EFFECTIVENESS OF NITROUS OXIDE IN A RURAL EMS SYSTEM

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Abstract — Prehospital systems need a safe, effective analgesic agent for the treatment of patients suffering from pain. Recent studies have documented the efficacy of nitrous oxide in urban and rural settings. This study reviews the findings on 200 patients (157 trauma, 23 medical, 18 musculoskeletal problems) who received nitrous oxide during a 28-month period in a rural EMS system. Eighty-five percent of the patients reported pain relief. Only minor side effects were noted. Patient satisfaction was high, and there was no abuse noted among personnel.

Keywords — Nitronox; analgesic; rural EMS; nitrous oxide; pain

INTRODUCTION

Physicians and dentists have used nitrous oxide to treat patients suffering from pain and discomfort for over 100 years. In the United States, until recently, the use of this gas has been limited to the doctor's office, dentist's office, or hospital. In the last 10 years, with the development of a portable delivery system, nitrous oxide became available for use in the prehospital setting.

Stewart et al have documented the effectiveness of nitrous oxide in the prehospital environment (1). Much of the data that has been generated to document the effectiveness of nitrous oxide by ambulance technicians has come from urban areas. Rural emergency medical service systems also need an effective analgesic for the treatment of pain as rural ambulances must often travel long distances before they reach the hospital.

The effectiveness, ease of use, and safety of nitrous oxide in a rural prehospital setting are examined in this paper.

MATERIALS AND METHODS

This is a prospective study to evaluate the effectiveness and safety of nitrous oxide in a rural prehospital EMS system. The study is conducted in Porter County, Indiana. Porter County is located in the northwest corner of the state. It comprises an area of 425 square miles and has a population of 124,000. The population per square mile is 291.8. The hospital is centrally located in the county. During this study there were 16 ambulances serving the county's population (126.6 square miles or 1:7,488 persons). Seven of the ambulances were equipped with nitrous oxide units (1 unit/17,714 persons).

Four ambulance services participated in the study. Porter County EMS (third service municipal entity), North Porter County Ambulance Commission (private unsubsidized ambulance service), Bethlehem Steel EMS (industrial-based ambulance service), and Lane Ambulance Service (private for-profit service). During the study, Porter County EMS was acquired by Porter Memorial Hospital, becoming a hospital-based ambulance service with county subsidy.

One month prior to incorporating nitrous oxide into the system's prehospital protocol, all paramedics, emergency department physicians, and emergency department nurses were taught the proper procedure for operating the nitrous oxide/oxygen inhalation (Nitronox®) apparatus. This training session (approximately 90 min
PROTOCOL

Nitrous Oxide (Nitronox)

A. Actual Gas Content

Nitrous Oxide 50% - Oxygen 50%

B. Method of Administration

Instruct the patient to do the following:

1. Hold the face mask securely over the face
2. Inhale normally until the pain is relieved, you become drowsy or side effect develops
3. Discontinue if you become too drowsy or experience side effect

C. Indications:

Administered to relieve pain or anxiety associated with the following situations:

1. Trauma (Burns, Musculoskeletal injury, soft tissue injury)
2. Acute Abdomen (Except Bowel Obstruction)
4. Myocardial Infarction Pain (Base Physician Order Only)
5. Any Other Pain Not Contraindicated Below

D. Contraindications:

1. Head injury with impaired consciousness
2. Sedated or intoxicated patients
3. Severe maxillofacial injury
4. Pneumothorax or tension pneumothorax
5. Decompression sickness
6. Pregnant patients (During first trimester)
7. Hypotensive patients
8. Bowel Obstruction
9. COPD patients (Unless approved by base station)
10. Any altered level of consciousness

NOTE:
This gas is for self-administration by the patient. Only under the direct order of a physician may the mask be applied by a paramedic to the face of a patient (such as in the case of bilateral upper extremity fractures). Failure to observe this basic regulation may result in significant danger to the patient and constitutes a violation of this protocol. N2O is not to be mixed with other analgesic agents (MS, Demerol) or sedatives (Valium). If it is necessary to give these medications, discontinue N2O first. Nitrous oxide may be especially useful in extrication situation.

