Nitrous Oxide Sedation in the Pediatric Patient

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Nitrous Oxide is both an *analgesic* and an *anxiolytic*

Joint Commission ‘00

- Four levels of sedation
  - **Minimal/Anxiolysis**
    - Respond normally to verbal commands
    - Cognitive function and coordination impaired
Joint Commission '00

**Moderate sedation**
- Respond to verbal or light tactile stimuli
- No intervention to maintain airway
- Adequate spontaneous ventilation

Joint Commission '00

**Deep sedation**
- Respond purposefully following repeated or painful stimulation
- Ability to maintain ventilatory function may be impaired

Joint Commission '00

**Anesthesia**
- Not arousable, even with painful stimuli
- Independent ventilatory function often impaired
The use of inhalation sedation with nitrous oxide (N₂O) and oxygen (O₂) has many significant advantages over other methods of sedation.

Why Nitrous Oxide?

FEAR of an unpleasant experience, namely PAIN.

Nitrous oxide relieves both the physiological and the psychological aspects of pain.

Rationale for Inhalation Sedation

The use of inhalation sedation with nitrous oxide (N₂O) and oxygen (O₂) has many significant advantages over other methods of sedation.

Indications

- Reduce anxiety
- Increase pain threshold
- Suppress gag reflex
- Increase tolerance for longer procedures
- Eliminate need for sedative premedication
- Potentiate effects of sedative premedication
Onset of Action
The onset of action of inhalation sedation is more rapid than that of oral, rectal and intramuscular (IM) sedation. IV sedation onset is roughly equal to inhalation.

<table>
<thead>
<tr>
<th>Route of Administration</th>
<th>Onset of Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oral</td>
<td>90 minutes</td>
</tr>
<tr>
<td>Rectal</td>
<td>30 minutes</td>
</tr>
<tr>
<td>IM</td>
<td>10 - 15 minutes</td>
</tr>
<tr>
<td>IV</td>
<td>20 seconds (arm - brain circulation), 1 to 2 minutes for clinical action</td>
</tr>
<tr>
<td>Inhalation</td>
<td>&lt; 20 seconds (pulmonary to brain), 2 to 3 minutes for clinical action</td>
</tr>
</tbody>
</table>

Advantages of Inhalation Sedation (N₂O – O₂)

- A non-flammable, sweet-smelling gas
- Relatively insoluble
- Stable
- Stored in BLUE cylinders

Physical Properties of Nitrous Oxide

- Nitrous oxide is inert
- Quickly absorbed from the alveoli of the lungs and physically dissolved in the blood
- Eliminated unchanged from the body
- Gas is rapidly excreted from the lungs when the concentration gradient is reversed
Elimination of N₂O

- Rapid
- Primarily through the lungs (MAC 104)
- Minimum alveolar concentration (MAC) is the percent of gas at 1 atm required to provide anesthesia in 50% of patients and represents potency
- Small amount through skin, sweat glands, urine, and intestinal gas

CNS Pharmacology

- CNS depressant
- Weak anesthetic potency - MAC 104%
- Relatively potent analgesic
- Response to suggestion enhanced
- Cough reflex moderately suppressed

Cardiovascular Effects

- Parallels inhaling 100% oxygen
- Slight decrease in heart rate
- No evidence of increased myocardial irritability
- No change to slight decrease in blood pressure
Respiratory Effects

- Slight stimulation—resulting in increased tidal volume
- Sense of smell decreased
- Pulmonary vasoconstriction -> increased PVR, therefore may exacerbate pulmonary HTN
- BEWARE: inhibits carotid body hypoxic drive

Diffusion Hypoxia

- Upon termination of nitrous oxide administration, the outpouring of nitrous oxide from the lungs can dilute the amount of oxygen available to the patient
- This danger is probably insignificant in healthy patients
- However, it is recommended that the patient receive 100% oxygen for 3-5 minutes at the termination of N₂O use to prevent possibility

Diffusion Hypoxia

- High outpouring of N₂O
- Dilutes available oxygen in lungs

Ventilate the patient for 3 to 5 minutes to prevent diffusion hypoxia!
Gastrointestinal Effects

- Nausea and Vomiting
  - Very low incidence
  - Usually, no special eating instructions prior to administration
  - Correlation with fluctuating concentrations of N₂O?

Contraindications

- 35 times more soluble in blood than nitrogen, N₂
- so fills and expands any air-containing cavities:
  - air embolism
  - pneumothorax
  - intracranial air
  - lung cysts
  - intraocular air bubbles
  - tympanoplasty
  - endotracheal tube cuff (monitor and reduce pressure periodically)

Contraindications

- Pneumothorax
- Closed head injury/increased ICP
- Pulmonary hypertension
- Abdominal distension/bowel obstruction
- Pregnancy
- ?Otitis media
Relative Contraindications

- COPD–bronchitis, emphysema
- URI
- Otitis Media, sinusitis
- Severe emotional disturbances
- Claustrophobia or irrational fear of "gas"
- Maxillofacial deformities or nasal obstructions
- Pregnant patients—especially in first trimester

Advantages

- Rapid onset and recovery
- Ease of dose control (titration)
- Limited physiologic effects
- Analgesic
- Suppression of gag reflex
- Potentiation

Disadvantages

- Weak agent
- Lack of patient acceptance
- Inconvenience—when working on maxillary anterior teeth
- Potential chronic toxicity
- Potential for abuse
- Necessary equipment
- Potentiation
Minimizing Risk

- Good scavenging system
- Adequate circulation of room air
- Limiting speech and mouth breathing of patient
- Proper size nasal hood
- Use in uncooperative child

Potential for Abuse

- Real concern
- Secure safely
- Common signs of abuse
  - Parasthesia or clumsiness of hands and legs
  - Loss of balance
  - Unsteady gait
What’s the big deal?

