

Dr. Zier's publications

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Nitrous oxide for pediatric medical procedural sedation

SAFETY OF HIGH-CONCENTRATION NITROUS OXIDE BY NASAL MASK FOR PEDIATRIC PROCEDURAL SEDATION: EXPERIENCE WITH 7802 CASES.

Zier JL, Liu M. Pediatric Emergency Care. 2011; 27(12):1107-12.

OBJECTIVES: Nitrous oxide is an effective sedative/analgesic for mildly to moderately painful pediatric procedures. This study evaluated the safety of nitrous oxide administered at high concentration (up to 70%) for procedural sedation.

METHODS: This prospective, observational study included all patients younger than 18 years who received nitrous oxide for diagnostic or therapeutic procedures at a metropolitan children's facility. Patients' age, highest concentration and total duration of nitrous oxide administration, and adverse events were recorded.

RESULTS: Nitrous oxide was administered on 7802 occasions to 5779 patients ranging in age from 33 days to 18 years (median, 5.0 years) during the 5.5-year study period. No adverse events were recorded for 95.7% of cases. Minor adverse events included nausea (1.6%), vomiting (2.2%), and diaphoresis (0.4%). Nine patients had potentially serious events, all of which resolved without incident. There was no difference in adverse event rates between nitrous oxide less than or equal to 50% and greater than 50% ($P = 0.18$). Patients aged 1 to 4 years had the lowest adverse event rate ($P < 0.001$), with no difference between groups younger than 1 year, 5 to 10 years, and 11 to 18 years. Compared with patients with less than 15 minutes of nitrous oxide administration, patients with 15 to 30 minutes or more than 30 minutes of nitrous oxide administration were 4.2 (95% confidence interval, 3.2-5.4) or 4.9 (95% confidence interval, 2.6-9.3) times more likely to have adverse events.

CONCLUSIONS: Nitrous oxide can be safely administered at up to 70% concentration by nasal mask for pediatric procedural sedation, particularly for short (<15 minutes) procedures. Nitrous oxide seems safe for children of all ages.

SEIZURES TEMPORALLY ASSOCIATED WITH NITROUS OXIDE ADMINISTRATION FOR PEDIATRIC PROCEDURAL SEDATION.

Zier JL, Doescher JS. *Journal of Child Neurology*. 2010; 25(12):1517-20.

Nitrous oxide is an inhaled agent commonly used by dental staff to provide anxiolysis and analgesia for dental procedures and by anesthesia personnel as an adjunct to more potent general anesthetic gases. More recently, nitrous oxide has been used to provide sedation/analgesia for a variety of medical procedures in children outside of the operating room, including lumbar puncture, laceration repair, fracture reduction, and urologic imaging. We report 3 cases of clinical seizure activity associated with nitrous oxide administration for pediatric procedural sedation. Although temporally related, no causality is established. Review of the medical and dental literature confirm the rarity of these events.

LEVEL OF SEDATION WITH NITROUS OXIDE FOR PEDIATRIC MEDICAL PROCEDURES.

Zier JL, Tarrago R, Liu M. *Anesth Analg*. 2010;110(5):1399-405.

BACKGROUND: Nitrous oxide (N₂O) delivered at a concentration <50% is accepted as a minimal sedation drug by both the American Society of Anesthesiologists and the American Academy of Pediatrics. The expected level of sedation at an N₂O concentration >50% is less clear.

METHODS: We conducted a retrospective chart review for all children receiving N₂O for procedural sedation at Children's Hospitals and Clinics of Minnesota. Patient age, maximal N₂O concentration, duration of N₂O administration, completion of procedure, and adverse events were recorded. Level of sedation was assessed on a 0 to 6 scale.

RESULTS: N₂O was administered on 1858 occasions to 1585 patients younger than 18 years. Most administrations (91.3%) were N₂O concentration >50%. Level of sedation scores were as follows: 6 (inadequate) = 1.3%; 5 (minimal) = 94.3%; and 4 (drowsy) = 4.3%; no patient reached a sedation score <4. Fifty-nine patients (3.3%) had adverse events of which 6 (0.3%) were atypical. There was no difference between N₂O < or =50% and N₂O >50% in the level of sedation or number of adverse events. More children < or =2 years (7.4%) achieved a sedation level of 4 than those older than 2 years (4%), but they experienced a similar rate of adverse events. There was no difference in the level of sedation by duration of N₂O administration. Inadequately sedated patients were younger than the remainder of the group. Most procedures (94.1%) were completed with the patient calm and still.

CONCLUSIONS: A significant number of children remain minimally sedated while receiving N₂O at concentrations >50% via nasal hood using a system designed to titrate N₂O concentration from 0% to 70%. Adverse event rates of patients receiving >50% N₂O in this manner are similar to rates reported in large studies of 50% N₂O administration.

EFFECTIVENESS OF SEDATION USING NITROUS OXIDE COMPARED WITH ENTERAL MIDAZOLAM FOR BOTULINUM TOXIN A INJECTIONS IN CHILDREN.

Zier JL, Rivard PF, Krach LE, Wendorf HR. *Dev Med Child Neurol.* 2008;50(11):854-8.

