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Review Article

Dead Body Preservation

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A Review of Dead Body Preservation: A Historical Perspective on Ancient Techniques in Ayurveda and Modern Advances

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It is important to learn anatomy both theoretically and practically in order to fully understand the concept of the body. Anatomy should study practically through the preservation and dissection of human cadaver. Numerous techniques for preserving dead bodies have been developed by modern medical science. Similar to this, Acharya Sushruta had elaborated a specific method for preserving dead bodies in Ayurveda before many centuries, which is commonly referred to as "Jalenimajjana Padhhati for Mrita Samrakshyana" (Hydro-biological approach for preserving a dead body). Acharya Sushruta had employed all natural components for this method, which are readily available everywhere. Nowadays variety of techniques and chemicals are employed to preserve dead bodies. With both approaches, the goal is to prevent decomposition and preserve the deceased body so that dissection may be completed with ease. This article aims to provide a scientific understanding of ancient method for dead body preservation by Achaya Sushruta method along with new advances.

Keywords: Preservation, Embalming, Plastination, Cryopreservation

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Introduction

Before many centuries *Acharya Sushruta* had given the importance about the knowledge of human body. This knowledge helps the physician to get an insight in to the patient. A Physician who has studied cadavers and learned about all the body's organs thoroughly will be able to treat patients without becoming confused.**[1]** *Acharya Sushruta* described the process for preserving and dissecting cadavers because he understood that dissection is essential for medical students to get practical understanding of anatomy. The foundation knowledge of anatomy is essential for the physician of all medical science. It is considered as the "pole star" of medical education. Dissection is a primary method of understanding anatomy, and the study of anatomy and dissection refers to the practice of physically cutting a body and examining its internal parts. This is most commonly used in medical education, where students dissect cadaver to study human anatomy with internal structures related to function and anatomical variations which is considered as a *"Unique educational tool".* Cadaver has been shown to simulate surgical and anatomical training better than any other existing method. For teaching, learning and research objectives of human anatomy, donated or unclaimed body are received by the department of anatomy of medical institutes. Therefore, one of the most crucial factors is to take into account when using human remains in educational settings is preserving cadavers from decomposition. In ancient time without any advanced equipment and instruments, *Acharya Sushruta* used natural environment with using plant materials to preserve the dead body. This particular technique for dead body preservation is which can be grossly called as Hydro-biological approach for preserving a dead body. In modern science various techniques were developed through several research, trial and inventions in many decades by using various categories of chemicals. One of the most important chemicals used for this purpose is formaldehyde. Embalming is one of the traditional methods of treatment for a dead body to protect from decay or to delay the natural break down of cells, which begins when die. Likewise, another advanced technique Plastination is used for body or body parts through which water and lipids in biological tissues are replaced by polymers for the long term preservation.

In this study we will focus on scientific interpretation of dead body preservation method given by *Acharya Sushruta* and various traditional along with new advance techniques.

Aims and Objective

1. To study the scientific method of preservation of dead body mentioned by *Acharya Sushruta*.
2. To study about the various traditional along with new advance techniques for the preservation.

Materials and Methods

Textual references from *Ayurveda* classics like *Sushruta Samhita*, *Ghanekar* commentary, Modern literatures etc. and some article references were used for this study.

Review of Literature

Preservation is the activity or process of keeping something safe and free from damage or decay.**[2]** Bacteria and fungus are known to be the main cause of organic decomposition and putrefaction, it is the art and science of modifying the human body to stop them. Numerous techniques for preserving dead bodies have been developed by modern medical science. Likewise, *Acharya Sushruta* had provided a specific method for preserving dead bodies in *Ayurveda* between 1000 and 1500 B.C (in *Upanishad Kala).* The phrase *"Sharire Sushruta Shreshtha"* appears in *Ayurveda* writings, indicating that *Acharya Sushruta* is the most qualified to describe the human body's anatomical features because he had provided comprehensive details on every single bodily part. He had also described the seven layers of *Twak* (skin) and their thickness,**[3]** body membranes (*Kala*),**[4]** *Srotas* (minutes channels),**[5]** *Marma* points (Special vital points)**[6]** etc. of human body. All was possible due to good scientific preservation and detail dissection.

