Kaleidoscope
HUNTER CHILDRENS' HEALTH NETWORK

HUNTER NEW ENGLAND
NSW HEALTH

Education package for nurse administered paediatric inhalation analgesia

August 2005

ACKNOWLEDGEMENT

This package was developed by the Nurse Educators at Kaleidoscope, the John Hunter Children's Hospital (JHCH) with the much valued input and support from Dr Susie Lord, Staff Specialist, Anaesthesia And Pain Management JHH and JHCH, Dr Patrick Farrell, Deputy Director Anaesthesia, JHH. Other nursing and medical staff at the JHCH reviewed and commented on the package.

To all of these people we offer our thanks.

CONTENTS

This Inhalation Analgesia learning package is designed for use by Registered Nurses and by Medical Officers who are non-anaesthetists. In order for these personnel to be accredited to deliver inhalation analgesia using a specific delivery system within HNEHealth they must:

1. Have basic paediatric life-support skills,
2. Satisfactorily complete this learning package including the exercises,
3. Attend the associated lecture given by an Anaesthetist,
4. Demonstrate skill to another accredited person using a particular system, and
5. Satisfactorily achieve the Inhalation Analgesia Clinical Competency Assessment.
6. Accreditation will be delivery system specific and steps 4-5 would need to be repeated if a person wishes to be accredited to use more than one system.

AIMS

- To provide a learning encounter that enhances the acquisition of knowledge, skills and behaviors required for the care of a child and his/her family where there is a need for pain relief using inhalation analgesia.
- To ensure that rationales underpinning practice are evidence based and congruent with a family centred approach to care.

OBJECTIVES FOR THE PACKAGE

On completion of this Package the Registered Nurse or Medical Officer will be able to:

- Discuss the theory related to the use of nitrous oxide (N_2O) for inhalation analgesia including pharmacology, contra-indications and adverse reactions.
- Discuss adjuvant strategies that can be used with inhaled analgesia.
- Explain to colleagues, parents and children the benefits, process and risks of inhalation analgesia.
- Identify and list at least 3 clinical situations appropriate for the use of inhalation analgesia.
- Explain the differing aspects of using N_2O via 'continuous flow' or 'demand' delivery systems and demonstrate the preparation and the management of a delivery device including troubleshooting strategies.
- Safely administer inhalation analgesia in accordance with the hospital policy.
- Monitor the child's condition and demonstrate appropriate management of adverse events.
- Complete a clinical competency assessment.
- Identify current clinical practice standards relevant to this skill and determine strategies to maintain best practice in relation to these standards.

EXPECTED OUTCOMES

- Accredited Registered Nurses and Medical Officers will administer inhalation analgesia in a safe, effective and sensitive manner and maintain their skills.

PACKAGE CONTENT

This learning package focuses on issues and practices relevant to the maintenance of comfort for the child during painful procedures. There is opportunity for you to address issues related to procedural pain, family participation in care, the care and use of the delivery apparatus, the development of clinical skills in the administration of inhalation analgesia, the ability to maintain the safety of the child and deliver effective post procedure monitoring and care.

You are encouraged to develop advanced and discerning assessment skills and the ability to analyse clinical and diagnostic data. The package with the clinical based scenarios focuses on clinical experience and provides you with the opportunity to explore real situations.

INTRODUCTION

"The amount of pain anyone experiences is a composite of physiological and psychological variables and is not predetermined solely by the extent of tissue damage. Context, biological variation, previous experience, and a variety of psychological factors modify the experience of pain and must be considered in every assessment of a child in pain" (Kilham & Isaacs, 2004).

Children in hospital may undergo many painful diagnostic and therapeutic procedures such as venepuncture, cannula insertion, lumbar puncture, bone marrow aspirates, dressing changes, minor operative procedures, and oncology procedures. Children with medical conditions such as cystic fibrosis, complex regional pain syndrome and cancer may experience pain as part of their disease process or associated treatment.

"Many studies show that pain in children is underestimated and, therefore, inadequately treated. Anxiety and pain even in minor procedures is a common and often overlooked problem, not least in paediatric oncology where long treatment-periods and repeated procedures are common" (Gregory, Sullivan, 1996). If pain is unrecognised it can become well established, severe and more difficult to control.

