# MINIREVIEW

# Procedures for Embalming Cadavers for the Dissecting Laboratory (44144)

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For centuries, preservation of the human body has been practiced for ceremonial, religious, emotional, prurient, or medical purposes (1, 2). Medical education has depended in large part on the preservative qualities of formaldehyde for cadavers since the turn of the 20th century (3, 4). Unfortunately, formaldehyde has been designated as, and is, a mitogen. Preservation of cadavers is a requirement for teaching gross anatomy to medical students or students in allied medical sciences and requires disease-free specimens containing little to no mitogenic agents. To achieve this end, cadavers must be tested for the presence of human immunodeficiency virus (HIV) and prepared with the minimal use of formaldehyde. The following discourse relates a method of achieving superior preservation of disease-free cadavers and their central nervous systems.

## Materials and Methods

**Disease Control.** The medical history of a donor is the first line of defense in the process of securing disease-free cadavers. No cadaver should be accepted for removal to the teaching institution's morgue if death was due to active tuberculosis or diagnosed Jakob-Cruetzfeldt disease or if, in life, the individual tested positive for HIV or hepatitis C. Cadavers that are not embalmed must be handled with those precautions afforded a live patient with a communicable disease (i.e., protective clothes and gloves). After a cadaver is received in the morgue, a blood sample obtained from either a direct heart puncture or a raised blood vessel is submitted to the testing laboratory for evaluation for HIV. The body is held in the morgue refrigerator at 38°F until the laboratory test results are returned, which is usually 24–48 hr. When a body tests positive for HIV, it is not embalmed and is cremated as soon as possible. Although hepatitis can be transmitted from cadavers to an individual handling the body, this does not present a danger to students after embalming and therefore is not part of the pre-embalming laboratory testing.

**Fixation of the Central Nervous System.** The central nervous system (CNS) degenerates rapidly after death. To prevent degeneration of the CNS, concentrated formaldehyde, 37% (Fisher Scientific, Springfield, NJ), is injected into the brain using a 13-gauge, 4-in. needle and a 50-ml syringe. To access the brain, the lower eyelid is retracted and the syringe needle is passed through the fascia surrounding and inferior to the eyeball to gain entrance to the superior orbital fissure. When the needle passes through the inferior orbital fissure, it has entered the confines of the dura mater. This injection is done bilaterally and is repeated 12–24 hr later. Ultimately, 150–200 ml are delivered to preserve the entire CNS.

**Embalming Mixture.** The stock embalming solution should be mixed thoroughly and stored in 1045-liter steel barrels equipped with inert liners to prevent corrosion by the contained phenol. The solution is composed of the following reagents: three parts propylene glycol (Bio Clinical Laboratories, Phillipsburg, NJ); three parts ethanol, 95% (R. W. Johnson Medical School, Piscataway, NJ); one part phenol, 90% (Kramer Chemical Co., Paterson, NJ).

In preparation for embalming the following ingredients (all from J&H Berge, Inc., South Plainfield, NJ) are added to 25 liters of hot tap water: potassium nitrate, 810 g; sodium borate, 567 g; and sodium lauryl sulfate, 3.8 g (equivalent to 0.01% of the final mix). The mixture is stirred gently to prevent foaming. Then, 12.5 liters of the stock solution are added to the dissolved salts, and the whole solution is mixed again, thoroughly. At this point, the embalming preparation is complete and ready to infuse.

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**Embalming Procedures.** The cadaver is embalmed through the axillary artery, preferentially. The axillary artery is raised and secured with surgical tape. The artery is incised, and an arterial tube (Dodge Chemical Co., Cambridge, MA) is inserted initially to direct the flow toward the heart. The arterial tube is tied in place with surgical tape, and subsequently its direction and flow is reversed to fix the associated limb. The use of the axillary artery is preferred because it compromises the fewest anatomical features and the resultant specimen is least detrimental to learning, as opposed to the use of the carotid or femoral arteries.

Embalming fluid can be delivered by gravity through the use of 19-liter carboys secured at a level of 6 ft, although an embalming machine works well if set at 2 psi initially to obtain the slowest infusion rate possible. Slow infusion of the body allows the fluid ample time to perfuse the tissues. In this manner, 28–38 liters of embalming fluid can be delivered to the body. To insure fixation of the calves, hamstrings, buttocks, and superficial and deep muscles of the back, embalming fluid is injected into these areas at multiple sites by either syringe or the embalming machine set at the lowest flow rate possible. An 8 in child's trocar (Dodge Chemical Co., Cambridge, MA) is used for its small diameter and is introduced through the skin at an angle. After infusion and on withdrawal, the pressure of the fluid injected closes the infusion site and minimizes fluid loss. The need for these ancillary injections is judgmental and depends on the experience of the individual doing the embalming and the character of the cadaver, although the best preparations are those that receive this attention.

