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Early and Late Scavenging of Anaesthetic Gases

P. CLEATON-JONES, D. MOYES, R. SHAW, J. AUSTIN, L. BONNER, H. FAIN, R. CRICHTON

SUMMARY

The effectiveness of two waste gas scavenger devices, the Carstens box and the Ventex apparatus, with regard to nitrous oxide pollution was studied under comparable conditions in an operating theatre. The scavengers were brought into use in the early and late stages of induction of anaesthesia, and nitrous oxide concentrations in the breathing zone and theatre peripheral air were measured. Both scavengers reduced nitrous oxide pollution at the sampling points. Similar reductions in nitrous oxide pollution in the breathing zone were obtained with both scavengers, but the Carstens box was more effective in reducing nitrous oxide pollution in the peripheral air.

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The harmful effects of long-term exposure of operating-theatre staff to air polluted with anaesthetic gases are under scrutiny. This is not a new phenomenon, since Hirsch and Kappers suggested in 1929 that inhalation of anaesthetic agents present in the air of operating rooms might have an injurious effect on the health of surgeons and those who assist them.[1] It is, however, a controversial matter. National surveys of anaesthetists in the UK[2] and in the USA[3] have shown an increase in the frequency of spontaneous abortion in women who work in operating theatres, but other authors have not confirmed this. Congenital anomalies may also be present in higher than expected numbers in the offspring of anaesthetists. This has been shown in the children of female anaesthetists in some studies[4,5] and among children of both male and female anaesthetists in another study.[6]

Although the effects of anaesthetic gas pollution are at present uncertain, health authorities in both the UK and the USA suggest the use of scavenging systems to lessen pollution.[7] This study was undertaken to examine the effects of two scavenging systems, connected to the anaesthetic circuit during the early and late stages of induction, on nitrous oxide pollution of air in an operating theatre.

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MATERIALS AND METHODS

The operating theatre at the Oral and Dental Hospital of the University of the Witwatersrand, Johannesburg, was the venue for the study. This is a room of 138 m³ capacity ventilated by means of two window-mounted air-cooling units (12 660 kJ/h), producing approximately two air changes per hour.

Sampling

Snatch air samples were collected by twice aspirating and expelling 20 ml of air in disposable polypropylene syringes, followed by aspiration of a final 20 ml sample which was injected into a gas-tight nylon storage bag. The samples were collected at two sites, initially before commencing the day's operating and thereafter at 10-minute intervals following the beginning of the first anaesthetic.

The sites sampled were: (*i*) in the breathing zone at the Heidbrink valve, and (*ii*) in the peripheral air at the air conditioner intake.

Each final air sample was collected within 1 second and the sampling was completed at both sites within 1 minute. The samples were then transferred to a laboratory for analysis in a gas chromatograph.

Gas Chromatographic Technique

The concentration of N_2O was determined in all the samples with a Pye Unicam model GCV gas chromatograph. N_2O was separated using a 2 m x 4 mm borosilicate glass column packed with 80 - 100 mesh Poropak type Q (Waters Associates, Milford, Mass., USA) at a column temperature of 80°C. Helium was used as the carrier gas at a flow rate of 25 ml/min. A katharometer was used to detect the N_2O, the filament temperature being 180°C and the detector temperature being 100°C. At the injection port the temperature was 150°C. Peak areas were integrated with a Pye DP 88 integrating computer and compared with those of commercially prepared 100 ppm and 1 000 ppm (v/v) in N_2 standard mixtures (Altec Associates Calibration Gas, Arlington Heights, Ill., USA).

Scavenging Devices

Two scavenging devices were used, both of which have been described in detail elsewhere.[8] The first, developed at Baragwanath Hospital by Carstens, consists of a Perspex box containing a 2 l reservoir bag. This bag is open at the base opposite an outlet attached to the main room suction. The outflow from the patient was attached to the bag inlet.

An adjustable inlet/outlet valve on the upper surface of the box completes the apparatus (Fig. 1).

