SPECIAL EDITION

CHAMPION®

Expanding Encyclopedia Of Mortuary Practices

Number 611, 1992

FORMALDEHYDE EXPOSURE IN EMBALMING ROOMS: METHODS OF CONTROL

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Part 1

ABSTRACT: A formaldehyde vapor exposure study in embalming rooms was conducted. Variables relating to formaldehyde exposure included ventilation systems, embalmers technique of vapor control and quantity and concentration of manufactured embalming fluids. Ventilation and embalmer technique contributed to an 85% reduction in average exposures. Embalming fluid emissions were found to correlate with the formaldehyde concentration (index) of the fluid. A 40% or greater reduction of emissions was obtained by use of glutaraldehyde based, fumeless and low index fluids. Recommendations for lowering formaldehyde exposure levels are discussed.

INTRODUCTION: Formaldehyde is a colorless, pungent gas with numerous toxic effects that all embalmers are exposed to for their entire working life. The irritant effects are well known to anyone who has ever embalmed with a high index fluid. The breathing of formaldehyde vapors will cause mild to severe irritation of the eyes and mucosal lining of the respiratory tract including the lungs. Dermatitis or other allergic reactions will occur when formaldehyde solutions come into contact with skin. In addition to being an irritant and skin sensitizer, formaldehyde has been implicated as a human carcinogen.

The basis for this concern has come mainly from exposure studies on rats that were exposed to very high levels of formaldehyde over long periods of time developing several forms of cancer. The jury is still out concerning formaldehyde as a proven human carcinogen despite several epidemiological studies both pro and con. On the basis of formaldehyde as a suspect carcinogen and known irritant, OSHA has set limits of exposure as 2ppm for 15 minutes (STEL) and 1ppm for an eight hour exposure (TWA). OSHA and other health organizations are extremely concerned about exposure to this chemical and the already low exposure limits will probably be lowered even further in the very near future to a TWA of no more than .75ppm with the STEL remaining at 2ppm and an action level of .5ppm.

What are the actual exposures in typical embalming rooms and what techniques lower those exposures? Several studies over the past 15 years have attempted to quantify formaldehyde exposures in mortuaries and the implications to embalmers and their workplace. The results of these studies indicate a very wide range of exposure from almost insignificant to shockingly high. Embalming rooms vary in size, layout, and ventilation capabilities. Studies have shown at least a 50% reduction of formaldehyde exposure when adequate ventilation is utilized. Also implicated is the embalming technique in handling the fluids containing formaldehyde (e.g. table drainage, careful mixing, prompt cleanup of spills, etc.), the quantity of fluid used, whether the body was autopsied or not and the total exposure time.

METHOD: For this study, three different measurement techniques were used. Formaldehyde concentrations in the air were measured during numerous actual embalmings under various different conditions and using different fluids. Also, fluids were compared by irrigating an embalming table with an equal dose of various fluids and then measuring formaldehyde concentrations in the air. Finally, cavity fluids were compared by simulating a spill of 4 ounces and measuring formaldehyde concentrations that resulted.

Measurements of formaldehyde concentrations in the air were taken during numerous embalmings that would all be classified as normal cases. If a case was abnormal or autopsied the monitoring was not done. The time for embalming was always in the range of 90-120 minutes. Samples were taken at the beginning of embalming and at the completion of each gallon of injected fluid (three gallons being the normal amount injected) the completion of cavity injection and a final monitoring at twenty minutes after embalming was complete.

Three different arterial and cavity fluid combinations were used for this portion of the study: a 25 index formaldehyde based fluid with a 15 index formaldehyde base cavity fluid (solution A), a glutaraldehyde fluid with 14% formaldehyde and a low odor cavity fluid of 3.5% formaldehyde (solution B), and finally, a glutaraldehyde fluid with very low formaldehyde content (4%) and a glutaraldehyde based fluid containing little or no formaldehyde for cavity fluid (solution C). All dilutions used were manufacturer recommended for normal cases and a total of 48 ounces of cavity fluid was used in each case. All three sets of the above fluids were monitored under no ventilation and "poor" technique conditions and additionally, under ventilation and proper technique.

Proper technique required the following procedures: adequate table irrigation at all times, careful mixing of fluids to eliminate spills, lid tightly on all bottles and embalming machine, careful cavity injection and prompt irrigation and cleanup of any spills. Injection rates were average taking approximately 10-12 minutes for each gallon injected and the pressure used was a typical 2-15 lbs. The embalming room was 17' x 12' x 8' and calculated out to an actual 1470 cu. ft. when deductions were made for cabinets and sinktops. The ventilation was above average for most embalming rooms as it was equipped with a 12" exhaust fan and a 6" forced inlet fan. The exhaust fan had an average flow of 320 cfm and the inlet fan passed 240 cfm. By calculation, the average number of air exchanges per hour was found to be 13.

Numerous arterial fluids were compared from various manufacturers by simulating embalming. This was done by the irrigation of the embalming table with a constant dilution in one gallon and monitoring formaldehyde concentrations immediately. All dilutions were 16 ounces of the fluid diluted to 1 gallon. This dilution was chosen arbitrarily for ease of sampling and to compare fluids ounce for ounce. Flow rates were the same as for the embalmings, being 10-12 minutes per gallon. The fluids were irrigated onto the head of the table and allowed to flow down the table to the drain.

Cavity fluids from several manufacturers were compared based on the formaldehyde concentrations that resulted from a 4 ounce spill on the head of an embalming table. Measurements were taken immediately after each spill.

