



FRANCESCO MARIA GALASSI, NICOLA DI FAZIO, ELENA VAROTTO, MARCO ARTICO, GABRIELE SAVIOLI, ANDREA PICCIONI, GIANPIETRO VOLONNINO, GIANPIERO D'ANTONIO, LAVINIA PELLEGRINI, LUIGI LA VIA, ANIELLO MAIESE, ELENA PERCIVALDI, RAFFAELE LA RUSSA

THE DEATH OF EMPEROR FREDERICK BARBAROSSA (AD 1190): PHYSIOPATHOLOGICAL AND PALAEOPATHOLOGICAL CONSIDERATIONS ON A CASE OF FATAL DROWNING DURING THE 3rd CRUSADE

ABSTRACT: In this case report the still unexplained death of the Mediaeval Emperor Frederick Barbarossa is examined from a biomedical perspective using original historical sources and contemporary medical knowledge. Barbarossa's case also serves as an example and a wake-up call for public health authorities on the danger represented by the public health problem of drowning, with particular reference to drowning in rivers and whirlpool-caused deaths.

KEY WORDS: Drowning - River - Creek - Whirlpool - Hydrocution syndrome - Palaeopathology - Public Health

INTRODUCTION

Frederick I "Barbarossa" (1122–1190) was holy Roman Emperor from AD 1155. Among his many deeds, he is primarily remembered historically for his Italian campaign against the Northern Italian *Comuni* fighting

for their independence. In May 1189, under the papal auspices and followed by one of his sons, the Duke of Swabia Frederick VI, and his most loyal feudatories, left Regensburg to fight against the Saracens in the East in what would be remembered as the Third Crusade (1189–1192). Despite his plans, he never reached his

destination because he met his death in the river Anatolian Salef (Cardini 1994), known today by its Turkish name of Göksu. Left without a charismatic leader, the crusader army straggled and was unable to avoid the failure of the expedition (Oppl 1998). The exact circumstances that led to the emperor's demise, as well as the precise dynamics of the events, are uncertain, since the chronicles reporting the event lack decisive details to retrospectively reconstruct a precise scenario.

SOURCES, METHODOLOGIES AND EPIDEMIOLOGY OF DROWNINGS

Despite the limitations in the historical sources, these scant textual references can be cautiously examined from a biomedical perspective by applying a palaeopathographic approach (Ashrafian 2012, Galassi, Ashrafian 2015, Rühli *et al.* 2016, Traversari *et al.* 2017, You *et al.* 2021). According to the anonymous and contemporary *Historia de expeditione Friderici imperatoris* (*History of the expedition of Emperor Frederick*) attributed to a certain Ansbert, possibly a compiler from the Austrian or German area, on June 10th, 1190, Barbarossa (*Figure 1*) "despising the dangers and wishing to alleviate the heat and circumvent the inaccessible mountains, attempted to swim across the river Salef, which was very impetuous at that point" (Chroust 1928). Against everyone's good advice, "he plunged into the water and, swept away by a whirlpool, the man who had often avoided great dangers perished miserably. [...] When the other nobles saw him drowning, they tried to help him, but it was too late" (Chroust 1928). Moreover, according to the Kurdish chronicler Ali Ibn al-Athīr, who reports the episode in his *al-Kāmil fi l-tārikh* (*The Complete History*), Frederick drowned in shallow water: "The King went down to the river to wash himself and was drowned at a place where the water was not even up to his waist" (Gabrieli 2010). What is striking about such descriptions is indeed the suddenness of his death and the futility of any aid rendered to the emperor, as well as the apparent inability of the sovereign, albeit accustomed to the exertions of military life, to react to such a mortal danger. The alleged shallowness of the riverbed should not, however, be misleading since, although, according to al-Athīr, the water did not reach his waist at the point where the sovereign bathed and presumably swam, if a whirlpool was indeed present there, the scenario could change radically.



FIGURE 1: Frederick I Barbarossa and his sons King Henry VI and Duke Frederick VI on a Mediaeval illustration of the *Chronicle of the Guelphs*. Image in the public domain from Wikimedia Commons.

Starting from the peculiar historical example identified, in order to better understand the problem of river-related drownings, we carried out a computerised search of articles dating from 2000 to 2023 using the following MeSH terms and text words: *drowning*, *hydrocution* and *river*. Additional data were identified through reference lists. The results obtained show that despite of a high number of drownings in rivers, the problem is still poorly studied in a specific way.

