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Brief Report

The use of inhaled nitrous oxide for analgesia in adult ED patients: a pilot study☆,☆☆

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ABSTRACT

Background: Oligoanalgesia challenges emergency department (ED) health care providers and remains an area of patient dissatisfaction. Nitrous oxide (NO) is a safe, quick-acting, and well-tolerated sedative agent with analgesic and anxiolytic properties that make it ideal for ED use.
Objectives: We seek to test the effectiveness of a self-administered and self-contained NO device as an analgesic agent in the ED and assess patient and staff satisfaction with this method.
Methods: We enrolled 85 patients 18 years and older in a prospective observational study of patients presenting to the ED with moderate to severe pain (≥30 mm on a 100-mm visual analog scale). Subjects received a mixture of 50% NO via a self-administered portable delivery device. Primary outcome was the reduction in baseline pain scores at 20, 40, and 60 minutes. Secondary outcomes were patient, nurse, and physician satisfaction as reported on a brief satisfaction questionnaire.
Results: There was a significant reduction in mean pain scores from baseline to 20 minutes that was sustained through the 60-minute period. Most subjects (93%; 95% confidence interval [CI], 85%-97%) and nurses (97%; 95% CI, 90%-99%) reported that the NO delivery system was easy to use and were satisfied with the level of pain relief and would use NO in the future (82%; 95% CI, 73%-89%). Physicians and nurses were also satisfied with the analgesic effects of NO (82%; 95% CI, 73%-89%).
Conclusions: The portable NO device is an effective analgesia adjunct for ED patients presenting with painful conditions, and patients, ED nurses, and emergency physicians are satisfied with its use. Nitrous oxide coupled with a nurse-driven analgesia protocol may provide a novel solution for improvement in ED analgesia rates and overall patient satisfaction with ED pain management.

1. Introduction

1.1. Background

Oligoanalgesia, or inadequate pain management, continues to challenge emergency department (ED) health care providers [1]. Despite a better understanding of pain mechanisms, barriers to effective pain relief, and implementation of evidence-based protocols, timely and effective pain management remains an area of patient dissatisfaction [2].

Many patients who come to the ED are in acute pain (60%-80%), yet receive inadequate or no analgesia [1–8]. Those who receive analgesia often experience lengthy delays between ED arrival and analgesic delivery [7]. Wilson and Pendelton [7] performed a retrospective medical record review of more than 198 patients, noting that only 44% of patients admitted to the hospital for a painful condition received analgesics while in the ED; of these, 69% waited longer than 1 hour and 42% waited more than 2 hours for pain medication. In a prospective cross-sectional study of ED pain management and patient experiences, Todd et al [8] found that only 50% of patients received an analgesic despite 63% reporting severe pain. The failure to treat pain can lead to increased sympathetic tone, tachycardia, hypertension, increased myocardial demand, and suppression of the endocrine and immune systems [9].

Anxiety is correlated with higher levels of pain and is present in 74% of all ED patients [10]. The exact mechanism for this association has not been fully elucidated, but probably involves the hippocampus. Ploghaus et al [11] have demonstrated that anxiety associated with a medical illness or anticipation of a painful event activates neurons in the hippocampus creating a state of hyperalgesia that increases a patient's perceived pain intensity and pain threshold. This may explain why both anxiolytic agents

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such as nitrous oxide (NO) and psychological interventions to reduce anxiety have proven beneficial in treating pain [12].

1.2. Importance

Nitrous oxide is a safe well-tolerated sedative agent with the potential for significant analgesic effects [13,14]. Rapid onset of action, ease of administration, and favorable cardiorespiratory profile suggest that NO may be an ideal analgesic agent for ED use. These properties also make it particularly promising for use in a nurse-driven ED protocol designed to help reduce delays in analgesia delivery. However, before such a protocol can be considered, more information regarding the effectiveness and acceptance of using a self-administered and self-contained NO device as an analgesic agent in the ED must be obtained.

1.3. Goals of this investigation

The current pilot study was designed to evaluate the analgesic effectiveness and patient and staff satisfaction of using the portable NO device in adult ED patients presenting with a painful condition. In particular, we examine the reduction in baseline pain scores at 20, 40, and 60 minutes. In addition, patient, nurse, and physician satisfaction is reported using a brief satisfaction questionnaire.

2. Materials and methods

2.1. Study design

This was a prospective nonblinded observational study of patients presenting to the ED with moderate to severe pain. Because NO is routinely used in our ED as an anxiolytic agent during painful procedures, the institutional review board waived oversight of the protocol. Nevertheless, research associates obtained verbal consent from all participants.

