

Original article

STUDY MUMMIFICATION TECHNIQUE ON A SELECTED GROUP OF THIRD
INTERMEDIATE PERIOD MUMMIES IN EGYPTIAN MUSEUM USING CT
SCANNING AS NON DESTRUCTIVE TOOL

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Received 13/1/2015

Accepted 17/5/2015

Abstract

Using advanced modern technology is considered one of the most important methods of scientific examination and registration. This should be used in the field of the conservation of mummies. Identifying the cause of the mummy and putting the mummy outwardly or inwardly are the first stage of good prognosis of damage, which naturally lead to the development of an appropriate plan for the operations of treatment and conservation starting from the stage of cleaning until museum presentation, through a consistent process with the requirements of preventive conservation. Computed Tomography Scanning (CT Scanning) is a non-invasive technique that does not harm the mummies. It has become an important tool for studying many features of ancient Egyptian mummies. The Study of Ancient Egypt, and particularly the examination of mummies, are subjects of interest of scientist and the public. It is fortunate that modern diagnostic methods of the study of ancient human beings can be applied today. The last forty years have seen a large number of CT scanning studies of Egyptian mummies from different museums and collections in Egypt, Europe and the USA. There is no doubt that this technique has proved to be a powerful tool in the field of Egyptian human remains research. CT studies confirm that the ancient Egyptian used several methods for the degree of quality of mummification This started with the selection of the most Suitable material to act as a filler for the internal to the body. CT studies confirm that the ancient Egyptian has used methods to support the body and maintain the external shape of the mummy. Research also stresses on the need for a new reading of the science of mummification according to the latest scientific methods of examination without any destructive activities toward the components of the various mummies. The main aim of this research is to study thoroughly the Third Intermediate Period mummies to show the level of sophistication of the technique of the mummification reached in this period.

Keywords: *Mummy, Mummification, CT Scanning, Skull, Thorax, Abdomen*

1. Introduction

The ancient Egyptians have left no account for their mummification techniques. Only classical writers, particularly Herodotus and Diodorus, who wrote from an outsider's point of view and at a fairly late date, providing the earliest description of the process. Three methods of mummification were described, virtually all subsequent knowledge has been gained by examination of the mummies themselves [1]. The only

way for the early researchers and scholars to understand the mummification procedures was opening coffins in non-scientific ways and removing the wrapping of the mummies in ways that were inaccurate. This process has damaged the mummies' cartonnage, coffins and wrappings along with attempt to dissect the mummies. Despite all of these destructive methods the early scholars were not lucky in the detection

of mummification. What they had proved is full of fallacies and needs to be re-examined. With the scientific development in the field of CT Scanning, the examining of mummies without damaging the coffins, wrappings, Cartonnage or the body itself has become possible. CT scanning examination gives a clear and complete idea about the methods of the ancient Egyptians mummification of the dead. Then, this research focuses on the Third Intermediate Period mummy scan. The CT images are used to study the position of the body and the extremities of each mummy. It also analyses the size, orientation and location of the evisceration incision that can be seen clearly by the CT images. The scans can also show where incision was stitched, left open, blocked with resin or covered with a metal plaque [2]. In cases where there is no evidence for an evisceration incision, further examination is carried out to

1.1. Historical background

The Third Intermediate Period (1076-723 BC) has been considered as a unique chapter of the ancient Egyptian history although the term “Intermediate” is used to describe the political decline that took place during this period. It does not reflect the cultural development that continued under individual district administration [3]. Most of the tombs from this period were originally built during earlier periods for other occupants and were reused during the Third Intermediate Period. The tombs are not marked by super structures except for in some cases tomb chapels, which were reused along with the usurped tombs [4]. Few early examples indicate that each tomb was used by one individual or a group who were probably

