Original Article

Indian Journal of Anatomy
Volume 11 Number 3, July – September 2022
DOI: http://dx.doi.org/10.21088/ija.2320.0022.11322.8

Evolution in Embalming Techniques

Shaheen Rizvi[1], Sharadkumar P Sawant[2]

How to cite this article:
Shaheen Rizvi, Sharadkumar P Sawant/Evolution in Embalming Techniques/Indian J Anat. 2022;11(3):79-84.

Abstract

Embalming is the art and science of preserving cadavers or human remains by treating them with chemicals. The use of balms and balsams to impregnate the dead body for preservation has gained the name embalming. A well fixed and well embalmed cadaver is a great asset not only for anatomical dissection but also for research purposes and for viewing by friends, relatives or the public at the time of cremation. This article discusses the chemicals used in embalming, types and methods of embalming, modern preservation methods, the precautions to be taken and the medicolegal aspects related to embalming. Chemicals used in embalming are a variety of preservatives, disinfectant agents and additives which are combined in various proportions to produce the embalming fluid, the predominant chemical being formalin. The modern embalming process is of four types, arterial, cavity, hypodermic and surface embalming. In anatomical embalming, the 3 methods recommended are the gravity method, electric injector or Mechanical pump method and injection method which are described in detail. The processes used are injection, distribution, diffusion and drainage. Other modern methods underway are Thiel method of soft embalming, Plastination and Cryopreservation. Extra precautions need to be taken for cadavers carrying infections such as TB or HIV. Regarding covid-19, WHO recommendation is in alignment with CDC (Centres for Disease Control and Prevention) which state that Embalming is not recommended to avoid excessive manipulation of the body; Adults >60 years and immunosuppressed persons should not directly interact with the body

Keywords: Embalming; Cadavers; Embalming Fluid; Gravity Method; Electric Injector; Mechanical Pump Method; Injection Method; Soft Embalming; Plastination and Cryopreservation.

Author's Affiliation: [1]Lecturer, [2]Professor and Head, Department of Anatomy, K J Somaiya Medical College, Somaiya Ayurvihar, Sion, Mumbai 400 022, India.

Corresponding Author: Shaheen Rizvi, Lecturer, Department of Anatomy, K J Somaiya Medical College, Somaiya Ayurvihar, Sion, Mumbai 400 022, India.

E-mail: shaheen.rizvi@somaiya.edu

Received on: 20.05.2022

Accepted on: 16.06.2022

INTRODUCTION

Dissection on a cadaver is a time honoured and best method of learning human anatomy in medical colleges. It helps students to figure out body structures layer by layer, their depth, their size, and their relationships with surrounding structures. It is also the expertise of a surgeon and serves as an important research tool. A cadaver is like the first patient for a student. Study of a cadaver conveys to

the student an appreciation of mortality, this helps them to develop attitudes of ethics, compassion, and humanism which are crucial requisites of the medical profession.[1]

In view of this, proper preservation of the cadaver becomes imperative. Embalming is the art and science of preserving cadavers or human remains by treating them with chemicals. The use of balms and balsams to impregnate the dead body for preservation has gained the name embalming. Embalming causes the coagulation of tissue proteins that get fixed and hardened.[2] The main object of embalming is to preserve the cadaver and prevent its decomposition. It helps to maintain a desired life like appearance of the body which is non hazardous for dissection by students, as well as environmentally safe. A well fixed and well embalmed cadaver is a great asset not only for anatomical dissection but also for research purposes by vascular surgeons, orthopaedics, ENT surgeons, cosmetic surgeons etc. Modern embalming is also implemented for better presentation of the cadaver for public viewing, especially if it is of some important personality, for viewing by friends, relatives or the public at the time of cremation, or when the cadaver has to be transported over long distances for cremation.

In this paper the various types, methods and chemicals used in embalming are discussed in detail although variation in techniques is very common.

CHEMICALS USED IN EMBALMING

There are a variety of preservatives, disinfectant agents and additives used in different combinations which vary from place to place. These chemicals are combined in various concentration to produce the embalming fluid. Chemicals used are:

Preservatives: They denature the cellular proteins making them unable to act as a nutrient source for bacteria, thus preventing bacterial growth. Embalming fluid also kills the bacteria themselves. These preservatives are a mixture of formaldehyde, glutaraldehyde and phenol. Formalin refers specifically to 37% aqueous formaldehyde. The end result also creates the simulation, via colour changes, of the appearance of blood flowing under the skin.

