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The influence of additional nitrous oxide during rapid anesthetic induction with sevoflurane

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Abstract: In this study, a vital capacity rapid inhalation induction technique was used, and 4.5% sevoflurane in 100% oxygen and with 66% nitrous oxide in oxygen were compared. Each anesthetic gas was used on a group of 17 unpremedicated volunteers. The induction time of sevoflurane in nitrous oxide with oxygen and sevoflurane in oxygen were 55 ± 10 s and 81 ± 22 s (SD), respectively, ($P < 0.05$). Notable cardiovascular instability was not observed in either group. Serious complications such as laryngospasm, breath holding, and excessive salivation were not observed in either group. In conclusion, the addition of nitrous oxide to sevoflurane in oxygen is a useful technique because there were no increases in complications during the accelerated rapidity of induction.

Key words: Induction—Sevoflurane—Nitrous oxide

Introduction

Ruffle et al. [1] showed that a vital capacity rapid inhalation induction (VCRII) with 4% halothane in oxygen can be accomplished safely. Wilton and Thomas [2] demonstrated that the addition of nitrous oxide to the inspired gas mixture further tends to reduce the induction time by roughly 30%. Eger [3] described the disadvantage of simultaneous introduction of nitrous oxide and halothane during induction of anesthesia. Nitrous oxide, which acts quickly, does not have enough overpressure to allow a patient to pass through the excitatory phase of anesthesia so the patient remains in this phase until halothane, which acts slowly, produces deeper anesthesia.

In the present report, an addition of nitrous oxide to 4.5% sevoflurane in oxygen was compared with same percent of sevoflurane in oxygen. We evaluated the characteristics of the induction using the VCRII technique with and without nitrous oxide.

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Materials and methods

The study was approved by the Clinical Human Research Committee. After informed consent was obtained from each volunteer, 17 subjects were assigned to receive sevoflurane in oxygen (oxygen group) and another 17 subjects were assigned to a sevoflurane in nitrous oxide (66%) and oxygen (nitrous oxide group). All subjects fasted for at least 8 h prior to the experiment. No subjects were premedicated.

The VCRII consisted of a vital capacity breath of 4.5% sevoflurane in 66% nitrous oxide and 33% oxygen or 4.5% sevoflurane in oxygen, held for as long as possible. The same mixtures of anesthetic gases were then continued for approximately 4 min, making the total time of anesthesia 5 min.

Mixtures of sevoflurane, nitrous oxide and oxygen, or sevoflurane and oxygen were delivered by an Ohmeda Vapor vaporizer (Ohmeda, Madison, USA) into the circle system of an Ohmeda anesthesia machine. The inspiratory and expiratory limbs of the circle were attached to a Y connector. Respiratory gases were sampled between the Y connector and the elbow connector with a mask attached. The vaporizer setting was determined by monitoring the circulating vapor concentration to prime the circuit with the desired concentration of sevoflurane.

The volunteers, who were breathing room air prior to induction of anesthesia, were instructed to breathe out to a residual volume. The anesthetic system and mask were then gently applied to their faces.

Loss of consciousness was defined as failure to respond to verbal commands. Verbal commands were repeated at 10-s intervals until the subjects failed to

Table 1. Incidence of complications during induction

	Oxygen group (n = 17)	Nitrous oxide group (n = 17)
Induction		
Complicated	3/17 (17.6%)	3/17 (17.6%)
Uncomplicated	14/17 (82.4%)	14/17 (82.4%)
Coughing	—	1/17 (5.9%)
Larygospasm	—	—
Breath holding	—	—
Movement	3/17 (17.6%)	2/17 (11.8%)
Secretion	—	—

respond. Induction time and excitatory phenomena, if present, were noted by an independent observer. Induction time was defined as the time between the end of the vital capacity inspiration and the loss of consciousness.

We defined an induction as "complicated" if one or more complications occurred. Possible complications could be categorized into one of the five groups shown in Table 1. Observations of complications were made using the definition by Lamberty and Wilson [4]. The five possible complications were a single cough, laryngospasm, breath holding, movement of a limb, and excessive salivation (defined as secretion sufficient to wet the experimenter's hands).

The observer, who was blind to the anesthetic agents used, asked the subjects to describe the smell of anesthetic gases and whether they would be willing to undergo a similar induction technique again immediately after the emergence from anesthesia.

