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HUMANA SUBURBAN HOSPITAL
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SUMMARY

In August, 1990 the National Institute for Occupational Safety and Health (NIOSH) received a confidential request for a Health Hazard Evaluation (HHE) from a group of employees at the Humana Suburban Hospital in Louisville, Kentucky. The employees asked NIOSH to investigate the occurrence of Down Syndrome among the children of women working in the operating and recovery rooms, and to evaluate possible exposures to waste anesthetics.

In November, 1990 an initial site visit was made. During the initial visit confidential employee interviews were conducted, personnel and medical records were requested, air monitoring and maintenance records were reviewed, and a brief walk-through was performed. In January, 1991 a second site visit was made during which a more extensive walk-through was conducted, and air samples were collected for measurement of halogenated anesthetics and nitrous oxide.

Two recovery room nurses reported having children with Down Syndrome. Interviews with operating room and recovery room nurses and hospital officials, and a review of hospital birth records yielded no additional cases. Air sampling data indicate that exposures on the day of the survey were well within the NIOSH Recommended Exposure Limits (RELs). While the survey found no evidence of over-exposures to waste anesthetics or of adverse health effects, it was recommended that the hospital continue the current practice of routine maintenance and testing. It was also suggested that a routine, in-house air monitoring program be initiated.

On the basis of data collected in this investigation, there was no evidence of over-exposure to anesthetic gases at Humana Suburban Hospital. The low concentrations that were measured in this survey indicate that the anesthetic scavenging and dilution ventilation systems were working well. There is insufficient evidence to conclude that the two cases of Down Syndrome (which is uncommon but not rare) reported by the nurses in the recovery room are related to chemical exposures in the work place.

KEYWORDS: SIC 8062, (General Medical and Surgical Hospitals) Nitrous Oxide, Halothane, Enflurane, Isoflurane, Waste Anesthetic, Down Syndrome

INTRODUCTION

In August 1990 the National Institute for Occupational Safety and Health (NIOSH) received a confidential request for a Health Hazard Evaluation (HHE) from a group of employees at the Humana Suburban Hospital in Louisville, Kentucky. The employees asked NIOSH to investigate the occurrence of Down Syndrome among the children of women working in the operating and recovery rooms. In addition, they requested an evaluation of possible exposures to waste anesthetics and to methyl-methacrylate used in a surgical cement.

In response to the employees' request NIOSH investigators made two visits to the hospital and conducted a review of the literature to determine whether Down Syndrome had previously been linked to anesthetic exposure. The initial visit included a review of hospital air monitoring and maintenance records, a brief inspection of the facility, and a series of employee interviews. Personnel and medical records for women working in the operating and recovery areas were also obtained. The second visit included a one day air sampling survey, during which airborne concentrations of waste anesthetics were measured in the recovery room and in three operating rooms.

Although NIOSH was also asked to investigate possible exposures to methyl-methacrylate, a decision was made not to conduct sampling for that compound. This decision was based on reports that the methyl-methacrylate cement is not used frequently and on the fact that the Kentucky Occupational Safety and Health Administration (OSHA) had recently monitored for methyl-methacrylate exposures at Humana Suburban Hospital. Air monitoring conducted by a Kentucky OSHA compliance officer found that employees had no detectable exposure to methyl-methacrylate.

BACKGROUND

Since the early 1970's a number of studies have been published in the peer-reviewed literature which describe possible adverse health effects among health care workers exposed to anesthetic agents (1-4). Most of these studies have been flawed in some respect or have produced inconclusive results. However, several reports have indicated possible links between exposure to waste anesthetic gases and adverse pregnancy outcome, including increased risk of congenital abnormalities and spontaneous abortion. Adverse effects have been reported in studies of women exposed to waste anesthetics and in the wives of men who were exposed. The findings from many of these studies have been summarized in other reports and reviews (5,6).