According to the WHO, drowning is defined as "the process of experiencing respiratory impairment from submersion/immersion in liquid" whose outcomes can be death, morbidity, or no outcome. Always according to the WHO, drowning is still the third leading cause of

accidental deaths in the world, accounting for about 7% with an estimated number of drownings of 236,000 annually, of which more than half are under 25 years age (WHO 2023). However, in cases of intentional drowning, in which the subject usually has suicidal intent, the age group involved is higher, despite both situations showed similar death rates (Woo *et al.* 2015). It is also necessary to consider, with reference to the historical fact, the danger of the river compared to other environments, which is indeed well delineated by the number of cases of drowning recorded in rivers compared to other aquatic environments. It is no coincidence, in fact, that reviews that have specifically focused on the number of fatal drownings in river waters have shown an incidence ranging from 0.20 to 1.89 per 1000,000 people (Peden *et al.* 2016a). The literature itself has also confirmed on a statistical-epidemiological level what could already have been intuitive, i.e., that the main risk factors include risk-taking behavior, male sex, poor swimming ability, an underestimation of the actual risk posed by a river, previous physical activities carried out before the dive, and alcohol or drugs consumption (Peden *et al.* 2016a). More controversial, however, is the relationship with the age of the drowned, since these are more usually still young individuals (Peden *et al.* 2016a). Additional risk factors identified are low incomes, the presence of rural areas and lack of supervision. Pre-existing comorbidities should also be considered. Recent reviews and past reports have shown that the presence of injuries or pre-existing diseases, also in consideration of the different pathophysiological mechanisms underlying death by drowning, can be a risk factor (Peden *et al.* 2016b). It is not secondary to highlight how in reality the phenomenon could be underestimated due to classification problems. As a matter of fact, the ICD divides aquatic locations into 4 subsets which are "bathtub", "swimming pool" and "natural water", which includes rivers, creeks, stream, beaches, oceans, harbors, lakes and dams (Peden *et al.* 2016a).

RESULTS AND DISCUSSION

Pathophysiology of drowning: a complex phenomenon

The exact pathophysiological mechanisms of drowning have been and still are a source of debate. Recent literature identifies different pathophysiological mechanisms depending on whether the immersion takes place in hot water (i.e. at a temperature higher than

35°), in cold water or if there is total submersion of the body and therefore of the airways. Specifically, it is possible to hypothesise that in hot water death occurs as a result of a cardiogenic shock due to the imbalance between the decrease in peripheral resistance because of the heat – which leads to an increase in heart rate – and external hydrostatic pressure that induces bradycardia, thus inducing the development of fatal ventricular arrhythmias. However, in cold water immersion, drowning is often followed by an inhibition of the possibility of holding breath due to the so-called "cold shock" which involves both the cardiovascular system (with peripheral vasoconstriction and hypertension) and consequent increased risk of fatal arrhythmias, and the respiratory drive by thermoreceptors with consequent "gasp response". These pathophysiological mechanisms complement the classic submersion in the liquid medium with aspiration and asphyxiation, electrolyte disturbances or ingestion of the liquid medium with emesis. Joost *et al.* describe 14 pathophysiological mechanisms that, directly or indirectly, intertwine with each other in the determinism of drowning. These include protective responses like diving response, hypothermia, or breath-holding, and life-threatening ones such as autonomic conflict or cold shock (Bierens *et al.* 2016). The pathophysiological mechanisms in drowning that do not directly involve asphyxia are generally called *hydrocution syndrome* or *atypical drowning*. These mechanisms are of fundamental importance, especially in patients with previous comorbidities. In fact, comorbidities can amplify the functioning of certain pathophysiological mechanisms, thus contributing to the lethal mechanism in some cases, i.e. in cases of elderly people with cardio-vascular diseases who are most likely to suffer fatal arrhythmias after immersing in hot water. To sum up, drowning has complex pathophysiological bases, on which factors intrinsic to the corpse and related to the environment act, still sources of doubts and worthy of further study.

The river: a drowning trap

As the medical-scientific literature of the last decade shows, drowning is not only a medico-legal problem, but also a public health concern, within which macro-category of drowning in a river context represents an extremely important topic, but still not sufficiently addressed by biomedical research.