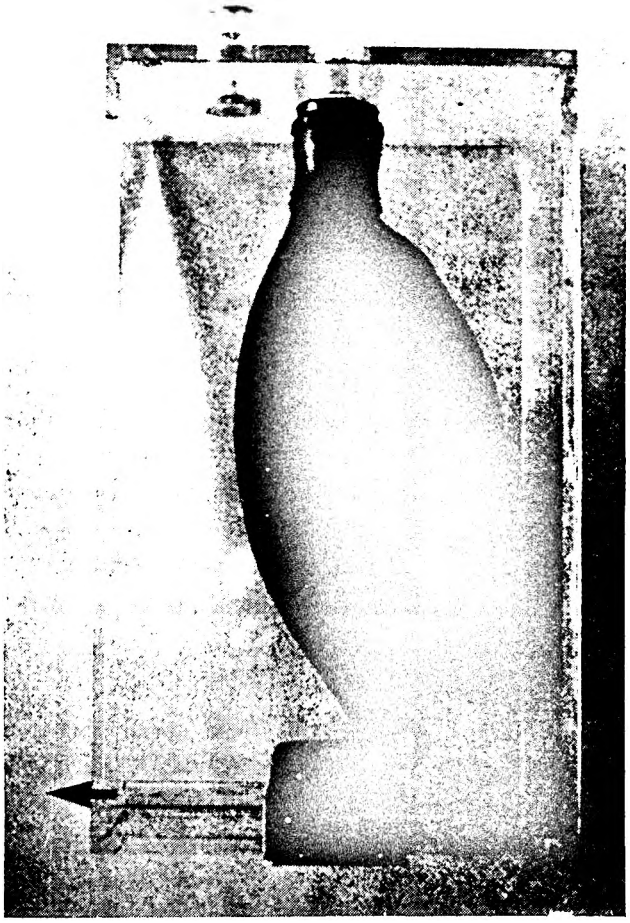

Fig. 1. Carstens box scavenger. This consists of a Perspex box surrounding a 2 l reservoir bag, into which waste gases flow, open at the distal end above a suction outlet (arrowed). An adjustable pressure relief valve is situated on the upper surface of the box.

The second device, the Ventex scavenger (Allan Cornish (Pty) Ltd, Johannesburg), consists of a metal tube with an attached reservoir bag, gravity-operated non-sprung inlet and outflow valves and a suction attachment adjustable through a needle valve (Fig. 2).

Piped suction (equivalent to a gas flow of 24 l/min) was adjusted to allow similar inflation of the reservoir bags on each scavenging device and in the Magill circuit.

Anaesthetic Technique

Anaesthesia was induced in patients in the operating theatre by intravenous thiopentone or alphaxalone and the gas flows set at O_2 3 l and N_2O 5 l/min. Halothane supply was adjusted as required. All patients were intubated via the nasal route with Portex non-cuffed endotracheal tubes (Portex, Hythe, Kent, England) and throat packs, either moistened gauze or vaginal tampons, were used.

The scavengers were used either early or late in the induction of anaesthesia. If used in the early stage they were attached to a hooded valve (F. H. Gardner Co., Oxford, England) in the Magill circuit before any anaesthetic gases were switched on. The patients were intubated, the circuitry connected to the endotracheal tube, and the gas flow begun. The throat pack was then inserted.

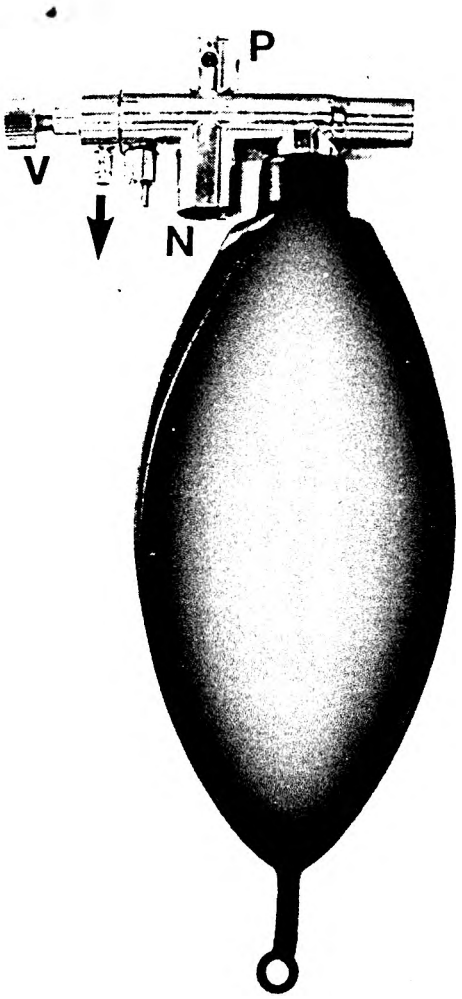

Fig. 2. Ventex scavenger. The device comprises a metal tube with negative (N) and positive (P) relief valves and suction (arrowed) controlled by a needle valve (V). A 2 l reservoir bag is attached to the device.

