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Improving Stakeholder Satisfaction: Nitrous Oxide for Peripheral Intravenous Cannulation for Pediatric Procedural Sedation

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A B S T R A C T

Peripheral intravenous (PIV) cannulation needed for pediatric procedural sedation (PPS) is a common source of stress for patients and families. The goal of this project is to investigate the perceived effectiveness of nitrous oxide (N_2O) in reducing anxiety and pain associated with PIV cannulation for PPS by various stakeholders. N_2O was used as an adjunct to local anesthesia and child life intervention to reduce the anxiety and pain associated with PIV placement before PPS. N_2O use was at the discretion of physician. Candidates included patients who were anxious or fearful about PIV placement or patients who had a failed prior PIV cannulation attempt without N_2O. At the completion of the procedure, a survey was administered to determine stakeholder satisfaction with N_2O for PIV cannulation. A total of 393 N_2O sedations for PIV cannulation were identified. Overall, procedure success was 96.2%. Most stakeholders reported that they were very satisfied: physicians—341/382 (89.3%), nurses—350/380 (92.1%), parents—347/383 (90.6%), and patients—331/377 (87.8%). Overall patient-parent agreement about N_2O satisfaction was 94.1%. The most common adverse events (AEs) seen were dysphoria—11/393 (2.8%) and vomiting—5/393 (1.3%). None of the patients required prolonged stay for AE. N_2O can be successfully used for PIV cannulation for PPS without clinically significant AE and has a high degree of satisfaction among the stakeholders. N_2O should be considered as a method to reduce anxiety and pain in patients requiring PIV cannulation and those subjected to repeated procedures.

Introduction

Patients commonly experience stress and anxiety related to peripheral intravenous (PIV) cannulation required before pediatric procedural sedation (PPS). In the guideline statement on minimizing pain related to procedures, the Royal Australian College of Physicians recommends both nonpharmacologic and pharmacologic interventions to reduce procedural pain, anxiety, and stress related to minor procedures (Guideline Statement: Management of Procedure-related Pain in Children and Adolescents, 2005). Inadequate relief of procedural pain affects the experience of the child and parent as well as the success of the procedure (Kennedy, Luhmann, & Zempsky, 2008).

Children with chronic illnesses require repeated procedures over time. The procedures may require frequent venipuncture or PIV cannulation at each visit. Venipuncture and PIV cannulation are some of the most common sources of anxiety and pain in hospitalized patients (Cummings, Reid, Finley, McGrath, & Ritchie, 1996). The child's perception of the ease or difficulty of the venipuncture and/or PIV cannulation can trigger varied emotional responses including extreme fear and anxiety. Children respond differently to painful procedures. Children who undergo repeated painful procedures are more likely to develop conditioned anxiety and behavioral distress. This response is related to a history of negative experiences rather than a cumulative effect of the number of procedures (McGrath & de Veber, 1986). Another consequence of poorly controlled pain is sensitization. Pain activates biochemical and cellular processes that can alter responses to pain for future

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procedures. Ultimately, the response to painful stimuli may be enhanced because of sensitization (Zempsky & Schechter, 2003).

Historically, adult health care providers have not prioritized treating the pain and anxiety associated with procedures in children (Stevens et al., 2011). Biologic, social, and other factors contribute to how pain is experienced (Craig, Versloot, Goubert, Vervoot, & Crombez, 2010). The fear of needles typically develops early in life (Bienvenu & Eaton, 1998). Peak onset of the fear of needles is between 5 and 10 years of age with the reported pain during needle puncture procedures decreasing with patient age (Bienvenu & Eaton, 1998; Goodenough, Champion, Laubreaux, Tabah, & Kampel, 1998).

Nitrous oxide (N_2O) is an anesthetic gas with anxiolytic, amnestic, and analgesic effects. The French drug agency (Agence Fancaise de Securite Sanitaire des Produits de Sante) recommends that N_2O be administered for 3 min before the start of the procedure and for no longer than a total of 30 min. The most common adverse effects associated with N_2O sedation are nausea and vomiting. N_2O has been shown to be safe and effective in reducing the pain and anxiety of venipuncture and PIV cannulation. Its rapid onset and offset make it particularly attractive for these relatively brief procedures (Brislin, Stayer, Schwartz, Pasquariello, 1995; Gall et al., 2001; Kanagasundaram, Lane, Cavalletto, Keneally, & Cooper, 2001; Tobias, 2013; Tsze, Mallory, & Cravero, 2016).

Patient and parent satisfaction with their hospital experience is important. Our objective is to report the experience of patients, parents, nurses, and physicians with N_2O use for PIV cannulation for PPS in an outpatient-oriented radiology area in our hospital and a freestanding outpatient center within our system.

