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Preoperative dental anxiety and mood changes during nitrous oxide inhalation

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Nitrous oxide at subanesthetic concentrations is used in dental procedures for its anxiolytic effects.¹ A number of studies have examined the mood effects of nitrous oxide in laboratory settings with subjects who do not report feeling anxious.²⁻⁵ Although there has been some variability in the type of reported mood effects, the majority

Regardless of their preoperative anxiety level, patients experienced a number of mood-altering effects during nitrous oxide inhalation.

of subjects reported effects that could be considered pleasant in nature (for example, “feel good,” “pleasant bodily sensations,” “elated”).

We wondered whether these pleasant mood effects also were experienced by dental patients, especially those with high preoperative anxiety. No studies, to our knowledge, have characterized mood effects during nitrous oxide inhalation in dental patients with different levels of preoperative anxiety. It may be inappropriate to infer that highly anxious patients will experience mood changes during nitrous oxide inhalation that are comparable to those experienced by patients with low preoperative anxiety. This study sought to determine if self-reported mood changes during nitrous oxide inhalation differed among patients with different levels of preoperative dental anxiety.

SUBJECTS AND METHODS

The study was approved by the local institutional review board. Subjects were dental patients at the Zoller Dental Clinic or other University of Chicago-affiliated

Background. An estimated 35 million Americans experience significant apprehension about dental procedures, while an additional 10 to 12 million are considered to be “dental phobic” and avoid needed dental care altogether.

Nitrous oxide is a general anesthetic used at subanesthetic concentrations to reduce anxiety during dental procedures. The purpose of this study was to characterize mood changes during nitrous oxide inhalation in patients with different levels of preoperative dental anxiety.

Methods. Forty-six patients who were to receive nitrous oxide during a dental procedure completed two anxiety scales. These patients were categorized into three groups: low anxiety, or LA, moderate anxiety, or MA, and high anxiety, or HA. They completed a visual analog scale of subjective effects before, during and after the dental procedure.

Results. A number of visual analog ratings, the majority of which could be considered pleasant, increased during nitrous oxide administration. It is significant that this increase in pleasant mood occurred in the HA and MA groups to the same degree as it did in the LA group. Patients in the HA and MA groups had elevated preoperative visual analog ratings of “anxious” that were reduced during nitrous oxide administration to a level equivalent to that reported by patients who had low preoperative anxiety. Patients in the HA group also had elevated preoperative visual analog ratings of “having unpleasant thoughts” and “feel bad” compared with the LA group. These ratings were reduced in the HA group to a level equivalent to that reported by patients in the LA group.

Conclusions and Clinical

Implications. Regardless of their preoperative anxiety level, patients experienced a number of mood-altering effects during nitrous oxide inhalation, the majority of which could be considered pleasant. Ratings of an unpleasant nature decreased markedly in patients with high anxiety. These findings suggest that nitrous oxide may be an effective therapy in reducing patient anxiety during dental procedures.



satellites and were aged 18 years and older. Potential subjects were to receive nitrous oxide during the dental procedure. Some patients asked the dentist (L.G.) for nitrous oxide, and other patients were asked by the dentist if they wished to receive nitrous oxide. With the second group of patients, the dentist took into consideration the patient's answers to two questions posed on a standard medical and dental history form in determining whether it was appropriate to administer nitrous oxide. The first question asked the patient whether he or she was nervous about receiving dental treatment, and the second asked whether the patient had experienced difficulties with dental treatment in the past.

The dentist also took into consideration the patient's stated or non-verbal (for example, body language) level of anxiety or nervousness about the forthcoming dental procedure and the patient's previous experience with exposure to nitrous oxide (that is, whether it was well-tolerated). We excluded patients who did not have the mental capacity to complete the mood forms during an orientation provided by the dentist.

We informed subjects via a study information sheet that the purpose of the study was to assess whether, and to what degree, nitrous oxide affects mood in patients undergoing dental procedures. The information sheet stated that subjects would be required to fill out mood forms periodically throughout the dental procedure, but that this would not increase the time they would be required to be in the clinic. The information sheet also stated that participation in the study would not affect the treatment delivered to subjects by the dental team, and that they could withdraw oral consent at any time without affecting their dental treatment.

Procedure. One of us (L.G.) obtained oral consent from each subject before the study began. Patients then were seated in the dental chair and were provided instructions on how to complete the three paper-and-pencil forms used in the study: the Dental Anxiety Scale,⁶ or DAS; the anxiety subscale of the Profile of Mood States,⁷ or POMS; and a visual analog scale, or VAS. Subjects then completed the forms.

