DOSAGES

Expressed in Watts /cm² of treatment head X time.
Treatment head usually 5cm² and total output of machine 15 watts, therefore maximum available is 3 W/cm².
For chonic conditions start at 0,5 mins and work up to 1,5 W/cm² or 2 W/cm² depending on patient's tolerance and machine.

Acute conditions, low dosage and short time to start, 0,25 W/cm² for 3 mins.

Try in chronic conditions to reach optimum dosage for Watts in three treatments then increase the time by 1 or 2 mins per treatment. Limit to 12 — 15 treatments.

Latest reading — disappointing, nothing new.

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PREMIXED NITROUS OXIDE AND OXYGEN — A REVIEW

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A physiotherapist is often confronted with the problem of having to treat a patient who is in pain. If adequate pain relief is not obtained, then not only is the treatment less effective, but it is always disagreeable for the patient. The use of potent narcotic analgesics does not solve this problem. If given in adequate dosage to provide effective pain relief, the patient often has respiratory depression and is drowsy and unco-operative. The ideal analgesic adjuvant for use during physiotherapy should have the following properties:

1. It should provide profound analgesia with minimal hypnosis — i.e. a conscious, co-operative patient free of pain.
2. Administration should involve a simple technique.
3. It should be sufficiently free of dangerous side effects, to enable administration to be performed by trained physiotherapists while not under direct medical supervision.
4. It should not be habit forming.
5. It should not interfere with or worsen diseases that the patient may have.

Such an agent may prove to be nitrous oxide.

History, Physical and Pharmacological Properties of Nitrous Oxide

Nitrous Oxide (Syn., Nitrogen monoxide; Formula, N_2O) is a colourless gas with a faint sweetish odour. It is supplied in blue cylinders into which it has been compressed to a pressure of 650 lb/sq. in. At this pressure, N_2O is in a liquid form. As it is released from the cylinder it returns to the gaseous state. It is non flammable.

N_2O is the oldest of the gaseous anaesthetic agents. It was first prepared by Priestley in 1776. In 1779 Humphrey Davy after experiments on himself, announced that it had anaesthetic properties, and suggested that it be used to relieve pain. His suggestion went unheeded until 1844 when Colton administered N_2O to Wells while a dentist extracted one of Wells' teeth. Wells' later attempt to introduce N_2O as an anaesthetic agent met with ridicule when during the demonstration the patient cried out. In 1868 Andrews introduced oxygen administration with nitrous oxide in the manner of its present-day use.

The early techniques of administering nitrous oxide were by giving the pure gas. Many of the effects and accidents which were ascribed to N_2O were the results of hypoxia. Provided sufficient oxygen (21% or above) is given, the effects on body systems are slight.

On the central nervous system, the effect depends on the concentration inhaled. Nitrous oxide has good analgesic properties while it is a weak anaesthetic agent. G. D. Parbrook[1,2] showed that a mixture of 25% nitrous oxide with 75% oxygen provides better analgesia than 15 mg of morphine. He showed that after ceasing to inhale 25% nitrous oxide, significant analgesia persisted for five minutes, and disappeared after 15 minutes. If concentrations of 50% and above are inhaled, consciousness is usually lost.

With subanaesthetic concentrations, a feeling of euphoria is often experienced — hence the name "laughing gas". Sensory effects include tingling, numbness, dizziness as well as auditory and visual disturbances. At the higher concentrations nausea and confusion may appear. Nausea is particularly likely if hypoxia is present. Depression of the respiratory centre does not occur. Habituation is a possible hazard with repeated use, especially in persons who tend to become euphoric.

There is no effect on bronchial secretions. Pulse and blood pressure remain unchanged, there being no direct action on the heart. Some improvement of peripheral blood flow does occur. Kidney and liver functions are unaffected. Depression of skeletal muscular tone is minimal. Smooth muscle is unaffected. Depression of bone marrow function in leukopaenia only occurs if nitrous oxide is inhaled continuously for more than 24-48 hours.[3,4]

Nitrous oxide is reasonably insoluble in the blood. Uptake and excretion via the lungs is rapid. Its effects are therefore rapidly acting and quickly wear off after terminating administration.[5] Today nitrous oxide is used in the majority

of general anaesthetics, either as a vehicle for carrying more potent anaesthetic agents or as part of the technique of "balanced anaesthesia".

The Use of Subanaesthetic Concentrations of Nitrous Oxide to Provide Analgesia

Minnitt[6] in 1931 developed and popularized the employment of nitrous oxide and air mixtures during childbirth. Nitrous oxide analgesia has been employed in dental surgery for at least 100 years.[7, 8] It has been used to relieve the pain of myocardial ischaemia since 1881 by Klikovich and this usage has been re-investigated more recently.[9, 10] In shocked states following trauma, 50% nitrous oxide/oxygen has been used to relieve pain and hypoxia.[11] Other situations in which nitrous oxide is used for pain relief include pain and ischaemic limb pain.[10]

Parbrook et alia investigated the use of 25% nitrous oxide in oxygen in the relief of post-operative pain. The best results were obtained when a combination of a narcotic analgesic e.g. methadone and 25% N_2O was used. This combination was suggested as an aid to post-operative chest physiotherapy.[1, 2]

Premixed Nitrous Oxide and Oxygen — Entonox

The Minnitt apparatus for use in obstetrics was designed to provide a 50-50% mixture of air and nitrous oxide. It has been shown that this is not safe, as 50% nitrous oxide in air provides only 10% oxygen. Furthermore, the machines sometimes deliver more than 50% nitrous oxide. There is therefore a strong likelihood that a patient would be rendered hypoxic while breathing from one of these machines.[12, 13] This danger is avoided in the Lucy Baldwin apparatus which provides a continuous flow of nitrous oxide and oxygen from separate cylinders. This machine is unfortunately very inaccurate as the mixing mechanism has not been perfected.

