



Expanding Encyclopedia Of Mortuary Practices

Number 614, 1993

THE USE OF OZONE IN EMBALMING ROOMS: A CRITICAL STUDY

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Part 1

ABSTRACT: A study of the usage of ozone in embalming rooms was conducted. The effects of ozonation on airborne formaldehyde exposure levels was studied. The relative effectiveness of ozone in different embalming scenarios was determined. Ozone was found to reduce the formaldehyde concentrations in air an average of 30-35% under normal embalming conditions. Ozone was less effective in reducing airborne formaldehyde exposure levels resulting from spills of various fluids, with reductions in exposures ranging from 0-30%. Ventilation was found to be far superior to ozone in reducing exposure to formaldehyde fumes. Ozone was found effective in odor control under all conditions. Health implications regarding the use of ozone are also discussed.

INTRODUCTION: Ozone or triatomic oxygen is a chemical that has received much publicity in recent years and virtually everyone is familiar with its importance in controlling ultraviolet radiation that reaches the earth's surface. The so-called ozone hole and its implications for life on the planet has placed this chemical in the forefront of atmospheric science and politics.

Ozone is a pale blue gas that is both irritating and extremely toxic to living organisms. It is unstable and a strong oxidizing agent which accounts for its many chemical properties and uses in industry. It is created from electrification or ionization of oxygen in air and its pungent smell is the characteristic odor that occurs after thunderstorms or in the vicinity of transformers or other electrical equipment. Ozone has many uses including odor control and air fresheners, bleaching of textiles, drinking water purification, treatment of swimming pool water, sewage treatment and as a sterilant and disinfectant.

Ozone was first used to treat drinking water in 1903 in Europe and has experienced a wide usage ever since in both Europe and Canada. It has also experienced widespread use in Europe in the treatment of waste

and sewage water since the 1930's. In the 1950's an effective ozone treatment for swimming pools was developed and recently it has been used as a sterilant in bottling factories. The popularity of ozone did not carry over to the United States and its use here has been relatively limited.

Ozone, being a powerful oxidant, is a very effective sterilant and sporicidal agent. Its effectiveness is very close to that of autoclaving and the only readily available chemical that is a stronger oxidant is fluorine. Ozone is much superior, for example, to chlorine or hypochlorite solutions (bleach) which are very dependent on the pH of the solution. Ozone concentrations required are typically 100-200 ppm with an exposure time of 45 minutes or longer. These concentrations have been found to be effective against organisms such as *Bacillus anthracis*, *Clostridium botulinum* and *Bacillus subtilis*.

Due to its extreme toxicity, ozone exposure to humans and animals has been extensively studied. Exposures of .2ppm for 5 hour increments over 3 weeks resulted in pulmonary edema and hemorrhage in rats. Sphering of red blood cells with its concomitant blood chemistry effects was also noted. The effects on red blood cells was very similar to the effects that result from exposure to ionizing radiation. A dose of 6ppm for 4 hours resulted in a mortality rate of 50%. Human studies have demonstrated sphering of red blood cells after exposures of .2ppm for 2 hours or longer. The sphering effect causes hemoglobin to less efficiently uptake oxygen for normal respiration. Observable reactions of humans are noted when the concentrations in air reach .5ppm. A concentration of .02-.05ppm is the limit for humans to detect ozone in the air. Some researchers believe that it is the noxious nitrogen oxide gases that are always present with ozone in the atmosphere that accounts for the smell. Airline crews during long flights at high altitude have experienced symptoms of ozone exposure. A typical smoggy day in a large city can generate concentrations of .2-.6ppm and generate an ozone alert. On the basis of these studies the threshold limit value (TLV) for exposure to humans has been set at .1 ppm.

Ozone in the upper atmosphere absorbs ultraviolet radiation and therefore protects the surface of the earth from potentially damaging effects from this radiation. This is the reason for the intense concern over the so called ozone hole. This topic is so steeped in global politics and rhetoric that it is difficult to sort out the scientific truth. Chlorofluorocarbons (CFC's) when released into the atmosphere rise to the ionization level and bind with ozone to form chlorine oxide and oxygen. This results in a reduction in the net amount of ozone present in the upper atmosphere resulting in an increase in damaging radiation that reaches the earth's surface. Some researchers and environmental groups want the manufacture and use of CFC's banned. There is some evidence to the contrary that indicates that natural volcanic eruptions result in more depletion of the ozone than the releases of CFC's. At any rate, there is something happening to the ozone layer and the result is potentially serious.

Ozone is used in air purifiers and air fresheners to eliminate the pollutants from the air in smoking rooms, hospitals and office buildings. By its oxidizing reaction, ozone should be able to reduce the exposure to toxic gases in the embalming room. Ozone reacts with formaldehyde according to the following formula.



NOTE: ILLUSTRATIVE ONLY - NOT MASS BALANCED.

