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Nitrous oxide: Use and safety (second edition)

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ABSTRACT

In dentistry, nitrous oxide is the most commonly used inhalation anxiolytic and sedation adjunct. It reduces anxiety, pain, and memory of the treatment experienced and is a valuable component of the armamentarium available to clinicians. When used correctly, it is predictable, effective, and safe.

LEARNING OBJECTIVES

This clinical study will provide the dental professional with the steps needed to deliver nitrous oxide in a safe and efficacious manner.

After reading this continuing education course, the reader should be able to:

1. Refer to the history of nitrous oxide
2. Understand the properties of nitrous oxide
3. Know the safety recommendations
4. Have the ability to deliver nitrous oxide in a safe manner, and know the contraindications

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INTRODUCTION

Officially known as dinitrogen monoxide by the International Union of Pure and Applied Chemistry (IUPAC), nitrous oxide (an oxide of nitrogen) is a small, inorganic chemical molecule with the formula N_2O.[1] It is commonly known as "laughing gas, nitrous, nitro, NOS, sweet air, protoxide of nitrogen, and hyponitrous oxide."[2] At room temperature, "it is a colorless, nonflammable gas, with a slightly sweet odor and taste,"[2] and it's used in surgery and dentistry for its anesthetic properties and analgesic effects.[3]

It is known as "laughing gas" due to its euphoric effects, a property that has led to its recreational use as a dissociative anesthetic.[4,5] As an industrial gas, it is used as an oxidizer in rockets, a boost for race car engine output, and in the food industry as a foaming agent for whipped cream.[2]

HISTORY

The history of nitrous oxide begins in 1772 with its isolation by theologian and scientist Joseph Priestly.[6] In 1798, Humphry Davy, an English chemist, noted the analgesic effects of nitrous oxide. In 1800, Davy published the history, chemistry, physiology, and recreational use of nitrous oxide. In his text, Davy mentioned, "As nitrous oxide appears capable of destroying physical pain, it may probably be used with advantage during surgical operations in which no great effusion of blood takes place."[7] Unfortunately, surgeons of this era failed to take note, and the gas was used primarily for public entertainment. Inhalation of nitrous oxide for recreational use began as a phenomenon among the British upper class in 1799, and they were known as "laughing gas parties."[8]

In 1844, American dentist Horace Wells realized the therapeutic applicability of the gas after self-administration.[9] His associate, William Morton, became its chief proponent and drove the use of inhalation anesthetic forward. Today, nitrous oxide is used in dental facilities worldwide.[10]

PHYSICAL PROPERTIES

Nitrous oxide gas is produced by heating ammonium nitrate crystals to 250°C, then scrubbing, compressing, and liquefying the gas before placing it in pressurized tanks.[11] Present as both liquid and gas in the tank, it vaporizes at room temperature as it is used. The color of the nitrous oxide tank varies by country. In the United States and Canada, nitrous oxide tanks are blue, with the pressure measuring approximately 750 pounds per square inch (psi) at 70°C (less at lower temperatures), irrespective of the size of the tank or the quantity of nitrous oxide remaining in it. Once there is no liquid phase remaining in the tank, the pressure will begin to drop. The shoulder of the nitrous oxide cylinder is marked with information including, but not restricted to, the brand, manufacturer's test date and serial number, inspector's mark, Department of Transportation specifications, and service pressure. See figure 1.

