HETA 87-176-1826
AUGUST 1987
ST. JAMES COMMUNITY HOSPITAL
BUTTE, MONTANA

NIOSH INVESTIGATOR:
Bobby J. Gunter, Ph.D., C.I.H.

I. SUMMARY

On March ll, l987, the National Institute for Occupational Health and Safety (NIOSH) received a request from the Director, Nursing Service, St. James Community Hospital, located in Butte, Montana, to evaluate exposures to glutaraldehyde which is used in respiratory therapy and in the sigmoidoscopy departments for sterilization of equipment. On April 2, l987 NIOSH performed an environmental evaluation in both of these areas. Three breathing zone air samples were collected; glutaraldehyde concentrations were 0.25, 0.38 mg/M^3, and below the laboratory detection limit of 0.002 mg/sample. Six general area samples were collected; one was below the laboratory detection limit and the other five had concentrations ranging from 0.48 to 0.20 mg/M^3 with an average concentration of 0.28 mg/M^3. Good local exhaust ventilation was the reason for low concentrations. Neither NIOSH nor OSHA have established exposure criteria for glutaraldehyde. The American Conference of Governmental Industrial Hygienists (ACGIH) has established a threshold limit value (TLV) of (C) 0.7 mg/M^3. The designation C refers to a ceiling value that should not be exceeded.

Technicians in the sigmoidoscopy and respiratory departments were informally interviewed. They showed interest in the toxicology of glutaraldehyde. Medical problems attributed to glutaraldehyde were not identified.

On the basis of environmental data, it was concluded that a health hazard did not exist from exposure to glutaraldehyde in either the sigmoidoscopy or respiratory therapy departments at Saint James Hospital (East and West). Recommendations that will improve the ventilation in both of these departments are included in this report.

KEYWORDS: SIC 8070 (Hospitals) Glutaraldehyde, respiratory therapy, sigmoidoscopy, sterilization

II. INTRODUCTION

NIOSH received a request from the Director, Nursing Services, on March ll, l987, to evaluate the respiratory and sigmoidoscopy departments for exposures to glutaraldehyde at Saint James Community Hospital Inc., Butte, Montana. An environmental investigation was conducted on April 2, l987. Results of the evaluation were discussed with the Director, Nursing Services, in June of l987.

III. BACKGROUND

Saint James Community Hospital in Butte, Montana is comprised of 2 facilities commonly referred to as Saint James (EAST) and (WEST). Respiratory therapy is performed at the larger of the two facilities (WEST) and the sigmoidoscopies are performed in the day surgery department located at St. James (EAST). NIOSH had done a previous hazard evaluation (HETA 86-403) in the surgery department of St. James (WEST) and hospital administration thought that an evaluation of the respiratory and sigmoidoscopy equipment sterilization rooms should be done in order to verify exposures to glutaraldehyde and add engineering controls if necessary.

IV. EVALUATION DESIGN AND METHODS

During this evaluation the two technicians were monitored for the entire time they were using glutaraldehyde. General room air samples were also taken in all areas of the respiratory and sigmoidoscopy equipment cleaning rooms.Six general area and three breathing zone air samples were collected on ORBO 23 tubes using vacuum pumps operating at approximately 100 cc/minute. These samples were taken for the entire time the glutaraldehyde solution was used. All the environmental samples were analyzed by NIOSH Method 253l. Tubes were desorbed with 2 ml toluene in a sonic bath for one hour. Analyses were performed by gas chromatography (FID) using a l5-meter DB-5 fused silica column (splitless mode)

V. EVALUATION CRITERIA

A. Environmental Criteria

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy).

In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the evaluation criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure.

Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: 1) NIOSH Criteria Documents and recommendations, 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLV's), and 3) the U.S. Department of Labor (OSHA) occupational health standards. Often, the NIOSH recommendations and ACGIH TLV's are lower than the corresponding OSHA standards. Both NIOSH recommendations and ACGIH TLV's usually are based on more recent information than are the OSHA standards. The OSHA standards also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH-recommended standards, by contrast, are based solely on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is legally required to meet those levels specified by an OSHA standard.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8- to 10-hour workday. Some substances have recommended short-term exposure limits or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high short-term exposures.

Neither NIOSH nor OSHA have established exposure criteria for glutaraldehyde. The ACGIH has established a TLV of (C) 0.7 mg/M3. The (C) refers to a ceiling concentration that should never be exceeded.[1]

B. Toxicology

Glutaraldehyde was originally developed as a sporicidal agent that did not have many of the undesirable properties of formaldehyde. Glutaraldehyde was used in this study for the sterilization of sigmoidoscopies and respiratory therapy equipment. It is used throughout hospitals, dental laboratories and other health care facilities for disinfection and sterilization. NIOSH estimates that about l4,000 workers are potentially exposted to glutaraldehyde.