Germicides (disinfectants): Quaternary ammonium compounds are used for their germicidal and deodorizing qualities.

Modifying agents: They control the rate of action of the main preservative chemicals of the embalming formulations. Formaldehyde used alone sears the walls of the small capillaries and prevents diffusion preservation in soft tissue areas. These agents include buffers, humectants and inorganic salts.

Buffers: Buffers agents that serve to control the acid-base balance of fluid and tissues. Can act as water conditioners and anticoagulants.

Inorganic salts: They have the ability to control osmotic qualities of embalming solution.

Humectants: They are used to hydrate the tissues. They control tissue moisture balance. e.g. Glycerol, Sorbitol and Lanolin. Glycerine is synthetically from petroleum products. It increases the power of other chemicals as it makes them stick better.[3]

Muscle Relaxants: Relax smooth muscle in the arterial walls and assist flow of fluids in the vascular system e.g. Magnesium chloride.

Anticoagulants: Used to maintain blood in a liquid state and thereby make it easy to remove from the circulatory system e.g. Types: Citrates, phosphates, oxalates, borates, and EDTA.

Surfactants: It promotes diffusion of the preservative elements through the capillary walls to saturate the tissues uniformly. Makes the embalming solution flow more readily and rapidly through the capillaries so that all of the millions of tissue cells are literally bathed by the embalming fluid. By reducing capillary attraction of blood and body liquids, surfactant causes the almost immediate clearing of blood from the capillaries. Surfactants incorporate colouring agents into the solution and obtain a normal appearance internally. They also increase the germicidal activity of chemical solutions. Surfactants function best in very low concentrations. Too much surfactant will cause excessive drainage as well as over saturation of tissue. Types sulfonated oils, polyethylene glycol ether.[4]

Dyes (colouring agents): To produce an internal cosmetic effect that closely simulates the natural colouring of the tissues. Active dyes colour tissue e.g. Eosin, Ponceau Red, Erythrosine and Amaranth.

Reodorants (Perfuming and Masking Agents): To enhance the odour of the embalming solution. Types wisteria, rose, and lilac oils and aromatic esters and wintergreen. Any attempt to mask HCHO generally results in neutralization or destruction of the active chemicals.

Water Conditioners Improve drainage by keeping blood in a liquid state, Dyes and most aldehydes function better as fixative or firming agents under slightly alkaline conditions.

Vehicles (Diluents): Serves as the solvent for the many ingredients incorporated into an embalming fluid. It can also provide some stability to the formulation. Types-glycerine, sorbitol, glycol or alcohol.[5]

These groups of chemicals are combined in various proportions to produce the embalming fluid, the predominant chemical being formalin. At times the chemicals are not effective enough in hindering growth of fungi, bacteria or maggots. Formaldehyde in the embalming fluid also causes a strong odour and eye irritations resulting in discomfort in the dissection room.

TYPES OF EMBALMING

The actual modern embalming process is of four types

Arterial embalming: Blood is drained from the body via the veins and replaced with embalming chemicals via the arteries.

Cavity embalming: It is the suction of the internal fluids of the cadaver by an incision just above the umbilicus and injecting embalming chemicals directly into body cavities using an aspirator and trocar.

Hypodermic embalming: Hypodermic embalming is a supplemental method in which embalming chemicals are injected into tissues with a hypodermic needle and syringe, in those areas where arterial fluid has not been successfully distributed during the main arterial injection.

