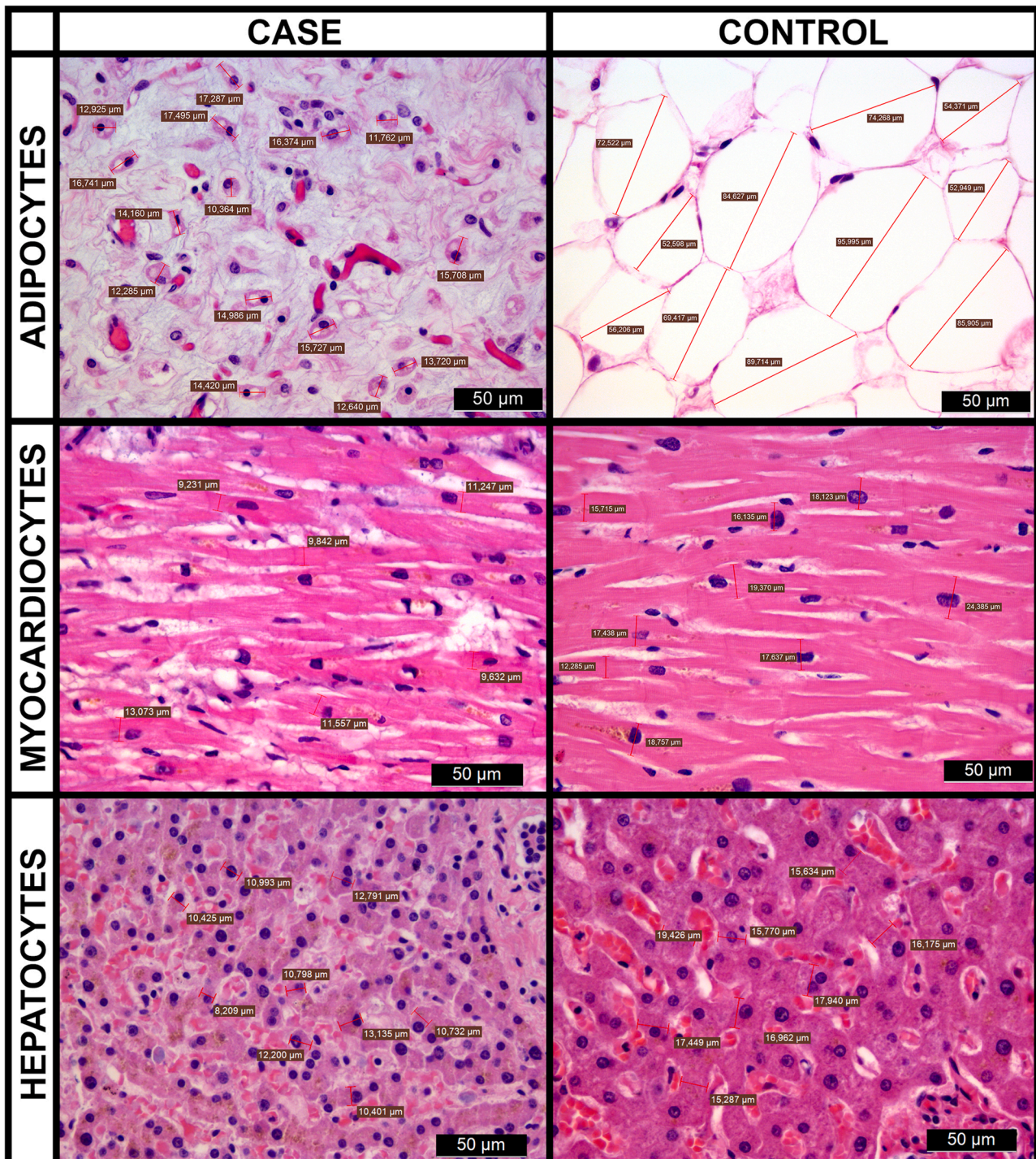


Fig. 4. Histological comparative analysis of the cell diameter of subepicardial adipose tissue, myocardium and liver parenchyma between the reported case and a control sample with a normal BMI.

which could have caused the ulcers, led to exclude any organic etiologies (e.g. chronic venous disease, chronic arterial disease, etc.) or a decubitus mechanism, but, instead, led to relate the injuries to a prolonged application of means of restraint [27,28].

Last, but not least, the forensic examination showed evidence of multiple and chronic repetitive trauma to the chest and limbs, presenting as numerous ecchymosis as well as multiple rib fractures of different ages. The number, distribution and production time of the fractures were consistent with what has previously been described in the literature in intimate partner homicides cases, where multiple fractures, both

healed and recent, affected predominantly the anterior and posterior wall of the rib cage [29,30]. On the basis of the extensive involvement of the rib cage, also affecting the posterior wall, it can be assumed that the fractures were caused by multiple hetero-inflicted traumas (e.g., a kicking of the woman while she was on the floor), rather than by repeated falls. Moreover, the poor alignment of the ribs at the old fracture sites, responsible for the rib cage deformity, indicated that medical care was probably limited or absent.