PHYSIOLOGY

The mechanism by which anesthetic gases produce general anesthesia is unknown. The leading theory suggests that they bind to proteins within neuronal membranes and modify ion fluxes and subsequent synaptic transmission. Unlike other anesthetics, "nitrous oxide produces a mild analgesic effect at subanesthetic concentrations."[12,13]

The mechanism for this effect most likely involves an interaction with the endogenous opioid system because it is abolished by administration of the opioid antagonist, naloxone. The strongest evidence for these analgesic effects is that nitrous oxide stimulates release of enkephalins, which bind to opioid receptors that trigger descending noradrenergic pathways. The most common estimate of analgesic efficacy suggests that

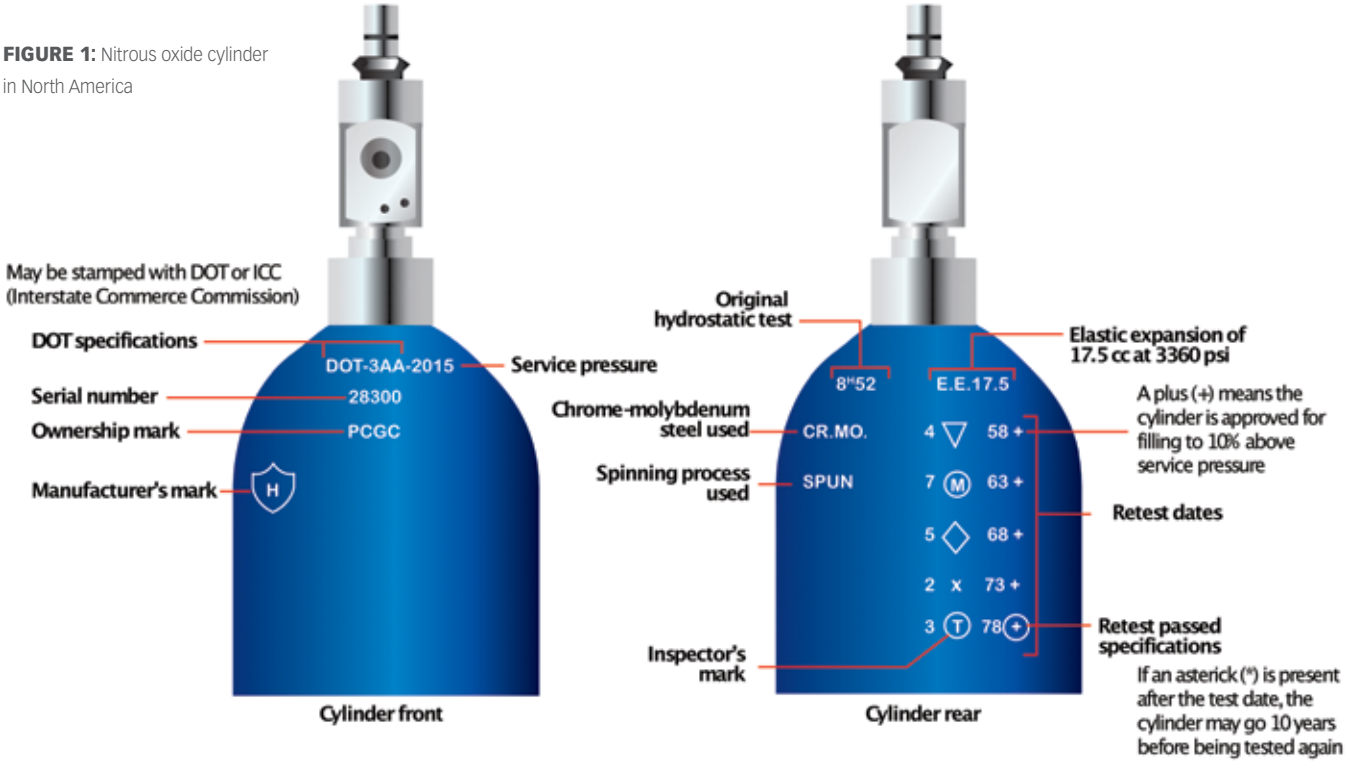

FIGURE 1: Nitrous oxide cylinder in North America

"30% nitrous oxide delivered by full mask is equivalent to 10 to 15 mg morphine."[12]

This interaction with the endogenous opioid system may account in part for abuse potential attributed to nitrous oxide.[14] N_2O also directly modulates a broad range of ligand-gated ion channels.[15,16] It may act to imitate nitric oxide (NO) in the central nervous system, and this may be related to its analgesic and anxiolytic properties.[17]

