International Journal of Research in Medical Sciences
Neelamegan S et al. Int J Res Med Sci. 2025 May;13(5):2273-2278
www.msjonline.org
pISSN 2320-6071 | eISSN 2320-6012

DOI: https://dx.doi.org/10.18203/2320-6012.ijrms20251347

Review Article

A journey through the history and future of cadavers in anatomy education

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Received: 04 March 2025
Accepted: 07 April 2025

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ABSTRACT

This article traces the development of cadavers in anatomy education from ancient times to contemporary advances, analyzing both their historical significance and future potential. It utilizes academic databases and libraries to find relevant literature, including PubMed, Google Scholar, JSTOR, and Web of Science. Specific keywords and phrases such as "history of cadaver use in medicine," "anatomical dissection history," "ethical issues in cadaver studies," "historical practices of dissection," and "evolution of medical practices with cadavers" were used to search for relevant articles. We selected articles that are directly related to the history of cadavers in medicine and that provide historical context, ethical discussions, and notable practices, while excluding those that are unrelated. The use of cadavers for dissection in medical teaching dates back to ancient Egyptian, Indian, Greek, and Roman traditions. The Renaissance saw a revival of anatomical studies despite ethical debates and restrictions, particularly during the Middle Ages, with figures such as Andreas Vesalius redefining the field. Advances in cadaver preservation techniques, including plastination and embalming, have improved quality and durability. However, the use of formalin raised health concerns, leading to the search for safer alternatives. Emerging technologies such as virtual reality (VR), augmented reality (AR), and 3D printing are revolutionizing anatomy education by providing interactive, practical, and ethically sound teaching resources. The article anticipates a future shaped by technological advances while acknowledging the enduring impact of cadavers in medical education.

Keywords: Embalming, Cadaver, Anatomy, Preservation

INTRODUCTION

Anatomy, the study of the structure and organization of the human body, is a foundation of medical education and research. For centuries, the use of cadavers, human bodies donated for scientific study, has played a crucial role in advancing our understanding of the human form.

This article embarks on a journey through the history and future of cadavers in anatomy education, exploring their evolution, ethical considerations, and the innovative alternatives that may shape the future of this essential field.

THE ORIGINS OF CADAVER DISSECTION

The history of cadaver dissection in anatomical studies dates back to ancient times. Early civilizations, such as the Egyptians and Greeks, recognized the importance of understanding human anatomy for medical practice. The Edwin Smith Papyrus, an ancient Egyptian medical text dating back to around 1600 BCE, contains descriptions of various surgical procedures, including those related to the human body.[1] While these early practices may not have involved systematic human dissection in the way we think of it today, they did include observations of human anatomy through surgical procedures and treatment of

injuries and illnesses. However, these practices were often shrouded in secrecy and surrounded by restrictions. Ancient Egyptian embalming techniques exemplify the careful preservation of bodies for the afterlife, with mummies serving as iconic examples. The process involved meticulous organ removal and preservation methods, offering insights into ancient embalming practices.[2]

India has a rich tradition of medical knowledge dating back thousands of years, and the practice of human dissection has been a part of its medical history. However, it's important to note that dissection methods and purposes varied over time and across different regions of India. Ancient Indian texts, such as the "Sushruta Samhita" and the "Charaka Samhita," contain descriptions of surgical procedures, including dissection techniques.

Sushruta, often considered the "Father of Surgery," is credited with detailed descriptions of surgical procedures and the use of dissection to understand human anatomy. These texts date back to several centuries BCE and are foundational works in the history of Indian medicine.[3,4]

In the realm of anatomy, the Greeks, particularly during the Hellenistic period, are known to have made significant contributions to the study of human anatomy through dissection. Notable figures like Herophilus and Erasistratus, who lived in Alexandria during the 3rd century BCE, are believed to have dissected human cadavers for anatomical research and were instrumental in advancing knowledge of human anatomy.[5-7]

The Romans made significant contributions to the early practice of human dissection and the study of human anatomy, building upon the knowledge of earlier civilizations, particularly the Greeks. While their contributions were not as extensive as those of the Greeks or later Renaissance anatomists, they did play a role in advancing the understanding of human anatomy. Galen, a prominent Roman physician who lived during the 2nd century CE, is one of the most influential figures in the history of medicine.[6,8,9] He was heavily influenced by the work of earlier Greek anatomists and physicians. Galen wrote extensively on anatomy, and his detailed descriptions of the human body were based on animal dissections. While he didn't dissect human cadavers himself, his work provided important insights into human anatomy and laid foundation for future anatomical studies.

