Asian Journal of Pharmaceutical and Health Sciences
www.ajphs.com

Embalming solutions and their adverse effects: An update

Rahul Kumar[1]*, Rakesh Kumar Verma[2], Rakesh Kumar Dixit[1], Navneet Kumar[2] , Narendra Kumar[1], D. K. Katiyar[1]

Department of Pharmacology, KG Medical University, Lucknow-226003 (U.P.), India.
Department of Anatomy, KG Medical University, Lucknow-226003 (U.P.), India.

ARTICLE HISTORY

Received: 16.01.2013

Accepted: 07.02.2013

Available online: 10.05.2013

Keywords:

Embalming solutions, Formaldehyde, Glutaraldehyde and Phenoxyethanol.

***Corresponding author:**

Email : rahulkgmu@gmail.com
Tel : +91 8400299366

ABSTRACT

Both formaldehyde and glutaraldehyde based embalming solutions are widely used in preserving dead bodies and in pathology, forensic medicine and museums. Phenoxyethanol may be an alternative to them. Each of them has its merits and demerits but none of them is totally non-toxic. This review is about various possible adverse effects of these embalmbing solutions.

INTRODUCTION

After death human body starts putrefaction, to prevent this process embalming is required. By this process dead body retains its morphological characteristics for a longer time period. Later on this preserved body is used in medical institutes for the study of anatomy by students. Anatomy is the backbone in medical curriculum in which students learn the external and internal structures of human body in detail. Moreover embalming procedure can also be used to keep dead bodies intact during transportation. Besides this, embalming solution is essential constituent in preservation of parts in pathology, forensic medicine and museums. These solutions contain number of chemicals mixed in appropriate ratio for their specific purposes. Important constituents are preservatives, buffers, anticoagulants, germicides, fungicides, perfuming agents, hygroscopic agents, dyes, etc.

An ideal embalming solution should neither alter the natural structures including color of the specimen, nor have any type of adverse effects in form of topical or systemic. It should also prevent growth of insects and maggots and the putrefaction process. All these characteristics are usually not found in the routinely used embalming solutions. Therefore it becomes an important issue to educate the persons regarding the possible damages produced by the embalming solutions. This review article has been written with intention to give the information regarding components used in the embalming solutions their advantages and disadvantages.

Important chemicals like formaldehyde, glutarldehyde, methyl alcohol, phenol, glycerine, oil of winter green, eosine solution, phenoxy ethanol are used to make the embalming solutions. Depending upon the concentration of individual chemical these solutions have been grouped in to three types: (a)Formaldehyde based embalming solution, (b) Glutaraldehyde based embalming solution and (c) Phenoxyethanol based embalming solution.

Formaldehyde

Formaldehyde (HCHO) is most commonly used chemical for embalming purposes. Formaldehyde is a colorless gas with a strong, suffocating odor. It is often mixed with alcohol to make liquid called formalin. The largest source of formaldehyde is the chemical manufacturing industry. Formaldehyde is found in cigarette smoke and also can be formed in the environment during the burning of fuels or household waste. Very small amount of formaldehyde is found naturally in the human body. Formaldehyde is a popular chemical because of its low cost and can be used for many purposes like making furniture, wall paneling, etc. Formaldehyde also can be used as germicide and preservative. It is also found in items such as dyes, textiles, plastics, paper products, fertilizer, and cosmetics. Formaldehyde solutions are used as a fixative for microscopy and histology. Formaldehyde-based solutions are also used in embalming to disinfect and temporarily preserve human and animal remains. The concentration of formaldehyde is usually expressed in terms of parts per million (1 ppm = 1.248 mg/cu.m.). This is prepared by

mixing the commercially available formalin solution with tap water in the proportion of 3:1 [1]. The use of formaldehyde in preserving the tissues, organs, and body parts is very common. Technicians in histology laboratory, students in anatomy classes, are exposed to this solution. Formaldehyde has been known to produce allergy, contact dermatitis, eczema, irritation and inflammation to mucus membranes, and if ingested can produce systemic toxicity which can be fatal. This also has tendency to produce mutations and development of malignancy. Permissible limits of occupational exposure to formaldehyde are 3 ppm in a time weight average breathing zone during an 8-hour period, a ceiling concentration of 5 ppm and an acceptable maximum peak of 10 ppm for no longer than 30 minutes during a one day shift. To reduce the toxic potential of formalin it needs to be buffered by addition of a small quantity of Sodium tetraborate to get a slightly alkaline solution with a pH of 7.2. This buffered formalin needs to be freshly prepared just before preparing the embalming fluid. These chemicals are mixed to make an embalming fluid.