Nitrous oxide possesses a minimum alveolar concentration (MAC) of 104%, making it impossible to induce general anesthesia below a concentration of 100% and without hyperbaric conditions.[18] Nitrous oxide sedation appropriately administered is safe for normal, healthy patients, and its effects on the cardiovascular and respiratory systems are minimal. Although a mild myocardial depressant, its minor central sympathetic stimulatory effect offsets this.[17]

Nitrous oxide has a low blood/gas partition coefficient (0.47), so only minimal amounts dissolve in blood. The fast onset and quick recovery seen with nitrous oxide/oxygen sedation are due to the rapid diffusion and saturation in blood.[19]

At a concentration of 50% to 70%, rapid uptake occurs from the alveoli to the pulmonary circulation and simultaneously creates a vacuum in the lungs that helps to pull more gas into the alveoli.

N_2O is a useful adjunct with general anesthetic inhalants, and when used in combination, nitrous oxide and the anesthetic agent are drawn into the lungs, providing a faster onset and quicker recovery, a function of concentration gradients. However, after administration is terminated, nitrous oxide is rapidly diffused back into the lungs along with oxygen and other gases. Due to this, oxygen exchange into the lungs and circulation are impaired, which can result in diffusion hypoxia. When inhalation of high concentrations of nitrous oxide is discontinued, high partial pressure in blood rapidly transfers nitrous oxide to the alveoli.[20] This dilutes the partial pressure of oxygen in the alveoli and may lead to hypoxemia. For this reason, it is conventional practice to provide the patient with 100% oxygen during the (approximately) first five minutes following discontinuation of nitrous oxide.

This concern is more theoretical than clinical, however. Hypoxemia is significant for only a matter of minutes and has been documented only when high concentrations (>70%) have been delivered by full mask or endotracheal tube.[21] These conditions cannot be met with the use of conventional dental nitrous oxide machines with nasal masks, and any tendency for diffusion hypoxia is usually inconsequential.[22] Nevertheless, providing 100% oxygen toward the end of a dental appointment has other benefits and is advocated. This practice allows discontinuation while providing a waning placebo influence, and it allows expired nitrous oxide to enter the scavenging apparatus of the machine, which is sound environmental practice.

INDICATIONS AND BENEFITS

Nitrous oxide is the most commonly used inhalation anesthetic/sedative in dentistry and has an excellent safety record[12,23,24] (see Chart 1). It reduces anxiety, pain, and memory of the treatment experienced. In medicine, the number of office-based anesthesia procedures are increasing more rapidly than are hospital-based procedures.[25] Nitrous oxide/oxygen conscious sedation is frequently used in oral surgery, particularly in the extraction of third molars, periodontal surgery, implant placement, and patients with behavioral or developmental issues. N_2O can be used for anxiolysis or conscious sedation.

CHART 1: Indications and relative/absolute contraindications for nitrous oxide

Indications for N_2O
1. For mildly apprehensive patient
2. For frightened child
3. To reduce awareness of time and fatigue
4. To reduce dental stress
5. To control gagging
6. When requested by a patient
Relative contraindications for N_2O
1. Patient with pulmonary disease
2. Patient with respiratory infections
3. Pregnant patient
4. Psychiatric patient
5. Immune-compromised patient
6. Patient with multiple sclerosis
7. Patient who uses marijuana or hallucinogenic drugs
8. Patient with blocked middle ear
9. Highly apprehensive patient
10. Patient with repeated exposures to N_2O less than one week apart
Absolute contraindications for N_2O
1. Patient with nasal obstruction
2. Patient who is completely uncommunicative due to either disability or language barrier
3. Patient with increased intracranial pressure
4. Patient refusal
5. Patient who is active substance abuser or recovered substance abuser
6. Lack of gas recovery affects dental team