While many children will tolerate diagnostic and therapeutic procedures awake, the provision of analgesia and sedation, or general anaesthesia (GA), is increasingly seen as a standard of care particularly for invasive procedures. The aims of procedural sedation are to minimise physical discomfort and pain, to control behaviour particularly movement, and to minimise psychological disturbance. For some children, GA may be necessary (eg. those with developmental delay or who have complex medical conditions). In selected cases, sedation by non-anaesthetists may be a safe and flexible alternative (Kilham & Isaacs, 2004)

Sedation is a continuum from anxiolysis to general anaesthesia. Four levels have been defined (JCAHO, 2001):

1. Minimal sedation – A drug-induced state during which patients respond normally to verbal commands. Cognitive function and coordination may be impaired. Respiratory and cardiovascular functions are unaffected.
2. Moderate sedation ("conscious sedation") – A drug-induced depression of consciousness during which patients respond purposefully to verbal commands, either alone or accompanied by gentle tactile stimulation. The airway remains patent without interventions, spontaneous ventilation is adequate and cardiovascular function is usually maintained.
3. Deep sedation – A drug-induced depression of consciousness during which the patient cannot be easily aroused but responds purposefully to repeated or painful stimuli. Patients may require assistance in maintaining a patent airway, spontaneous ventilation may be inadequate, and cardiovascular function is usually maintained.
4. General anaesthesia – A drug-induced depression of consciousness during which patients cannot be aroused even by painful stimuli. Patients often require assistance maintaining a patent airway, may need assisted positive pressure ventilation, and cardiovascular function may be impaired.

Non-anaesthetists should perform only minimal or conscious sedation. Deep sedation when required or inadvertently obtained requires the involvement of anaesthetists or other doctors with advanced paediatric airway and resuscitation skills.

Nitrous oxide (N_2O) is one of several drugs that may be used to achieve conscious sedation and analgesia. It may be used alone for brief procedures or in combination with other drugs for more painful or prolonged procedures. Other drugs might include:

- Topical local anaesthetic creams - EMLA® cream
- Oral analgesics – paracetamol, codeine, morphine
- Intravenous analgesics – opioids, ketamine
- Anxiolytic drugs – oral, nasal or intravenous midazolam

It is important to consider non-sedating drugs (paracetamol, topical local anaesthetics) before additional sedative drugs because adverse events are more likely to be associated with the use of multiple (especially 3 or more) sedating medications (Kaplan & Yang, 2002).

Inhalation analgesia can also be supplemented with non-pharmacological strategies. Distraction is the most commonly endorsed non-pharmacological intervention with younger children, whereas music/art therapy, relaxation, hypnosis, imagery and massage can be used effectively with older children and adolescents (Martin-Herz et al, 2003).

Despite widespread use, there are relatively few controlled trials of the efficacy of nitrous oxide for painful procedures in children:

- In children undergoing **venous cannulation**, 70% N_2O / oxygen (O_2) was more effective than EMLA cream for providing anxiolysis and analgesia in one study (Vetter, 1995), and equi-effective in another (Paut et al, 2001).
- In children aged 2-7 years undergoing repair of **minor lacerations**, 50% N_2O / O_2 was more effective than 100% oxygen in decreasing anxiety (Burton et al, 1998).
- In children undergoing **facial laceration** repair, continuous-flow 50% N_2O / O_2 was more effective than midazolam in reducing distress, and had fewer adverse effects and shorter recovery times than midazolam (Luhmann et al, 2001).
- In children undergoing manipulation of **forearm fractures** in the emergency department, N_2O was as effective and as safe as intravenous regional anaesthesia for pain relief, and procedures performed using N_2O required significantly less time for completion (Gregory & Sullivan, 1996).
- In children 0-18 yrs undergoing **fiberoptic bronchoscopy**, premixed 50% N_2O / O_2 was significantly more effective than 50% nitrogen / O_2 as measured by higher procedural success, better satisfaction and behaviour scores, and lower pain scores (Fauroux et al, 2004).
- In children aged 12-16 undergoing **dental extractions**, 70% N_2O / O_2 was equi-effective compared to IV midazolam, and inhalation analgesia was associated with a faster recovery time (Wilson et al, 2003).