In late scavenging, the patients were intubated and connected to the circuit, gas flow was begun, and the pack was inserted. A scavenger was then attached to the circuit.

Control samples were collected during operations when no scavenger was attached to the anaesthetic circuit. The order of use of the scavenging devices was randomized using a table of random numbers, and each technique was used on 4 days.

Before the start of the investigation, the effect of the

operating theatre ventilation on the concentration of N_2O in the air was observed in the following manner. A Magill circuit with attached catheter mount was placed on the operating table so that the Heidbrink valve was in the position at which it would lie during an anaesthetic. The minute volume gas flow was set at 8 l/min (O_2 3 l/min, N_2O 5 l/min) for 20 minutes. Samples of air were collected as described above at the Heidbrink valve and air conditioner intake prior to commencing gas flow and then at 10-minute intervals for 140 minutes.

Statistical Analysis

The concentrations of N_2O measured in parts per million (v/v) were tabulated and means and standard deviations calculated. The statistical tests used were the one-way analysis of variance and Scheffe's multiple comparison test. A probability value of less than 0,05 was selected as the level of statistical significance.

RESULTS

The pattern of the rise and fall of nitrous oxide concentration in the operating-theatre air is shown in Fig. 3. There was a rapid increase in N_2O concentration after gas flow commenced. On the cessation of gas flow, the N_2O concentration diminished rapidly for the first 10 minutes, after which the fall in concentration was slower. The initial level was reached after 140 minutes. The N_2O concentration at the position of the Heidbrink valve was greater than in the peripheral air for the first 80 minutes and thereafter the two were almost identical.

On the sampling days the numbers of general anaesthetics administered varied from 1 to 4 per day and the total period of N_2O gas flow from 50 to 100 minutes per day. The mean gas flow times per patient during the sampling period in each group were similar, however, ranging from 22 to 27 minutes, and the total gas flow in each group varied from 290 minutes (no scavenging) through 300 (Ventex, early; Carstens, late), 310 (Carstens, early) to 350 minutes (Ventex, late).

The percentage frequency distribution of the concentrations of N_2O measured in the breathing zone during the times that the gas was flowing is shown in Table I. This shows a wide variation in the concentrations with a trend towards lower concentrations when the scavengers were used. The N_2O concentrations in the peripheral air were

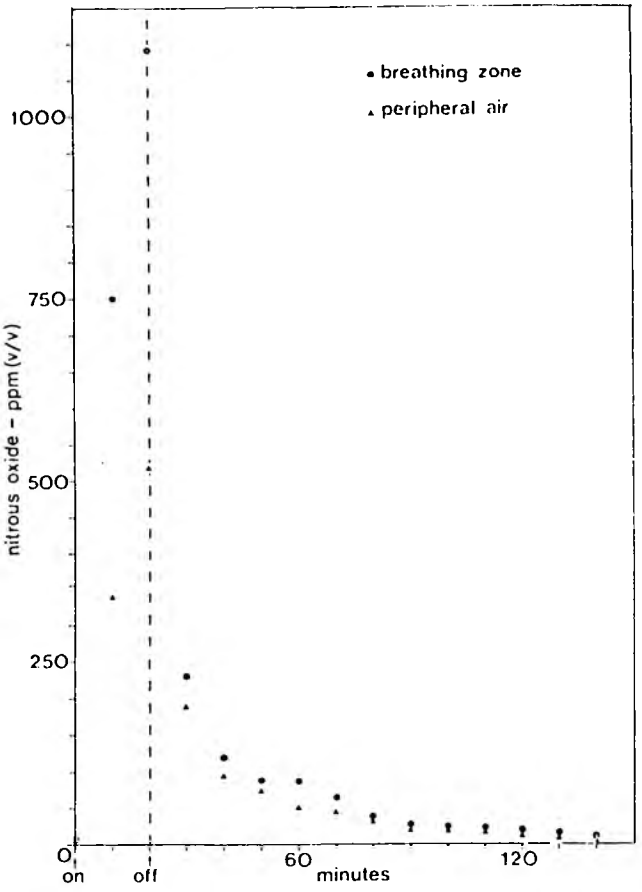

Fig. 3. Concentrations of N_2O in ppm (v/v) in the breathing zone and peripheral air after a 20-minute flow of N_2O (O_2 3 l and N_2O 5 l/min) into the operating theatre.