This randomized, double-blind, placebo-controlled study compared the efficacy of inhaled nitrous oxide (N₂O) with enteral midazolam for sedation of children with cerebral palsy (CP) undergoing botulinum toxin A (BoNT-A) injections. Fifty children (29 males, 21 females; mean age 8y 2mo [SD 4y 5mo]; range 1-16y) were randomized to sedation with N₂O (n=25) or midazolam (n=25). Groups were similar in type of CP (diplegia, 11; triplegia, three; quadriplegia, 16; hemiplegia, 16; other, three) and Gross Motor Function Classification System level (Level I, 4; II, 24; III, 4; IV, 13; V, 5). Both groups were equally sedated at time of injection (p=0.661), but those in the midazolam group were more sedated at time of discharge (p<0.001). N₂O was more effective in reducing pain compared with midazolam as measured using the Face, Legs, Activity, Cry, Consolability (FLACC) scale (p=0.010), parental estimate of pain (p=0.009), and nursing estimate of pain (p=0.007). Parents in the N₂O group rated it better than prior sedation with midazolam for BoNT-A injections (p=0.031). Physicians and nurses reported no difference in ease of procedure between the groups. One child in the midazolam group and eight in the N₂O group had adverse effects, all of which resolved promptly. N₂O appears to be an effective means of sedation for children undergoing outpatient BoNT-A injections.

CREATION OF A REGISTERED NURSE-ADMINISTERED NITROUS OXIDE SEDATION PROGRAM FOR RADIOLOGY AND BEYOND.

Farrell MK, Drake GJ, Rucker D, Finkelstein M, Zier JL. *Pediatr Nurs.* 2008;34(1):29-35.

Children undergoing urethral catheterization for urologic imaging under existing sedation practices were identified as an underserved patient population. Using a multidisciplinary approach, a registered nurse (RN)-administered nitrous oxide sedation program was developed to meet the needs of these children. Program development required delineation of RN scope of practice, evaluation of equipment, formulation of an educational program, and compliance with occupational safety standards. The program was implemented in 2004 using standard "dental" nitrous oxide equipment coupled with distraction and imagery to enhance the efficacy of the sedation experience. Initial assessment via telephone questionnaire indicated fewer adverse effects and more rapid return to baseline than oral midazolam, the sedative previously used for these procedures. Ongoing evaluation continues to confirm patient and environmental safety. The nitrous oxide program has expanded to provide sedation for additional tests in radiology as well as in other hospital departments. By implementing an RN-administered nitrous oxide program, children's access to this sedative/analgesic agent is increased.

SEDATION WITH NITROUS OXIDE COMPARED WITH NO SEDATION DURING CATHETERIZATION FOR UROLOGIC IMAGING IN CHILDREN.

Zier JL, Kvam KA, Kurachek SC, Finkelstein M. *Pediatr Radiol.* 2007;37(7):678-84.

BACKGROUND: Various strategies to mitigate children's distress during voiding cystourethrography (VCUG) have been described. Sedation with nitrous oxide is comparable to that with oral midazolam for VCUG, but a side-by-side comparison of nitrous oxide sedation and routine care is lacking.

OBJECTIVE: The effects of sedation/analgesia using 70% nitrous oxide and routine care for VCUG and radionuclide cystography (RNC) were compared.

MATERIALS AND METHODS: A sample of 204 children 4-18 years of age scheduled for VCUG or RNC with sedation or routine care were enrolled in this prospective study. Nitrous oxide/oxygen (70%/30%) was administered during urethral catheterization to children in the sedated group. The outcomes recorded included observed distress using the Brief Behavioral Distress Score, self-reported pain, and time in department.

RESULTS: The study included 204 patients (99 nonsedated, 105 sedated) with a median age of 6.3 years (range 4.0-15.2 years). Distress and pain scores were greater in nonsedated than in sedated patients ($P < 0.001$). Time in department was longer in the sedated group (90 min vs. 30 min); however, time from entry to catheterization in a non-imaging area accounted for most of the difference. There was no difference in radiologic imaging time.

CONCLUSION: Sedation with nitrous oxide is effective in reducing distress and pain during catheterization for VCUG or RNC in children.

CASE-SERIES OF NURSE-ADMINISTERED NITROUS OXIDE FOR URINARY CATHETERIZATION IN CHILDREN.

Zier JL, Drake GJ, McCormick PC, Clinch KM, Cornfield DN. *Anesth Analg.* 2007;104(4):876-9.

BACKGROUND: Children undergoing urologic imaging studies requiring urethral catheterization experience considerable discomfort and psychological distress. Nitrous oxide sedation may mitigate these detriments but the requirement for physician administration has limited the applicability of this technique.

METHODS: Registered nurses underwent the nitrous oxide training requirements prescribed for state licensure of dentists and dental hygienists, with special emphasis on pediatric sedation principles. To evaluate the safety of nurse-administered nitrous oxide, we consecutively enrolled all children (ASA PS I-II) sedated for urethral catheterization for urologic imaging in an observational trial designed to identify sedation-related adverse events.

RESULTS: Nitrous oxide was administered on 1018 occasions. There were no major adverse events (apnea, oxygen saturation <92%). Minor adverse events (diaphoresis, nausea, vomiting) occurred in 4% of patients. Eight patients (1%) were described as over-sedated. In 11 (1%) patients, nitrous oxide provided insufficient sedation for completion of urologic imaging.

CONCLUSIONS: Nitrous oxide sedation can be provided by a nurse-administered program in pediatric radiology. Administration of nitrous oxide for pediatric procedures by adequately trained nursing staff with appropriate multidisciplinary oversight may increase children's access to this sedative/analgesic drug.