ANXIOLYSIS

Anxiolysis is the prevention or reduction of anxiety. An anxiolytic is a medication or other intervention that inhibits anxiety.[26]

The main indication for nitrous oxide is to diminish anxiety and fear in patients, and this is often accomplished by using low-dose N_2O and high-dose oxygen. Low-dose N_2O can also induce relaxation of psychological tension in dental patients who have dental phobias. Also, high-dose oxygen contributes to "manage presyncope due to pain stimuli."[27]

Nitrous oxide/oxygen significantly improves cooperation in fearful children. In particular, children who are too young and/or unable to cooperate or overcome their fears are candidates for N_2O use to enable necessary care without further trauma. Physical restraints for children are an option that is controversial and traumatic, whereas the use of N_2O/O_2 as an anxiolytic reduces fear and anxiety and alleviates pain, which may encourage (rather than discourage) future cooperation.[28-30]

CONSCIOUS SEDATION

Conscious sedation is the use of a combination of drugs to induce relaxation and provide some analgesia during a medical or dental procedure. Nitrous oxide/oxygen reduces pain and anxiety in anxious and fearful patients, including those who are phobic and unreceptive to other techniques and for whom the only other alternative may be general anesthesia. Conscious sedation has been found to be efficacious, reliable, and more cost-effective than general anesthesia. Pharmacological agents and techniques

used in dentistry for sedation include enteral sedation with benzodiazepines or intravenous conscious sedation using a variety of agents, including benzodiazepines, narcotic analgesics, and hypnotic/amnesic agents.[31] With multiple drug regimens, extra caution must be exercised.

In surveys of patients who do not visit the dentist, fear of needles and pain were responsible for up to 28% and 21% of adult patients respectively.[32] A number of techniques are available to reduce fear and anxiety and increase cooperation with treatment, including behavioral techniques and communication.[33] Hypnosis has been used to reduce fear, the perception of pain, and to alter memory, although not all patients are suggestible for hypnosis. Acupuncture and acupressure have also been used.[34,35]

Functional and cognitive deficits can make dental treatment difficult for special needs patients.[36] As with fearful patients, behavioral interventions may be helpful. In some circumstances, physical support or protective stabilization is used. Nitrous oxide/oxygen sedation is an effective method to enable treatment in patients with reduced mental development as well as other special needs patients. Consideration must be given to the ability of the patient to communicate and understand the procedure.

CONTRAINDICATIONS

As with any inhalation drug, there are both relative and absolute contraindications with N_2O. These include patients with respiratory illnesses such as chronic obstructive pulmonary disease and asthma, nasal obstruction, and pregnancy, among others.

COPD: "Patients with chronic obstructive pulmonary disease have a reduced ability to move gases into and out of the lungs because of reversible bronchospasm and irreversible bronchial obstruction."[37] Hypoxemia and hypercarbia can result from chronic hypoventilation or poor gas exchange across the respiratory membranes. Some authorities suggest that nitrous oxide should be avoided in patients who have significant chronic obstructive pulmonary disease. Reasons cited include depression of hypoxemic drive: since high oxygen concentrations are delivered with nitrous oxide, its use may remove the stimulus for hypoxemic drive. However, if the principles of moderate sedation are followed, the patient can always be instructed to breathe more deeply.

Asthma: "All inhalation agents share a tendency to increase respiratory rate but decrease tidal volume. Their net influence on minute ventilation is reflected as the degree of hypercapnia that occurs during administration. Nitrous oxide is distinguished from other agents in that it does not reduce net ventilation."[12]

"Since N_2O is not irritating to the tracheobronchial tree, asthma is not a contraindication to the use of N_2O, providing the patient is not having an attack. In fact, there is benefit in administering nitrous oxide since, in many asthmatics, the primary precipitant appears to be emotional stress, especially in children. No dental procedure should be attempted if the patient is having respiratory difficulty due to asthma."[37]