Reference should be made to the so-called "drowning traps" or whirlpools. A whirlpool (*gorgo* in Italian, from a reconstructed vulgar Latin form **gurgus*, from the

Classical Latin term *gurgēs*) is nothing more than a portion of a riverbed that deepens into the ground, thus eventually causing a whirling motion of the waters of the stream in question (Treccani 2022). Such eddies are capable of sucking into their depths anything that passes through that stretch of river, even well-trained bodies – of note the *Encyclopedia Britannica*'s dictionary uses the example of a swimmer "caught in a *whirlpool* and *nearly drowned*" as an idiomatic expression, thus testifying to the frequency of unfortunate events linked to whirlpools (Britannica 2024). Indeed, news reports (News 2023, Stop Drowning Now 2024), especially in summertime, are full of episodes of this kind, often reporting tragic deaths of young people looking for a few hours of recreation who, having dived or even more kindly immersed themselves in the river waters, end up being irreparably drawn into the whirlpool, which does not give them, or their friends or potential rescuers present at the scene time to save the unfortunate victims.

Byard has highlighted the problem of the "drowning trap" in a recent work on fatal drownings in rivers, pointing out that once sucked into the whirlpools, a body can reach the bottom quickly even if the movement down river is not particularly strong. The same author points out that even from a pathological-forensic point of view, when dealing with bodies presumably drowned in a river, in consideration of the non-specific signs that are often found at autopsy, the flow, height and conditions of the water at the point of the alleged drowning should be detected (Byard 2017). It is also worth noting what Farstad and Luttrell have highlighted in their review, namely that the strong currents of a river can sometimes hide certain structures such as trees or rocks that can then act as entangling agents in drowning determinism (Farstad, Luttrell 2020).

Causes and manner of the death: still a dilemma

Returning to the historical case of Barbarossa, it is thus reasonable to think that the elderly emperor, exhausted by the march through the mountains and oppressed by the heat, wanted to cool off and the presence of a whirlpool may have brought a premature end to his existence. Alternatively, if the waters of the river were indeed cold – apart from the high temperatures of the surroundings – and Barbarossa's immersion too rapid, it is not inconceivable that the unfortunate victim developed hydrocution syndrome, i.e. a syncopal episode caused by neurovegetative reflexes (vasoconstriction occurs, triggering central nervous reflexes in the brainstem). In this case, the fainting might

have been temporary, contributing to the drowning in the vortex described above – since Barbarossa could not even have attempted to resist the vortex – or it might have been of such magnitude that it directly caused a cardiorespiratory arrest, thus resulting in the subject's death, justifying his demise despite the shallow waters of the river. However, a combined mechanism of action between the two described cannot be excluded *a priori*.

The uncertainty surrounding Barbarossa's death is also a consequence of a well-known concept in forensic pathology: the diagnosis of drowning is not an easy diagnosis, even at the autopsy table (Stephenson *et al.* 2019).

The *post-mortem* signs in bodies recovered from water are indeed extensive and varied. Many of the signs found during the external examination of a body recovered from water, such as wrinkling of the hands, plume of foam, abrasions, although common, are nonspecific and not always present. Similar considerations can be made regarding the signs found during the autopsy: the finding of frothy material within the airways, pleural effusions, pulmonary oedema, internal organ haemorrhages, or fluid in the stomach are all non-pathognomonic signs of drowning and often even absent. Interpreting such signs, even histologically, is often further complicated by the progression of decomposition phenomena. Even the use of more sophisticated techniques proposed over the years, such as blood dilution tests or the study of algae and diatoms, have proven ineffective or unreliable due to many reasons like the high risk of contamination (*ante-/post-mortem*) and low specificity. The numerous research lines, including those on immunohistochemical techniques (Brinkmann *et al.* 1997, An *et al.* 2011, Frisoni *et al.* 2022), indicate the difficulty of this thanatological diagnosis, which today can only rely on the convergence of specific information (including historical sources, as in this case) and autopsy findings (Piette, De Letter 2006).

One final aspect, more of a historical and security nature, needs to be considered in the examination of the death of the Holy Roman Emperor: the sources report that he took a bath in the river but do not mention the presence of an adequate escort of soldiers around him, as one would expect of a leader of this importance since hazards to his personal health had necessarily to be taken into account such as environmental ones (as the hypothesis discussed in this paper) or ambushes by his enemies trying to catch him off guard. The available sources do not allow scholars to expand on this, yet even in the contemporary setting, the presence of other people in the proximity of victims of whirlpools is often

not sufficient to save their lives. This may well have been the case in Barbarossa's death and, at any rate, such a personal security failure on his bodyguards would perhaps not be adequate enough to mention. This particular side of the story remains, nonetheless, purely speculative.