Materials and methods

Training

An emergency medicine physician champion with experience in the use of N_2O administration developed a training program, which included a didactic session, written test, and clinical experience component. The didactic session covered pharmacologic and physiologic effects of N_2O. A score of 100% on the written examination was required to proceed to the clinical component of training that included device setup, safety, and technique for the administration of N_2O. Each physician first observed the device setup and N_2O administration in one patient, and then subsequently was monitored by a trained physician who had successfully completed the training for two device setups and administration before being allowed to administer N_2O on their own. This training program was used to train all sedation service physicians providing procedural sedation in this study, which include pediatric anesthesiologists as well as critical care and emergency medicine physicians.

Procedures

A prospective open-label study was conducted to evaluate stakeholders' experience with N_2O for PIV cannulation. This study was approved by the institutional review board and adhered to the guidelines of Declaration of Helsinki. The patient was placed in a standard room in the radiology area used for the workup and sedation of patients before their procedure. Before the administration of N_2O, lidocaine 4% topical anesthetic cream was placed on potential intravenous sites and, if indicated, the patient was seen by child life. At the start of the procedure, an appropriately sized mask was selected for the child. The child (patient) was then allowed to choose a scented lip balm, which was rubbed on the inside of the mask. In a study by Tsze et al. (2016), most patients were monitored with direct observation and/or pulse oximetry, and 28.6% did not have any cardiopulmonary monitoring. For this study, all patients were monitored with continuous pulse oximetry throughout the procedure. Oxygen (fractional inspired oxygen [FiO_2], 1.0) was delivered via the mask, held by a parent or caregiver to facilitate acceptance, for a minimum of 1 min followed by N_2O delivery to a maximum of 70% for 4 to 5 min before beginning the procedure. The intravenous is placed by one of the sedation team nurses. Once the procedure was complete, oxygen (FiO_2, 1.0) was again administered to prevent diffusion hypoxia, a respiratory effect of N_2O discontinuation that occurs as the N_2O moves from the blood into the alveolus lowering the partial pressure of oxygen. Supplemental oxygen mitigates this effect by increasing the fractional inspired oxygen concentration (Tobias, 2013).

N_2O was administered using a Porter/Matryx Tall 4 Cylinder E Stand equipped with a Porter MXR 3000 flow meter (Porter Instruments, Hatfield, PA; a division of Parker Hannifin). The system is a continuous flow system that mixes oxygen and N_2O from separate E cylinders. The system can provide 0% to 70% N_2O. There are two important safety features in this system. The first ensures that at least 30% oxygen is provided to the patient, and the second is a failsafe so that if the oxygen supply is exhausted, N_2O cannot be delivered. All expired gas is scavenged via the system to an external vent (Figure 1).

N_2O was used to supplement local anesthetic and child life intervention for PIV cannulation before PPS for imaging studies. Patients were selected by the physician for N_2O use if they were anxious, fearful of PIV placement, or had previously failed PIV cannulation attempt without N_2O. Later in the study period, some parents and/or patients requested N_2O based on prior personal experience with N_2O from previous PPS.

Data Collection

Data were collected via a postprocedural survey from January 1, 2014 to September 30, 2016 after the administration and recovery from N_2O. A physician questionnaire included demographics, AE, interventions for AE, success rate, and satisfaction. Nurses, parents, and patients were asked to rate their satisfaction with the experience as very satisfied, satisfied, and dissatisfied. For patients who could not verbally respond to questioning, either because of age or developmental stage, the physician administering N_2O determined the level of satisfaction based on markers of satisfaction such as lack of crying or withdrawal. The data analysis was generated using SAS software, version 9.4. Copyright © 2013 SAS Institute Inc. and all other SAS Institute Inc. product or service names are registered trademarks or trademarks of SAS Institute Inc., Cary, NC.

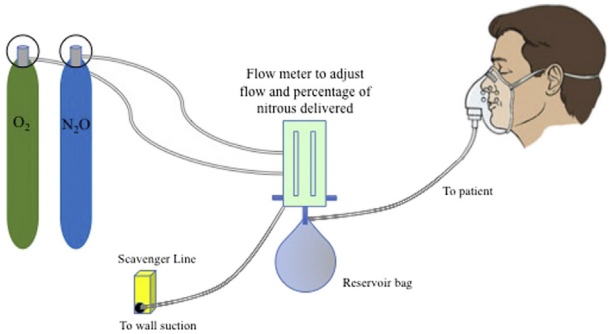

Figure 1. Schematic nitrous oxide (N_2O) delivery system. The N_2O delivery system allows for continuous flow of 0% to 70% N_2O mixed with oxygen (O_2) measured by the flow meter. A built-in safety feature ensures that at least 30% O_2 is delivered.