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GLUTARALDEHYDE: SAFE USE IN EMBALMING AND EXPOSURE CONCERNS AS A PREFERRED ALTERNATIVE TO FORMALDEHYDE

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Abstract: Glutaraldehyde hazards and exposure concerns during embalming use are delineated and discussed. Methods of safe use in embalming are catalogued. Myths and rumours concerning the dangers of glutaraldehyde in embalming are debunked. Comprehensive exposure monitorings results are reported which show low to marginal exposures during all phases of embalming operations. Comparison to formaldehyde in health effects and exposure values shows glutaraldehyde to be a reduced exposure hazard in almost all categories of consideration in embalming operations. The embalming industries unwillingness to seek alternatives to formaldehyde, such as glutaraldehyde, is discussed and debated. Recommendations for reasonable and moderate use of glutaraldehyde in embalming, as a lowered exposure hazard alternative to formaldehyde is followed by an extensive bibliography.

MYTHS, RUMOURS, "COMMON" KNOWLEDGE, AND "IT'S ALWAYS BEEN DONE THAT WAY", ALWAYS TRUMPS THE TRUTH.

—JHB

INTRODUCTION: This article will investigate in depth the myths and realities of glutaraldehyde exposure in embalming rooms and health hazards and effects from use as compared to formaldehyde. Unfortunately, there is more myth than reality regarding this topic in the funeral industry.

This is a direct result of the formaldehyde-apology stance and attitude of the embalming industry in general. The fallout from this mindset is automatic or manufactured condemnation of any alternatives to formaldehyde as either too dangerous and nasty or useless for embalming, or both. This situation is mostly fueled by fear and ignorance and general shock that an old friend, like formaldehyde, is not the best or only choice, as it has been for over 100 years. This is an unfortunate situation, but that's just the way it is.

Glutaraldehyde will be assessed methodically as a chemical of choice for embalming and evaluated as a health hazard and relative exposure risk. Like all hazardous chemicals in embalming there is good and bad concerning glutaraldehyde and these will be delineated. Any chemicals capable of embalming dead bodies and neutralizing decomposition and decay, in addition to inducing a high-level sanitation ability and slowing or eliminating microbial overgrowth, is inherently hazardous, otherwise they would be useless for embalming purposes. To pretend that one embalming agent is deadly and hazardous and another one is virtually harmless is ludicrous.

What really matters is the relative value derived for the relative exposure risk that is associated with the various chemicals used in embalming. As I have stated in other writings, the overall goal in chemical selection in embalming should be a balancing of the overall total exposure risk as compared to the effectiveness in achieving acceptable and desirable embalming results.

The results of this extensive overview of glutaraldehyde and formaldehyde exposure concerns for embalmers leads inevitably to the following: both glutaraldehyde and formaldehyde are hazardous and effective embalming agents and careful precautions for either must be in place for safe use. Glutaraldehyde, by virtually all assessments of exposure criteria and health effects and their sequelae appears to have a significantly reduced potential for total exposure in embalming scenarios, as compared to formaldehyde. This derives from glutaraldehydes' drastically reduced volatilities compared to formaldehyde and the reduced quantities and concentrations of glutaraldehyde necessary to effectively embalm compared to the much larger quantities of more concentrated formaldehyde solutions necessary to achieve similar embalming results. This is a very hard pill for a recalcitrant embalming industry to swallow. Be that as it may, we now take a look at glutaraldehyde indepth and analyze its relative exposure hazards and health concerns.

AN OVERVIEW: Glutaraldehyde is a high volume chemical in the U.S. predominately in disinfection/sterilization/preservation industries. Since its appearance in the late 1950's, glutaraldehyde has dominated the disinfection/sterilization industry for decades. It effectively supplanted formaldehyde in both concentration and time requirements and solved the formaldehyde resistance problems with several sterilization methodologies. Formaldehyde is virtually unheard of anymore in the U.S. for routine disinfection/sterilization that is medical/dental/hospital based. Worldwide, formaldehyde is in increasing disuse with glutaraldehyde or other methods the much preferred alternatives.