2.2. Setting

The study was conducted in the ED at an urban teaching hospital and level 1 trauma center with 600 beds and an annual ED census of approximately 100 000 patients. Research associates were available in the ED 24 hours a day/7 days a week to enroll eligible patients, ensure adherence to the study protocol, and collect all outcome data.

2.3. Selection of participants

All patients 18 years or older with moderate to severe pain (≥30 mm on a 100-mm visual analog scale [VAS]) from any one of the following conditions were eligible for the study: abdominal pain, musculoskeletal (reproducible) chest pain, dental pain (eg, abscess, caries, and tooth fracture), neck pain (without focal weakness), back pain (without focal weakness), flank pain, extremity pain (traumatic and nontraumatic), headache (without focal weakness or altered mental status), cellulitis, abscess, minor to moderate burns, and wounds (eg, lacerations and foreign bodies). Patients were excluded if they were pregnant, had only mild pain (<30 mm on a 100-mm VAS), possible cardiac chest pain, concern for possible closed-space obstruction (eg, small bowel obstruction and pneumothorax), clinical signs of cardiopulmonary instability (eg, blood pressure < 100 mm Hg, heart rate >110 beats/min, respiratory rate >30 breaths/min, or oxygen saturation as measured by pulse oximetry [Spo_2] <95%), major trauma, or altered mental status or intoxication from any cause. Non–English-speaking patients, nursing home residents, individuals in police custody, and those patients who in the discretion of the treating physician should not receive NO were also excluded. After routine ED nursing assessment (which included a focused history and physical examination and vital signs), all eligible subjects were screened by a research associate to assure eligibility, explain the study protocol, and obtain verbal consent.

2.4. Protocol

Study patients were placed on cardiac, capnography, and pulse oximetry monitors, and baseline pain scores were obtained by a research associate using a 100-mm VAS. A mixture of 50% NO was then initiated using a portable delivery device with a self-contained scavenging system (Linde Gas North America, Murray Hill, NJ). By study protocol, NO could be initiated by the nursing staff without a physician order. Emergency department nurses were also allowed to assist patients in self-administration of the NO and remove the mask if oversedation (evidenced by hypoxia or significant change in mental status or alertness) occurred. In addition to baseline, research associates obtained pain scores at times 20, 40, and 60 minutes. The length of NO administration, as well as the use and type of additional analgesia, was at the discretion of the treating physician. After NO was discontinued, the patient, nurse, and physician were asked to complete a short satisfaction questionnaire.

2.5. Data collection

Data were collected using a standardized electronic data collection form linked to each participant using a unique identification number to assure confidentiality. The Capnostream 20 $ETCO_2$ monitor (Oridian Medical, Needham, MA) sampled and recorded $ETCO_2$ and Spo_2 every 5 seconds. At the completion of each case, all device data were transmitted to a network-protected Excel/SPSS spreadsheet for analysis. Survey responses were also stored in a network protected Excel/SPSS spreadsheet linked to each participant using the same unique identification number.

2.6. Outcome measures

The primary outcome measure was reduction in baseline pain scores after 20, 40, and 60 minutes of NO administration. Secondary outcome measures included patient, nurse, and physician satisfaction with NO use. The total time of NO administration and the use and timing of additional pain medications were also obtained.

Vital signs including heart rate, respiratory rate, blood pressure, peripheral SaO_2, and $ETCO_2$ were recorded every 5 seconds. Hypoxia, (Spo_2 of <92%), respiratory depression (loss of $ETCO_2$ waveform, $ETCO_2$ >50 mm Hg, or a change from baseline ≤10% for >15 seconds), and all adverse events, including interventions for over sedation and respiratory depression (eg, verbal or physical stimulation, airway repositioning, additional oxygen, positive pressure ventilation, and endotracheal intubation) were also recorded.

2.7. Primary data analysis

Data were analyzed using SPSS (IBM, Armonk, NY) and Stata Software (StataCorp LP, College Station, TX). Paired-samples *t* tests were used to compare mean pain scores at baseline and those reported at 20, 40, and 60 minutes.

3. Results

3.1. Characteristics of study subjects

Between October 2013 and August 2014, 85 patients were enrolled in the study. Demographic information, baseline pain scores, and duration of NO administration are provided in Table 1. Most patients presented with an abscess or orthopedic injury (Table 2).

3.2. Main results

There was a clinically and statistically significant reduction in mean pain scores from baseline to 20 minutes of NO administration that was