While uncontrolled surveys do not prove efficacy, they do provide helpful data regarding safety and the incidence of adverse events. Two large French surveys reporting 1,019 (Annequin et al, 2000) and 7,511 (Gall et al, 2001) administrations of pre-mixed 50% nitrous oxide / oxygen for various paediatric procedures concluded that:

- Minor side-effects were observed in 37% of children, all of which were transient and resolved within 5 minutes after the discontinuation of inhalation.
- Major adverse events were encountered in only 0.3% despite most administrations having been performed by educated nursing staff rather than medical officers. Major adverse events included respiratory events (eg. oxygen desaturation, airway obstruction, apnoea), cardiovascular events (eg. bradycardia) or oversedation (eg. loss of verbal contact or persistence of sedation for longer than 5 minutes after discontinuation of inhalation).

An Australian survey of 90 children undergoing nitrous oxide inhalation analgesia for repeated painful procedures (lumbar puncture, bone marrow aspirate, venous cannulation or dressing change) reported:

- Minor side-effects in 14% of children. Vomiting occurred in 7.8%, excitement in 4.4%, and dysphoria in 2%.
- 8 children developed desaturation (<95%) but none developed hypoxia, airway obstruction or aspiration.
- 93% fulfilled the criteria for conscious sedation, and 65% had no recollection of the procedure.

ACTIVITY 1.

You are the registered nurse / medical officer working on Hope Ward and you have the care of Johnny who is a 9 year old with cellulitis of the leg secondary to an unidentified spider bite. He was admitted to the ward yesterday for a course of IV antibiotics. This morning his cannula site was checked and appears to have 'tissued'. His mother, Margaret, reports that Johnny is very scared, as this is his first admission to hospital. She tells you that he was upset and distressed by the several attempts that were needed to insert his IV cannula yesterday. Johnny is currently sitting in bed quietly with tears running down his face and looking at his arm.

a) What do you see as the major issues in this scenario?

b) Suggest some methods you could use to address the distress of Johnny and his mother?

c) Give reasons for your answer.

NITROUS OXIDE

Physical properties

Nitrous oxide (N_2O) is a colourless, sweet smelling gas with analgesic properties. It is neither flammable nor explosive but will support combustion. It has a boiling point of -89ºC so it is a gas at room temperature and pressure. It is readily compressible under 50 atmospheres pressure at 28ºC to a clear liquid. 90% of the N_2O in a full N_2O cylinder is in liquid form.

N_2O is a poorly soluble anaesthetic agent (blood/gas partition co-efficient of 0.47). This means that the alveolar partial pressure of N_2O will rapidly increase to reach the inspired partial pressure. Pulmonary transfer of N_2O (from alveoli to blood) is then rapid, with onset of effect in seconds and peak analgesia within two minutes. Likewise, it is rapidly eliminated from the blood, via the lungs, when inhalation ceases. Because the exiting N_2O dilutes the inspired gas in the alveoli, "diffusion hypoxia" may occur unless the inspired oxygen is increased for 3-5 minutes at the end of N_2O use.

During administration, N_2O dissolved in the blood will also move out of solution into other gas-filled spaces in the body – bowel, middle ear, pneumothorax. The air (mostly nitrogen) already occupying these spaces is less soluble in blood, so it leaves the spaces slower than the N_2O comes in. If the space is compliant then its volume will increase (eg dilated bowel), but if not compliant the pressure increases (eg. the blocked middle ear). This has implications for adverse effects (see below).

Pharmacological actions

N_2O is a weak anaesthetic agent but caution must be exercised as some patients may lose consciousness with 50% N_2O. N_2O is a powerful analgesic. The specific mechanisms of N_2O analgesia are unclear but its effects may be due to action at opioid receptors that then produces the analgesic, sedative and anxiolytic effects (Bruce and Franck, 2000).

N_2O does not bind to any carrier proteins during transport and therefore avoids the difficulties of drug interactions (Frampton et al 2003). It does not combine with haemoglobin nor is it metabolised in the body. It has minimal effect on the cardiovascular system.

