



NITROUS OXIDE ADMINISTRATION IN PEDIATRICS

Amy E. Reed, RN, CCRN, CPN

Leslie Bagley, MSN, APRN-PCNS-BC, CNS

Elizabeth Galloway, MD

Objectives:

- Identify appropriate candidates to receive nitrous sedation
- Recognize contraindications for nitrous oxide use
- Describe side effects associated with nitrous sedation
- Discuss preparation, basic administration, & documentation
- Understand legal issues and ways to minimize occupational overexposure during nitrous oxide administration

Requirements for Completion

Provider	Complete 6 hours of didactic training, Healthstream module on Nitrous Oxide/Oxygen Administration, pass written exam, and have nitrous oxide privileges with MedStaff	See “Requirements for Nitrous Oxide Sedation Privileges” within Moderate and Deep Sedation Delineation of Priviledges
Nurse	PALS, Complete 6 hours of didactic training, Healthstream module on Nitrous oxide/Oxygen Administration, pass written exam, and have completed three nitrous oxide administrations with experienced mentor	Continued competency is maintained by annual policy review and performed minimum 5 nurse administered nitrous oxide cases every 12 months or recert with 3 cases with mentor

Who can receive nitrous oxide?

- Nitrous oxide can be safely administered to children between ages **6 months to 18 years** per policy at PAMC.
- Part of the “**Comfort Promise**” coupled with other dimensions (i.e. guided imagery, distraction) to reduce pain and anxiety during difficult or painful procedures
- Regarded as **minimal** sedation
- If delivered with another sedative or analgesic medications, it is considered **moderate** sedation.

Indications for nitrous oxide use may include:

- Urinary catheterization
- PIV insertion / PICC insertion / blood draws
- Wound care / suturing / dressing changes
- Fracture reduction / pin pull / casting
- NG tube placement
- Joint injection
- EEG lead placement
- Vaccine administration
- Lumbar puncture
- Abscess drainage
- Abuse exams



When NOT to use nitrous



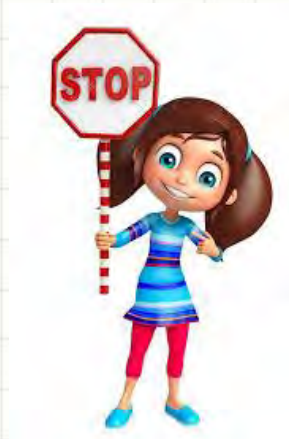
Absolute Contraindications

- Sensitivity to nitrous oxide
- Pneumothorax
- Cystic Fibrosis
- Significant bowel obstruction
- Pregnancy
- Current Air embolism
- Severe bullous emphysema
- COPD/congenital pulmonary airway malformation
- Congenital cystic adenomatoid malformation
- Craniotomy or pneumoencephalography in past three weeks unless images show no free air
- Decompression sickness
- Increased intracranial pressure
- Impaired level of consciousness or psychological impairment
- Vitamin B12 deficiency
- Treatment with Bleomycin
- Methylenetetrahydrofolate reductase deficiency
- Current or recovering drug or alcohol addiction

When NOT to use nitrous

Relative Contraindications

- Maxillofacial injuries—may prevent proper fit of mask
- **Current upper respiratory tract infection**
- Middle ear occlusion or other disturbances
- Intraocular surgery (involving injected gas) in the last ten weeks
- Treatment with opioid pain medication within the **past 2 hours**



Nitrous Oxide Properties

- Weak aesthetic gas
 - 104% MAC (high percentage-low potency)
- Airway reflexes remain intact with nitrous oxide alone
- Gas expansion
 - Nitrous oxide replaces nitrogen in closed spaces
 - Diffuses in more rapidly than nitrogen diffuses out
 - Trapped gas will expand and can double in volume in 10 minutes

Nitrous Oxide Properties

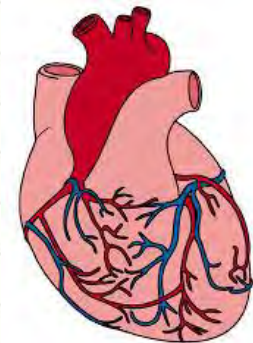
- Sweet-smelling, colorless gas
- Heavier than air/oxygen
- Rapid onset of action
 - Seconds to minutes
 - Rapid equilibrium between alveolus and capillary
- Crosses blood-brain barrier easily
- Eliminated unchanged with exhalation from the lungs