Glutaraldehyde is currently marketed as a replacement for formaldehyde in reusable artificial kidney dialysis processes. The following information is an accumulation of toxicology and chemistry data that has been previously published in HETA 86-226.(2)

C. Chemistry[3,4,5,6,]

Chemistry of Glutaraldehyde--Products containing glutaraldehyde are most frequently available as 2%, l0%, 25%, and 50% aqueous solutions, which have no flash points and are non flammable. In general, glutaraldehyde is a saturated dialdehyde with the following formula: CHO-CH2-CH2-CH2-CHO. Its molecular weight is l00.l3. In contrast to formaldehyde, which is a simple aldehyde, glutaraldehyde has two active carbonyl groups. Under proper conditions these two groups, either singly or together, undergo most of the typical aldehyde reactions to form acetals, cyanohydrins, oximes, and hydrazones. Through the crosslinking reaction, the carbonyl groups react with protein.

As a raw material, glutaraldehyde is synthesized and commercially available as an acidic aqueous solution. Aqueous solutions of glutaraldehyde are mildly acid in reaction and at a acid pH of approximately 3-4, glutaraldehyde solutions are stable for a period of many months. In this acid state they are not sporicidal. When rendered alkaline, however, the glutaraldehyde gradually undergoes polymerization. Above a pH of 9, the polymerization proceeds comparatively rapidly and eventually loses activity. In the pH range of 7.5 to 8.5 the polymerization reaction is slowed down considerably, so that full antimicrobial activity (sporicidal, bactericidal, viricidal, and fungicidal) is maintained for at least two weeks.

Most glutaraldehyde used in hospitals is a 2.0% concentration which has a two-component system that must be mixed together, or activated, prior to use for disinfection or sterilization. The activated solution that contains 2.0% glutaraldehyde is buffered to an alkaline pH of 7.5 - 8.5 as described above. To buffer this concentration of glutaraldehyde to the required alkaline range, the addition of 0.3 percent of sodium bicarbonate is necessary. Although other alkalinating agents may be employed, the alkali metal bicarbonates, such as sodium bicarbonate, have given best results.

To provide greater utility to the activated or buffered glutaraldehyde solution, it has been convenient to add, in addition to the alkaline buffer, surfactants to promote the wetting and rinsing of surfaces, sodium nitrate as a corrosion inhibitor, a peppermint oil odorant, and yellow and blue FD and D dyes, indicating that activation through mixing the two components has been completed. Before the addition of the buffer-dye combination, the unactivated glutaraldehyde solution is colorless; after the addition, the solution turns a characteristic fluorescent green. It should be noted that there are approximately eight different brands of this type of material on the market and each may have slightly different chemical ingredients and may be in different concentrations.

The 2% water solution is used as a cold disinfectant and sterilizer for hospital, medical and dental work. Other than the 2% solution the most frequently used are the 25 and 90% solutions which are used as intermediates and fixatives for tissues, and for crosslinking polyhydroxy material and proteins.

a. Toxicology

The majority of research articles available on glutaraldehyde today concern its ability to disinfect and/or sterilize against spores, bacteria, virus and fungus. There have been no epidemiological research studies reported in the literature to date and there have been only a limited number of human toxicological findings which have been reported recently on glutaraldehyde. The following is an accumulation of the more important information on animal, as well as the human toxicity studies currently available.

b. Dermatologic Effects

The Environmental Protection Agency in 1969, under the Federal Insecticide, Fungicide and Rodenticide Act (FIRMA) established that glutaraldehyde was considered to be a moderate skin irritant based on information collected during animal studies at that time.[7]

In one study aqueous solutions of 2 percent activated glutaraldehyde produced faint yellow staining of the skin and hair on rabbits after the first application. The staining became more intense and turned to golden brown over the six week period of application. Discoloration persisted up to 35 days after application ceased. A mild "rash" appeared during the early stages but disappeared despite continued application of the solution. In the same study a 25 percent solution of glutaraldehyde produced a severe erythematous reaction with edema after one to two daily applications with necrosis and eschar formation in seven to ten days.

Activated glutaraldehyde retains the skin sensitizing properties of pure glutaraldehyde.[8] One study reported that allergic contact dermatitis was found in radiologists and among X-ray technicians using solutions containing glutaraldehyde. The authors concluded that all persons with hand dermatitis who handle X-ray films should have a patch test with one percent aqueous solution of glutaraldehyde.[9]

c. Respiratory Tract Effects

Glutaraldehyde has a pungent odor, an odor recognition threshold of 0.04 ppm by volume in air and an irritation response level of 0.3 ppm.[6]