Down syndrome is the most common autosomal chromosome abnormality in live born infants. It occurs in approximately 1 in 700 newborns for mothers of all ages. The incidence increases with increased maternal age, occurring in about 1 in 200 newborns for mothers age 35 or more and 1 in 100 for mothers age 40 years or more (7). While there does appear to be some increased risk of congenital abnormalities in the children of workers exposed to anesthetics, there is currently no evidence that Down Syndrome is associated with

occupational exposure to these agents. There are some reports of Down Syndrome being associated with exposure to ionizing radiation, but a review of the literature found no evidence of a link with exposure to any chemical agent.

In response to concerns over possible adverse effects from frequent exposure to waste anesthetics, NIOSH published the document "Criteria For a Recommended Standard; Occupational Exposure to Waste Anesthetic Gases and Vapors" in 1977 (8). As part of that document, NIOSH issued a Recommended Exposure Limit (REL) for nitrous oxide (N₂O) of 25 parts per million (ppm) expressed as a time-weighted average (TWA) concentration. It was also recommended that TWA concentrations of halogenated anesthetics be limited to 2 ppm. Although NIOSH RELs are usually based on a 10-hour work day, these recommendations are based on a one-hour sampling period. That is, the average concentration over any one-hour time period should not exceed the recommended values. Because the health effects information for anesthetic agents is not definitive, the RELs should be viewed as maximum exposure levels and should not be thought of as safe levels of exposure. On this basis, the Criteria Document recommends that exposures be kept as low as is technically feasible.

In addition to the NIOSH recommendations, the American Conference of Governmental Industrial Hygienists (ACGIH) has also issued Threshold Limit Values (TLVs) for N₂O and some halogenated compounds. In most cases the ACGIH TLVs are higher than the NIOSH RELs. At this time the Occupational Safety and Health Administration (OSHA) has not set a Permissible Exposure Limit (PEL) for waste anesthetics.

Previous NIOSH investigations of anesthetic levels in hospital operating rooms have shown that concentrations of waste anesthetic gases do sometimes exceed NIOSH recommendations (9,10,11). These findings are in agreement with published data, including a recent study of anesthetic exposures at 74 hospitals in Ontario, Canada (12). In that study 15 to 20 percent of samples exceeded the 2 ppm REL for enflurane, and up to 6 percent of the samples exceeded the REL for other halogenated anesthetics. The 25 ppm REL for N₂O was also exceeded in many hospitals. The average N₂O concentrations were found to be highly variable, with the mean exposures ranging from 2 ppm to over 500 ppm. In 12 of 14 job categories tested, the average exposure levels exceeded the NIOSH recommended limits.

The authors of the NIOSH Criteria Document and the authors of the Ontario study believe that most overexposures that occur in operating rooms result from failure to use scavenging equipment, malfunctions of the scavenging equipment, improper room ventilation, or as a result of improper work practices. If the rate of dilution ventilation is sufficient, and if gas scavenging equipment is well maintained, tested on a routine basis, and used according to NIOSH recommendations, exposure levels can be maintained below the recommended limits. Specific requirements for ventilation and engineering controls are included in the NIOSH Criteria Document as well as in publications of The American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) (13,14).

In addition to exposures occurring during surgery, anesthetic exposures can also occur in recovery rooms when patients exhale anesthetics after being brought out of surgery. Because emphasis is usually placed on controlling exposures in the operating room, the highest exposures sometimes occur in the recovery room. Although the potential for extremely high peak levels of exposure is less than in the operating rooms, previous NIOSH surveys have occasionally found average concentrations that exceed the NIOSH RELs. Local control systems of the type used in operating rooms are not a practical solution to this problem. However, proper use of dilution ventilation, as described in the ASHRAE and NIOSH publications noted earlier, should provide sufficient control.

EVALUATION PROCEDURES AND RESULTS

Medical Assessment

During the initial visit, a NIOSH physician conducted private interviews with five of the nurses who worked in the recovery room or the operating rooms. The nurses were selected on the basis of availability at the time of the initial NIOSH visit. Of the five nurses interviewed, three nurses had worked in the recovery room exclusively. Of the two operating room nurses, one had worked in the recovery room before moving to the operating room staff. Separate nursing staffs are employed in the operating rooms and recovery rooms, without rotation between the two areas. The two nurses with children having Down Syndrome both worked in the recovery room. No other reports of operating room or recovery room personnel having babies with Down Syndrome were elicited from the nurses or hospital officials interviewed or from the review of hospital birth records.