On completion of these forms, the dentist placed a nasal mask over the patient's nose and

began to administer nitrous oxide in a concentration that he deemed appropriate for the given patient. The dentist did not look at the completed patient forms and determined the concentration in the same manner for all patients. The initial concentration was determined largely on the basis of answers to questions related to alcohol use. For example, if a patient reported no alcohol use or very limited use (that is, one drink every once in awhile), the initial concentration was between 10 and 20 percent nitrous oxide in oxygen. If a patient reported more consistent or nightly alcohol consumption, the initial concentration was between 30 and 40 percent nitrous oxide in oxygen.

The initial concentration of nitrous oxide was determined largely on the basis of answers to questions related to alcohol use.

In determining the initial concentration, the dentist also considered the emphasis a patient placed on being "in control." For example, a subject who reported that he or she was very uncomfortable in situations in which he or she was not in control received a lower initial concentration of nitrous oxide in oxygen (for example, 20 percent) than a subject who was more comfortable with not having "complete control" (for example, 40 percent). Sometimes the dentist increased or decreased the nitrous oxide concentration during the procedure, based on his assessment of the comfort level of the patient.

After at least five minutes at the initial concentration, the dentist asked the patient how he or she was feeling. If the patient reported any adverse effects (for example, dizziness, nausea), the concentration was decreased. Conversely, if the patient reported a lack of effects (for example, absence of tingling in arms and legs) or a strong feeling of anxiety, the dentist increased the concentration. He told patients who had never received nitrous oxide before that it "took the edge off the procedure," would relax them and would produce effects similar to those of their usual alcohol consumption. Nitrous oxide was delivered via a dental anesthesia machine, which mixed nitrous oxide with oxygen. The maximum concentration of nitrous oxide that could be delivered by this machine was 60 percent.

The dentist readministered the VAS before beginning the dental procedure, but no sooner than five minutes after the patient had begun inhaling a given concentration of the nitrous oxide. The dentist recorded the concentration of

nitrous oxide administered and the amount of time the patient had been inhaling this concentration at the time he or she completed the VAS (for the second time). The dental procedures performed on the patient population varied and included placement of resin-based composite restorations, extractions, cleanings, endodontic treatment and operative procedures.

After the dental procedure was completed and nitrous oxide was no longer delivered, the dentist, as part of usual practice, administered 100 percent oxygen for three to five minutes to flush out any remaining nitrous oxide in the patient. Directly after this oxygen flush, the patient was asked to complete a third and final VAS.

Dependent measures. *DAS.* We used two validated measures to assess anxiety before the dental procedure. The DAS is a four-item scale designed to measure anxiety specifically for dental treatment, and has good internal consistency (reliability) and concurrent validity.⁶ Subjects answered each of the four questions (for example, "When you are waiting in the dentist's office for your turn in the chair, how do you feel?") by circling one of five statements, ranked from 1 (indicating no anxiety) to 5 (indicating extreme anxiety). We summed the numbers across the four items; anxiety scores could range from 4 to 20. Any subject who scored 13 or above on the DAS was considered to have high dental anxiety.^{8,9} Those who scored from 7 to 12 were considered to have moderate anxiety, and those who scored 6 or below were considered to have low dental anxiety.¹⁰

POMS. The POMS consists of a number of adjectives commonly used to describe momentary mood states.⁷ In this study, we used anxiety, one of the eight scales of the POMS (determined by factor analysis), which consisted of nine items (that is, "tense," "shaky," "on edge," "panicky," "relaxed," "restless," "uneasy," "nervous" and "anxious") that were rated on a numerical scale from 0 ("not at all") to 4 ("extremely"). Patients circled the number next to each item that best corresponded to how they were currently feeling. We determined a patient's score on the anxiety scale by adding the numbers checked for each adjective (except for the score for "relaxed," which we subtracted from 4; we then added the result to the total) and dividing that total by the number of

adjectives (that is, nine). The potential range of scores on this scale was 0 to 4.

VAS. We developed a VAS, which consisted of 21 100-millimeter horizontal lines, each labeled with an adjective or phrase (that is, "stimulated" [energetic], "high" ['drug' high], "anxious," "sedated" [calm, tranquil], "lightheaded," "tingling," "confused," "drunk," "elated" [very happy], "nauseated," "coasting" ['spaced out'], "sleepy" [drowsy, tired], "down" [depressed], "having pleasant thoughts," "having unpleasant thoughts," "having pleasant bodily sensations," "having unpleasant bodily sensations," "feel good," "feel bad," "difficulty concentrating" and "floating"). We labeled the end points of the lines "not at all" and "extremely." Patients were

instructed to make a vertical slash on each line indicating how they felt at that particular moment.