Figure 1. Nitrous oxide protocol.
stressed the indications, contraindications, and therapeutic effects of nitrous oxide as outlined in a treatment protocol adopted for the participating EMS systems (Figure 1). Subsequent review sessions were conducted every 6 months, and any new paramedic entering the system received thorough training in the use of nitrous oxide prior to being released to function at the advanced life support level.

Proper operation and safety features of the inhalation unit were emphasized. Prehospital technicians and emergency nurses were permitted to sample the effects of the gas in a controlled classroom setting. Plastic tank seals with sequential numbering were used to lock the inhalation units, and a time log was placed inside the plastic case. The time log tracked usage of the gas in minutes.

At the training sessions, data collection forms were distributed and their proper usage discussed (Figure 2). This form requests information from the paramedic and the patient. The intensity of pain, side effects, complications, and degree of relief are recorded on the form. Blood pressure, pulse, respirations, presence of gag reflex, and transport position are also documented. The data collection form is filled out by the prehospital technician who interviews the patient before, during, and after nitrous oxide administration. Nitrous oxide is contraindicated in our system for patients experiencing the following conditions: any altered level of consciousness, suspected pneumothorax, severe maxillofacial injury, decompression sickness, pregnant patients (during first trimester), hypotensive patients, bowel obstruction, and chronic lung disease (COPD).

The paramedics may usually offer nitrous oxide to the patient without consulting the base hospital physician. One exception is suspected myocardial infarction pain. The consensus of our emergency physician staff is to require paramedic consultation with the base station hospital prior to administering nitrous oxide to suspected myocardial infarction patients. No myocardial infarction patients received nitrous oxide during this study.

RESULTS

Two hundred patients were offered nitrous oxide for relief of their pain between September 9, 1986, and December 29, 1988. The patients ranged in age from 7 to 89 years. There were 90 female patients and 110 male patients included in this study. The administration time for the gas ranged from 15 seconds to 70 minutes with a mean administration time of 20.6 minutes. Distance traveled between the scene of the incident and the receiving facility ranged from less than one mile to 24 miles. The mean distance to the hospital with a patient on board was 11.1 miles. The transportation time from the scene of the incident until arrival at the receiving facility ranged from 2 minutes to 38 minutes. The mean transportation time was 17 minutes.

Severity of pain was rated on a scale of 0 to 3. A pain rating of 0 represents severe pain (characterized by screaming, writhing, or constant groaning). A pain rating of 2 represents spontaneous complaints of pain (no screaming or constant groaning). A pain rating of 1 represents a complaint of pain only when asked. A pain rating of 0 represents no pain and no complaints of pain when asked. Stewart et al used the same scale to measure pain in their study.

There were 80 cases without proper documentation of the degree of pain relief. According to documentation by the paramedics, 8 patients (6%) reported complete relief, 93 patients (77%) reported partial relief, and 19 patients (15%) reported no relief. Of the 19 patients who reported no relief, 2 were unable to activate the demand valve mechanism and one did not properly follow instructions on the use of the device. These three patients did not receive any nitrous oxide.

Seventy-three patients received a rating of 0 from the paramedics prior to administration of Nitronox®. Eight of these patients (7% of all patients rated and 11% of the patients receiving a 0 rating) maintained a rating of 0 during administration of Nitronox®. Thirty-five patients (29% of all rated patients and 48% of all patients with a 0 rating) improved to a 2 during administration.

Twenty-four patients (20% of all patients rated and 27% of all patients with a 3) improved to a 1 during administration. Six patients (5% of all rated patients and 8% of all patients with a 3 rating) improved to a 0 during administration. Forty-three patients received a rating of 2 from the paramedics prior to administration of Nitronox®. Seven of these patients (6% of all rated patients and 16% of all patients with a 2 rating) maintained a rating of 2 throughout administration. Thirty-four patients (28% of all rated patients and 79% of all patients with a 2 rating) improved to a 1 during administration of Nitronox®. Two patients (2% of all rated patients and 5% of all patients with a 2) improved to a 0 rating. Four patients received a rating of 1 from the paramedics prior to administration. All four of these patients (3% of all rated patients and 100% of the patients who received a 1 rating) maintained the rating throughout administration (Table 1).