Barach and Rovenstine[14], (1945) were the first to use nitrous oxide and oxygen in one cylinder. Their intention was to eliminate the dangers inherent in the use of hypoxic mixtures of nitrous oxide. Tunstal[27] in 1961, working with the British Oxygen Company, introduced premixed nitrous oxide and oxygen for use as an analgesic in obstetrics. The premixed gas at present available is a 50:50% mixture of nitrous oxide and oxygen, and is called "ENTONOX". It is sold in a specially coloured cylinder (blue with a white top). The cylinder is filled to a pressure of 1 386 Kg/sq cm (1 980 lb/sq in.) at 19,8°C. It has been found that under these conditions, in spite of the partial pressure of nitrous oxide exceeding that at which it should liquefy, it remains in the gaseous phase.

However, when the temperature of the cylinder drops to below − 7°C the situation is different.[16] The nitrous oxide then liquefies and settles to the bottom of the cylinder. On being opened, such a cylinder will at first supply a high concentration of oxygen, with little N_2O. As the cylinder empties, so the O_2 concentration falls and the N_2O concentration rises until almost pure N_2O is being released. A person breathing such a mixture would quickly become hypoxic. Warming the cylinder does not necessarily reverse this state, unless the cylinder is shaken.

The "Entonox" "demand"-valve fits directly onto the 500 litre pin-index cylinder. This valve opens only when the patient breaths from it. A five foot length of corrugated rubber tubing, handpiece, expiratory valve and face mask are attached to the valve. The unit bears a pressure gauge indicating the cylinder contents. The "demand" valve responds to inspiratory effort by the user, and automatically shuts itself off at the end of inspiration. It can deliver a flow in excess of 275 litres/min, which easily accommodates the largest inspiratory effort. The intermittent "demand" flow economizes on the use of gas. In order to obtain gas from the apparatus, it is necessary to effect an air-tight seal between the mask and face. The mask may be replaced by a mouthpiece and nose-clip. These items should, of course, be sterilized in between use with different patients.

In review on the therapeutic uses of nitrous oxide G. D. Parbrook[17] has divided its analgesic effects into four zones, dependant on concentration (see table).

Many persons, on inhaling 50% N_2O for sufficient time to achieve saturation (e.g. 20 minutes), would become confused and excited, and a few would lose consciousness. The technique of Entonox administration is to give a sufficient number of breaths to achieve analgesia without producing anaesthesia (Zone 1). Response is normally very rapid, being the time taken for blood to circulate between the lungs and the brain. Even one deep breath can have appreciative effects. The number of breaths necessary, depends on various factors which include the patients individual susceptibility, the presence of pulmonary disease, previous medication, tidal volume and respiratory rate. Parbrook has, however, stated that ten deep breaths of Entonox is equivalent to saturation with 25% nitrous oxide. An alternative method is to produce dilution of the Entonox by air. This may be done by a continuous flow of Entonox into an air-entraining oxygen mask.

The Use of Entonox in Obstetrics:

Fifty per cent N_2O/O_2 is employed extensively in modern obstetrical units. It is usually administered intermittently, beginning with the start of each labour pain and continuing until the contraction has passed. Being rapidly acting, it provides pain relief during each uterine contraction. Not only is co-operation retained, but mother and foetus are ensured with more than adequate oxygenation. The Central Midwives Board of Great Britain has approved that midwives who have been trained in the use of the Entonox apparatus, may administer it while not under direct supervision. Phillips and MacDonald (1971)[18] concluded that Entonox was safer than both trichlorethylene and pethidine.

Uses of Entonox in Physiotherapy:

The incidence of post-operative chest complications is highest after upper abdominal operations. Pain leads to "splinting" of the diaphragm, shallow respiration and unwillingness to cough. It is possible that Entonox may provide the patient with sufficient pain relief to enable him to take a few deep breaths and cough. In this situation administration would have to be repeated at frequent intervals as deep breathing and coughing would lead to rapid excretion via the lungs. Its use may of course be extended to other situations in which deep breathing and

Plane	Zone	Patient Contact	Analgesia	Amnesia	Psychological Effects	Approx. N_2O%
"Analgesia"	1	Present	Moderate	None	Slight Sedation	5-25
	2	Present	Marked	Slight	Inebriation	26-45
"Amnalgesia"	3	Present	Almost total	Almost complete	Somnolence	46-65
	4	Lost	Patient fully unconscious			66-85

coughing is painful, e.g. after thoracotomy, rib fracture and laminectomy. It has been used for pain relief during vibration therapy in crushed chests[19]. Dale Mitchell reported favourable results with chest physiotherapy after thoracotomy especially when it was combined with a narcotic[20]. Parbrook has also reported best results when a narcotic analgesic was used in addition to nitrous oxide.

The value of the use of Entonox in burned patients is reported in this journal. Here the danger of bone-marrow depression may safely be ignored as the actual duration of administration each day is short. The remote possibility of development of tolerance and habituation must, however, be borne in mind.

Contra-indications:

There are a few situations in which nitrous oxide should be avoided.

1. N_2O tends to increase pre-existing nausea.
2. N_2O diffuses rapidly into air containing body spaces, increasing their volume. Gaseous abdominal distension, closed pneumothorax, after air-encephalography, and after tympanoplasty are relative contra-indications, but not necessarily for short-term intermittent administration.
3. Continuous administration for periods longer than 24-48 hours leads to leukopaenia.

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