Effect of Supplemental Gases on End-tidal CO_2 and Oxygen Saturation in Patients Undergoing Fentanyl and Midazolam Outpatient Sedation

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Forty-six American Society of Anesthesiologists Class I and II adults were randomly assigned to one to two study groups. Each subject received 0.7 μg/kg of fentanyl and a titrated dose of midazolam. One group received 100% supplemental oxygen (O_2) while another group received 50% nitrous oxide (N_2O) and 50% O_2. End-tidal carbon dioxide ($EtCO_2$) and O_2 saturation (SpO_2) were measured at 5-min intervals throughout the procedure. We conclude that there was no significant difference in $EtCO_2$ or O_2 saturation between the two groups.

Key Words: Nitrous oxide; Outpatient sedation.

The administration of nitrous oxide (N_2O) and oxygen (O_2) for outpatient oral and maxillofacial surgical procedures is a well-recognized and accepted practice.[1] Lytle and Yoon[2] reported that N_2O was used more frequently than local anesthesia and was second only to O_2 as the most commonly used agent for dental outpatient anesthesia. Because of the widespread use of N_2O, it is not surprising that it has been used in conjunction with intravenous sedation.[3]

Conscious sedation in conjunction with regional anesthesia is an accepted method of rendering patients comfortable and cooperative for outpatient procedures.[4,5] Inherent in the concept of conscious sedation is the fact that at no time is sedation deep enough to deprive the patient of protective reflexes. Intravenous opioid administration followed by a titrated dose of benzodiazapine is a frequently used conscious sedation technique. Stuebner[6] has reported that adding N_2O and O_2 to intravenous sedatives is a popular modification of this technique.

Numerous studies[7-10] have shown various degrees of respiratory depression following the intravenous administration of diazepam, fentanyl, or methohexital. Because of these findings, many authors[4,11-13] recommend the addition of supplemental O_2 to the sedation regimen. Kraut[14] showed significant differences in oxygen tensions in sedated patients receiving 100% O_2 compared with patients breathing room air. Even if the patient does not reach a depth of anesthesia that compromises protective reflexes, hypoxia is a potential danger. A conscious patient may be significantly hypoxic without clinical evidence of hypoxia.[14]

This study compared the end-tidal carbon dioxide ($EtCO_2$) tension and O_2 saturation (SpO_2) in patients receiving 100% O_2 to those receiving 50% N_2O and 50% O_2 during intravenous sedation for outpatient oral surgery.

METHODS

Forty-two American Society of Anesthesiologists Class I and II patients over the age of 18 who presented to the Oral and Maxillofacial Surgery Service of the Montefiore Medical Center, Bronx, NY, for removal of teeth requiring a minimum of 20 min of operating time were entered into this Institutional Review Board-approved study. A power analysis was performed to determine the number of patients required to detect a clinically no-

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Table 1. End-tidal Carbon Dioxide Differences Between Treatment Groups at Baselines

		Group A		Group B	
	P value	Mean	Standard Deviation	Mean	Standard Deviation
Preoperative	NS	38.60	4.50	38.60	3.80
Start	NS	41.10	3.30	40.30	5.90

NS, not significant.

table difference between groups with 80% power, using a two-tailed test with a Type I error of 0.05. All patients were asked to sign an institutionally approved consent prior to participating in this study. The patients were instructed not to eat or drink for 6 hr before their surgical appointments and were accompanied by escorts to and from the clinic on the day of surgery.

A table of random numbers was used to assign patients to the study groups. Group A received a 6-L/min flow of 100% O_2 via a nasal hood during the surgical procedure. Group B received a 6-L/min flow of 50% N_2O and 50% O_2. Treatment groups were unblinded.

Arterial blood pressures (Dinamap 18465x, Critikon, Tampa, FL), heart rate, SpO_2, and $EtCO_2$ were monitored (601 Poet, Criticare Systems, Inc., Milwaukee, WI). The $EtCO_2$ monitor used nasal prongs. All monitored parameters were automatically recorded at 5-min intervals throughout the surgical period.

After a baseline determination of the above parameters (preoperative baseline), the nasal hood was placed, and O_2 with or without N_2O was administered for 3 min before administration of intravenous sedation. During this period, an indwelling intravenous cannula was placed, and the administration of 0.9% sodium chloride was initiated. After 3 min, fentanyl and midazolam were administered. Each patient received 0.7 μg/kg of fentanyl. Midazolam was then slowly titrated to effect, with a maximum allowable dose of 10 mg.

Once the patient was adequately sedated, start of surgery baseline measurements were obtained and local anesthesia (2% lidocaine hydrochloride with 1: 100,000 epinephrine) was administered. Following the onset of regional anesthesia, the indicated teeth were surgically removed. After the surgery was completed, the gaseous mixture was changed in Group B to 100% O_2 for a 5-min period. When the patients were sufficiently alert and their vital signs stable on room air, the patients were discharged from the clinic in the care of their escort.