The effectiveness of Nitronox® was compared with the type of injury as diagnosed by the emergency department physician (Table 2). Sixty-six patients who received self-administered Nitronox® were ultimately diagnosed to have either a fracture or a dislocation. Five of these patients (8% of the fracture/dislocation group) reported complete relief of pain to the paramedic. Forty-eight (73% of the fracture/dislocation patients)
## Nitrous Oxide Project
**Porter Memorial Hospital MIC Program**

**Data Research Form**

<table>
<thead>
<tr>
<th>Case Number</th>
<th>Paramedic Cert. Number</th>
<th>Date</th>
</tr>
</thead>
</table>

**Patient complaint and brief Hx:**


**Other analgesia/medications administered:**

**Describe patient during administration:**

<table>
<thead>
<tr>
<th>Item Observed</th>
<th>Before Rx</th>
<th>During Rx</th>
<th>Upon ED Arrival</th>
<th>Position of patient during administration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pt. responds to pain</td>
<td></td>
<td></td>
<td></td>
<td>____________________ Sitting ______________</td>
</tr>
<tr>
<td>Pt. responds to voice</td>
<td></td>
<td></td>
<td></td>
<td>____________________ Supine _______________</td>
</tr>
<tr>
<td>Pulse Rate</td>
<td></td>
<td></td>
<td></td>
<td>____________________ Head-up ______________</td>
</tr>
<tr>
<td>Blood pressure</td>
<td></td>
<td></td>
<td></td>
<td>____________________ Other _______________</td>
</tr>
<tr>
<td>Gag reflex present</td>
<td></td>
<td></td>
<td></td>
<td>____________________</td>
</tr>
<tr>
<td>EKG Interpretation</td>
<td></td>
<td></td>
<td></td>
<td>____________________ Side Effects __________</td>
</tr>
<tr>
<td>Pt. Grade of Pain 1,2, or 3 only</td>
<td></td>
<td></td>
<td></td>
<td>____________________ Nausea ________________</td>
</tr>
<tr>
<td>Medic Grade of Pain 1,2, or 3 only</td>
<td></td>
<td></td>
<td></td>
<td>____________________ Vomiting ____________</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>____________________ Vertigo ______________</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>____________________ Other _______________</td>
</tr>
</tbody>
</table>

**How To Rate Pain On Above Scale**

0 = No complaints, even when asked, denies pain  
1 = Complains of pain, only when asked. (no nausea/vomiting)  
2 = Spontaneously complains of pain/not screaming or groaning  
3 = Severe pain, patient screaming, writhing, groaning constantly

**Additional Comments**

**Paramedic Filling Out Report**

**2nd Technician on the Call**

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*Figure 2. Nitrous oxide project data research form.*
reported partial relief of pain, and 13 (20% of the fracture/dislocation patients) reported no relief. Soft tissue injury was the indication for Nitronox® in 15 patients. None of these 15 patients reported complete relief. Ten patients (67% of the soft tissue injury patients) reported partial relief, and 5 patients (33% of the soft tissue injury patients) reported no relief. Twenty-eight patients received Nitronox® for a sprain or strain. Two patients (7% of the sprain/strain patients) reported complete relief, 25 patients (89% of the sprain/strain patients) reported partial relief, and only 1 patient (4% of the sprain/strain patients) reported no relief. There were 11 patients with various types of nonspecific pain such as urinary calculus, etc. These 11 patients were grouped together. One patient (9% of this group) reported complete relief, and 10 (91% of this group) reported partial relief.

Paramedics recorded the patient's problem (complaint) and their clinical impression (paramedic's perception of patient's problem) on the prehospital trip report. Recent trauma (within 24 hours) accounted for 157 of the cases (78%). Twenty-three patients presented

with medical emergencies (11%), and 18 patients presented with chronic muscle or nerve problems (9%). In two cases the clinical impression was not documented by the paramedics (1%).