Toxicity

N_2O can irreversibly oxidise vitamin B12-dependent enzymes rendering them inactive in several biochemical reactions. Prolonged (6-8 hours) or repeated (every 2-4 days) administration of N_2O may lead to bone marrow suppression (megaloblastic anaemia, agranulocytosis) due to interference with an enzyme that controls DNA synthesis. Chronic exposure (years) to high concentrations may cause a sensorimotor polyneuropathy often combined with signs of spinal cord degeneration due to interference with an enzyme involved in myelin sheath repair.

Occupational issues

Worksafe Exposure standard TLV-TWA states that the maximum N_2O concentration in the work space should not exceed 25 ppm during the period of gas administration (National Institute for Occupational Safety and Health, 1994; BOC, Medical Products and Services, ND). Occupational exposure to N_2O can be kept below this level if there is adequate room ventilation and / or scavenging equipment is used (National Occupational Health and Safety Commission,1997).

Some studies suggested that men and women who work in areas where trace levels of anaesthetic gases are present may have increased rates of involuntary infertility, spontaneous abortion and congenital abnormalities in their offspring (Penniman, 2003). However, other studies have refuted this.

OTHER DRUGS USED WITH INHALATION ANALGESIA

Other agents that may be used to enhance (or reverse) analgesia and anxiolysis during inhalation analgesia administered by accredited nursing and medical staff include:

Analgesics

Depending on the level of pain expected during the procedure, the following may be used alone or in combination. Only one opioid agent should be administered.

EMLA topical local anaesthetic

- Apply to site of painful procedure 1 hour before procedure.
- See guidelines for application.

Paracetamol

- 15 mg/kg PO (maximum 1g) given at least 30 minutes before the procedure.
- If the child is not receiving regular paracetamol and no other contra-indications exist, the dose may be increased to 30 mg/kg.
- Ensure that the maximum total dose in 24 hours does not exceed 90 mg/kg.

Codeine

- 1 mg/kg PO (maximum 60 mg) given 30 minutes before the procedure.

OR

Morphine

- 0.3 mg/kg PO (maximum 15 mg) (or 10% of the total daily oral morphine requirement if opioid tolerant) given 30 minutes before the procedure.

OR

- 10-30 mcg/kg IV 10 minutes before the procedure, plus 10-30 mcg/kg q5mins PRN during the procedure via Patient Controlled Analgesia (PCA) or Nurse-controlled analgesia (maximum total dose 120 mcg/kg IV).

Anxiolytics

Midazolam

- O.3 mg/kg PO (maximum 15 mg) given 15-20 minutes before procedure
- Reduce dose to 0.3 mgs/kg if using with opioid.

Antiemetics

Antiemetics are not routinely administered to children for prophylaxis against vomiting. However, if a child has had a previous episode of nausea or vomiting during inhalation analgesia it is reasonable to give a dose of ondansetron (wafer / IV) 30 minutes before a repeat procedure.

Antagonists

Naloxone

- 5 mcg/kg IV over 1-2 minutes can be repeated every 2-3 minutes (maximum dose 2 mg) for opioid-induced respiratory depression (rare if the above dosing guidelines are followed).
- The duration of action of naloxone is shorter than the typical opioids it reverses, so any child given naloxone should be observed carefully for return of opioid-induced side effects.

Flumanenil

- 5 mcg/kg IV, can be repeated every 1-2 minutes (maximum dose 40 mcg/kg or 2 mg) for benzodiazepine-induced over-sedation (rare if the above dosing guidelines are followed).
- Re-sedation may occur. Flumazenil may increase the risk of seizures in pre-disposed patients.

INDICATIONS

Inhalation analgesia using nitrous oxide / oxygen mix is indicated for the short-term relief of acute pain of any aetiology (see Table 2 - contra-indications section for exclusion criteria). The pain or discomfort could be a result of injury or be due to a procedure carried out in hospital. Table 1 below contains a few examples.

