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Nitrous oxide analgesia and children's perception of pain

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Abstract

The purpose of this study was to investigate the analgesic properties of nitrous oxide during Class I cavity preparation in the primary dentition. The Eland Color Scale was used to evaluate pain perception. Fifty children ages 4-10 participated in this double-blind investigation. Two groups of 25 children were exposed to either 100% oxygen or a concentration of nitrous oxide necessary to achieve relative analgesia. The analgesic effects of nitrous oxide were evaluated: (1) five min after induction, (2) with the handpiece running by the tooth, (3) after penetration of the enamel, (4) after penetration of the dentin, and (5) five min postoperatively. The results of this study indicated that nitrous oxide analgesia significantly decreased the intensity of pain perceived during Class I cavity preparation in the primary dentition.

Nitrous oxide has been utilized by dental practitioners for nearly one hundred years. Initially, the elimination of pain was the primary objective of nitrous oxide analgesia.[1] It was used, especially in children, as a substitute for local anesthesia.[2] Today, greater emphasis is placed on nitrous oxide as a psychosedative agent than as an analgesic. Due to this emphasis, the original utilization of nitrous oxide as an analgesic agent in dentistry has, to a large extent, been ignored. However, recent human and animal experimental studies have substantiated the analgesic nature of nitrous oxide.[3-5] Additional scientific evidence has indicated that nitrous oxide may be used as an analgesic agent in dentistry.[6-8]

There are three basic approaches to measuring acute clinical pain. According to Stewart,[9] these include: (1) a person's subjective report of pain, either verbal or written; (2) observations of a person's behavior; and (3) instrumental measurement of autonomic signs of pain, such as increase in blood pressure, pulse, or excessive perspiration. The most reliable measure-ment of pain in Stewart's opinion is the patient's subjective assessment of the pain as opposed to an objective interpretation.

A common way to measure pain is to ask the person experiencing the pain to describe the sensation he is feeling and the intensity of that sensation. Many scales have been designed for that purpose. Stewart[9] developed scales with ratings to demonstrate different intensities of pain ranging from none to unbearable.

Stewart also has designed a color scale to evaluate pain in adults based on the concept of sensory matching. The Stewart Pain Color Scale uses the sensory stimuli of color intensity to measure and compare clinical pain.

Although there is a plethora of pain assessment scales, most cannot be used to assess children's pain effectively. An adult is able to tell the location, quantity and sensitivity of pain experienced. However, a child's expression of pain may be hampered by a variety of factors: age, developmental stage, verbal competency, body language, and emotional maturity.

In an unpublished master's thesis, Eland[10] attempted to develop a method for children in the 4- to 8-year-old age group to communicate their pain intensity. It was from this attempt that the fabrication of the Eland Color Scale used in this study had its inception. With data gathered from children, she was able to show that they could color where they hurt on body outlines. Eland later modified the color scale conceived by Stewart. She showed that children between 4 and 10 years can use color to describe pain. As a first step in developing the color scale, 342 children were presented with eight crayons (yellow, orange, red, blue, green, purple, brown, and black) and asked to choose a color that was "like hurting." The

colors most frequently chosen to represent pain were red, black, and purple.

Eland then used her color scale to measure pain experienced by children who did or did not receive a topical anesthetic prior to a diphtheria-pertussis-tetanus (DPT) immunization. Four of eight colors were chosen to represent no pain, mild pain, moderate pain, and severe pain. Numerical values were assigned to the colors to expedite statistical computations; the severe pain color was assigned a value of 3; moderate, 2; mild, 1; and no pain, 0. The mean amount of pain expressed by the children who received the topical anesthetic prior to DPT immunization was 1.85 and the mean amount of pain for aerosol air prior to DPT immunization was 2.55.

The purpose of this study was to investigate the analgesic properties of nitrous oxide during Stage 1, Plane 2 of anesthesia, or relative analgesia as defined by Guedel (Figure 1).[11*] The analgesic effects during Class I cavity preparation were evaluated using the Eland Color Scale (Figure 2).

Methods

An experimental group of 50 children was chosen as follows:

1. All children were healthy, emotionally stable, and between 4 and 10 years (they had a mean age of 6 years, 4 months).
2. An additional health history was taken to exclude all children who had: a cold, upper respiratory infection, or other form of nasal obstruction; a middle ear infection or sinusitis; or tuberculosis or other pulmonary condition.
3. Each child was evaluated for colorblindness using the psuedoisochromatic plates formulated by the American Optical Corporation.
4. Primary molars in which "ideal" Class I cavity preparations were indicated as the treatment of choice were selected. The teeth chosen were: vital, free of previous restoration, nonmobile, without history of trauma, objectively and subjectively asymptomatic, and had at least two-thirds of the root present.