Scientific analysis for preserving dead bodies mentioned by *Acharya Sushruta*

Acharya Sushruta had mentioned about scientific preservation of dead bodies using natural environment and some medicinal herbs in *Sushruta Samhita*. He had also described criteria for proper selection of dead body for preservation, preserving materials, methods of preservation, and the dissection instruments in a scientific manner.**[7]**

Table 1

Criteria for Selection of dead body	Preservation material	Dissecting instruments
▪ Dead body have all the body parts ▪ Death is not due to poison ▪ Death is not due to any long-term diseases ▪ The dead body should not be of a very old person	▪ Extreme cold rivers with slow flowing water ▪ Cage (Bamboo or iron) ▪ Remote area with less sunlight intensity ▪ Some medicinal Plants	▪ Kurcha (Brush) made up of: Ushira, Hair, Bamboo, Balvaja.

Figure 1: Plant materials were used for preservation of dead body by *Acharya Sushruta.*

Method of preservation described by *Acharya Sushruta*

After proper selection of a dead body as per the selection criteria, first all the feces should be removed from gut for further processing. The dead body should be wrapped with the medicinal plant materials like: Fibers of: *Saccharum munja* Roxb. (*Munja*), *Desmostachya bipinnata* (*Kusha*), *Crotalaria juncea* (*Shana*), and the barks of five plants i.e.; *Ficus benghalensis* (*Nyagrodha* or Banyan Tree), *Ficus religiosa* (*Ashvatha*), *Ficus glomerata* Roxb. (*Udumbara*), *Ficus lacor* (*Plaksha*), *Thespesia populnea* (*Pareesha*). Once the body has been wrapped in these materials, it should be placed in a cage in a remote dark area away from the civilization and submerged in cold, continuously slowly flowing river or fountain water. After fully swelling of the body due to contamination of water, the body should be removed from water after completion of seven days. Then all the herbal covering should be removed and start the dissection of cadaver by slowly scrubbing with an instrument *Kurcha* (brush like structure) made up of *Vetiveria zizanioides* (*Ushira*), Straight strong hair, Bamboo, and some barks of tree. Thus, dissection began with the skin and progressed to reveal deeper tissues and internal organs. Students should learn by direct perception for teaching and learning purposes.

Various advanced methods for Preservation:

For preservation of the dead body, several decades or centuries of research, trials, and discoveries employing a variety of chemical categories have led to the development of numerous methodologies in modern science.

Natural elements like as freezing and dryness, which can be caused by dry heat or dry cold due to the nature of the soil, can preserve dead bodies. This can be called as natural mummification. Artificial mummification was established by old Egyptians.

Several substances that dehydrate and desiccate, like natron salt and vegetable materials, as well as substances that have antibacterial properties, like mastic, lichen, cassia, onions, beeswax, coniferous resin, henna, and gum Arabic, were used in this process.**[8]**

Embalming:

The technique of chemically treating a deceased person's body to delay organic decomposition, lessen the growth and presence of microbes, and restore a respectable physical look is known as embalming. By the use of preservation chemicals or embalming fluids it delayed the natural break down of cells, which begins when after die. It helps the bodies temporarily to prevent the processes that cause to decay. Aim of the embalming is to preserve and ensure the no chance of infections, store the softness of the tissue as like as un-embalmed body, maintain the colour of muscles, organs, arteries and vein etc. Embalming process can be summed up as the following:

- **Arterial embalming:**

By this process, embalming chemical liquid inserted into the blood vessels usually via the right common carotid artery or through femoral artery by using gravitational force or by using embalming machine. It is simple traditional method, least expensive method of embalming and high success rate.

- **Cavity embalming:**

In this process, the internal fluids of the cadaver are removed by suction machine and the injecting embalming chemicals are introduced into body cavities by using a trocar.

- **Hypodermic embalming:**

Embalming liquid chemicals are introduced in to the body by using hypodermic needle and syringe to ensure the fluid reach all part of the body.