1.2. Bab el gusus tomb

More than 150 priests of Amun and temple officials were buried in Bab el-Gusus tomb, fig. (1) (the Door of the Priests) at Deir el Bahari, also known as the “second cache” which was disco-

identify any other methods of evisceration that could have been used. The CT scans are used to determine which internal organs are removed and where they are repositioned inside the body. They also try to establish if any treatment of the genitals or if any evidence for post mortem restoration of the body has been carried out by the embalmers. The route used by the embalmers to extract the brain can be shown on CT images as a damage to the ethmoid passage. This can indicate brain removal through the nose. If the brain is removed but the nasal route is intact, this indicates that the embalmers have extracted the brain through the foramen magnum. CT images can provide evidence for this procedure. Evidence for other mummification procedures, such as incisions for subcutaneous packaging or the inclusion of false eyes, is sought in CT images [2].

family members but later burials from this period included a large number of coffins all crammed in one tomb such as the royal cache (DB 320), Bab el Gusus (Research mummies have been detected in bab el Gasus) and KV35. These tombs are characterized by lack of wall paintings and by rich and heavily decorated paintings on the inside and outside surfaces of the coffins and mummy cases [5]. At Thebes, private interments were allowed within the enclosures of temples such as the Ramesseum and Madinet Habu during the 22nd Dynasty which mirrored the funerary practice in Tanis. The Valley of the Kings in Luxor was intensively used for private burials during this dynasty and other later periods [1].

vered in January 1891 [6]. Large numbers of coffins in addition to funerary items were packed in two chambers and two passageways [7].

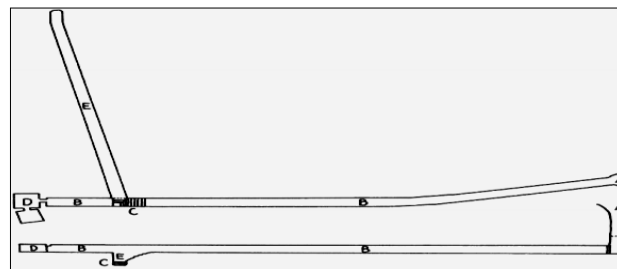


Figure (1) Plan and elevation of Bab el gusus tomb at Deir el Bahari, (after Niwinski 1984:75) [8]

2. Materials and Methods

In 2009 mummies were examined by Computer Tomography analysis at the Egyptian Museum in Cairo. In order to evaluate the mummies, the team using Siemens Emotion 6 (Florsheim, Germany), performed whole-body, 6-slice CT. According to Hughes [9], the operating

conditions are listed in tab. (1-a). In the current research; 5 mummies were studied using CT scans to determine their different features and mummification characteristics, these mummies were listed in table (1-b)

Table (1-a) System operating conditions

PHYSICIAN	Scan	KV	Mas\ref	CTDIvol	DLP	TI	eSL
Pation Position H-sp	-	130	-	-	-	-	-
Topogram	1	130	-	-	-	5.9	0.5
Head	2	130	130	17.63	415	12.3	0.5
Control scan	3	130	45	9.85	1	0.8	0.5
Dental	4	130	45	12.36	148	0.8	1.0
Operation Body scan	5	130	31\124	4.68	506	1.5	1.0
Body scan	6	130	26\124	3.52mAS	100	1.5	1.0

Table (1-b) The studied mummies

No.	Mummy name & Description	Location		Discovery Date
		Discovering	Current	
1	Tjanefer Mummy, (Priest of Amun, H-3 rd Intermediate, Dynasty 21, map symbol (A))	Deir el-Bahri Bab el-Gasus Cache West Thebes	Cairo Museum	1891
2	Tayuheret Mummy, (Wife Priest of Amun, H-3 rd Intermediate, Dynasty 21).		TR 28.4.26.13	1860
3	Mummy of Paduimen, (Priest of Amun, H-3 rd Intermediate, Dynasty 21), map symbol (A).		Cairo Museum	1891
4	Mummy of Nesimut, (Priest of Amun, H-3 rd Intermediate, Dynasty 21), map symbol (B).		CG61091	1891
5	Mummy of Nesitanebetawy, (Priest of Amun, H-3 rd Intermediate Dynasty 21), map symbol (B).		TR 28.4.26.2	1891
			Cairo Museum	1891
			TR 28.4.26.13	

