Journal of Animal and Veterinary Advances 10 (12): 1561-1567, 2011
ISSN: 1680-5593

Shellac: A Non-Toxic Preservative for Human Embalming Techniques

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Abstract: It is extremely important to fix and preserve cadavers adequately not only for the sake of anatomical studies but also for the financial justification. However, the difficulties in handling and the problems of preservation of human anatomical preparations and the potential health and safety problems for staff and students in gross anatomy laboratories and the need to comply with increasingly restrictive exposure limits to components of embalming chemicals have led the research team to fashion a new embalming technique. The study was performed at the Department of Anatomy, Faculty of Medicine, King Abdulaziz University, Jeddah, Saudi Arabia through the years 2008-2010. About 10 cadavers were selected from the fridges of the dissection lab of the Anatomy Department; 5 for long-term preservation and five for softening purposes. The procedure involved rinsing the cadavers with the Shellac embalming solution in a pressurized tank, under a pressure of 1.5 bars for 3 days. In this study, it is revealed that there is a remarkably high embalming capacity of Shellac as shown from the well preserved dissected parts and organs in the softened cadavers. The remaining cadavers, intended for long-term preservation, mummified using Shellac could be retained in normal room conditions; whereby it was easy to soften again by simply replacing it inside the softening tank for 2-3 days. The significant use of Shellac throughout the embalming technique, as a less hazardous and financially more viable material, was discussed juxtapose more conventional and known toxic materials used in standard embalming techniques.

Key words: Shellac, human cadaver, formaldehyde, embalming, standard, KSA

INTRODUCTION

Gross anatomy is the core subject and is one of the fundamental topics in medical education. It describes the normal structure of the human body and forms a springboard for study of any anatomical abnormalities (Bay and Ling, 2007; Shamsuddin *et al*., 2009). Dissection of human cadavers still play an important role in learning it and is ideally the most valuable mean of gaining an understanding of proper anatomy as well in undergraduate as in postgraduate education (Parker, 2002; Rizzolo and Stewart, 2006; Korf *et al*., 2008).

It is extremely important to fix and preserve cadavers adequately not only for the sake of anatomical study but also for the financial justification. However, the difficulties in handling and the problems of preservation of human anatomical preparations and the potential health and safety problems for staff and students in gross anatomy laboratories and the need to comply with increasingly restrictive exposure limits to components of embalming chemicals, have led many investigators either to fashion new embalming techniques or to improve the standard employed techniques which used the formaldehyde as an essential ingredient (Ikeda *et al*., 1993; Bajracharya and Magar, 2006).

Concern has been expressed in relation to the occupational exposure to formaldehyde by workers in anatomical laboratories (Papst, 1987) and this was recently emphasized by Blair *et al*. (1990) whose findings indicated that there was a greater than average incidence of malignancies of the haemopoietic and lymphoid system amongst anatomists and embalmers in many laboratories. In addition, formadehyde has been declared a potential carcinogen. This substance has been shown to cause mutation in various primitive organisms and in cultured mammalian cells (Nishioka, 1973; Chanet *et al*., 1976). Inhaled formaldehyde also caused nasal carcinoma in rats and mice (Albert *et al*., 1982).

Several European countries restrict the use of formaldehyde, including the import of formaldehyde-

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reated products and embalming. The European Union is considering a complete ban on the use of formaldehyde as a biocide (including embalming) under the Biocidal Products Directive (98/8/EC) (The European Parliament and The Council of the European Union, 1998, 2003). Countries with a strong tradition of embalming corpses, such as Ireland and other colder-weather countries have raised concerns. Despite reports to the contrary, no decision on the inclusion of formaldehyde on Annex I of the Biocidal Products Directive for product-type 22 (embalming and taxidermist fluids) had been made as of September 2009 http://en.wikipedia.org/wiki/Formaldehyde-cite_note-14.