ANOTHER HISTORICAL CASE: DIFFERENT IMPLICATIONS OF DROWNING

More fortunate than Barbarossa had been, about 1524 years earlier, in 334 BC, Alexander the Great, the conqueror of Asia, who immersed himself in the icy waters of the river Cydnus (equally in Anatolia) because of the great heat that was afflicting him and had experienced a comparable life-threatening condition. Alexander the Great developed symptoms like those of pneumonia sepsis (fever, tremors, confusion) ultimately cured by his physician Philip the Acarnanian despite erroneously being informed through a letter sent to him by his general Parmenio to beware of the said physician [Plut. Alex. 19] (Plutarch 1919).

This anecdote gives us the opportunity to discuss one of the most frequent and relevant complications of non-fatal drownings, namely the development of pneumonia. It is known, in fact, that the inhalation of water during non-fatal drowning leads to lung contamination by various bacteria that are often multi-resistant to antibiotic therapy (Tadié *et al.* 2012, Bossi-Küpfer *et al.* 2007). The study of the microbiological ecology of rivers, especially those that pass through large population centers, can be an excellent strategy to optimise treatment in cases such as that of Alexander the Great. As far as non-disease-related morbidity is concerned, traumatic or sporting injuries are significant, which do not appear exceptional if we think of the popularity that some sports practiced on rivers are having (Wilson *et al.* 2013).

TO RAISE THE EMBANKMENTS: WHAT MUST BE DONE

In view of what has been said so far, the recent recommendations issued by governmental and non-governmental bodies, such as the WHO itself, appears adequate. For example, the use of signs warning of the danger, depth and peril of flooding can be considered as cost-effective systems. Similarly, the use of mandatory life jackets during recreational activities on rivers could be highly effective. On the other hand, the control of

drownings because of water traffic accidents could be more difficult to approach, in view of the cost that alternative solutions (such as the construction of bridges) could have (Peden *et al.* 2018). Enhancing control measures and addressing the use of alcohol and drugs, which are known risk factors for drowning near rivers, could also be effective intervention points. An autopsy should always be conducted in cases of drowning as it is essential for understanding the mechanisms and causes that led to the death, as well as for clarifying judicial doubts.

AFTER BARBAROSSA'S DEATH: THE ANTHROPOLOGY OF MEDIAEVAL EMBALMING

The emperor's son, Frederick VI, placed himself at the head of the troops with the aim of bringing the body of the deceased sovereign to Jerusalem to be buried with all honours – the journey is briefly mentioned in the anonymous *Epistula de morte Friderici imperatoris*, written by a cleric who was an eye-witness to the events and agrees with the version of drowning – but he did not succeed (Chroust 1928). Given the heat, vinegar, used at such times to preserve the bodies as much as possible from putrefaction (a cadaveric degradation process accelerated by the high ambient temperatures), proved to be completely ineffective, so the body was dismembered and boiled, after the Germanic manner, the individual's remains, which were interred along the way: the heart and entrails in Tarsus, the flesh in the church of St. Peter in Antioch, the bones in Tyre (Schutz 2010). A few months later Frederick VI also fell ill, probably contracting malaria like much of his army, and died on 20th January 1191 in Acre, where he was buried (Hosler 2018).

CONCLUSIONS

Barbarossa's death should serve as an historic-medical example for the still too neglected medical topic of fatal river drowning, which are not so unusual and deserves further scientific, preventive, and social attention in both advanced and low-income countries. This case aims to focus attention on the epidemiology of the phenomenon that should be investigated more accurately to better delineate the risks factors related to this environment and therefore define social and economic evidence-based strategies for prevention. Another aim is to highlight how

the diagnosis of drowning remains a challenging issue from a forensic pathological perspective, making the convergence of autopsy results and testimonies crucial. Further studies are needed to clarify doubts regarding drowning diagnosis, even for justice purposes.

