

Argomento n. 1

Descrivere i principi su cui si basano le tecniche di plastinazione

Argomento n.2

Descrivere le principali metodiche di
preparazione di calchi vascolari con resine

Argomento n.3

Descrivere le principali metodiche di preservazione di cadaveri

Argomento n. 4

Descrivere la gestione tecnica e organizzativa di un programma di donazione del corpo

Argomento n.5

Descrivere la gestione tecnica e organizzativa di un laboratorio di anatomia microscopica e relativo sistema di Qualità

REVIEW

Human Preservation Techniques in Anatomy: A 21st Century Medical Education Perspective

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Anatomy is the cornerstone of education for healthcare professionals with the use of human material providing an excellent teaching tool in the modern curricula. The ability and quality of preservation of human remains has enabled such use. The introduction of formaldehyde as a preservative in 1893 was an important step in the history of preservation. With the European Union directive on the use of formaldehyde and its expected banning, anatomists are trying to find a more convenient and safe substitute. In this review, we compare the different techniques used based on the need for embalming, fixative used, period of preservation and the features of the embalmed specimen. The fact that embalming is used in different disciplines, multiple purposes and described in different languages has led to the development of ambiguous interchangeable terminology. Overall, there is a lack of information specifically classifying, listing and comparing different embalming techniques, and this may be due to the fact that no internationally recognized experimental standards are adhered to in this field. Anatomists strive to find an embalming technique that allows the preserved specimen to accurately resemble the living tissue, preserve the body for a long period of time and reduces health risk concerns related to working with cadavers. There is a need for embalming to shift to an independent modern day science with well-founded research at the heart of it. While this may take time and agreement across nations, we feel that this review adds to the literature to provide a variety of different methods that can be employed for human tissue preservation depending on the desired outcome. Clin. Anat. 28:725–734, 2015. © 2015 Wiley Periodicals, Inc.

Key words: embalming; anatomy; cadaver; soft-preserve; hard-fix; education; research; Thiel; Genelyn; formaldehyde

INTRODUCTION

For more than 3,000 years human beings have tried to stop after-death body decay to preserve the mortal frame for the afterlife or reanimation (Weiglein, 2002). For example, the mummification performed by the ancient Egyptians and cryopreservation in the 20th century (Jones, 1997). Embalming is a chemical process that is used to preserve and sanitize the human body after death (Bradbury and Hoshino, 1978). The practice of embalming in more recent times has been performed to keep the dead body in good condition until after the funeral which is believed to have started in 1861 during the American civil war (Ezugworie et al., 2008). Injecting fluids into the

body's vessels as part of the embalming process only came after William Harvey described the blood circulation (Aird, 2011). The basic constituents of the various embalming formulas are divided into six general chemical groups: preservative or fixative, disinfectant, modifying agent (buffer, anticoagulant, and surfactant,

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Received 17 February 2015; Revised 29 May 2015; Accepted 29 May 2015

Published online 28 June 2015 in Wiley Online Library (wileyonlinelibrary.com). DOI: 10.1002/ca.22585

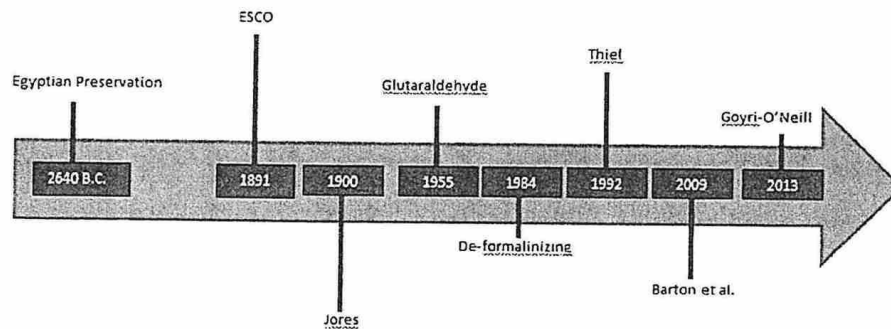


Fig. 1. A timeline of different preservation techniques from the ancient Egyptian to the current embalming technique. (ESCO = The Embalmet's Supply Company, Ontario). [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

humectant), dyes, perfuming agents and diluents (Mayer, 2011).