3. Results

Much knowledge about the mummification history and techniques used during the third intermediate period is obtained, through investigating more mummies that belongs to this important period. The mummification techniques used to preserve each mummy are recorded and the results are compared to reach conclusions regarding the possible reasons for any observed differences to determine the possibility of using the CT images as an aid in the restoration and conservation processes. These results provide us by valuable information about the condition and preservation state of internal structures, cracks and defects that are not visible with the naked eye or inaccessible through other investigation methods. The results of CT examinations could be mentioned in the following

points: **1-** Ancient Egyptians embalmers succeeded in reaching the body to the stage of full drying went to the completeness and mastering the process of mummification was in the New Kingdom (Dyn 18 - Dyn 20), citing that the mummies dating back to that period without paying attention to several other criteria represent important at least drying. **2-** The embalmers introduced fundamental changes and revolutionary concepts to the mummification process. They had mastered the traditional techniques seeking perfection by aiming to retain the life-like form of the body and to preserve its features so that the mummy would be a true and complete representation of the deceased, fig. (2). It is also important to note that the embalmers of this dynasty gained valuable experience and knowledge

when they rewrapped and restored the mummies of the kings and queens of the New Kingdom. These mummies were disturbed by the tomb robbers who wanted to steal the amulets and gold jewelry hidden between the linen wrappings. **3-** CT images provided evidence that the brains of all examined mummies have been removed through the left nostril, where, this brain was not found in its entirety leaving remnants of the dura mater in the inferior of the posterior cranial fossa, fig. (3). **4-** Packing the body was not the only change the embalmers undertook during this period. As an essential step of the mummification process, the internal organs (stomach, lungs, intestines and liver) were usually removed from the body and treated with natron; the embalmers of the 21st dynasty returned the internal organs back to the abdominal cavity after treating and wrapping them

separately with linen bandages, fig. (4). **5-** Full insulating method of the mummy, Embalmers, after drying and filling, confirm the isolation by using strips of linen dipped in fusible resin and adding other filling materials such as soft sand enveloping them around the body. Then the expulsion of bubbles was attempted between the skin and the body wraps to limit the growth of microorganisms at the bottom layer of linen dipped in resin. Afterwards, the mummy was left to dry. In this process, the embalmers used a large number of wraps around the body to isolate it from the surrounding environment, fig. (5). **6-** Finally, it could be noted that the position of the arms appears to be the same in all the mummies of this collection. This position has been confirmed by the CT images of all mummies. Evidence for subcutaneous packing in the legs was observed in mummies, fig. (6).

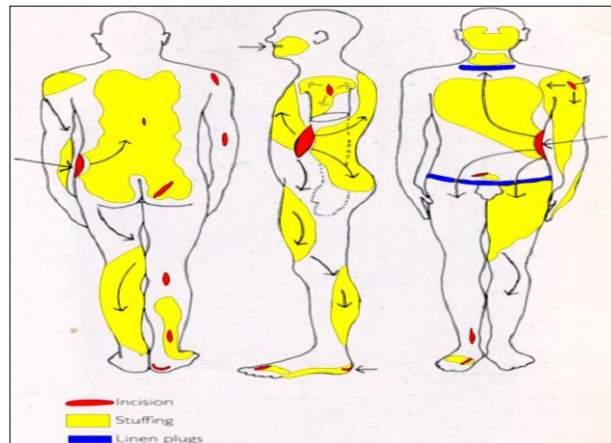


Figure (2) Diagram illustrating the locations of the subcutaneous packing, the incisions, the linen plug and the stuffing that was performed by the embalmers during the 21st dynasty (after Ikram & Dodson, 1995)

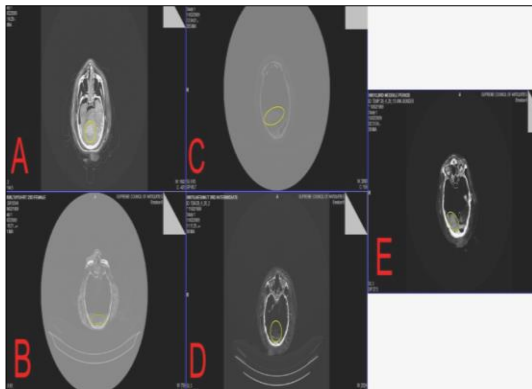


Figure (3) CT axial image showing the damaged ethmoids and filling material (probably a combination of soil and resin) inside the cranial cavity.