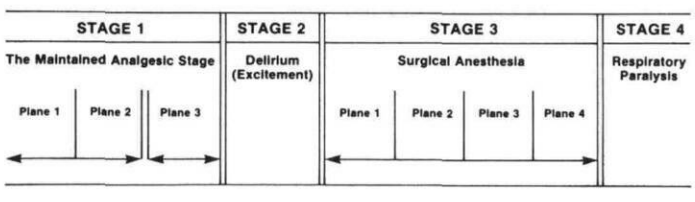

FIGURE 1. Schematic representation of the relation of the maintained analgesic stage to the other stages of anesthesia.

*Relative analgesia (Stage 1, Plane 2 of anesthesia) was defined by the following criteria: respiration was normal; general muscles were relaxed; pupils were normal and contracted when exposed to light; rate of blinking was reduced; eyes had a relaxed, dreamy, faraway look; mouth was maintained open without props; patient followed directions, was relaxed, euphoric, less aware of immediate surroundings; some patients experienced a tingling in fingers, toes, lips, or tongue; some patients felt a warm wave suffuse entire body; patients experienced a humming, droning, or vibratory sensation and feeling of lethargy or drowziness; voice became throaty; and thoughts wandered beyond the treatment room environment.[1]

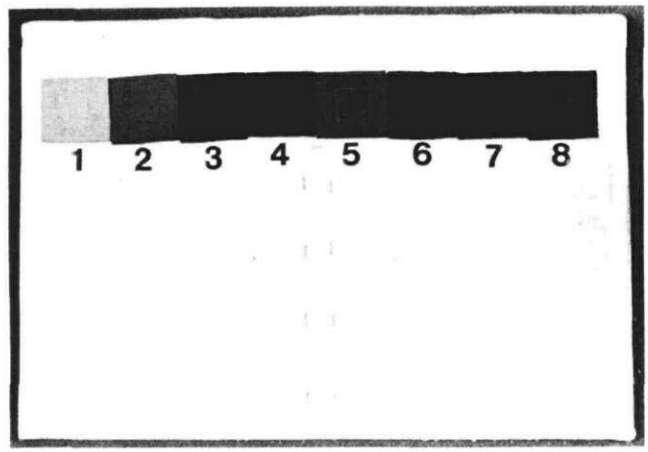

FIGURE 2. The Eland Color Scale.

Each child was tested for colorblind status and then interviewed in a consultation room prior to the dental procedure. (The colorblind test ensured accurate communication of colors used in the Eland Color Scale.) They then were questioned about things that hurt them in the past. These responses were coordinated with four colors of their choice representing severe, moderate, mild, and no pain.

The following procedure was conducted by one of the researchers.

1. Eight felt squares — yellow, orange, red, green, blue, purple, brown, and black — were placed in a row on a white felt background and presented to each child in the same order.
2. The child was asked, "Of these colors which is like _____?" (The event identified by the child as hurting the most.) That color square was placed on the felt board away from the other colors (it represented severe pain — numerical value of 3).
3. The child was asked "Which color is like_____ ?" (The event identified by the child as a hurt but less than the most painful event.) That color square was placed below the square chosen to represent severe pain (it represented moderate pain — numerical value of 2).
4. The child was asked "Which color is like_____

?" (The event identified by the child as hurting just a little.) That color square was placed below the colors representing severe and moderate pain. (it represented mild pain — numerical value of 1).
5. The child was asked "Which color is like not hurting at all?" That color was placed below the previously chosen colors at the bottom of the column of color squares (it represented no pain — numerical value of 0).

The study population was divided into two groups of 25 participants; one group was exposed to 100% oxygen, the other to a concentration of nitrous oxide necessary to achieve relative analgesia, which never exceeded a concentration of 60% nitrous oxide. The range was from 40% to 60% nitrous oxide with a mean concentration of 51%. A table of random numbers was used to assign the children to treatment groups.

The research was conducted by the two authors. Investigator A was responsible for nitrous oxide administration and determination of when the appropriate stage of relative analgesia had been attained. Only Investigator A was aware of which treatment group to which the participant was assigned.

Investigator B was responsible for interviewing the patient, establishing and administering the Eland Color Scale and executing the cavity preparation. Investigator B was not informed of whether the child was receiving oxygen only or nitrous oxide and oxygen.

The child was placed in a comfortable posture in the dental chair and the nasal inhaler was positioned properly. No cognitive information was offered to the child as to the nature or purpose of the nitrous oxide analgesia. The child was told that the "clown mask" would be placed on his nose and that he should breathe through his nose. The child was reassured that the mask would be removed if he did not like the feeling he got from breathing the air.