Body's Response to Nitrous Oxide

- Rapid onset of action (Peak effect 3- 5 minutes)
 - Rapid equilibrium between alveolus and capillaries
 - Crosses blood/brain barrier easily
- Eliminated unchanged with exhalation from the lungs
 - No significant metabolism by the kidneys or liver
 - Not stored in the tissues
- Can cause induction of loss of consciousness at high concentrations (>70%)

Cardiovascular Effects

- No change or slight increase in blood pressure
 - Mild vasodilation
- No change in heart rate but high concentrations can cause myocardial depression
- Nitrous can be used with common heart ailments
 - Heart murmurs
 - Congenital defects
 - HTN
 - History of cardiac surgery



CNS Effects

- CNS Depressant
 - No increased risk in patients with CVA or seizures
 - Contraindicated after pneumoencephalography or craniotomy surgery



Respiratory Effects

- Presence of chest congestion may create mucus plugs
- May cause increase pressure in sinuses or inner ear
- Contraindicated in patients with pneumothorax, hypoxic drive, cystic fibrosis, or COPD

Hematopoietic System Effects

- Due to the simultaneous administration of oxygen, nitrous can be given to patients with
 - Anemia
 - Sickle cell
 - Leukemia
 - Hemophilia



Desirable Characteristics of Nitrous Oxide

- **Analgesic:** Decreases the sensation of pain
- **Anxiolytic:** Relaxes and increases sense of well-being
- **Amnestic:** May be difficult to recall procedure

Age Specific Assessment Prior to Nitrous Oxide Administration



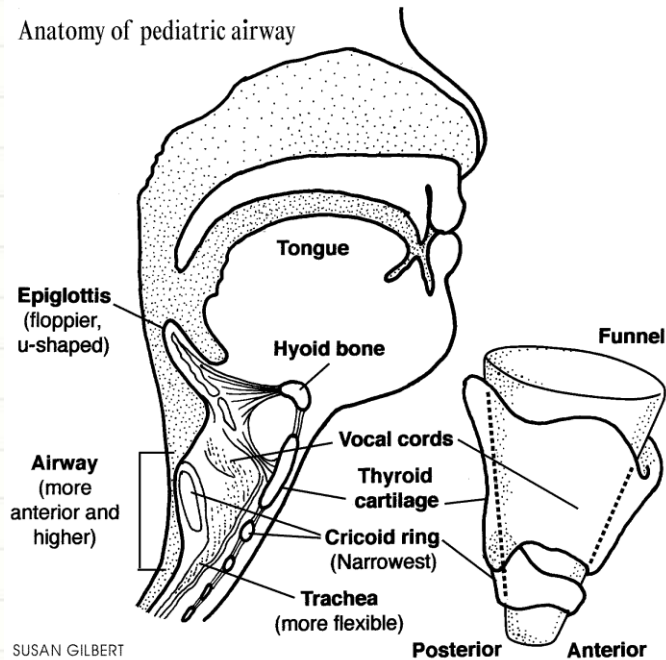
Stages of Development

- Prenatal: conception to birth
- Infancy: birth to 12 months
- Early Childhood: 1-6 years
- Toddler: 1-3 years
- Preschool: 3-6 years
- Middle Childhood: 6-12 years
- Adolescence: 13-18 years
- Adult: 18+

