**Journal of Neonatal Surgery**
***ISSN(Online): 2226-0439***
***Vol. 14, Issue 13s (2025)***
*https://www.jneonatalsurg.com*

OPEN ACCESS

# Mummification Of The Human Body For Medical Education: A Comparative Analysis Of The Methods

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Cite this paper as: Rajesh Kumar Meena, Mukta Mala Mohan, Devendra Kumar Nama, Astha Mathur, Himani Choudhary, Neha Modiyani, Viraj Alawa, Soni Gupta, (2025) Mummification Of The Human Body For Medical Education: A Comparative Analysis Of The Methods. *Journal of Neonatal Surgery*, 14 (13s), 414-421.

**ABSTRACT**

Mummification is the method of embalming the dead body during the period of ancient Egyptians era. Different methods for mummification are ancient method, chinchoro method (The Black Mummy Technique, The Red Mummy Technique, The bandaged mummies), sokushinbutsu method, modern Method (Arterial embalming, Cavity embalming, Hypodermic embalming Hypodermic embalming, Surface embalming). Plastination is a scientific method or process used in anatomy and forensic medicine departments for medical teaching that preserves the body or body parts.

***Keywords:*** *Egypt, Human body, Medical education, Mummification*

## 1. INTRODUCTION

The methods of embalming, or treating the dead body is called mummification. The ancient egyptiansused this by removing all moisture from the body, leaving only a dried form that would not easily decay. It was important in their religion to preserve the dead body in as 'life-like' a manner. The English word mummy came from the latin word 'mummia' which is derived from the Persian 'mum' meaning wax and refers to an embalmed corpse which was wax- like.[i]

The Egyptians considered life to continue after death, which is why it was crucial that the body be preserved. The decomposition of a corpse happens after death. A body must be deprived of oxygen and moisture in order to stop it from disintegrating.[ii]

In the desert, the early Egyptians buried their dead in small pits. The dead body's fluids was rapidly extracted by the hot, dry sand, becoming a natural mummy. But the Egyptians found that the body would not remain preserved if it was initially placed in a coffin.[2]Thus, they developed the more specific way to mummy the bodies.

The process entails removing the brains and viscera, packing the body cavities with a mixture of herbs and balsamic flavours, and then allowing the corpse to dry out. Because the Ancient Egyptians believed that the heart governed all ideas, memories, and intelligence, they removed the brains and viscera but left the heart within the body.[iii,iv]

The second major period in the history of embalming is the European Renaissance, when the main application of embalming techniques was to preserve the deceased for scientific objectives such as dissection and study. Later, throughout the Renaissance, scientific advancements in medicine began to have an impact on embalming. Advancement in embalming methods were needed for preservation, and bodies were needed for dissection.[v]

**Methods**

Probably around 4000 BC, ancient Egypt was the old world society that had developed embalming to the greatest extent in classical antiquity, and they utilised it for more than 30 centuries. Egyptians are credited with creating the mummification technique. For a variety of reasons, including the belief that the preservation of the body invigorated the soul after death, which would return to the preserved corpse in Egypt to other cultures, such as Peru, where climate also supported a sort of mummification, embalming has been practiced widely throughout history.[vi]

**Different methods of mummification**

Mummification or embalming has gone a long way of development in the history. Some of the popular ways of mummification are-:

**Ancient method**

Around 3500 BCE,[vii] mummification became a common technique in ancient Egypt. Cemeteries became prevalent during Egypt's early dynastic period (c. 3150–c. 2613 BCE), when the mastaba tomb had supplanted the simple burial. Mastabas were viewed as the body's eternal home rather than its location of final resting. It was now believed that the tomb served as the site of the soul's transition from this life to the next. However, it was believed that the soul could not complete its trip if the body had to remain intact. The soul would need to orient itself by what was familiar after it was released from the body. For the Egyptians, death was only a change in state rather than the end of life. In order to achieve this, the body needed to be meticulously preserved so that the soul could recognise it both later on and when it awoke in the tomb. Mummification was the accepted method of burying the dead by the time of the Old Kingdom of Egypt (c. 2613–2181 BCE), and funeral rites revolved around mummification and death. The cult of Osris, who had already gained popularity as a mummified ruler and was sometimes depicted with green or black skin, signifying both death and resurrection, served as a major inspiration for these ceremonies and their emblems.[viii]