Shellac is natural polymer of animal origin which is derived from the hardened secretion of the lac insect, Laccifer (Tachardia) lacca (order Homoptera, family Coccidea). These are scale-like insects which grow on some specific types of trees in China, India, Burma, Thailand, Laos, Cambodiaand Vietnam. The resin is secreted as a covering for the insect larvae. The lac is collected from host trees by cutting branches containing resinous insectsand grinding and further processing. Processing involves various steps including melting, screening and filtering and can involve solvent extraction and decolorising with activated charcoal (USFDA, 2001, 2002).

Shellac is composed of complex mixture of aliphatic and alicyclic hydroxy acids and their polyesters. Components include aleuritic acid, shelloic acid, jalaric acid and other compounds. A dye called laccaic acid is associated with the crude lac and removed by processing. Shellac is soluble in alcohol and alkaline solutions but insoluble in water and possesses a very low water and acid permeability (Limmatvapirat *et al*., 2005; Luangtana-Anan *et al*., 2007).

Due to the natural origin of Shellac and protective properties by forming a superficial protective film, it is widely used in the food industry, sealing, glossing and in the pharmaceutical industry where it is used as an acceptable enteric coating material for phyto-pharmaceuticals and food additives where synthetic polymers do not fit into the product image (Sankaranarayanan, 1989; Smolinske, 1992; McGuire and Dimitroglou, 1999; McGuire and Hagenmaier, 2001). Shellac was also traditionally used as a dental lac in many Pacific countries and in the last few decades, several primary clinical trials have been conducted suggesting the efficiency of this resin as a professional dental product in dental caries prevention and dentin hypersensitivity management (Limmatvapirat *et al*., 2004, 2007).

Upon review of the aforementioned literature, no reports were found to suggest the use or investigation of shellac in tissue preservation. Therefore, this study was designed to evaluate the efficiency of Shellac and its effects on human cadaveric preservation, along with its potential to reduce hazards associated with the use of more conventional embalming procedures; posing Anatomy Department the field of human dissection.

MATERIALS AND METHODS

The study was conducted in the dissection lab of the Anatomy Department, Faculty of Medicine, King Abdul Aziz University, Jeddah, Saudi Arabia after approval of the Ethical Committee of the Faculty. About 10 locally donated complete human cadavers were obtained from the fridge of the dissection lab of the Anatomy Department; six females and four males. Their ages ranged from 58-69 years as recorded in their files.

Equipment and materials: About 20, 100 and 250 L capacity storing tanks (2 from each) (Fig. 1), pressurized tank (Fig. 2), pumps (2), air compressor, spray gun

Fig. 1: A photograph showing the 250 L capacity storing tank with attached 2 pumps

Fig. 2: A photograph showing the pressurized tank

connected to air compressor, cutting plate, small hammer and hand tools, 100 kg dry Shellacand 150 L of ethyl alcohol.

Solution preparation: The approximate quantity of shellac used in the embalming procedure was 80 kg of dry resin (purchased from the local markets) which was placed in a 250 L capacity plastic tankand in a separate tank, 120 L of ethyl alcohol and 80 L of clean water were mixed together. Diluted ethyl alcohol was added to the dry shellac causing a reaction between the components and wax to settle at the bottom. Following a 2 h period, a semi transparent solution could be observed with most of the wax deposited at the base of the tank. The solution was thus primed to be used for processing research.

Preparation of the cadavers: About 10 cadavers were selected; 5 for long term storage and 5 for softening purposes. All cadavers were cleaned by water and dried in open air. The breast and skull areas were opened to allow the solution to enter into all internal voids. The skull was drilled through the nose, ear or both; to insure complete circulation of the solution whereas the breast was opened by longitudinal cutting. Following this, the cadavers were kept in the pressure tank.

Pressure tank usage: The cadavers were raised about 10 cm above the bottom of the pressure tank allowing maximum circulation of the solution through the lower drain outlet then the pump was used to pour the prepared solution from the storing tank into the pressure tank. The quantity of solution was kept below the top level of the tank, securing a free gap required to be filled by pressurized air. As solution levels were confirmedand the tank tested to be firmly closed, it was connected to the air compressor. The given air pressure was adjusted at a pressure of 1.5 bars for 3 days. With the completion of this pressure period, pressurized air was released through the pressure release tank after which the testing tank was opened and the cadaver to be retained for long term storage was taken out to be covered by the waxed solution. This process was done by using an air spray while the softened cadavers were kept inside the tank (the tank was used as a softening apparatus).