Data analysis. We calculated DAS and POMS anxiety scores and compared them using Pearson product moment correlations. We performed repeated measures of analyses of variance, or ANOVA, on VAS ratings using anxiety level (that is, low, moderate, high) and time (baseline [preoperative],

inhalation, recovery) as the factors. Two other one-way ANOVAs determined if nitrous oxide concentration administered to patients or latency to administration of the second VAS (that is, how long the patient had been inhaling nitrous oxide before rating his or her mood) differed as a function of anxiety level. We considered F values to be significant at $P < .05$, and made adjustments for within-factors degrees of freedom (Huynh-Feldt) to protect against violations of symmetry. In addition, we used Tukey post hoc comparison tests when significant effects were attained.

RESULTS

Anxiety measures. The low-anxiety, or LA, moderate-anxiety, or MA, and high-anxiety, or HA, groups consisted of 12 subjects (four women and eight men), 21 subjects (14 women and seven men) and 13 subjects (eight women and five men), respectively. The mean (\pm standard error of the mean, or SEM) scores on the DAS for the LA, MA and HA groups were 5.0 (\pm 0.2), 9.6 (\pm 0.3) and 15.5 (\pm 0.6), respectively. The mean (\pm SEM) scores on the POMS for the three groups were 0.4 (\pm 0.1), 1.0 (\pm 0.1) and 2.4 (\pm 0.2), respectively.

**The three groups
 differed significantly
 from each other on
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 Anxiety Scale and
 Profile of Mood
 States scores.**

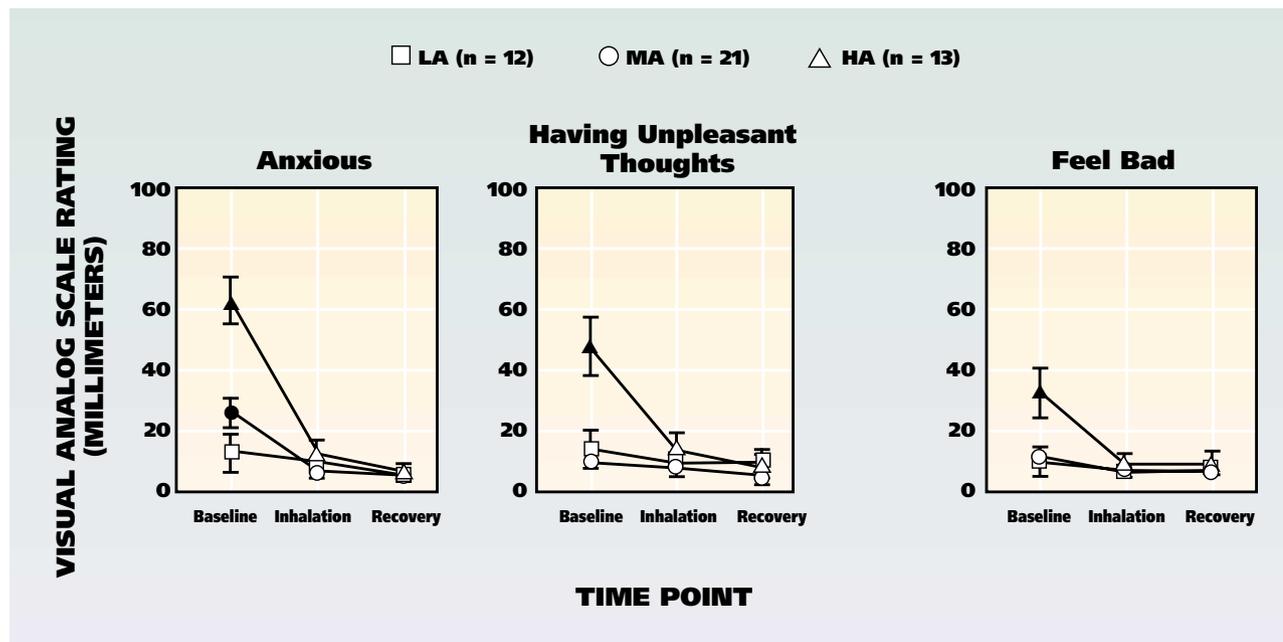


Figure. Mean visual analog scale ratings of “anxious” (left), “having unpleasant thoughts” (center) and “feel bad” (right) in the low-anxiety, or LA, moderate-anxiety, or MA, and high-anxiety, or HA, groups during baseline, inhalation and recovery periods. Brackets represent the standard error of the mean. Solid symbols at baseline indicate that ratings were decreased significantly from baseline to inhalation, as determined by Tukey post hoc testing.

