

ENVIRONMENTAL HEALTH RISK OF CHRONIC EXPOSURE TO NITROUS OXIDE IN DENTAL PRACTICE

Jolanta Szymańska

Annals of Agricultural and Environmental Medicine, Lublin, Poland

Szymańska J: Environmental health risk of chronic exposure to nitrous oxide in dental practice. *Ann Agric Environ Med* 2001, **8**, 119–122.

Abstract: Nitrous oxide may be used to alleviate dental anxiety and to diminish or eliminate dental pain. The benefit of nitrous oxide sedation is a cooperative and satisfied patient. By reducing the patient's perception of pain it allows them to relax and cooperate during dental procedures. However, the dental surgery personnel, chronically exposed to N₂O, are at serious risk. The chronic effects of occupational exposure to nitrous oxide have long been the subject of debate. Safety standards have been established in the United States and Europe since many years. The potential detrimental action on the reproductive, neurological, haematological, hepatic and renal systems, plus the possibility of increased cancer risk have been the subject of active research, although absolute occupational effects are still uncertain. To provide a safer work-place for those at risk of exposure to waste anesthetic gases, preventive measures are recommended.

Address for correspondence: Jolanta Szymańska, DMD, AAEM Editors, Instytut Medycyny Wsi, Jaczewskiego 2, P.O.Box 185, 20-950 Lublin, Poland

Key words: dentistry, nitrous oxide, sedation, occupational hazards.

INTRODUCTION

Nitrous oxide and oxygen are widely used for conscious sedation in dental surgeries in many countries. Desire for stress reduction conducted to the popularity of this method. Inhalation of nitrous oxide is administrated via a special nosepiece. The gases are inhaled continually as the nitrous oxide ceases to have effect immediately after cessation of its administration. A patient recovers full consciousness within five minutes after administration of 100% oxygen.

The method is most effective in blocking pain perception in the soft tissues and by itself may be sufficient to eliminate mild to moderate discomfort during periodontal instrumentation [21]. By reducing the patients' perception of pain it allows them to relax and cooperate during dental procedures (which is especially helpful in the treatment of children).

Nitrous oxide does not block all pain perception and must be used with local anesthesia for most dental procedures. In paedodontic treatment, the method is successful in children over 4–5 years of age.

In nitrous oxide sedation, the patient preserves reflexes, especially the cough reflex, and consciousness. The main advantages of the method are: elimination of anxiety and stress caused by the treatment, partial anesthesia, analgesic effect (weak), reduction of vomiting and cough reflex; intubation and access to blood vessels are not necessary; it does not cause depression of the respiratory centre and may be safely used in patients with slightly marked systemic disease; it allows the limitation or elimination of local anesthesia. Dentists may administer it single-handed in an easy and safe way, using the water cooling system of turbine handpieces. The N₂O equipment may also be used to provide pure oxygen if necessary. Nitrous oxide sedation alters the patient's perception of time, making it seem to pass more quickly. With a relaxed, conscious and cooperative patient, dental treatments become less stressful for patients and dental office personnel [14, 23, 24].

N₂O is an inorganic gas, unflammable, nonexplosive, heavier than air, colour- and odourless. It condenses under pressure, and is not metabolized by the human organism.

It is removed very rapidly via the respiratory way, and ceases to have effect almost immediately after its administration has been stopped (after 10 min 95% of the dose is eliminated). It does not disturb carbohydrate and lipid metabolism, does not affect the respiratory centre and cardiovascular system, does not irritate mucous membrane of trachea and bronchi, does not damage liver and kidneys, does it induce addiction. On the whole, work with a patient to whom N₂O has been administered is easier. As a weak anesthetic agent, N₂O is generally considered a very safe drug [9, 22, 24], but the dental surgery personnel chronically exposed to N₂O are at serious risk (because dental patients are not intubated, dental staff are at greater risk from waste N₂O exposure than operating theatre personnel [33]).

In 1983, the American Dental Association (ADA) reported that 35% of dentists used N₂O to control patients' pain and anxiety [8]. In 1991, 58% of dentists used N₂O equipment [2]. The percentage of paediatric dentists using N₂O increased from 65% in 1980 to 88% in 1988 [7].

The estimated percentage of dentists using nitrous oxide sedation in some countries amounts to 50% in USA and Japan, 45–50% in Denmark, 30–40% in the UK, 30% in Sweden and Australia, and 10% in Italy [24].

OCCUPATIONAL EXPOSURE

The chronic effects of occupational exposure to nitrous oxide have long been the subject of debate [1]. The potential detrimental action on the reproductive, neurological, haematological, hepatic and renal systems, plus the possibility of increased cancer risk have been the subject of active research, although absolute occupational effects are still uncertain [5, 35].