Surface embalming: is another supplementary application of embalming fluid to the skin of the cadaver to preserve damage suffered during autopsy, organ donation, or disease.[6]

METHODS USED IN EMBALMING

There are many cadaver embalming devices in use such as electrical injector (with compressor motor), gravity-based perfusion tank (positioned 3mt high from the ground), mechanical pump, bulb syringe and hand pump. In anatomical embalming, the 3 methods recommended are the gravity method, electric injector or Mechanical pump method and injection method. The processes used are injection, distribution, diffusion and drainage. Anatomical embalming is performed into a closed circulatory system. The fluid is usually injected with an embalming machine into an artery under high pressure and flow, and allowed to swell and saturate the tissues. The deceased is left to sit for a number of hours, after which the venous system is opened and the fluid allowed to drain out.[7]

GRAVITY FEED EMBALMING

The container dispensing the embalming fluid is elevated above the body's level, and fluid is slowly introduced over an extended time, sometimes as long as several days. The rate of the flow can be shown approximately by the level of embalming fluid in the container. The flow rate is increased gradually to 400 ml/minute if there is no obstruction. After approximately 8-10 lit of the embalming fluid have been pumped into the body, leakage of fluids from the nose and mouth can be seen. This indicates that the trunk is filled with embalming fluid. Further pumping allows the fluid to perfuse the limbs and the brain. Total time required to infuse 15 litre of the embalming fluid is about 40 minutes depending on the size and the physical condition of the body. A change in the colour of the body to greyish and blisters on the skin surface, indicate a good perfusion. If there are parts of the body that look reddish and feel soft, manually injection of the embalming fluid is done locally with a 50 ml syringe. The palm of the hand and the sole of the feet are injected too. Finally, the pump is turned off, the cannulae are removed and the artery is ligated. The body orifices are covered with cotton wools saturated with the embalming fluid. Unlike standard arterial embalming, no drainage occurs, and the body distends extensively with fluid. The distension eventually reduces, often under extended (up to six months) refrigeration, leaving a fairly normal appearance. No separate cavity treatment of the internal organs is given. Anatomically embalmed cadavers have a typically uniform grey colouration, due both to the high formaldehyde concentration mixed with the blood and the lack of red colouration agents commonly added to standard, nonmedical, embalming fluids. Formaldehyde mixed with blood causes the grey discoloration also known as "formaldehyde grey" or "embalmer's grey".[8]

INJECTION METHOD

The different injection techniques which can be used are one-point, Split Injection/ Drainage, Multipoint or Six-point injection. In one-point injection, a single point is used for both injection and drainage; most commonly the right common carotid artery and accompanying Internal jugular vein or Femoral artery and vein. In split injection, the injection is from one point and drainage is from

another point; commonly used are right femoral artery for injection and right Internal jugular vein for drainage. In Split Injection/Drainage, for injection one or more sites are used and drainage is from one or more locations. It solves the problem of poor distribution. Six-point injection or sectional embalming is used for autopsied bodies. It is used as a primary injection technique during advanced decomposition. Drainage may be taken from one location. Rt. IJV (insert drainage tube towards the heart). The following vessels are identified, raised and ligated (6 points).

a. Rt. CCA (insert injection tube towards the heart/head)
b. Lt. CCA (insert injection tube towards the head, tie off proximal end)
c. Rt. Axillary/ brachial art. (insert injection tube towards the rt. Hand, ligate proximal end).
d. Lt. Axillary/ brachial art. (insert injection tube towards the lt. Hand, ligate proximal end).
e. Rt. femoral art. (insert injection tube towards the rt. foot, ligate proximal end).
f. Lt. femoral art. (insert injection tube towards the lt. foot, ligate proximal end).

Injection is in the following order: Rt leg, left leg, Rt arm, left arm, Trunk, left side of head and Rt side of head. The purpose of drainage is to make room for arterial fluids, ensure even distribution, avoid discolouration, odour formation and gas, avoid microbial activity and prevent decomposition.[9]

MECHANICAL PUMP METHOD

The embalming pump is mounted over a flat and steady surface. The inlet tube is properly immersed into the embalming fluid and the inlet tube and outlet tube of the device are suitably secured to avoid leakage. A cannula fitted to the outlet tube is introduced either into the common carotid and femoral artery. The pump is operated with the aid of a lever. At first the cannula valve is kept closed and the lever is pushed front and pulled back. This creates a negative pressure drawing the embalming fluid from the source (container with embalming fluid) to the tank. It also creates the essential pressure required to inject the fluid from the tank into the cannula. Subsequently, the cannula valve is opened and the fluid stored in the tank flows into the artery. This pump doesn't emit smoke, noise and does not require fuel (petrol / diesel), electrical power resources; this instrument is eco-friendly, hassle free, easily portable. It can also be used in rural areas during power failure or electrical inaccessibility.[10]