Glutaraldehyde will also be found in the leather tanning industry as a preferred replacement for old-style formaldehyde tanning. Virtually all aldehyde based tanning in the U.S. is glutaraldehyde driven,

due to the lowered overall exposure impact during the process and creation of a superior endproduct leather. Glutaraldehyde tanned hides exhibit less brittling, reduced bleaching, less drying and cracking and creates a longer-lasting, more supple feeling final product that has much higher consumer acceptance.

Table 1

Glutaraldehyde Concentrations (PPM)
No Ventilation

Normal Embalming 30+ ounces 6% Arterial 32 ounces 16% Cavity	0	<.05	<.05	<.05	0.06	0.05
Difficult Embalming 36+ ounces 6% Arterial 48 ounces 16% Cavity	0	<.05	<.05	0.05	<.1	<.1
	Start	1st Gal.	2nd Gal.	3rd Gal.	After Cavity	20 Min. After

Glutaraldehyde has additional uses as a preservative/antimicrobial in kaolins/paper coating slurries, concrete admixtures, latex emulsion paints, commercial printing fountain inks, and silicon emulsions. Concentrations are typically .1%-.5% for most applications. Glutaraldehyde is also used as a microbiocide in water cooling towers to eliminate potential microbial growths, such as Legionnaires disease and others. Glutaraldehyde has some usage in the large animal veterinary field as a hoof treatment, mange control and also in egg farms and chicken hatcheries and incubators. Glutaraldehyde is also a much preferred fixative for cytochemistry labs, histology work and as a preservative for trans-

plant tissues during transit and storage. The embalming use of glutaraldehyde has been extensively covered by me in a previous Champion Encyclopedia article, and I refer you to that for review.

EXPOSURE CONCERNS AND HEALTH EFFECTS FROM EXPOSURE: Cancer-causing potential is a serious concern for any hazardous chemical used in embalming. Glutaraldehyde is not classified as carcinogenic by any regulatory or advisory agency anywhere. NTP classifies it as a non-carcinogenic and ACGIH gives it a A4 classification (i.e. not classifiable). Glutaraldehyde is only on one regulatory list — as a pesticide under FIFRA (because of its use as a microbiocide). In fact, numerous studies have demonstrated that glutaraldehyde is not a teratogen, nor is it an in vivo mutagen or carcinogen. Consequently, cancer concerns are not a concept with glutaraldehyde use.

REALITY CHECK: FORMALDEHYDE IS CLASSED AS A CARCINOGEN BY VIRTUALLY EVERY AGENCY IN THE WORLD. IT IS THE CAUSE OF THE FORMALDEHYDE ACT CFR1910.1048. OSHA, ACGIH, NTP, EPA, IARC, NIOSH, AND FRG ALL CLASSIFY FORMALDEHYDE AS CARCINOGENIC. FORMALDEHYDE IS ON 8 REGULATORY LISTS AND IS ONE OF ONLY A HANDFUL OF CHEMICALS WITH ADDITIONAL REGULATIONS PURSUANT TO OSHA.

ALLERGIC REACTIONS: Glutaraldehyde is a proven skin sensitizer and causes contact dermatitis (after repeated exposures and lack of hygenic safety practices). The instances are low and appear to be only a few percent of actual skin sensitizations. Most cases have been reported in nurses and tied to concomitant use of latex gloves. Poor safety practices and use of disposable thin latex gloves are, no doubt, a major contributor to the instances of contact dermatitis, as this type of problem is not seen in industrial applications where impervious gloves and good safety practices are mandatory. Glutaraldehyde is proven to not significantly penetrate skin in harmful amounts and if percutaneous absorption should occur, there is no bioaccumulation due to relative rapid metabolic processes and elimination. No cross sensitization to formaldehyde will occur.

Sporadic reports attribute asthma or asthma-like symptoms to glutaraldehyde inhalation. These reports are relatively few and cannot be duplicated in animal studies. None of the studies have ever documented a true inhalation driven IgE immune — mediated hypersensitivity to glutaraldehyde, which is essential for a diagnosis of true occupational asthma. A large cohort study of 340 nurses involved in glutaraldehyde usage as a sterilant/disinfectant found no evidence of asthma and no clinical or objective findings that glutaraldehyde is a respiratory sensitizer. Only one nurse was positive for IgE glutaraldehyde, but almost twenty nurses tested positive for latex sensitivity.