REFERENCES

- AN J. L., ISHIDA Y., KIMURA A., KONDO T., 2011: Immunohistochemical examination of intracerebral aquaporin-4 expression and its application for differential diagnosis between freshwater and saltwater drowning. *International Journal of Legal Medicine* 125: 59–65. DOI: 10.1007/s00414-010-0523-8
- ASHRAFIAN H., 2012: Henry VIII's obesity following traumatic brain injury. *Endocrine* 2012, 42, 1: 218–219. DOI: 10.1007/s12020-011-9581-z
- BYARD R. W., 2017: Drowning deaths in rivers. *Forensic Science, Medicine and Pathology* 13: 388–389. DOI: 10.1007/s12024-017-9857-6
- BBC News, 2013: Pembrokeshire: Mum struggles to understand son's drowning death. 25 July 2023. <https://www.bbc.co.uk/news/uk-wales-66294850> (accessed 8th June 2024).
- BRITANNICA, 2024: The Britannica Dictionary, *sub voce* "Whirlpool": <https://www.britannica.com/dictionary/whirlpool> (accessed 8th June 2024).
- BIERENS J. J., LUNETTA P., TIPTON M., WARNER D. S., 2016: Physiology of Drowning: A Review. *Physiology (Bethesda)* 31,2: 147–166. DOI: 10.1152/physiol.00002.2015
- BOSSI-KÜPFER M., GENINIA A., PEDUZZI R., DEMARTA A., 2007: Tracheobronchitis caused by *Aeromonas veronii* biovar sobria after near-drowning. *Journal of Medical Microbiology* 56, Pt 11: 1563–1564. DOI: 10.1099/jmm.0.47202-0
- CARDINI F., 1994: L'Imperatore Annegato ed Altri Principeschi Incidenti in Terra Santa. In: G.M. Cantarella, F. Santi (Eds.): *I Re Nudi. Congiure, assassini, tracolli ed altri imprevisti nella storia del potere*. Pp. 39–88. Centro Italiano di Studi sull'Alto Medioevo, Spoleto (Italy).
- CHROUST A., (Ed.) 1928: *Historia de expeditione Friderici I imperatoris*. Pp. 91; 173–178. In: MGH, *Scriptores Rerum Germanicarum*, Nova Series 5, Berlin.
- FARSTAD D. J., LUTTRELL J. M., 2020: Flush Drowning as a Cause of Whitewater Deaths. *Wilderness & Environmental Medicine* 31,1: 11–15. DOI: 10.1016/j.wem.2019.09.006
- FRISONI P., DIANI L., DE SIMONE S., BOSCO M. A., CIPOLLONI L., NERI M., 2022: Forensic Diagnosis of Freshwater or Saltwater Drowning Using the Marker Aquaporin 5: An Immunohistochemical Study. *Medicina (Kaunas)* 58,10: 1458. DOI: 10.3390/medicina58101458
- GABRIELI F., 2010: *Arab Historians of the Crusades: Selected and Translated from the Arabic Sources*. translated by E. J. Costello. London, Routledge & K Paul.
- GALASSI F. M., ASHRAFIAN H., 2015: Has the diagnosis of a stroke been overlooked in the symptoms of Julius Caesar? *Neurological Sciences* 36,8: 1521–1522. DOI: 10.1007/s10072-015-2191-4
- HOSLER J. D., 2018: *The siege of Acre, 1189–1191: Saladin, Richard the Lionheart, and the battle that decided the Third Crusade*. Pp. 63–64. New Haven, Yale University Press.
- OPPL F., 1998: *Friedrich Barbarossa (Gestalten des Mittelalters und der Renaissance)*. Darmstadt, Wiss. Buchges.
- PEDEN A. E., FRANKLIN R. C., LEGGAT P. A., 2016a: Fatal river drowning: the identification of research gaps through a systematic literature review. *Injury Prevention* 22,3: 202–209. DOI: 10.1136/injuryprev-2015-041750
- PEDEN A. E., FRANKLIN R. C., LEGGAT P. A., 2016b: The Hidden Tragedy of Rivers: A Decade of Unintentional Fatal Drowning in Australia. *PLoS One* 2016b;11(8):e0160709. DOI: 10.1371/journal.pone.0160709
- PEDEN A. E., FRANKLIN R. C., LEGGAT P., 2018: Preventing River drowning deaths: Lessons from coronial recommendations. *Health Promotion Journal of Australia* 29, 2: 144–152. DOI: 10.1002/hpja.24
- PIETTE M. H., DE LETTER E. A., 2006: Drowning: still a difficult autopsy diagnosis. *Forensic Science International* 163,1–2: 1–9. DOI: 10.1016/j.forsciint.2004.10.027
- PLUTARCH1919: *Plutarch's Lives*. With an English translation by Bernadotte Perrin. Cambridge, MA, Harvard University Press; London, William Heinemann Ltd.
- RÜHLI F. J., GALASSI F. M., HAEUSLER M., 2016: Palaeopathology: Current challenges and medical impact. *Clinical Anatomy* 29,7: 816–822. DOI: 10.1002/ca.22709
- SCHUTZ H., 2010: *The Medieval Empire in Central Europe. Dynastic Continuity in the Post-Carolingian Frankish Realm, 900–1300*. P. 235. Newcastle, Cambridge Scholars.
- STEPHENSON L., VAN DEN HEUVEL C., BYARD R. W., 2019: The persistent problem of drowning – A difficult diagnosis with inconclusive tests. *Journal of Forensic and Legal Medicine* 66: 79–85. DOI: 10.1016/j.jflm.2019.06.003
- STOP DROWNING NOW 2024: Facts & Stats About Drowning, online at: <https://www.stopdrowningnow.org/drowning-statistics/> (accessed 5th August 2024).
- TADIÉ J. M., HEMING N., SERVE E., WEISS N., DAY N., IMBERT A., DUCHARNE G., FAISY C., DIEHL J. L., SAFRAN D., FAGON J. Y., GUÉROT E., 2012: Drowning associated pneumonia: a descriptive cohort. *Resuscitation* 83, 3: 399–401. DOI: 10.1016/j.resuscitation.2011.08.023
- TRAVERSARI M., BALLESTRIERO R., GALASSI F. M., 2017: A likely case of goiter in the Madonna col Bambino dormiente (1465/1470) by Andrea Mantegna (1431–1506). *Journal of Endocrinological Investigation* 40, 2: 237–238. DOI: 10.1007/s40618-016-0548-z
- TRECCANI – *Vocabolario online*, 2022: *sub voce* "gorgo", online at: <https://www.treccani.it/vocabolario/gorgo/> (accessed 8th June 2024).
- WHO 2023: Drowning. Online at: <https://www.who.int/news-room/fact-sheets/detail/drowning>
- WILSON I., MCDERMOTT H., MUNIR F., HOGERVORST E., 2013: Injuries, ill-health and fatalities in white water rafting and white-water paddling. *Sports Medicine* 43, 1: 65–75. DOI: 10.1007/s40279-012-0007-8