Table 1. Examples of Indications For Use Of Inhalation Analgesia

Fracture manipulation	Suturing of lacerations/suture removal
Venepuncture	Vascular procedures
Bone marrow aspiration	Lumbar puncture
Radiological procedures	Dermatological procedures
Wound dressing changes	Burns dressing
Orthopaedic joint manipulation	Mobilisation of contractures
Wound drain removal	Examination of wounds or fractures
Gastrostomy tube/button change	

CONTRA-INDICATIONS

Table 2**.** Contra-Indications for the Administration of Inhalation Analgesia

Contra-indication	**Rationale**
Undrained Pneumothorax	N_2O passes into all gas-containing spaces in the body faster than nitrogen passes out. This can cause expansion of the gas space, compressing surrounding structures
Bowel obstruction	
Air embolism	
Decompression sickness or following a recent underwater dive/air embolism	
Following air encephalography	
Severe bullous emphysema	
During myringoplasty Following recent middle ear surgery	
Inspired O_2 requirements > 50%	Less than 50% N_2O may be inadequate for analgesia
Head injuries with impaired consciousness or raised intracranial pressure	N_2O will cause sedation that may confound neurological observation, further compromise airway reflexes, decrease ventilation and increase intracranial pressure
Maxillo-facial injuries	The patient may not be able to hold the mask tightly to the face or use the mouthpiece adequately
Vomiting or bowel obstruction	Risk of aspiration
Gastro-oesophageal reflux	Risk of aspiration
Solids or milk intake within 4 hours or water within 2 hours	Risk of aspiration
Inadequate personnel, monitoring or equipment	Risk to patient safety
Consent not given	Legal and ethical implications

Table 3. Additional Contra-Indications for Inhaled Analgesia Administered by Non-anaesthetists

Relative Contra-indication	**Rationale**
Child's age < 1 year	Airway management may be more difficult. An anaesthetist is required
History of difficult airway, craniofacial abnormality or neck swellings	Airway management may be more difficult. An anaesthetist is required
Snoring, stridor or sleep apnoea	Airway management may be more difficult. An anaesthetist is required
Altered state of consciousness, pre-existing intoxication or heavy sedation	Airway reflexes may be compromised by increased sedation. An anaesthetist is required
Partially obstructed airway	Increased sedation may worsen airway obstruction. An anaesthetist is required
Pneumonia	Increased risk of airway problems and desaturation. An anaesthetist is required
Chronic CO_2 retention (patients with chronic obstructive lung disease or cyanotic heart disease)	The increased inspired O_2 may depress ventilatory drive. An anaesthetist is required

ACTIVITY 2

Johnny's cannula needs to be re-inserted and he is looking frightened and holding his arm.

a) What are the available options you can employ to reduce Johnny's anxiety and pain during cannulation?

b) What questions would you need to ask Johnny and his mother to determine the most appropriate solution?

c) If Johnny's mother reported that Johnny was a frequent snorer, and that his snoring had been made worse over the last few days because he has a mild cold, would you change your strategy? If so, why and what would you do?

PRECAUTIONS

Inhaled analgesia administered by non-anaesthetists may be unsuitable or inadequate for some procedures and for some children. In planning a procedure, consideration of intravenous drugs or general anaesthesia may be necessary. If in doubt, contact the Acute Pain Registrar or Duty Anaesthetist for advice.

Patients should be advised not to drive, use machinery or perform other demanding psychomotor tasks until 12 hours after inhaled analgesia (24 hours if additional sedative drugs are used).

If Entonox is to be administered more frequently than every 2-4 days or for more than 6-8 hours, routine blood cell counts should be performed to check for:

- evidence of megaloblastic change in red cells
- reduced production of leukocytes.