Patient vital signs (blood pressure, pulse, and respiration), presence of gag reflex, neurological response, and side effects were recorded on the data collection form. During administration of nitrous oxide, none of the patients lost consciousness, all of the patients maintained an intact gag reflex, and only one patient vomited. The paramedic evaluated the gag reflex by asking the patient to swallow. The maintenance of an intact gag reflex is consistent with other studies suggesting that nitrous oxide-oxygen analgesia does not cause depression of the pharyngolaryngeal reflexes. (2). There was no significant change in blood pressure or pulse rate in any of the patients. While under the influence of the nitrous oxide, some patients exhibited a tendency to breathe more deeply and faster than normal. We are uncertain as to why this occurred. Arterial blood gas results were not recorded during the study.

In this study a lead-II cardiac rhythm strip was recorded and interpreted in 50 of the patients. The cardiac rhythm was monitored prior to and during administration of Nitronox®. During administration of nitrous oxide, none of the 50 patients experienced a change in their ECG pattern. The ECG interpretation in the emergency department matched that of the paramedic in the field in 100% of the cases. Eighty percent of the patients were experiencing normal sinus rhythm, and 8% were experiencing sinus tachycardia. The remaining rhythms included sinus bradycardia, atrial fibillation, sinus dysrhythmia, and one patient experienced premature atrial contractions. Side effects occurred with 31 patients (15%). Twelve patients complained of dizziness (6%), 8 patients experienced nausea (4%), and 4 patients became drowsy (2%). Additional side effects were giddiness, a floating sensation, and tingling of the extremities. Each of these additional side effects accounted for less than one percent of the total patients.

### Table 1. Patients' Pain Ratings Prior to and during Nitronox

<table>
<thead>
<tr>
<th>Prior to Nitronox</th>
<th>During Nitronox</th>
<th>Total This Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>8 (11%)</td>
<td>8 (11%)</td>
</tr>
<tr>
<td>2</td>
<td>36 (48%)</td>
<td>36 (48%)</td>
</tr>
<tr>
<td>1</td>
<td>24 (33%)</td>
<td>24 (33%)</td>
</tr>
<tr>
<td>0</td>
<td>6 (8%)</td>
<td>6 (8%)</td>
</tr>
<tr>
<td></td>
<td>73 (100%)</td>
<td>73 (100%)</td>
</tr>
<tr>
<td>Level 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>7 (16%)</td>
<td>7 (16%)</td>
</tr>
<tr>
<td>1</td>
<td>34 (79%)</td>
<td>34 (79%)</td>
</tr>
<tr>
<td>0</td>
<td>2 (5%)</td>
<td>2 (5%)</td>
</tr>
<tr>
<td></td>
<td>43 (100%)</td>
<td>43 (100%)</td>
</tr>
<tr>
<td>Level 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>4 (100%)</td>
<td>4 (100%)</td>
</tr>
<tr>
<td>0</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td></td>
<td>4 (100%)</td>
<td>4 (100%)</td>
</tr>
</tbody>
</table>

3 Rating = severe pain, patient screaming, whining, groaning constantly.
2 Rating = spontaneously complains of pain, but not screaming or groaning.
1 Rating = complains of pain only when asked.
0 Rating = no complaints, denies pain even when asked.

### Table 2. Effectiveness of Nitronox According To Injury Type

<table>
<thead>
<tr>
<th>Category</th>
<th>Complete Relief</th>
<th>Partial Relief</th>
<th>No Relief</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fracture/Dislocation</td>
<td>5 (8%)</td>
<td>48 (73%)</td>
<td>13 (20%)</td>
</tr>
<tr>
<td>Soft tissue injury</td>
<td>0 (0%)</td>
<td>10 (67%)</td>
<td>5 (33%)</td>
</tr>
<tr>
<td>Strain/Strain</td>
<td>2 (7%)</td>
<td>24 (86%)</td>
<td>1 (4%)</td>
</tr>
<tr>
<td>Other pain</td>
<td>1 (6%)</td>
<td>10 (91%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Totals</td>
<td>8 (6%)</td>
<td>93 (78%)</td>
<td>19 (16%)</td>
</tr>
</tbody>
</table>

