The Benefits of Introducing the Use of Nitrous Oxide in the Pediatric Emergency Department for Painful Procedures

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Contribution to Emergency Nursing Practice

- The current literature on nitrous oxide indicates that it is safe and effective for use in minimal to moderate sedation for painful procedures in children.
- The article reviews the action and administration of nitrous oxide as well as nursing implications and considerations.
- Key implications for emergency nursing practice: Nitrous oxide has rapid onset, relative safety and quick recovery, and can decrease patient length of stay in the emergency department.

Case Study

Jack is an 8-year-old boy who presents to the Pediatric Emergency Department after suffering a laceration to his knee. Jack is highly anxious and is terrified of the thought of requiring stitches to repair his wound. Upon presentation, he is crying, clinging to his mother, and is uncooperative with the nursing staff members who would like to examine his injury. The nursing staff speak at length with Jack and are able to calm him down and convince him to allow the nurses to evaluate his knee. On examination, they discover that Jack has a large laceration over his knee that will require extensive cleaning, exploration, and repair with sutures. Jack's parents ask the nursing staff what would be the best method to help decrease Jack's anxiety and to achieve pain control during the procedure.

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Introduction

Children who present to the emergency department are often subjected to painful procedures to treat their injuries or illnesses. The treatment of their injuries is essential and possibly lifesaving, but the pain they must endure for treatment is not necessary. There are multiple options to help control pain in a child including nonpharmalogical interventions and pharmacological interventions such as oral, intranasal, intradermal, intravenous, and inhalation medications. However, pain management in the emergency department is suboptimal for pediatric patients despite advances in medical research outlining available analgesics and disproving the myth of the lack of pain in children and infants.[1] If a child's pain is effectively managed, his or her cooperation and anxiety will decrease, allowing the medical staff to complete procedures successfully.[1]

In 2001, the American Academy of Pediatrics published a declaration stating that all efforts should be made by health care professionals to reduce the pain children may experience secondary to medical procedures.[2] To combat the discomfort and anxiety of a painful intervention, many emergency departments will perform a procedural sedation (PSA) on children. PSA and analgesia is performed by an anesthesiologist or non-anesthesiologist involving the administration of a sedative or dissociative agent (eg, ketamine) with a possible analgesic (eg, fentanyl) to produce a state that allows the patient to undergo a painful procedure while sustaining spontaneous cardiovascular and respiratory functions.[3] As noted in recent literature by Huang and Johnson in 2016, an ideal PSA would include (1) providing both sedation and analgesia, (2) quick onset of action and rapid recovery after discontinuation, (3) maintaining spontaneous cardiovascular and respiratory function, and (4) imposing an amnesic effect on the patient. To perform the majority of PSAs, intravenous medications are required and a peripheral IV (PIV) would need to be inserted. Placing a PIV line in a child can be time consuming, requires special skills, and is painful to the patient.[4]

To meet the needs of the patient who arrives to the emergency department in distress and in need of a possibly painful procedure, nursing staff must advocate for their patient. The child should be given adequate pain relief while maintaining patient safety. An ideal pharmalogical agent that meets the goal of providing safe and effective pain relief is the use of nitrous oxide (N_2O). Also, the rapid onset and recovery of N_2O will lead to shorter length of stay for the patient in the emergency department.

What is N_2O?

N_2O is a small inorganic molecule—a colorless, tasteless, and odorless gas—that has been recognized to be an anesthetic and analgesic when inhaled.[3] It was first discovered by chemist Joseph Priestly in 1772, but was used little in the clinical arena for analgesic purposes.[5] In 1863, after the discovery of how to convert the N_2O into a gas-ether inhalation mixture, dentists and surgeons started using N_2O as an analgesic for tooth extractions and minor procedures.[3] In the 19th century, N_2O was more common as a recreational drug—referred to as laughing gas—than its use in a professional clinical setting.[3]

How Does N_2O Work?

In current practice, N_2O is used for analgesia and anxiolysis in both clinical and emergency situations. It has been used successfully in dentistry, obstetrics, oncology, and pre-emptive analgesia, along with application prior to painful medical procedures including IV insertion, ophthalmologic interventions, and biopsies.[6] It is administered via inhalation, absorbed by diffusion through the lungs, and eliminated via respiration.[7] N_2O is not metabolized; it is eliminated through the lungs in an unchanged state. Because it is not metabolized by the body, N_2O does not bind to any carrier proteins through transport, thus avoiding any possible drug interactions.[8] The patient should feel the effects of N_2O within 30 to 60 seconds of administration.[9,10] When patients stop inhaling N_2O, they will stop feeling the effects of the medication within 1 to 2 minutes, without any residual effect.[6]

The mechanism of action of N_2O as an anesthetic is not entirely clear. One theory is that it reduces the excitatory influence of the nervous system.[11] The analgesic property of N_2O affects the opioid receptor in the same way morphine would on receptors in the spinal-cord system, causing a decrease in the amount of pain a person may experience.[11]

N_2O helps to manage a mildly to moderately anxious child through its ease of administration and rapid reversibility.[11] Although the mechanism of action of N_2O as an anxiolytic is not completely understood, it is believed that there is a similar association to how the body may process benzodiazepines through the gamma aminobutyric (GABA) receptors.[11]

Administration

N_2O is stored as a vapor overlying a liquid in a small portable blue tank (standard in the United States) that makes it easy to store and transport in any emergency department.[3] Nitrous oxide can be delivered as 50% to 50% or 70% to 30% N_2O-oxygen mixture via a hand-held mouthpiece or demand-valve mask. A 30% concentration of oxygen is required to avoid hypoxemia.[3] A 50% to 50% concentration is considered a minimal sedation that is effective with minor painful procedures which can be self or nurse administered.[12] Both concentrations of N_2O are effective in providing pain relief, but the higher dose of N_2O (70%) is preferred for PSA and is managed by a credentialed provider. Both have been found to be safe with no significant difference in adverse events compared with the lower concentration of N_2O.[13]

Within dentistry, N_2O is given via continuous flow through a mask. In a medical setting, patients are able to control the amount of N_2O they receive. The flow of N_2O is initiated only after patients have made an adequate seal of the mask around the nose and mouth or have sealed their lips around the mouthpiece and have made a deep inhalation.[5] As the patient inhales, the demand valve on the mask creates negative pressure, causing the valve to open and allow the gas to flow through the device. The demand valve will close with exhalation, causing the N_2O delivery to stop.[5] Children may safely deliver the N_2O to themselves via a self-administered mask with a demand valve.[14] Concerns have arisen regarding medical staff being exposed to N_2O and feeling the effects of the gas. To combat this concern, the Food and Drug Administration (FDA) approved a scavenger device that will gather the exhaled gas upon exhalation.[5] Once the patient exhales into the mask, the scavenger apparatus will collect the N_2O into a water reservoir that can be easily disposed of instead of being released into the air. Up to 70% of the exhaled N_2O can be collected with the scavenger system.[15]

Benefits of N_2O

N_2O is an easy medication to use prior to any painful procedure with multiple benefits to the patient and to the medical staff. Besides the administration of N_2O being pain