NITROUS OXIDE

Properties & Pharmacokinetics:
- Odorless, colorless gas that is a potent analgesic, but weak general anesthetic.
  - 20% N2O has been found to be equipotent to 0.2mg/kg morphine sulfate.
- Also has potent anxiolytic and amnestic properties
- N2O is relatively insoluble in blood and remains unchanged.
  - N2O diffuses rapidly into the blood and reaches equilibrium.
  - Blood-gas partition coefficient is 0.47
- Rapidly taken up from the lungs.
  - Clinical effects begin in less than 30sec.
  - Peak effects occur in less than 5min.
  - Achieves 90% arterial saturation in 15-20min.
- The Minimal Alveolar Concentration (MAC) of nitrous oxide is 105% (defined as the concentration at which 50% of people will not move in response to a painful stimulus). When used alone can only produce GA in a hyperbaric chamber.
- Intense analgesia is produced in concentrations 20-50%.
- Unconsciousness is produced when nitrous concentrations exceed 70-80%.
- Recovery is very rapid. Arterial blood loses 70% of its N2O concentration in 3min.
- The rapid diffusion of N2O may cause hypoxemia.
  - Must be used with a minimum of 30% oxygen.
  - When N2O is discontinued, patients should be placed on high flow oxygen via a NRBM for at least 5min.

Contraindications & Systemic Effects:
- Gas filled structures expand when N2O is inhaled.
  - N2O should be avoided in patients with pneumothorax, bowel obstruction, occluded middle ear.
- N2O increases cerebral blood flow and intracranial pressure and should be used with caution in patients with closed head injury.
- Mixed CV effects:
  - direct myocardial depressant – reduces CO, HR and contractility;
  - but also has sympathomimetic effects stimulating the release of endogenous catecholamines increasing CO, HR, and contractility.
- Has minimal effects on respiration (at inhaled concentrations of 10-50%).
- Blunts protective laryngeal reflexes.
- N2O is a teratogen and has been associated with fetal wastage and pre-term delivery.
  - N2O should not be used in pregnancy (particularly 1st trimester).
- N2O can produce GA when combined with other sedative/analgesic agents, and should be used with caution.
- In general, N2O should only be used in conjunction with local/regional anesthetics.
  - N2O should not be used as a substitute for local anesthesia, rather as an adjuvant to it.
Matrix Nitrous Delivery System:

- **Digital LED flowmeter**
  - Allows you to dial in the mix O2:N2O.
  - Can give digital read out of flow for either N2O or O2 (automatically calculated).

- **Reservoir bag**
  - Serves as a reservoir of extra gas should the patient inspire more gas than is being supplied through the hoses.
  - Provides the mechanism for monitoring the patient’s respirations.
  - Functions in an emergency as a method of providing positive pressure ventilation to the patient.

- 3 hose attachments: N2O, O2, waste gas (scavenger)

- **Anesthesia circuit and Face mask:**
  - The circuits and masks are disposable.
  - Allows for end-tidal N2O monitoring (measure of actual inspired % N2O, which is not necessarily what is delivered/dialed).
  - Requires the black elbow joint attachment for waste gas.

- **Nasal hoods:**
  - Disposable nasal scented hoods attach into white tubing system.
  - White tubing system is NOT disposable, and needs to be autoclaved between uses.
  - Fits directly onto machine – does not require black elbow joint (DO NOT THROW IT AWAY).

- **Alarms**
  - The machine will alarm/not function unless O2 is attached and running.
  - The maximum amount of N2O able to be delivered is 70%.
  - The minimum amount of O2 able to be delivered is 30%.
  - The minimum flow rate is 3L/min

Steps to Using the Matrix Machine:

- Connect the oxygen, nitrous, and waste gas lines to the wall.
- Connect the tubing system and reservoir bag to the machine (either disposable anesthesia circuit or non-disposable white tubing).
- Turn the machine on.
- Push the “O2 Flush” button and fill the reservoir bag approximately 2/3 full.
- Select the appropriate L/min flow rate
  - Avg adult = 6-7L/min
  - Avg child = 4-5L/min
  - If the bag over-inflates, turn down the flow rate. (Or, this may be related to mouth breathing if using a nasal hood).
  - If the bag completely deflates, turn the flow rate up.
- Begin with 100% O2, then titrate to the desired percentage of N2O. This should generally be between 20-50%.
Guideline for the Use of Nitrous Oxide in the Emergency Department

- **Purpose:**
  - To provide appropriate monitoring for all patients receiving nitrous oxide.