- **Surface embalming:**

Concentrated embalming chemicals are applied on damaged body parts, particularly to locations where artery fluids may not reach them.

Chemicals components of embalming fluid:

Embalming fluids should have properties that there is no chance of infection into the contact with the dead body; they should also ensure the preservation of the body, avoid alterations and disruptions in putrefaction, and avoid contamination by insects and maggots.

Different types of the chemicals are the components of embalming fluid.**[9]**

- **Preservatives:** Formaldehyde, Glutaraldehyde and Phenol. (Formalin refers to 37% aqueous Formaldehyde).
- **Germicides (disinfectants):** Glutaraldehyde, Ammonium compounds
- **Buffers:** Borax (Sodium borate), Sodium phosphate, Citrates and Sodium salt of EDTA
- **Humectants (hydrate soln.):** Glycerine, Sorbitol
- **Anticoagulants:** Sodium citrate, Sodium oxalate and Sodium salt of EDTA
- **Dyes (coloring agents):** Eosin, Erythrosine
- **Perfuming agents:** Benzaldehyde, Cloves oil
- **Vehicles (Diluents):** Water, Alcohols, Glycerol.

Procedure of Arterial embalming through Femoral Artery:

First the dead body should be collected with proper washing then placed on the dissection table in the supine position. A pot filled with mixture of preservation fluid placed 5-6ft above the surface of the dead body or may be embalmer machine used for embalming. Then fell and trace the inguinal ligament in between anterior superior iliac spine and pubic tubercle. Cut the skin, then superficial fascia, then deep fascia. Then the femoral sheath will be visualized. After that an incision is given below the 4 cm of inguinal ligament. In femoral sheath femoral artery is present in laterally and femoral vein medially. A cannula fixed into the femoral artery and allowed to transfer the preservation fluid from the pot into the body through this cannula. 5-7 liters fluid required for the preservation of a single body. The process is continued until the fluid comes out from noes ears eyes etc. Then the body is kept in a covered tank solution of 5% formalin and water for 3 months. Then it may be used for the purpose of dissection.

Plastination:

It is an inventive technique for preserving anatomical specimens involves replacing all physiological fluids with a polymer by forced impregnation mostly by silicone, epoxy, and polyester which harden and finally result in natural looking, dry, odorless and durable specimens. It was invented in 1977 at Heidelberg University in Germany by Dr. Gunther Von Hagens. It’s a technique that preserves biological tissues for a long time with a highly durable surface that is fully visible. The palatinate specimens are great teaching aids and don't have any negative formalin effects.

Types of Plastination:

- **Whole body or whole organ Plastination:** All the body or organ fluids are replaced by polymers by this process.
- **Sheet Plastination:** It involves epoxy or polyester resin impregnation of thin and ultra-thin tissue sheets (2 -5mm), producing dry, odorless, non-toxic and long-lasting sheets.
- **Luminal cast Plastination:**

Luminal cast plastination is a process that produces a three-dimensional cast of the lumen, or cavity, of a specimen by using polymers and dissolving the tissue surrounding it. This method is applied for the vascular patterns of coronary arteries, liver, spleen, kidney, and other organs.

Procedure:

The three major methods of plastination are silicone plastination, sheet plastination with epoxy and polyester. The process of plastination consists of some basic steps. These are the preparation of specimen by fixation and dissection if required, dehydration for removal of fluid, defatting for removal of fat or lipid substances, forced polymer impregnation, positioning and curing. Fresh or formalin-fixed (embalmed) specimens can be palatinate. After preparation of specimen water and tissue fluids are removed by standard dehydrating procedure for plastination is freeze substitution in acetone at - 25°C.**[9]** It takes about 3-5 days for complete dehydrate. Acetone is a very successful dehydration and a defatting agent.

Removal of excessive fat (defatting) from organ is done by removing the dehydrated specimens from -25°C to room temperature for some weeks. This phase can be completed after the specimen's lipid starts to turn slightly opaque and lose its white color. The next step is the forced impregnation of polymers. The principle of forced impregnation is to replace the acetone with the polymers e.g.; silicon, epoxy or polyester. For this a forced vacuum machine is required. The last step is positioning and curing or hardening using by curing agents.**[10]**

Polymer materials are used for Plastination:

For the preservation of the whole cadaver, only limb or viscera commonly Silicon**[10]** is used. S10 method is ideal for dissected specimens. So it is considered as the gold standard in plastination.