Steps of Mummification-

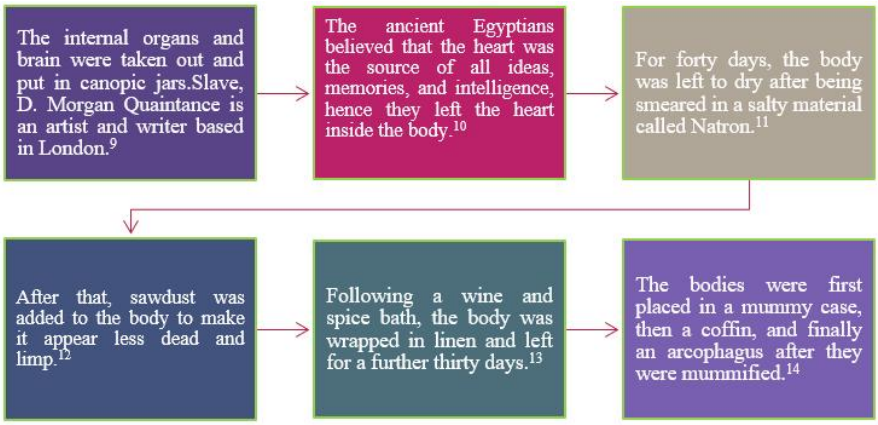


**Figure 1: Showing the steps of Mummification**

**Chinchoro method**

Between 7000 and 3700 BP, during the Archaic Period in the Andes, the Chinchorro Tradition flourished.[ix]Over the course of 5000 years, these people gained a deep grasp of human anatomy and morphology, which they used to create the earliest mummies in recorded human history.[x]Mummification procedures differed in how the deceased corpses were prepared, emptied, and filled as well as in the external finishes applied. The distinction in finishes has been used to categorise the various burial rites of these ancient coastal people.[xi,xii,xiii]The main techniques for complex mummification have been identified: the Chinchorro, the Black Mummy Technique, the Red Mummy Technique, and the Bandaged Mummy Technique.[xiv]

*The Black Mummy Technique*-(between 7000 and 5000 BP) entailed dissecting, cleaning, and strengthening the skeleton

before a clay mould of the body was made. After the body was formed, the skin was replaced and covered in a glossy black coating. The face was covered by a clay mask painted in the same way.[20]

*The Red Mummy Technique*- The body and head cavities of (4500–4000 BP) were empty before being filled with a range of materials, including feathers, clay, and plant fibre, setting them apart from the black mummies. After it was filled, the body was painted red. A lengthy black wig, held in place with a black cap, covered the deceased's head. The face was hidden under a black mask.[20]

*The Bandaged Mummies*-are a variation of the red ones where the skin was bandaged over the body. [20]

**Sokushinbutsumethod**

Enlightenment was the goal of the self-mummification practice, which was unique to Buddhist monks of the Japanese Shingon sect. Even though Japan is not the ideal place for mummification, some 20 monks have succeeded in becoming mummies by undergoing intricate processes. Combining aspects of Buddhism, Shintoism, Taoism, and other religions, the esoteric Shingon cult. They follow the ideology of Shugendo, which holds that self-denial and discipline are the paths to spiritual power. This sect was established by the Japanese monk Kukai, who flourished from 774 to 835 AD. As his life came to an end, Kukai abstained from food and liquids and entered a profound state of meditation, which finally led to his voluntary death. His bones were buried on Mount Koya in Wakayama Prefecture. To the amazement of those who opened his grave, Kukai (known as Kobo-Daishi after his death) appeared to be dozing. His hair was robust and healthy, and his appearance remained the same.[xv]