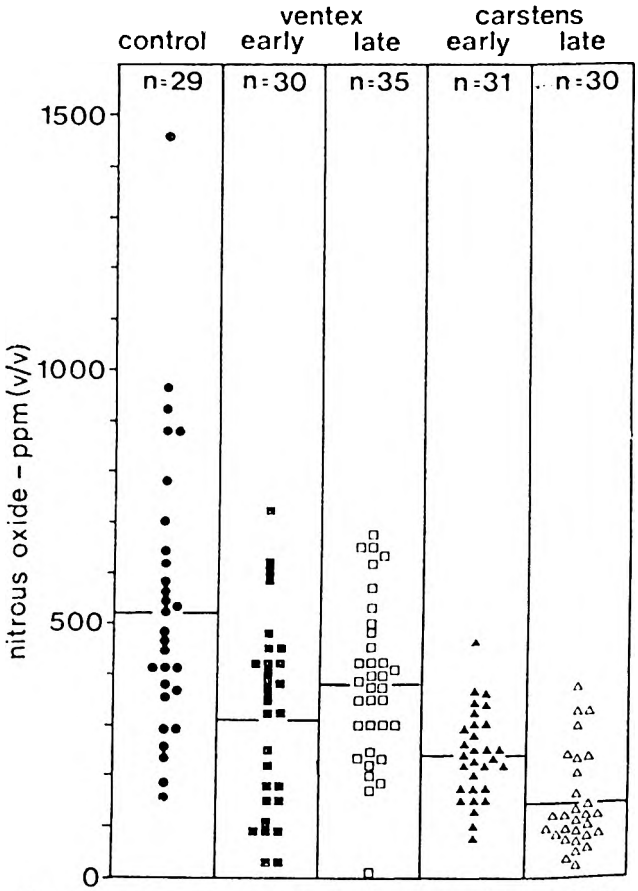

Fig. 4. Scattergram showing the concentrations of N_2O in peripheral air while N_2O was being administered. Each symbol represents a single recording and the horizontal line indicates the mean concentrations.

TABLE I. PERCENTAGE FREQUENCY DISTRIBUTION OF N_2O POLLUTION BREATHING ZONE

N_2O concentration (ppm (v/v)	Control (no scavenger) ($N = 29$)	Ventex early ($N = 30$)	Ventex late ($N = 35$)	Carstens early ($N = 31$)	Carstens late ($N = 30$)
>100 000	34	10	11	3	0
10 001 - 100 000	38	27	26	29	13
1 001 - 10 000	21	23	43	32	23
101 - 1 000	7	30	20	32	47
0 - 100	0	10	0	3	17

TABLE II. DETAILS OF N_2O CONCENTRATIONS IN PPM (V/V) DURING THE PERIODS THAT GAS WAS FLOWING

	Control	Ventex early	Ventex late	Carstens early	Carstens late
No. of samples	29	30	35	31	30
Breathing zone					
Range	469 - 221 007	86 - 245 897	263 - 116 389	65 - 255 421	49 - 18 265
Mean	71 663	29 565	25 316	19 715	5 096
SD	70,999	54 426	38 059	47 805	15 610
% reduction in pollution	—	59	65	72	93
Peripheral air					
Range	146 - 1462	29 - 710	2 - 648	80 - 347	41 - 365
Mean	519	307	377	241	145
SD	287	181	156	84	89
% reduction in pollution	—	41	27	54	72

lower, were spread over a narrower range, and are shown in scattergram form in Fig. 4. The trend towards lower concentrations when the scavengers were used can be clearly seen. Details of the ranges of N_2O concentrations, means and standard deviations are listed in Table II. Also indicated are the percentage reductions in pollution. These were calculated by subtracting the mean N_2O concentration when each scavenger was used from the mean control concentration and expressing this difference as a percentage of the control.