For the body at different levels or sections of tissue commonly used Epoxy polymer technique (E12). The process of epoxy plastination produces accurate, semi-transparent sectional specimens that are of excellent for examination of gross anatomical structures. For the preparation of head slices, brain slices and body slices commonly Polyester polymer technique (P40) is used.**[11]**

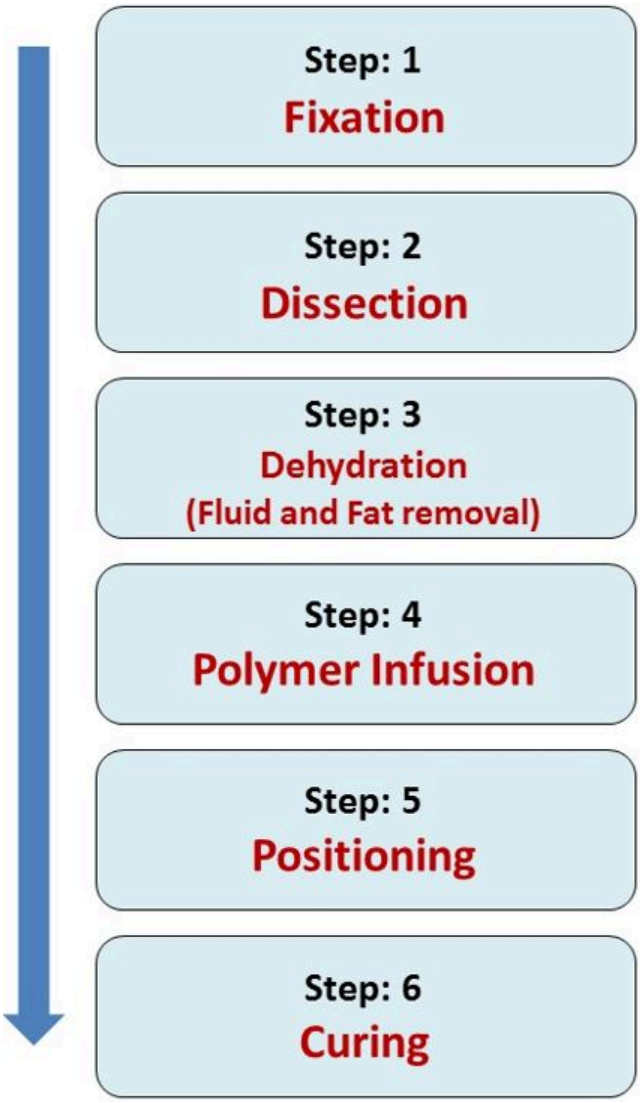

Figure 2: Process of Plastination

Cryopreservation

Cryopreservation is the process by which any living cells, tissues, organs or entire dead bodies are protected from decay by storing them at extremely low temperatures.

Procedures:

The process involves three key steps once someone has been declared legally dead, according to the Cryonics Institute.

The body is first submerged in an ice bath right away. Meanwhile, automatic CPR and the anticoagulant heparin are used to keep blood flowing, and a breathing mask is used to keep oxygen flowing to the body's organs, especially the brain. The body is then "vitrified," which means that its organs and cells are ready for the extremely low temperatures they will soon be exposed to.

This involves injecting of cryoprotective chemicals, which function as antifreeze and prevent the cellular damage caused by freezing, to replace the body's fluids. After that the body is prepared for the cold, the process of controlled cooling begins. Finally the body is gradually cooled to very low temperatures, typically using liquid nitrogen, to the point where all metabolic activity halts. The cooled body is stored in a specialized container, usually a cryostat, which keeps it at the ultra-low temperature necessary for preservation. This takes place slowly, over several days, until the body reaches a temperature of minus 200 degrees Celsius.**[12]**

This method of preservation is expensive and time consuming. Although cryopreservation can protect the cells at a very low temperature, each step of the procedure can damage the cells if not carried out properly.