Pediatric vs. Adult Airway

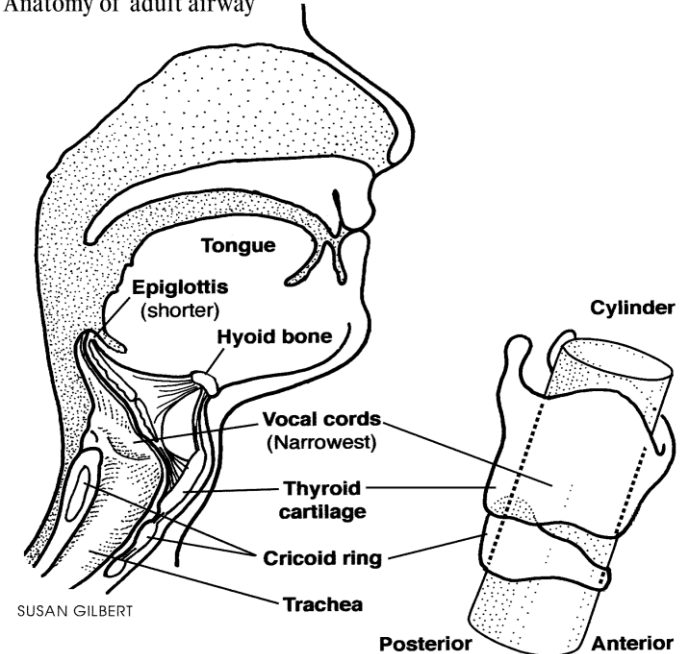
- Pediatric Airway

Anatomy of pediatric airway

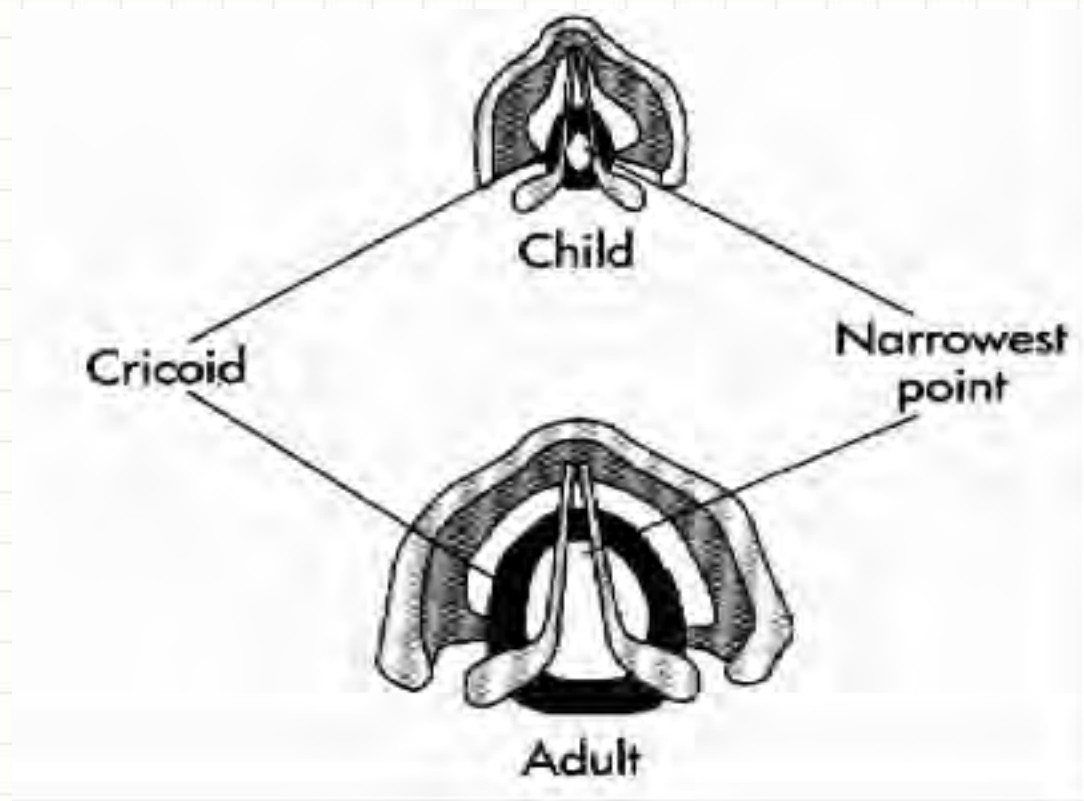


- Adult Airway

Anatomy of adult airway



Pediatric Larynx vs. Adult



Airway and Breathing

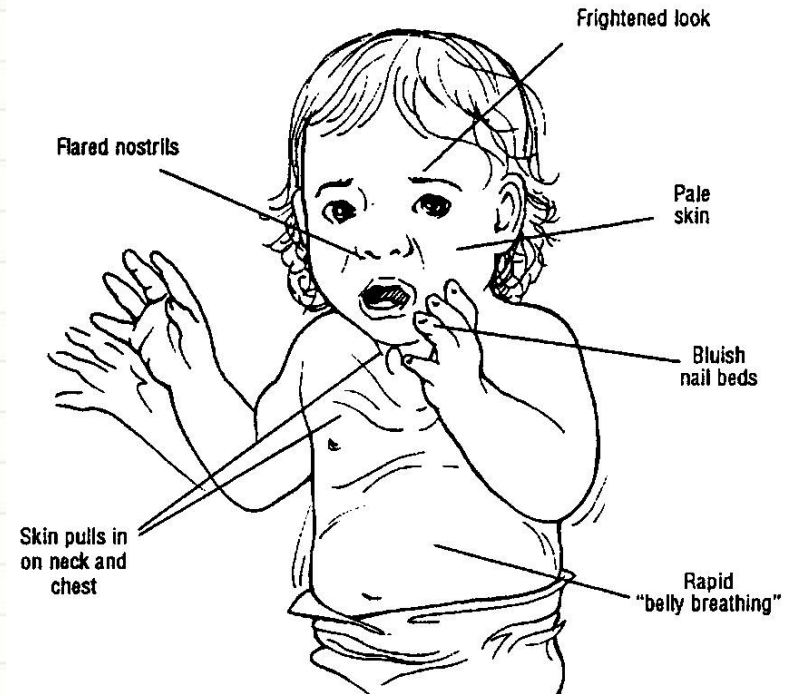
- Airway
 - Vocalization or cry?
 - Tongue deviation?
 - Loose teeth or foreign obstruction?
- Breathing
 - Rate, depth, and pattern of respirations
 - Chest rise and fall symmetrical
 - Accessory muscle use or retractions
 - Skin color
 - Breath sounds

Respiratory Parameters

Age	Respiratory Rate
Infants (1 mo-12 months)	30-53
Toddlers (1-2 years)	22-37
Preschool (3-5 years)	18-30
School Age (6-11 years)	18-30
Adolescent (>12 years)	16-22

Signs of Respiratory Distress

- Tachypnea, tachycardia
- Retractions, accessory muscle use
- Nasal flaring
- Grunting
- Stridor or wheezing
- Mottled color
- Changes in level of consciousness



Circulation Assessment

- Pulse
- Skin color
- Capillary refill
- Blood pressure not always reliable in pediatric patients



Normal Heart Rate Parameters

Age	Awake Heart Rate	Resting Heart Rate
Neonate (0-29 days)	100-205	80-160
Infant (1 mo-12 months)	100-180	75-160
Toddler (1-2 years)	98-140	60-90
Preschool (3-5 years)	80-120	60-90