THIEL METHOD OF SOFT EMBALMING

It is a technique which relies on a mixture of salt compounds and very low amounts of volatile formaldehyde and formalin to effect fixation of tissue. Fluid is injected into external iliac artery and drained through superior sagittal sinus, so carotid and femoral vessels are left undamaged.[11] Specimens preserved by this method are odourless and colour of tissues is retained. Cadavers are highly flexible too. Thus, specimens are of high quality and learning is improved. Clinical procedures like lumbar puncture, intubation etc and cosmetic procedures can be effectively learnt.[12]

PLASTINATION

Plastination is a newer process where tissues are replaced by polymers. It allows students to have hands on experience without exposure to formalin. Plastination of soft tissues, organs, bones and teeth is of great value in preserving delicate and friable specimens. Specimens are odourless and appear dry and biological inert. They are durable and resistant to damage caused by frequent handling.[13]

CRYOPRESERVATION

Body preservation method current to the 21st century is cryopreservation. Cryopreservation is a process where cells or whole tissues are preserved by cooling to low sub-zero temperatures, such as (typically) 77 K or "196°C (the boiling point of liquid nitrogen). At these low temperatures, any biological activity, including the biochemical reactions that would lead to cell death, is effectively stopped. However, when vitrification solutions are not used, the cells being preserved are often damaged due to freezing during the approach to low temperatures or warming to room temperature.[14]

MEDICOLEGAL CONSIDERATIONS

Embalming changes the appearance of the body as well as organs and tissues. This makes it difficult to detect injuries or poisons. Hence in suspected cases of suicide or homicide organs and specimens should be removed before embalming. Conducting embalming before autopsy invites liability under

section 201 IPC (causing disappearance of evidence of offence or giving false information to screen offender). Any disrespect of the corpse invites applicability of section 297 IPC. Embalming incisions can be incorrectly interpreted sometimes for non-existent antemortem stab wounds.[15]

Precautions with Infectious cadavers

There have been reported cases of TB and HIV spread from a cadaver to embalmers. HIV has been recovered from bone fragments, brain, bone marrow, spleen, and lymph nodes from a patient with AIDS at autopsy six days after death. Hence extra precautions need to be taken by embalmers.[16] These include taking extreme care to prevent cuts, lacerations and splashing of contaminated blood or body fluids, wearing two pairs of intact disposable gloves, safety glasses or goggles, or a face shield (with safety glasses or goggles) when there is a chance of fluids splashing. Pack and cover open sores or lesions and orifices with cotton soaked in sodium hypochlorite solution. All equipment used should be disposable. Treat blood, body fluids and aspirated contents with a medical grade disinfectant for 30 minutes before disposal.[17]

COVID Precautions

Wearing proper PPE and making every possible effort to minimize splashing and aerosolization of fluids. NFDA (National Funeral Directors Association) are following guidelines on embalming from the World Health Organization (WHO).

While WHO's recommendations align with CDC (Centres for Disease Control and Prevention) guidance in important areas-bodies can be buried or cremated; there is no evidence of people becoming infected from exposure to the bodies of people who died of COVID-19; and families should avoid contact (i.e., touching, kissing, etc.) the body of the decedent it differs on two key points: Embalming is not recommended to avoid excessive manipulation of the body; Adults >60 years and immunosuppressed persons should not directly interact with the body.[18]

CONCLUSION

A well fixed and well embalmed cadaver is a great asset not only for anatomical dissection but also for research purposes and for viewing by friends, relatives or the public at the time of cremation. In embalming fluid, a variety of preservatives, disinfectant agents and additives which are combined in various proportions to produce the embalming fluid, the predominant chemical being formalin but sometimes are not effective enough in hindering growth of fungi, bacteria or maggots. Formaldehyde in the embalming fluid also causes a strong odour and eye irritations. A number of modern methods are getting popular, Thiel method of soft embalming, Plastination and Cryopreservation. More research is needed so that the use of formaldehyde can be greatly minimised.