Softening tank: The prepared solution was discharged in the storing tank and both inlets (upper and lower) and the middle outlet were opened for circulation of the solution. The cadavers were in touch with the solution with the pump in working condition all the time (this process prevented blockage through a circulation loop). The cover of the tank was closed under normal atmospheric pressure where the cadavers remained soft, clean and preserved throughout ready for dissection at any required time. It was found that the cadavers could be used in open air for a long time but if kept out of the tank for a period more than 1 week they may have hardened purely due to the hardening of resin however, it was found to be straightforward to soften them again by replacing them back in the same tank.

Long term stored cadaver preparation mummification: After spraying the cadaver with a waxed solution, it hardened within 2 days. This cadaver could easily be stored in room condition and if it was required for dissection/examination, it was again straightforward to re-soften by replacing it inside the softening tank for a couple of days.

RESULTS AND DISCUSSION

In this research, the first evident result was that the use of shellac extract in the technique of human cadaver's preservation gave a dissection room that is virtually free of smell as compared with those standard techniques which used the formaldehyde as a main embalming agent.

Regarding the cadavers retained for long term storage, spraying by the waxed Shellac solution resulted in a mummified cadaver which hardened within 2 days and exhibited brownish glistening discoloration of the skin (Fig. 3 and 4). These cadavers could be stored in normal room conditions for a long timeand when they were required for dissection/examination, softening entailed a straight forward procedure of replacing in inside the softening tank for 2 or 3 days.

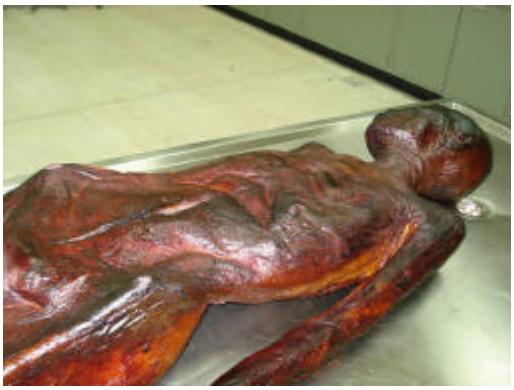

Fig. 3: A photograph showing the mummified cadaver which prepared for long term storing

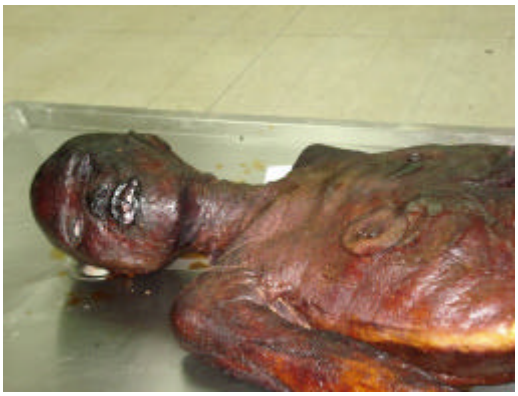

Fig. 4: A photograph showing the upper part of the above mummified cadaver

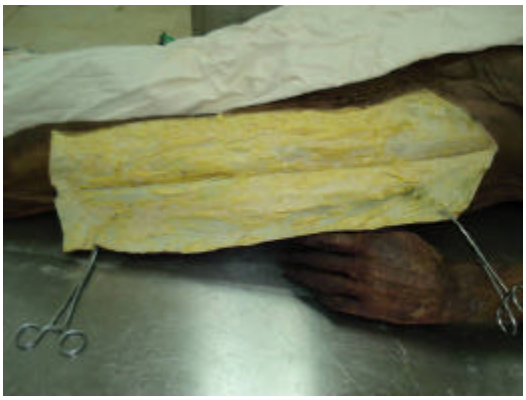

Fig. 5: A photograph showing a softened cadaver with dissected front of the thigh. Notice well preserved subcutaneous fat