Environmental Assessment

Although no evidence of occupational disease was found in the initial medical investigation, an air sampling survey was conducted as a follow-up on January 29, 1991. Nine air sampling stations were set up in the following locations; two stations each in operating rooms 2, 5, and 9; and three stations in the recovery room. In each operating room one station was set up at the anesthesia machine and the second was set up on the opposite side of the room. The sampling locations in the recovery room are indicated on Figure 1. Each station included two collection devices; one for nitrous oxide and one for halogenated anesthetics. Air samples were collected during surgery in the operating rooms and from approximately 8:30 AM to 2:00 PM in the recovery room.

A total of nine air samples were collected on activated charcoal and sent to a contract laboratory for measurement of halogenated anesthetics. Collection and analysis were performed according to the basic procedures described in NIOSH method 1003 (15). Samples were eluted with carbon disulfide and analyzed for isoflurane, halothane, and

enflurane by gas chromatography using a flame-ionization detector. The analytical limit of detection (LOD) for each compound was 0.01 milligrams per sample. The lowest airborne concentration that can be reliably detected with this method is dependent on the sampling time, and for this data set the limit ranged from 0.1 to 0.5 ppm. This LOD would allow average concentrations as low as one fourth of the REL to be detected.

In addition to the samples collected on charcoal tubes, eleven air samples were collected in Mylar® bags for analysis of N₂O. The N₂O concentration in each sample was measured on-site using a portable infrared spectrometer (MIRAN®). The infrared method has been widely used in measurement of anesthetic gases and, depending on the configuration, can detect N₂O concentrations down to 1 ppm. The LOD is dependent on the instrument configuration and in this case was estimated at between 1 and 5 ppm, or about one fifth of the REL.

The air sampling results and details of the sampling protocol are presented in Tables 1 and 2. As shown in Table 1, halothane concentrations were below the LOD in all cases. Although the actual levels were too low to be accurately measured, these results indicate that the TWA concentrations were less than 0.5 ppm. Isoflurane and enflurane concentrations in the operating rooms were also below the LOD. Due partly to the extended sampling times used in the recovery room, isoflurane and enflurane could be detected in that area, but concentrations were again too low to be accurately measured. In all cases the TWA concentrations of halogenated materials were below the NIOSH recommended limits.

As shown in Table 2, N₂O concentrations ranged from non-detectable to about 5 ppm. As with the halogenated materials, the highest concentrations were recorded in the recovery room. However, even the maximum levels were barely detectable and were well below the NIOSH REL.

DISCUSSION AND RECOMMENDATIONS

The concentrations of halogenated anesthetics that were recorded in this survey were less than 25% of the NIOSH RELs and N₂O levels were less than 20% of the REL. Based on these results, the hospital staff appears to be doing an excellent job of exposure control. This is consistent with observations made during the survey and with our review of hospital maintenance and monitoring records. Based on these data, exposures to waste anesthetic gas do not appear to represent a health hazard to employees.

In addition to the environmental survey, a brief evaluation of employee reproductive history was also made. The occurrence of Down Syndrome was reported by two employees. However, there is no evidence in our data or in the literature that would indicate an association with exposure to anesthetic gases or other chemical agents. An epidemiologic study to address this

question would require a much larger group of exposed personnel than the recovery/operating room staff at a single hospital. The small number of people involved made a full epidemiological study unfeasible.

