The Effect of Various Concentrations of Nitrous Oxide and Oxygen on the Hypersensitive Gag Reflex

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The purpose of this study was to compare the effectiveness of various concentrations of N₂O/O₂ on obtunding a hypersensitive gag reflex. We hypothesized that the administration of nitrous oxide and oxygen would obtund a hypersensitive gag reflex enough to allow a patient to tolerate the placement and holding of a digital x-ray sensor long enough to obtain a dental radiograph. Volunteers claiming to have a hypersensitive gag reflex were first screened to validate their claim and then tested by placing a size 2 digital x-ray sensor in the position for a periapical radiograph of the right mandibular molar area and holding it in place for 10 seconds. Subjects were first tested using room air only, then 30%, 50%, or 70% nitrous oxide until they were able to tolerate the sensor without gagging or discomfort. A visual analog scale was used for subjective responses, and other statistical tests were used to analyze the results. We found that for some subjects, 30% nitrous oxide was sufficient; for others, 50% was needed; and for the remainder of the subjects, 70% was sufficient to tolerate the test. Using a combination of 70% nitrous oxide and 30% oxygen allowed all patients claiming to have a hypersensitive gag reflex to tolerate the placement and holding of a digital x-ray sensor long enough to take a periapical radiograph.

Key Words: Gag reflex; Hypersensitive gag reflex; Dental radiographs; Nitrous oxide and oxygen.

The gag reflex is a normal protective response¹; however, it can be hypersensitive and make dental treatment difficult or impossible. A hypersensitive gag reflex (HGR) may be either somatogenic or psychogenic in origin.^{2,3} In dentistry, this response may be triggered by the dental injection, x-ray sensor/film, rubber dam, or other procedures.⁴ HGR may cause self-

consciousness, embarrassment, avoidance of dental treatment, fear, anxiety, and a negative impact on overall quality of life.⁵⁻⁹

Various behavioral and pharmacological methods have been suggested to reduce HGR in dental patients.¹⁰⁻¹⁶ It has been claimed that nitrous oxide and oxygen sedation (N₂O) is able to completely obtund the HGR¹⁷; however, we searched the literature and could find no study in which this was proven. The main objective of this study was to compare the effectiveness of various concentrations of N₂O/O₂ in obtunding a severe HGR.

Received November 9, 2015; accepted for publication February 8, 2016.

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Anesth Prog 63:181-184 2016

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ISSN 0003-3006/16

SSDI 0003-3006(16)

METHODS

This prospective clinical study protocol was approved by the University Hospital Institutional Review Board.

Equipment

We used a Porter AVS 5000 unit to deliver the N₂O and O₂, a Rinn XCP-DS FITTM posterior periapical (PA) ring kit, a posterior PA digital sensor (Planmeca Pro Sensor), to simulate the taking of a radiographic image, and a Hu-Freidy Type CW aspirating anesthetic syringe with a capped 27-gauge disposable hypodermic needle to simulate an inferior alveolar (IANB) injection.

Sample Size Determination

We performed a pilot study ($n = 6$) to estimate sample size and to test the feasibility and reliability of this study. The mean difference (SD) in visual analog scale (VAS) score without and with N₂O was 2.2 (2.0) mm. The sample size of 9 for the paired t test was calculated with IBM SPSS SamplePower 3 software, with 5% as the significance level and a power of 80%, and the sample size of 11 was with 90% power. We expected that 20% of the participants would drop out during the research procedure. The anticipated number of dropouts was added on to the total number of subjects. The final estimated recruitment was 11 to 14. We estimated the gag reflex proportion, in which 5 (93%) of the subjects had a gag reflex without N₂O and 1 subject had a gag reflex with N₂O, to calculate the sample size for a McNemar test. This confirmed that the above sample size was appropriate. We also used published data from a similar study, which used a spoon for stimulus with and without N₂O/O₂ among 15 subjects.¹⁷ Time for eliciting a gag reflex without N₂O was 8 (3.7) seconds and with N₂O was 24 (10) seconds and was used to calculate sample size, and the above sample size was confirmed as an appropriate size.

Surveys

We used the Predictive Gagging Survey (PGS)¹⁸ to confirm the patients who identified themselves as having an HGR and the Modified Dental Anxiety Survey (MDAS)¹⁹ to assess the patients' dental anxiety.

Inclusion Criteria

We included patients who presented to the Case Western Reserve University School of Dental Medicine Graduate Endodontic Clinic, were American Society of Anesthesiologists (ASA) class I and II, claimed to have an HGR, and were 7 years of age or older. All participants signed a consent form and completed the PGS, which consisted of 10 questions, and the MDAS, which consisted of 5 questions. Each patient was tested using the same sequence of events, namely, mandibular PA x-ray and a simulated IANB.

Exclusion Criteria

We excluded patients who were ASA class III or IV, pregnant, edentulous, or refused to participate.

Radiographic Tolerance Test

Standard sterilization and infection control procedures were followed throughout and for all tests.

The sensor in the sensor holder was positioned for a standard PA radiograph of the right mandibular molars, and the patient was asked to bite down on it. It was left in place for a maximum of 10 seconds (the time previously determined that it takes to place a sensor, position the x-ray unit tube, and take a radiographic image) or until the patient gagged, in which case it was removed immediately.

IANB Nerve Block Test

Standard procedures for administering a right IANB nerve block injection were followed using a capped 27-gauge needle attached to the syringe.²⁰ The capped needle was placed in contact with the intraoral mucosa and held in place for a maximum of 1 minute. If the patient gagged before 1 minute, the syringe was removed immediately.