ADVERSE EFFECTS AND THEIR MANAGEMENT

ADVERSE EFFECTS	MANAGEMENT	RATIONALE
Airway Obstruction	Cease N_2O and give 100% O_2 Remove particulate vomit and suction airway Reposition head and use jaw thrust Call for emergency help if unresolved Consider Guedel or emergency airway management	Clear and maintain airway, maximize oxygenation
2. Respiratory Arrest	Call for emergency help Cease N_2O and give 100% O_2 Check ABC and institute CPR according to current guidelines	Resuscitation
3. Cardiac Arrest	Call for emergency help Cease N_2O and give 100% O_2 Check ABC and institute CPR according to current guidelines	Resuscitation
4. Desaturation	Cease N_2O and increase O_2 Look for and manage the cause	Increase oxygenation
5. Dizziness or disorientation	Inhalation may be ceased until these side effects start to wear off and the sensation of pain starts to return The patient may choose to put up with these effects and continue inhalation (+/- reduced N_2O concentration) to maintain effective pain relief	To provide effective analgesia with minimal side-effects
6. Earache	Inhalation should be stopped and alternative analgesia prescribed	To prevent perforation of the eardrum
7. Inadequate sedation and analgesia	Observe the patient throughout the procedure to determine: • Level of pain and distress • Whether they are using the N_2O effectively & the circuit is not leaking Instruct / assist with use of mask or mouthpiece If remains inadequate, cease painful procedure and arrange alternative analgesia	To ensure that adequate pain relief is provided
8. Mask intolerance	Use the 'snorkel method' and try a mouthpiece or place lips directly around the patient end of the filter	Maximize patient comfort and compliance
9. Nausea and vomiting	If the patient complains of nausea they should be encouraged to cease inhalation if they wish Less commonly the patient may vomit. If so: • Remove the mask / mouthpiece immediately • Clear any obstruction to breathing • Provide 100% O_2 via the alternative supply and Ambubag • Reassure the patient • Clear vomit from the mask / mouthpiece and filter or replace them The patient may then recommence administration if they wish or the procedure can be delayed while alterative analgesia is arranged	The side-effects of N_2O wear off quickly once inhalation ceases To prevent inhalation of vomit
10. Oversedation	Whilst using a continuous flow system: • Leave the mask in place but immediately cease the N_2O and increase the O_2 concentration to 100% Whilst using a demand-valve system: • If patient-held, then the patient will lose their seal on the mask / mouthpiece and N_2O / O_2 flow will cease • If the operator is assisting with holding the mask, then they should remove the mask / mouthpiece so and N_2O / O_2 flow will cease If using less than 50% O_2 concentration at the time, then provide 100% O_2 for several minutes to avoid diffusion hypoxia	To prevent deeper stages of sedation which may lead to: - airway obstruction - aspiration - inadequate ventilation - desaturation

ACTIVITY 3

Johnny doesn't snore and is otherwise well. Before giving consent though, Johnny's mother wants to know how dangerous the gas is.

a) What is your response?

b) Who is responsible for obtaining informed consent?

EQUIPMENT

It is important to understand the equipment used to administer N_2O inhalation analgesia. You will need to know how it works, how to check it, and problems that may occur. The following discussion of equipment is divided into:

- The gas supply – cylinders or wall outlets
- The nitrous oxide delivery systems – the type of machine
- The breathing circuit – the bits that connect the machine to the patient (the bag, tubing, connections, airway filter and mask / mouthpiece)
- The scavenging system – that carries the expired gas out of the work space
- Monitoring equipment
- Suction and emergency resuscitation equipment

Gas supply

N_2O comes in various size cylinders painted blue. Due to the N_2O being in liquid form, until the cylinder approaches empty, the gas pressure gauge does not indicate content. The content can be measured by weighing the N_2O cylinders.

Pure N_2O should never be used alone. An inspired oxygen (O_2) concentration of at least 30% is necessary to avoid hypoxia. Oxygen may be supplied via cylinder (black with white shoulders) or wall outlet (white). Wall outlet supply is considered safer because it is connected to the hospital's large O_2 supply and has an alarm in case of hospital O_2 supply failure (an extremely rare event), whereas cylinders have to be checked to ensure that they contain enough O_2 for the procedure. O_2 and N_2O are connected to the mixing machine and the concentration of each can be adjusted.

Figure 1. Gas Cylinders – Oxygen (on the left) is presented in black and white cylinders; Nitrous Oxide (on the right) in blue cylinders.

N_2O and O_2 can also be presented in pre-mixed Entonox® cylinders which contain 50% N_2O and 50% O_2. The gas concentration cannot be altered. It is stored in cylinders at 120 bar or 12,000 kPa. This pressurised mixture remains gaseous at temperatures above –6°C. Entonox cylinders are blue with the shoulder painted in blue and white quadrants.