**Storage and Curing.** An embalmed body is sprayed with Mold-X (Dodge Chemical Co., Cambridge, MA) to prevent the development of mold and placed in a polyethylene tubing (Doug Brown Packaging Products, Inc., Royal Oak, MI). The ends of the tubing are tightly sealed with string ties. The bodies are stored in a room that is maintained at a constant 55°F and allowed to cure for 6 months before they are used for dissection. A refrigerated storage room could be used. When the bodies are retrieved from storage for use, they are removed from the encasing plastic and washed with tap water in preparation for transport to the dissection floor.

**Latex Infusion of the Vascular System.** The ideal cadaver for latex infusion is one received shortly after death from which blood can be drained immediately. To expel blood, a mixture of Medaflow or Permaflow V2, 950 ml (Dodge Chemical Co., Cambridge, MA), in 28 liters of water is infused with an embalming machine initially set at 2 psi. The axillary artery and vein are used for this purpose. Thereafter, the cadaver is embalmed as described above.

When the body has cured for a week or more, the axillary artery used previously to infuse embalming fluid is opened. The femoral artery on the same side of the body is raised to inject latex to color and distend the arterial system. Not all bodies accept latex well for their own reasons; however, many do, and the resulting preparation provides a positive reinforcement for the students. We use a peristaltic pump (Manostat Series A, Varistaltic Pump; Fisher Scientific, Springfield, NJ) set at its lowest flow rate, which is just enough force to get the latex to flow. Red or blue latex is infused undiluted (Carolina Biological Supply, Burlington, NC). The amount used varies with each cadaver. Usually, 300 ml are infused through the femoral artery before the latex appears at the open axillary artery. The axillary artery is clamped, and an additional 300 ml are infused. The infusion cannula is then removed, the superior portion of the femoral artery clamped, and the cannula reversed to perfuse the limb. Thus, the perfusion process requires 500–900 ml of latex. Thereafter, the cadaver is left undisturbed for 15 days to allow the latex to stabilize.

Plastic casts of the vascular system may be produced using Batson's No. 17 Plastic and Corrosion Kit (Polysciences, Inc., Warrington, PA). The preparation of the body and the vascular system to make plastic casts is the same as the preparation for latex infusion. Thereafter, the procedures prescribed by the manufacturer are followed.

**Maintenance during Dissection.** The bodies are covered with toweling (Harbor Linen, Cherry Hill, NJ) moistened with Roccal-D (The Upjohn Co., Kalamazoo, MI) to provide moisture. Rocal D acts as a bactericide, deodorant, fungicide, and virucide. It is used diluted 1:127 (i.e., 150 ml are added to 19 liters of tap water). The moistened toweling is covered with a sheet of plastic large enough to allow its edges to be tucked beneath the body. The plastic sheet prevents evaporation and maintains the condition of the tissues for as long as 6 months.

**Curing and Storage of Brains after Removal.** Brains are removed and studied during the gross anatomy course. Thereafter, they are held for the subsequent neuroanatomy course. To prepare the brains for the neuroanatomy course, they are soaked overnight in tap water to facilitate the removal of the formaldehyde used to fix the brain originally. The brains are then placed in a solution of alcohol:polyethylene glycol:water, 1:1:2 containing 125 ml of Zephiran Chloride (Winthrop Laboratories, NY, NY) per 19 liters of the mixture. Brains are stored in this mixture indefinitely.

## Discussion

There is nothing magical about the preservation of cadavers. Formaldehyde is a good fixative, but it must be used sparingly for the safety of the dissector. The process described above also produces a good specimen. The preservative qualities of alcohol and phenol are well established, but the use of the various sodium salts requires a rationale. Sodium lauryl sulfate is a surfactant and enables embalming fluid to access all areas of the cadaver. Sodium nitrate is well known as a preservative. Sodium borate acts to buffer the embalming mixture at pH 9 and affords protection against mold growth and bacterial decomposition. Thus, each salt functions to benefit the process of preserving the body. Polyethylene glycol is superior to glycerine as a solu-

bilizer and is an inhibitor of mold growth. During curing or storage, Mold-X is used to prevent development of mold on the body. In the past, paraformaldehyde crystals (Action Powder; Dodge Chemical Co., Cambridge, MA) were distributed over the body within the encasing polyethylene tubing to preserve the external surfaces of the cadaver by preventing development of mold. Because of the toxic properties of paraformaldehyde and the attendant necessary neutralization of the contaminated wash water, we have discontinued the use of paraformaldehyde crystals. After dissection begins, deterioration of the anatomical material by desiccation is prevented by a moistening solution. Evaporation of the moistening solution that is applied to the covering toweling is inhibited by the encasing plastic sheeting. The moistening solution contains benzalkonium chloride, a major component of both Zephiran Chloride and Roccal-D. It wards off contaminating mold and bacterial growth. Zephiran Chloride is preferred for use in storing brains because it is essentially colorless. Neither preparation is noxious or odoriferous.

The fixed and cured cadaver presents with a gray skin color and upon dissection the muscles present with a gray hue. The blood vessels often appear pink in color, particularly those of the mesenteries. The large volume of fluid used to preserve the body prepares the body so that fascial planes and muscle compartments are dissected easily. It is felt that the ease of dissection is created by the mechanical distention of all the tissue compartments by the sheer volume of the embalming fluid.

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