The main concern of the embalmer for funeral reasons is the outer appearance of the body, the preservation of tissue and the disinfection of the body to reduce any potential infection risks (Davidson and Benjamin, 2006; Trompette and Lemonnier, 2009). Embalmers aim to disinfect the body to decrease any chances of infection to the general public that are viewing the body and to maintain a healthy working environment (Davidson and Benjamin, 2006). Embalming solutions are tested for their ability to kill bacteria such as *Staphylococcus aureus*, *Pseudomonas aeruginosa*, and *Proteus vulgaris* (Woodburne and Lawrence, 1952). The study of human morphology also requires the preservation of the body to allow anatomical investigation over an extended period of time, or the use of fresh cadavers for a shorter investigation. Human cadavers could be a source of infection for both students and teachers when used for dissection, therefore, embalming is used to reduce or eliminate that risk (Shoja et al., 2013). The sourcing of cadavers has gone through many challenges and phases. It has also passed through periods of changing legislation, where challenges have originated from religious and cultural issues, or other personal considerations (Anyanwu et al., 2011). Different sources and methods of cadaver acquisition have been used in anatomical history. An example of these sources include bodies of gibbeted victims and bodies of those executed by other means, stolen bodies from graveyards, unclaimed bodies, criminals that died in battle or in prison, bodies of victims of murder, and most recently body donation (Anyanwu et al., 2011).

One of the practical methods used to teach human anatomy is by dissecting a human cadaver. Dissection has been described by some anatomists as "a mainstay of properly rigorous basic science training" (McLachlan et al., 2004). It is widely believed that the process of dissection adds a three dimensional view to the students' knowledge, and reinforces concepts introduced in lectures and tutorials (Turner et al., 2005).

Formaldehyde was first discovered by August Wilhelm von Hofmann in 1863 and its introduction as a

fixative in 1893 was an important step in preservation (Blum, 1893; Binawara et al., 2010). Figure 1 is a timeline of different preservation techniques, from ancient Egyptian to currently used methods, according to their dates of usage. Formaldehyde is used to preserve human tissue, and also used to preserve zoological and entomological specimens (Fox et al., 1985). One of the main functions of formaldehyde is the cross-linking of tissue constituents proteins, which make the tissue less accessible to microorganisms, preventing its decay (Fox et al., 1985; Mason and O'Leary, 1991; Titford, 2012). Vapors secreted from formalin-embalmed cadavers have been suggested to be carcinogenic even with the use of personal protective equipment in the gross anatomy laboratory (Hubbell et al., 2002; Guo et al., 2012). Formalin embalmed cadavers do not exhibit many of the qualities of living organs, among which are color, softness, pliability, the pulsatile nature of the heart and arteries, and the expansion of aerated lungs (Hubbell et al., 2002).

An extensive literature search was performed to document the different embalming techniques that are used to preserve human cadavers. The aim of this review is to focus on the preservation of a full human cadaver. The main criteria used to filter the results can be divided into four categories. The first criterion is whether the solution described in the article has been used or it could potentially be used on a human cadaver. The second criterion is the fixative or preservative used in the solution (formalin vs. non formalin). Since the value of the fixative can be assessed in relation to the efficacy of the method of delivery and subsequent storage practices, these details were mentioned when available but were not used as a criterion as they are not available for all techniques. The third criterion is the preservation period under which the cadaver could be used before decomposition starts. The fourth is the quality of tissue and organs of the preserved human cadaver, though there are no clear criteria on how to decide whether the embalmed body is soft or hard-fixed.

Some terms used for describing preservation techniques are considered to be ambiguous; therefore