In respect to the softened cadavers, detailed observations showed that they remained consistently soft and preserved throughout, ready for dissection at any given time. When used, these cadavers were exposed to open air for 5-6 days but if kept out of the tank for a period of >1 week; they became hard. Once again they were straightforward to re-soften by simply replacing them in the same tank. The noted preservative properties of the embalming solution were proven to be remarkably high with a dissection room that is virtually free of smell. Upon examination, the gross anatomy of tissues and organs showed no structural distortion on dissection with tissues remaining supple and easy to dissect. The skin exhibited brownish glistening discoloration with no color changes in the subcutaneous structures, even over a significant period. The mussels of the limbs were soft, easy to be alienated and did not exhibit also any color changes (Fig. 5-7).

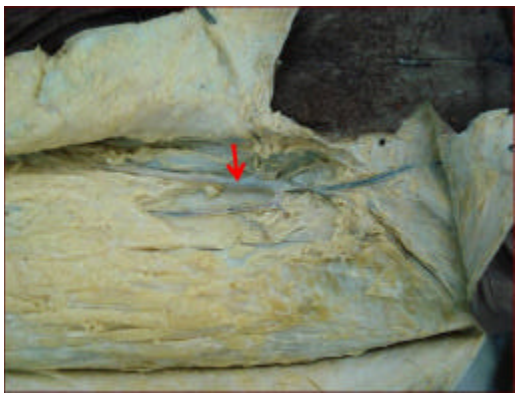

Fig. 6: A photograph showing a softened cadaver with dissected front of the thigh. Notice well preserved superficial veins (↑ = great saphenous vein)

Fig. 7: A photograph showing a softened cadaver with dissected front of the thigh. Notice well preserved and normal discolored muscles of the anterior compartment of the thigh

Regarding the tissues that are normally quite sensitive due to poor embalming such as the brain, retained some light brownish discoloration was observed in some preserved cadavers. Also, in some specimens there were minor color deposits on internal organs (Fig. 8 and 9).

Anatomy education is an essential part of the medical curriculum. Human (cadaveric) anatomical preparations have always been an excellent medium for the medical students to learn the correct anatomic structures, landmarks and relationships (Rizzolo and Stewart, 2006). A successful embalming procedure is necessary for a long-lasting preservation of the cadaver for anatomical study. However, most of the standard techniques use many toxic chemicals e.g., formaldehyde, propylene glycol, isopropyl alcohol, carbolic acid and liquefied phenol (Bajracharya and Magar, 2006).

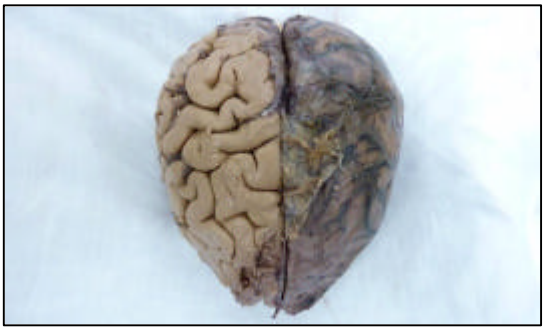

Fig. 8: A photograph showing a brain of softened cadaver. Notice the slight brownish discoloration of the brain surface and meninges

Fig. 9: A photograph showing opened abdominal cavity of softened cadaver. Notice the slight brownish discoloration of the mesentery and peritoneum

In recent years there has been an increasing awareness of the potential health hazards of exposure to formaldehyde and other ingredients in correspondence to the workplace. The (long awaited) introduction of new standards restricting levels of exposure to formaldehyde has resulted in the need to try and find practical solutions to fulfill with health and safety regulations or face closure of gross anatomy laboratories. University authorities, Safety Officers and Medical Faculties are being faced with potential major litigation in the event that workers are exposed to formaldehyde levels above the legal limits or believe their personal safety is compromised (Coleman, 1995; Coleman and Kogan, 1998).

