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Anesthetic waste gas exposure in dental surgery

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Exposure to nitrous oxide in dental operatories was monitored using a MIRAN infrared analyzer. A "typical" TWA exposure was established for the surgeon, assistant and anesthesiologist. Exposures as high as 24,000 ppm were recorded while TWA's ranged from 78 to 1328 ppm.

introduction

Not until the late 1960's was any real concern expressed over chronic exposure to anesthetic gas. In 1967, A.I. Vaisman published the results of a twenty year epidemiological study of Russian anesthesiologists attributing to them a higher incidence of spontaneous abortion and abnormal pregnancies among exposed females.[1]

Since then, numerous epidemiological and toxicological studies have been undertaken which have, in general, corroborated and expanded Vaisman's initial findings.[2-10] Of particular interest is the recently published survey of dental practitioners and oral surgeons conducted by the Ad Hoc Committee on the Effects of Trace Anesthetics on the Health of Operating Room Personnel.[11] According to this report, "In the comparison of the health of individuals exposed or unexposed to inhalative anesthetics, there was a significant increase (78%) of spontaneous abortion in the spouses of exposed dentists and a significant increase (156%) in liver disease for exposed dentists."[11]

Numerous investigations of operating room environments have been conducted and several investigators have measured the exposure of dentists to waste anesthetic gas.[12-14] Generally, samples in these studies were taken at various sites throughout the operatory using a gas tight syringe to be later analyzed by gas chromatography. This technique allows an instantaneous spot check to be made. However, numerous samples must be taken to determine the average exposure throughout the day.

methodology

Our current study is an attempt to quantify the levels of exposure in dental operatories using a continuous sampling instrument, the MIRAN™ infrared gas analyzer. Absorption of infrared energy of 4.8 μm wavelength by N_2O was continuously monitored by the MIRAN and recorded on an auxiliary strip chart recorder. To monitor the levels in the surgeon's breathing zone, a small probe was attached to a surgical headlight. Its tip was situated approximately one inch out and two inches above the nose. This probe was connected to a larger sampling line (one half inch tygon) leading to the sample cell of the MIRAN. Thus any movement or activity of the subject affecting the inhaled concentration was also represented in the sample. The same sampling line was used throughout all experiments. Residence times for the N_2O-air mixtures were less than 0.5 seconds and wall absorption was assumed to be minimal.

A similar sampling technique was employed to measure exposure to the anesthesiologist and dental assistant. Additional samples were taken at various locations throughout the operatory to determine average room concentrations.

The MIRAN is capable of measuring anesthetic gases other than nitrous oxide. However, the use of these gases (halothane, fluothane, penthrane, etc) among the surgeons studied was infrequent. Consequently, only a single sample of halothane exposure was obtained. However, it is not unreasonable to assume that the ratios of concentrations of these gases in air to the concentrations administered would be similar to that measured for N_2O, since all are administered in the gaseous state. The halogenated agents are significantly more potent than nitrous oxide, consequently, the concentrations administered are much lower, frequently less than one percent by volume. The individual's exposure to these materials would therefore be proportionately reduced.

The halogenated anesthetic agents are potentially more toxic than nitrous oxide to the human body and are primary suspects in the increased incidence of liver disease. Nitrous oxide has been considered to be more benign, but could play a role in the rise in spontaneous abortion. Toxicological testing of N_2O has exhibited increased congenital abnormalities and fetal death rates in both mammalian and avian species.[15-17]

results

Sampling was conducted during both general anesthesia and analgesia administration. The balanced anesthesia technique utilized diazepam (valium), 1% methohexital (brevital) and nitrous oxide.[18] Nitrous oxide was delivered at a rate of seven liters per minute (7 Lpm) mixed with 3 Lpm of oxygen, or a 70% mixture (by volume).

During the general anesthetic procedure, people were normally present; the surgeon, dental assistant and anesthetist. The anesthetist monitored the anesthetic administration and physically supported the patient's head and jaw to maintain a patent airway. This position contributed to a less variable exposure to exhaust gases than either that of the surgeon or assistant.

During either anesthesia or analgesia the surgeon and assistant's exposure varied with the nature of their work. The highest measurements, 24,000 ppm, were recorded when the surgeon worked extremely close to the patient's mouth. The lowest measurements, 550 ppm, were observed when he turned to examine x-rays.

The dental assistant's routine requires frequent movement away from the patient to get instruments for the surgeon. As a result, her average exposure was significantly less than that of the surgeon.

Table I summarizes data obtained during general anesthesia administration. Measurements of nitrous oxide exposure were made during third molar extractions on adult patients. N_2O was usually administered at a constant rate throughout the entire surgical procedure.

The halothane measurement was made during administration to a small child. The concentration was frequently adjusted (reduced to zero

TABLE I
General Anesthesia

Anesthetic	Location	Duration Minutes	Range of Exposure ppm	Average Exposure ppm	Standard Deviation
3 Lpm O_2,	surgeon	24	500 - 6000	2650	70
7 Lpm N_2O	anesthetist	40	280 - 6500	1860	100
(70% N_2O)	assistant	25	1440 - 5000	2480	11.5
	4 in. from pop-valve	24	28,000 - 90,000	49,000	-
8 Lpm O_2, Halothane (0.3 - 1.0%)	anesthetist	16	7.5 - 59	28.5	1.5

TABLE II
Analgesia

Anesthetic	Location	Duration Minutes	Range of Exposure ppm	Average Exposure ppm	Standard Deviation
		45	120 - 2660	400	70
	surgeon	75	80 - 22,000	620	160
O_2		40	280 - 4800	1450	70
4 Lpm		44	520 - 4800	1540	40
N_2O	assistant	46	14 - 180	70	16
2 Lpm		40	90 - 250	160	11
(33%)	4 in. from pop-valve	-	13000 - 90000	49000	1600
	general room	-	100 - 320	180	9
		22	350 - 5000	710	50
	surgeon	19	710 - 8500	3000	120
O_2		37	880 - 24000	4600	90
4 Lpm					
	assistant	22	160 - 530	290	27.5
N_2O		27	220 - 580	380	18
3 Lpm					
	general room	-	-	200	4
(42%)					
	background between surgeries	-	39 - 270	54	-

occasionally) to maintain the desired anesthetic plane. As a result, the exhaust concentration fluctuated significantly, yet the average personal exposure remained at the relatively high level of 28.5 ppm.

