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EXPOSURE OF DENTAL STAFF TO NITROUS OXIDE

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ABSTRACT

Background of study: Using nitrous oxide for sedation in paediatric dentistry is effective. Pollution from nitous oxide traces is an occupational hazard which should be monitored.

Aim / Objective: to compare the nitrous oxide traces between different dental procedures and to monitor the nitrous oxide traces in the working environment.

Research Methodology: Nitrous oxide was measured in 27 dental procedures according to two methods. First method, measurements were recorded every two minutes during the inhalational sessions. Second method measurements were recorded from different distances from the operation site.

Results: Twenty one sessions used for the first method. No statistical difference was found between the means of the nitrous oxide traces through the extraction and conservative sessions. Age group from 6 to 8 years had the highest measured traces. High traces recorded during stressful events.

Six sessions were selected for the second method. The distance obeys the inverse square law.

Conclusion: lack of cooperation would lead to excessive pollution. Encouraging patient to breathe through the nose was found be very helpful in reducing pollution. It is recommended to check the equipment for leaks, to make sure that the mask is of the appropriate size and tight fitting, and to ensure that scavenging and surgery ventilation is adequate.

Keywords: nitrous oxide, pollution, dentistry

INTRODUCTION

Dental anxiety in children is a well known problem that prevents many children from receiving dental treatment. Managing dental anxiety in children incorporates a variety of behavioural management techniques.1 These techniques should be tailored according to anxiety severity, the age of the patient, the degree of cooperation and the patient’s medical history.2

For some patients sedation will be necessary and using inhalation sedation using nitrous oxide/oxygen is well established in paediatric dentistry. Use of inhalation sedation with low to moderate concentrations of nitrous oxide with oxygen is considered safe, and there is no any reported mortality over 45 years of use.3 Inhalation of nitrous oxide is administered via a special nosepiece. There will be a continuous uptake of the gases and once the nitrous oxide is stopped, it`s effect will stop immediately. Recovery from sedation occurs in a very short period of time (few minutes) after administration of 100% oxygen.4

There are reports about nitrous oxide pollution which highlighted the potential health hazard,5 though the available evidence is weak.6 In some of these reports, authors mentioned a variety of problems such as haematological abnormalities, neurological deficits or increased risk of spontaneous abortions in women.7,8 Taking these potential occupational hazards into consideration, it rises the risk to dentists and dental nurses who are regularly exposed to nitrous oxide when undertaking inhalation sedation.

The British Health and Safety Commission advises that the maximum exposure of clinical staff to nitrous oxide gas should be 100 ppm over an 8 hour time weighted average period.9 In the 1990s practitioners were educated in ways to effectively scavenge trace gas contamination, with the primary method being the evacuation system and the scavenging nasal hood/mask in addition to regular monitoring programs.10 Leakage of gas from the mask delivery system and inefficient scavenging of waste gas from the surgery atmosphere can lead to significant pollution of the dental surgery.9 There are many nitrous oxide analysers and dosimeters like the infrared nitrous oxide analyser which is used in many studies. Several types of dosimeters are available which can be worn as label badges during working hours.11

In order for dentists to feel comfortable that they are attaining safe levels of nitrous oxide within their surgeries they need to understand the risk of pollution from different procedures and also the risk to individuals within the surgery dependent on where they are placed relative to the source of pollution.

AIM AND OBJECTIVES

The purpose of this study was to compare the measured nitrous oxide traces between the different dental procedures and to monitor the nitrous oxide traces in the working environment of the dental staff at variable distances at the paediatric dentistry department of Liverpool Dental Hospital.

RESEARCH METHODOLOGY

This was a cross sectional study, ethical approval was not required as regular monitoring is part of the safety routine.

Measurement of nitrous oxide was done in a convenience sample of 27 child patients attending the Paediatric department of the Liverpool Dental Hospital for dental treatment. The Department of Paediatric Dentistry is an open clinic design in that the dental units are separated by short partitions. The nitrous oxide machine used was the MDM Quantiflex which is a continuous flow type. The machine matches the universal safety measures of the sedation machines. It has the main parts which are the flowmeter, circuit bag, air entrainment valve, scavenging nasal hood and expiratory valve, and the conducting tubes. It uses continuous gas flow and the rate can be adjusted.

One examiner monitored the nitrous oxide traces; he was trained in the use of the nitrous oxide analyser (the Medigas PM3010 N2O Analyser). The Medigas PM3010 N2O Analyser is a handheld infrared nitrous oxide monitor which can measure nitrous oxide concentrations in the range of 0-1,000 ppm with a resolution of 5 ppm. Readings can be displayed in real time or as an 8 hour TWA (Time Weighted Average). The analyser was calibrated and checked by the Medical Engineering Department at the Royal Liverpool Hospital.