Figure 2. Entonox cylinder.

Delivery systems

Several different delivery systems are available within HNEHealth for administering N_2O / O_2 mixes. However, these delivery systems fall into two main categories:

1) *Continuous flow systems*

- These included the Quantiflex and MXR delivery machines.
- They have separate connections for the N_2O and O_2 gas supplies.
- The N_2O and O_2 pass through flow meters that allow the operator to adjust the relative concentrations of the 2 gases - N_2O between 0-70% and O_2 30-100%.
- They will only work if O_2 is supplied. All flow ceases if the O_2 supply fails.
- Otherwise, gas flow is continuous and is not influenced by the child's respiratory effort or their seal on the mask / mouthpiece. For this reason it may be the delivery device chosen for very young children (eg less than 4 yo). However, because flow will continue even if the child becomes over-sedated, this system requires more vigilant monitoring of the child's level of consciousness by the operator.

Figure 3. The Quantiflex® system.

Although no longer manufactured, there are still a large number of these machines in operation. The mixer has 2 controls. A thumb-wheel in the middle of the panel sets the mixture from 30% to 100% O_2 with the balance being N_2O. Adjusting the round knob at the bottom of the control panel sets the total gas flow. Each gas flows through a ball flow meter and the flow is read from the centre of the ball. If O_2 failure occurs, the falling flow and pressure causes the N_2O pressure to fall proportionately until finally it ceases, as O_2 supply is lost. If this is unrecognised, and the operator holds the mask firmly in place, this could lead to suffocation. Continuous observation of the flowmeters, patient and pulse oximetry is vital.

Figure 4. The MXR® system.

This is gradually replacing the Quantiflex system. The ball flow meters and O_2 failure system are similar to the Quantiflex system (see above). If O_2 failure occurs, the falling flow and pressure causes the N_2O pressure to fall proportionately until finally it ceases, as O_2 supply is lost. If this is unrecognised, and the operator holds the mask firmly in place, this could lead to suffocation. Continuous observation of the flowmeters, patient and pulse oximetry is vital.

2) ***Demand-valve systems***

- These include the Entonox® and Midogas® delivery systems.
- The Entonox system is connected to the Entonox pre-mixed cylinder and allows only 50% N_2O / 50% O_2, whereas the Midogas system is connected to separate O_2 and N_2O supplies and permits up to 75% N_2O.
- The gas mix will only flow if there is enough negative pressure generated within the breathing circuit to open the demand valve. A tight seal between the patient and mask / mouthpiece of the breathing circuit, and a good inspiratory effort are required to generate this negative pressure. With coaching, children 5 yrs and over are usually able to hold their own mask / mouthpiece and use this system.
- If a child becomes over-sedated using these systems, they usually lose their seal, reduce their respiratory effort, gas flow ceases, they inhale room air and gradually recover from the effects of the N_2O.

The Entonox System.

The Entonox cylinder is attached to the Entonox regulator via a yoke that is indexed by a single large pin. The regulator has 2 functions – firstly to reduce the gas pressure to safe levels and secondly to allow flow to commence when a slight negative pressure is created by the patient's inspiration and cease flow when a slight positive pressure is created by the patient's exhalation.

If the Entonox cylinder is empty then no flow will occur and the patient will usually remove their mask. However if the operator holds the mask firmly in place, this could lead to suffocation.

Check cylinder pressure before commencing, and monitor the patient and pulse oximetry throughout.

Figure 5. The Entonox cylinder attached to the Entonox regulator

Figure 6. The Midogas® System.

The unit is connected to separate O_2 and N_2O supplies and is turned on by a gas switch at the lower right side of the front panel. A lever in the middle of the front panel allows the composition of the gas mix to be continuously varied from 100% O_2 to 25% O_2 / 75% N_2O. Gas flow is initiated by a negative pressure of less than 1 cm H_2O generated by the patient's inspiration and ceases when inspiration ends. There is an emergency O_2 button, just to the left of the mixture control lever, which will flood the breathing circuit with 30L/min O_2. In the event of O_2 supply failure, a whistle alarm sounds, and an air inlet opens, but N_2O flow will continue. Note that if the N_2O is set at 75% and the O_2 fails then the patient may receive only 10% O_2 (ie. 50% air).

