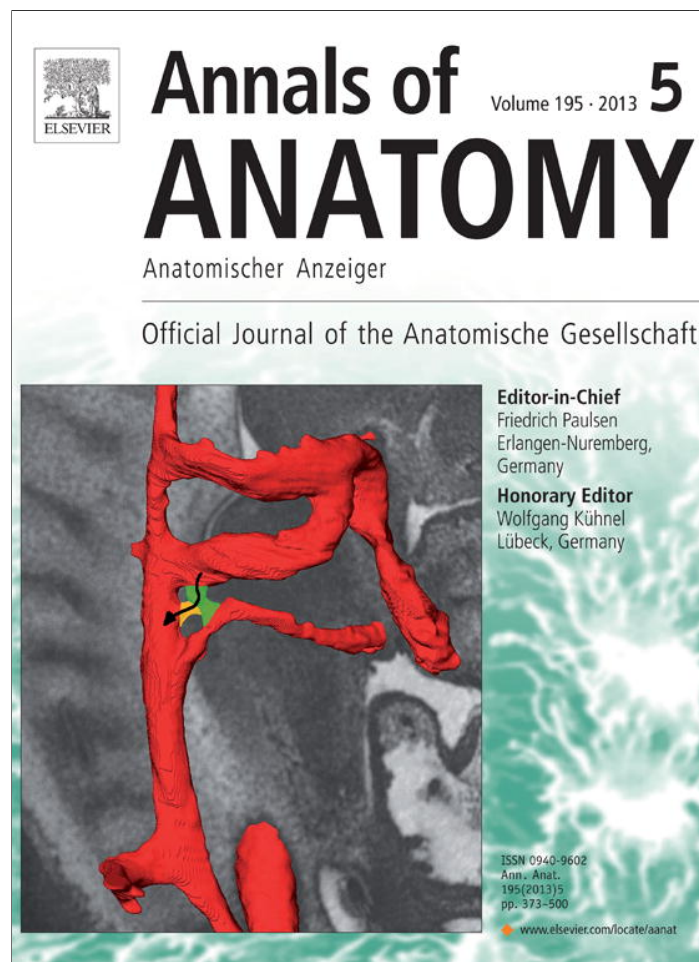


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## Research article

## Multidetector CT investigation of the mummy of Rosalia Lombardo (1918–1920)

Stephanie Panzer<sup>a,\*</sup>, Heather Gill-Frerking<sup>b</sup>, Wilfried Rosendahl<sup>c</sup>, Albert R. Zink<sup>d</sup>,  
Dario Piombino-Mascali<sup>d</sup><sup>a</sup> Department of Radiology, Trauma Center Murnau, Biomechanics Laboratory, Paracelsus Medical University Salzburg and Trauma Center Murnau, Prof.-Küntschler-Strasse 8, D-82418 Murnau, Germany<sup>b</sup> Mummies of the World Touring Company, NTK Services, P.O. Box 545, Epsom, NH 03234, USA<sup>c</sup> Reiss-Engelhorn-Museen, C5 Zeughaus, D-68159 Mannheim, Germany<sup>d</sup> EURAC-Institute for Mummies and the Iceman, Viale Druso 1, I-39100 Bolzano, Italy

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## SUMMARY

Whole-body multidetector computed tomography (CT) was performed on the mummified corpse of two-year-old Rosalia Lombardo, an anthropogenic mummy displayed in the Capuchin Catacombs of Palermo, Sicily, Italy. Rosalia Lombardo reportedly died of bronchopneumonia in 1920 and was preserved by the embalmer and taxidermist Alfredo Salafia with a formaldehyde-based fluid. Rosalia Lombardo's body is still exhibited in the Capuchin Catacombs inside the original glass-topped coffin in which she was placed. Only her head is visible: the rest of her body is covered by a sheet.

CT images of Rosalia's body within her coffin were of reduced quality because of distinct metal artifacts caused by the coffin itself. Nevertheless, a detailed radiological analysis was possible for most of the body. Analysis of the data from the CT examination revealed indicators for the historically-reported endovasal and intracavity treatment. Rosalia's entire body was preserved in a remarkable state. The exceptional preservation of her internal organs made it possible to consider a radiological diagnosis of pneumonia.

For this study, CT was determined to be the ultimate method for investigation, since Rosalia's body had to be kept untouched in her sealed coffin for conservation purposes. The CT examination offered new insights into the current preservation status of the body, and the superior contrast of CT allowed detailed assessment of different tissues. Post-processing methods provided reconstructions on any desired plane, as well as three-dimensional reconstruction, for the best possible visualization and interpretation of the body.

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## 1. Introduction

Rosalia Lombardo, who has also been referred to as the “Sicilian Sleeping Beauty”, is probably one of the best preserved bodies in the Capuchin Catacombs of Palermo, Sicily, Italy. The daughter of military officer Mario Lombardo (1890–1980) and Maria Di Cara (1897–1966), Rosalia was born on December 13, 1918, and died on December 6, 1920, only a week before her second birthday. According to the post-mortem report, she died of bronchopneumonia. She was “temporarily” brought to the Capuchin Catacombs of Palermo on December 8, 1920, where she remains today (Farella, 1982; Piombino-Mascali, 2009; Piombino-Mascali et al., 2010).

