Nitrous Oxide – Oxygen Administration: Contamination and Scavenging

Introduction to potential health hazards of trace anesthetics and proposed techniques for limiting occupational exposure.

Animal Studies

Several studies have examined the effects of nitrous oxide on the development of animal embryos with inconsistent results. Discrepancies between these conclusions are due to:

- Different animals
- Different gas concentrations
- Different times during pregnancy of exposure
- Different durations of exposure

Mutagenicity tests of other inhalational anesthetics have also provided no evidence of carcinogenicity or organ toxicity, although some animal studies indicated that chronic exposure to nitrous oxide concentrations of 1000 ppm or higher can result in teratogenicity.

Human Studies

Cohen 1975: Retrospective Questionnaire defined
Levels of Exposure as:

<table>
<thead>
<tr>
<th>Hours</th>
<th>Exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>None</td>
</tr>
<tr>
<td>1-2999</td>
<td>Light</td>
</tr>
<tr>
<td>≥ 3000 Hours</td>
<td>Heavy</td>
</tr>
</tbody>
</table>

Return Rate: 70%

Dentists: 21,000/120,000
Assistants: 22,000/150,000

Epidemiological Errors:
- Retrospective
- Inadequate Control
- Incomplete Return
- Biased Return
- Unknown Exposure
- Unsupported by other studies
- Unsupported Diagnosis of defect

Other Notes or Questions to Ask:
Cohen 1980 (Heavily Exposed is redefined as >8 hours per week):

<table>
<thead>
<tr>
<th>Heavily Exposed Dentist</th>
<th>Female Assistants Exposed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.7 fold increase in liver disease</td>
<td>1.6 fold increase in liver disease</td>
</tr>
<tr>
<td>1.2 fold increase in kidney disease</td>
<td>1.7 fold increase in kidney disease</td>
</tr>
<tr>
<td>1.9 fold increase in neurological disease</td>
<td>2.8 fold increase in neurological disease</td>
</tr>
<tr>
<td>1.5 fold increase in spontaneous abortions in wives</td>
<td>2.3 fold increase in spontaneous abortions</td>
</tr>
<tr>
<td>1.5 fold increase in Cancer Rates</td>
<td></td>
</tr>
</tbody>
</table>

**N₂O Contamination Factors**

1. Movement 48%
2. Talking 46%
3. Mask Leakage 17%
4. Poor Suction 13%
5. Laughing 11%
6. Mouth Breathing 7%
7. Moustache 5%

**Comparison of the Tested Masks**

<table>
<thead>
<tr>
<th>N</th>
<th>Mask Type</th>
<th>Mean ppm N₂O</th>
</tr>
</thead>
<tbody>
<tr>
<td>35</td>
<td>Brown</td>
<td>43.4</td>
</tr>
<tr>
<td>29</td>
<td>Porter</td>
<td>48.2</td>
</tr>
<tr>
<td>24</td>
<td>Parkell</td>
<td>54.4</td>
</tr>
<tr>
<td>23</td>
<td>Dupaco</td>
<td>61.2</td>
</tr>
<tr>
<td>33</td>
<td>Fraser- Harlake</td>
<td>62.7</td>
</tr>
</tbody>
</table>

**Other Notes or Questions to Ask:**
Carbon Dioxide Absorber

How can we minimize occupational exposure?

![Image of a carbon dioxide absorber]


↑ Vit B12 = increases human sperm motility  
↓ Vit B12 = increases human infertility


- Effect of 20% N\textsubscript{2}O on rat spermatogenesis after 5-week exposure:
  - Decreased sperm count
  - Abnormal multinucleated giant cells
  - Total recovery after 3 days


“Concentrations at which there were no longer significant effects of nitrous oxide on rat litter size over a 10-day exposure period were between 3250-3500 ppm”


**Effect of N\textsubscript{2}O on rat testicular methionine synthetase activity after 1 hour exposure**

<table>
<thead>
<tr>
<th>Level</th>
<th>Exposure</th>
<th>Reduction</th>
<th>Recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td>10%</td>
<td>1 hour</td>
<td>29%</td>
<td>48 hours</td>
</tr>
<tr>
<td>50%</td>
<td>1 hour</td>
<td>63%</td>
<td>72 hours</td>
</tr>
</tbody>
</table>

**Other Notes or Questions to Ask:**

http://bestdentalCE.com    drmarkdonaldson@gmail.com
- Deoxyuridine suppression test on dentists using nitrous oxide suggest 400 ppm as a safe level
- Provided the first direct evidence that occupational exposure to N₂O can result in altered vitamin B₁₂ metabolism and impaired synthesis of methionine synthase (a crucial enzyme for DNA formation)

The MTHFR gene provides instructions for making an enzyme called methylenetetrahydrofolate reductase. This enzyme plays a role in processing amino acids, the building blocks of proteins. Methyltetrahydrofolate reductase is important for a chemical reaction involving forms of the vitamin folate (also called vitamin B₉). Specifically, this enzyme converts a molecule called 5,10-methylene-tetrahydrofolate to a molecule called 5-methyltetrahydrofolate. This reaction is required for the multistep process that converts the amino acid homocysteine to another amino acid, methionine. The body uses methionine to make proteins and other important compounds. A study in 2000 had identified only 24 cases of severe MTHFR deficiency (from nonsense mutations) across the whole world (Sibani, Sahar; Christensen, Benedicte; O’Ferrall, Erin; Saadi, Irfan; Hiou-Tim, Francois; Rosenblatt, David S.; Rozen, Rima (2000). "Characterization of six novel mutations in the methylenetetrahydrofolate reductase (MTHFR) gene in patients with homocystinuria". Human Mutation. 15 (3): 280.)

- Evidence is overwhelming that prolonged exposure to clinical concentrations of N₂O inhibits cellular proliferation of the formed elements of the blood and can lead to megaloblastic anemia, leukopenia and thrombocytopenia.
- A time-weighted average of 100ppm for an eight-hour workday and/or a time-weighted average of 400ppm per anesthetic administration would provide adequate protection of dental personnel.

Other Notes or Questions to Ask:
ADA guidelines are 50 ppm TWA for offices, 25ppm TWA for hospital settings

**ADA Workshop Panel Conclusions**

1. N₂O/O₂ is a very valuable tool for pain and anxiety control and it should continue to be taught at all levels of dental education.
2. Chronic occupational exposure to N₂O/O₂ in offices without scavenging units may be associated with deleterious neurological and reproductive effects on the health of dental personnel.
3. Where scavenging systems are used there has been no such evidence to date. Appropriate scavenging systems and methods of administration should be adopted.
4. It should be clearly indicated that potential health hazards of N₂O do not apply to the patient.
5. N₂O levels vary significantly among offices using scavenging systems. Therefore a protocol should be implemented.
6. State dental boards regulate certification programs requiring evidence of satisfactory completion of educational programs.

**Recommended Checklists**

- **On Installation** - Whole system (spectrophotometer)
- **Daily**
  - Rubber hoses
  - Nasal masks
  - Connectors (high and low pressure)
  - Reservoir bags (visual)
- **Quarterly**
  - Whole system (spectrophotometer/badge)

**Other Notes or Questions to Ask:**
References and Recommended Reading for Nitrous Oxide Contamination & Scavenging


Other Notes or Questions to Ask:


Gillman M. Nitrous oxide/oxygen conscious sedation without adequate scavenging. SADJ. 2005 Mar;60(2):68, 77


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