COMPETING INTERESTS

The authors declare that they have no competing interests.

Authors' contributions

SR drafted the manuscript, performed the literature review & SPS assisted with writing the paper.

ACKNOWLEDGEMENT

Authors are thankful to Dean Dr. Varsha Phadke Madam for her support and encouragement. Authors also acknowledge the immense help received from the scholars whose articles are cited and included in references of this manuscript. Authors are also thankful to the teaching and non-teaching staff of Anatomy Department. The authors are also grateful to authors / editors / publishers of all those articles, journals and books from where the literature for this article has been reviewed and discussed.

REFERENCES

1. Sharadkumar P. Sawant, Shaheen Rizvi, Cadaveric Oath and Its Relevance for Students of Anatomy, Indian Journal of Anatomy, Volume 5, Issue 2, May-Aug 2016, Pages 189-193.
2. Bradbury S, Hoshino K. An improved embalming procedure for long lasting preservation of the cadaver for anatomical study. Acta anat. 1978; 101:97–103.
3. Blessing A, Olubunmi E, Abidemi O. Human Embalming Techniques: A Review. AmJBiomedSci [Internet]. 2018;10(2):82–95.
4. Bajracharya S, Magar A. Embalming: An art of preserving human body. KUMJ. 2006;4(16):554–7.
5. Hayashi S, Naito M, Kawata S, Qu N, Hatayama N, Hirai S, et al. History and future of human cadaver preservation for surgical training: from formalin to saturated salt solution method. Anat Sci Int [Internet]. 2016;91(1):1–7.
6. Pal A, Batra S. Embalming and other methods of

dead body preservation. Int J Med Toxicol Leg Med. 2010;12(3):15–9.

7. Mayer, Robert G. Embalming: History, Theory and Practice. Appleton & Lange. 1990.
8. Frederick, L.G. & Strub, Clarence. The Principles and Practice of Embalming (Fifth Edition). Professional Training Schools Inc & Robertine Frederick. 1989
9. Ikeda A, Fujimoto K, Yoshii I, Matsumoto S, Nishitani K, Ikeda K. Arterial embalming method of the cadaver and its application to research. Kaibogaku Zasshi. 1993 Aug; 68(4):410-21.
10. J Muthuvel Vijayan Kanagasabapathy, Ezhilarasan Sathurusangaravel, Evolution Med Dent Sci / eISSN - 2278-4802, pISSN - 2278-4748 / Vol. 10 / Issue 19 / May 10, 2021
11. Eisma R, Lamb C, Soames R. From Formalin to Thiel Embalming: What Changes? One Anatomy Department's Experiences. Clin Anat [Internet]. 2013; 26:564–71.
12. Ottone NE, Vargas CA, Fuentes R, Sol M del. Walter Thiel's Embalming Method Review of Solutions and Applications in Different Fields of Biomedical Research. Int J Morphol. 2016;34(4):1442–54
13. Pentea M, Hulea C, Stancu A, Butnariu M, Cristina RT. Developing the Plastination Laboratory for the Technique S10. Mater Plast. 2016;53(1):150–2.
14. Jang T, Park S, Yang J, Kim J, Seok J, Park U, et al. Cryopreservation and its clinical application. Integr Med Res [Internet]. 2017;6(1):12–8.
15. Mohd Saleem Itoo, Embalming and its medico legal aspects, Kashmir Medical Journal Vol: 7 No.1 (Jan- March 2013) 6-10.
16. Nyberg M, Suni J, Haltia M. Isolation of human immunodeficiency virus (HIV) at autopsy one to six days postmortem. Am J Clin Pathol 1990; 94:422-425. [Medline]
17. Timothy R. Sterling, M.D., Diana S. Pope, R.N., M.S., William R. Bishai, M.D., Ph.D., Susan Harrington, M.P.H., Robyn R. Gershon, M.H.S., Dr.P.H., and Richard E. Chaisson, M.D., Transmission of Mycobacterium tuberculosis from a Cadaver to an Embalmer. NEJM 2000 342:246-248
18. Collection and Submission of Postmortem Specimens from Deceased Persons with Confirmed or Suspected COVID-19, https://www.cdc.gov/.