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MAKING AN INFANT MUMMY ANALYSIS AND EXPERIMENTAL INVESTIGATIONS OF HOW TO PREPARE A 19TH CENTURY INFANT MUMMY

Andreas G. Nerlich[1], Stephanie Panzer[2], Pascale Röcker[1], and Oliver Peschel[3]

[1] Institute of Pathology, Academic Hospital Munich-Bogenhausen
Andreas.Nerlich@extern.lrz-muenchen.de, pascale-roecker@freenet.de
[2] Department of Radiology, Trauma Center Murnau and PMU Salzburg
Stephanie.Panzer@bgu-murnau.de
[3] Institute of Legal Medicine, University Munich. oliver.peschel@med.uni-muenchen.de
Address for correspondence: Prof. Dr. Andreas Nerlich
Institut für Pathologie. Klinikum München-Bogenhausen. Englschalkingerstr. 77
D-81925 München, Germany. Phone: +49-89-9270-2310 Fax: +49-89-9270-2067
Andreas.Nerlich@extern.lrz-muenchen.de

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Abstract. The identification of an exceptionally well-preserved infant mummy from early 19th century Naples - born to a high Bavarian general and court officer - provides an excellent example for the efficiency of the mummification procedures at that time. We identified an autoptic removal of various inner organs, the reduction of the muscle mass of both thighs and shanks, the filling of the empty body cavities with cotton and spices with a mixture of sodium- and potassium-sulphate as the main constituents of the conservation, but no use of any other fixative, such as heavy metal. These features parallel the embalming techniques of early 18th century France. In order to evaluate the feasibility of that procedure, we applied the procedure to a comparable piglet of 10kg weight. The procedure proved to be easily performed and very efficient with an excellent outcome after several months under typical storage conditions.

Keywords. Embalming - infant mummy - Naples

INTRODUCTION

With the rise of science during the Renaissance period increasing attempts were undertaken to preserve dead bodies for eternity - mainly for the (high) aristocracy. Before the systematic application of heavy metal (Tranchina 1835a/b), alumina salts (Gannal, 1841) and - later - cross-linking fluids, such as phenol and formaldehyde (Laskowski, 1886; Blum, 1894) by the mid of the 19th century the permanent conservation of cadavers was difficult, however, occasionally was brought near to perfection.

The identification of an exceptionally well-preserved infant mummy from early 19th century Naples - born to a high Bavarian general and court officer - provides an excellent example for the efficiency of the mummification procedures at that time.

In this report we describe the findings about the techniques and procedures that were applied in order to conserve the infant at the age of approx. 1 1/4 years. Accordingly, we identified the autoptic removal of inner organs (lungs, heart, liver, spleen, bowels, kidneys, bladder and uterus, but also the brain), reduction of the muscle mass of both thighs and shanks, the filling of the empty body cavities with cotton and a mixture of sodium- and potassium-sulphate as the main constituents of the conservation, but no use of neither arsenic nor sublimate. These features parallel the embalming techniques of French early 18th century authors (Penicher, 1699; for further reading see: Magnus, 1839).

In order to evaluate the feasibility of that procedure, we applied the mummification procedure to a piglet of 10kg weight - which is comparable in size and tissue composition (especially fat concentration) to a young infant. The procedure proved to be easily performed and very efficient with an excellent outcome after more than one year under the storage conditions that prevailed in the crypt burial of the young infant.

This report is the first that describes the combined analytical and experimental approach identifying an efficient and well applicable technique to preserve infant mummies in the pre-formaldehyde fixation period.

MATERIAL AND METHODS

The crypt of Wackerstein (near Ingolstadt/ Bavaria) that had been built by the Royal Bavarian General Wilhelm von Jordan in 1836 contains four mummified

members of that family (and an additional burial of an unrelated Royal Bavarian General, for a detailed description of the crypt see: Nerlich, 2016). During the crypt renovation all bodies were removed and could therefore extensively be examined. Out of the four Jordan burials, the mummified body of the small infant was most remarkable since this body was artificially mummified while all other individuals had been naturally mummified due to the climatic conditions of the crypt (Nerlich, 2016).

Carolina von Jordan was born on the 25th March, 1815 in Portici (close to Naples, Italy) where her parents had been living for a short period. Approx. 1 ¼ years later, Carolina died in Naples where her body was embalmed for the return to Bavaria. There the mummified body was kept for almost 20 years in the cold storage room of the local brewery of her parents (where especially during summer times the ice for the brewery was stored). Accordingly, the small mummified corpse was buried as the first individual in the Wackerstein Crypt in the year 1836. (A detailed description of life and death of the infant will be provided in the near future).

Fig. 1. The mummy of Carolina von Jordan.

