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GLUTARALDEHYDE EXPOSURE IN EMBALMING ROOMS: A COMPREHENSIVE STUDY

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ABSTRACT: A glutaraldehyde vapor exposure study in embalming rooms was conducted. Various scenarios of potential and actual exposure were investigated. These involved actual embalmings, spillage and use of sanitation solutions. All tests were conducted under worst case situations in which no attempt to reduce exposure was used. Results indicate that exposures were well below recommended limits and were at the limits of detectability in most cases. With the use of proper techniques of exposure control the exposure to glutaraldehyde fumes would be negligible. The use of glutaraldehyde products in embalming rooms with proper technique is well within accepted safety standards.

INTRODUCTION: Glutaraldehyde is a five carbon straight chain dialdehyde that is used extensively in some embalming formulations. Glutaraldehyde is a liquid that is commercially available as a 25% aqueous solution with a mild sweet odor and a slight straw color. It has a specific gravity of 1.066 at standard temperature and is therefore slightly more dense than water. Glutaraldehyde is a very reactive and unique chemical from an embalming standpoint, being able to react with proteins over a wide range of pH and without adverse side effects common to fixation.

Since its successful commercial manufacture in the 1950's, it has been extensively investigated for its potential chemical usage. It is now a chemical of industrial commerce and is most commonly produced from derivatives of dihydro pyrans by patented processes. Its principal uses that interest us are in the leather and tanning industry, disinfection and sterilization chemistry and as a protein cross-linking agent for tissue sample preservation.

Glutaraldehyde is used extensively in the manufacture of high quality leather products due to its ability to produce a natural looking product with a minimum of shrinkage or distortion. This product also exhibits more elasticity and reduced brittleness. Glutaraldehyde has replaced traditional tanning agents such as formaldehyde in many manufacturing applications despite the higher cost of glutaraldehyde compared to simpler aldehydes.

The extensive use of glutaraldehyde as a superior sanitizer, disinfectant and cold chemical sterilant hardly needs to be commented on. Its application throughout the chemical and biological field as a fungicide, bactericide, viricide and sporicide are legion. The only germicides superior to glutaraldehyde in concentration required and rapidity of action are exotic and toxic gases such as ethylene oxide and beta-propiolactone. The most effective glutaraldehyde product is a 2% aqueous solution that is pH activated by addition of a buffering solution. These formulations are normally prepared as needed as they have a reduced shelf life at the higher pH's to which they are buffered.

From an embalming standpoint, the other important property of glutaraldehyde is its ability to fix protein. It has seen extensive use in the cytochemical field and in staining procedures in histology. Glutaraldehyde has been found to be a superior chemical for tissue culture preservation. The resultant fixed tissue exhibits less distortion and stretching when glutaraldehyde is the fixative agent. The ability of glutaraldehyde as a superior fixative is perhaps due to the unique intramolecular distance of the two reactive aldehyde groups. This would allow more efficient cross-linking of proteins with an increase in preservative effect due to a greater total reaction and creation of a more stable fixed protein.

The increased use of glutaraldehyde in embalming operations has prompted the investigation of this chemical from a safety and exposure standpoint. Current recommended threshold limit values for glutaraldehyde exposure are .2ppm. At greater than .3ppm glutaraldehyde can result in headaches and drowsiness as it is a central nervous system depressant. Long term chronic overexposure can possibly result in mutagenic effects. Serious topical or ingestion overexposures seem unlikely in embalming operations due to the relatively dilute solutions that are characteristically used and the acute toxicity of glutaraldehyde being of a low order. On the basis of this information, OSHA currently requires a TWA (time-weighted average) of no more than .2ppm based on a fifteen minute exposure. In this study we have attempted to quantify glutaraldehyde vapor exposure during normal embalming operations in a typical embalming room.

METHOD AND FINDINGS: For this study, numerous air samplings were taken during the use of glutaraldehyde formulations in actual and simulated embalming operations. The method of measurement of glutaraldehyde concentrations in the air was by use of glutaraldehyde vapor monitors supplied by Advanced Chemical Sensors. The monitors were worn during fifteen minute exposures under various conditions of airborne glutaraldehyde exposure. The accuracy of these monitors is acceptable under the guidelines of OSHA and NIOSH. The embalming room used for testing was typical in size and design. It measured 17' x 12' x 8' and calculated to an actual 1470 cu. ft. when deductions were made for cabinets and sinktops. Air temperatures during all monitorings were 65-75 degrees.