REALITY CHECK: FORMALDEHYE IS A DOCUMENTED MAJOR SKIN SENSITIZER AND COMMON CAUSE OF ALLERGIC CONTACT DERMATITIS. FORMALDEHYDE IS

#3 ON THE LIST OF THE TOP TEN ALLERGENIC CHEMICALS AND IS ALWAYS IN A FIRST LINE PATCH TESTING PROTOCOL. FORMALDEHYDE IS A TRUE INHALATION SENSITIZER AND CAUSES IMMUNE-MEDIATED HYPERSENSITIVITIES AND TRUE ASTHMAS AND ASTHMATIC CONDITIONS WITH NUMEROUS REPORTED INSTANCES IN THE LITERATURE. FOR THE RECORD, BREAKTHROUGH TIMES AND PERMEATION RATES FOR LATEX GLOVES ARE WORSE FOR FORMALDEHYDE THAN GLUTARALDEHYDE. LATEX GLOVES IN EMBALMING ARE USELESS FOR FORMALDEHYDE AND GLUTARALDEHYDE.

GENOTOXICITY: Glutaraldehyde is mutagenic in a few specific studies involving cultured bacterial cells (i.e. in vitro). In vivo studies, involving live animals have uniformly been negative regarding genotoxic effects. The evidence indicates that glutaraldehyde is not an in vivo genotoxic agent under normal use conditions. These results are in spite of the fact that glutaraldehyde has an order of magnitude greater tissue reactivity than formaldehyde.

REALITY CHECK: FORMALDEHYDE IS A PROVEN IN VIVO AND IN VITRO MUTAGENIC CHEMICAL IN NUMEROUS STUDIES, INCLUDING BUT NOT LIMITED TO DROSOPHILA MELANOGASTER AND OTHERS. FORMALDEHYDE HAS ALSO BEEN IMPLICATED IN SEVERAL EPIDEMIOLOGICAL STUDIES OF HUMANS IN REGARDS TO TERATOGENIC EFFECTS AND REDUCED FERTILITIES IN FEMALES IN THE WOOD-WORKING INDUSTRY.

INHALATION EFFECTS: Glutaraldehyde, like any other hazardous chemical, has consequences from inhalation. Adequate ventilation and a safe, hygenic workplace minimizes these effects. Most agencies limit exposure to glutaraldehyde at .05-.1PPM, and Dow Chemical, the manufacturer itself, recommends a inhalation exposure limit of .1PPM. Irritant effects from inhalation start to appear at .3PPM and includes nasal and throat discomfort, tearing of the eyes and general nasal irritation and burning sensation. These effects increase in intensity as exposure concentrations increase and become severe at 1.0PPM, where the eyes and respiratory tract are significantly irritated and immediate steps must be taken to eliminate the exposure. The odor threshold is exceedingly low, which is good, and generally established at 1PPB (parts per billion) or even possibly lower. In fact, the accepted global exposure values are 100+ times the odor threshold. Having such an extremely low odor threshold allows detection of glutaraldehyde in the workplace long before any exposure or health effects manifest themselves. The other positive factor is glutaraldehyde's very low vapor pressures when in typical aqueous solutions, which generate very low titers of airborne chemical.

Table 2

Glutaraldehyde Concentrations (PPM)
15 Minute Exposure
No Ventilation

2% Sanitizing Solution	<.05
2% Sanitizing Solution/Agitation	<.05
48 oz. spill 16% Solution	<.05

MONITORINGS IN EMBALMING ROOMS: I have personally conducted numerous monitorings of glutaraldehyde and formaldehyde in embalming rooms during all phases of embalming operations. I have devoted an earlier Champion Encyclopedia exclusively to this topic. To summarize my findings, please refer to Tables 1 and 2. As you can see, glutaraldehyde exposure values are repeatably very low or undetectable (i.e. below a value of .05PPM) for almost all types of embalming operations — and this is without ventilation. When acceptable and recommended ventilation is used during embalming operations, the glutaraldehyde monitorings are even lower — approaching undetectability of badge monitors. I have recently, through more exhaustive monitorings with newer glutaraldehyde-based chemicals, reconfirmed these basic trends. I refer you to Table 3 for an overview of my most recent monitoring results using 2.5% disinfectants and New Era Cavity 48 (a modern cavity fluid with 15% glutaraldehyde and a relatively volatile chemical mixture). As is obvious, from examination of Table 3, monitorings are uniformly quite low when adequate ventilation and safety precautions for use are utilized. In my estimation, it appears that glutaraldehyde exposure in embalming scenarios is eminently achieveable with adequate ventilation and standard safety procedures in place in most modern em-

balming rooms and glutaraldehyde inhalation is fully controllable under virtually all circumstances of use.