Monitoring was performed using an automatic noninvasive blood pressure monitor (Nippon Colin, Komaki, Japan) with ECG oscilloscope and pulse oximetry, and a multigas monitor (Capnomac Ultima, Datex, Helsinki, Finland). Respiratory gases were sampled at a rate of 150 ml/min with a multigas monitor.

Results are presented as means ± standard deviations. Statistical analyses were performed with the chi-square test, and continuous variables were analyzed using analysis of variance (ANOVA). P values less than 0.05 were taken to indicate statistical significance.

Results

Anesthesia was successfully induced in all subjects of both groups. Demographic data for the two groups are shown (Table 2). Both groups were comparable with respect to age, sex, weight, and height.

The mean time required for induction of anesthesia was significantly shorter in nitrous oxide group than in the oxygen group (55 ± 10 s and 81 ± 22 s, respectively, $P < 0.05$).

There were no significant differences between the nitrous oxide group and the oxygen group in oxygen saturations as measured by pulse oximetry. Oxygen saturations were 97.1% ± 0.6% and 97.2% ± 0.8% respectively prior to induction and increased to 99.0% ± 0.6% and 98.9% ± 0.7%, respectively, following application of the anesthetic mask.

End-tidal sevoflurane concentrations in each group were shown (Fig. 1). The differences between end-tidal concentrations in the nitrous oxide group and those in the oxygen group were statistically insignificant at intervals from 1 to 3 min and significant at intervals from 4 to 5 min.

Cardiovascular stability was similar in the two groups. Significant reductions of systolic and diastolic blood pressures were seen in each group (Table 3). The differences between blood pressure values prior to anesthesia and those at intervals of 2–5 min thereafter were statistically significant in the oxygen group, and those at intervals of 1–5 min thereafter were statistically significant in the nitrous oxide group. Heart rates did not change over time in either groups.

The five most common complications of inhalation induction of anesthesia are presented in Table 1. Each group had a few complications of induction. None of the serious complications, laryngospasm, breath holding, and excessive salivation, occurred in either group. Coughing and movements were of mild intensity in both groups.

Sixty percent of the subjects in both groups described the anesthetic's smell as pleasant and more than 88% of subjects in both groups indicated that they would be willing to undergo similar induction of anesthesia again (Table 4).

Table 2. Demographic data

	Men	Women	Age (years) (range)	Weight (kg) (range)	Height (cm) (range)
Oxygen group (n = 17)	12	5	25.6 ± 2.4 (23–32)	59.8 ± 7.1 (47–75)	167.4 ± 7.0 (155–178)
Nitrous oxide group (n = 17)	11	6	24.8 ± 2.5 (22–33)	60.9 ± 9.5 (41–76)	168.2 ± 9.6 (152–180)

Data are expressed as mean ± SD.

Table 3. Comparison of cardiovascular variables

	Before induction	After induction, Time (min)				
	Control	1	2	3	4	5
Oxygen group (n = 17)						
Systolic BP (mmHg)	119	118	108*	103*	99*	98*
	(11)	(14)	(13)	(11)	(9)	(10)
Diastolic BP (mmHg)	66	65	58*	53*	50*	51*
	(7)	(8)	(7)	(7)	(8)	(7)
Heart rate (beats/minute)	72	72	73	74	75	73
	(14)	(12)	(13)	(13)	(14)	(13)
Nitrous oxide group (n = 17)						
Systolic BP (mmHg)	115	106*	96*	95*	93*	92*
	(10)	(14)	(12)	(8)	(9)	(10)
Diastolic BP (mmHg)	63	57*	52*	50*	48*	47*
	(8)	(10)	(7)	(9)	(9)	(8)
Heart rate (beats/min)	67	65	67	66	65	63
	(10)	(11)	(12)	(11)	(9)	(10)

Values are expressed as mean ± SD.
BP, blood pressure.
*$P < 0.05$ *vs* control value in each group.