Nasal obstruction: The "inability to use a nasal mask is an absolute contraindication to the use of nitrous oxide. Generally, such patients fall into one of two categories: those who cannot inhale adequately through the nose because of anatomic and/or disease-induced nasopharyngeal obstructions, and those who cannot tolerate and sustain placement of the nasal mask because of psychological and/or cognitive disturbances. Examples include the severely phobic, cognitively impaired or uncooperative pediatric patients, deviated septum, nasal polyps, upper respiratory infection, allergic rhinitis, and severe sinusitis. In this latter regard, any compromise in patency of the eustachian tube may lead to pressure increases within the middle ear, as previously mentioned. In fact, it has been suggested that any recent surgery of the ear presents a contraindication for nitrous oxide."[12]

"Any nasal obstruction will severely restrict the patient's ability to breathe through the nose. Since nitrous oxide must be administered via a nasal mask, this becomes a relative contraindication depending on the severity of the obstruction. Patients who are mouth breathers, either due to nasal restriction or simply from habit, do not do well attempting to breathe through the nasal mask and often cannot exchange well enough nasally to be comfortable."[37]

Multiple Sclerosis: "Multiple sclerosis is a disease characterized by nerve demyelination especially in the central nervous system."[37] "Neurologic symptoms of weakness, incoordination, paresthesia, and speech disturbances are common. Neither occupational exposure to anesthetic agents, nor general anesthesia or usage of nitrous oxide has any impact on MS risk and is safe also for people with a genetic susceptibility to the disease. However, further studies would be valuable in order to clarify whether other forms of organic solvents contribute to the triggering of MS."[38]

Pregnancy: "Nitrous oxide readily enters fetal circulation, and because of the possible toxicity of N_2O to cells undergoing mitosis, pregnant patients should not receive nitrous oxide electively, especially in the early weeks of pregnancy. However, necessary emergency dental care should not be denied a pregnant patient, and if it is determined that N_2O is necessary to reduce stress, it may be used following consultation with the obstetrician."[37] "Widely used in Europe as a labor analgesic, nitrous oxide (N_2O) is making a dramatic return in the United States."[39]

Psychiatric patients: Psychiatric patients may present sedated due to their normally prescribed medication. It is best to consult the patient's psychiatrist and/or treating physician before administering N_2O. If permitted, these patients should be titrated carefully, with close monitoring, as their reactions may be unpredictable.

Inability to communicate: "Since much of the patient monitoring with N_2O conscious sedation is done verbally, being unable to communicate with the patient becomes a contraindication to the use of N_2O. This would include severely mentally retarded patients, very young patients, language barriers, or any condition that prevents easy exchange of thoughts between doctor and patient."[37]

Hallucinogenic drugs: The use of hallucinogenic drugs such as marijuana is contraindicated for N_2O.[40] Marijuana can enhance an already pleasant situation, and conversely increase the dysphoria of an already stressful situation. Following heavy use of marijuana, the drug may remain in the circulation for seven or more days due to its very long half-life. Hallucinogenic drugs act in a similar manner only with a great deal more intensity,

and patients may experience frightening hallucinations.

Intracranial pressure: "Nitrous oxide has been shown to increase intracranial pressure in patients with certain injuries and intracranial disorders; therefore, N_2O should not be administered to these patients."[37]

"The role of vascular tone in determining cerebral perfusion pressure is increasingly being appreciated. It has been suggested that zero flow pressure, the arterial pressure at which blood flow ceases, represents the effective downstream pressure of the cerebral circulation. Nitrous oxide is a cerebral vasodilator and may therefore decrease zero flow pressure and increase cerebral perfusion pressure. However, these effects may be opposed by the increase in intracranial blood volume produced by cerebral vasodilation."[41]

Highly apprehensive patients: N_2O should not be used alone in an apprehensive patient or as a substitute for anesthesia since it is a relatively weak agent.[37]