Figure 1: (a) Anubis, Greek name of a jackal-headed god was also an embalmer associated with mummification in ancient Egyptian mythology, (b) Sushruta 6th century BC was a surgeon who lived in ancient India and is the author of the book Sushruta Samhita, (c) Erasistratus (304–250 BC) was a Greek anatomist and royal physician, (d) Herophilos (right) teaching anatomy, (e) Andreas Vesalius, (f) Matteo Realdo Colombo (1515–1559) was an Italian professor of anatomy and a surgeon at the University of Padua, (g) Gabriele Falloppio (1522–1562) was an Italian priest and anatomist often known by his Latin name Fallopius, (h) Bartolomeo Eustachi (1500–1574), was an Italian anatomist, (i) Henry Gray FRS (1827–1861) was a British anatomist and surgeon, (j) injecting arterial system with vacuum pump, illustration from the book, art and science of embalming by Carl Lewis Barnes, and (k) image and description of embalming instrument from Clarkes text book of embalming.

During the middle ages, the Church's influence hindered the advancement of anatomical knowledge.[10,11] Cadaver dissection was discouraged, and it was considered forbidden practice to dissect human bodies. This period gave rise to a dependence on animal dissection and limited the progress of human anatomical research.

THE RENAISSANCE AND THE RESURGENCE OF CADAVER DISSECTION

The Renaissance period was a transformative era for the practice of human cadaver dissection and the study of human anatomy. During this time, significant advancements were made in our understanding of the human body, laying the foundation for modern anatomical knowledge and medical education. Andreas Vesalius, a Flemish physician, is often regarded as the father of modern anatomy. His groundbreaking work, "De humani corporis fabrica" (on the fabric of the human body), published in 1543, represented a turning point in the study of human anatomy.[6,8] Vesalius emphasized the importance of direct observation through human dissection, challenging traditional reliance on ancient texts. He and his students conducted extensive dissections, making detailed and accurate illustrations of human organs and structures. Vesalius's work played a pivotal role in advancing the field of anatomy.

In addition to Vesalius, other pioneering anatomists of the Renaissance period, including Realdo Colombo, Gabriele Falloppio, and Bartolomeo Eustachio, conducted human dissections and made significant contributions to the understanding of human anatomy.[12-14] Their work, often based on direct observation and systematic dissection, furthered our knowledge of the human body. This era saw figures like Henry Gray, who authored "Gray's Anatomy," revolutionizing medical education through his anatomical works. Henry Gray (1827-1861) was a British anatomist and surgeon who are best known for his work, “Gray’s Anatomy”, which is one of the most famous and enduring anatomy textbook in the world.[15]

THE ETHICAL DILEMMAS OF CADAVER USE

The use of cadavers in anatomy education has always raised ethical concerns. The source of cadavers has been a subject of debate, with the historical prevalence of grave robbing and body snatching contributing to a dark past. In response to these issues, regulations and ethical guidelines have been established to ensure that cadavers are sourced ethically and that the donors' wishes are respected.

An important ethical consideration is the respect and dignity of the deceased. Many institutions have implemented protocols to ensure that cadavers are treated with the utmost respect and used exclusively for educational and research purposes. Donor programs have become instrumental in providing a legal and ethical source of cadavers. The Anatomy Act of 1832 in the United Kingdom marked a turning point by legally regulating the acquisition of unclaimed bodies for medical education and research. Anatomy Act was enacted in India in 1948. Anatomy Act is the state act promoted by legislature and published in the State Government Gazette.[16,17] This act provides to take possession of unclaimed dead bodies in hospital, prison, public places for purpose of aforesaid. India first experienced body donation in 1956. With increase in medical institution in the country, there is increase in demand of cadavers for dissection. So, to overcome this demand, the Anatomy Act was enacted by various states in India to provide the supply of unclaimed bodies to medical and teaching institutes for purpose of anatomical examination and dissection. Due to anatomical Act, unclaimed bodies are used legally in medical institute and after dissection/used body are criminated properly according to social and religious customs.[18,19]

THE EVOLUTION OF CADAVER PRESERVATION AND DISSECTION TECHNIQUES

Advancements in preservation techniques have significantly enhanced the longevity and quality of cadavers. One practice that has endured through the ages is embalming, the art of preserving a deceased person's body. While embalming has cultural and religious significance in some societies, it plays a unique role in academia and scientific investigations, allowing researchers, students, and medical professionals to study and work with human anatomical specimens.