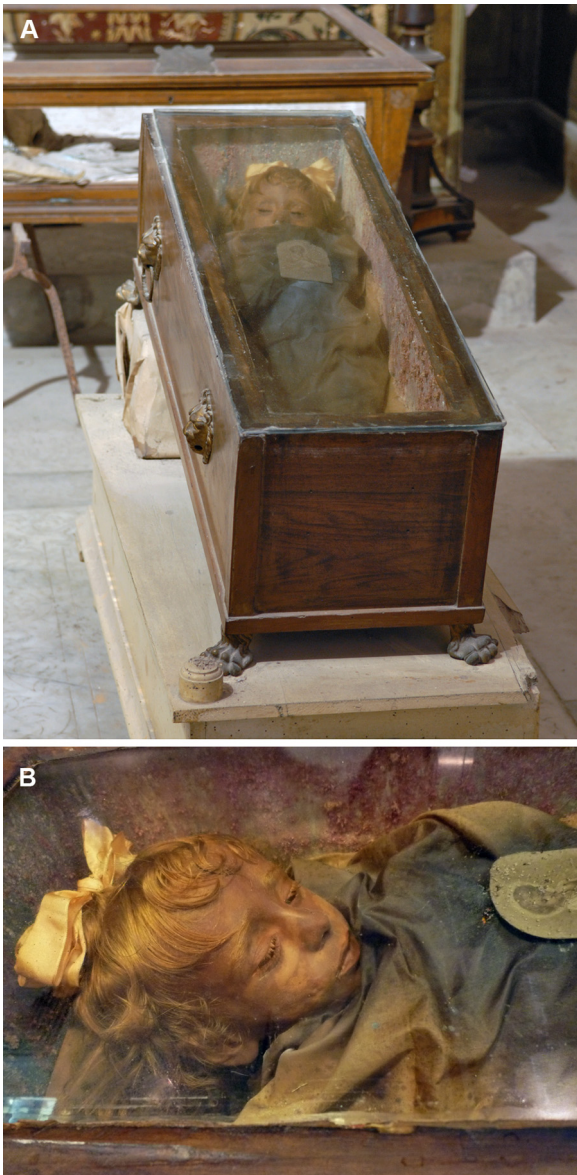
The Lombardos decided to have their daughter's corpse preserved by Professor Alfredo Salafia (1869–1933) prior to her entombment. Salafia, a self-taught taxidermist and embalmer, was responsible for the preparation of many prominent citizens of Palermo from 1902 onwards. The procedure he devised was characterized by simplicity, consisting of a single-point injection, preferably into the femoral artery via a gravity injector. Other procedures normally adopted in modern embalming, such as blood drainage, cavity treatment or additional injections, were believed to be unnecessary in most cases (Piombino-Mascali, 2009; Piombino-Mascali et al., 2009).

In September 2007, a handwritten memoir by Salafia revealed the “secret” formula of his preservative. The chemical formula consisted of 7 L of one part glycerin, one part formalin saturated with both zinc sulfate and chloride, and one part of an alcohol solution saturated with salicylic acid. Since Salafia developed his preservative in the early 1900s, it was suggested that his “Perfection Fluid” was one of the earliest formaldehyde-based formulas during the transition from “old” to “modern” embalming chemicals – a process eventually leading to the replacement of heavy metals.

\* Corresponding author.

E-mail addresses: [stephanie.panzer@bgu-murnau.de](mailto:stephanie.panzer@bgu-murnau.de) (S. Panzer), [heather@ntknet.com](mailto:heather@ntknet.com) (H. Gill-Frerking), [wilfried.rosendahl@mannheim.de](mailto:wilfried.rosendahl@mannheim.de) (W. Rosendahl), [albert.zink@eurac.edu](mailto:albert.zink@eurac.edu) (A.R. Zink), [dario.piombino@eurac.edu](mailto:dario.piombino@eurac.edu) (D. Piombino-Mascali).





**Fig. 1.** (A) The body of Rosalia Lombardo, preserved by Alfredo Salafia with his method of embalming in 1920. The body is covered by a sheet, with only the head visible. (B) Close-up of the face of Rosalia Lombardo.

Additionally, Salafia's memoir also disclosed his occasional use of paraffin wax diluted in ether, which was introduced into the deceased's face in order to keep the features plump and lifelike (Piombino-Mascali, 2009).

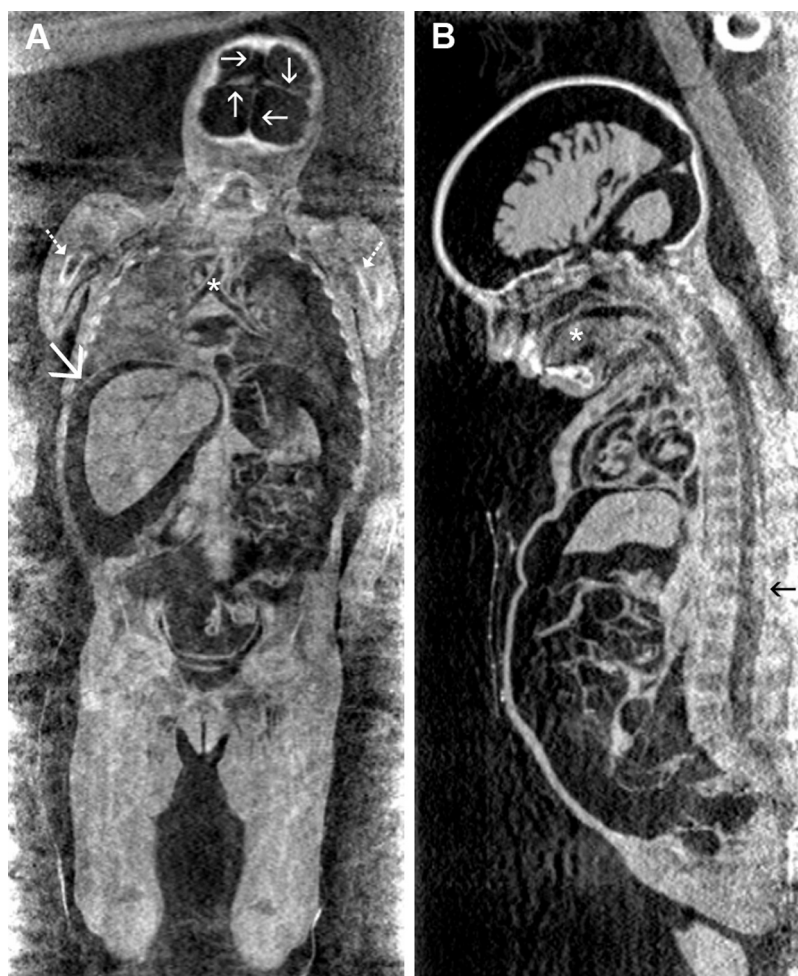
Rosalia Lombardo's body is still exhibited in the original glass-topped coffin in which she was placed. Only her head is visible; the rest of her body is covered by a sheet. Her face shows a remarkable state of preservation – she still looks as though she is alive and sleeping (Fig. 1). In the past few years, however, signs of oxidation and decay have become more obvious. Specifically, the child's hair and accompanying textiles have become lighter, while her face has darkened and has shrunk.

