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SURGICAL PROCEDURES DURING ANCIENT EGYPTIAN MUMMIFICATION

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The authors attempted to replicate Egyptian mummification with a human cadaver. In a previous paper, the authors reported their findings on the use of natron in ancient mummification. This paper discusses the surgical procedures used in evisceration during mummification.

Key words: Egypt, experimental archaeology, mortuary practices.

Los autores intentaron replicar el sistema de momificación egipcia en un cadáver humano actual y en un trabajo anterior, los autores publicaron sus resultados sobre el uso de natron en la momificación antigua. Este informe presenta los procedimientos quirúrgicos utilizados durante el proceso de momificación.

Palabras claves: Egipto, arqueología experimental, prácticas mortuorias.

The ancient Egyptians practiced mummification for more than two thousand years, but they have left us no description of the surgical procedures undertaken during embalming. The closest we have are the few papyri that describe what happened to the mummy *after* the surgical procedures.

The Rind Papyri, discovered in 1856 by Alexander Rhind, a Scottish Lawyer, describes many details of mummification (Birch 1863). The two Rind Papyri were discovered in an intact tomb of the Roman period. The first was prepared for Montu-Sehef, who lived in Mermothes and died at the age of 59 in 9 BC, during the first year of the reign of Emperor Augustus. Written in both hieratic and demotic, it provides interesting details of mummification. The papyrus specifies the exact dates on which various rituals of mummification take place. We learn that the mummy was bathed in the "Pool of Khonsu," the legs, arms, torso and back were at rest for thirty days in the "Place of Cleansing". The papyrus states that during the first thirty-six days of mummification, eight ceremonies were performed, followed by an additional nine days…until the seventh day, when the mummy was finally placed in its tomb. Considering all the ceremonies described in the papyrus, it is surprising that there is no mention of the surgical procedures, the removal of the brain and evisceration, performed at the time of mummification.

The second papyrus in the tomb, was for Taami, the wife of Montu-Sehef, who was the owner of the first papyrus. Taami's papyrus is also written in hieratic and demotic text and suggests that she had little time to mourn her husband. Taami died forty-eight days after him. In these papyri, we are provided with details of the mummification procedures, but there is again no mention of the surgical procedures that were used.

The only other papyri that tell us anything about mummification are called "The Ritual of Embalming". One version is in the Egyptian Museum in Cairo, and the other is in the Louvre in Paris (Serge 1952).

The Cairo text was discovered in 1857 in a tomb at Thebes belonging to a man named Heter who bore the titles " *Divine Father",* "*Prophet of Amun*", and "*Chief of the Priests of Sekhmet*". The papyrus described the bandaging of a mummy, including the order in which the limbs were to be wrapped, and the rituals performed. It is difficult to understand the purpose of this papyrus. It is not like the *Book of the Dead*, which has spells to assist the deceased's resurrection in the next world. Rather, it describes a procedure that should have already taken place by the time the mummy had been placed in the tomb. It certainly was not intended as an embalmer's reference, since it was written to be sold to the family and placed in the coffin. It is, in fact, an ancient form letter. The papyrus, written in a fine professional hieratic hand dating from the Roman period, left blank spaces where the deceased's name would occur, and were later filled in by the deceased's family in crude hand. Perhaps the papyrus was intended to insure that proper rituals accompanied the mummy, in case the actual rituals and bandaging were not performed correctly.

The Louvre Papyrus also gives details of mummification. It stipulates that the embalming was to begin four days after death. This allowed time to let the deceased remain at home for a period of mourning and to allow his family and friends to organize the procession to ferry the body across to the west bank of the Nile for burial. The bandaging took place forty-six days after death, so there was forty-two days for various pre-bandaging rituals to occur. The papyrus describes how frankincense oil was used too in the mummification. It describes the anointing of the body with fats and instructs on how "thick oil" (resin) was to be used to adhere the bandages to the mummy. In spite of these details, we still haven't heard the surgical procedures that were used in the mummification mentioned. Why?