1. **Procedure:**

1. In accordance with the UCH Sedation Guidelines, sedated patients should be monitored closely for:
   - Hypoxemia
   - Hypoventilation
   - Airway obstruction
   - Hypoperfusion
   - Potential for aspiration

   These potential side effects must be rapidly identified and appropriately treated.

2. **Guidelines:**

   - Candidates for sedation should meet ASA Class I or II criteria (see appendix 1).

3. **Personnel:**

   All sedations in the Emergency Department utilizing Nitrous oxide are performed under the supervision of the Attending Physician on-duty.

   - For procedures, in addition to the physician or suture nurse performing the procedure itself, an administering physician will be responsible for the actual nitrous oxide administration and monitoring of the patient. A registered nurse knowledgeable in CPR and the emergency medication cart will be present during (and following) the administration of sedative medication.

4. **Monitoring:**

   During the administration of nitrous oxide, the patient should be under direct observation by both the physician administering the medications and the assisting nurse. Patient’s respiratory rate and pattern of respiration must be observed before and throughout nitrous oxide administration. Once the patient is noted to be stable with respect to respirations, oxygenation and perfusion, continuous or frequent observation by the nurse should occur until the patient is fully recovered.

   During the sedation, the child’s color (nail beds, mucosa, etc.) should be visually monitored on a continuous basis. If a restraint devise is used and it covers the patient, a hand or foot should be kept exposed. Restraining devices should be checked to prevent chest restriction. Head position should be such to assure an open airway.

   - **Baseline:**
     - Vital signs
     - Mental status
   - **Throughout Procedure:**
     - Cardiac tracing
     - Pulse oximetry
     - End-Tidal CO₂
     - Inspired & expired N₂O
   - **Frequent:**
     - Respiratory rate
     - Blood pressure
5. **Equipment:**

   Immediately available:
   - Suction with large bore catheter
   - Free flow O² mask
   - Ambu bag/mask/oral airways
   - Emergency cart with airway equipment and resuscitation medications

6. **Post Procedure Monitoring:**

   - Continuous ECG and pulse oximetry should usually be monitored until the patient awakens. An RN should be assigned to closely observe the patient during the recovery period.

7. **Documentation During Treatment:**

   - The patient’s chart shall contain documentation at the time of treatment that the patient’s level of consciousness and responsiveness, heart rate, blood pressure, respiratory rate, and oxygen saturation were monitored until the patient satisfied predetermined discharge criteria (see Appendix 2).

   - The patient’s chart shall also contain a time-based record that includes the name, route, site, time dosage, and patient effect of any additionally administered medications.

   - During administration, the expired concentration of nitrous oxide and the duration of administration shall be documented.

   - Adverse events shall be documented.

8. **Documentation After Treatment:**

   - The time and condition of the child at discharge from the treatment area or facility shall be documented; this should include documentation that the child’s level of consciousness has returned to a state that is safe for discharge by recognized criteria (see Appendix 2).