In one study, activated glutaraldehyde versus pure glutaraldehyde increased the irritant effects to the upper respiratory tract of workers. Another study indicated that the vapor from pure glutaraldehyde was noticable and considered irritating by some persons. The authors, therefore, concluded that glutaraldehyde should be kept covered whenever possible and used in a well-ventilated area in such a manner so as to prevent prolonged breathing of the vapor.[10]

d. Eye Effects

Studies on the effects of glutaraldehyde on the eyes of rabbits produced severe corneal opacity and irritation of the iris and conjunctiva. These reactions were not reversed during a seven-day observation period. In rinsed eyes, there was similar irritation of the conjuctive which remained during the seven-day observation period. The cornea and iris showed less irritation, which was partially reduced during the seven-day observation period.[11]

e. Mutagenic and Teratogenic Effects

In the most recent publication of the Registry of Toxic Effects of Chemical Substances (RTECS), 1983-84 three studies were cited in which glutaraldehyde was evaluated for possible mutagenic and teratogenic effects in animals. The study on mutagenic research on chickens showed that glutaraldehyde at 8% did not produce DNA damage.[12]

The second study references stated that glutaraldehyde did not produce teratogenic effects. The study did illustrate, however, that glutaraldehyde administered to mice at 50 gm/kg produced central nervous system, musculoskeletal and craniofacial damage (including nose and tongue). It was also determined in this study that glutaraldehyde at 8 gm/kg produced fetotoxicity (i.e., stunted fetus).

The third study showed that glutaraldehyde acts as an antimitotic and fixative substance to the eggs of a non-mammalian test species (Pleurodele) when they were treated with a .050 M solution.

f. Other Research

The results of two studies demonstrated in increased irritation from glutaraldehyde when the dialdehyde is activated. In one study mice were exposed at 8 and 33 ppm (33 and 133 mg/M^3) of alkalinized glutaraldehyde for 24 hours. The animals reacted with distinctly nervous behavior, panting and washing of the face and limbs, with symptoms disappearing after a few hours. Half of each group were sacrificed immediately postexposure, and the rest one day later. Lungs and kidneys showed no histopathologic damage, but the livers of the mice exposed at 33 ppm showed definite signs of toxic hepatitis, possibly still reversible, since it was present to a somewhat lesser degree in the animals autopsied one day postexposure.[6]

In a second study, simulating a complete cold-sterilizing procedure lasting twelve minutes, the integrated sample of activated, 2% aqueous solution resulted in 0.38 ppm (1.33 mg/M^3) of glutaraldehyde measured at the operator's breathing zone. Although some irritation had been felt throughout this procedure, it was not until the end of the operation, when the equipment being sterilized was air-hose dried, that severe eye, plus nose and throat irritation were felt by the operator and the investigators, who also experienced sudden headache.[6]

A NIOSH investigation concluded that a health hazard existed at a hospital where glutaraldehyde was used in small animal research studies, and as a sterilant and disinfectant of respiratory therapy equipment. Glutaraldehyde concentrations in 8 personal breathing zone samples ranged from none detected to 1.5 mg/M^3. Six of these exceeded the ACGIH TLV of 0.7 mg/M^3. Medical questionnaires revealed that 9 of 11 exposed workers reported irritative symptoms compatible with exposure to glutaraldehyde. Eye and throat irritation were the most prevalent symptoms.

In summary, the current literature illustrates that glutaraldehyde is a relatively strong irritant to the nose and a severe irritant to the eye. It can produce staining and may be slightly irritating to the skin. It also may cause skin sensitization (allergic contact dermatitis) from occasional or incidental occupational exposures. Furthermore, it appears that the relatively strong irritant effect of pure glutaraldehyde on the eyes, nasal passages, upper respiratory tract and skin are slightly enhanced when the dialdehyde is activated. Finally, recent information suggests that glutaraldehyde is not mutagenic or teratogenic, but is fetotoxic.[13]

VI. RESULTS

Three breathing zone and six general area air samples were collected and analyzed for glutaraldehyde. The highest concentration was 0.48 mg/M^3 and two of the samples were below the limits of laboratory detection. The average concentration for all nine samples was 0.22 mg/M^3. There are neither OSHA nor NIOSH evaluation criteria, however, the ACGIH recommends a TLV of 0.7 mg/M^3 as a ceiling value that should never be exceeded. None of these samples exceeded the TLV.

VII. CONCLUSIONS

There were no overexposures to glutaraldehyde. Informal interviews with two workers that routinely use glutaraldehyde did not indicate that they were overly concerned with this compound. Hospital management has done an excellent job ventilating the glutaraldehyde cleaning tank used in the sigmoidoscopy area. The glutaraldehyde disinfecting, and sterilizing solution is placed in a large container, this container is placed in another container after the scopes are placed into the solution, this container has an exhaust, ventilation system attached. All the glutaraldehyde vapors are ventilated thus eliminating most of the exposure.