In conclusion, the cause of death was identified in a multi-organ failure due to starvation and prolonged state of immobilization.

Table 1

Estimated loss of weight of the major organs.

Organ	Weights (g)		Estimated loss of weight (%)
	Case	Reference values (mean) [17]	
Heart	155	362	50.1
Right lung	298	597	50.1
Left lung	230	491	53.1
Liver	670	1624	58.7
Spleen	35	160	78.1
Right kidney	60	148	59.4
Left kidney	70	148	52.7

The teaching messages of this paradigmatic case are therefore both in the clinical and forensic fields.

First of all, pathological investigation of malnutrition/starvation, particularly when caused by neglect, is challenging and requires the integration of clinicopathological and autopsy data, excluding any reasonable alternative etiologies, such as underlying organic or metabolic disorders. In the case here presented, the clinical and pathological evidence of severe malnutrition secondary to prolonged external deprivation of food, together with the signs of a prolonged application of means of restraints to the lower limbs and of hetero-inflicted traumatic injuries, posed a high degree of suspicion of abuse and neglect in a person not belonging to the at-risk categories usually described in the forensic literature.

Therefore, it is essential for clinicians not to forget that the co-presence of cachexia and limb ulcers could be determined by an abuse or neglect behavior also in a middle-aged patient. Special attention should be paid to any physical conditions not explainable by the medical history or contrasting with the information provided by the family members. The expertise of the forensic pathologist is crucial to reconstruct the most probable means of production of any traumatic injuries starting from forensic evidence and comparing that evidence to the allegations of the caregivers and family members in order to highlight any discrepancies. Furthermore, in the post-mortem setting, the forensic pathologist has to integrate all available clinical, autopsy and histopathological findings in order to identify the cause of death and its eventual causal relationship with an abuse/neglect behavior, which might have remained hidden during life.

Informed consent

Consent to participate and consent for publication were not applicable. This article contains data acquired as part of a forensic judicial investigation and in accordance to the Italian police Mortuary Regulation. Consequently, in accordance with the Italian law, ethical approval was not required in this specific case. Publication of data is allowed when the case has been closed and with the authorization of the public prosecutor; anonymity of the subject has been guaranteed.

Article classification

Forensics; Autopsy; Pathology; Histopathology; Clinical forensic medicine.

Declaration of Competing Interest

None.