Evaluation of anteroposterior (AP) radiographs of the mummy (Panzer et al., 2010) taken in July 2008, revealed that not only the head, but the entire body was preserved. Additionally, several preserved organs were discernible on the radiographs. In December 2010, we had the opportunity to investigate Rosalia's body by multidetector computed tomography (CT). This technique, considered a "gold standard" in mummy studies, was used to



**Fig. 2.** Anteroposterior scout image shows Rosalia lying inside her coffin. Image quality was reduced by distinct artifacts caused by the thin layers of lead lining the coffin on the base and side walls, as well as the multiple metallic ornaments garnishing the outside of the coffin. The crown-heel average of Rosalia's body was approximately 76 cm. Note the bottle underneath the head at the front end of the coffin.

further investigate the embalming procedure employed, to analyze the extent of the preservation in detail, to identify any possible changes to the body since her preparation, and to provide a permanent record of the mummy's features. CT was believed to be the best non-destructive method to investigate Rosalia because she had to be kept untouched in her sealed coffin, in order to maintain the preservation of the body. The cross-sectional imaging offered by CT technology allows for the non-destructive assessment of the complete skeleton, soft tissues and internal body cavities. Further advantages of CT include the superior contrast and the capacity to remove superimposed embalming materials. Post-processing software allows the user to make cuts along different planes and to create three-dimensional models (e.g., Hoffman et al., 2002; Lee et al., 2007; O'Brien et al., 2009; Oh et al., 2011).



**Fig. 3.** Overview of the whole-body CT. (A) Coronal multi-planar reformatted (MPR) image shows the head, trunk and thighs. The skeleton is preserved with differentiation between hyperdense cortical and hypodense spongy bone (dotted arrows). The surrounding soft tissues appear as a relatively homogeneous mass. Intracranially, parts of the dura are visible (short arrows). The thoracic cavity is separated from the abdominal cavity by a predominantly visible hyperdense diaphragm (long arrow). The abdomen is distinctly widened and inflated. Note the preservation of the trachea including the lower bifurcation (asterisk). (B) Sagittal MPR image of the head and trunk shows a board inserted on an angle at the front end, lifting Rosalia's head. The position of the vertebral column is unremarkable. The spinal cord terminates in the cauda equina at the level of approximately lumbar vertebra 1 (arrow). The oropharynx and the nasal cavity are inflated. Preservation of the tongue is visible (asterisk).

## 2. Materials and methods

Within the framework of the “Sicily Mummy Project” (Piombino-Mascali et al., 2011), the coffin containing Rosalia Lombardo was examined by a mobile 4-section CT scanner (Alliance Medical, Warwick, UK; LightSpeed Plus, GE Healthcare, Milwaukee, WI, USA), which was positioned in front of the Capuchin Church next to the entrance of the Catacombs.

Whole-body CT was performed in a single acquisition. Preliminary anteroposterior and laterolateral scout images (80 kV, 10 mA) were obtained to include the whole object and to optimize the field of view. Helical scanning parameters were as follows: 1.25-mm section thickness, 1.25-mm reconstruction interval, 120 kV, 150 mA, 0.5-s rotation time, and standard algorithm.

Radiological evaluation was carried out at the Picture Archiving and Communicating System (PACS) (ImpaxEE, Agfa HealthCare, Bonn, Germany) in the Department of Radiology of the first author. Image data post-processing including multi-planar reconstructions (MPR), maximum intensity reconstructions (MIP) and three-dimensional surface reconstructions (3D VR) was performed