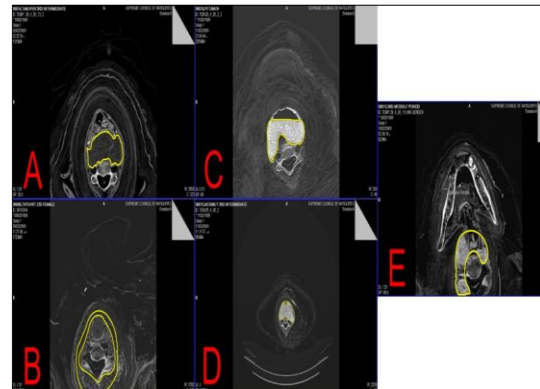


Figure (4) CT axial image showing the neck packages were made of heterogeneous material which are low density materials.

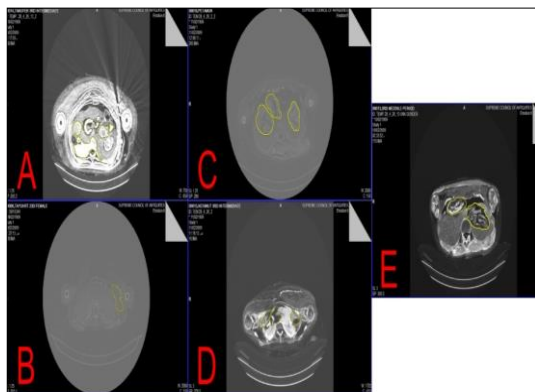


Figure (5) Yellow circles shows the internal organs of the body after stuffed and bring it back to thorax and abdomen

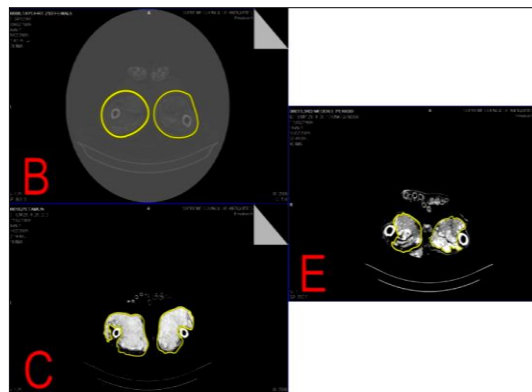


Figure (6) Extremities, yellow circles represent types of packing material used by embalmers in mummy body.

4. Discussion

4.1. Cosmetic modifications

As shown in fig. (2), the embalmers were disappointed by the shriveled and deformed features of some of these mummies that highlighted the need for applying new “cosmetic” mummification techniques [10]. They noticed that the facial appearance of the deceased changed after mummification, as the mummies appeared shriveled and thin, so packing materials (sand, linen, sawdust mixed with a fatty material) such as butter or grease and in some cases mud were placed in specific areas of the face so that the body would have a life-like appearance. In addition, he embalmer extended his arm within the internal incision in thoracic and abdominal spaces to reach the to small intestine; it started with filling the body from inside by linen dipped in resin, clay and other packing materials. Then the other hand (or any other thing) was extended inside the thighs to drive fillers in both thighs and

4.2. The skull and the head

Through explaining fig. (3), it could be noted that the brain was not found in its entirety leaving remnants of the dura mater in the inferior of the posterior cranial fossa. The anterior of the ethmoid air cells bilaterally, the left side of the cribriform plate, and the nasal septum were damaged. The posterior ethmoid air cells, superiorly, and the nasal conchae were intact. This indicates a very low angle of insertion of the excelebration tool,

legs to the ankles and sometimes- other cracks were done in the skin of feet, ankle and knee to fill these parts with materials used in the pattern included below. Within the same context, it could be said that after filling the neck and the lower limbs with these materials, the visceral coils were put again in their original place inside the body, and then the skin was separated from the abdominal muscles near the internal incision on both sides. After that, the hand is extended between the skin and the flesh to fill the pectoral part as well as the chest with the same materials. However, when they found it was difficult to reach a specific part inside the body, they cut these parts to fill it with the required filling materials. Finally, the shoulders and the arms were filled by a special incision in the shoulder but thighs were filled from the mouth.