Classical embalming mixtures, used for decades are now impractical. The search for newer low-formaldehyde embalming solutions or those with formaldehyde-substitutes has become an urgent issue. However, the subject has been largely neglected and relatively few reports on embalming of cadavers for gross anatomy laboratories have appeared or addressed this issue. Most of the reports deal with the need to reduce the concentration of the formaldehyde in embalming fluids or the use of formaldehyde substitutes (Bradbury and Hashino, 1978; Logan, 1983; Frolich *et al*., 1984; Wineski and English, 1989; O'Sullivan and Mitchell, 1993; MacDonald and MacGregor, 1997).

In this respective research, it has been clearly shown that Shellac embalming solution resulted in remarkably high, long-term preservation of cadavers with notable dissection properties and a dissection room that is virtually free of smell complying with the most rigid environmental safety restrictions. The idea to use Shellac as a major component in the embalming solution was derived from its widespread use as a food preservative with no or little known hazardous effects.

Shellac is used as an ingredient in edible fruit coatings to limit water loss and prevent desiccation and weight lossand to prevent entry of pathogens. Shellac coatings were fairly impermeable to oxygen and water and form a barrier on the fruit surface that reduces gas exchange. Reduction in oxygen levels will reduce the rate of respiration of fruits and vegetables and prolong shelf life by delaying the oxidative breakdown of the product (Kaplan, 1986; Specht *et al*., 1998; Hagenmaier, 2000; USFDA, 2001). Although, we do not yet know the entire mechanics of the preservation process, we do strongly believe that Shellac provides distinct and significant chemical properties to the embalming solution; similar to those of processed foods.

Various embalming procedures of human bodies were employed by different medical schools, placing a concerted amount of effort to decrease the amount of hazardous chemicals and improve the quality of embalming so that specimens can withstand varying degrees of handling and drying during extended periods of time cadavers are exposed during dissection in medical anatomy courses. In this domain, Coleman (1995) had introduced a novel type of dissection bed with an internal motor that causes a downflow of formaldehyde-rich vapors which is absorbed by a replaceable active carbon filtration system. Moreover, Coleman and Kogan (1998) had experimented with a new embalming mixture in order to reduce the percentage of formaldehyde with a relatively high salt content in cadaver. Recently, the process of plastination which has received worldwide acceptance for its value in preparing durable material for teaching and museum display has been applied in many medical schools (Whitten *et al*., 1991; Al-Zuhair *et al*., 1995; Von Hagens, 1996; Saeed *et al*., 2001). The plastinated preparations are non-toxic, dry and available for use in any environment and maintain and reveal precise anatomical detail. However, it is difficult technically, logistically, complexly, time consuming and expensive to implement. Thus, the fragility of specimens leaves great disadvantages facing many medical schools.

As far as we are aware, this is the first report of its kind in modern times, testing the use of Shellac in the

preservation of cadavers. The most important advantage of the study still seems to be the low toxicity levels unlike those known to be found when using formaldehyde, propylene glycol, isopropyl alcohol, carbolic acid and liquefied phenol-alongside remarkable preservation state of tissues/histology etc. Concluding, Shellac has been unremittingly successfully used for decades in food preservation and in pharmaceutical industries with its properties exhibiting fairly good resistance to desiccation and microbial spoilage.

CONCLUSION

In the study, we believe we have discovered a significant breakthrough in innovative embalming procedures. The utilization of Shellac as a main component fulfills the desired properties required for successful embalming of cadavers for gross anatomy teaching, more crucially potentially less hazardous. The procedure contributes towards the safety and research environment in the anatomy teaching laboratory, aimed at improving the working conditions in dissection rooms where students, teachers are the main beneficiaries, as well as technical staff in charge of the embalming procedure.

ACKNOWLEDGEMENT

This research was supported financially By Salem Bogshan Chair for Alzheimer's Disease, King Abdulaziz University, Saudi Arabia.

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