Male dentists who worked in offices where N₂O was used eight hours per week or more had significantly higher incidences of liver, kidney and neurological diseases. Unexposed wives of these dentists had a 1.5-fold increase in spontaneous abortion rates. Female chairside assistants in these surgeries also had an increased incidence of liver, kidney and neurological disease as well as a 2.3-fold increase in number of spontaneous abortions when compared to dental assistants in control group offices where N₂O was not used [6]. Additional reports associate other adverse health effects with such exposure including: infertility and reproductive difficulties; congenital anomalies and foetal growth retardation; increased incidence of cervical cancer, kidney and liver diseases; adverse effects on bone marrow function and the immune response, as well as generalized neurological disorders [19, 25, 30, 31, 33].

A decreased psychomotor performance on visual perception, immediate memory, cognition and motor responses with human subjects receiving as little as 50 ppm N₂O over two-hour period was observed.

Sweeney *et al.* [34] were the first to demonstrate an adverse influence of N₂O on vitamin B12 metabolism and DNA synthesis in humans. European authors proposed a

threshold limit of 400 ppm per anesthetic exposure - the level two to three times lower than the concentration at which appreciable depression of vitamin B12 function has been documented [19, 26, 34, 37].

The following possible adverse effects of chronic exposure to nitrous oxide are reported: reproductive problems (reduced fertility, spontaneous abortion, testicular changes, decreased sperm count, decreased number of children), neurological defects, haematological and immunological problems (decreased leukocyte count, decreased leukocyte motility and chemotaxis, megaloblastic anaemia), liver problems, kidney problems, malignancy, miscellaneous cytotoxicity [5, 10, 25, 29].

EXPOSURE LIMITS

The toxicity of N₂O are concentration- and time-dependent [1]. Safety standards have been established in the USA and Europe since many years [16, 18]. In Europe the recommended concentrations range from 25 parts per million (ppm) - in France and Denmark to 100 ppm - in Sweden. A level of 100 ppm is under consideration by the British Health and Safety Commission [3]. Yagiela [37] suggests that a time-weighted average of 100 ppm for an eight-hour workday/or a time weighted average of 400 ppm per anaesthetic administration would provide adequate protection for dental personnel and be achievable with existing pollution control methods. 25 ppm is the safety level for operating theatres recommended by the National Institute for Occupational Safety and Health in the USA [36]. The American Conference of Governmental Industrial Hygienists recommended an N₂O exposure limit of 50 ppm [11].

Dunning *et al.* [11, 12] reported that dentists' exposure levels were significantly higher than the recommended 25–50 ppm. In both analysed groups - dentists and dental assistants from Nebraska - N₂O level was respectively 97 and 59 ppm. Estimated peaks of exposure averaged 1,415 and 986 respectively for the two groups. Dentist exposure levels were significantly higher than those of dental assistants.

One investigation reporting 632 ppm N₂O in the breathing zone of a dentist and 532 ppm in the waiting room, showed that a scavenging system can leak [28].

Badger and Robertson [4] measured the concentration of nitrous oxide in a dental surgery during paedodontic procedures and during N₂O sedation with scavenging, and found significant increases in the mixed room air with uncooperative children (222 ppm) compared with cooperative child patients (124 ppm).

SAFETY RECOMMENDATIONS

To provide a safer work-place for those at risk from exposure to waste anesthetic gases, the following preventive measures should be implemented:

- reduction of exposure levels of nitrous oxide to minimum,
- monitoring levels of nitrous oxide in the surgery,

- using effective scavenging equipment and monitoring devices,
- using an effective delivery system including a readily visible and accurate flow meter, a vacuum pump with the capacity for up to 45 l of air per minute per workstation [20],
- regular inspection of anesthetic administration equipment for leaks;
- regular maintenance and servicing of equipment,
- direction of waste gas away from windows, ventilators, air-conditioning inlets, or other areas that might allow gases back into the office,
- venting of exhaust gases to the exterior,
- maintenance of adequate ventilation (the general ventilation should provide good room air mixing),
- using an airsweep fan,
- minimizing conversation with patients and control of mouth breathing during the use of nitrous oxide,
- shutting off and securing the equipment after each day's use.
- fitting the nasal mask on the patient as well as possible. The problems of gas leakage around poorly fitting nasal masks and oral exhalation have previously been suggested as the primary causes of such surgery pollution [1, 13, 15, 17, 27, 33, 36].

Additional recommendations:

- improvement of circulation in the surgery by opening a window or using a nonrecycling air conditioning system;
- using a variety of mask sizes to ensure a proper fit for individual patients.

Schumann [32] suggests that the following health care personnel should avoid exposure to nitrous oxide:

- women in the first trimester of pregnancy,
- infertile individuals using *in vitro* fertilisation procedures,
- individuals with neurological complaints,
- immunocompromised individuals who are at risk from bone marrow suppression.

CONCLUSIONS

To sum up, it seems correct to say that the benefits of using N₂O are greater than the risks which may be minimized by following the safety recommendations. Occupational exposure to nitrous oxide can be minimized by the use of scavenging systems, local exhaust systems, careful sedation technique, and equipment management.

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