References

- [1] C. Ortmann, G. Fechner, T. Bajanowski, B. Brinkmann, Fatal neglect of the elderly, *Int. J. Leg. Med.* 114 (3) (2001) 191–193, <https://doi.org/10.1007/s004140000173>.
- [2] R.M. Hoover, M. Polson, Detecting elder abuse and neglect: assessment and intervention, *Am. Fam. Physician* 89 (6) (2014) 453–460.
- [3] C.B. Dyer, M.T. Connolly, P. McFeeley, The clinical and medical forensics of elder abuse and neglect, in: R.J. Bonnie, R.B. Wallace (Eds.), *Elder Mistreatment: Abuse, Neglect, and Exploitation in an Aging America*, National Academies Press (US), Washington (DC), 2003.
- [4] F. Ventura, F. Caputo, C. Micera, A. Molinelli, Elder abuse: a retrospective analysis of autopsy cases from the department of legal medicine in Genoa from 2006 to 2017, *J. Elder. Abus. Negl.* 32 (4) (2020) 388–398, <https://doi.org/10.1080/08946566.2020.1755760>.
- [5] K.A. Collins, A.T. Bennett, R. Hanzlick, Elder abuse and neglect. Autopsy Committee of the College of American Pathologists, *Arch. Intern. Med.* 160 (11) (2000) 1567–1568.
- [6] A.P. Giardino, M.A. Lyn, E.R. Giardino, Introduction: child abuse and neglect, in: *A Practical Guide to the Evaluation of Child Physical Abuse and Neglect*, Springer, Cham, 2019, pp. 3–26.
- [7] World Health Organization, Elder abuse. (<https://www.who.int/news-room/fact-sheets/detail/abuse-of-older-people>) (Accessed 23 January 2023).
- [8] M.S. Lachs, C. Williams, S. O'Brien, L. Hurst, R. Horwitz, Risk factors for reported elder abuse and neglect: a nine-year observational cohort study, *Gerontologist* 37 (4) (1997) 469–474, <https://doi.org/10.1093/geront/37.4.469>.
- [9] M. Johannesen, D. LoGiudice, Elder abuse: a systematic review of risk factors in community-dwelling elders, *Age Ageing* 42 (3) (2013) 292–298, <https://doi.org/10.1093/ageing/afs195>.
- [10] M.J. Gorbien, A.R. Eisenstein, Elder abuse and neglect: an overview, *Clin. Geriatr. Med.* 21 (2) (2005) 279–292, <https://doi.org/10.1016/j.cger.2004.12.001>.
- [11] L.F. Hamp, Analysis of elder abuse and neglect definitions under state law, in: R. J. Bonnie, R.B. Wallace (Eds.), *Elder Mistreatment: Abuse, Neglect, and Exploitation in an Aging America*, National Academies Press (US), Washington (DC), 2003.
- [12] F.E. Mennen, K. Kim, J. Sang, P.K. Trickett, Child neglect: definition and identification of youth's experiences in official reports of maltreatment, *Child Abus. Negl.* 34 (9) (2010) 647–658, <https://doi.org/10.1016/j.chiabu.2010.02.007>.
- [13] B. Madea, J. Ortmann, E. Doberentz, Forensic aspects of starvation, *Forensic Sci. Med. Pathol.* 12 (3) (2016) 276–298.
- [14] R.B. Dettmeyer, M.A. Verhoff, H.F. Schütz, Death by starvation and dehydration, in: R.B. Dettmeyer, M.A. Verhoff, H.F. Schütz (Eds.), *Forensic Medicine: Fundamentals and Perspectives*, Springer, Berlin, Heidelberg, 2014.
- [15] M. de Onis, C. Monteiro, J. Akre, G. Glugston, The worldwide magnitude of protein-energy malnutrition: an overview from the WHO Global Database on Child Growth, *Bull. World Health Organ* 71 (6) (1993) 703–712.
- [16] W. Janssen, Histological findings in starvation. *Forensic Histopathology*, Springer, Berlin, Heidelberg, 1984.
- [17] G.L. de la Grandmaison, I. Clairand, M. Durigon, Organ weight in 684 adult autopsies: new tables for a Caucasoid population, *Forensic Sci. Int.* 119 (2) (2001) 149–154, [https://doi.org/10.1016/S0379-0738\(00\)00401-1](https://doi.org/10.1016/S0379-0738(00)00401-1).
- [18] B. Madea, Death as a result of starvation, in: M. Tsokos (Ed.), *Forensic Pathology Reviews*, Humana Press, Totowa NJ, 2005.
- [19] P. Saukko, B. Knight, Neglect, starvation and hypothermia, in: *Knight's Forensic Pathology*, CRC Press, Boca Raton, 2016.
- [20] O. Prokop, Das verhungern, in: O. Prokop (Ed.), *Forensische Medizin*, VEB Verlag, Berlin, 1966.
- [21] L.A. Leiter, E.B. Marliss, Survival during fasting may depend on fat as well as protein stores, *JAMA* 248 (18) (1982) 2306–2307.
- [22] G. Altun, B. Akansu, B.U. Altun, D. Azmak, A. Yilmaz, Deaths due to hunger strike: post-mortem findings, *Forensic Sci. Int.* 146 (1) (2004) 35–38, <https://doi.org/10.1016/j.forsciint.2004.03.022>.
- [23] R.G. Brower, Consequences of bed rest, *Crit. Care Med.* 37 (10 Suppl) (2009) S422–S428.
- [24] G. Trudel, H.K. Uthoff, M. Brown, Extent and direction of joint motion limitation after prolonged immobility: an experimental study in the rat, *Arch. Phys. Med. Rehabil.* 80 (12) (1999) 1542–1547, [https://doi.org/10.1016/S0003-9993\(99\)90328-3](https://doi.org/10.1016/S0003-9993(99)90328-3).
- [25] J. Anders, A. Heinemann, C. Leffmann, M. Leutenegger, F. Profener, W. von Renteln-Kruse, Decubitus ulcers: pathophysiology and primary prevention, *Dtsch. Arzteblatt Int* 107 (21) (2010) 371–381.
- [26] D.M. Hunsaker, J.C. Hunsaker, Elder abuse, in: M. Tsokos (Ed.), *Forensic Pathology Reviews*, Humana Press, Totowa NJ, 2006.
- [27] L. Danielsen, O.V. Rasmussen, Dermatological findings after alleged torture, *Torture* 16 (2) (2006) 108–127.
- [28] D. Cuculic, I. Sosa, A. Petaros, Decubitus ulcers and ligature marks as evidence in a homicide case, *Forensic Sci. Int.* 254 (2015) e13–e17, <https://doi.org/10.1016/j.forsciint.2015.06.020>.
- [29] M. Steyn, N. Bacci, S. Holland, Patterning of fractures in a case of intimate partner homicide (IPH), *J. Forensic Sci.* 66 (2) (2021) 766–774, <https://doi.org/10.1111/1556-4029.14619>.
- [30] C. Liebsch, T. Seiffert, M. Vlcek, M. Beer, M. Huber-Lang, H.J. Wilke, Patterns of serial rib fractures after blunt chest trauma: an analysis of 380 cases, *PLoS One* 14 (12) (2019) e0224105, <https://doi.org/10.1371/journal.pone.0224105>.