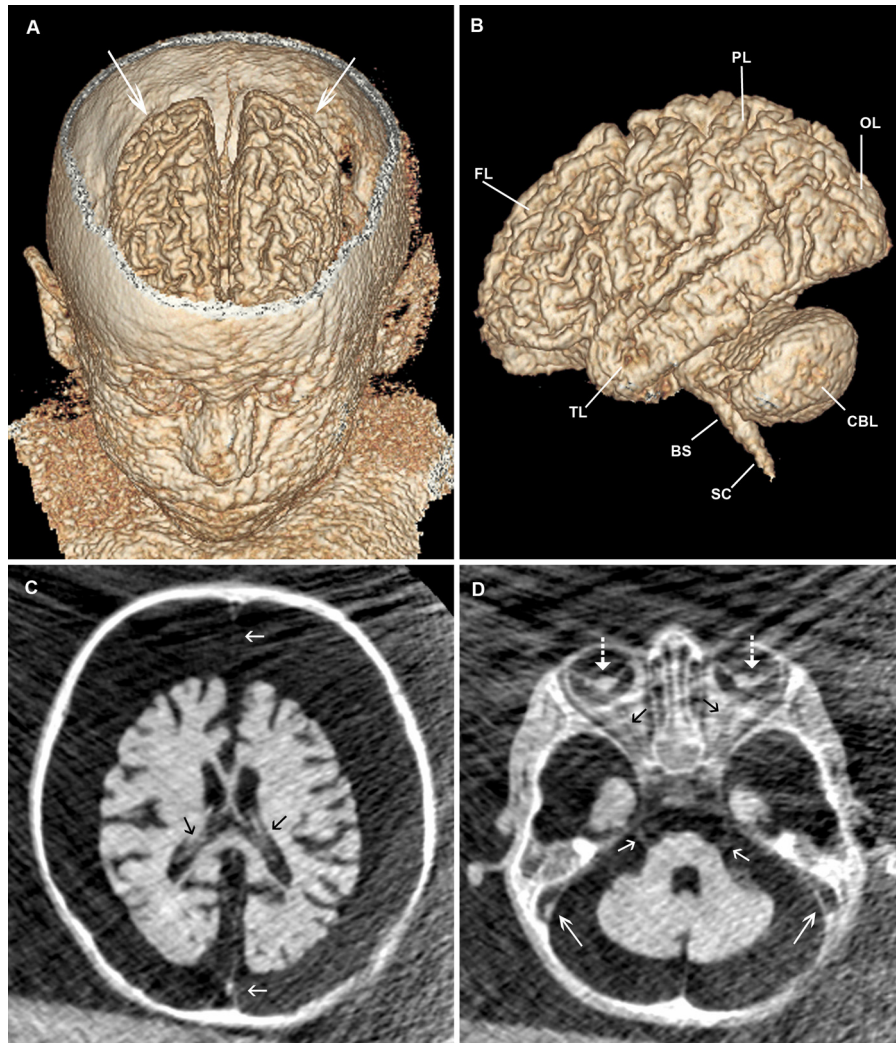
using the PACS and the adjacent workstation (Advantage Windows 4.4, GE Medical Systems, Milwaukee, WI, USA).

## 3. Results

Despite the best possible adjustment of scanning parameters, CT image quality was diminished by distinct metal artifacts from the coffin's lining and ornaments (Fig. 2). Nevertheless, detailed radiological analysis of CT images was possible for most parts of the body.

Rosalia's entire body was preserved. The skeleton was preserved with differentiation between hyperdense cortical and hypodense spongy bone. Teeth and ossicles were discernible. The surrounding soft tissues appeared as a relatively homogeneous mass (mean, 650 HU) without major shrinkage. In the upper part of the thoracic cavity, air-filled spaces were visible bilaterally. Soft tissue structures, such as the external ear and the external genitals, the eyes and retrobulbar structures, and the tongue were preserved in detail. The cutis was, for the most part, definable as a slightly hyperdense structure. The thoracic cavity was separated from the abdominal





**Fig. 4.** Preservation of the central nervous system. (A) Oblique anteroposterior three-dimensional (3D) reformatted image with virtual craniotomy shows both convoluted cerebral hemispheres (arrows) with position in the midline. Artifacts reduced the image quality, especially on the left side, resulting in an irregular illustration of surfaces, including left external ear structures. (B) Laterolateral 3D reformatted image of the isolated brain shows detailed preservation. BS, brain stem; CBL, cerebellum; FL, frontal lobe; OL, occipital lobe; PL, parietal lobe; SC, spinal cord; TL, temporal lobe. (C) Oblique axial MPR image at the level of the lateral ventricles shows the moderately shrunken brain with ventrally- and dorsally-adjacent partially-visible falx (white arrows). The cerebral ventricles are symmetrically preserved with the choroid plexus being partially discernible (black arrows). (D) Oblique axial MPR image at the level of the orbits and the cerebellum illustrating the trigeminal nerve bilaterally, in its course from the brainstem to the skull base (short white arrows). On both sides, the sigmoid sinus is visible (long white arrows). Bilaterally, the eye bulb is visible containing the preserved lens (dotted arrows). Inside the orbital fat pad, the optic nerve is discernible (black arrows).

cavity by a predominantly visible hyperdense diaphragm. The abdomen was markedly dilated and inflated (Fig. 3).