### Table 3. Problems Encountered in the Administration of Nitronox

<table>
<thead>
<tr>
<th>Problems Encountered</th>
<th>Number</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>None documented</td>
<td>178</td>
<td>88%</td>
</tr>
<tr>
<td>Patient did not follow instructions for proper use of unit</td>
<td>13</td>
<td>7%</td>
</tr>
<tr>
<td>Oxygen tank depleted</td>
<td>2</td>
<td>1%</td>
</tr>
<tr>
<td>Gagged nose equipment</td>
<td>1</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>Patient unable to activate demand valve</td>
<td>5</td>
<td>2%</td>
</tr>
<tr>
<td>Cervical collar prevented adequate face mask seal</td>
<td>1</td>
<td>&lt;1%</td>
</tr>
</tbody>
</table>
Nitrous Oxide Questionnaire

During administration of Nitrous Oxide I felt: (Check all that apply)

___ Dizzy ___ Nausea ___ Numbness ___ Light-headed
___ No Side Effects ___ Other (Please explain)

During administration of Nitronox, did you experience:

___ Complete relief of pain ___ Partial relief of pain ___ No relief

If you experienced a similar situation in which you were suffering pain, would you want to receive the nitrous oxide for relief of pain?

___ Yes ___ No (Why or why not?)

Have you ever taken Nitrous Oxide previous to this incident?

___ Yes ___ No

Do you have any past medical history of: (Please check all that apply)

___ Bowel Obstruction ___ Cardiac Problem
___ Emphysema ___ Seizure
___ Chronic Bronchitis ___ Asthma

Was the Nitrous Oxide administration continued in the Emergency Dept.?

___ Yes ___ No

Please rate the courtesy and cooperation of the following persons on a scale of one to ten (with ten being the highest rating):

Paramedics ___
Emergency Department Nurses ___
Emergency Department Physicians ___

Figure 3. Nitrous oxide questionnaire.

Problems related to usage occurred in 22 cases (11%) (Table 3). Seventeen of these incidents (85% of the problems) involved patients who did not follow instruc-
tions properly or patients who could not breathe deeply enough to activate the demand valve. In these cases, the problem was merely a failure of the patient to be able to
Twenty-five percent of all patients who returned questionnaires claimed a previous experience with nitrous oxide. Eighty percent stated that they would desire treatment with nitrous oxide again if they were suffering from pain. All of the patients surveyed indicated that the paramedics explained the use of the inhalation unit to them. It is significant to note that 7 of the patients (17% of all questionnaires) said that they still did not understand how to use the gas following explanation by the paramedic.

There is a notable difference between the side effects reported by the patients (on the questionnaire) and the side effects reported by the paramedic (at the time of the incident). According to the questionnaire, the side effects consist of light-headedness (25%), numbness (17%), nausea (2%), and dizziness (2%) (Table 5).

**DISCUSSION**

In 1800, Sir Humphrey Davy first suggested that nitrous oxide could possibly be used “...with advantage during surgical operation...” (1). Some 40 years later, nitrous oxide was used in the United States by Horace Wells, a dentist who had his tooth extracted while under the effects of the gas (1). In 1969 Peter Baskett, an anesthetist from Bristol, utilized a mixture of 50% nitrous oxide and 50% oxygen in the ambulance service. Baskett determined that a self-administered 50:50 mixture was safe and effective for emergency care (1).

In the United States, much of the research regarding nitrous oxide in the prehospital setting comes from the Pittsburgh emergency medical services (EMS) system. This research demonstrates that nitrous oxide is a safe and effective sedative/analgesic agent that is suitable for prehospital care (1,3,4). An increasing number of ambulance services in the United States now include nitrous oxide as a part of their treatment protocols. In Indiana, the site of this nitrous research project, use of nitrous oxide in the prehospital setting has been conservative. Whitley County (Indiana) EMS first used the gas on rural ambulances in 1985. Nitrous oxide has been a part of the prehospital treatment protocol at Porter Memorial Hospital since 1986.