- Noninvasive
- Rapid onset
- Brief duration
  - 100% O2 washout after completion
  - 1 – 5 minutes: End-tidal N\textsubscript{2}O = Zero
Indications

- Painful procedures
  - Laceration repair
  - Abscess (with local)
  - Simple fracture reduction
  - Burn debridement
  - Dressing and wound care
  - Removal of drains

Indications

- Wiggly procedures
  - Lumbar punctures
  - Ear FB removal
  - IV start
  - VCUG

Indications

- Patients you’d rather not go deep
  - Macroglossia
Indications

- Patients you’d rather not intubate
  - Macroglossia
  - Micrognathia

- Down’s Syndrome
  - Macroglossia
  - Small mouth
  - Small trachea
  - Atlanto-axial instability

Inappropriate Patients

- Chest tube removal
- Oral lacerations
- Pain control not adequate
- Other medications needed
Indications: NPO Status

- "There is lack of evidence that gastric emptying has any impact on the incidence of complications or on outcome in PSA."
- "It must be carefully noted that in spite of the statements made in this policy, institutions will still be accredited on the basis of ... JCAHO."


Indications – NPO


"later on in our series, we requested that children...ingest a few crackers or half a single serving box of cereal. This eliminated our problem with nausea and vomiting."

Pre-procedural fasting state and adverse events in children receiving N2O

- 220 ED patients
- 4/63 who met NPO (6.3%)
- 11/155 who did not (7.1%)
- Almost all 70% nitrous
Patient Selection

- Medical history and physical exam
- Parental consent
- Mild–moderate anxiety
- Strong gag reflex
- Capacity to be compliant and follow directions

Administration Rules

- **Never** use less than 30% oxygen.
- Provide 6–8 liters (.1L/kg) of gas per minute for adult, less for child.
- Continually monitor patient.

Administration

- Prior to sedating patient
  - Make sure equipment is set up and working properly
  - Select nasal hood of proper size
  - Have patient use restroom if necessary
  - Make sure you have an assistant!
Administration—continued

- Introduce child to equipment (slowly)—use tell, show, do
- Make adjustments to ensure mask fits snugly but comfortably
- Establish a total liter per minute of gases first with 100% O₂:
  - 3–7 liters per minute depending on size of patient

Administration—continued

- Encourage the patient to breathe through nose
  - Light finger pressure under lower lip
  - Tap on nosepiece
  - Keep reminding them verbally
- Slow vs. Rapid induction

Administration—continued

- During induction explain what the child might be feeling:
  - Tingling feeling of hands and feet
  - Numbness of lips and tongue
  - Sensation of warmth
  - Sensation of floating
  - Feeling of heaviness
  - Droning sounds
  - Hearing distinct but distant
Administration—continued

- Watch patient for signs of proper level of sedation
- Therapeutic nitrous oxide levels usually between 30%-50%
- Try avoiding exceeding 50%. Have used 60%
- Vomiting is rare but watch for signs of nausea
- If patient does vomit:
  - Don’t panic
  - Turn head to side
  - Suction mouth
  - 100% O₂ and complete procedure

Administration—continued

- Upon termination of procedure
  - Inhalation of 100% O₂ for 3-5 minutes
  - Have child sit up in chair for several minutes

Advantages of Inhalation Sedation
(N₂O – O₂)

**Recovery Time**

Recovery time from inhalation sedation is rapid and is the most complete of any technique.

N₂O is not metabolized by the body, the gas is rapidly and virtually completely eliminated from the body within 3 to 5 minutes. In all other techniques the recovery from sedation is considerably slower.

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<tr>
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<tr>
<td>IV</td>
<td>&gt; 2 to 3 hours</td>
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<tr>
<td>Inhalation</td>
<td>Usually Complete 3 to 5 minutes after 100% O₂</td>
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Side Effects
- Amnesia/lightheadedness
- Headache
- Nausea/vomiting
- Insomnia/nightmares
- Most side effects related to diffusion hypoxia.
- caused by inadequate post oxygenation

Signs of Oversedation
1) Giddiness and laughter
2) Dissociation form surrounding
3) Extreme drowsiness leading to periods of sleep
4) Sluggishness
5) Stage II– excitement and irritability followed by labored breathing and difficulty in chest excursions.
6) Roller coaster breathing
7) unresponsiveness

Biotransformation and Toxicity
- Eliminated by exhalation.
- .004% metabolized in gut bacteria.
- Irreversibly oxidizes cobalt atom of vitamin B12, inhibiting B12–dependent enzymes:
  - methionine synthetase (myelin formation and erythrocyte production)
  - thymidylate synthetase (DNA synthesis)
- Prolonged exposure can lead to
  - bone marrow depression (megaloblastic anemia)
  - peripheral neuropathy
  - pernicious anemia
- Controversial:
  - teratogenic –usually avoided in early pregnancy
$\text{N}_2\text{O Scavenging System}$

![Diagram of a typical nitrous oxide scavenging system.](image)

Figure 6-1: Diagram of a typical nitrous oxide scavenging system.