Three different embalming scenarios were chosen for investigation. Glutaraldehyde concentrations in the air were measured during various embalmings using glutaraldehyde based fluids that contained little or no formaldehyde (0-2%). The embalmings would all be classified as normal and required a typical 90-120 minutes. Standard embalming techniques were used but no attempt to minimize our exposure to any fumes was used. No ventilation was used, the lids were left off all fluid bottles and the embalming machine and a minimum of table irrigation was used. If a spill occurred there was no attempt to contain it. One embalming was classified as a difficult case. A larger quantity and concentration of fluid was used and several points of injection were necessary. This difficult embalming also required a longer exposure time of 2 hours. The typical quantity of fluid used was three gallons of total solution (except in the above mentioned difficult case, where four gallons of solution was used.) The dilution rate resulted in an injection solution of 1.2% - 1.5% glutaraldehyde. In all cases, the cavity was treated with 48 ounces of a 16% glutaraldehyde fluid. Measurements were taken at various times during the embalming operation and the results are summarized in Table 1.

TABLE 1

GLUTARALDEHYDE CONCENTRATIONS (PPM)

	Start	1st Gal	2nd Gal	3rd Gal	After Cavity	20 min. after
Normal Embalming	0	<.05	<.05	<.05	0.06	0.05
Difficult Embalming	0	<.05	<.05	0.05	<.1	<.1

Additionally, glutaraldehyde concentrations in the air were measured during the use of a typical sanitizing solution. A 2% glutaraldehyde with appropriate buffer was made in the amount of 1/2 gallon. Fifteen minute exposures to the vapors of this solution were then monitored. An additional exposure was measured with this solution while it was vigorously agitated and frothing. During all measurements the operator attempted to maximize his exposure by standing directly over the solution at all times.

Finally, the glutaraldehyde concentration in the air was measured during a contained spill of 48 ounces of 16% glutaraldehyde fluid. Again, the operator attempted to maximize his exposure by standing directly over the spill. The results of these monitorings are summarized in Table 2. It can be seen that the concentrations of glutaraldehyde measured are quite low relative to the threshold limit values for this chemical.

TABLE 2

GLUTARALDEHYDE CONCENTRATIONS(PPM)
15 MINUTE EXPOSURES

2%sanitizing solution	<.05
2%sanitizing solution/agitation	<.05
48oz. spill 16%solution	<.05

DISCUSSION: A reexamination of Tables 1 and 2 lead us to the conclusion that the concentrations of glutaraldehyde present in the air during embalming operations are almost insignificant in all but one situation and even in that situation it is less than half of the permissible level. Most monitor readings were, in fact, at or very close to the limits of detectability (<.05ppm). This result is even more surprising when the conditions of monitoring are taken into account. An absolute worst case scenario was used during all the monitorings. This included no ventilation of any type, no attempt at proper technique of vapor reduction and no operator precautions. If ventilation and proper technique had been used we are convinced that no detectable amount of glutaraldehyde would be present.

We found glutaraldehyde extremely pleasant to use even without ventilation. No noticeable reaction to the chemical was noted by either embalmer. The bodies were well embalmed with good distribution and even the difficult case was judged acceptable. The firming action was moderate and increased in firmness within 18 hours. The condition of the cavities was especially noteworthy, being very firm and fully embalmed with a minimum of reaspirated fluid detected.

Compared to formaldehyde, glutaraldehyde is much less likely to be a vapor exposure hazard. If formaldehyde fluids had been used in the same situations in which glutaraldehyde was used, the concentrations measured in the air would have been well over exposure limits. This is to be expected as formaldehyde is a gas and typical exposure concentrations in the air of formaldehyde have been determined by us in a previous investigation. Formaldehyde fumes, of course, can be controlled by good ventilation, but the exposure reductions will not equal the reductions achieved by the use of glutaraldehyde. A combination glutaraldehyde/formaldehyde fluid would be a logical alternative to reduce overall exposure. By substitution of glutaraldehyde for formaldehyde you are not substituting one exposure hazard for another equal exposure hazard. You are, in fact, substituting a lesser exposure hazard for a greater one. The net result would be a reduction of total exposure to any toxic fumes.

We conclude that exposure to glutaraldehyde fumes in embalming rooms is very low and probably undetectable if ventilation and professional technique for vapor reduction is used. Overexposure appears possible only through deliberate misuse or a serious accident such as ingestion of the chemical. If exposure to toxic fumes is the prime consideration in an operation then glutaraldehyde is indicated as the chemical of choice.

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