Ancient beginnings: Egyptian mummification

The origins of embalming can be traced back to ancient Egypt, where mummification was a sacred practice dating as far back as 2600 BCE. The Egyptians believed that preserving the body was essential for the deceased to embark on their journey to the afterlife. Mummification included the removal of organs, drying the corpse, and wrapping it in linen bandages, creating the iconic mummies we associate with Egypt.[20]

SCIENTIFIC EVOLUTION OF EMBALMING

Fast forward to the 17th century, embalming took a significant scientific turn. English physician William Harvey, renowned for his groundbreaking work on the circulatory system, pioneered the use of chemical injections to preserve bodies.[21] However, it was the Scottish physician William Hunter who first applied this knowledge to the field of embalming.[22] He published a report outlining the best procedures for preserving bodies for burial, marking the birth of modern embalming techniques.

The modern embalming process

Arterial embalming, the primary method used today, involves injecting embalming fluids into the major blood

vessels to replace bodily fluids with formalin. The process differs between bodies destined for dissection and those for funerals. Medical colleges typically use a sanitizing agent to prepare bodies for embalming, injecting chemicals into the femoral artery and sometimes draining blood. The injected solution, containing alcohol, formalin, phenol, and water cause tissue expansion, which subsides over time. Additional chemicals may be used during dissection to prevent dehydration and mold formation. Medical colleges and museums may employ more advanced preservation techniques like freeze-drying or plastination. The embalming fluid aims to preserve tissue, retain natural color, and prevent dehydration, mold, and bacterial contamination. Surface and hypodermic embalming are supplemental methods used when vascular injection is insufficient.[23] Vascular embalming utilizes the body's blood vessels to preserve and sanitize the body, while cavity embalming treats body cavities directly, often done after arterial embalming. Arterial embalming involves injecting preservative solution into large arteries, bypassing the heart, and flowing through the circulatory system.[39,40]

Formalin embalming: a double-edged sword

Formalin, while cost-effective and efficient against microbial contamination, comes with trade-offs. As time passes, the preserved tissue becomes less similar to the body's natural structures and becomes more compressed. Prolonged inhalation of formalin fumes has been linked to health risks, including nasal sinus cancer and leukemia, particularly myeloid leukemia.[24] Further reduction of formaldehyde exposure in formalin-embalmed specimens can be achieved by treating them with chemical agents such as monoethanolamine (MEA), potassium permanganate, or sodium metabisulfite infutrace™ solution, which are designed to capture and neutralize formalin.

The search for alternatives

Given the health concerns associated with formalin, there is an ongoing quest for alternative embalming methods. These methods are often chosen based on the specific needs and objectives of academic and research institutions.[25-30] Various preservation methods are employed to maintain cadaveric and biological specimens, each with its distinct advantages and limitations.

Thiel embalming is designed to preserve cadavers while retaining a natural appearance and tissue elasticity through a specialized fluid. This method is invaluable for research and surgical training because it maintains the balance between preservation and tissue properties, although it requires costly, specific embalming fluids and can be labor-intensive and complex. Additionally, its long-term efficacy is less proven compared to traditional techniques.

Formaldehyde-free and low-formaldehyde content fluids are seen as environmentally friendly and less hazardous alternatives to formalin, which appeals to those concerned about health effects. However, these fluids may not preserve tissues as effectively as traditional formalin, and their variability in chemical composition can lead to inconsistent preservation. They can also be more expensive.

Polymer preservation (plastination) involves immersing tissues in a polymer solution, which enhances durability and decay resistance, creating specimens with realistic colors and textures ideal for long-term anatomical studies. Despite its benefits, plastination results in relatively inflexible specimens, making it challenging to reflect deeper anatomical features, and the process is both time-consuming and costly, requiring specialized equipment and training. Lastly, cryopreservation preserves biological structures by freezing tissues at extremely low temperatures, a method frequently used in cellular and molecular biology research. It effectively maintains biological structures but demands constant low temperatures, incurs high energy costs, and risks ice crystal formation that can damage tissues. This method also requires complex and costly infrastructure and may not be suitable for all types of specimens.

A CONTINUING JOURNEY

The development of embalming procedures was the result of a series of innovations, experiments, and cultural variations throughout history. These methods evolved alongside medical discoveries and technological advancements, all aimed at delaying decomposition, ensuring a dignified presentation, and minimizing the use of formalin due to its carcinogenic effects. As the world of embalming continues to adapt to new challenges and discoveries, the need for international standards in the field becomes more apparent. These standards should focus on the safe and effective preservation of bodies for academic and scientific purposes, fostering both respect for the deceased and advancements in knowledge for future generations. Embalming is not just a practical procedure; it is a testament to humanity's enduring curiosity, reverence for the past, and commitment to understanding the intricate mysteries of life and death.