School Age (6-11 years)	75-118	60-90
Adolescent-Adult	60-100	50-90

Normal Blood Pressure Parameters

Age	Systolic	Diastolic
Neonate	60-84	20-53
Infant (1 mo-12 mo)	72-104	20-56
Toddler (1-3 years)	68-112	20-72
School Age (5-11 years)	75-120	37-80
Adolescent-Adult	88-130	44-81

PH&S W&C CPS Governance (2015)

Blood Pressure Calculations for Pediatrics:

$90 + (2 \times \text{age in years}) = 50\% \text{ systolic BP}$

$70 + (2 \times \text{age in years}) = \text{lowest acceptable systolic BP}$

Pre-sedation Assessment

- **SAMPLE**
 - Signs and Symptoms
 - Allergies
 - Medications patient is currently taking
 - Last meal (NPO status)
 - Events surrounding injury, illness, reason for procedure
- Recent URI
- Pregnancy Test if greater than 9 y.o. or started menses
- Modified Aldrete PAR pre-sedation score
- ASA classification

Modified Aldrete PAR Score

- PAR: Post Anesthesia Recovery
- Each patient is scored pre-sedation on the following scale as a baseline
- Patient is scored with vital signs post-sedation until patient is at baseline x2 to determine discharge readiness.
- 0-2 score based on the following categories:
 - Activity, Respiration, Circulation, Consciousness, Color/Oxygen saturations, Dressing, Pain, Ambulation, Fasting/Feeding, and Urine output.