Due to the excellent state of conservation of the mummy we investigated the obvious technique that had been used for the conservation procedure. This included a whole-body CT- and X-ray examination, a partial autopsy with opening of the skull and the

chest/ upper bowel from the dorsal side and the removal of filling material from both sides for subsequent microscopical and chemical analyses. Thereby, we investigated the substances that had been used for embalming.

In a second step, we established an experimental animal model to monitor the embalming procedure and its effects. Therefore, we used a piglet of 10 kg weight – which is comparable to the estimated weight of Carolina von Jordan at her time of death. The specific regulations of this embalming will be described below.

RESULTS

Embalming procedure of Carolina von Jordan

The body of the infant had been opened by a longitudinal incision form the xyphoid to the pubis and a transverse incision from the right to the left lower bowel. Both incisions had been carefully closed by multiple stiches that were slightly dehiscent on the right lower bowel site. Here some filamentous white material protruded from the incision. A similar defect had been cut into the dorsal skull bone where the brain had been removed through an ovoid defect of the occipital skull. Furthermore, on both thighs and shanks parts of the musculature had been removed by dorsal longitudinal incisions that had again been closed by careful sutures.

All inner organs had been removed through these openings. The body cavity such as the skull were then refilled by a dense filamentous material that could be identified microscopically as typical (and otherwise untreated) cotton. Besides the cotton fibres small particles were seen that could be attributed to various herbal structures of amorphic and filamentous origin. Unfortunately, the state of preservation of those particles was too poor for further identification. Finally, the body cavities contained a white powder - interspersed between the cotton fibres and particles - that was further analysed chemically and that proved to represent sodium, potassium and calcium sulphate in crystalline structure. Added to these salts we identified tin particles.

The experimental approach

In order to simulate the obvious embalming procedure, we used a female piglet of approx. 10 kg weight that had been euthanized for an inflammation of the eye. The animal was obtained shortly after death, the embalming procedure was performed one day after death.

Fig. 2. The experimental model 10 days after the embalming.

Therefore, the body was carefully washed with running water. Subsequently, bowel and chest were opened by a longitudinal incision from the pubis to the xiphoid and all inner organs were removed. Similarly, skin and bone of the skull were opened at the occiput, the brain was fragmented and also removed. Subsequently, the empty cavities were carefully washed, all residues of blood and fluid were very carefully removed by sponges and the cavities were filled with a mixture of numerous herbs, radices, spices and vegetal substances precisely following the prescription of body embalming given by Louis Penicher in his 1699 protocol that had been adopted to the reduced weight proportions of the animal. At variance to the findings in the infant's body we used horse hair instead of untreated cotton being the main carrier substance for the ingredients and the main filling material in total. All substances had been either obtained already as powder or were processed to powder form.

After filling of the body cavities, the body openings were stuffed with embalming material, the surface was impregnated by the embalming fluid which mainly contained 70% ethanol. Subsequently, the animal was completely covered by linen bindings and stored in a well-ventilated room at room temperature.

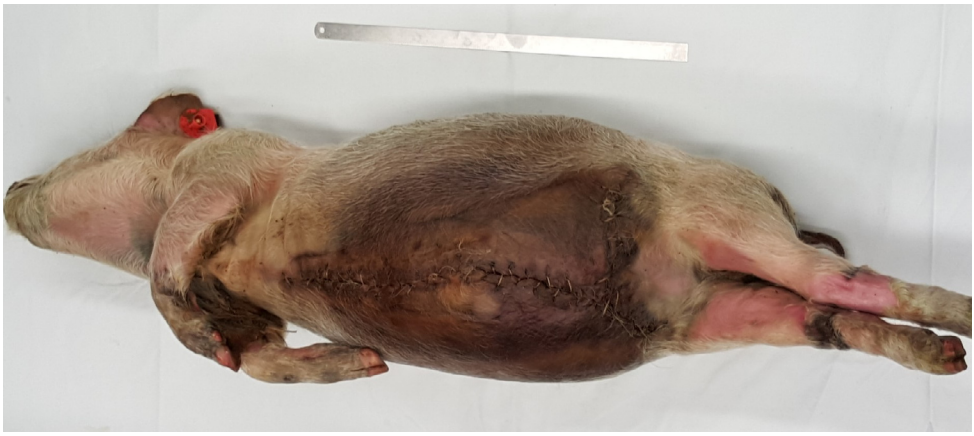

Fig. 3. The experimental model after 6 weeks following removal of the bindings.

