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Original Article

Nitrous Oxide Levels In Operating and Recovery Rooms of Iranian Hospitals

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Abstract

Background: Nitrous oxide (N_2O) is the oldest anesthetic in routine clinical use and its occupational exposure is under regulation by many countries. As studies are lacking to demonstrate the status of nitrous oxide levels in operating and recovery rooms of Iranian hospitals, we aimed to study its level in teaching hospitals of Tehran University of Medical Sciences.

Methods: During a 6-month period, we have measured the shift-long time weighted average concentration of N_2O in 43 operating and 12 recovery rooms of teaching hospitals of Tehran University of Medical Sciences.

Results: The results show that the level of nitrous oxide in all hospitals is higher than the limits set by different countries and anesthetists are at higher risk of exposure. In addition, it was shown that installation of air ventilation could reduce not only the overall exposure level, but also the level of exposure of anesthetists in comparison with other personnel.

Conclusion: The high nitrous oxide level in Iranian hospitals necessitates improvement of waste gas evacuation systems and regular monitoring to bring the concentration of this gas into the safe level.

Keywords: *Nitrous oxide occupational health, Ventilation, Environmental monitoring, Iran*

Introduction

Nitrous oxide (N_2O) has been used as an analgesic and weak anesthetic for a long time. For general anesthesia, N_2O decreases the induction time and the dosage of intravenous inducing agents (1). Concomitant use of this gas with more potent anesthetics leads to less cardiovascular and respiratory depression and reduction of the cost of general anesthesia (2). The importance of nitrous oxide is further highlighted by its high amnestic potency(2)and the faster recovery time as the result of its use (3).

In spite of the advantages of nitrous oxide for patients, there are several concerns in regards to the occupational safety of this gas. There are reports that long-term exposure of women to trace amounts of N_2O can lead to increased rate of spontaneous abortion and decreased fertility. Congenital malformations were also reported in some studies and there is preclinical evidence of fetotoxicity upon exposure to higher doses of this gas (reviewed by Olfert, 2006 (4) and Sanders *et al*, 2008 (5). Altered vitamin B12 status (6), impairment of neuropsychological functions such as vigilance (7), genotoxicity (8) and depression (9) are other phenomena reported upon occupational exposure to nitrous oxide.

Accordingly, to increase the safety of working with N_2O, occupational exposure limit (OEL), which is expressed as a shift-long time-weighted average (TWA) in parts per million (ppm), have been set by different countries. The most effective way for controlling the air level of N_2O is employment of a good scavenging system combined with effective air ventilation (10). As there is no study to dem-

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onstrate the status of nitrous oxide levels in operating and recovery rooms of Iranian hospitals, this issue has not effectively come to the attention of occupational health policy-makers in this country.
Accordingly, in this report we aimed to study the level of N_2O in teaching hospitals of one of the high-level Iranian medical universities to attract the attention of safety officers to the potential existing occupational hazard and warrant taking appropriate measures for its control.

Materials and Methods

As most operations are performed during the morning shifts, all samplings were performed during these shifts. The operating and recovery rooms of teaching hospitals of Tehran University of Medical Sciences (IUMS) were included in this study in which nitrous oxide (N_2O) (2-3 L/min) is used during anesthesia. Sampling, measurements, and analysis were performed according to the method employed by Mierdl *et al*, 2003 (11). The nitrous oxide levels were determined in 43 operating and 12 recovery rooms by Bacharach N_2O Monitor 3010 (Bacharach, Inc., New Kensington, PA) with gas detection based on an infrared-absorption principle. The rooms' temperatures were between 20-22° C at the time of each measurement.
During the six-month study period, the time-weighted average (TWA) of nitrous oxide concentration in each measurement spot was determined in 3 shifts during morning shifts. The measurement spots for each operating room were: I) 15 cm from surgeon's face II) 15 cm from nurse's face III) 5 cm from anesthetist's face and IV) 5 cm from anesthetic mask of the patient. Measurement spot for each recovery room was 5 cm from face of the nurse. The mean of three measurements were calculated for each spot.
Data are presented as mean±SD. Data analysis and calculations were performed with SPSS statistical package (version 16.0 for windows, release 16.0.1). Statistical significance was determined with analysis of variance (ANOVA) and the significance level was established at $P< 0.05$.

Results

Measurement of TWA concentration of nitrous oxide performed in all operating and recovery rooms in their routine functioning condition. 14% of operating and 50% of recovery rooms lacked any ventilation system. Among the others, ventilation system was not operational in 20.9% of operating and 8.3% of recovery rooms (Table 1). 18.6% of operating rooms lacked scavenging system. In those rooms, which were equipped with this system, it was not connected to anesthetic machine in 25.6% of rooms, and in 23.4% of other rooms, the exhaust pipes were not connected to the outside vent.
The shift-long TWA exposure of operating and recovery room staff to nitrous oxide concentrations is shown in Table 2. This table shows that compared to other staff, anesthetists are exposed to higher concentrations of N_2O regardless of condition of the ventilation system in the room. When the ratio of exposure of anesthetist to recovery room nurse is compared, it shows that ventilation system can reduce the exposure ratio from 4.02 to 1.83.