In interpreting our environmental results, hospital management and employees should be aware that they are based on a limited sample size, and may not be representative of conditions at other times. Previous NIOSH investigations and published reports have both shown that over-exposures to waste anesthetic agents can and do occur in some health care facilities. In most cases, high level exposures are the result of equipment failures or improper work practices and can be prevented through careful attention to maintenance and operating procedures. In other studies it has been shown that even a small leak in the high-pressure N₂O delivery system can result in exposures over the REL. Although the anesthetic concentrations measured in this survey were low, it is important that the hospital continue its monitoring, control, and maintenance programs. In addition, it is recommended that a routine air monitoring program also be developed to insure that leaks or other malfunctions are quickly detected. An air monitoring program should include quarterly evaluations of exposure during actual surgical procedures. Although NIOSH does not endorse specific commercial products, a number of easy to use, passive monitoring systems are available and have been reviewed in the literature (16).

REFERENCES

1. Cohen, E. N., J. W. Belville and B. W. Brown. Anesthesia, Pregnancy and Miscarriage: A Study of Operating Room Nurses and Anesthetists. *Anesthesiology* 34:343-347 1971.
2. Knill-Jones, R. P., L. V. Rodriguez and D. D. Moir. Anaesthetic Practice and Pregnancy: Controlled survey of Women Anesthetists in the United Kingdom. *Lancet* i:1326-1328 1972.
3. Knill-Jones, R. P., B. J. Newman and A. A. Spence. Anaesthetic Practice and Pregnancy: Controlled survey of Male Anesthetists in the United Kingdom. *Lancet* ii:807-809 1975.
4. American Society of Anesthesiologists. Occupational Disease Among Operating Room Personnel: A National Study. *Anesthesiology* 41:321-340 1974.
5. Ahlborg, G., C. Hogstedt, L. Bodin and S. Barany. Pregnancy Outcome Among Working Women. *Scand. J. Work Environ. Health* 15:227-233, 1989.
6. Anesthetic Exposure in the Workplace. E. N. Cohen editor, PSG Publishing Company, Littleton, Massachusetts 1980.
7. Rudolph, A. M. ed. Pediatrics. 18th Edition, Appleton & Lange. Norwalk, CT. 1987.

8. National Institute for Occupational Safety and Health. Criteria for a Recommended Standard; Occupational Exposure to Waste Anesthetic Gases. U.S. Department of Health and Human Services, 1977.
9. Gunter, B. J. and S. J. Reno. The National Institute for Occupational Safety and Health, Health Hazard Evaluation Report, Primary Childrens Hospital, Salt Lake City, Utah. HETA Report No. 86-375-1735 1986.
10. Gunter, B. J. and W. Daniels. The National Institute for Occupational Safety and Health, Health Hazard Evaluation Report, University Hospital, Denver, Colorado. HETA Report No. HETA-88-258-1941.
11. Gunter, B. J. and W. Daniels. The National Institute for Occupational Safety and Health, Health Hazard Evaluation Report, West Seattle Community Hospital, Seattle, Washington. HETA Report No. HETA-87-013-1803.
12. Rajhans, G. S., D. A. Brown, D. Whaley, L. Wong and S. S. Guirguis. Hygiene Aspects of Occupational Exposure to Waste Anesthetic Gas in Ontario Hospitals. Ann. Occup. Hyg. 33(1):27-45, 1989.
13. ASHRAE. Handbook and Product Directory, Volume 7, Health Facilities. The American Society of Heating, Refrigeration, and Air-Conditioning Engineers, Atlanta Georgia 1978.
14. ASHRAE. Ventilation for Acceptable Indoor Air Quality. ASHRAE 62-1989 The American Society of Heating, Refrigeration, and Air-Conditioning Engineers Atlanta, Georgia 1989.
15. National Institute for Occupational Safety and Health. Manual of Analytical Methods, Third Edition. P. M. Eller editor, U. S. Department of Health and Human Services 1984.
16. Bishop, E. C. and H. A. Hossain. Field Comparison Between Two Nitrous Oxide (N₂O) Passive Monitors and Conventional Sampling Methods. Am. Ind. Hyg. Assoc. J. 45(12):812-816 1984.