REALITY CHECK: THE SAME CANNOT BE SAID FOR FORMALDEHYDE. IT IS DIFFICULT OR VIRTUALLY IMPOSSIBLE SIXTY TO SEVENTY PERCENT OF THE TIME TO SUCCESSFULLY EMBALM WITH FORMALDEHYDE AND REMAIN WITHIN THE SAFETY LEVELS OF ACGIH. THE ODOR THRESHOLD OF FORMALDEHYDE IS (.5-1.0PPM) WHICH IS FAR ABOVE ACGIH EXPOSURE LIMITS AND AT OR ABOVE THE OSHA ACTION LEVEL. IF YOU CAN SMELL FORMALDEHYDE, YOU ARE OVEREXPOSED. THERE IS NO SAFETY MARGIN.

SPLASH ACCIDENTS/SPILLS/DISPOSAL: Safety practices and protective equipment and apparel should always be used with any hazardous chemical to avoid accidental eye or skin contact and glutaraldehyde is no different in this respect. Being a powerful fixative, glutaraldehyde in any significant concentrations are extremely injurious to eye tissue and unprotected skin surfaces.

Spills should be promptly contained and cleaned up as per instructions of the MSDS (Material Safety Data Sheet) and manufacturers directives and guidelines. Protective clothing, eye protection and impervious gloves should be religiously used.

Disposal of quantities of glutaraldehyde can be done effectively and safely by utilizing the Sodium Bisulfite or Sodium Hydroxide method of neutralization as per the manufacturers recommendations. The environmental fate of glutaraldehyde is a rapid metabolism in an aerobic system that is complete at 48 hours with a half life of 12 hours. In an anaerobic system complete metabolism occurs after 3 days with 95% degradation occuring in the first 24 hours. Glutaraldehyde is just not persistent in environmental fate studies. The small amounts of effluent from embalming fluids that appear in the sewage disposal system would rapidly react with the major raw sewage stream and any remainder would appear to relatively rapidly degrade.

REALITY CHECK: FORMALDEHYDE IS NO LESS DANGEROUS TO USE IN THE EMBALMING ROOM THAN GLUTARALDEHYDE IN REGARDS TO SPLASH ACCIDENTS AND SPILLS. IN FACT, THE INDUSTRIAL RECORD FOR SERIOUS EXPOSURE INCIDENTS AND DEATHS IS FAR WORSE FOR FORMALDEHYDE. FORMALDEHYDE IMPACTS THE WASTE STREAM IN ESSENTIALLY THE SAME WAY THAT GLUTARALDEHYDE DOES. THE AMOUNT OF FORMALDEHYDE USED IN EMBALMING IS TYPICALLY 2-4 TIMES THE AMOUNT OF GLUTARALDEHYDE USED, WHICH DRASTICALLY INCREASES EXPOSURES.

MYTH-INFORMATION: The formaldehyde apologists are working overtime on this issue. The fear that an acceptable and reduced hazard alternative to formaldehyde exists for the embalming of dead human bodies, such as glutaraldehyde, is simply unthinkable. How could the embalming industry reevaulate and change what it has been doing for over 100 years?! These fears are understandable but unacceptable. If better solutions exist, they should be utilized. The search for and implementation of superior and lowered risk embalming solutions has been my master criterion during my tenure at the Champion Company.

Some of the myths perpetuated regarding glutaraldehyde are as follows: It's too dangerous to use in embalming rooms, it doesn't embalm anyway, it's the only reason you have to use nitrile gloves, it's banned in Europe, etc.,etc.,etc. Basically these are almost too foolish to answer, but quickly — if you think glutaraldehyde is too dangerous to use in embalming rooms, you need to first ban formaldehyde. If it doesn't embalm, then how is it the preferrred aldehyde-based leather tanning agent in the U.S.?! If it's the only reason we use nitrile gloves in embalming, then how come the breakthrough time for formaldehyde with disposable latex gloves is about 90 seconds?! Sorry, glutaraldehyde is not banned, however formaldehyde comes closer to that definition in Europe where formaldehyde is considered a chemical to be avoided.