While parenteral narcotics can be used in the prehospital setting by advanced personnel for analgesia and sedation, their usage is problematic. There is a prolonged onset with narcotics unless an intravenous route is used. Narcotics may cover pertinent signs and symptoms for a prolonged time. Inability to sign a subsequent consent for treatment form can delay hospital treatment when narcotics have been administered to the patient. The potential for significant decreases in blood pressure

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**Table 4. Effectiveness of Nitronox According to Paramedic Documentation at the Time of the Event and as Indicated on the Postincident Questionnaire**

<table>
<thead>
<tr>
<th>Effectiveness</th>
<th>Paramedic documentation</th>
<th>Questionnaire</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete relief</td>
<td>8 (77%)</td>
<td>14 (35%)</td>
</tr>
<tr>
<td>Partial relief</td>
<td>93 (78%)</td>
<td>21 (51%)</td>
</tr>
<tr>
<td>No relief</td>
<td>19 (15%)</td>
<td>6 (14%)</td>
</tr>
</tbody>
</table>

properly self-administer the nitrous oxide. In one case, the hose and mask mechanism was inadvertently stepped on and the Nitronox® unit would not function properly. On two occasions the oxygen tank in the Nitronox® unit became depleted and this was sensed by the blender unit. At this point, the unit appropriately shut off in each case.

Since data on effectiveness varied slightly from published studies, patients were contacted to confirm the prehospital data. A follow-up questionnaire was mailed to the last 100 patients who received nitrous oxide in the prehospital setting (Figure 3). Patients who had not received Nitronox® in the last 12 months were not included because of the length of time that had elapsed. An addressed, stamped envelope was provided with the questionnaire. The follow-up questionnaire was used to determine the patient’s perception of nitrous oxide following treatment. Forty-four questionnaires (44%) were returned. In two cases, the patients had subsequently died of terminal illness and the form was completed by a survivor. These two cases were not included in the data. One additional patient denied ever receiving nitrous oxide although records clearly state that he did. This left 41 questionnaires to evaluate. On the questionnaire, 14 patients claimed complete relief of pain (34% of returns), 21 patients reported partial relief of pain (51%), and 6 patients (15%) stated that they experienced no relief of pain. These statistics vary from the paramedic data compiled at the time of the event, which indicates that only 8 patients (7%) experienced complete relief, 93 (78%) reported partial relief, and 19 (15%) stated no relief (Table 4).

**Table 5. Comparison of Side Effects from Paramedic Documentation at the Time of the Event and Patient Response on Postincident Questionnaire**

<table>
<thead>
<tr>
<th>Side Effects</th>
<th>n (%)</th>
<th>n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>169 (85%)</td>
<td>26 (65%)</td>
</tr>
<tr>
<td>Dizziness</td>
<td>12 (6%)</td>
<td>1 (2%)</td>
</tr>
<tr>
<td>Nausea</td>
<td>8 (4%)</td>
<td>1 (2%)</td>
</tr>
<tr>
<td>Drowsiness</td>
<td>4 (2%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Tingling/float/giddiness/ light-headed/numbness</td>
<td>7 (3%)</td>
<td>11 (27%)</td>
</tr>
</tbody>
</table>
are more pronounced with narcotics. Nitrous oxide, on
the other hand, clears rapidly in a matter of several
minutes and is less of a problem in these cases.

Nitrous oxide is marketed for use in the United States
under the name of Nitronox®. Nitronox® is a blended
mixture of 50% nitrous oxide and 50% oxygen. The
prehospital inhalation unit consists of one oxygen tank
and one nitrous oxide tank. There is a blender valve unit
which mixes the gases from the two tanks in a 50:50
concentration of nitrous oxide and oxygen.