The facility where the respiratory equipment is sterilized with the glutaraldehyde has some problems. The area where the technician cleans the respiratory equipment is used as a passageway to other areas of the hospital. While the technician is trying to clean and sterilize equipment, people are continually walking by, slamming doors and disrupting the technicians material flow and concentration. It would be advisable to either put this procedure somewhere else or eliminate the flow of traffic through her department.

VIII. RECOMMENDATIONS

1. As stated above, a better arrangement should be made for the individual cleaning the respiratory equipment. The area should not be used as a hallway to other areas of the hospital.

2. The ventilation system used for the sigmoidscope disinfecting should be shared with other facilities. It is very effective and is not an expensive piece of equipment.

IX. REFERENCES

1. Crandall, Michael S., C.I.H., "Montgomery Hospital, Morristown, Pennsylvania", HETA 86-226-1769, NIOSH, January 1987.

2. ACGIH, Threshold Limit Values (TLV) for Chemical Substances in the Work Environment, 1984-85.

3. Stonehill, A.A., et.al., :Buffered Glutaraldehyde - A New Chemical Sterilizing Solution," A.J.H.P. 20: 458-465 (September) 1963.

4. Miner, N.A., et.al., "Autimicrobial and Other Properties of a New Stabilized Alkaline Glutaraldehyde Disinfectant/Sterilizer," A.J.H.P. 34: 376-382 (April) 1977.

5. Borick, P.M.: Chemical Sterilizers (Chemosterilizers), In Advances in Applied Microbiology, Academic Press, New York, NY, 1968, pp. 291-312.

6. Glutaraldehyde - Documentation of the Threshold Limit Values - Fourth Edition, ACGIH, 1983, pp. 204-205.

7. Anon: Regulations for the enforcement of the Federal Insecticide, Fungicide, and Rodenticide Act, section 362.116, 7 CFR part 362, Federal Register 34: 6106-6112 (April 4) 1969.

8. Jordan, W.P., et. al.: "Contact Dermatitis from Glutaraldehyde," Arch. Derm. 105: 94 (1972).

9. Fisher, A.A., "Reaction to Glutaraldehyde," with particular reference to radiologists and x-ray technicians, CUTIB Vol. 28, 2, pp. 113-114 and 119-122, 1981.

10. "Human Sensory Irritation Threshold of Glutaraldehyde Vapor Report to Dr. N.A. Miner," Arbrook, Inc., Arlington, TX (February 19, 2976).

11. Anon: Regulations for the Enforcement of the Federal Insecticide, Fungicide, and Rodenticide Act, part 162, Federal Register 40: 28279 (July 3) 1975.

12. NIOSH: Registry of Toxic Substances 1983-84 Cumulative Supplement v.1, p. 966.

13. Pryor, P.D., "National Jewish Hospital, Denver, Colorado" HETA 83-074-1525, NIOSH, November 1984.

X. AUTHORSHIP AND ACKNOWLEDGEMENTS

Report Prepared By: Bobby J. Gunter, Ph.D., C.I.H.
Regional Industrial Hygienist
NIOSH - Denver Region
Denver, Colorado

Originating Office: Hazard Evaluations and Technical Assistance Branch
Division of Surveillance, Hazard Evaluations, and Field Studies (DSHEFS)
Cincinnati, Ohio

Report Typed By: Marile F. DiGiacomo
Secretary
NIOSH - Denver Region
Denver, Colorado

XI. DISTRIBUTION AND AVAILABILITY

Copies of this report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, Publications Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), Port Royal Road, Springfield, Virginia 22161. Information regarding its availablity through NTIS can be obtained from NIOSH Publications Office at the Cincinnati address. Copies of this report have been sent to:

1. St. James Community Hospital
2. U.S. Dept. of Labor/OSHA - Region VIII
3. NIOSH - Denver Region
4. Colorado State Health Dept.

For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

Table 1

Breathing Zone and General Room Air Concentrations of
Glutaraldehyde at
Saint James Hospital
Butte, Montana
April 2, 1987

Sample #	Location	Sampling Time	Mg/M^3 Glutaraldehyde
01	Personal (RCST)	9:57a - 12:17p	0.25
02	General Area (work bench)	9:41a - 12:20p	0.21
03	General Area (wall)	9:42a - 12:18p	0.22
04	General Area (exhaust fan)	9:39a - 12:22p	0.28
05	General Area (sink)	9:38a - 12:10p	0.20
06	Personal (RCST)	1:54p - 4:00p	*
07	General Area (sink)	1:55p - 4:00p	*
08	Respiratory Therapy (tech.)	3:30p - 4:15p	0.38
09	Respiratory Therapy (Gen.)	3:30p - 4:15p	0.48
Evaluation Criteria			0.70
Laboratory Limit of Detection mg/sample			0.002

RCST = Registered Central Services Technician
* = Below the laboratory limit of detection