There are two reasons that come to mind. First, there was a prohibition against defiling a human body. Making an incision in the abdomen was, paradoxically, both necessary and yet ritually prohibited. Thus, Diodorus Siculus in his famous description of mummification says:

> ...the one called the slitter cuts the flesh, as the law commands, with an Ethiopoan stone and at once takes to flight on the run, while those present set out after him, pelting him with stones, heaping curses on him and trying, as it were, to turn profanation on his head; for in their eyes everyone is an object of general hatred who applies violence to the body of the same tribe or wounds him or, in general does any harm (Siculus n.d.).

Obviously, the stoning of the slitter was not intended to cause injury. It was a ritual that had to be directed against those who damaged a human body, even when it was necessary for mummification. Perhaps the opening of a human body and the removal of the internal organs was too profane to be written.

There is a second, and more mundane reason why the surgical procedures in mummification were not written. They were a trade secret. The Hawara Papyri (Reymond 1973) frequently called the "Embalmer's Archive" reveals that the art of mummification was practiced only by families whose trade was caring for the dead. The "Archive" provides specific titles for the members of the profession and makes a distinction between those who perform actual mummification and those who merely carried out funerary rituals. The "Archive" even includes the oath taken by the embalmers of different families to specify the territory each one controlled. Like the "Ritual of Embalming" papyri discussed earlier, the "Archive" makes no mention of surgical procedures. The process may well have been a secret handed down from father to son.

There may not be a simple explanation as to why there is no written record of how to mummify a human. But there is a papyrus dealing with how to prepare an Apis bull. The only papyrus that describes surgical procedures is the "Apis Papyrus" . In this papyrus there is a detailed description of how the Apis bull was embalmed, including the removal of the internal organs. Human mummification was a continuous industry; the skills would be passed on to apprentices. The mummification of the Apis bull, on the other hand, was not an on-going industry. There was only one Apis bull alive at any one time. Since a bull can live more than thirty years, it was possible that the last person who mummified an Apis bull had died by the time it was necessary to repeat the process on the next Apis. Thus the procedure had to be preserved in writing.

The first description of the surgical aspects of human mummification comes from the Greek, Herodotus (Herodotus n.d.: 86-89). It is doubtful that he would have been permitted to witness a mummification, and also he is extremely brief in his description of the surgical procedures.

> ...They first draw out part of the brain through the nostrils with an iron hook, and inject certain drugs into the rest. Then, making a cut near the flank with a sharp knife of Ethiopian stone, they take out all the intestines, and clean the belly, rinsing it with palm wine and bruising spice; and presently, filling the belly with pure ground myrrh and casia and other spices, save only frankincense.

Herodotus has described the two essential surgical procedures, the removal of the brain and evisceration. Let us examine each in detail.

Herodotus says the *iron* hook was used, which may be the case. It is well established that iron was in use in Egypt at the time of Herodotus' visit (Lucas 1989: 237-240; Wainwright 1932: 3-15), so he certainly could be right on this. The hook, he says, is used to "draw out" parts of the brain. This is an important detail as we will show later. It may suggest that gravity assists the process. He also mentions that not all of the brain was removed this way; drugs were somehow injected.

With regard to evisceration, he is equally brief. All we are told is that via an incision in the flank, "all the intestines" are removed. Autopsies on mummies have shown this to be basically true. So again, Herodotus seems accurate, as far as he goes. More details, however, are supplied by Diodorus Siculus, who visited Egypt four centuries after Herodotus.

Diodorus says that the slitter made the incision on the left and then:

> When they have gathered to treat the body after it has been slit open, one of them thrusts his hand through the opening in the corpse into the trunk and extracts everything but the kidneys and heart...(Siculus n.d.: 91)

We know from examination of mummies that Diodorus is correct about the incision being on the left side. The advantage is that there is better access to the descending colon from the left side. When Diodorus mentions that the heart and kidneys were left *in situ*, he is again correct, though sometimes the kidneys were removed. After Diodorus, the records about the surgical procedures in mummification are silent for two thousand years.