Blockages: "Because nitrous oxide has a solubility coefficient that is 35 times more than nitrogen, it can quickly displace nitrogen in any closed cavity, dramatically increasing the pressure within. Therefore, conditions such as blocked eustachian tubes, blocked bowel, acute blocked sinusitis, and pneumothorax that allow a rapid pressure increase in a closed body cavity, leading to pain, contraindicates the use of N_2O."[37]

Depression of bone marrow activity: "Exposure to N_2O causes a depression of bone marrow activity resulting in a reduction in the production of erythrocytes and leukocytes. However, since normal marrow contains a 'store' of mature cells sufficient to supply several days' needs, and the marrow recovers to return to production within three to four days, no hematologic change is seen following an isolated anesthetic or conscious sedation exposure to nitrous oxide. However, a second exposure within this period of time will extend inhibition of synthesis, which may exceed the safety factor of stored cells. Since repeated exposures at close intervals may produce leukopenia, frequent exposure to nitrous oxide (less than one week between administrations) should be avoided."[37]

Immunocompromised: "Because N_2O seems to reduce chemotaxis (the motility of leukocytes) toward foreign proteins such as bacteria, as well as to reduce leukocyte action against tumor cells, patients with compromised immune systems should avoid nitrous oxide unless urgently required. This would include patients with AIDS or those taking immunosuppressive drugs."[37]

Unwilling patients: "N_2O should never be used on an unwilling patient. If, after explaining the benefits, the patient does not want N_2O, it should not be used."[37]

DENTAL TEAM AND UNINTENDED INHALATION

A review of the advantages and harmful effects of N_2O in dental management by Ogawa and Misaki found that, while N_2O inhalation sedation is effective for dental treatment, leakage of N_2O in the operatory affects the health of dental staffs.[27] A report has been issued by the National Institute for Occupational Safety and Health (NIOSH) on the "Hierarchy of Controls," listing needs for staff protection.[42] In addition to inadequate ventilation and scavenging systems, other equipment issues that may affect team members include equipment malfunctions and failures, and leaks due to poor connections.[43]

In a study by Staubli et al., vitamin B12 levels were measured in anesthetic staff administering nitrous oxide in a pediatric emergency department. It showed reduced vitamin B12 plasma levels by measuring homocysteine, methylmalonic acid, vitamin B12, blood count, and the MTHFR C677T genotype. The study concluded that, provided a safety demand valve is used, the use of nitrous oxide (50%-70%) is safe for the vitamin B12 status of medical personnel.[44]

MODES OF DELIVERY

There are two types of nitrous oxide/oxygen delivery systems: built-in and portable. A built-in system requires a central system with the supply source of N_2O-O_2 located in a storage area (cylinder room) separate from the treatment rooms. Flowmeters and the accessory equipment required for the delivery of the gases reside in the treatment rooms. Located in the dental office cylinder storage room, the manifold is a primary component of the nitrous oxide central system. In general, it serves to join multiple compressed-gas cylinders. One or more N_2O and O_2 cylinders may be attached to the manifold, but only one line for each gas exits the manifold. The exit lines carry the gases under low pressure (50-55 psi) to operatories plumbed for N_2O-O_2 delivery. Access to N_2O and O_2 in individual treatment rooms is achieved via operatory outlets. Cylinder storage room components typically include a manifold with safety pressure relief valves, regulators for each cylinder, an alarm monitor gauge, a cable, an N_2O-O_2 supply source (cylinders purchased from a gas supply company), tank restraints, various hoses, and gas lines. Conveniently located somewhere between the cylinder storage room and the operatories plumbed for nitrous oxide is a zone valve that can be accessed in case there is reason to shut down the supply of gas immediately.