The Procedure

Before the start of each inhalation session, permission was taken from the operators. Also parents and patients were informed about the study and assured that there would be no disruption of the dental treatment.

Nitrous oxide traces were measured for two procedures:

First Procedure

In the first procedure, measurements were recorded every two minutes during 21 inhalational sessions as close as possible to the operation site within a circle of 20 cm diameter. A stopwatch was used from the time the mask was placed over the patient's nose to the time it was removed, during this time nitrous oxide traces were recorded by the Medigas analyser.

The following information was recorded:

1- The patient's age and sex.

2- Nitrous oxide flow (litre per minute) and concentration (in percentage).

3- The nature of the dental treatment such as extraction, conservative, etc.

4- General comments as to whether windows were opened or closed, fan was working or not, etc.

5- In each 2 minute reading, a note was recorded about the current dental procedure and the patient behaviour such as giving local anaesthesia, cavity preparation, extraction, patient is talking, crying, etc.

The Second Procedure

In this procedure measurements were recorded in 6 sedation sessions from different distances from the operation site at zero, one, two, three, four and five metres.

Data Processing

The Analyser measured nitrous oxide traces in numbers in ppm (part per million). Outcomes were assessed using descriptive statistics and by t-test.

RESULTS

Data was collected from 27 paediatric inhalational sessions. It was assumed that nitrous oxide traces will be more fluctuant and variable in the first measurement method than that in the second method, and therefore, 21 sessions were selected for the first procedure whereas only 6 sessions for the second procedure. In the 21 sessions, nitrous oxide traces were measured every 2 minutes throughout the session. In 6 sessions, nitrous oxide traces were measured from different distances from the operation site: at zero, one, two, three, four, and five meters. In all the nitrous oxide inhalation sessions a scavenging nasal mask was used and the fan was working.

A- Measurements taken every 2 minutes during inhalational sessions

In the 21 sessions the treatments were 12 extractions (57%), 7 conservative treatments (33%), 1 fluoride application (5%) and 1 acclimatization (5%). The treatments were carried for 6 males (29%) and 15 female (71%) patients with age ranges from 6 to 17 years, mean is 9.9 years (SD 3.7).

The mean nitrous oxide concentration was 30.7% (SD 5.1, ranged from 20% to 40%) and the mean flow rate was 6.6 l/min (SD 1.3, ranged from 5 l/min to 10 l/min). In all the sessions, sampling of the atmosphere was made at 20 cm from the patient in the horizontal plane.

The mean of measured nitrous oxide traces was compared in the extraction (91.7 ppm, SD 133.7) and conservative (32.4 ppm, SD 58.8) sessions and found to be not significant statistically ($p>0.05$, table 1). There was no relationship between age and measured nitrous oxide ($p>0.05$).

In general, levels of nitrous oxide varied widely between treatment sessions. In one fluoride application session it reached 2725 ppm (the patient was talking at the time); 4460 ppm in an extraction session (at the time the patient started to cry after being given local anaesthesia); and 1975 ppm in an extraction session (at the time of tooth extraction), figure 1.

B- Measurements taken at various distances

Nitrous oxide traces were measured in 6 sessions, 4 sessions were conservative treatment and 2 sessions were extraction, 4 females and 2 males. The mean age of the patients was 10 years (SD 3.5, age range 6 to 14 years). The mean nitrous oxide concentration used during the sessions was 3.8% (SD 2.0) with a range from 30% to 35%, and the mean flow was 6.2 l/min (SD 1.1) ranges from 5 l/min to 8 l/min.

The mean measured nitrous oxide traces were 602 ppm (SD 514) at zero distance, then decreased by increase in distance from the operating site (at 5 metre: 9 ppm, SD 17.5), figure 2.

DISCUSSION

The importance of keeping pollution of nitrous oxide to the absolute minimum levels cannot be understated. The problem is of great concern to staff who have to work in such an environment constantly, rather than patients where exposure, although at a high level to produce the desired clinical effects, is only occasional. There may also be concerns in respect of accompanying adults, e.g. pregnant mothers who may be at the chairside with their child. Problems of chronic exposure to nitrous oxide have been cited in the literature review but the most important ones are haematological changes. Chronic occupational exposure to nitrous oxide may cause depression of vitamin B12 activity11 and altered DNA synthesis in the bone marrow and mild megaloblastic changes. 12, 13

The aim of this study was to monitor as accurately as possible, the levels of nitrous oxide in the surgery under different conditions. These included continuous monitoring in the immediate vicinity of the operator and also at varying distances.