During this century, the discussion is picked up again but topics focused on how the brain was removed. In 1911, Karl Sudhoff published a pioneering study on "Egyptian Embalming Instruments". As the title suggests, the paper is concerned primarily with tools used by embalmers, but in an almost casual manner, Sudhoff mentions that he removed the brains of human cadavers in an ancient Egyptian manner.

> Ging man nun den Schadel. Ein, zerris das Tentorium und alle sich entggegenstellenden festen Membranteile im Schadelinnern unter Einhaken der Hakenspitzen oder unter Stossen mit der gevolbten Stumpfseite des Hakens, ruhrte das leicht mazerierte Gehirn um und legte die Lieche dannauf den Bauch, so lief unter leichtem Nachelfen mit Haken oder seinem Stielende in 15-20 Minuten das Gehirn so gut wie vollig aus, wie wir defindige Anatomiediener Hagedorn und ich) uns nachtraglich bei der Eroffnung der Schadelholen in einer Reihe von Fallen unberzeugen konnten (Siculus n.d.: 165-6).

There is only one article written specifically on the removal of the brain (Leek 1969), and it has some unusual features. Leek attempted to determine how the ancient embalmers removed the brain by using a stainless steel probe, surgical hammer and chisel in his attempt to remove the brains from two sheep. The anatomy of the sheep (Ovis Domestica) is, of course, quite different from that of a human. Also, the steel tools Leek used differ from those used by the ancient embalmers. But there is still something to be learned from his attempts. Leek describes placing his long probe through the nasal passage and penetrating into the cranial vault. When the tool was withdrawn it "held a covering of brain tissue which was glutinous and viscid in character". Although this covering was thin, it would have been only a question of time before most of the brain was removed by repeated insertions and withdrawals of the instruments.

From Leek's account, it is clear that he never, in fact, removed the brain. After a few trial probes, he concluded that the brain could have been removed because "its viscid consistency caused it to adhere to the instrument (Leek 1969: 113)". He began the process but never completed it. As we will discuss below, we do not believe the process he used is adequate for the brain's removal.

Leek, however mentions a second variation in which he suggests the head is turned face downwards so that the brain could drain out. Again, he never did it. "Had the process been continued and the head turned face downwards, much or all of the tissue would eventually have drained away" (Leek 1969: 113).

We do not mean to suggest that Leek's observations are without value, we merely wish to point out that he did not remove the brain by the technique he describes. In appendix II to Leek's article, Mark Lister Patterson describes how he actually removed the brain of a human in an attempt to replicate ancient Egyptian methods.

The description is frustratingly brief, only two very short paragraphs, and this is meant to describe three very different methods used. Patterson does not say if the three methods were used on one cadaver, or if several cadavers were used. He does mention that in one method, the rod was rotated to breakdown the brain tissue and the skull is positioned so that it would drain out. In another method, the brain was aspirated through a wide bore catheter with a piston-type syringe, but it is unlikely that the ancient embalmers had such apparatuses. In the third method, the brain was evacuated by irrigating the interior of the skull with water, essentially flushing the tissue out.

With the work of Sudhoff, Leek and Patterson as background, we began our attempt at a complete mummification in the ancient Egyptian manner. Prior to beginning work on a mummy candidate, we performed trials in order to plan and observe our intended approach bilaterally through the sinus, penetrating the ethmoid plate that would allow us access into the cranial vault and ultimately remove the brain.

In the first trial, we had a human head specimen with calvaria exposed and the brain removed as in a routine autopsy. From that vantage point we could observe the insertion of the straight bronze rod as it entered along the vomer, tapping it through the ethmoid on both sides of the nasal cavity until it penetrated the skull base. This

permitted us to judge the correct angle and see the location of the rod in relationship to the brain.