The portable unit is a self-contained delivery system. Mobility is the major advantage of the portable unit. It is usually the system of choice in offices where space limitations will not accommodate a central storage room or when economic constraints are an influencing factor. Also, the portable system is most likely the answer when frequency of N_2O-O_2 use is low. Components of the portable unit typically include a manifold with safety pressure relief valves, regulators for each cylinder, an alarm monitor gauge, an N_2O-O_2 supply source (cylinders purchased from a gas supply company), tank restraints, various hoses, and gas lines. In the portable system, the manifold, the N_2O-O_2 gas cylinders, and the flowmeter function as one unit. All components reside in the treatment room. Located on the portable unit, the manifold is a primary component of the nitrous oxide system. Two or four N_2O and O_2 gas cylinders (depending on whether the portable is a two-cylinder or four-cylinder system) may be attached to the manifold, but only one line for each gas exits the manifold. The exit lines carry the gases under low pressure (50-55 psi).

CONCLUSION

Nitrous oxide is a valuable agent that assists patients who are anxious and fearful. It has an excellent safety record when used for anxiolysis and conscious sedation. There are, however, certain parameters that must be followed to ensure that every patient receives the proper and correct mode of treatment in this area.

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QUESTIONS

1. According to the International Union of Pure and Applied Chemistry (IUPAC), nitrous oxide is officially known as:
A. Trinitrogen toluene
B. NOS
C. Nitrous oxide
D. Dinitrogen monoxide

2. The history of nitrous oxide began with its isolation in 1772 by the theologian and scientist:
A. Horace Wells
B. Gavis Gavone
C. Judas Priest
D. Joseph Priestly

3. Nitrous oxide gas is produced by heating which of the following to 250°C?
A. Ammonium nitrate crystals
B. Ammonium hydroxide
C. Trinitrotoluene
D. Dilithium crystals

4. Unlike other anesthetics, nitrous oxide produces a mild analgesic effect at what concentrations?
A. Level 4 anesthesia
B. Supraanesthetic
C. Subanesthetic
D. A and B

5. After administration is terminated, the nitrous oxide is rapidly diffused back into the lungs along with oxygen and other gases. Due to this, oxygen exchange into the lungs and circulation is impaired, which can result in:
A. Diffusion hypoxia
B. Hypertonicity
C. Hyperalgesia
D. Hypotonic induction

6. The use of a combination of drugs to induce relaxation and provide some analgesia during a medical or dental procedure is called:
A. Anxiolysis
B. Conscious sedation
C. Level 4 anesthesia
D. All of the above

7. To reduce fear, all of the following have been used except:
A. Acupuncture
B. Pilates
C. Hypnosis
D. Acupressure

8. Since N_2O is not irritating to the tracheobronchial tree, it is not contraindicated for which of the following?
A. Cardiac arrhythmias
B. Psychosis
C. Asthmatics
D. Thalassemia

9. In an article by Munson, it has been suggested that a contraindication for nitrous oxide would include any recent surgery of the:
A. Ear
B. Neck
C. Nose
D. None of the above

10. Nitrous oxide is or was commonly known as all except which of the following?
A. Hypernitrous oxide
B. NOS
C. Sweet air
D. Protoxide of nitrogen

11. In the pregnant patient, the use of nitrous oxide:
A. Is absolutely contraindicated
B. Is recommended during early pregnancy
C. May be used following consultation with the obstetrician
D. Can be used in all cases

12. A moderate "stressful" dental experience may become traumatic because nitrous oxide appears to increase the effects of which of the following?
A. Triazolam
B. Marijuana
C. Percogesic
D. Haloperidol

13. The definition of anxiolysis is the:
A. Induction or reduction of anxiety
B. Prevention or induction of anxiety
C. Prevention or enhancement of anxiety
D. Prevention or reduction of anxiety

14. In the brain, nitrous oxide acts as a:
A. Renal vasodilator
B. Cerebral vasodilator
C. Vaso-vagal reactor
D. Renal vasoconstrictor

15. Leukopenia can be caused by repeated exposure of nitrous oxide at close intervals, usually:
A. One month between administrations
B. One week between administrations
C. Two months between administrations
D. Inconsequential regarding time between visits