Occupational exposure to formaldehyde by inhalation is mainly from three types of sources: thermal or chemical decomposition of formaldehyde-based resins, formaldehyde emission from aqueous solutions (for example, embalming fluids), and the production of formaldehyde resulting from the combustion of a variety of organic compounds (for example, exhaust gases) [2]. Once absorbed, formaldehyde is very quickly broken down. Almost every tissue in the body has the ability to break down formaldehyde. It is usually converted to a non-toxic chemical called formate, which is excreted in the urine and is converted to carbon dioxide and breathed out of the body. But formaldehyde can be toxic, allergenic, and carcinogenic [3]. Acute exposure of formalin adversely affects pulmonary system. It may decrease vital capacity much more as compared to other pulmonary parameters. This may be attributed to bronchoconstriction produced by formalin [4]. Experimental studies have shown that exposure of formaldehyde may damage liver. This destruction is directly proportional to the length of exposure of formaldehyde. Few clinical studies have also shown the damaging effect of formaldehyde on liver of human beings. The hepatic damage occurs in form of congestion of hepatic parenchyma and elevation of hepatic enzymes [5-7]. Neurological toxicities after exposure to formaldehyde in human beings are manifested in form of fatigue, headache, myalgia etc. If toxicity is due to formaldehyde ingestion, person may have loss of memory, seizures, altered behavior, altered consciousness and in severe cases coma. Animal exposure of formaldehyde has shown brain damage in form of altered neurotransmission. The main neurotransmitter changes are increased serotonin and dopamine metabolites in hypothalamus [8, 9]. Hematopoietic system is not much affected by the formaldehyde exposure. However intravascular coagulopathy, alteration of red cell count and hemoglobin concentration has been reported in some studies [8]. Gastrointestinal tract is not much affected when exposure is through inhalation. However, when ingested it may adversely affect the GIT. If toxic dose of formaldehyde is ingested it produces inflammatory lesions of orophyarnx, soft palate, pharaynx, epiglottis, esophagous, stomach. These lesions are due to contact irritant and corrosive nature of formaldehyde. The lesion may be in form of ulcerations and necrosis. Clinically this toxicity manifests in form of abdominal cramps, vomiting, haematemasis, malena, altered gut motility etc. Chronic ingestion of formaldehyde may also give rise to gastric and esophageal malignancies [8-10]. Though renal system is not a major target of formaldehyde metabolism, however risk of renal failure and anuria is there in persons acutely exposed to the formaldehyde. The animal experiments have shown that formaldehyde can produce renal papillary necrosis, polyuria, increased blood nitrogen [9]. Formaldehyde is a skin irritant and dermal sensitization agent. Contact dermatitis, allergic dermatitis, erythema, epidermal hyperplasia have been shown to occur due to chronic exposure of formaldehyde in animals as well as in human beings [11]. Air born formaldehyde exposure most frequently produces eye irritation. Endocrine system and reproductive organs are minimally affected [12].

Formaldehyde may have mutagenic and carcinogenic potential. Out of all cancers nasopharyngeal cancer has been well established to have association with formaldehyde exposure. Fortunately formaldehyde has not been correlated with teratogenic potential [13-15].

To reduce the risk of damage due to formaldehyde, certain measures can be adopted. Replacing the formaldehyde with less hazardous chemical, reducing the concentration of formaldehyde in the solution, proper storage of product, closing the jar when not used, disposal of exposed clothes are some of them. Facility of fume hood just at the site of embalming, wearing personal protective equipments like face mask, safety goggles, self contained breathing apparatus, gloves, water proof smock, head gear etc further reduces the chances of exposure. Careful monitoring of lung function tests, chest x-ray, allergy testing, and examination of eyes time to time should be adopted. Other important work practices recommended are labeling the container, educating employee regarding the possible adverse effects, monitoring the air concentration of the room, avoiding eating and smoking at work place. Formaldehyde is inflammable and precautions to prevent fire should be taken. Any spill should be immediately informed. If spill occurs evacuate the room and reach to the safe place, eliminate all ignition points, spread the dry sand over the chemical, ventilate area. If contact has occurred the person should wash skin, eyes, remove contaminated clothing and should be treated as an emergency [16].