In our next attempt, we repeated the procedure on a second human head specimen in which the brain and calvaria were left in tact. As before the bronze rod was inserted into the left nasal cavity reaching the inferior ethmoid bone. With a hand held wooden block, the rod was then tapped until it fractured the thin bone plate and entered the cranial vault. We repeated this procedure on the right side, also entering the skull base. At this point several X-rays were taken to verify the angle and location at which the rod entered to reach the brain. Using a long bronze wire tool with a hooked end, we attempted to extract the brain, by hooking the tissue in a manner similar to Leek's first procedure. This was found ineffective. Small pieces of the meninges were removed as the dura mater tore, but very little else adhered to the hook when it was removed. We repeatedly inserted the hook, but soon we became convinced that the brain could not be removed in this manner.

Our final trial was on another intact specimen. Following the same procedure as before, we reached the brain from the nasal sinus area, but this time we attempted to flush the brain out by infusing the cranium with water using the positive pressure of a hydraspirator. This, too, was unsuccessful. The water and pressure exerted by the force distended the soft tissues around the orbital area of the face. No brain tissue came out. We were now convinced that irrigation with water was not the key to the removal of the brain, but rather that maceration as described by Sudhoff was the crucial element.

On May 24, 1994 we attempted both the removal of the brain and the evisceration of the body cavities in the manner we feel is the most like that performed by the ancient Egyptian embalmers. The first step was the brain evacuation.

Brain Evacuation

The decedent body was placed lying on its back and with the cervical spine extended. Using the nasal septum and vomer bone as anatomical guides, the bronze rod instrument was inserted with the sharpened chisel end forward into the right nasal passage until the ethmoid bone was reached. We used a hand-held wooden block to tap the instrument through the bone structure. The resulting hole permitted the instrument to enter the cranial vault and penetrate the skull base, entering the cranial vault land marked at the olfactory tract. The instrument was extended to its greatest depth when it went through the brain and reached the posterior sutures that communicate the parietal bones. The same procedure was repeated on the left side, so that now there were two relatively small holes reaching into the right and left brain hemispheres. Using the hooked end of our instrument, the bony spine between them was fractured and removed to enlarge the hole at the skull base. This would permit easier evacuation of the tissues and fluids en mass, brain, dura mater, etc.

As in Sudhoff's description, the removal of the brain required the destruction of the membranes and the liquefaction of the soft tissues to permit easy drainage out through the passage created from the skull base and out the nasal cavity. To macerate the brain, we used a bronze wire, very much like a coat hanger with one end coiled so it would be just smaller than the opening made in the cranial floor of the skull.

The wire was inserted into the right nasal passage and into the cranial vault. With the coiled end extended into the right hemisphere of the brain, the wire was rotated for approximately twenty minutes to reduce the brain tissue to a semi-liquid state. Periodic removal of the wire brought out residue of dura and aerated brain tissue. Attempts to remove larger pieces of dura mater or tissue was done without success due to tearing and maceration. The thick and tough dura mater was reduced to thin strands. We then repeated the same procedures to the left hemisphere of the brain.

The brain cavity was irrigated, filled to capacity with water using a hollow reed connected to a leather bladder type flask. This method used only the force of gravity pressure and thus the force did not distend the soft outlying tissues of the face. The body was repositioned so that it was lying on its abdomen. The head was placed on a downward slope to enhance drainage from the frontal lobe of the brain cavity, through the openings created and out the nasal passages. Inserting the wire with its coiled end permitted the initial and easy removal of a significant amount of brain dura mater tissue to escape. The body was left in that position for approximately an hour and a half to allow for the thorough drainage. The pan used to collect the drainage was substantially filled, and further probing with the head in position did not produce additional discharge of fluid or tissue. We, therefore, concluded that most of the loose brain tissue and debris had been evacuated.

Although no more of the soft tissue was running out, we wanted to be sure that we had completely evacuated the cranium, a problem that the ancient Egyptian embalmers also faced. We repositioned the body on its back and using the wire tool, forced several strips of linen, that were one inch wide and two feet in length, through the nasal passages and into the cranium. With the wire tool and linen, we then swabbed the area and removed them. At first the linen came out covered with soft tissue residue and bloody fluid, but after several repetitions they came out clean. We were then confident that most if not all the brain tissue had been removed. This was a procedure that certainly the ancient embalmers could have followed, and we now believe that it probably was.