Table 1: The frequency distribution of ventilation and scavenging systems status in operating and recovery rooms

	Ventilation system				Scavenging system				
	Equipped		Not equipped	Total	Equipped			Not equipped	Total
	Operational	Not operational			Operational	Not connected to anesthetic machine	Not connected to outside vent		
Operating rooms[no. (%)]	27(62.8)	10(20.9)	6(14)	43(100)	14(32.4)	11(25.6)	10(23.4)	8(18.6)	43(100)
Recovery rooms[no. (%)]	5(41.7)	1(8.3)	6(50)	12(100)	0	0	0	12(100)	12(100)
Total	32(58)	11(20)	12(22)	55(100)	14(25.4)	11(20)	10(18.2)	20(36.4)	55(100)

Table 2: The shift-long exposure of operating and recovery room staffs to nitrous oxide (TWA/ppm)

	Anesthetist (Mean±SD)	Surgeon (Mean±SD)	Operating room nurse (Mean±SD)	Recovery room nurse (Mean± SD)	*P* value*	Anesthetist/recovery room nurse exposure ratio
Rooms equipped with ventilation system, operational	138.5±123.1	139.2±121.2	98.7±97.3	75.5±40.4	< 0.001	1.83
Rooms equipped with ventilation system, not operational	326.8±277.7	188.1±74.0	216.8±149.0	96.6± 60.2	< 0.001	3.38
Rooms with no ventilation system	440.0±129.1	399.4±116.9	367.7±88.1	109.4± 97.7	< 0.001	4.02

TWA time weighted average
* ANOVA

Discussion

In this study, we have shown that the shift-long TWA exposure of operating and recovery room staff to nitrous oxide in teaching hospitals of Tehran University of Medical Sciences is higher than the occupational exposure limits (OELs) set by different countries. Although 58% of the rooms were equipped with the operational air ventilation system, the N_2O level was above the recommended level. OEL is 100 ppm in some European countries such as UK, Germany, and Sweden; 50 ppm in countries such as Denmark and Norway; and 25 ppm in USA, Australia, and New Zealand (5).

Although, several studies report proper control of nitrous oxide levels in operating (11) and recovery rooms (12), and outpatient pain management facilities (13), there are still concerns about exposure of healthcare personnel to high concentration of this gas in both developing and developed countries. For example, evaluation of operating rooms in Polish hospitals showed that nitrous oxide levels are higher than the standard limits set by most European countries (14). Another example is a recent study in Sweden showing that 25% of midwives and assistant midwives were exposed to TWA concentrations of N_2O higher than the Swedish standard of OEL (15). An additional instance is a 2003 UK report that showed 76% of evaluated midwives were exposed to nitrous oxide levels higher than British recommended level (16). Current study shows that in comparison with other healthcare staff, anesthetists are exposed to higher concentrations of this gas. This observation has been reported in other studies as well (17). Accordingly, proper monitoring of the status of anesthetic gases including N_2O is necessary in all hospitals and should be seriously taken into account by occupational health sector. Scavenging and ventilation systems should be installed in all relevant rooms. Effective scavenging system can reduce the level of exposure by 94% (18). One of the interesting findings of current report is that it shows air ventilation can reduce not only the overall exposure level, but also the level of exposure of anesthetist in comparison with other personnel. Regular monitoring should be performed and include anesthetic machine, scavenging system and air ventilation. Leakage from anesthetic machine is an important issue, as in a recent study it was shown that this leakage was associate with the highest mean concentration of nitrous oxide in operating rooms (19). The importance of monitoring and audition is further highlighted by a report showing that private hospitals with better audition had lower levels of this gas as compared with public hospitals (20). The value of regular monitoring is sometimes ignored in not only developing but also developed countries. For example, it was shown in 2003 that only one fifth of New Zealand's public hospitals are regularly monitor for the level of anesthetic waste gases and 50% had not performed this monitoring for at least 4 years (21). For ease of performance of audition, monitoring can be performed by a fixed-

position sampling in anesthetic, surgeon, and nurse's zones (17).

Current report shows that the risk of exposure to nitrous oxide has not been taken seriously by Iranian healthcare authorities. Therefore, the exposure level of healthcare personnel is much higher than the highest recommended exposure limits. Similar conditions may exist in other neighboring countries, as the authors did not find any recent publication from these countries addressing the nitrous oxide level in healthcare facilities. National regulations, installation of functional evacuation systems and regular monitoring are key issues that can guarantee a safer working environment for hospital staff. The personnel, and especially anesthetists who are at higher risk of exposure, should be trained about the control measures. In addition, they should be encouraged to report the faults in the equipment as soon as they are aware of, and do not wait for the regular visit of the occupational officer.

Finally, it could be concluded that the level of nitrous oxide in Iranian hospitals is higher than the recommended limits and this warrants enactment of appropriate regulations and set up of regular monitoring system to bring the concentration of this potentially hazardous gas into the safe level.