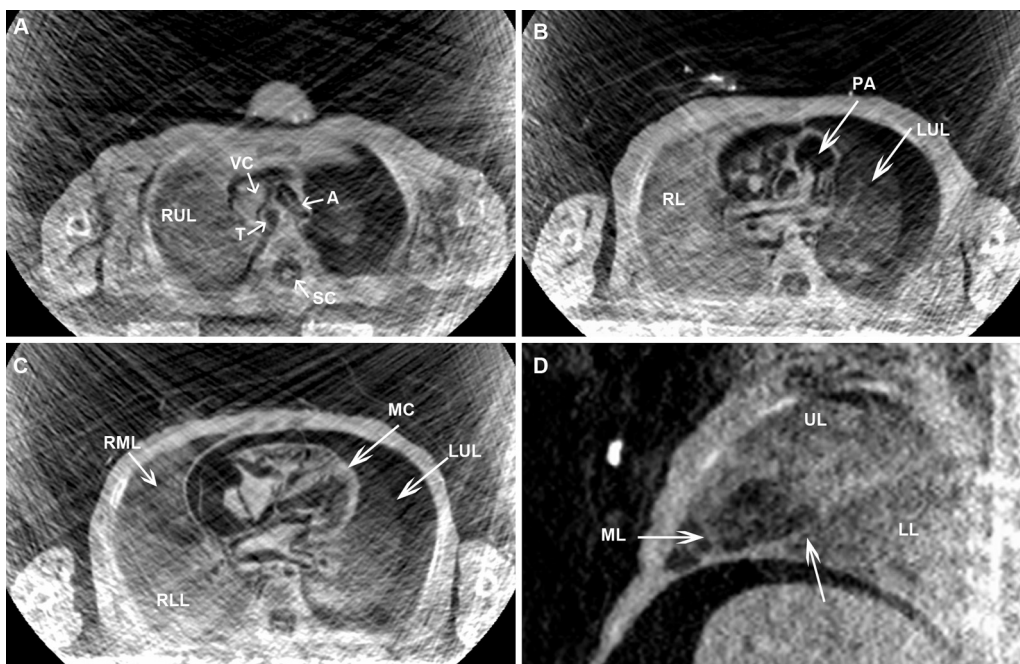
Analysis of the data acquired during the CT examination revealed the excellent preservation of organs and organ systems.

The central nervous system showed detailed preservation of gyri and sulci of distinguishable cerebral lobes, as well as preservation of cerebellar hemispheres, brainstem and spinal cord. The entire brain was moderately shrunken. The cerebral ventricles were symmetrically preserved and the choroid plexus was partially discernible. Brain parenchyma was illustrated as a homogeneous mass (mean, 465 HU), without recognizable differentiation between cortex and white matter. The trigeminal nerve was preserved on both sides. Bilaterally, the eye bulb was discernible as a round to oval air-filled structure with a hyperdense border containing the preserved hyperdense lens which was dislocated dorsally but still fixed to structures of the lens. The orbital fat pad was shown as a hyperdense structure delimited to the bony orbit by a small border of air. Inside the orbital fat pad, the optic nerve was discernible as a hyperdense structure surrounded by hypodense tissue or by air (Fig. 4).

The respiratory system showed preservation of the trachea, including the lower bifurcation with air present. The right hemithorax was almost completely filled by lung parenchyma, with a relatively homogeneous and hyperdense illustration of the upper and lower lobes (mean, 345 HU), and an inhomogeneous illustration of the middle lobe with slight collapse ventrally and bordered by a thick hyperdense pleura medially. The interlobar septum was discernible. On the left side, the upper (mean, 6 HU) and lower lobe were distinctly collapsed (mean, 146 HU). Bilateral hilar vessels and bronchi were discernible, extending into the central parts of the lungs. All mediastinal vessels were inflated and/or filled with hyperdense material (Fig. 5).

The gastrointestinal tract was preserved as a predominantly inflated canal with a continuous border of differing thickness. Intestinal loops were distributed over wide parts of the abdomen and mesenteric structures were recognizable in between (Fig. 6).

The internal parenchymatous organs and the uterus were preserved as moderately shrunken hyperdense structures (liver: mean, 419 HU; spleen: mean, 614 HU; pancreas: mean, 630 HU; kidneys: right: mean, 662 HU; left: 615 HU; uterus: mean 780 HU). The gall



**Fig. 5.** Preservation of the intrathoracic organs and structures. (A) Axial MPR image at the level of the aortic arch illustrating inflation of the aortic arch with a centrally visible thin hyperdense structure. The superior vena cava and parts of the azygos vein are filled with hyperdense material. The trachea is air-filled. The right upper lobe is shown as a relatively homogeneous mass, the left upper hemithorax is mainly filled with air. Note the hyperdense spinal cord. A, aorta; RUL, right upper lobe; SC, spinal cord; T, trachea; VC, vena cava. (B) Axial MPR image at the level of the pulmonary artery shows an inflated pulmonary artery with branching into the right and left pulmonary artery with partial filling of the lumina by hyperdense structures. The right lung is illustrated as a hyperdense mass. The left upper lobe is partially collapsed. LUL, left upper lobe; PA, pulmonary artery; RL, right lung. (C) Axial MPR image at the level of the left atrium shows air-filling of all four heart chambers with central hyperdense structures. The heart anatomy is preserved in detail. On the right side the middle lobe appears as an inhomogeneous structure and the lower lobe as a hyperdense mass. On the left side the upper lobe is partially collapsed. Bilateral hilar vessels and bronchi are discernible. LUL, left upper lobe; MC, myocardium; RLL, right lower lobe; RML, right middle lobe. (D) Sagittal MPR image of the right chest shows the hyperdense right upper and lower lobes and the inhomogeneous middle lobe with discernible interlobar septum (arrow). LL, lower lobe; ML, middle lobe; UL, upper lobe.

bladder and adrenals were not recognizable. Liver and spleen had nearly retained their original shapes. The liver was divided into the right and left lobe with a thin linear structure recognizable in the anatomical course of the ligamentum teres. The portal vein with branching was visible and hypointense structures were discernible inside the parenchyma. The body and tail of the pancreas were detectable directly ventral to the vertebral column, with extension to the spleen. Both kidneys were preserved as distorted structures located dorsally along the vertebral column.