Nitrous Oxide and Oxygen Administration

All tests were performed initially without N₂O. If the patient gagged before the maximum allotted testing time (MAT), 30% N₂O was administered and the test was repeated. If gagging occurred again before the MAT, 50% N₂O was administered and the test repeated. If gagging occurred again before the MAT, the test was repeated using 70% N₂O. The remaining gas was oxygen at the appropriate percentage to equal 100%.

Correlation of Visual Analog Scale (VAS) Scores at Baseline and Hypersensitive Gag Reflex Patients' Modified Dental Anxiety Survey (MDAS), Predictive Gagging Survey (PGS), and Gagging Severity Index (GSI) Scores

Correlations	MDAS	PGS	GSI
VAS at baseline			
Pearson correlation	.054	.792	.137
P	.853	.001	.640

Analysis

The number of patients who were able to tolerate the tests and the N₂O concentrations needed for toleration were recorded, tabulated, and analyzed. The Fisk and Dickinson's Gagging Severity Index (GSI)²¹ was used to assess each patient's HGR with and without N₂O. The McNemar Test with Bonferroni²² corrections was used to compare the number of subjects who could tolerate the stimulus with different N₂O concentrations. The significance level was set at $P < .05$. The data were entered into REDCap (Research Electronic Data Capture), and statistical analysis was completed using SPSS software.

RESULTS

Fourteen subjects participated in this case series. The mean score of the PGS was 10.21 (SD = ± 2.80). The mean MDAS score was 12.71 (SD = ± 5.38), which is less than the calculation indicating dental anxiety. The mean GSI score was 2.00 (SD = ± 0.68). The gender ratio was 50 : 50 (7 women : 7 men). The race distribution was 8 whites, 4 blacks, and 2 Asians. The reported ethnic background was 11 non-Hispanics/non-Latinos and 3 Hispanics/Latinos. The mean age of the patients was 42.14 years (SD = ± 19.58), with a range of 24 to 77 years.

Table 1 shows the correlation between the VAS score at baseline and the MDAS, PGS, and GSI scores. The VAS at baseline significantly and positively correlated with the PGS (Pearson correlation = .792, $P = .001$).

No HGR patients were able to tolerate the digital sensor without N₂O/O₂ (baseline). At 30% N₂O/O₂, 36% (5/14) of the HGR subjects were able to tolerate the placement of the sensor. At 50% N₂O/O₂, 7 additional subjects (accumulated 86% [12/14]) were able to tolerate the sensor. At 70% N₂O/O₂, 2 additional subjects (accumulated 100% [14/14]) were able to tolerate the sensor placement (Figure 1).

The VAS score means were compared at the level of N₂O/O₂ at which subjects were able to tolerate the stimulus at their baseline, which was at 0% of nitrous

Percentage of subjects with reduced hypersensitive gag reflex at each level of N₂O.

oxide (room air). This indicated a significant reduction of the VAS. The standard deviation of the means at the baseline and the last level of level of N₂O/O₂ were 6.12 (2.48) and 1.93 (1.94), respectively (paired t test, $t = 6.05$, $df = 13$, $P < .001$).

The simulated IANB administration was not tested with N₂O/O₂. No HGR subjects in this study had an HGR reaction to the IANB procedure without N₂O/O₂; therefore, 30% N₂O/O₂ administration was not indicated.

An analysis of variance test was conducted to compare the differences between the MDAS, PGS, GSI, and VAS at baseline and VAS that was indicated when they were able to tolerate the sensor placement among the levels of N₂O/O₂, which they used to tolerate the stimulus, and we could not see any differences of these indicators.

DISCUSSION

Although claims have been made that N₂O reduces the gag reflex, to our knowledge, this is the first clinical study to show that N₂O does in fact reduce the HGR to varying degrees at various concentrations and allows patients to tolerate a digital x-ray sensor long enough to obtain a dental PA radiograph. Conversely, although some may claim from clinical experience that nitrous oxide is not sufficient for some patients needing radiographs, we could find no studies to substantiate this. Such studies or case reports would have to report the concentrations and other variables that could affect the results. Although in some instances expert opinion is the best possible evidence available, it is considered the lowest level of evidence.²³ This study was limited to the HGR as elicited by the insertion of a digital x-ray sensor. Other dental procedures that could cause gagging, such as impression taking, use of the dental dam, toleration of a bite block,

and so forth, should be specifically studied. Future studies addressing these issues may be relevant. It might also be of interest to study the effect of nitrous oxide on the reduction of discomfort during dental treatment due to fibromyalgia and other chronic pain conditions.

The advantages of using N₂O include rapid onset and termination, ability to titrate, ease of use, safety, common use in dentistry, and a generally pleasant experience for the patient. The fact that the N₂O units permissible in the United States have a maximum 70% nitrous oxide delivery limit, while delivering 30% oxygen (the oxygen concentration in the air we breathe is approximately 21%), is fortunate since we found that at this concentration, all of the subjects were able to tolerate the x-ray sensor. Techniques studied such as acupuncture^{21,24,25} and cranial nerve blocks¹³ have the disadvantages of being invasive, uncomfortable, not reversible, and longer acting than N₂O.

It is not clear how nitrous oxide inhibits the HGR, and the complete pharmacodynamic mechanisms of nitrous oxide have not been determined. It is possible that the anxiolytic (sedative) properties of nitrous oxide play a major role in the reduction of the gag reflex. N-methyl-D-aspartate receptor blockade may inhibit painful perceptions in the central nervous system as well.

Being able to manage conditions that play a role in avoidance of dental care is an important part of clinical practice. Knowing that one of those conditions can be managed very easily, and with relatively few contraindications, can only be a benefit in dental practice.

The simulation of the IANB nerve block in this study failed to produce a gag reflex, and therefore, there was no need to use N₂O in this part of the experiment.

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