The three groups differed significantly from each other on both the DAS and POMS scores. We found a statistically significant correlation between scores on the DAS and scores on the POMS ($r = .77$, $P = .001$). Because of a clerical oversight, ages were not recorded for 23 subjects. For the 23 subjects for whom we did obtain this information, the mean (\pm standard deviation) age was 41.3 years (± 10.3 years), with a range from 26 to 73 years.

Drug concentration. Nitrous oxide concentrations at the time that the second VAS was completed ranged from 20 to 50 percent in this study. However, nitrous oxide concentrations did not differ significantly between the three anxiety groups. The mean (\pm SEM) concentrations of nitrous oxide administered to subjects in the LA, MA and HA groups at the time the second VAS was completed were 40.6 percent (± 2.0 percent), 38.3 percent (± 2.3 percent) and 39.2 percent (± 2.3 percent), respectively ($P = .78$). The amount of time that patients had been inhaling these concentrations before completing the second VAS also did not differ significantly between the three anxiety groups (21.3 minutes [± 9.2 minutes], 16.7 minutes [± 1.9 minutes] and 16.7 minutes [± 2.8 minutes] in the LA, MA and HA groups, respectively) ($P = .76$).

VAS. We observed statistically significant

anxiety level \times time effects (that is, according to ANOVA, time [the three points at which the VAS was administered] had an effect on VAS adjectives, depending on the anxiety level of the group) for VAS ratings of “anxious” ($P = .001$), “having unpleasant thoughts” ($P = .001$) and “feel bad” ($P = .001$) (Figure). Tukey post hoc testing revealed that subjects in both the MA and HA groups exhibited a statistically significant decrease on the rating of “anxious” from baseline (that is, preinhalation period) to inhalation that persisted into the recovery period. In addition, in subjects in the HA group, we observed significant decreases for the ratings of “having unpleasant thoughts” and “feel bad” from baseline to inhalation, and these decreases persisted into recovery. These two ratings, as well as the “anxious” ratings, were low in the LA group at baseline, as well as at the other two time points.

We found an anxiety level \times time effect for the rating of “sedated (calm, tranquil)” ($P = .07$) that approached statistical significance. Mean “sedated” ratings were lower in the HA group than in the LA group at baseline (10.6 mm vs. 32.4 mm), and subjects in the HA group exhibited a larger increase in this measure during inhalation than did subjects in the LA group (an increase of 33.3 mm vs. 7.7 mm). The study revealed no other anxiety level \times time effects for

the remaining VAS ratings. We observed a main effect of anxiety level on the rating of “sleepy (drowsy, tired)” ($P < .05$), with patients in the HA group being less sleepy (8.2 ± 2.4 mm) than patients in the LA group (25.1 ± 4.3 mm).

We observed a main effect of time ($P < .005$) for the ratings of “lightheaded,” “tingling,” “drunk,” “elated (very happy),” “coasting (‘spaced out’),” “having pleasant thoughts,” “having pleasant bodily sensations,” “feel good,” “difficulty concentrating,” “floating,” “high (‘drug’ high) and “sedated (calm, tranquil)” (Table). Tukey post hoc testing revealed that the ratings increased significantly from baseline to inhalation. At recovery, these VAS ratings returned to levels that did not differ significantly from those found at baseline, with the exceptions of “elated (very happy)” and “having pleasant thoughts.”

DISCUSSION

The primary purpose of our study was to examine mood changes during nitrous oxide inhalation in dental patients with different levels of preoperative dental anxiety. The results of the study show that the mood changes experienced during nitrous oxide inhalation in patients with high anxiety did not differ from those experienced by

patients with low anxiety. This included mood changes that could be considered pleasant in nature. We also found that dysphoria was markedly decreased during nitrous oxide inhalation in subjects in the HA group; in particular, VAS ratings of “anxious,” “having unpleasant thoughts” and “feel bad” in this group decreased

