



Original Article

Pupillary response to nitrous oxide administration in cataract surgery under general anesthesia

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Abstract

Background: Despite recent innovations in cataract surgery, pupillary diameter is one of the most important affecting factors in outcome of this surgery. As cataract surgery is performed ideally when the pupil is sufficiently dilated, anesthesia may contribute significantly in success or failure of this operation. This study was performed to evaluate the effect of nitrous oxide on pupillary diameter in cataract surgery under general anesthesia.

Methods: Forty patients with cataract, scheduled for operation under general anesthesia, were randomly allocated into two groups. After induction of anesthesia, anesthesia was maintained with isoflurane and nitrous oxide – oxygen (60%-40%) in group 1 versus oxygen 100% in group 2. Pupillary diameter, heart rate and blood pressure were monitored and recorded, before induction of anesthesia, just before tracheal intubation, and one and 5 min after laryngoscopy and tracheal intubation.

Results: Statistical analysis of the results using Mann–Whitney test showed no significant difference in pupillary diameter between two the groups.

Conclusion: According to the results of this study, nitrous oxide has no effect on pupillary diameter of patients under general anesthesia, so it could be safety used, in this regard, in ophthalmic operations.

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Keywords: Anesthesia; Nitrous oxide; Pupil; Reflex

1. Introduction

The use of modern techniques in cataract surgery in recent years has become increasingly popular. Given that cataract surgery is one of the most common of ophthalmic surgeries,

achieving new ways to increase efficiency and reduce the risk of complications is desirable.^{1,2}

Despite recent advances in techniques of ophthalmic operation, pupillary size is still one of the important and factors affecting determining final results.³ Since constricted pupils can impose adverse effects, specifically on cataract surgery, pupillary dilatation has a vital role in its success and outcome.^{4,5}

The effects of anesthetics on pupillary diameter are variable. Desflurane and sevoflurane increase but alfentanil and nalbuphine decrease pupillary size during surgery under general anesthesia.^{6,7}

Conflicts of interest: The authors declare that they have no conflicts of interest related to the subject matter or materials discussed in this article.

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Nitrous oxide is one of the oldest and most widely used anesthetics. Its application during anesthesia is common worldwide.^{8,9} Nitrous oxide has a linear molecule ($\text{N}\equiv\text{N}-\text{O}$) and is a colorless, odorless, and non-flammable gas at standard temperature and pressure. It has no irritant effect on the human respiratory system. This gas is 1.5 times heavier than air and naturally exists in the atmosphere at a concentration of 0.5 ppm. Nitrous oxide is produced normally by heating ammonium nitrate up to 270 °C with substances such as nitric oxide, nitrogen dioxide, chlorine gas, carbon monoxide and nitrogen. Purification of nitrous oxide is a difficult process.^{9–12}

Nitrous oxide is one of the weakest anesthetic gases, with minimum alveolar concentration (MAC) of 104%. It means that even with the maximum permitted prescription (70% concentration), it cannot be used as a sole anesthetic. Therefore, it should be used in combination with other anesthetics, inhaled or intravenous, to induce or maintain anesthesia.

Generally, nitrous oxide is known as a weak anesthetic but strong analgesic and facilitates reduction of the required dose of other potent anesthetic drugs.^{9,12,13}

Nitrous oxide has a low blood solubility (blood/gas partition coefficient of 0.47) with rapid increase of its relative pressure in blood after administration.⁹

A limited number of studies have evaluated the effect of this gas on human pupillary diameter, with controversial results.^{4,14,15} In this research, the effect of nitrous oxide on pupillary diameter in cataract surgery under general anesthesia was investigated.

2. Methods

This study was designed as a prospective, interventional, double blind clinical trial. Considering the standard deviation, appreciable change in pupillary diameter was determined to be 1 mm to achieve 95% confidence interval with 80% test power.

Forty patients with cataract, 50–80 years old, American Society of Anesthesiologists Physical Status (ASAPS) 1 or 2 were enrolled in the study after their consent was obtained. They were randomly allocated in two groups, 20 patients per group, on the basis of the rightmost odd or even number of their file number.

Exclusion criteria were: patients with obesity (BMI > 30), blood pressure above 160/90 mmHg, glaucoma, pseudo exfoliation pupillary adhesions, optical trauma, clear corneal opacity (leucoma), diabetes and endotracheal intubation lasting more than 30 s.

All patients received the same method to induce dilation of pupils half an hour prior to induction of anesthesia, with 4–5 drops of homatropine and phenylephrine 5%, every 5 min, for three times. Pressure on the punctum and lacrimal sac was applied for 15 s after application of each drop. Then, patients were taken to the operating room and standard monitoring (non-invasive blood pressure, electrocardiogram, pulse oxymetry and capnography) were applied. Premedication, 0.03 mg/kg intravenous midazolam and 2 µ/kg of fentanyl, was given to all patients, then 5 mg/kg pentothal and 0.6 mg/

kg atracurium were administered respectively for induction of anesthesia and muscle relaxation. This was followed by endotracheal intubation 3 min later. Anesthesia was maintained with isoflurane plus 40% oxygen and 60% nitrous oxide in the first group and 100% oxygen in the second group with preservation of normocapnia and normoxia.

Pupillary diameter was measured by pupillometer (Colvard Pupillometer, OASIS, United States) at four time points: before anesthesia induction, before endotracheal intubation, and one and five minutes after intubation. The blood pressure and heart rate were recorded at each time. Collected data were analyzed by SPSS 16 statistical software. Demographic findings were investigated and compared by Mann–Whitney test.

3. Results

Patients' demographic characteristics are shown in Table 1. As can be seen, there were no significant differences between the mean age and sex of the patients (Table 1). As Table 2 indicates, the average blood pressures at all time points were compared between the two groups and showed no statistically significant difference ($P > 0.05$) (Table 2).

In Table 3, comparison of the average heart rate between both groups is shown and indicates no statistically significant difference (Table 3).

Table 4 demonstrates the comparison of the mean pupillary diameter of groups 1 and 2 at four studied time points. Statistical analysis revealed no significant difference ($P > 0.05$).

Table 5 shows changes in mean pupillary diameter from the 1st to 3rd and 4th time points (respectively one and 5 min after endotracheal intubation). No statistically significant differences were noted ($P > 0.05$).

Mann–Whitney test was used to compare the results.

All patients had a favorable condition after surgery. No case of vomiting or cardiovascular or respiratory complication was observed, and all of them achieved a favorable level of consciousness within 15 min after the surgery.

4. Discussion

“Because human pupillary size is under control of the sympathetic and parasympathetic systems, therefore, drugs that affect the autonomic nervous system have the ability to affect the pupillary diameter”.⁴

Many studies indicate that nitrous oxide activates the sympathetic nervous system.^{4,16–18} Fukunaga, using direct recording of visceral nerve activity in cats anesthetized with 9% halothane, found that after adding 70% nitrous oxide to the inhaled gas, the sympathetic activity increased 13%. Ebert

Table 1
Characteristics of patients undergoing cataract surgery under general anesthesia using nitrous oxide according to age and sex.

Group	Age mean (y)	Male	Female
Nitrous oxide	64.2	13	7
Without nitrous oxide	64.3	12	8

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