- WOO S. H., PARK J. H., CHOI S. P., WEE J. H., 2015: Comparison of clinical characteristics of intentional vs accidental drowning patients. *American Journal of Emergency Medicine* 33(8): 1062–1065. DOI: 10.1016/j.ajem.2015.04.051
- YOU W., GALASSI F. M., VAROTTO E., HENNEBERG M., 2021: Genghis Khan's death (AD 1227): An unsolvable riddle or simply a pandemic disease? *International Journal of Infectious Diseases* 104: 347–348. DOI: 10.1016/j.ijid.2020.12.089
- ZHU B. L., ISHIDA K., QUAN L., LI D. R., TANIGUCHI M., FUJITA M. Q., MAEDA H., TSUJI T., 2002: Pulmonary immunohistochemistry and serum levels of a surfactant-associated protein A in fatal drowning. *Legal Medicine* 4: 1–6. DOI: 10.1016/s1344-6223(01)00051-7

- ⁷ "Rodolico-San Marco" Hospital, Catania, Italy.
- ⁸ Department of Surgical, Medical, and Molecular Pathology and Critical Care Medicine, Institute of Legal Medicine, University of Pisa, Pisa, Italy.
- ⁹ Center of Archeological Sciences, Gargano, Foggia, Italy.
- ¹⁰ Department of Clinical Medicine, Public Health, Life Sciences, and Environmental Sciences, University of L'Aquila, L'Aquila, Italy.

* Corresponding authors.

Francesco Maria Galassi^{1*}, Nicola Di Fazio², Elena Varotto³, Marco Artico⁴, Gabriele Savioli⁵, Andrea Piccioni⁶, Gianpietro Volonnino^{2*}, Gianpiero D'Antonio², Lavinia Pellegrini², Luigi La Via⁷, Aniello Maiese⁸, Elena Percivaldi⁹, Raffaele La Russa¹⁰

¹ Department of Anthropology, Faculty of Biology and Environmental Protection, University of Lodz, Poland. E-mail:

francesco.galassi@biol.uni.lodz.pl

² Department of Anatomical, Histological, Forensic and Orthopedic Sciences, Sapienza University, Rome, Italy. E-mail:

gianpietro.volonnino@uniroma1.it

³ Archaeology, College of Humanities, Arts and Social Sciences, Flinders University, Adelaide, SA, Australia.

⁴ Department of Sensory Organs, Policlinico Umberto I, Sapienza University of Rome, Rome, Italy

⁵ Emergency Department, IRCCS Fondazione Policlinico San Matteo, Pavia, Italy.

⁶ Department of Emergency Medicine, Policlinico Agostino Gemelli, Catholic University of Sacred Heart, Rome, Italy.