THE FUTURE OF ANATOMY EDUCATION: ALTERNATIVES AND INNOVATIONS

As technology advances, there is a growing shift towards alternative methods for anatomy education. Virtual reality (VR) and augmented reality (AR) have introduced immersive experiences that enable students to explore the human body in three dimensions without the need for physical cadavers.[31,32] These technologies offer interactive learning environments that can be customized to meet the specific needs of students. The future of anatomy education may involve cutting-edge virtual reality simulations and AI-assisted tools. Virtual dissection tables like the Anatomage table offer immersive, ethical alternatives to traditional cadaver dissection.[33,34] AI tools

could provide real-time guidance during dissections and create highly realistic virtual human models for interactive learning experiences.

Synthetic human corpse models, replicating the appearance and feel of human tissues and organs, have also become valuable tools in modern medical education.[35] They offer practical, ethical, and repeatable learning experiences, providing students with hands-on experience without the limitations associated with working on real human bodies. While they don't replace all aspects of cadaver study, synthetic models are pivotal in modern medical education.

Additionally, 3D printing has emerged as a promising tool in anatomy education.[36-38] It allows for the creation of anatomical models that replicate the complexity of the human body with great precision. 3D-printed models are cost-effective and can be produced in various sizes and levels of detail to cater to different educational needs.

CONCLUSION

The journey through the history and future of cadavers in anatomy education is marked by a long evolution from taboo and secrecy to regulation, ethical considerations, and technological advancements. Cadavers have been instrumental in advancing our understanding of human anatomy, but the field is now on the edge of a transformation. Alternative methods, such as VR, AR, and 3D printing, are poised to complement or even replace traditional cadaver dissection, making anatomy education more accessible, ethical, and effective than ever before. While we honor the invaluable contributions of historical practices, we also anticipate a bright future where innovative approaches ensure that the study of anatomy remains dynamic and accessible for generations to come. While the role of cadavers in the future of anatomy education may change, their legacy as the foundation of anatomical knowledge will endure.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: Not required

REFERENCES

1. Van Middendorp JJ, Sanchez GM, Burridge AL. The Edwin Smith papyrus: a clinical reappraisal of the oldest known document on spinal injuries. Eur Spine J. 2010;19(11):1815-23.
2. Huber B, Hammann S, Loeben CE, Jha DK, Vassão DG, Larsen T, et al. Biomolecular characterization of 3500-year-old ancient Egyptian mummification balms from the Valley of the Kings. Sci Rep. 2023;13(1):12477.
3. Loukas M, Lanteri A, Ferrauiola J, Tubbs RS, Maharaja G, Shoja MM, et al. Anatomy in ancient India: a focus on the Susruta Samhita. J Anat. 2010;217(6):646-50.
4. Susruta. An English translation of the Sushruta samhita, based on original Sanskrit text. Volume 1. Calcutta: Kaviraj Kunja Lal Bhishagratna. 1907.
5. Serageldin I. Ancient Alexandria and the dawn of medical science. Glob Cardiol Sci Pract. 2013;2013(4):395-404.
6. Elizondo-Omaña RE, Guzmán-López S, García-Rodríguez Mde L. Dissection as a teaching tool: past, present, and future. Anat Rec B New Anat. 2005;285(1):11-5.
7. Von Staden H. The discovery of the body: human dissection and its cultural contexts in ancient Greece. Yale J Biol Med. 1992;65(3):223-41.
8. Harcourt G. Andreas Vesalius and the anatomy of antique sculpture. Representations. 1987;(17):28-61.
9. Habbal O. The science of anatomy: a historical timeline. Sultan Qaboos Univ Med J. 2017;17:e18-22.
10. Mavrodi A, Paraskevas G. Mondino de Luzzi: a luminous figure in the darkness of the Middle Ages. Croat Med J. 2014;55(1):50-3.
11. Ghosh SK. Human cadaveric dissection: a historical account from ancient Greece to the modern era. Anat Cell Biol. 2015;48(3):153-69.
12. Eknoyan G, De Santo NG. Realdo Colombo (1516-1559). A reappraisal. Am J Nephrol. 1997;17(3-4):261-8.
13. Mortazavi MM, Adeeb N, Latif B, Watanabe K, Deep A, Griessenauer CJ, et al. Gabriele Fallopio (1523-1562) and his contributions to the development of medicine and anatomy. Childs Nerv Syst. 2013;29(6):877-80.
14. Dario A, Armocida GO, Locatelli D. An ancestor of the stereotactic atlases: the Tabulae Anatomicae of Bartolomeo Eustachio. Neurosurg Focus. 2019;47(3):E11.
15. Shahi N, Brooks AL, Yeo CJ, Cowan SW, Isenberg GA. Remembering Dr. Henry W. Gray (1827-1861) and his timeless contribution to modern medical education. Am Surg. 2016;82(11):1043-5.
16. Kumar K, Chandarana M, Kumar A. Body donation and its ethics. World J Phar Life Sci. 2019;5(9):105-7.
17. Parthasarathy P. Body donation and its relevance in anatomy learning. Drug Invent Today. 2018;10:2877.
18. Sarma A. Body donation and its importance in teaching of anatomy. Int J Health Res Med Leg Pract. 2014;1:14-8.
19. Dange M, Jape R, Bhagwat S, Humne S, Deshpande A. The anatomy act. J Ayurveda Holist Med. 2013;3:26-8.
20. Sluglett J. Mummification in ancient Egypt. West Engl Med J. 1990;105 (4):117-9.
21. Ribatti D. William Harvey and the discovery of the circulation of the blood. J Angiogenes Res. 2009;1:3.
22. Friedlaender GE, Friedlaender LK. Art in science: William and John Hunter-Gifts of the Enlightenment. Clin Orthop Relat Res. 2019;477(4):700-4.
23. Mayer RG. Embalming: history, theory, and practice. 5th edition. New York: McGraw-Hill Medical. 2012.