The equipment used for measurement was a Gastec Sensidyne Model 800 sampling pump with the appropriate gas sampling tubes. Air temperatures during all samples were 65-75 degrees. No compensations for relative humidities or pressure differences was deemed necessary. Several samples were taken over different times and in all cases the reported ranges are averages. The sensitivity and repeatability of the Sensidyne system being average, only consistent and relatively large differences in concentrations were considered statistically significant. Additionally, formaldehyde vapor monitors from Advanced Chemical Sensors were used during most of the test to verify and confirm the initial findings. The accuracy of the vapor monitors exceeded that of the Sensidyne sampling pump and their readings were weighted heavier for calculation of averages. The readings of the vapor monitors correlated relatively well with the Sensidyne samplings.

All measurements were taken at chest height level of the embalmer and at the same location in all samplings. The embalmer stood at the head of the table at approximately the upper chest area of the embalmed subject. This sampling method attempted to sample from the breathing zone of the embalmer at all times. One defect in ventilation design was noted: the exhaust fan was positioned at the head of the table and at near ceiling height which would tend to draw fumes past the operator during operation. This is a typical design flaw of embalming rooms except those of very recent construction. The total number of individual samples taken during the study was approximately 120.

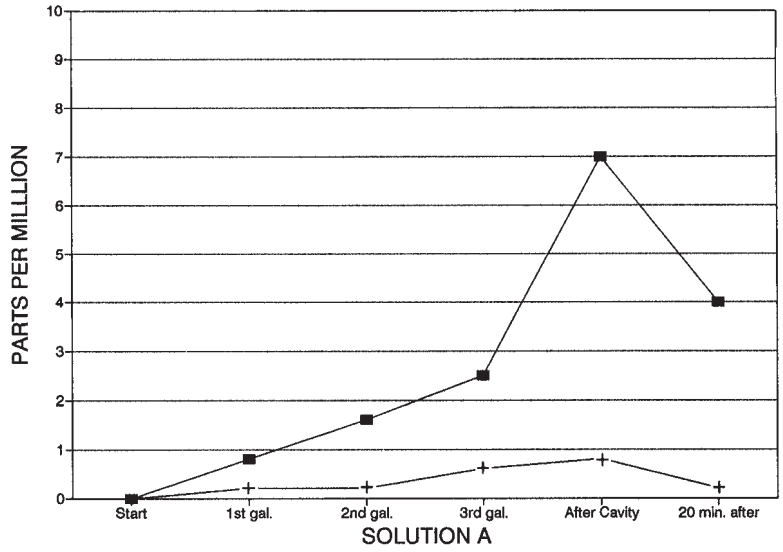
TABLE 1

FORMALDEHYDE CONCENTRATIONS (PPM)

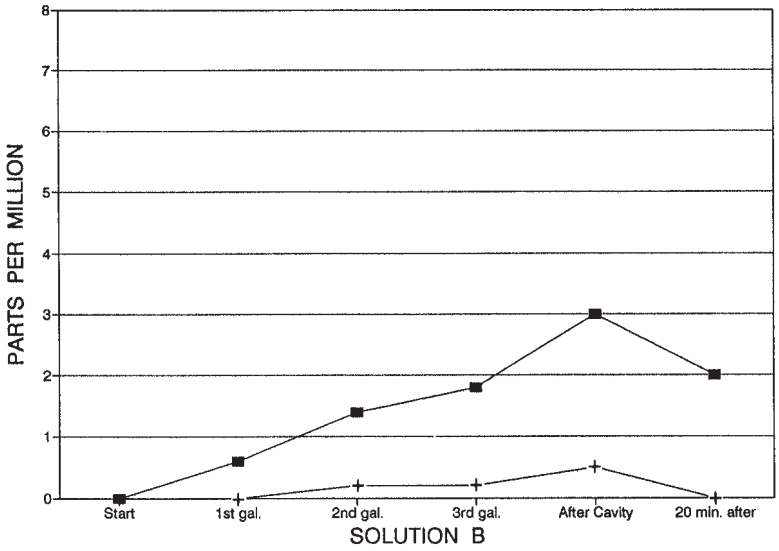
Solution A no vent/technique	0	0.8	1.6	2.5	7	4
Solution A with vent/technique	0	0.2	0.2	0.6	0.8	0.2
Solution B no vent/technique	0	0.6	1.4	1.8	3	2
Solution B with vent/technique	0	0	0.2	0.2	0.5	0
Solution C no vent/technique	0	0	0	0.2	0.2	0
Solution C with vent/technique	0	0	0	0	0	0
	Start	1st gal.	2nd gal.	3rd gal.	After Cavity	20 min. after

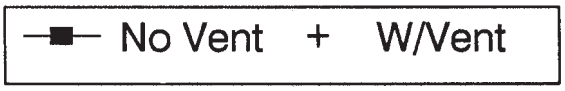
FINDINGS: The formaldehyde concentrations in air that were measured during the various embalming conditions are summarized in Table 1. By reference to the plotted data (Graphs 1, 2, 3) we arrive at an 85% reduction for ventilation/technique and an accompanying 40% reduction in exposure when glutaraldehyde based fluids containing less formaldehyde are used. Notice also that the use of a glutaraldehyde fluid containing almost no formaldehyde reduced exposures to a near undetectable level. The various arterial fluids and their relative (arbitrary) values are plotted in Graph 4. It can readily be seen that the fluids correlate as a function of index with some variations. The cavity fluid measurements are summarized in Graph 5. It is to be noted that the range and spread of data is greater than is the case with the arterial fluids. We believe this to be due to the relative higher concentration of chemical as the fluids are used undiluted and the higher concentrations of methanol and other volatiles that are present in these fluids.

GRAPH 1



GRAPH 2





GRAPH 3