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FIGURE 1
Locations Of Recovery Room Sampling Stations

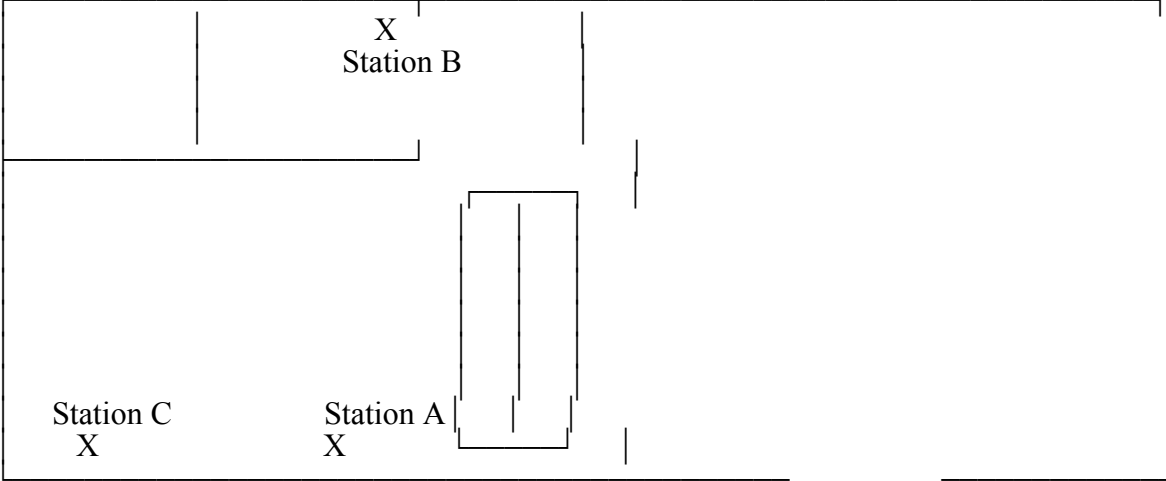


TABLE 1
Halogenated Anesthetic Concentrations

Sampling Location	Sampling Time (min)	Volume (liters)	TWA isoflurane	Concentration enflurane	(ppm) halothane
Recovery Room - Location A	190	9.5	0.1 - 0.4*	0.1 - 0.4*	< 0.1
Recovery Room - Location B	55	2.7	< 0.5	< 0.5	< 0.5
Recovery Room - Location C	180	9.0	0.1 - 0.4*	< 0.1	< 0.1
Operating Room #2 - Anesthesia Machine	75	3.8	< 0.4	< 0.4	< 0.3
Operating Room #2 - Supply Cabinets	75	3.8	< 0.4	< 0.4	< 0.3
Operating Room #5 - Anesthesia Machine	280	14	< 0.1	< 0.1	< 0.1
Operating Room #5 - Back Wall	280	14	< 0.1	< 0.1	< 0.1
Operating Room #9 - Anesthesia Machine	100	5.0	< 0.3	< 0.3	< 0.2
Operating Room #9 - Return Air Vent	100	5.0	< 0.3	< 0.3	< 0.2

* Anesthetics were detected, but concentrations were too low to be accurately quantified.
NIOSH REL = 2 ppm

Sampling locations in the recovery room locations are indicated on Figure 1.
Sampling rate: 50 ml/minute
Sampling media: Activated charcoal

TABLE 2
Nitrous Oxide Concentrations

Sampling Location	Sampling Time (min)	Concentration (ppm)
Recovery Room - location A (8:30-11:00)	165	3
Recovery Room - location A (11:00-2:00)	155	1
Recovery Room - location B (8:30-11:00)	150	ND
Recovery Room - location B (11:00-2:00)	165	1
Recovery Room - location C (8:30-11:00)	147	2
Recovery Room - location C (11:00-2:00)	163	ND
Operating Room #2 - Supply Cabinets	100	ND
Operating Room #5 - Anesthesia Machine	280	ND
Operating Room #5 - Back Wall	280	ND
Operating Room #9 - Anesthesia Machine	100	5
Operating Room #9 - Return Air Vent	100	ND

NIOSH REL: 25 ppm

ND: Not Detected, concentration below 1 ppm.

Sampling locations in the recovery room locations are indicated on Figure 1.