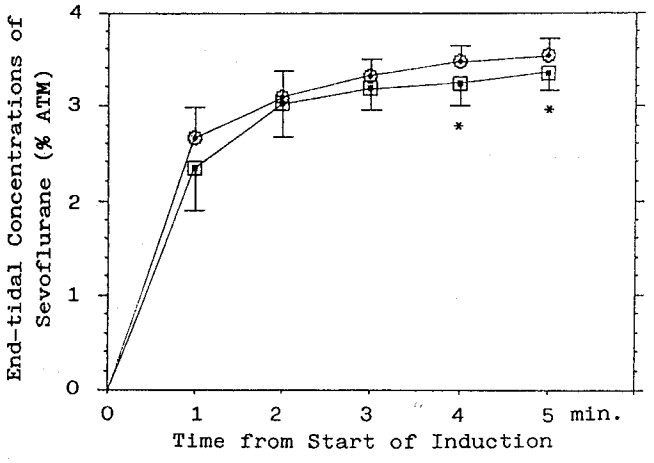

Fig. 1. End-tidal sevoflurane concentrations in oxygen group (*open squares*) and nitrous oxide (*open circles*) group versus time during vital capacity rapid inhalation induction. *$P <$ 0.05, nitrous oxide group *vs* oxygen group. *ATM*, atmosphere

Table 4. Acceptability and smell

	Oxygen group	Nitrous oxide group
Same induction again?		
Yes	17/17 (100%)	15/17 (88.2%)
No comment	—	1/17 (5.9%)
No	—	1/17 (5.9%)
Smell		
Pleasant	11/17 (64.7%)	11/17 (64.7%)
No comment	5/17 (29.4%)	2/17 (11.8%)
Unpleasant	1/17 (5.9%)	4/17 (23.5%)

Discussion

This report is the first direct comparison of sevoflurane in nitrous oxide and oxygen, and sevoflurane in oxygen using the VCRII technique. The induction time in the nitrous oxide group required approximately 70% as much as the oxygen group. The difference in the induction time between the two groups was statistically significant. The induction time required in the nitrous oxide group (55 ± 10 s) is close to that required with the use of intravenous thiopental.

The differences of the end-tidal concentrations of sevoflurane between the nitrous oxide group and the oxygen group were not significant at intervals from 1 to 3 min, and significant at intervals from 4 to 5 min. We speculated that the absence of significant differences of the end-tidal concentration of sevoflurane at intervals from 1 to 3 min was due to the variability of the performance of the VCRII technique and the respiratory depression produced according to the anesthetic plane [5]. Nevertheless, theoretically the addition of nitrous oxide results in an increase in alveolar concentration of sevoflurane by the second gas effect. The shortened induction time seems to be caused mainly by the reduction of sevoflurane MAC produced by the additive effect of nitrous oxide.

Eger [3] pointed out the disadvantage of simultaneous introduction of nitrous oxide and a second gas (halothane) during anesthetic induction. Excitement is most likely to occur at concentrations of 0.5–1 MAC. If used from the start of induction, the rapidly obtained effect of 50–80% nitrous oxide (0.5–0.8 MAC) may cause entry into but not passage through this 'zone of excitement.' Consequently, it may cause excitement before the more soluble vapor is able to produce deeper

anesthesia. However, the simultaneous use of nitrous oxide and sevoflurane was not associated with increasing the excitatory movements of the induction. The blood/gas partition coefficient of sevoflurane is close to that of nitrous oxide [6] and then sevoflurane might act more quickly than other soluble agents such as halothane.

Another disadvantage of the additional nitrous oxide is oxygen saturation. We were afraid that the addition of nitrous oxide to sevoflurane in oxygen would cause hypoxia or hypotension during induction and/or intubation because preoxygenation with 100% oxygen has usually been employed as part of the technique of rapid induction of anesthesia. Khoo et al. [7] estimated the maximum safe level of inspired nitrous oxide which can be given during preoxygenation. Healthy patients were preoxygenated with 100% oxygen, 50% oxygen: 50% nitrous oxide, or 30% oxygen: 70% nitrous oxide for 1 min, and all groups showed similar arterial desaturation during thiopentone and suxamethonium—induced apnea and intubation. In the present study, hypoxia did not occur using this technique because a vital capacity breath provided more than enough oxygen. There were no differences between the nitrous oxide group and the oxygen group in the saturations of oxygen during induction but the saturations were not confirmed during and shortly after intubation. Cardiovascular stability was similar in the two groups. Significant reductions of systolic and diastolic blood pressures were seen but remained at clinically safe levels in both groups.

In conclusion, the addition of nitrous oxide to sevoflurane in oxygen was useful for induction of anesthesia because there was no increase in the number of complications during the accelerated rapidity of induction.

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