Evisceration

As we have mentioned, there is no ancient text that details the removal of the internal organs at the time of mummification and there are many unanswered questions about this procedure. For example, we do not know the order in which the organs were removed, nor why sometimes the kidneys were left in place but in some mummies were removed. It is often assumed that because the ancient Egyptians practiced mummification, they were knowledgeable in anatomy, but this is not necessarily true. We must remember that embalmers worked through a small abdominal incision, unable to see the organs as they dissected them. This is literally like performing surgery in the dark. There is no definite word in Middle Egyptian for "kidney" (Walkers 1996: 278; Weeks 1970: 72). It is possible that some embalmers were unaware that there were kidneys. Also, to anyone with even a rudimentary knowledge of anatomy, it seems strange that there were only four canopic jars; there are more internal organs. It has been pointed out (Gordon 1990: 26-29) that the hieroglyphic determinative of both internal and external organs are of animals, not humans. This suggests that ancient Egyptian physicians were more familiar with animal anatomy than human anatomy. As far as we know, the ancient Egyptians did not practice dissection until the Ptolemaic times and this certainly supports the theory that the ancient Egyptians were not so skilled in anatomy as their patients would have liked. To answer some of the questions left for us by the ancient embalmers, we attempted to replicate the procedures used.

An incision, approximately 2 ½ inches long, was made using an Obsidian stone flake blade that was two inches to the left of the umbilicus following a sagittal and hypochondriac plane. The incision was deepened into the anterior abdominal wall at the superior level of the tendinous intersection of the rectus abdominis muscle, though the anterior layer of the rectus sheath and the transverse abdominis and below the deep fascia, exposing the peritoneum cavity.

The right hand of the prosector was placed inside and moved throughout the cavity to rule out connective tissue adhesions and to insure the integrity of the visceral lining and freedom within the abdominal cavity. With the right hand still inside the cavity, the diaphragm and inferior portion of the esophagus was located. The hand followed the path along the gastric fundud, tracing the body of the stomach to the pylorus. The superior aspect of the duodenum was ligated and an incision was made above the

ligature using a small curved bronze knife, freeing the upper portion of the intestinal tract. The stomach remained in place for separate removal.

To remove the intestinal tract with minimal waste discharge, several ligatures were applied both superior and inferior to the tenicoli, transverse colon, and small bowel prior to removal. The upper most portions of the intestinal tract, including the omentum and pancreas were removed from the body and placed on a tray for rinsing and treatment with natron. With the upper portion of the intestinal tract removed, the next organ to be removed was the spleen. The gastric and epiploic vessels near the gastro-splenic and spenorenal ligament were incised and the spleen removed.

The kidneys were removed next. The kidneys in normal anatomical position are somewhat isolated, anterior to the diaphragm, transversus abdominis aponeurosis, quadratus lamborum and psoas muscles. Using the curved small bronze knife, an incision was made through the lateral border of the fibromuscular capsule exposing the left kidney, its major vessels and ureter from the hilus. The blood vessels and ureter were excised and the kidney removed from the capsule. The same procedure was followed for the right kidney. With the kidneys removed, the next step was the removal of the digestive tract at mid level that remained in the greater sac of the peritoneum at the level of the pelvic floor.

The ligatures made to the teni coli, traverse colon and small bowels prior to the removal of the upper portion of the intestinal tract were located and retracted. The remaining ligaments (folds) that attach between organs and the peritoneum body wall were severed. At the level of the pelvic floor, incisions were made to free and release remaining visceral contents of the greater sac at the superior aspect of the rectum. These organs were removed, rinsed and placed in natron.