It can be seen that ozone converts formaldehyde to formic acid and oxygen which is then fully oxidized to carbon dioxide and water. Formaldehyde is therefore ultimately neutralized by conversion to harmless chemicals. In this investigation we undertook to determine the effectiveness of ozone generators in reducing

formaldehyde exposures to embalmers during normal embalming operations in a typical embalming room.

METHOD: For this study, a commercially available ozone generator was used during various embalming operations. Formaldehyde and ozone levels were monitored during the various embalming operations with and without the use of the ozone generator. Ventilation was not used during any of the operations.

Measurements of formaldehyde concentrations in the air were taken during several embalmings that would be classified as normal cases. The time for embalming was approximately 90-120 minutes. Samples were taken at the beginning of embalming and the completion of each gallon injected (three gallons being the normal amount injected), the completion of cavity injection and finally at twenty minutes after the embalming was completed.

Two different arterial and cavity fluid combinations were used during the study: a 25 index formaldehyde based arterial fluid with a 15 index formaldehyde based cavity fluid (solution A) and a glutaraldehyde based arterial fluid with 14% formaldehyde and a low odor cavity fluid of 3.5% formaldehyde (Solution B). All dilutions of fluid were based on manufacturers recommendations for normal cases and a total of 48 ounces of cavity fluid was used in each case.

Additionally, formaldehyde concentrations in the air were monitored during spills of 1 ounce and 4 ounces of a 15 index formaldehyde based cavity fluid on the head of the embalming table. Also, measurements were taken during a simulated embalming by irrigation of the table with one gallon of a solution containing 16 ounces of a glutaraldehyde based arterial fluid containing 25% formaldehyde. Injection rates were typically 10-12 minutes per gallon and the pressure used was 2-15 lbs.

The embalming room used during the study was 17'x12'x8' and was an actual 1470 cu. ft. when deductions were made for cabinets and sinktops. A minimum amount of table irrigation with water was used during all the embalming operations. Air temperatures were in the range of 65-75 degrees. The ozone generator was situated six feet from the embalmer and was positioned at a height of 5 feet from the floor. The air flow from the ozone generator was positioned so as to pass over the body at all times. The output of the fan in the ozone generator was found to be 52 cfm which calculated out to 2 room air exchanges per hour.

The equipment used for formaldehyde and ozone sampling was a Gastec Sensidyne Model 800 sampling pump with the appropriate gas sampling tubes. Additionally, formaldehyde concentrations were measured with vapor monitors from Advanced Chemical Sensors. The reported formaldehyde concentrations are an average of several monitorings and samplings taken during various times. All measurements were done at chest height 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. The sampling method attempted to sample from the embalmer's breathing zone at all times. Additionally, ozone sampling was taken after 30 minutes of ozone generation at the generators low, medium and high settings.

FINDINGS: The actual formaldehyde concentrations measured in the air using the various combinations of embalming fluids during the normal cases are summarized in Table 1. The formaldehyde concentrations measured using Solution A and Solution B (with and without ozone) is found in Graphs 1 and 2. Upon examination of this data, it is found that ozone reduced the formaldehyde concentrations in the air an average of 30-35% during a normal embalming operation.

TABLE 1
FORMALDEHYDE CONCENTRATIONS (PPM)

Solution A w/Ozone	0	0.5	1.5	2.5	6	3
Solution A w/o Ozone	0	0.8	2	3	9	4
Solution B w/Ozone	0	0.2	1.2	1.2	2	1.5
Solution B w/o Ozone	0	0.6	1.4	1.8	3	2.2
	Start	1st Gal	2nd Gal	3rd Gal	After Cavity	20 min. after

Ozone was much less effective in reducing the formaldehyde concentrations found in the air after a spill of cavity fluid. Table 2 shows that ozone reduced the formaldehyde readings only 15% in 30 minutes and 30% after one hour. Ventilation was much more effective in reducing the formaldehyde titers in air with a 70% or greater reduction occurring in only 2-5 minutes. In fact, ozone did not reduce the formaldehyde concentrations an observable amount after a 4 ounce spill of the same cavity fluid in a 30 minute time span.

Additionally, ozone did not reduce the formaldehyde concentrations during a simulated embalming by irrigation of the table with one gallon of a prepared arterial embalming solution containing an average of 3% formaldehyde. In this instance, the embalming room air was predosed with ozone for 30 minutes prior to formaldehyde monitoring. Significant and repeatable formaldehyde reductions were not observed during these samplings. Finally, ozone concentrations generated by the ozone generator's various settings were determined. Minimum output was found to generate <.07ppm, medium setting generated >.1ppm and at the maximum output generated .7ppm.

TABLE 2
FORMALDEHYDE CONCENTRATIONS (PPM)

1 oz. cavity spill	12 - 13
15 min. wait	12 - 13
30 min. Ozone	11 - 12
60 min. Ozone	9 - 10
After 2 min. vent	2