9. **Nitrous Oxide Quick-connect Access and Storage:**

   - The quick-connect for nitrous oxide will be locked in the Accudose unit when not in use. This will be checked twice daily with narcotic inventory checks.
## APPENDIX 1: ASA Classification

### PHYSICAL STATUS CLASSIFICATION OF THE AMERICAN SOCIETY OF ANESTHESIOLOGISTS (ASA)

<table>
<thead>
<tr>
<th>Status</th>
<th>Disease State</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>No organic, physiologic, biochemical, or psychiatric disturbance</td>
</tr>
<tr>
<td>II</td>
<td>Mild to moderate systemic disturbance that may or may not be related to the reason for surgery. (Examples include Mild asthma, well-controlled diabetes)</td>
</tr>
<tr>
<td>III*</td>
<td>Severe systemic disturbance that may or may not be related to the reason for surgery. (Examples include heart disease that limits activity, poorly controlled essential hypertension, diabetes mellitus with complications, chronic pulmonary disease that limits activity)</td>
</tr>
<tr>
<td>IV*</td>
<td>Severe systemic disturbance that is life-threatening with or without surgery. (Examples include congestive heart failure, advanced pulmonary, renal or hepatic dysfunction)</td>
</tr>
<tr>
<td>V*</td>
<td>Moribund patient who has little chance of survival but is submitted to surgery as a last resort (resuscitative effort). (Examples include cerebral trauma, pulmonary embolus)</td>
</tr>
</tbody>
</table>

*Anesthesia consultation required*
APPENDIX 2: POST-SEDATION MONITORING

MODIFIED ALDRETE SCORING SYSTEM

<table>
<thead>
<tr>
<th>Activity</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Able to move 4 extremities voluntarily or on command w/normal strength or at baseline for patient</td>
<td>2</td>
</tr>
<tr>
<td>Able to move 2 extremities voluntarily or on command</td>
<td>1</td>
</tr>
<tr>
<td>Able to move 0 extremities voluntarily or on command</td>
<td>0</td>
</tr>
<tr>
<td>Respiration</td>
<td></td>
</tr>
<tr>
<td>Able to deep breathe and cough freely</td>
<td>2</td>
</tr>
<tr>
<td>Dyspnea or limited breathing</td>
<td>1</td>
</tr>
<tr>
<td>Apnea</td>
<td>0</td>
</tr>
<tr>
<td>Circulation</td>
<td></td>
</tr>
<tr>
<td>BP = 20% of preanesthetic level</td>
<td>2</td>
</tr>
<tr>
<td>BP = 20-50% of preanesthetic level</td>
<td>1</td>
</tr>
<tr>
<td>BP &lt; 50% of preanesthetic level</td>
<td>0</td>
</tr>
<tr>
<td>Consciousness</td>
<td></td>
</tr>
<tr>
<td>Fully awake, or at baseline for patient</td>
<td>2</td>
</tr>
<tr>
<td>Arousable with verbal stimulation</td>
<td>1</td>
</tr>
<tr>
<td>Not responding or arousable to painful stimuli</td>
<td>0</td>
</tr>
<tr>
<td>Color</td>
<td></td>
</tr>
<tr>
<td>Pink</td>
<td>2</td>
</tr>
<tr>
<td>Pale, dusky, blotchy, jaundiced, other</td>
<td>1</td>
</tr>
<tr>
<td>Cyanotic</td>
<td>0</td>
</tr>
</tbody>
</table>

* At the UofC, patients are required to have a Modified Aldrete Score of 9 or greater for discharge

RECOMMENDED DISCHARGE CRITERIA

1. Cardiovascular function and airway patency are satisfactory and stable.
2. The patient is easily arousable, and protective reflexes are intact.
3. The patient can talk (if age appropriate).
4. The patient can sit up unaided (if age appropriate).
5. For a very young or handicapped child, incapable of the usually expected responses, the pre-sedation level of responsiveness or a level as close as possible.
6. The state of hydration is adequate.

FINAL DISCHARGE CRITERIA

- Patients must have an Aldrete score of 9 or greater
- Patients should also meet the recommended discharge criteria as listed above
- Patients should also have their pain needs addressed and have an appropriate discharge plan in place
REFERENCES:


DISCLAIMER:
This clinical guideline has been developed for the purpose of unifying the general emergency care of use of nitrous oxide. It is intended to aid, rather than substitute for, professional judgment. It is not intended to serve as a rigid protocol or a written proxy for the standard of care. Failure to comply with this guideline does not represent a breach of the standard of care.