nearly parallel to the face, rather than a more deeply angled transnasal craniotomy that passed through various portions of the sphenoid. A small, coiled opacity was found in the linen and brain on the right side, perhaps it is a piece of a broken exacerbation tool. Two bone fragments, likely portions of the ethmoid air cells and cribriform plate, were also found in the brain and linen in the dependent portion of the cranium. No nasal

tampon was found and the skull base and spine were unremarkable. However, the spinal cord was found in the cervical vertebrae. The eyes and tongue were intact without apparent packing, and there was no apparent packing of the naso/oro/hypopharynx. Also, fig. (4) it could be mentioned that the evidence of mummification packages in the neck was observed from five

4.3. Thorax and abdomen

Evaluating fig. (5) attests that the mummies studied were eviscerated by an incision on the left side of the abdomen. The incision formed a narrow oval of approximately 20 cm circumference, the heart was present in the pericardial sac and remained connected to the aorta. The heart and vessels appear empty of blood, the ventricles and atria remain patent and the lungs were removed with the primary bronchi severed several centimeters. The diaphragm was incised mid-hemithorax on the right side and largely excised on the left side. The liver, stomach, intestines,

4.4. Extremities

Regarding extremities; figure (6) approved that the position of the arms appears to be the same in all the mummies of this collection. The arms are in the prone position and the elbows are extended with the hands over the thighs according to the custom of the third intermediate period. This position has been confirmed by the CT images of all mummies. Evidence for subcutaneous packing in the legs was observed in two mummies; CT image shows the twisted left leg and the disarticulated bones inside the cartonnage case. There

mummies. The neck packages were made of heterogeneous materials which are low density materials. Evidence for damage of the cervical spine was reported from one of mummies, (mummy-B). Bead shaped objects (sand particles) were reported from the wrappings around the neck in (mummy-B), where a rod was placed to support the head

kidneys, were not intact in the body cavity. The embalmers removed the abdominal organs, from the body, then treated them with natron. The organs were then returned to the abdominal cavity after treating and wrapping them separately with linen bandages. A number of supporting rods and poles were detected during this examination of two mummies; In A and B there are one large pole and a cane that were used by the embalmers to support the neck and the body which were left in place.

is also a dense package, probably linen saturated with resin, next to the left leg. Some loose material was placed between the legs and feet of a few mummies. Finally, it could be claimed that using a modern CT scanner gives a physical condition of how the mummy looks like and it shows how the body mummy preserved. Also, the analysis with cutting edge CT scanners has given valuable insights into the embalming and burial processes without opening the cases and disturbing the body.

5. Conclusion

The scientific study of mummies has been developed immensely from the use of radiographic technology since it was developed in 1895. The radiographic examination of mummies, which is a non-invasive and essential procedure in any multidisciplinary study of mummified remains, has provided vital and valuable archaeological and medical information. CT images could provide Evidence for mummification procedures, such as incisions of subcutaneous packaging or the inclusion of false eyes. CT images are useful to get much knowledge about the mummification techniques used during the Third Intermediate Period through investigating more mummies that belong to this important period in the history of mummification, to record the mummification techniques used to preserve each mummy and to compare the results to reach conclusions regarding the possible reasons for any differences observed. This would

determine the possibility of using the CT images as an aid in the restoration and conservation processes and may provide valuable information about the condition and state of preservation of internal structures, cracks and defects that are not visible with the naked eye or inaccessible through other investigation methods. The CT images also are regarded as part of the documentation process of the mummies as they can record the condition of each mummy at the time of examination.

Acknowledgments

The author expresses great thanking and gratitude to the members of the scientific team "HORUS" as the mummies were part of a project Computed Tomography Scanning the Egyptian mummies at the Egyptian Museum.

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