Investigator A administered oxygen for a control period of 3 min prior to nitrous oxide delivery. Nitrous oxide was delivered via an open-air nasal mask system with a portable analgesia machine.[a] A scavenging mask[b] was employed to maximize pollution control. Determination of the oxygen concentration in the mask was accomplished with an oxygen analyzer[c] fixed to the nasal mask. The analyzer served as a safety check on the concentration of nitrous oxide delivered by the analgesia machine. The oxygen flow rate was adjusted until the flow rate of the machine matched the patient's tidal volume. The concentration of nitrous oxide was increased in half-liter increments and the concentration of oxygen adjusted until the appropriate concentration of nitrous oxide was established. When Investigator A determined that the child was in the stage of relative analgesia the child was maintained at this concentration for 5 min before Investigator B was summoned and the four-color scale was reviewed with the child. The child was asked, "Which color does your tooth feel like now?" Both investigators were present for the duration of the procedure.

The procedure proceeded as described in the four steps below. After each step the child was asked, "Which color does your tooth feel like now?"

1. The handpiece was run adjacent to, but not touching the tooth to be prepared for approximately 10 sec.
2. A cutting bur was used on a high-speed handpiece without water to brush lightly and penetrate slightly the enamel of the tooth for approximately 10 sec.
3. The bur was allowed to penetrate the dentin using light brushing action for approximately 10 sec.
4. The restoration was completed with cotton roll isolation and the child was oxygenated postoperatively for 5 min.

No local anesthetic was used, but the child was informed that if at anytime he was experiencing unbearable pain, he should raise his hand. If the child was experiencing unbearable pain or "severe pain" as communicated with the aid of the Eland Color Scale, the procedure was discontinued and treatment was completed after administering a local anesthetic.

Discussion

This study was pursued because of the following considerations.

1. Many clinicians have stated empirically that nitrous oxide can be used effectively for cavity preparation in the primary dentition. Others have challenged this viewpoint and questioned the necessity of any analgesia or anesthesia for cavity preparation in the primary dentition.
2. Previous reports provide evidence that nitrous oxide is analgesic both for animals and humans. However, the majority of the research has been completed in fields other than dentistry.
3. The effect of nitrous oxide analgesia on pain perception in humans has been evaluated in a number of ways, but these methods have been difficult to employ with children. Therefore, this study investigated an instrument developed exclusively for children.

[a] Quantiflex M.D.M. Analgesia Machine Model # DM.D — Fraser Sweatment Inc.; Lancaster, NY.

[b] Brown scavenging mask, Analor IV with Pedo scavenger assembly 3-70-1500-43 — MDT Diagnostic Co.; North Charleston, SC.

[c] Beckman OM12 Oxygen Monitor Model # 147320 — Beckman Instruments, Inc., Electronic Instruments Division; Schiller Park, IL.

TABLE 1. Mean Values and the Standard Deviations of Pain Perceived by the Children*

Procedure	*Nitrous Oxide*	*Oxygen*
Five minutes after induction	$\bar{x}$ = 0.00 s.d. = 0.00	$\bar{x}$ = 0.00 s.d. = 0.00
The handpiece running by the tooth	$\bar{x}$ = 0.00 s.d. = 0.00	$\bar{x}$ = 0.04 s.d. = 0.20
Penetration of enamel	$\bar{x}$ = 0.12 s.d. = 0.33	$\bar{x}$ = 0.80 s.d. = 0.64
Penetration of dentin	$\bar{x}$ = 0.64 s.d. = 0.86	$\bar{x}$ = 1.88 s.d. = 0.88
Five minutes postoperatively	$\bar{x}$ = 0.00 s.d. = 0.00	*$\bar{x}$ = 0.46 s.d. = 0.83

* N = 24, one child unable to respond.

It is very difficult to compare this study with most studies in the literature. The concentration of nitrous oxide necessary to achieve a state of relative analgesia ranged from 40% to 60% nitrous oxide with a mean concentration of 50.6%. Even though the oxygen analyzer indicated this amount, it is doubtful that the child was receiving that concentration with an open, loose mask system and open mouth with no rubber dam. It was decided that relative analgesia is an individual response and that it was therefore inappropriate to recommend a specific or even a mean concentration of nitrous oxide that would be an analgesic dose. Other studies used predetermined concentrations of nitrous oxide or established a mean concentration of nitrous oxide for relative analgesia.