The Nitronox® unit has a number of safety features.
The blender system will activate an alarm if the concen-
tration of nitrous oxide and oxygen varies from 50:50.
When the oxygen tank is depleted, the unit will shut
down, preventing the patient from receiving a 100%
concentration of nitrous oxide. This valve functioned
appropriately in two cases during this study. Alter-
ately, the patient will receive a 100% concentration of
oxygen if the nitrous oxide tank is depleted. A negative
pressure at the face mask is required to open the supply
valve. This requires the patient to maintain a tight face
mask seal and inhale actively.

In its pure form, nitrous oxide is colorless, heavier
than air, and has no odor. While it supports combustion,
it is not flammable by itself. One characteristic that
distinguishes nitrous oxide from other prehospital anal-
egesics is its ability to diffuse rapidly across membranes
(1). Because of this unique property, nitrous oxide has a
rapid onset of action and swift elimination of effect
when inhalation stops, usually within 2 to 5 minutes (1).

Previous studies have concluded that “diffusion hypoxia is not seen in normal subjects following self-administration of nitrous oxide.” (5). Holcomb et al concluded “that the phenomenon of diffusion hypoxia does exist but cannot be seen with an FiO2 higher than 21% or room air.” (6).

In a study of 20 healthy volunteers, Stewart et al
determined that in patients without respiratory or cardio-
vascular compromise, arterial hypoxemia does not occur
following administration of a 50:50 concentration of
nitrous oxide and oxygen for 15 minutes (5). Our study
did not objectively measure arterial blood gas variation
during nitrous oxide administration. No subjective prob-
lems were noted attributable to oxygenation, however.

Reported side effects of nitrous oxide include drows-
iness, light-headedness, nausea, and vomiting (1,7).
These findings were confirmed in our study with the
additional subjective patient complaint of numbness
(Table 5).

Nitrous oxide has been used as an agent of abuse. It
has been reported that lay people, students, and profes-
sonals have participating in recreational use of the gas
(1,7). Although there is abuse potential, there is little
evidence of misuse by prehospital technicians (1). In our
program, we were not able to detect any abuse of nitrous
oxide. Tank seals remained intact and time logs were
consistent with gas usage. This finding is felt to be due,
at least in part, to the opportunity to “sample” nitrous
oxide during the orientation. This practice may tend to
curb curiosity, lessen abuse potential, and allow for a
better understanding of the effects of nitrous oxide.

Currently, there is no scavenger device available for
the prehospital Nitronox® unit. A scavenger device has
been developed for use in the hospital setting, but it is
not practical for use in an ambulance (7). During this
study, paramedics were instructed to turn on the venti-
lation fan while the patient was receiving nitrous oxide.
None of the paramedics involved in this study reported
experiencing any side effects during administration of
nitrous oxide to patients.

CONCLUSION

We have determined that there was no loss of gag reflex
in any of the patients who received Nitronox® during
this study. Patient vital signs were not adversely af-
fected during administration of the gas. The EKG
pattern was consistent throughout administration, and
there were no new ectopic beats during nitrous oxide
administration. Although side effects were present in
15% of the cases, none of these were felt to be critical to
the patient. It is worthwhile to note the increased
effectiveness rating that the patients gave Nitronox®
after the event compared with the effectiveness rating
they reported to the paramedic at the time of the event.
Administration problems were minimal, and our data
determined that most of them could have been pre-
vented. Better explanation by the paramedic to the
patient on the proper use of the inhalation unit would
have eliminated the majority of the problems. None of
the problems that were encountered during this study
resulted in an adverse patient outcome. Thorough pa-
tient instruction regarding proper use of the Nitronox®
unit is important. It is significant that 17% of the
patients who returned questionnaires reported that they
did not understand how to use the Nitronox® unit. It is
equally important to note that 80% of the patients who
responded, stated that they would desire to have nitrous
oxide again for similar pain. This study concludes that a
self-administered 50:50 concentration of nitrous oxide
and oxygen is a safe and effective analgesic for the rural
prehospital environment. Nitrous oxide has some advan-
tages over narcotics analgesic in the prehospital setting.
This gas is an appropriate adjunct for paramedics work-
ing in rural EMS systems considering the long transport
times (mean = 17 min in this study) and distance
traveled with a suffering patient (mean = 11.1 miles in
this study).
REFERENCES