The navel was wrapped by a thin hyperdense string and showed a central defect (Fig. 6)

The heart anatomy was preserved in detail with recognizable hyperdense myocardium and interventricular septum, parts of the heart valves and papillary muscles. All chambers of the heart were filled with air and revealed an additional hyperdense structure (mean, 628 HU) centrally that extended continuously via the cervical veins up to the transverse sinus on both sides, via the aorta up to the descending part, and into all other filling and draining vessels of the heart (Fig. 5A–C). The central parts of the vasculature were mainly filled with air, as were parts of the peripheral vasculature of the lower extremities (Fig. 7).

Over the whole mummy, the only detectable applied foreign bodies were the hyperdense string wrapped around the navel (Fig. 6D), and the externally-visible barrette.

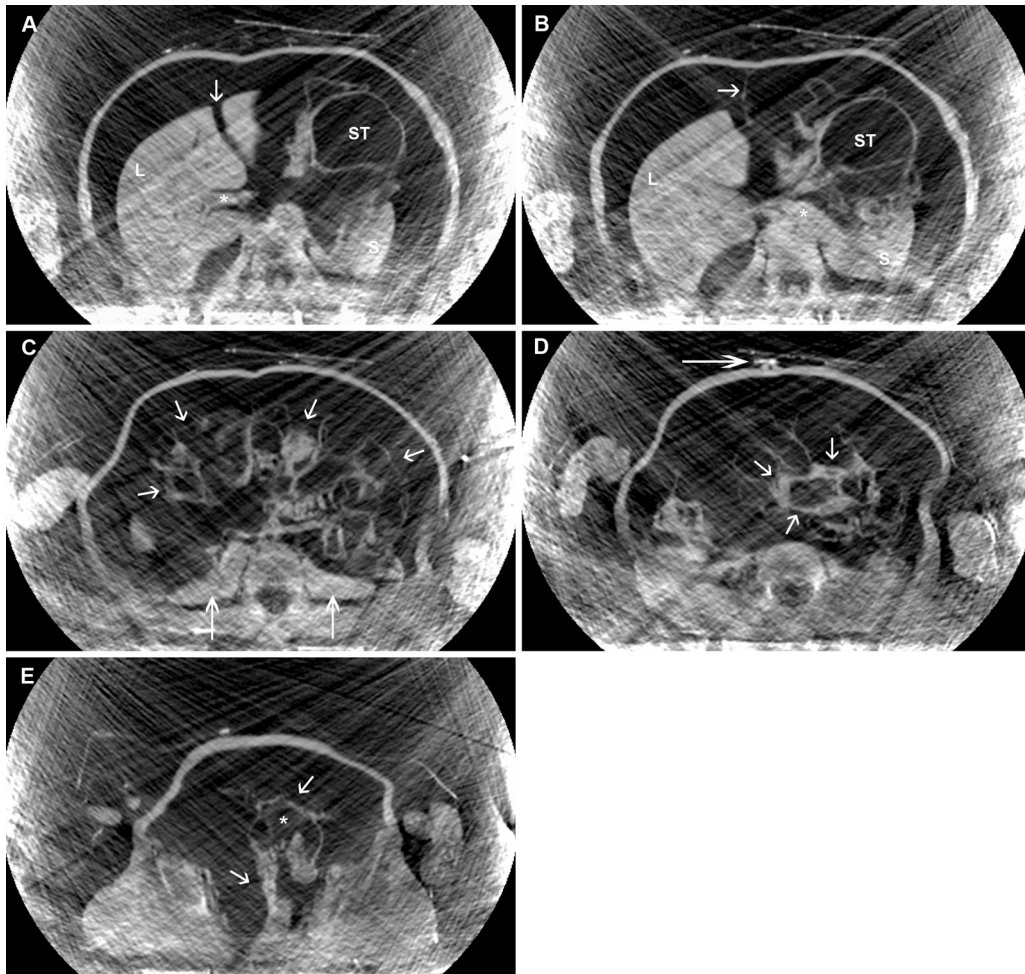
#### 4. Discussion

In this study, we analyzed the whole-body CT examination of Rosalia Lombardo, with special focus on indicators for the historically-known embalming treatment, the preservation status of different tissues and pathological findings.

##### 4.1. Endovascular treatment

Analysis of the CT examinations revealed indirect indicators for the historically-reported endovascular treatment of Rosalia's body (Piombino-Mascali, 2009). The mediastinal vessels, some parts of the abdominal and iliac vessels, and parts of vessels in the periphery of the lower extremity were widened and inflated. Furthermore, the veins from the skull base to the right chambers of the heart, all of the chambers of the heart, and the filling and draining vessels, formed a continuous central hyperdense structure which was mainly encased by air. We assume that the injected fluid widened the vessels at the time of treatment and subsequently led to a fixation of the vessel walls in the widened state. Over time, the fluid seems to have dissolved or evaporated. The visible hyperdense central structures are most likely remnants of blood. Desiccation, and probably reaction with the preservative fluid, may have led to the high density. Empirically, the formation of post-mortem blood clots is closely linked to the length of the agonal interval. In patients with a protracted period of dying, as is assumed in the case of Rosalia during her reported course of infectious disease, extensive post-mortem clotting, mainly in the venous system, is expected (Ross et al., 2012). The fact that Salafia normally did not use blood drainage prior to the endovascular injection supports the assumption of preserved endovascular blood clotting inside Rosalia's vascular system. Based on the chemical formula of Salafia's preservative fluid, hyperdense endovascular remnants were not really expected on CT images, because of the rather low atomic number of the components. In contrast, preservation of endovascular embalming fluid was detectable in the X-rays of other mummies from the Catacombs; those individuals were injected with solutions containing heavy metals with a high atomic number, such as mercury (Panzer et al., 2010).