It could be theorized that 100% oxygen may have some analgesic properties and therefore be an inadequate control in this study. However, Wood et al. found that shock levels maintained during air exposure did not differ from levels maintained during exposure to 100% oxygen in rats and monkeys.[12] Devine et al. evaluated sensation threshold, pain threshold, tolerance threshold, and painfulness of the last shock in humans.[5] They found no significant differences in these parameters between a placebo group which received 100% oxygen and a control group which received air. Since subjects in both studies experienced no difference in pain perception while exposed to 100% oxygen or to air, 100% oxygen was used as a control for this study.

TABLE 2. A Comparison of Groups with the Need for Local Anesthesia for Cavity Preparation

	Local Anesthesia Administered	
Group	Yes	No
Nitrous oxide	01	24
Oxygen	13	12

Results and Conclusion

The mean amount of pain perceived and the standard deviations of the scores for the following procedures are listed in Table 1: (1) 5 min after induction, (2) the handpiece running by the tooth, (3) penetration of enamel, (4) penetration of dentin, and (5) 5 min postoperatively. There was no significant pain perceived after a 5-minute induction with nitrous oxide or oxygen, or with the handpiece running next to the tooth. There was pain perceived during enamel penetration in both groups. The mean amount of pain perceived by the children during enamel penetration was 0.12 with nitrous oxide and 0.80 with oxygen. The mean amount of pain perceived by the children during dentin penetration was 0.64 with nitrous oxide and 1.88 with oxygen. The mean amount of pain perceived 5 min postoperatively was 0.00 with nitrous oxide and 0.46 with oxygen.

A local anesthetic was given only to those children who were experiencing severe pain (Table 2). Only 1 child of 25 in the test group required a local anesthetic for cavity preparation with nitrous oxide, whereas 13 children of 25 in the control group required a local anesthetic for cavity preparation with oxygen only.

In conclusion the authors found that nitrous oxide analgesia significantly decreased the intensity of pain perceived during Class I cavity preparation in the primary dentition and played a significant role in reducing the need for a local anesthetic.

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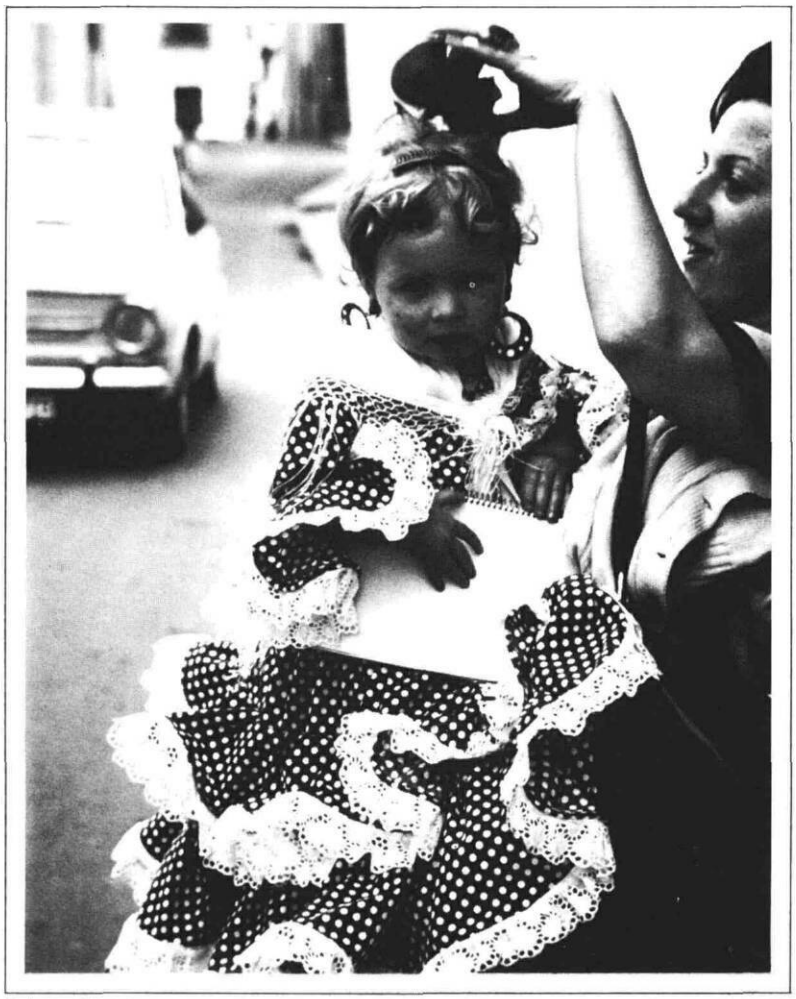

Little Spanish Lady

Dr. Theodore Croll