Changes from each baseline parameter were computed for data evaluated at each timepoint and were tested for significance using paired *t*-tests of Wilcoxon Signed Rank tests if assumption of normality was not met. Differences between the treatment groups with regard the $EtCO_2$ and SpO_2 values were tested for significance using Student's *t*-tests for independent samples at each timepoint, as well as for changes from baseline at each timepoint. Changes from baseline to the end of surgery were assessed similarly. In addition, for each baseline parameter, repeated-measures analysis of variance was performed using data at each timepoint through 15 min and for data involving changes from baseline to 15 min. Tests of significance were two-tailed and performed using an alpha error of 0.05.

Table 2. Changes in End-tidal Carbon Dioxide Over Time By Treatment Group

	Group A P Value[a]		Group B P value	
Variable (Change from)	From Preoperative Baseline	From Start of Surgery Baseline	From Preoperative Baseline	From Start of Surgery Baseline
5	0.015	NS	NS	NS
10	0.005	NS	0.006	NS
15	NS	NS	NS	NS
End	NS	NS	NS	0.015
Change	NS		NS	

NS, not significant.
[a] Within-group changes were assessed for significance using a Wilcox Signed Rank test.

RESULTS

Patients were randomly assigned to one of the groups. The mean amount of midazolam in the O_2 group was 6.50 mg and in the N_2O/O_2 group, 6.20 mg. $EtCO_2$ differences between the two treatment groups at the preoperative baseline and start of surgery baseline were not statistically significant (Table 1).

Changes from the preoperative baseline in $EtCO_2$ at 5 and 10 min were significant for the O_2 group and at 10 min for the N_2O/O_2 group (Table 2). Differences

Table 3. End-tidal Carbon Dioxide Differences Between Groups

	P Value	Group A		Group B	
Minutes	(Between Groups)	Mean	Standard Deviation	Mean	Standard Deviation
5	NS	41.60	4.20	40.80	5.70
10	NS	41.90	4.00	41.30	5.20
15	NS	40.60	4.30	38.98	6.00
End	NS	39.23	4.67	37.00	6.03

NS, not significant.

Table 4. Changes In Oxygen Saturation Over Time by Treatment Group

Variable (Change from)	Group A P Value		Group B P Value	
	From Preoperative Baseline	From Start of Surgery Baseline	From Preoperative Baseline	From Start of Surgery Baseline
5	NS[a]	NS	NS	NS
10	0.0098	NS	NS	NS
15	NS	NS	NS	NS
End	0.016	NS	NS	NS
Change	NS		NS	

NS, not significant.
[a] Within-group changes were assessed for significance using a Wilcox Signed Rank test.

Table 5. Oxygen Saturation Differences Between Treatment Groups

Oxygen	P value (Between Groups)	Group A		Group B	
		Mean	Standard Deviation	Mean	Standard Deviation
5 Min.	NS	98.55	1.57	98.55	0.69
10 Min.	NS	98.82	0.50	98.45	0.76
15 Min.	NS	98.77	0.53	98.50	0.61
End	NS	98.82	0.50	98.70	0.57

NS, not significant.

between the groups derived from the repeated-measures analysis of variance were not significant (Table 3). Time trends for the two groups were significant for timepoint values, for changes from preoperative baseline, and for changes using the start of surgery baseline measure ($P < 0.05$).

SpO_2 values within the O_2-only group demonstrated significant differences at 10 min and at the end of surgery when compared to preoperative baseline ($P < 0.05$). There were no significant changes from the preoperative baseline in the N_2O group (Table 4). There were no significant changes from the preoperative baseline in the N_2O group (Table 4). Using a repeated-measures analysis of variance, there were no significant differences between the groups over time with regard to SpO_2 (Table 5).

There were no complications for patients in either treatment group, and all patients were hemodynamically stable throughout surgery.

DISCUSSION

The addition of 50% N_2O did not have a clinically notable effect on $EtCO_2$ or SpO_2. Patients in both groups of this study appeared well sedated and comfortable. The surgeons found no difference in operating conditions for either group. Previous studies have demonstrated decreased O_2 saturation during intravenous sedation when supplemental O_2 is not administered.[14,15] This study demonstrated significant differences in SpO_2 at 10 min and at the end of surgery when compared to baseline in the O_2 group. When reminded to breathe more deeply, the SpO_2 quickly returned to baseline. These findings reinforce the need for O_2 monitoring with pulse oximetry during conscious sedation. Administration of supplemental O_2 via nasal cannula or nasal mask are effective methods in maintaining O_2 saturation.

The addition of N_2O did not significantly decrease the amount of midazolam required to achieve sedation and did not confer any clinical advantages over the O_2-only group.

Without an adequate scavenger system, the environmental hazards posed by N_2O outweigh any possible benefits obtained in using N_2O. However, those practitioners who choose to supplement intravenous sedation with N_2O/O_2, contrasted with those who administer O_2 only, do not appear to place their patients at increased risk of hypoxia or hypercapnia.

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