Glutaraldehyde

Glutaraldehyde an aliphatic dialdehyde is a colorless liquid with pungent smell. It is one of the best biocide agents for disinfection and sterilization at hospitals. This is very widely used in medical, scientific, and industrial application. As fixator in histochemistry and microscopy, tanning agent and as ingredients in cosmetics and pharmaceuticals are some of the important uses of gluteraldehyde pharmaceuticals [17, 18]. Radiologists use gluteraldehyde as hardener in x-ray developing solution [19]. Though considered a relatively safe, it possesses irritating and corrosive properties. The strength of gluteraldehyde may vary from 1 to 50% [20]. This variable concentration exposure may give rise multiple unexpected toxic effects. In general due to its corrosive and irritant effects it produces throat irritation, nasal bleeding, burning eyes, precipitation of asthma and sneezing [21]. Due to its tanning effect it also discolors the hands of handling persons. Large acute dose can precipitate severe headache, vomiting, and altered consciousness. The persons commonly exposed to glutaraldehyde are staff workers involved in sterilization of endoscopes, dialyzing machine, research workers, and x-ray film developers. Glutaraldehyde exhibits superior properties to formaldehyde in relation to the fixation, disinfection and sterilization. It is more effective in less concentration and in less time exposure as compared to formaldehyde. Regarding the embalming properties, glutaraldeyde is slow diffusing, but

develops rapid irreversible reactions with the body proteins. This is in contrast to the formaldehyde which is fast diffuser, but produces reversible reactions with proteins. This characteristic of glutaraldehyde favors its use as embalming solution. Only disadvantage of glutaraldehyde as embalming solution is the slow tissue perfusion resulting in appearance of signs of embalmation very late. Hardening and stiffening of body occurs after long duration. So the body has life like appearance for a longer time. Another advantage of glutaraldehyde is that reactions are less affected by pH alterations and it reacts even at the higher pH where formaldehyde becomes inactive. Because of slow diffusion and perfusion rate glutaraldehyde reacts less with blood and blood perfused tissues. This leads to minimum coagulation and more clearing of blood from tissues. This persevered tissue becomes clearer in appearance. However, if glutaraldehyde solution is kept for long time yellowish tanning and darkening of tissues occur.

Regarding the toxic potential of glutaraldehyde, it is relatively safe but numbers of animal studies have indicated that oral ingestion can produce gastrointestinal damage, alteration of behavior, precipitation of seizures. Local external contact has tendency to produce contact dermatitis, brown discoloration of skin, exfoliation of skin, conjunctivitis. Vapor inhalation of glutaraldehyde may precipitate bronchospasm, nasal discharge, excessive lacrimation, salivation, and dyspnoea [22]. Another drawback of glutaraldehyde is that it may produce photosensitivity to the ultra-violet rays. This may be responsible for the erythematous lesions after sun exposure. There is no proven risk of glutaraldehyde as genotoxic and mutagenic agent but most of the studies are based on animals. Therefore chances of mutagenicity, genotoxicity, and carcinogenicity cannot be excluded in humans. The persons exposed to glutaraldehyde for long duration should undergo through regular medical checkups. The teratogenic potential has not been reported in animal studies but if possible the exposure of glutaraldehyde should be avoided during pregnancy and lactation [23].

Phenoxyethanol

Phenoxyethonol also known as phenoxytol or phenoxyethyl alcohol is a colorless or light yellow, viscos liquid. This is a strong oxidizing agent. It is incompatible with acidic solutions and also has combustible property. Phenoxyethanol is a modern antimicrobial preservative. Presently this is used as common preservative in diphtheria, tetanus, and pertusis vaccine. This inactivates both bacterial and fungal growth. Other use of phenoxyethanol is as preservative of cosmetic materials. Due to its ability to inhibit phagocyte activity it is supposed to be toxic to all cells. Moreover it can alter the immunity of the exposed persons.

As for the other alternative chemicals in place of formaldehyde, Frolich *et al* in 1984 tried using phenoxyethanol as its non-toxic substitute. It proved to be impractical as the amount required was large, i.e., about 600 litres for each cadaver needing continuous emersion to prevent mould formation and the fixation process taking 5 to 10 months [24]. Various adverse effects by Phenoxyethanol can be: central nervous depression, nausea, vomiting, & sometimes diarrhea, prominent headache, later abdominal & lumbar pain, costovertebral angle tenderness, transient polyuria & then oliguria, progressing to anuria, acute renal failure, less critical pathological lesions may appear in brain, lungs, liver, meninges & heart [25].

Other components which are used in embalming solution are methyl alcohol, carbolic acid, sodium tetraborate, glycerine, eucalyptus oil, and eosine. Methyl alcohol helps in precipitation of proteins and reducing contamination. This also helps in dispersion of formaldehyde into the body tissues. Carbolic acid helps by its germicidal and fungicidal actions. Sodium tetraborate is used as buffer agent and stabilizing agent. Eucalyptus oil acts as perfume and eosine helps in giving the reddish color to the tissues.

CONCLUSION

Considering all the characters of chemicals used in embalming solution one can see that it is impractical to find out non toxic embalming solution. The person involved in process of embalming as well as students should be taught regarding the possible hazardous effects and methods to minimize. The place should be well equipped for handling of any emergency condition. Each one involved should be taught regarding the procedures of basic life supports. If any untoward incidence happens the person should be stabilized by basic life support followed by shifting to the place equipped with advance life support system.