Acknowledgments

The authors declare no conflict of interests.

Ethical Considerations

Ethical issues including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc. have been completely observed by the authors.

References

1. Ng JM, Hwang NC (2000). Inhaling nitrous oxide reduces the induction dose requirements of propofol. *Anesth Analg*, 90: 1213-16.
2. Hopkins PM (2005). Nitrous oxide: a unique drug of continuing importance for anaesthesia. *Best Pract Res Clin Anaesthesiol*, 19: 381-89.
3. Luhmann JD, Schootman M, Luhmann SJ, Kennedy RM (2006). A randomized comparison of nitrous oxide plus hematoma block versus ketamine plus midazolam for emergency department forearm fracture reduction in children. *Pediatrics*, 118: e1078-e1086.
4. Olfert SM (2006). Reproductive outcomes among dental personnel: a review of selected exposures. *J Can Dent Assoc*, 72: 821-25.
5. Sanders RD, Weimann J, Maze M (2008). Biologic effects of nitrous oxide: a mechanistic and toxicologic review. *Anesthesiology*, 109: 707-22.
6. Krajewski W, Kucharska M, Pilacik B, Fobker M, Stetkiewicz J, Nofer JR *et al*. (2007). Impaired vitamin B12 metabolic status in healthcare workers occupationally exposed to nitrous oxide. *Br J Anaesth*, 99: 812-18.
7. Scapellato ML, Mastrangelo G, Fedeli U, Carrieri M, Macca I, Scoizzato L et al. (2008). A longitudinal study for investigating the exposure level of anesthetics that impairs neurobehavioral performance. *Neurotoxicology*, 29: 116-23.
8. Sardas S, Izdes S, Ozcagli E, Kanbak O, Kadioglu E (2006). The role of antioxidant supplementation in occupational exposure to waste anaesthetic gases. *Int Arch Occup Environ Health*, 80: 154-159.
9. Levine J, Chengappa KN (2007). Exposure to nitrous oxide may be associated with high homocysteine plasma levels and a risk for clinical depression. *J Clin Psychopharmacol*, 27: 238-239.
10. Krajewski W, Kucharska M, Wesolowski W, Stetkiewicz J, Wronska-Nofer T (2007). Occupational exposure to nitrous oxide - the role of scavenging and ventilation systems in reducing the exposure level in operating rooms. *Int J Hyg Environ Health*, 210: 133-38.
11. Mierdl S, Byhahn C, Abdel-Rahman U, Matheis G, Westphal K (2003). Occupational

exposure to inhalational anesthetics during cardiac surgery on cardiopulmonary bypass. *Ann Thorac Surg*, 75: 1924-27.
12. Nayebzadeh A (2007). Exposure to exhaled nitrous oxide in hospitals post-anesthesia care units. *Ind Health*, 45: 334-37.
13. Ekbom K, Lindman N, Marcus C, Anderson RE, Jakobsson JG (2008). Health aspects among personnel working with nitrous oxide for procedural pain management in children. *Acta Anaesthesiol Scand*, 52: 573-74.
14. Lukaszewski M, Kubler A, Durek G (2004). [Spectrophotometric evaluation of nitrous oxide pollution in the work place of the anesthesiologic personnel in operating rooms]. *Pol Merkur Lekarski*, 17: 438-42.
15. Westberg H, Egelrud L, Ohlson CG, Hygerth M, Lundholm C (2008). Exposure to nitrous oxide in delivery suites at six Swedish hospitals. *Int Arch Occup Environ Health*, 81: 829-36.
16. Henderson KA, Matthews IP, Adisesh A, Hutchings AD (2003). Occupational exposure of midwives to nitrous oxide on delivery suites. *Occup Environ Med*, 60: 958-61.
17. Rovesti S, Ferrari A, Faggiano D, Vivoli G (2005). [Monitoring occupational exposure to volatile anaesthetics in the operating theatre: environmental and biological measurements]. *Ann Ig*, 17: 219-30.
18. Sanabria CP, Rodriguez PE, Jimenez ME, Palomero RE, Goldman TL, Gilsanz RF *et al*. (2006). [Occupational exposure to nitrous oxide and sevoflurane during pediatric anesthesia: evaluation of an anesthetic gas extractor]. *Rev Esp Anestesiol Reanim*, 53: 618-25.
19. Sartini M, Ottria G, Dallera M, Spagnolo AM, Cristina ML (2006). Nitrous oxide pollution in operating theatres in relation to the type of leakage and the number of efficacious air exchanges per hour. *J Prev Med Hyg*, 47: 155-59.
20. Cassano F, De MG, Bavaro P, Dentamaro A, Basso A, Giacomantonio A *et al*. (2003). [Occupational exposure to inhalation anesthetics: 10 years of measurements at hospitals in Puglia]. *G Ital Med Lav Ergon*, 25 Suppl: 279-81.
21. Sharples A (2003). Pollution: just a whiff of gas? *Paediatr Anaesth*, 13: 467-72.