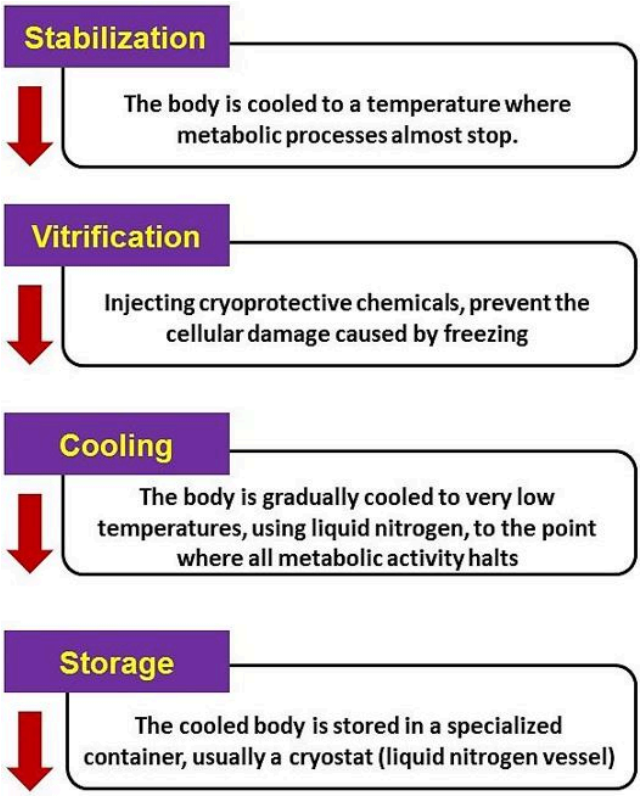

Figure 3: Process of Cryopreservation

Discussion and Conclusion

Anatomy, especially through dissection, is crucial for understanding the body structures and functions, enabling a fundamental knowledge for medical procedures, diagnosis, and treatment, as well as advancing medical technology and research. Therefore, the study of anatomy is called as the polestar of medical education while dissection is considered as the sharp end of medical education. Likewise, in *Ayurveda*, 1000-1500 before B.C. *Acharya Sushruta* and various *Acharyas* had given the importance of dead body preservation and dissection to become a good physician.**[13,14,15]**

Acharya Sushruta has described the process of preservation and dissection of human dead body in a scientific and sequential manner. He has provided comprehensive details about every bodily part; he is the most qualified person to describe the anatomical structures of the human body. He has shown seven different kinds of *Kalas* (membranes) and their sequence, as well as seven layers of skin and their thickness. This was possible because of good preservation and dissections. Many techniques are now being developed to maintain the dead body for an extended period of time due to scientific and research advancements.

In this method of scientific preservation delays the normal breakdown of cells and protects the body and organs from damage, destruction, or decomposition. The most important method is Embalming, by which special chemicals mainly formaldehyde and others are used for these purposes. The embalming method of preservation is a simple traditional with a high success rate. It is relatively lower cost but has many health hazards. Because formaldehyde can causes irritation to the ENT pathway and induce occupational asthma. It is considered as a "probable human carcinogen" agent, which can cause leukemia if exposed in the long run.**[16]**

In recent years, Plastination method of preservation for anatomical specimens is more popular among the anatomists and students. Because these specimens are considered as superior in relation to synthetic models, on account of their ability to reflect anatomical variations. These are realistic and accurate depictions of preserved corpses that perfectly show all structures that three-dimensional models are unable to do.

In 1948 Cryopreservation was accidentally discovered by C. Polge and by this method preserves of organs and cells at a very low temperature such as in liquid nitrogen. Various biological tissues and organs are stored by these procedures like cryopreservation of human livers and hearts for storage, semen, stem cells, umbilical cord, Oocyte, and embryo etc.**[17]** The goal of all preservation techniques are to prevent decomposition and preserve the dead body's natural appearance so that dissection can be completed with ease.

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