TABLE

VAS* RATINGS AT PREOPERATIVE, INHALATION AND RECOVERY TIME POINTS (N = 46).			
VAS MEASURE (RANGE 0-100 MILLIMETERS†)	MEAN (\pm SEM‡) RATING		
	Preoperative	Inhalation	Recovery
Stimulated (Energetic)	26.8 (3.3)	24.3 (3.5)	22.7 (3.3)
High (“Drug” High)§	4.2 (1.1)	38.5 (3.9)	10.5 (1.9)
Anxious**	33.5 (4.5)	9.8 (1.8)	5.7 (1.2)
Sedated (Calm, Tranquil)§	22.9 (3.1)	43.1 (4.5)	29.7 (3.5)
Lightheaded§	6.1 (1.4)	32.4 (4.3)	12.8 (2.5)
Tingling§	5.2 (2.2)	27.5 (4.0)	9.2 (1.9)
Confused	7.1 (2.4)	7.8 (1.8)	6.5 (1.4)
Drunk§	5.3 (2.2)	18.1 (3.3)	6.9 (1.5)
Elated (Very Happy)§	16.3 (3.0)	32.3 (3.9)	26.3 (4.0)
Nauseous	4.9 (1.2)	4.7 (1.3)	4.5 (1.2)
Coasting (“Spaced Out”)§	5.7 (1.5)	24.5 (3.5)	12.9 (2.3)
Sleepy (Drowsy, Tired)	14.2 (2.6)	18.5 (3.3)	14.7 (2.9)
Down (Depressed)	8.9 (2.2)	6.7 (1.9)	6.7 (1.6)
Having Pleasant Thoughts§	22.0 (3.2)	42.2 (3.9)	32.0 (3.7)
Having Unpleasant Thoughts**	21.5 (4.1)	9.9 (2.1)	7.8 (1.8)
Having Pleasant Bodily Sensations§	14.4 (3.0)	37.1 (4.4)	22.5 (3.4)
Having Unpleasant Bodily Sensations	8.4 (2.1)	7.4 (2.0)	7.0 (1.5)
Feel Good§	32.4 (3.4)	51.2 (4.0)	38.8 (3.8)
Feel Bad**	16.6 (3.2)	7.1 (1.5)	7.2 (1.7)
Difficulty Concentrating§	8.6 (2.1)	16.4 (2.7)	9.4 (2.3)
Floating§	5.2 (1.4)	40.9 (4.4)	12.7 (2.2)

* VAS: Visual analog scale.
 † 0 indicates “not at all” and 100 indicates “extremely.”
 ‡ SEM: Standard error of the mean.
 § Ratings with a significant main effect of time.
 ** Ratings with a significant anxiety level \times time effect.

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from baseline to nitrous oxide inhalation and were commensurate with VAS ratings reported by subjects in the LA group (Figure).

The elevated mood during inhalation of nitrous oxide observed in our clinical study is consistent with mood changes that we have observed in our laboratory.^{5,11,12} The reduction in anxiety in the HA and MA groups is consistent with clinical and preclinical studies that provide evidence that nitrous oxide is an anxiolytic drug.^{1,13-16} However, without a placebo-controlled condition (that is, a group of patients breathing oxygen or room air), we cannot be certain that nitrous oxide produced the reported mood effects, including a reduction in anxiety, in the three groups of patients in our study. While acknowledging this caveat, we deemed it unethical to decrease the standard of care that some of these patients (that is, patients with high or moderate dental anxiety) would typically receive (an anxiolytic drug).

A second caveat to this study is that neither the dentist nor the patient was blind to the drug being administered. Certainly, expectations on the part of the patient may have played a role in the mood changes reported during nitrous oxide inhalation. However, the mood changes reported were similar in nature to those reported in studies that used a double-blind design when examining mood effects of nitrous oxide.^{11,12}

Last, the dentist did have appropriate clinical knowledge of patients' self-reported nervousness about dental treatment (via a standard medical and dental history form). This may have affected his interaction with patients. However, again we deemed it unethical to decrease the standard of care that all patients usually would receive.

CONCLUSION

Patient anxiety is a major concern in dental practice, because it often functions as a barrier to

needed dental treatment. An estimated 35 million Americans experience significant apprehension about dental procedures, while an additional 10 to 12 million are considered to be "dental-phobic" and avoid needed dental care altogether.¹⁷ The results of our study suggest that nitrous oxide, which is relatively noninvasive and inexpensive, not only reduces dysphoria in patients with high levels of preoperative dental anxiety, but also elevates mood (for example, increased ratings of "elated") to the same

degree as that in patients who are not anxious.

This constellation of mood changes could result in anxiety reduction in the short term (for example, if a patient needs to see the dentist the following week) and in the long term (if a patient needs to see the dentist one year later). Indeed, randomized clinical trials in pediatric patients have demonstrated that nitrous oxide is more efficacious than behavior management, oxygen alone or no treatment in reducing anxiety in the short term¹⁷⁻¹⁹ and long term.²⁰

In a related vein, the constellation of mood changes observed in our study also could promote more frequent visits to the dentist for preventive and curative treatment by patients with dental anxiety. We believe that properly designed prospective clinical trials are needed to determine the relative efficacy of nitrous oxide, compared with other treatments, in reducing anxiety and promoting dental health in adults with dental anxiety. ■

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