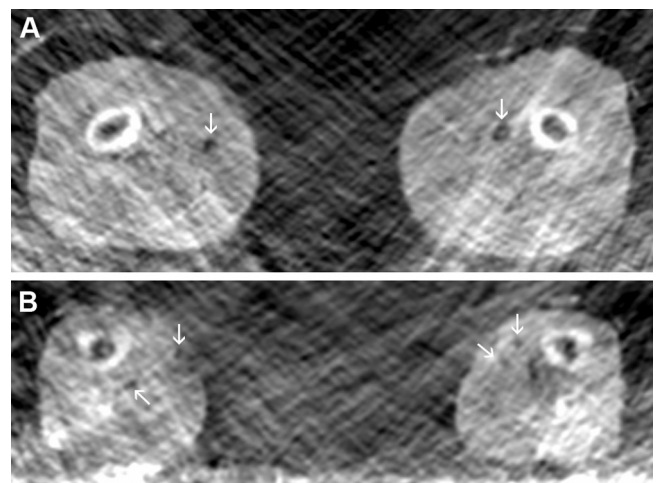


**Fig. 6.** Preservation of the intraabdominal organs and structures. (A) Axial MPR image at the level of the liver shows the moderately shrunken liver and spleen in the original shape. The liver is divided into the right and left lobe (arrow). The portal vein with branching is visible (asterisk). The stomach is inflated and demarcated by a continuous wall. L, liver; S, spleen; ST, stomach. (B) Axial MPR image below the level of the liver hilum shows preservation of the pancreas body and tail (asterisk). Note the thin linear structure in the anatomical course of the ligamentum teres (arrow). L, liver; S, spleen; ST, stomach. (C) Axial MPR image at the level of both kidneys shows them as distorted structures (long arrows). Intestinal loops are mainly preserved inflated (short arrows). (D) Axial MPR image at the level of the navel, which is wrapped by a thin string (long arrow). (E) Axial MPR image at the level of the pelvis shows preserved sigmoid colon in its physiological location (arrows), with air-filled ventral parts (asterisk).

Salafia specified the femoral artery as the preferred injection point. He discouraged the use of the carotid and axillary arteries as possible injection sites due to rigor mortis (Piombino-Mascali, 2009). As far as the evaluation of CT data was possible due to artifacts, we could not identify soft tissue cuts or other defects that indicated a possible injection site. The visible air-filled spaces noted bilaterally in the upper part of the thoracic cavity are suggested to be a common post-mortem finding in embalmed bodies.

#### 4.2. Cavity treatment

The abdomen was extremely wide and a thin string wrapped around the region of the navel clearly indicated that a body cavity treatment had been used. In his files, Salafia noted that, in some cases, he used a cannula inserted through the navel to fill the abdomen with embalming fluid (Piombino-Mascali, 2009). At present, Rosalia's abdomen is filled with air, not with fluid. The enclosed preserved parenchymatous organs, parts of the intestine and mesenteric structures seem to be fixed in their positions. Many of the intestinal loops are also markedly widened, so the possibility of an additional intestinal filling must be considered. We assume that the embalming fluid widened the cavities at the time of treatment and subsequently led to a fixation of the adjacent



**Fig. 7.** Inflated structures in the space of soft tissues of the lower extremities. (A, B) Axial MPR images at the level of the thigh and lower leg show well-described air-filled structures in the medial parts of the musculature in anatomical regions of superficial and deep vessels (arrows).

structures in this state, similar to what was observed with the vasculature. During the preservation processes, the mesenteric fat completely dissolved and, since the preparation of the body, the fluid has evaporated. The phenomenon of abdominal “bloating” related to the decay of the body, as described in the forensic (Clark et al., 1997) and paleopathological literature (Aufderheide, 2003, 2011), is assumed not to apply in this case (see next paragraph). There was no evidence that embalming fluid had been injected intramuscularly or intermuscularly all over the body, which Salafia had described using for some cases (Piombino-Mascalì, 2009). Also, we could not find clear evidence of the application of a facial paraffin treatment, although it seems very likely that this method was used, considering how perfectly preserved Rosalia's face appears to be. The bottle next to Rosalia's head may have served as reservoir for disinfecting substances that were dispersed within the space inside the sealed coffin, possibly acting as an additional external preservation treatment (Piombino-Mascalì et al., 2009).

#### 4.3. Time of embalming

The high quality of preservation of the pancreas proved that Salafia embalmed Rosalia's body shortly after death. After death, the tissues of a human corpse undergo changes which may eventually lead to skeletonization of the remains, if the body is not embalmed or otherwise exposed to conditions which may allow preservation. The entire process is referred to as decomposition, and is further subdivided into autolysis and putrefaction. Autolysis is the process by which hydrolytic enzymes that are present in cytoplasmic granules in all cells, called lysosomes, are released into the cytoplasm. These changes are the earliest detectable post-mortem chemical changes. The time at which autolysis begins in different cell types and organs is quite variable. Generally, it begins much sooner after death in those cell types which contain large numbers of lysosomes, such as the pancreas. In addition, the process is temperature-dependent and retarded by refrigeration (Clark et al., 1997; Aufderheide, 2003, 2011). Salafia obviously embalmed Rosalia before self-digestion of the pancreas occurred and, according to his manuscript, he aimed to begin the embalming procedure within the first 24 h after death (Piombino-Mascalì, 2009). Following autolysis, the second phase of post-mortem decay in an untreated human corpse is characterized by putrefactive changes, and is initiated when bacteria from the gut proliferate and begin to invade other tissues. During this process the abdomen can be massively inflated by gas (“bloating”) (Clark et al., 1997; Aufderheide, 2003, 2011). Since Salafia embalmed Rosalia's body before autolysis occurred, and therefore long before putrefaction was initiated, decomposition-related “bloating” was excluded as the cause of the abdominal distension that was noted during our CT examination.