The status of the animal was monitored every third day by observing the following three criteria: loss of fluid at the surface, consistency of the body surface and olfactorily condition of the object. Each parameter was given between 0 and 3 points so that the total scoring was between 0 and 9 points. In parallel, the body weight was recorded. Thereby, during the first six weeks a slight deterioration of

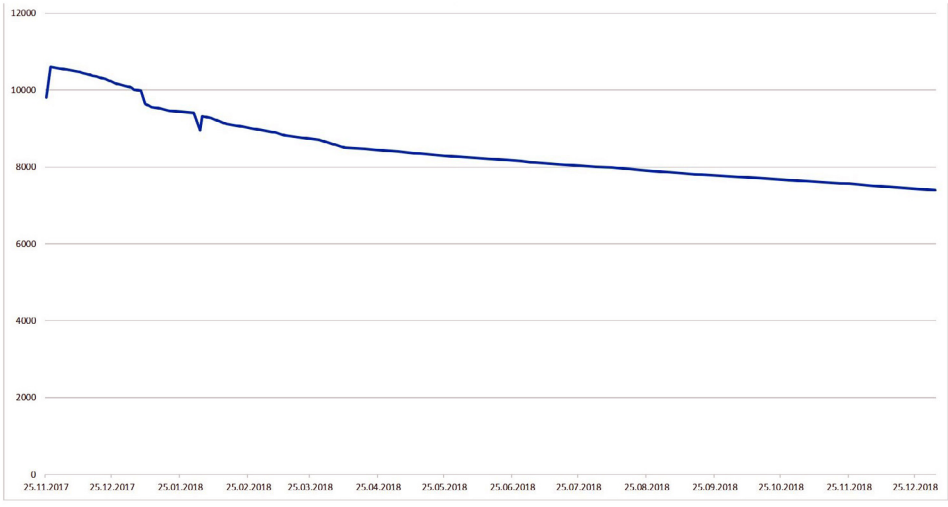

Fig. 4. Monitoring of the weigth loss during the experimental procedure.

the animal's condition was identified reaching up to a value of maximum 4 points. Following removal of the surface bindings and transfer of the animal into a cool storage room at 8° C, the condition ameliorated to 2 points and remained there for more than 12 months.

The body weight continuously dropped from 10 kg to 8.3 kg within the one year's surveillance period. In total, the object was in excellent condition during and after this period.

After 12 months we performed a whole-body CT-scan of the experimental sample such as performed with the infant mummy before. Here, an excellent preservation of the soft tissue structures and a regular structure of all osseous and non-osseous tissues was observed. The abdomen was filled by a layered amorphous material similar to the body cavities of the infant mummy.

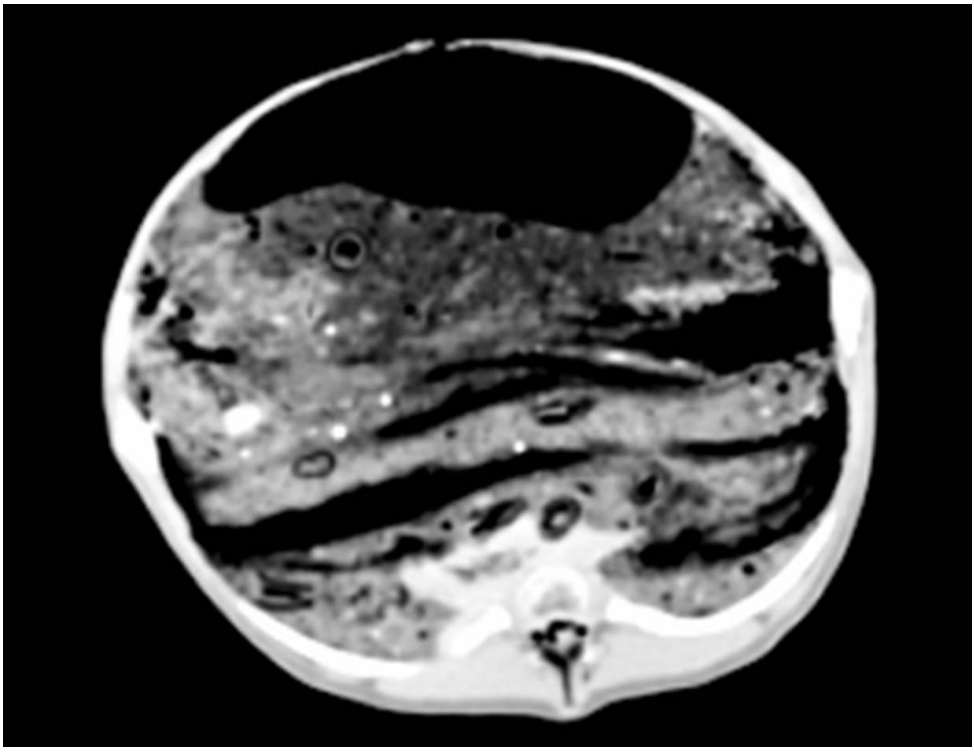

Fig. 5. A CT-scan through the body of the animal during the experiment reveals a layered filling with the embalming substance and otherwise very well-preserved soft tissue structures.