Modified Aldrete PAR Score in EPIC

Modified Aldrete Score

Time taken: 17:12:31 5/11/2020 Show: Row Info Last Filed All Choices

[+ Add Row](#) [+ Add Group](#) [Responsible](#) [+ Create Note](#)

Modified Aldrete Score

Activity	<input type="text"/>	2-->able to move 4 extremities voluntarily or on com...
Respiration	<input type="text"/>	2-->able to breathe and cough freely 1-->dyspnea, limited breathing or tachypnea 0-->apnea or mechanical ventilator
Circulation	<input type="text"/>	2-->BP within 20% of pre-anesthetic level
Consciousness	<input type="text"/>	2-->fully awake 1-->arousable on calling 0-->not responding
O2 Saturation	<input type="text"/>	2-->able to maintain O2 saturation greater than 92% on roo...
Dressing	<input type="text"/>	2-->dry and clean or not applicable 1-->wet but marked and not increasing 0-->growing area of wetness
Pain	<input type="text"/>	2-->pain free 1-->mild pain handled by oral medication 0-->severe pain requiring parenteral medication
Ambulation	<input type="text"/>	2-->able to stand up and walk straight, on ordered bedrest, or performing at pr... 1-->vertigo when erect 0-->dizziness when supine
Fasting/Feeding	<input type="text"/>	2-->able to drink fluids or NPO 1-->nauseated 0-->nausea and vomiting
Urine Output	<input type="text"/>	2-->has voided, adequate urine output per device, or not applic... 1-->unable to void but comfortable 0-->unable to void and uncomfortable

ASA CLASSIFICATION

- American Society of Anesthesiologists Physical Classifications System of Patients

Classification	Definition	Example
ASA 1	Normal healthy patient	Healthy, non-smoking
ASA 2	Mild systemic disease	Current smoker, pregnancy, obesity, well controlled diabetes/HTN, mild lung disease
ASA 3	Severe systemic disease	Poorly controlled diabetes/HTN, COPD, Morbid obesity, active hepatitis, cancer, ETOH dependence, implanted pacemaker, history (>3 months) MI, CVA, TIA
ASA 4	Severe systemic disease with constant threat to life	Recent (<3 months) MI, CVA, TIA, ongoing cardiac ischemia, sepsis, DIC, ARDS
ASA 5	Moribund patient who is not expected to survive without the operation	Ruptured aneurysm, massive trauma, intracranial bleed, ischemic bowel in the face of multiple organ dysfunction
ASA 6	Declared brain dead patient whose organs are being removed for donor purposes	



Ramsay Sedation Score

- One of the most widely used sedation scales for assessing and monitoring sedation levels and mandated per PAMC policy.
- Provides early warning of sedation that is deeper than intended
- Documented every five minutes with vital signs in Epic



Ramsay Sedation Score in EPIC

Ramsay Score

Time taken: 17:14:52 5/11/2020 Show: Row Info Last Filed All Choices

[+ Add Row](#) [+ Add Group](#) [Responsible](#) [+ Create Note](#)

▼ Ramsay Score

Ramsay Scale Score

- 1-->patient anxious and agitated or restless, or ...
- 2-->patient cooperative, oriented and tranquil
- 3-->patient responds to commands only
- 4-->exhibits brisk response to light glabellar tap or loud auditory stim...
- 5-->exhibits sluggish response to light glabellar tap or loud auditory stim...
- 6-->exhibits no response

Preparing for Nitrous Administration

1

- Educate the family (e.g. advantages, SE, contraindications). Obtain verbal consent for nitrous administration

2

- Obtain pregnancy test if child is over nine years old or started menses (pregnancy is absolute contraindication)

3

- Ensure appropriate orders are in EPIC

Preparing for Nitrous Administration

- Gather supplies
 - Mask, tubing, O2 sat probe & monitor, flavored lip balm, scents, stickers
 - Emergency supplies: suction, anesthesia bag & mask
 - Sentry sedate, extra tanks
- Perform safety check
 - See Sentry Sedate Video (separate education module)
- Ensure “CAUTION Nitrous Oxide in Use” sign is visible



Preparing for Nitrous Administration



- Prepare the patient for nitrous oxide (get the mask ready, medical play with the mask)
 - There is no fasting requirement before nitrous oxide administration.
 - However, it may be prudent to limit the oral intake prior to their procedure if known history requiring escalating sedation, etc.