Self-mummification, or sokushinbutsu, was an extremely intricate process. Undertaken in three phases, each lasting a thousand days, the procedure wasn't always fruitful. Self-mummification was forbidden in the late 19th century because it was viewed as a barbarous and outdated practice. [21]

Process-[21]

- The process of self-mummification began with giving up most foods. For a millennium, the monks consumed nothing but seeds and nuts. They engaged in an intense sequence of workouts to eliminate any remaining body fat.
- There was considerably greater difficulty in the second stage. And the monks abstained from water. Only one extremely poisonous tea, urusei essence tea (which is typically used to manufacture paints and varnishes), was permitted for them to consume. This drink was meant to deplete the monks of all bodily fluids while also poisoning their tissues to stop worms and bugs from attacking their corpses when they passed away. Tree bark and roots had taken the place of the seeds and nuts at this point.
- The final phase lasted until passing away. They were placed in a stone grave and made to lie in the lotus position. The bell the monk rung each day signalled that he was still alive. The tomb was locked for another thousand days when the boom subsided. The procedure was deemed successful if the monk's body was in good shape. Regretfully, this is extremely uncommon.

## 2. MODERN METHOD

The technique of chemically treating a deceased person's body to lessen microbial growth and presence, delay organic decomposition, and restore a visually presentable state is known as embalmment. In essence, it is the process of artificially sustaining the body after death. In many countries and societies, embalming has been a practice since prehistoric times. It was utilised for around thirty centuries in dynastic Egypt, where it was extensively developed. However, modern methods have superseded the ancient Egyptian mummification process, some of which are quicker and don't need amputation.[xvi]

Today's embalming is credited to Dr. Thomas Holmes. He utilised turpentine, mercury, arsenic, and several kinds of alcohol. It is reported that during the American Civil War, he embalmed more than 4,000 soldiers and officers. August Wilhelm von Hofmann's discovery of the chemical formaldehyde in 1867 was a breakthrough in the field of embalming science. It was a more cost-efficient and efficient preservative.[xvii]

Modern embalming methods are the product of decades or even centuries of study, experimentation, and innovation rather than the work of a single practitioner. Although there is a standard version provided below, technique variations are highly prevalent. There are typically four steps involved in the embalming procedure:

*Arterial embalming*- entails injecting embalming agents into blood vessels, typically through the carotid artery on the right side. The vein in the right jugular is drained of blood. An embalming machine is used to inject the embalming solution, and the embalmer then massaged the cadaver to guarantee that the fluid is distributed properly. If circulation is inadequate, alternative injection sites are utilised.[xviii]

*Cavity embalming*- the use of an aspirator and trocar to remove the cadaver's internal fluids and introduce embalming chemicals into bodily cavities.[xix]

*Hypodermic embalming*-the subcutaneous injection of embalming agents as required. [25,xx]

*Surface embalming*-which supports the alternative techniques, particularly for visible or damaged body portions. [26,xxi]

**Medical education and mummification**

Plastination is a scientific method or process used in anatomy and forensic medicine departments for medical teaching that preserves the body or body parts. Through the use of specific plastic, the body's water and fat are substituted, producing specimens that are touchable, smell-free, and even preserve the majority of their original characteristics. By allowing the exhibition of internal organs that are dry and nearly lifelike, the plastination approach has a distinct advantage over all other methods. The plastination technique is a four-step process that uses integrated basic processes:[xxii]

*Specimen Preparation and Fixation*:Producing plastinates requires the preparation of superior dissected specimens. The embalming process under fixation often involves a formaldehyde solution to stop the body from decomposing. Before or after prosection, specimens can be fixed. But fixation should come after prosection to ensure final specimen shape and desired position, reduce exposure to formalin vapours, and ensure both. When employed as a fixative, 10% formaldehyde solutions are typical; specimen bleaching may be lessened using lower percentage formalin solutions. To prevent the brain from shrinking during conception, it is necessary to repair it with a high (10–20%) proportion of formalin for a few months.[xxiii]A specimen that is more flexible and realistic-looking can be obtained by minimal fixation, a low formalin %, and a brief time frame (one to two days). For hollow organs to keep their lumen and shape, they must be fixed. Maintaining the specimen's native anatomical position during fixation and the initial dehydration wash is advantageous. [xxiv]