#### 4.4. Organ preservation

Overall, good preservation status of the entire body was visible through the analysis of the CT images; the preservation of the internal organs was remarkable. The parenchymatous structures of the brain, liver, spleen and parts of the pancreas were shrunken, but retained their shape. In the case of the liver, at least parts of the intraparenchymatous vessels were also preserved. Furthermore, both kidneys were preserved, although they were distorted and located dorsally. It is possible that the kidneys could not resist the intraabdominal pressure after the abdomen was filled during the embalming process. The heart and uterus, as organs composed mainly of muscle, were well preserved. The hyperdense aspect of all these organs on CT images is a well-known phenomenon in mummy studies, and is explained by shrinking, dehydration and

interaction with the applied embalming fluid, as well as the subsequent preservation processes (Hübener and Pahl, 1981; Rühli et al., 2004). In general, the remarkable organ preservation seen in Rosalia Lombardo is the result of an extremely effective treatment by embalming fluid, in which intracranial and intrathoracic structures were probably only treated endovascularly, while intraabdominal organs were treated endovascularly and externally, via cavity treatment. Therefore, the ingredients of the embalming fluid were effective in stopping early decay and preventing further decomposition, allowing excellent preservation of the body to the present day. From CT images alone, it is not possible to know the actual consistency of the embalmed organs. Limited information is available regarding the organ preservation of a body embalmed by Salafia, six months after the process. The autopsy revealed that all tissues were firm and dry: even the internal organs were well preserved and no decomposition odor was detected (Piombino-Mascalì, 2009).

#### 4.5. Pathological changes

Analysis of the CT images revealed a variable preservation condition of preserved lung parenchyma between the left and right sides, indicating pathological changes on the right side. In contrast to the partially-collapsed left lung, the right lung almost completely filled in the right hemithorax. Due to the remarkable preservation status of the intrathoracic organs and structures, the different lobes and several air-filled bronchi were discernible. The upper and lower lobes were shown as relatively homogeneous and hyperdense structures, whereas the middle lobe was shown as an inhomogeneous structure with less density. In dry mummies a consolidated area of lung bears a 95% probability of representing pneumonia (Aufderheide, 2003). In corpses undergoing virtual autopsy by CT, pneumonia is known to cause hyperdensity (Dirnhofer et al., 2006). Lung alterations caused by interval-dependent overlap of blood sedimentation (internal livores) should be considered as a differential finding in the dorsal parts of the lung (Dirnhofer et al., 2006). Due to the suggested lobar involvement of hyperdensity in terms of consolidation, some remaining air-filled bronchi and the lack of volume loss, we assume that the diagnosis is that of lobar pneumonia (Weissleder et al., 1997). However, other pulmonary infections (e.g., viral, fungal, parasitic) may have caused the visible lung alterations. Further differential diagnoses such as lung hemorrhage or malformation cannot be conclusively excluded. Pneumonia is a well-documented disease in paleopathology, with a high mortality rate of the very young and the elderly (Walker et al., 1987; Aufderheide, 2003; Emery, 2005). According to the post-mortem report, Rosalia died of bronchopneumonia (Piombino-Mascalì, 2009). That report was based on an external inspection carried out by a physician to confirm death and to establish its cause. Therefore, the reported bronchopneumonia might have been diagnosed even before her death. In accordance with the historical records, we assume that Rosalia died of pneumonia at a time prior to the availability of effective therapies.

#### 4.6. Limitations of the study

A few limitations to this study have been identified. Distinct metal artifacts reduced CT image quality and made interpretation difficult in some areas. The CT scanner available for this study was an older generation model which did not allow advanced CT techniques, such as dual-source or dual-energy techniques, which may have diminished artifacts. Finally, given that Rosalia's body had to be kept untouched within her sealed coffin, CT was the only method available for analysis and there is no possibility for any comparative methodological analyses.



## 5. Conclusions

The use of whole-body CT examination of the mummy of Rosalia Lombardo enabled new insights into the preserved body. Analysis of the CT data provided new information in comparison to the only medical images previously available: AP radiographs of a mummy for which only the face and head were visible inside a glass-topped coffin, revealing the preservation of the entire body and at least of some organs. Despite the disadvantageous situation caused by the artifacts due to the coffin's lead lining and ornaments, the cross-sectional technique and superior contrast of CT allowed detailed assessment of different tissues. Post-processing methods provided reconstructions on any desired plane, as well as 3D reconstruction, for the most accurate interpretation of findings. Analysis of the data from the CT examination also revealed indicators for the historically-reported endovascular and intracavity treatments. Rosalia's entire body was in an excellent state of preservation, especially the internal organs. The radiological diagnosis of probable pneumonia was possible only due to the exceptional condition of the organs. Nevertheless, our investigation represents an assessment only 90 years after Rosalia's death and subsequent embalming treatment. It is not possible to determine what specific changes occurred at which point in time. Furthermore, it is impossible to identify what change may occur in the future, or when.

## Acknowledgments

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## Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at <http://dx.doi.org/10.1016/j.aanat.2013.03.009>.

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