There was no significant difference between the mean of the measured nitrous oxide traces in the extraction sessions from that in the conservative sessions. There was also no relationship between age and nitrous oxide pollution, gender or with the concentration of nitrous oxide used and nitrous oxide air levels. There were a few sessions where nitrous oxide levels reached a very high level, sometimes exceeding 1000 ppm (0.01%). Donaldson and Meechan 10 suggested that when this occurred it was related to leakage of the nitrous oxide sedation machine or cylinders, poorly fitting masks, inadequate scavenging, patient mouth breathing, and poor surgery ventilation. In this study, where large variations in nitrous oxide levels were seen, this was associated with patients who were talking, crying etc. throughout the procedure. It may therefore be associated with pollution from expired air as a result of crying, talking, etc, or from leakage around the mask due to patient movement, etc. These findings are similar to those of *Henry et al.* 14 who stated that patient behaviour can result in significant increase in nitrous oxide levels in the ambient air.

Particular attention to these aspects is required to ensure pollution is significantly reduced to acceptable levels. Given that the results showed that the higher nitrous oxide levels were recorded at the time when patients were talking, laughing, crying, local analgesia administration, extraction, and rubber dam application, good sedation and behaviour management is important. Relaxed and comfortable patients are less likely to talk, cry etc.

The lack of observable differences found related to type of treatment or age could also be attributed to errors in the sampling such as the sample size, randomization, etc.

It is obvious by looking at the results of the second part that the distance obeys the inverse square law: the nitrous oxide concentration decreases as the distance from working site increases. The greatest nitrous oxide concentrations was at zero metre from the working zone which was also described by *Cleaton-Jonset et al.* 15 This is reassuring for other personnel in the surgery including accompanying parents who are approximately 2 metres away with levels of 50 ppm. Conversely, concerns are raised in respect of the operator and assisting dental nurse who are in the working zone during these administrations.

CONCLUSION

There is no doubt that for many patients, nitrous oxide sedation provides a good quality of sedation for them to be able to cope with treatment. This study has highlighted potential problems in respect of nitrous oxide pollution which is of concern to all personnel in surgery during the sedation sessions.

RECOMMENDATIONS

1. In this study the sample size was very limited. A future study with a larger cohort would be much more meaningful and would, hopefully, confirm the trends which we have found.
2. Patient selection is of utmost importance as a struggling, crying child would lead to very excessive pollution.

3. Patient conditioning to breathing through his/her nose at all times would be very helpful. Talking to patients through (with the help of normal behavioural management techniques) stressful events e.g. local analgesia administration, extractions, etc. would limit the amount of disruption and the pollution at these times.
4. Ensure equipment is checked for leaks and that the mask is of the appropriate size and tight fitting.
5. Ensure that scavenging and surgery ventilation is adequate.

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Table 1. Comparison between the measured nitrous oxide in extraction and conservative treatment sessions

	Paired Differences					t	df	Sig. (2-tailed)
				95% Confidence Interval of the Difference				
	Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Extraction and conservative treatment	31.6	118.0	44.6	-77.5	140.7	.7	6	.5

Figure 1 The measured N2O traces in an extraction session

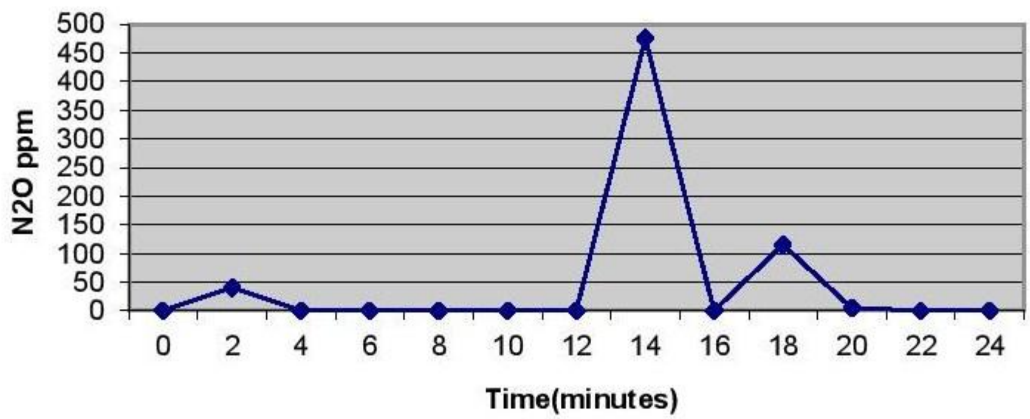

Figure 2 The average N2O traces measured in the 6 sessions.