Table 3

Glutaraldehyde Concentrations (PPM)
Various Exposure Scenarios

2.5% Glutaraldehyde Disinfectant/Open Container No Ventilation/12x12 Room	15 min. → .02 PPM 30 min. → .02 PPM 60 min. → .01 PPM
2.5% Glutaraldehyde Disinfectant/Open Container With Ventilation/12x12 Room	17 hours → .006 PPM
One bottle spill of Cavity 48 (approx. 15% Glutaraldehyde) No Ventilation/12x12 Room	15 min. → .04 PPM 1 hour → .04 PPM

Table 3 (continued)

Glutaraldehyde Concentrations (PPM)
Various Exposure Scenarios

Two bottle spill of Cavity 48 (approx. 15% Glutaraldehyde) No Ventilation/12x12 Room	15 min. → .04 PPM 30 min. → .08 PPM 1 hour → .05 PPM
48 ounce spill of Cavity 48 (approx. 15% Glutaraldehyde) Initial - No Ventilation With Ventilation at 15 → 30 minute With Ventilation plus spill clean up at 30 min → 1 hour	15 min. → .05 PPM 30 min. → .05 PPM 1 hour → .02 ppm

CONCLUSIONS AND SUMMARY: From the above discussion, it should appear obvious that glutaraldehyde is a chemical that with appropriate ventilation, protective gear and standard safety precautions, can be used safely in embalming rooms. Despite both glutaraldehyde and formaldehyde having similar chemical characteristics and both being effective embalming agents, glutaraldehyde appears to have a lower overall exposure impact during embalming operations than formaldehyde. This, no doubt, derives from the much reduced volatilities of glutaraldehyde solutions compared to formaldehyde solutions and the much lower vapor pressures of glutaraldehyde in general. Also, an important factor is the reduced concentrations and total quantities of glutaraldehyde required for effective embalming compared to formaldehyde. In the entire scheme of things, taking into consideration all factors pertaining to health, exposure, monitoring results and physio/chemical properties, glutaraldehyde is a preferred alternative to formaldehyde in typical embalming scenarios.

This conclusion flies directly in the face of the formaldehyde-apology advocates. They are wrong in this situation. Formaldehyde is not more acceptable or safer to use than glutaraldehye, if anything, the evidence when looked at scientifically and methodically points in the opposite direction. By all parameters, formaldehyde is more of an exposure concern and problem than glutaraldehyde when used in traditional quantities and concentrations in embalming rooms. That's just the way it is. To vociferously profess that formaldehyde is somehow safe and glutaraldehyde is not is to be misinformed and misguided. Heavy use of formaldehyde maximizes exposure and contributes little to safe and effective embalming.

A blended approach to the use of glutaraldehyde/formaldehyde in embalming operations is an excellent solution to traditional embalming problems with lowered exposure impacts. Utilizing glutaraldehyde as the primary fixative/sanitizer and formaldehyde as a secondary additive for dehydration/hardening purposes achieves excellent overall embalming results with significant reduced exposures overall. I have discussed this concept and technique in several earlier Champion Encyclopedia articles, and I refer you to them for consideration.

FINAL REALITY CHECK: THE GOAL OF CHEMICAL SELECTION IN THE EMBALMING ROOM SHOULD BE A JUXTAPOSITIONING AND BALANCING OF EFFECTIVE AND DESIRABLE EMBALMING RESULTS VERSUS A LOWERED TOTAL OVERALL EXPOSURE RISK OF THE CHEMICAL MIX CHOSEN. THAT GOAL IS ABSOLUTE AND SHOULD NEVER BE COMPROMISED. FORMALDEHYDE FAILS MISERABLY IN ACHIEVING THIS GOAL.

BIBLIOGRAPHY: The literature on glutaraldehyde is extensive. I refer you to the following cites as an overview of the current research and studies. As regards formaldehyde — the literature is overwhelming, damning and complex. A massive bibliography of literature cites for formaldehyde has been published by me in the immediately preceding Champion Encyclopedia to this issue. To avoid needlessly reprinting that voluminous listing, I refer you to it for reference to the above article.

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