*Dehydration:*For the plastination process, the high water content present in all biological specimens must be eliminated. This is accomplished using a procedure called dehydration, in which the samples are submerged for four to five weeks in a cold solvent (typically acetone) at a temperature of -25 degrees Celsius. The acetone gradually replaces the tissue water over a period of four to five weeks. During the first exposure to acetone, it would be simple to dilate the bodily organs to their maximum extent in frozen acetone. This ensures that the organ will thereafter undergo maximal dilation during the plastination process by freezing it in a dilated condition.[xxv]

*Impregnation:*The third step involves submerging the dehydrated specimen in a liquid polymer bath, such as epoxy resin, silicone rubber, or polyester. The acetone is forced to boil at a low temperature by creating a vacuum. The specimen's acetone and polymer are drawn out by the vacuum, whereupon they enter the tissues and vessels.[32,xxvi]

*Hardening:*To harden the impregnated specimen, it is cured using heat, gas, or UV radiation. The specimen filled with polymer is put inside a sealed chamber and exposed to a curing gas. Within 48 hours, the specimen will be dry to the touch due to the hardening of the polymer throughout by this gas. After the curing process is finished in a few months, the specimen can be kept at room temperature indefinitely. [32, 33]

## 3. DISCUSSION

Despite the strengths and weaknesses of the various embalmment techniques, the medical education plastination techniques have proven to be more effective than the ancient techniques. Since these techniques can keep a body intact for decades without the body decomposing by autolysis and putrefaction.

The plastinated specimen is stronger, easier to handle, chemical-free, and conveniently storeable. Plasminated specimens are generally more enjoyable for students to touch than wet specimens. The institution can set up self-directed learning stations for students to study anatomy and forensic pathology using these plastinated specimens. The specimens that have been plastinated are more robust, flexible, and lifelike. In the course of the following two years, Von Hagens created the Körperwelten (BODY WORLDS) public exhibitions, which featured entire bodies that had been dissected to highlight different human anatomical systems and structures and plastinated in lifelike poses.[xxvii]Plasmination is therefore helpful in medical education as teaching aids and serving models because it enables students to accurately interpret three-dimensional images of shapes and sizes. For instance, gastrointestinal tracts that have been plastinated are utilised to aid in the teaching of endoscopic technique and anatomy.[xxviii]Plastination offers relatively more detailed features as all the structures are fully preserved in their natural state, with the help of plastination we can preserve the parasites present in the flesh such as larvae in the putrid flesh can be preserved for demonstration.Fragile tissue sample such as intra-cerebral hematoma can be preserved perfectly and made durable for the future use.

*Importance of mummification for medical education-*

1. Preserved in mummy cells is a record of disease, which doctors and scientists can examine to learn about viruses and bacteria.[xxix]

2. Studying mummies can help us learn more about past cultures and develop improved vaccines and other treatments. [35]

3. Plastinated specimens as a teaching aid in anatomy-

Plastinated specimens are dry, durable, odorless and give a true to life appearance. Human plastinated specimens are today's milestone in medical education. They have become an ideal teaching tool not only in anatomy but also in pathology, obstetrics, radiology and surgery.[xxx]

Teaching of topographic anatomy along with its clinical application in clinical years is now considered essential. Its very difficult to display formaline fixed prosected parts in the hospital wards. In these circumstances the plastinated specimens would be an ideal teaching tools in medical teaching.[36]

Human cadavers remain the best way to provide 3-dimensional pictures of anatomy to medical students. The human gross anatomy laboratory experience continues to play a major role in the objective of learning anatomical concepts and the relationships that are later applied to the understanding of clinical situations.[xxxi]

The time spent on repeated reading of a textbook is less effective than the time spent thinking about the subject and visualizing a structure and its relation to the surrounding structures.[xxxii]

Most of the time spent in a gross-anatomy course should be utilized in developing a 3-dimensional mental picture of the anatomy of a living patient.[xxxiii]