Table II reveals a wide variation in N_2O concentrations, especially in the breathing zone, exemplified by wide ranges and high standard deviations. Use of the Carstens box in the late stage was associated with the greatest reduction. Statistical analysis of differences in mean N_2O concentrations using Scheffe's multiple comparison test showed the following:

In the breathing zone all the scavenging devices significantly reduced N_2O pollution below the level noted when no scavenger was used. There were no significant differences between the mean N_2O concentrations noted when each of the methods of scavenging were used.

All the scavenging methods produced statistically significant lower concentrations of N_2O in peripheral air. Some significant differences were seen between the methods. Late use of the Carstens box produced significantly lower N_2O concentrations than either early or late use of the Ventex device. Also, early use of the Carstens box was associated with significantly less pollution than late use of the Ventex device. Comparisons between early and late use of the Ventex device and also between early and late use of the Carstens box showed no statistically significant differences.

DISCUSSION

The choice of sampling sites in pollution studies is difficult and always represents a compromise between the desirable and the feasible.[7] Our choice of one site in the breathing zone and another (termed peripheral air) at the air conditioning intake is based on the suggestion of Whitcher.[10] Within each of the zones chosen, the concentrations of nitrous oxide will vary with time because of the three factors that determine gas movement within a room, namely variations in air flow into the room, variation in temperature and the presence of moving bodies. These were not controlled in our study which was conducted during routine operating sessions. The order of use of the scavenging device was randomized to reduce possible bias over choice of operating day.

Four possible types of nitrous oxide monitoring are possible. These consist of sampling of the air in operating theatres with snatch samples, such as was used in this study, with continuous sampling,[11] or with the use of continuous monitoring devices such as the Miran infrared absorption analyser (Wilks Scientific Corp., South Norwalk, Conn., USA). It is also possible to use integrated personal sampling of occupational exposure of staff.[11] Snatch samples collected in nylon bags have proved convenient and reliable in our hands[12] and have produced values similar to continuous monitoring.[13]

The slow reduction in nitrous oxide concentration obtained when no operation was in progress confirmed the poor ventilation in the operating theatre. Although the scavengers reduced pollution, this was much higher than the 30 ppm (v/v) upper limit suggested by Whitcher *et al.*[11]

This study has not revealed a marked superiority of either of these devices over the other, nor does there appear to be strong justification for the early use of these scavengers.

We wish to thank our operating-theatre colleagues who co-operated in the study, Mr Allan Cornish for having donated the Ventex device, and Mrs J. Long for secretarial assistance.

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Lorazepam as a Premedicant in Dental Surgery

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SUMMARY

In a double-blind study, 100 young, healthy (American Society of Anesthesiologists physical status I) patients received lorazepam (Ativan; Wyeth) 2,5 mg or placebo orally as premedication before general anaesthesia for extraction of wisdom teeth.

Lorazepam produced a significant reduction in the incidence of pre-operative anxiety and post-anaesthetic headache compared with placebo ($P<0,01$). Anterograde amnesia was also more frequent in the patients who had received lorazepam ($P<0,001$).

The medicolegal implications of using lorazepam as a premedicant in dental surgery at a day clinic are discussed.

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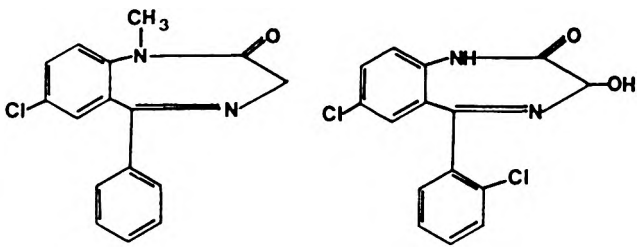
Most patients presenting for dental surgery under general anaesthesia are naturally apprehensive, and may prefer to be unaware of the period immediately preceding the operation. The unpredictable length of the surgical procedure poses problems in the timing of administration of premedicant drugs. An oral premedicant with a short latency of onset and reasonable duration of action which relieves anxiety and produces anterograde amnesia therefore appears highly desirable.

Lorazepam (Ativan; Wyeth) is the ortho-chloro-phenyl derivative of oxazepam, the main metabolite of diazepam (Fig. 1). In animals, lorazepam is 20 times as potent as chlordiazepoxide.[1] It is non-toxic to man,[2] doses of up to 7,5 mg being well tolerated, although electro-encephalographic changes characteristic of hypnotic agents have



DIAZEPAM LORAZEPAM

Fig. 1. Molecular formulae of diazepam and lorazepam.

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