- Gather staff
 - Child Life Specialist if available
 - 1 RN for nitrous oxide delivery and
 - Adequate staff for the procedure

Preparing for Nitrous Administration

- Minimize stimulation in the room.
 - It should be **quiet** with only **one voice** using distraction and guided imagery techniques as necessary (e.g. softly singing, i-Pad, etc.)
- Place pulse oximeter sat probe on patient.
- Obtain baseline vital signs, oxygen saturation, and Ramsay Sedation score (documented in EPIC Q5 min)
- Complete Nitrous Oxide Flowsheet in EPIC.



The Perfect Nitrous Administration

- Light-headedness
- Tingling sensation of hands and feet
- Warmth over chest, cheeks, or face
- Feeling of floating
- Euphoria
- Relaxation



Concentrations of Nitrous Oxide

- Mild: <50% N₂O/O₂
- Moderate: 50% and/or with another sedative/analgesic agent
- Deep: >_50% and/or with another sedative/analgesic agent

Over Sedation with Nitrous

- Agitation, excessive movement
- Diaphoresis
- Nausea/vomiting
- Asleep, unable to respond to verbal commands
- Sedation level of 6 (Ramsay Scale)

Under Sedation with Nitrous

- Crying, combative, tense
- FLACC-r score greater than 5
- Ramsay scale score of 1



Side Effects of Nitrous Sedation

Minor (8%)

- Nausea/vomiting
- Tearing
- Crying/agitation
- Hiccups
- Dizziness
- Hallucinations
- Headache
- Diaphoresis, pallor

Major (rare)

- Apnea
- Stridor
- Pulmonary aspiration
- Laryngospasm/bronchospasm
- SpO₂ <90%
- Bradycardia
- Cardiovascular instability
- Unplanned admission to hospital

Post Administration

- Turn off Nitrous oxide and maintain face mask on the patient delivering 100% oxygen for 3-5 minutes.
- Document any changes in nitrous concentration, patient response, full set of vital signs, start and stop times, recovery time, adverse effects of sedation and sedation failure.
- Document Pain and Post-sedation Modified Aldrete PAR scores.
- Patient may be discharged to inpatient room or home when they are at Modified Aldrete PAR baseline score x 2.

Things to remember

- It is important to give as much O₂ recovery as possible. The nitrous oxide needs to get “flushed out” of the lungs (3-5 minutes if possible).
- Ensure there is a POC pregnancy test documented for girls age 9 and older if menses has started.
- Written and signed consent is not needed by parent or guardian.
- Patient does not need to be NPO for nitrous oxide procedure but it is beneficial if they have had an empty stomach so that it decreases the chance of nausea and vomiting.



Emergency Situation Management

- **Diffusion Hypoxia**—transient decrease in alveolar oxygen tension if room air is inhaled after nitrous administration instead of 100% oxygen.
 - Patient may experience postoperative headache, lethargy, nausea
 - Prevent/treat by applying 100% oxygen 3-5 minutes after N₂O and longer if needed until patient fully recovered
- **Vomiting**—seen at high concentrations (>50% nitrous).
 - Use of antiemetics to reduce N₂O nausea/vomiting unclear
 - Suction and protection of airway reflexes

Airway Management during Nitrous Administration

- Airway obstructions commonly occur as result of tongue occlusion.
 - During minimal/moderate sedation, laryngeal and pharyngeal reflexes should remain intact allowing cough and gag reflexes to protect airway.
- Head-tilt/chin lift or jaw thrust to relieve airway obstructions
- Pulse oximeter left in place to continuously monitor oxygen saturations
- Suction, BVM, and oxygen at bedside
- If vomiting occurs, patient placed upright position and airway cleared.

Abuse of Nitrous Oxide

- Nitrous is considered an “inhalant”. Not a controlled substance
 - Has the ability to produce a rapid, euphoric high when inhaled
 - Relatively inexpensive, readily available, and legal to purchase, not detected in urine drug tests
 - Found as a whipped cream propellant—restaurants reporting having to lock up whipped cream cans to prevent servers from sampling N₂O on the job
 - Feeling of floating or flying, vivid, visual colorful images and loss of inhibitions. Hallucinations, auditory illusions resulted. Cases of aberrations of sexual nature reported
- Negative side effects of fatigue, fainting, nausea, seizures, cardiac arrest, and death have been reported with abuse.

Use and Abuse



EXHIBITION OF THE LAUGHING GAS.