Cottam[xxxiv] pointed out that only less than one 3rd of North American residents are adequately trained in gross anatomy. Our particular concern is the recent trend in anatomic instruction towards the digital world and away from dissection. Computers are now replacing yesterday's experienced teaching faculty.[xxxv]

Both, health care and medical education need standards based on the best long term interests of recipients. Standards in medical (anatomic) education are inextricably linked to standards for health care. Medical education is changing dramatically. Future modifications must be based on sound academic reasoning.[xxxvi] Otherwise these may provide the courts with a new attack on "educational malpractice". The diversion of medical students from cadaveric morphological study to the digital world can be avoided by providing an Anatomy Laboratory with a full range of plastinated specimens.

4. There is significant role in teaching and learning related to the anatomy in area of surface anatomy and applied aspectmentioned in **Minimum Standard regulations for Homoeopathic Medical Colleges and attached hospitals 2013(MSR)**, but in **Minimum Standard regulations for Homoeopathic Medical Colleges and attached hospitals 2022(MSR)**not mentioning of mummified body, which reduces the importance of mummification in anatomical study.

There is significant role in teaching and learning related to the anatomy in area of surface anatomy and applied aspect as per **the Minimum Essential Standards, Assessment and Rating for Undergraduate Ayurveda Colleges and teaching Hospitals, Regulations, 2024.**

In **Minimum Essential Standards, Assessment and Rating for Undergraduate Siddha Colleges and teaching Hospitals, Regulations, 2024** not mentioning of mummified body, which reduces the importance of mummification in anatomical study.

In **Minimum Essential Standards, Assessment and Rating for UGUnani Colleges and attached teaching Hospitals, Regulations, 2023** not mentioning of mummified body, which reduces the importance of mummification in anatomical study.

In **Minimum Standard regulations for UG Sowa-RigpaColleges and attached teaching hospitals, Regulations 2023** not mentioning of mummified body, which reduces the importance of mummification in anatomical study.

In **National Medical Commission (Minimum Standard Requirments) For Establishment Of New Medical College/Increase Of Seats In MBBS Course) Guidelines, 2023-Regulations** not mentioning of mummified body, which reduces the importance of mummification in anatomical study.

## 4. MUMMIFICATION AND RESEARCHES

1. A research on **Mummification in a forensic context: an observational study of taphonomic changes and the post-mortem interval in an indoor setting**presents some novel findings regarding desiccation in an indoor setting. A dataset of 102 forensic autopsy cases displaying desiccation to various degrees and in differing patterns was evaluated. In this work, we classified observed changes into three different types: 1) leathery desiccated skin, 2) parchment-like desiccated skin, and 3) soft tissue desiccation, i.e., desiccation of subcutaneous fat and underlying musculature. This classification was based on the texture of the skin and its visual appearance. An observable difference was that leathery desiccated skin was more common in distal parts of the limbs and parchment-like skin was seen in anatomical regions with more subcutaneous fat, such as thighs and upper arms. Soft tissue desiccation was often seen distally, with a similar distribution pattern as leathery desiccated skin. The results highlighted that desiccation changes could appear at widely different post-mortem interval (PMIs), making estimation of PMI based on visual assessment of a desiccated body surface difficult.[xxxvii]

2. **A review on the materials used during the mummification processes in ancient egypt**-Mummification is considered one of the most important in the history of ancient Egyptian civilization. The artificial mummification process started in the Fourth Dynasty during the Old Kingdom reached its peak in the New Kingdom. This review focuses on the usage of mummification materials such as Natron salt, Coniferous resin, Mastic, Myrrh, Beeswax, Bitumen, Cassia, Onions, Lichen, Henna and Gum Arabic in ancient Egypt to determine their effectiveness in the preservation of the body. For each material, the chemical formula, the history, and the role in the preservation of the body are presented. It is shown that natron salt was the most important material to desiccate a corpse, and that the vegetable materials mentioned above have anti-bacterial

properties that protected the body from microbial attack.[xxxviii]