DISCUSSION

In human history, it has been a continuous aim of certain civilizations to conserve human cadavers for the eternity. This is very well known for ancient Egypt, where the conservation technique developed over time and reached excellent results especially during the New Kingdom when the technique used a whole set of embalming substances including oils, waxes, honey, spices etc. (Brenner, 2014).

While this knowledge was gone lost in Europe during Middle Ages, the basic technique of human embalming was preserved in Arabian and Persian medicine from where it "returned" to Europe. With the advent of the Renaissance period the conservation of human bodies – particularly in aristocratic families – received increasing interest. The transmission of Persian medical texts provided some basis for the application of ancient embalming protocols. Accordingly, some kind of "embalming industry" developed in major European cities (Magnus, 1839).

At that time, the embalming procedures mainly followed the ancient Egyptian techniques that included evisceration of body cavities, drying of the body using dehydrating agents/ chemicals, then filling of the empty body with spices, oils etc., surface sealing with resins, honey, and bitumen and finally bandaging of the complete body. This technique of "dry embalming" was used until the end of the 19th century when the identification of formaldehyde as an excellent conservation chemical changed the general procedure.

However, since the mid of the 17th century and the development of medical knowledge, particularly the detection of blood circulation by William Harvey in 1616 (Keynes, 1966), alternative embalming techniques emerged. The infusion of fixation substances through the blood vessels provided alternative embalming, called "wet embalming". The application of heavy metal solutions, containing either sublimate or arsenic, provided excellent results (Rysch, 1701; Magnus, 1839). However, though these techniques were more and more refined, the high toxicity prevented general application. Finally, this technique even was abolished by law in order to prevent dissimulation of poisoning.

Carolina von Jordan was clearly embalmed using the "dry embalming" technique. Accordingly, her intestines, lungs, heart and brain were removed at autopsy, the body cavity was filled with cotton, spices and chemical components that both dried the corpse and "stabilized" the dry body tissues. Particularly, the application of sodium, potassium and calcium sulphate should have significantly contributed to tissue preservation. In a further attempt to reduce the body mass, muscle of

the thighs and shanks had been removed. As a further conserving factor may have acted the fact that her embalmed body was kept for almost two decades under dry and constantly cool storage conditions.

Since the body was excellently conserved, we intended to clarify by which way the mummy had been established. Therefore, we used an experimental approach using an animal model of comparable weight and a comparable surface. Both parameters seem essential since the size / weight and the surface structure may interfere with the success of any embalming procedure. The used model of a piglet of identical weight as the infant has the advantage, that the skin surface and the tissue composition are both very similar to humans (especially the fat tissue component is almost identical between piglet and human infant; Kearns et al., 2003; Toro-Ramos et al., 2015; Bauer & Judas, 2014) while all larger/ heavier animals and those with feathers or furs interfere with the embalming outcome.

With our experimental approach we monitored the time period of this Renaissance embalming technique, i.e. whether the reported procedures allow the timely preparation of an infant mummy within a short period of time – and with such an excellent outcome in terms of conservation.

The preparations before the embalming period were laborious and costly, but well feasible and the numerous ingredients could easily be stored under adequate storage conditions so that any well-equipped ancient pharmacy would have rapidly provided the embalming material. Furthermore, the mechanical manipulations of opening, emptying, washing, cleaning and re-filling of the body such as the surface embalming could easily and timely be performed. Accordingly, it is well conceivable that the procedure could successfully be executed in ancient times.

Following the initial manipulations, we followed the presumed time course of Carolina von Jordan's body: after storage at room temperature, we removed the bandages after c. 6 weeks (which most likely covers the maximum time period for preparation and transport of the mummy from Southern Italy to Germany) and kept subsequently the body at constantly low temperature as in the cold storage room (of her parent's brewery in Wackerstein). During the follow-up period of more than 1 year the mummy constantly lost weight most presumably by dehydration of the body via sublimation. The repeated control of the mummy's condition revealed initially a slight deterioration of surface and olfactory conditions which rapidly ameliorated after removal of the bandages and storage in the cold room. Since then, the mummy showed a very constant and excellent performance including a firm surface and excellently conserved soft tissues. The body weight grad-

ually decreased. The good preservation situation was also confirmed by the CT scans that had been applied after a 1 year follow-up period.

In summary, our experiment provides circumstantial evidence that the embalming procedure that obviously had been applied to the cadaver of Carolina von Jordan 1816 in Naples produced an excellently well conserved human mummified body that was easily transported within few days/ weeks from Naples to Bavaria – a transport that required at that time at least a 2-3 week travel under difficult transportation conditions (additionally taking the summer time with high temperatures into account). The subsequent storage in her parent's brewery storage room under low room temperature might have rendered the ongoing mummification process of the infant even more successful. Nevertheless, we can here unambiguously show that the embalming technique of the early 19th century was very well developed and provided excellent body conservation.

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