The Nitrous Oxide, or Laughing Gas, was discovered by Dr. Priestly, who produced it by abstracting a part of the Oxygen from the Nitric Oxide. It is composed of equivalent parts of Oxygen and Nitrogen. Before the time of Sir Humphry Davy, it was considered irrespirable; but by some very interesting experiments, he proved this opinion to be incorrect; he also wrote a work, entitled, "Researches on the Nitrous Oxide." It is named Laughing Gas on account of the very exhilarating emotions produced in those who respire it for a short time: laughing, dancing, jumping, acting, reciting, and (last but not least) fighting are amongst the prominent effects displayed by persons under its influence. The Febrile



Chronic Exposure Health Hazards

- Affects Vitamin B12 metabolism
 - Megaloblastic hematopoiesis, leukopenia
 - Greatest risk for pregnant women, those with vitamin B12 deficiencies, and impaired wound healing
 - Myeloneuropathy, sensory and proprioception impairment
- Evidence of fetal toxicity, skeletal abnormalities, and miscarriages
- Peripheral neuropathy noted with habitual N₂O usage
- Addictive nature low, however tolerance with chronic use noted

How to Avoid Chronic Exposure to Nitrous

- Dosimetry badge worn by nurse/provider and monitored for exposure
 - Determines the amount of N₂O exposure of an individual over time.
 - Wear entire shift not just during N₂O administration
- Scavenging system working properly—minimizing trace amounts of gas before, during, and after use by the patient
 - When expired N₂O is exhaled, vacuum suction ports transport gas to outside atmosphere.
- Firm seal of mask on patient—patient talking, fighting, or restlessness will leak N₂O
 - No leaks or cracks in nitrous machine tubing
 - Maintenance and inspection of reservoir bag and conduction tubing before each administration

Legal Considerations

- Alaska Board of Nursing Advisory Opinion
 - RN must complete 6 hours of training including didactic, skills, written exam, and minimum of 3 observed cases for competency.
 - Nitrous must not exceed 70% and pulse oximetry is continuously monitored.
 - RN must obtain verbal consent. Provider initiates written orders.
 - Facility policy and competency in place
 - RN is dedicated to nitrous administration and must remain with patient. No other tasks can compromise continuous monitoring.
- **Due to reports of aberrations of sex nature, a third party must be present at all times.**
- Documentation



Dosimetry

- New orientees to nitrous must undergo initial dosimetry monitoring
- Staff must wear dosimetry badge twice annually
- Wear whenever new nitrous equipment introduced or after machine at Clinical Engineering dept. (by next five staff members)
- Badge must be worn for period of time or “occurrence”
 - Minimum 15 minutes vapor exposure time and worn for maximum 8 hours
 - If multiple cases performed, dosimetry badge is worn entire shift to max 8 hours

Documentation Requirements

- Location and type of procedure
- ASA classification
- Pre and Post Modified Aldrete PAR scores
- Concentration of nitrous oxide administered
- Pulse oximetry, Ramsay Sedation Scale sedation every five minutes
- Patient/family education
- Presence of verbal consent
- Maximum oxygen flow rate
- Start and stop times of nitrous oxide administration
- Response to treatment—Sedation Failure?
- Recovery time with 100% oxygen
- Adverse events of sedation

References

- Alaska Board of Nursing (2017). *Advisory on nitrous oxide. Use in the pediatric population.*
- American Society of Anesthesiologists. (2018). Website: <https://www.asahq.org/resources/clinical-information/asa-physical-status-classification-system>.
- Clark, M.S. & Brunick, A.L. (2015). Handbook of nitrous oxide and oxygen sedation.(4th ed.). St. Louis, MO: Elsevier.
- Fairbanks Memorial Hospital (2016). RN administered nitrous oxide/oxygen for minimal sedation in pediatrics. Fairbanks, AK.
- Hazinski, M.F. (1999). Manual of pediatric critical care. St Louis, MO: Mosby.
- Mason, K.P. (2012). Pediatric sedation outside of the operating room (2nd ed.). New York, NY: Springer.
- Mason, K.P. (2015) Pediatric sedation outside of the operating room. New York, NY: Springer.
- PH&S W&C CPS Governance. (2015). Anchorage, AK.
- Ramsay, M.A. et al. (1974). Br. Med Journal, 656-659.
- San Antonio Military Pediatric Center. (2003) Pediatric emergency manual. San Antonio, TX: SAUSHEC.

Questions?