3. **Experimental mummification—In the tracks of the ancient Egyptians**

By this study understanding natural and artificial postmortem alterations in different tissues of the human body is essential for bioarchaeology, paleogenetics, physical anthropology, forensic medicine, and many related disciplines. With this study, we tried to gain a better understanding of tissue alterations associated with the artificial mummification techniques of ancient Egypt, in particular for mummified visceral organs. We used several entire porcine organs and organ sections (liver, lung, stomach, ileum, and colon), which provided a close approximation to human organs. First, we dehydrated the specimens in artificial natron, before applying natural ointments, according to the ancient literary sources and recent publications. We periodically monitored the temperature, pH value, and weight of the specimens, in addition to radiodensity and volumetric measurements by clinical computed tomography and sampling for histological, bacteriological, and molecular analyses. After seven weeks, mummification was seen completed in all specimens. We observed a considerable loss of weight and volume, as well as similar courses in the decay of tissue architecture but varying levels of DNA degradation. Bacteriologically we did not detect any of the initially identified taxa in the samples by the end of the mummification process, nor any fungi. This feasibility study established an experimental protocol for future experiments modeling ancient Egyptian mummification of visceral organs using human specimens. Understanding desiccation and mummification processes in non-pathological tissues of specific visceral organs may help to identify and interpret disease-specific alterations in mummified tissues in ancient Egyptian canopic jars and organ packages contained in whole mummies.[xxxix]

4. **"Modeling ancient Egyptian embalming": radiological assessment of experimentally mummified human tissue by CT and MRI-** objective of this study was to assess changes in different tissues during the process of artificial mummification by natron using computed tomography (CT) and magnetic resonance imaging (MRI), and to translate the results to image interpretation in paleoradiological studies of ancient mummies. As a material a human lower limb (LL) was amputated from a female donor 24 h post-mortem and mummified by artificial natron (54 % NaCl, 16 % Na2SO4, 18 % Na2CO3 12 % NaHCO3) in ancient Egyptian style. The LL was kept in a fume hood at 16–25 °C and 30–75 % relative humidity. CT and MRI were performed at specific intervals with quantitative evaluation of Hounsfield units (HU) and signal intensities (SI).Evaluated tissues showed different HU and SI changes during the experimental mummification. All tissues revealed an overall but varying increase of HU in CT examinations. All tissues except for the compact bone revealed an overall but varying decrease of SI in the IR and T2-weighted sequences of the MRI. Typical findings included a distinct increase of HU in the cutis at the end of the study and a temporary increase of SI in the IR and T2-weighted sequences in all muscle groups.[xl]

5. **Embalming and other methods of dead body preservation[20]**-Embalming is the process of preserving a human deadbody with the purpose of postponing decomposition for aslong as possible. It is a process intricately entwined withcenturies of human history .Embalming is both an artand science. The treatment of the dead body with aqueoussolutions of soluble germicidal and preservative chemicalsby way of vascular and a cavity injection to prevent putrefaction is called embalming. Embalming is restored-

1. In medical colleges to preserve the deadbodies for the purpose of dissection.

2. When the dead body has to be transported from one country to another for burial or cremation and the time taken in transit is such aswould ordinarily lead to decomposition.

3. Necessity to preserve the dead body of someimportant personality for public view.

## 5. CONCLUSION

By definition, mummies are human (or animal) remains with preservation of non-bony tissue. The Egyptians were very religious and like many other cultures, they believed in an after -life. For Egyptians, an arduous journey before being judged in the Hall of Two Truths by the god Osiris and having their heart weighed against the feather of truth. A big part of the journey meant making sure their physical body was kept in good shape so that their soul could move back and forth. Later on, embalming was done by anatomists for detailed study of anatomy, cadaveric dissection is a necessity of every student of medical science.

**Acknowledgements**- Author acknowledges Principal& Medical SuperintendentDr.Puneet R Shah &Dr.Sangeeta Jain (Head Of Department of Anatomy) University College of Homoeopathy Kekri for their guidance and support.

**Financial support and sponsorship**: Nil

**Conflicts of interest**: Nil

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