Analgesia usually consisted of an intravenous injection of diazepam and administration of nitrous oxide. A total flow (O_2 and N_2O) of six or seven liters per minute was used with N_2O constituting twenty to fifty percent of the mixture. The surgeon and dental assistant were the only personnel usually present. As this study was conducted in the clinic of a dental school, students frequently observed the surgery. However in normal practice only the surgeon and assistant would necessarily be exposed.

Table II presents an analysis of the data collected during analgesia administration. Two different surgeons and three different assistants were monitored. Additionally, two different anesthetic concentrations were employed. The concentration administered to an individual patient remained constant throughout the surgery unless it was diluted via the diluter valve on the nose-piece. This consisted of opening the nose-piece pop-valve to the atmosphere allowing a portion of the anesthetic to be mixed with room air. The use of this technique significantly raised the exposure of the surgeon because anesthetic gas was immediately exhausted at the nose-piece.

The use of the air powered hand piece noticeably decreased the surgeon's exposure. It is hypothesized that the use of this instrument disperses the anesthetic gas away from the breathing zone of the surgeon.

As expected, the average exposure of the surgeon and assistant varies directly with the concentration administered to the patient. The average room concentration during surgery is significantly lower than the exposure of either surgeon or assistant. Between surgeries, the room concentration exhibits the classic exponential decay as it is diluted by the general ventilation system which provides 31 room air changes per hour. Anesthetic concentration would increase throughout the working day in non-ventilated rooms or those using a re-circulating ventilation system.

Using the data in Tables I and II, an attempt to define the "typical" daily exposure was made. It has been estimated that an oral surgeon administers eight to thirteen anesthetics per day.[6,10] In estimating a time-weighted average (TWA) exposure for dental personnel, the following assumptions were made:

— operations per day 8
— average time per operation 25 minutes

TABLE III
Estimated Average Exposure (TWA)

Individual	Concentration N_2O	TWA Exposure during surgery ppm	Average Background ppm	Overall TWA Exposure ppm
	Analgesia			
	33%	933		411
Surgeon	42%	3133		1328
	Average	1831	54	785
	33%	112		78
Assistant	42%	339		172
	Average	194	54	112
	Anesthesia			
Surgeon		2650	54	1126
Anesthetist	70%	1860	54	797
Assistant		2480	54	1064

— surgeon's and anesthesiologist's exposure to background concentration	200 minutes
— assistant's exposure to background concentration	280 minutes
— working day	480 minutes

Based on these assumptions, a typical TWA exposure has been established, Table III. As this table illustrates, the TWA exposure of the surgeon and anesthetist administering N_2O throughout a "normal" working day would be excessively high. Tests have demonstrated an apparent diminuation of recall faculties in subjects exposed to 500 ppm N_2O for four hours.[19] One should also consider the implication pf the teratogenic effects exhibited with N_2O exposure in toxicological testing.

The daily exposure of any particular surgeon would deviate from the estimated TWA only to the degree that his work practices and environment differ from those measured. However, the tabulated results are representative of conventional surgical practices in a typical dental operatory.

discussion

Although no cause-effect relationship between chronic anesthetic gas exposure and adverse health effects has been definitely established, current epidemiological and toxicological evidence indicates there is reason for concern. As the nature of the work involved minimizes the probability of other differences between exposed and unexposed oral surgeons, the adverse health effects reported in the epidemiological survey between these groups lends strong support to the theory of chronic effects.

In addition to the potential physical danger, there is also the possibility of impairment of psychological and motor responses.[19–20] In a profession as demanding as oral surgery for precise interpretation and execution of nervous system stimuli, anything that could adversely affect this system should be closely guarded.

Currently, NIOSH is sponsoring a study of the effectiveness of gas-scavenging equipment for dental offices. Significant improvement has been realized in conventional operating rooms by the use of such systems.[21] A recent report has recommended methods for controlling occupational exposure to N_2O in dental operatories.[22]

Nitrous oxide has proven to be a reliable, safe, and convenient agent for anesthesia and its continued use in dental surgery is unquestionably warranted from the point of view of patient comfort and care. However, concern is equally warranted for the health and safety of dental personnel. Advances are needed in the present technology of anesthetic administration. Modification in present equipment for effective scavenging, and dissemination of information concerning its proper operation and maintenance could reduce waste anesthetic exposure to a more acceptable level.

Sometime after such modifications are made, it would be advisable to repeat the epidemiological surveys. If anesthetic gases are indeed responsible for adverse health effects, a reduction in their incidence could be expected. The added incremental cost of control is a small wager against the possibility of liver cancer, spontaneous abortion, or fetal abnormality.

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A new dust control system for foundries

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No dust collectors are required to control the dust pollution problem of a foundry sand system. Hot dry sands, the source of the dust problem, are cooled without mechanical coolers,