16. At room temperature, nitrous oxide is:
A. Sweet tasting
B. Flammable
C. Acrid
D. Colored

17. Nitrous oxide tanks are colored blue in which of the following places?
A. United States
B. Canada
C. Middle East
D. A and B

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QUESTIONS

18. Wells and Morton were the earliest proponents of:
A. Intravenous anesthesia
B. Inhalation anesthetic
C. General anesthesia
D. Oral sedatives

19. Following cessation of nitrous oxide, 100% oxygen is delivered for three to five minutes to prevent:
A. Hyperemia
B. Hypoxia
C. Porphyria
D. Malignant hyperthermia

20. Patients with compromised immune systems should avoid nitrous oxide unless urgently required, since nitrous oxide seems to reduce:
A. Lyftaxis
B. Chemotaxis
C. Homeostasis
D. Macrophage activity

21. Nitrous oxide is tailor made for all but what type of patient?
A. Nervous
B. Healthy
C. Phobic
D. Unwilling

22. A reduction in plasma levels of vitamin B12 in staff that administered nitrous oxide was demonstrated in a study by:
A. Staubach
B. Stover
C. Staubli
D. Stabler

23. Nitrous oxide has a solubility coefficient that is how many times more than nitrogen?
A. 15
B. 25
C. 35
D. 45

24. As an industrial gas, nitrous oxide is used:
A. As an oxidizer in rockets
B. In auto racing to increase engine output power
C. As a foaming agent for whipped cream
D. All of the above

25. Which of the following is not a relative contraindication to N_2O?
A. Pulmonary disease
B. Respiratory infections
C. Pregnancy
D. Nasal obstruction

26. Psychotropic drugs usually alter which of the following?
A. Adrenothymal function
B. Cardiac output
C. Renal output
D. Cerebral cortex function

27. Emotional stress, especially in children, is the primary precipitant to which of the following?
A. Nasopharyngeal obstructions
B. Severe sinusitis
C. Asthma attack
D. Cognitive disturbances

28. The fast onset and quick recovery seen with nitrous oxide/oxygen sedation is due to its rapid diffusion and saturation in:
A. Blood
B. Serum
C. Central nervous system
D. Cerebral tissue

29. Which of the following pharmacological agents are used in dentistry for sedation?
A. Benzodiazepines
B. Narcotic analgesics
C. Hypnotic/amnesic agents
D. All of the above

30. Humphry Davy, an English chemist, published the history, chemistry, physiology, and recreational use of nitrous oxide in what year?
A. 1700
B. 1800
C. 1850
D. 1900

NOTES

PUBLICATION DATE:	DECEMBER 2019
EXPIRATION DATE:	NOVEMBER 2022

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Nitrous oxide: Use and safety (second edition)

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EDUCATIONAL OBJECTIVES

1. Refer to the history of nitrous oxide
2. Understand the properties of nitrous oxide
3. Know the safety recommendations
4. Have the ability to deliver nitrous oxide in a safe manner, and know the contraindications

COURSE EVALUATION

1. Were the individual course objectives met?

Objective #1: Yes No Objective #2: Yes No

Objective #3: Yes No Objective #4: Yes No

Please evaluate this course by responding to the following statements, using a scale of Excellent = 5 to Poor = 0.

2. To what extent were the course objectives accomplished overall?	5	4	3	2	1	0
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4. How would you rate the objectives and educational methods?	5	4	3	2	1	0
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6. Please rate the instructor's effectiveness.	5	4	3	2	1	0
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10. Do you feel that the references were adequate? Yes No

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12. If any of the continuing education questions were unclear or ambiguous, please list them.

_____

13. Was there any subject matter you found confusing? Please describe.

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14. How long did it take you to complete this course?

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8.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	23.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
9.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	24.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
10.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	25.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
11.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	26.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
12.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	27.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
13.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	28.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
14.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	29.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
15.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	30.	Ⓐ	Ⓑ	Ⓒ	Ⓓ

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