REFERENCES

1. Dixit D. Role of standardized embalming fluid in reducing the toxic effects of formaldehyde. Indian Journal of Forensic Medicine & Toxicology 2008; 2(1):2008-012008-06.
2. Formaldehyde, 2-Butoxyethanol and 1-tert-Butoxypropan-2-ol, IARC Monographs on the Evaluation of Carcinogenic Risks to Humans 88, Lyon, France: International Agency for Research on Cancer, 2006. 39325.
3. Toxicological Profile For Formaldehyde. Agency for Toxic Substances and Disease Registry. Public Health Service 1999; 1657.
4. Farah Khaliq and Praveen Tripathi. Acute effects of formalin on pulmonary functions in gross anatomy laboratory. Indian J Physiol Pharmacol 2009; 53 (1): 9396.
5. Selman Cikmaz, Tunc Kutoglu, Mehmet Kanter, Recep Mesut. Effect of formaldehyde inhalation on rat livers: A light and electron microscopic study. Toxicol Ind Health March 2010; vol. 26 no. 2: 113-119.
6. Freestone J, Bentley A. Case of formaldehyde poisoning. Br J Pharm Pract 1989; 11:20-21.
7. Koppel C, Baudisch H, Schneider V, et al. Suicidal ingestion of formalin with fatal complications. Intensive Care Med 1990; 16:212-214.
8. Burkhart KK, Kulig KW, McMartin KE. Formate levels following a formalin ingestion. Vet Hum Toxicol 1990; 32:135-137.
9. Eells JT, McMartin KE, Black K, et al. Formaldehyde poisoning: Rapid metabolism to formic acid. JAMA, J Am Med Assoc 1981; 246:1237-1238.
10. Kilburn KH. Neurobehavioral impairment and seizures from formaldehyde. Arch Environ Health; 1994 49:37-44.
11. Rudzki E, Rebandel P, Grzywa Z. Patch tests with occupational contactants in nurses, doctors and dentists. Contact Dermatitis 1989; 20:247-259.
12. Appelman LM, Woutersen RA, Zwart A, et al. One-year

inhalation toxicity study of formaldehyde in male rats with a damaged or undamaged nasal mucosa. J Appl Toxicol 1988; 8:85-90.

13. Blair A, Saracci R, Stewart PA, et al. Epidemiologic evidence on the relationship between formaldehyde exposure and cancer. Scand J Work Environ Health 1990a; 16:381-393.
14. Partanen T. Formaldehyde exposure and respiratory cancer - a meta-analysis of the epidemiologic evidence. Scand J Work Environ Health1993; 19:8-15.
15. Garry VF, Oatman L, Pleus R, et al. Formaldehyde in the home: Some environmental disease perspectives. Minn Med 1980; 63:107-111.
16. Carrier G., Bouchard M., Noisel N., Bonvalot Y. Fradet S.: Impacts of lowering the permissible exposure value for formaldehyde Health impact of an occupational exposure to formaldehyde; 2004. IRSST, Report RA13-386.
17. Takigawa T, Endo Y. Effects of glutaraldehyde exposure on human health. J Occup. Health 2006; 48:75-87.
18. Hirose R, Hori M, Shukuwa T, et al. Topical treatment of resistant warts with glutaraldehyde. J. Dermatol. 1994; 21:248-253.
19. Yoshinaga S, Mabuchi K, Sigurdson AJ, Doody MM, Ron E. Cancer risks among radiologists and radiologic technologists: review of epidemiologic studies. Radiology 2004; 233:313-321.
20. Harold T Mckone. Embalming: A living rite. Chemistry chronicles 2002; 33-34.
21. Liss GM, Tarlo SM, Doherty J, et al. Physician diagnosed asthma, respiratory symptoms, and associations with workplace tasks among radiographers in Ontario, Canada. Occup. Environ. Med. 2003; 60:254-261.
22. Norback D. Skin and respiratory symptoms from exposure to alkaline glutaraldehyde in medical services. Scand J Work Environ Health health 1988; 366-371.
23. Makropoulos V, Alexopoulos EC. Case report: hydroquinone and/or glutaraldehyde induced acute myeloid leukaemia? J. Occup. Med. Toxicol. 2006; 1:19.
24. Frolich KW, Andersen LM, Knutsen A, Flood PF. Phenoxyethanol as a non-toxic substitute for formaldehyde in long term preservation of human anatomical specimens for dissection and demonstration purposes. Anat Rec 1984; 208:2718.
25. Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984: III-176.