24. Brenner E. Human body preservation - old and new techniques. J Anat. 2014;224(3):316-44.
25. Liao PY, Wang ZG. Thiel-embalming technique: investigation of possible modification in embalming tissue as evaluation model for radiofrequency ablation. J Biomed Res. 2019;33(4):280-8.
26. Ottone N, Vargas CA, Fuentes R, Sol M. Walter Thiel's embalming method. Review of solutions and applications in different fields of biomedical research. Int J Morphol. 2016;34:1442-54.
27. Coleman R, Kogan I. An improved low-formaldehyde embalming fluid to preserve cadavers for anatomy teaching. J Anat. 1998;192(Pt 3):443-6.
28. Neha V, Patankar H, Choudhari V. Plastination: an incipient way of learning anatomy - a review. J Anat. 2021;7:164-8.
29. Singh O, Mishra BK, Pandit S, Maheshwari TP, Hasan S. Plastination: a promising method for preserving biological specimens: a review article. Int J Sci Res Publ. 2013;3(6):1-5.
30. Baust JG, Gao D, Baust JM. Cryopreservation: an emerging paradigm change. Organogenesis. 2009;5(3):90-6.
31. Jiang H, Vimalesvaran S, Wang JK, Lim KB, Mogali SR, Car LT. Virtual reality in medical students' education: scoping review. JMIR Med Educ. 2022;8(1):e34860.
32. Moro C, Štromberga Z, Raikos A, Stirling A. The effectiveness of virtual and augmented reality in health sciences and medical anatomy. Anat Sci Educ. 2017;10(6):549-59.
33. Bartoletti-Stella A, Gatta V, Mariani GA, Gobbi P, Falconi M, Manzoli L, et al. Three-dimensional virtual anatomy as a new approach for medical student's learning. Int J Environ Res Public Health. 2021;18(24):13247.
34. Goshu B. Teaching gross anatomy: Anatomage table as an innovative line of attack. Int J Anat Var. 2020;13(1):76-9.
35. Ravi K, Patra A, Pushpa N. Future of cadaveric dissection in anatomical science education. Natl J Clin Anat. 2022;11:123-5.
36. McMenamin PG, Quayle MR, McHenry CR, Adams JW. The production of anatomical teaching resources using three-dimensional (3D) printing technology. Anat Sci Educ. 2014;7(6):479-86.
37. Garas M, Vaccarezza M, Newland G, McVay-Doornbusch K, Hasani J. 3D-Printed specimens as a valuable tool in anatomy education: A pilot study. Ann Anat. 2018;219:57-64.
38. Saleem SN, Seddik SAE, El-Halwagy M. Scanning and three-dimensional-printing using computed tomography of the "Golden Boy" mummy. Front Med (Lausanne). 2023;9:1028377.
39. Barnes CL. The Art and Science of Embalming Descriptive and Operative. Chicago Illinois: Trade Periodical Company. 1896.
40. Clarke JH. Clarke's text-book on embalming: illustrating and describing the anatomy of the human body as is needed by the professional or expert embalmer: Clarke Chemical Works, Springfield, Ohio. 1885.

Cite this article as: Neelamegan S, Meenakshisundaram M, Variyar KK, Dhanasekaran M, Pandian H. A journey through the history and future of cadavers in anatomy education. Int J Res Med Sci 2025;13:2273-8.