The contents of the perinal region and rectum remained for separate removal. A deep incision was made anteriorly encircling the peritoneum and the pelvic floor and extending posterior and deep to the anal canal. The visceral pelvic fascia was only slightly membranous, with moderate fat and areolar. The bladder was reflected to incise attachments and structures within the perineal region (i.e., the puboprostatic ligament, membranous urethra), and the rectum was excised from the ani internus.

At this point we were ready to remove the stomach. It had been located earlier when the superior aspect of the duodenum had been ligated to remove the upper portion of the peritoneal sac. Now the ligature made previously, superior to the duodenum and inferior to the pyloric sphincter, was retracted and the stomach incised free at the esophagastric junction, left of the midline and below the diaphragm. Once removed, the stomach was rinsed and placed in natron.

The last organ in the abdominal cavity to be removed was the liver. It is by far the largest organ and occupies an extensive area in the right side of the abdominal cavity. We were not sure if it could be removed in one piece through the initial 2 ½ inch abdominal incision we had made earlier. To remove the liver, the triangular ligaments were cut that connect the liver to the diaphragm. Once the ligaments were free, the hepatic vessels were incised. At first we attempted to push the liver out from the cavity with one hand, but it could not fit through the small incision. Then we attempted to manipulate the liver with both hands on the outside of the abdominal cavity, but it still would not go through the opening. Finally, the incision was lengthened by one-half inch and with much manipulation, the liver finally was removed intact. The liver was delivered through the incision a lobe at a time. One lobe following the next out, much like delivering a newborn baby at term.

Thoracic Cavity

The diaphragm, the most important muscle of respiration, separates the abdominal cavity from the thorax. It is divided into three parts: sternal, lumbar, and costal (rib). We wished to remove the lungs while leaving the heart and its great vessels intact, so incisions were made approximately two inches along the right and left lateral costal borders, leaving the sternal and lumbar attachments in place.

With one hand inserted through the diaphragm along the costal side, the existing attachments to the left of the lung and the pulmonary and bronchial inlets were identified. Using the right index and middle finger as guides with the knife between them, the pulmonary vessels and bronchial branches were cut and freed. The lung was now manipulated against the pleura and rib cage to remove air within the alveolar spaces, decreasing the lung mass, and it was removed from the body. The same procedure was used for the removal of the right lung from the right lateral costal border of the diaphragm. The heart was left fully intact within the pericardial sac with its great vessels in place, just as ancient Egyptian mummification required.

Observations

With regard to brain removal, we are quite certain that it was not removed with the body supine on the embalmer's table as had been suggested. Our experience indicates that an organ as fluid as the brain could not have been lifted out piece-meal with a hooked instrument. Almost certainly the brain was broken down into a semi-liquid state and then, assisted by gravity, it was evacuated through the nasal passage when the cadaver was positioned with the head downward. X-rays of several mummies attest to the fact that bodies in the embalmers' shops were subjected to such positioning. Often two hardened resin levels in one cranium show that the resin was introduced, allowed to harden, and then the body was repositioned and the resin introduced again, producing a second fluid level.

Our experimental removal of the internal organs establishes at least a reasonable order in which the organs could have been removed. An observation relevant to the ancient embalmers' knowledge of anatomy is worth noting. Some organs, such as the kidneys hidden behind the peritoneum, could indeed have been unnoticed or easily overlooked by the embalmers.

To hold the internal organs, we had created replicas of fairly large canopic jars with wide openings. When it came time to put the liver in its jar, it would not fit, so we sectioned it. We suspect this is precisely what the ancient embalmers did. On display in the Metropolitan Museum of Art in New York is half of a liver, perhaps the result of the same problem that we ran into. One wonders what was done in the many cases when the volume of the organs exceeded the capacity of the canopic containers. For example, if one looks at the four canpoic coffinettes in which the organs of Tutankhamen were placed, it was evident that they could not possibly hold all the organs. The content of these containers has never been properly studied and indeed, a careful study of the contents of the canopic jars in general might provide interesting insights into the world of the ancient Egyptian embalmer.

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