Breathing circuits

It is important to follow instructions regarding the decontamination and sterilization of re-usable breathing circuits and masks. Similarly, follow hospital procedures with respect to disposal of single-use circuits, filter and masks. The 2 types of breathing circuits that will be used for inhalation analgesia are:

1) *The Bains (coaxial) circuit*

- This circuit is used with continuous flow delivery devices.
- It consists of a 'Bains block', connected to both a corrugated outer tube and a smaller smooth inner tube that run together from the 'block' to the patient connection (the filter / mask / mouthpiece).
- The Bains block is a solid piece of equipment that directs the fresh (inspired) gas flow down the smaller inner tube, collects the expired gas that returns along the outer tube, and houses connections to the reservoir bag, the expiratory valve, and scavenging connector.
- Fresh gas flows for use with Bains circuit:
  - 150 mls/ kg/minute
  - but never less than 3.5 Lmin
  - always err on the side of increased flow.

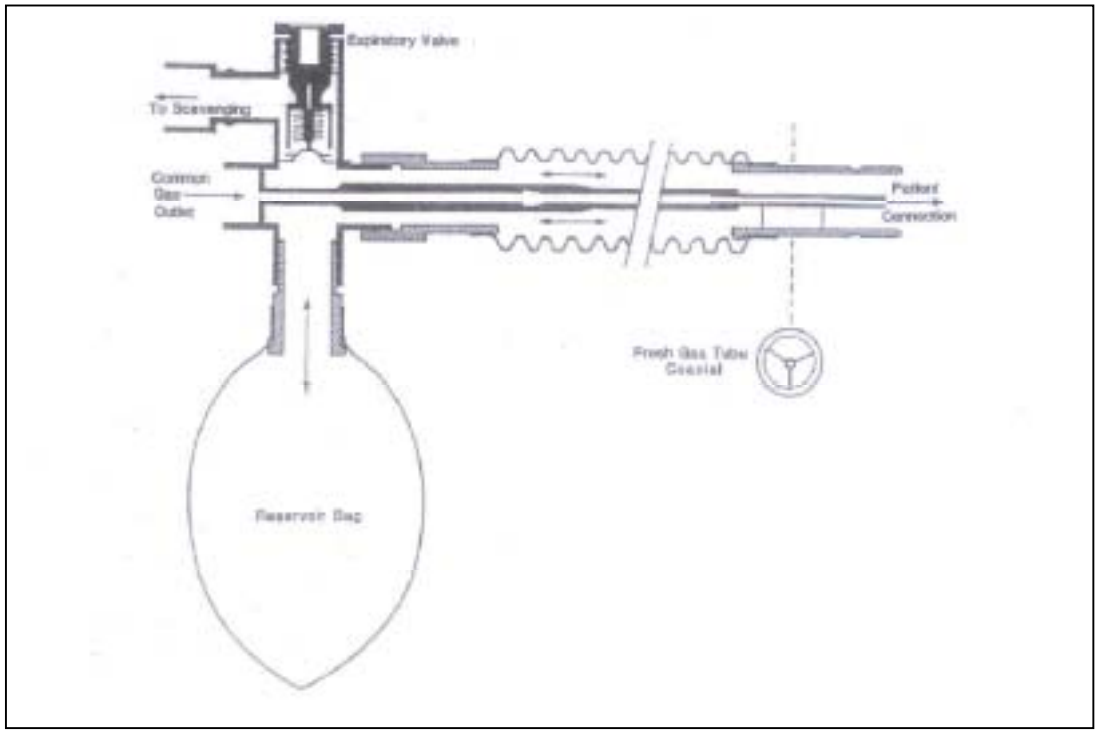

Figure 7. Bains circuit.

2) *Magill circuit*

- This circuit is used with the demand-valve delivery systems.
- It consists of a simple corrugated tube that connects the common gas outlet on the delivery device to a T-shaped hand-piece that has connections for the filter and mask on one arm and a flap non-return valve for expiration on another.
- When flow starts, gas enters along the inspiratory limb and when the patient exhales, flow ceases and the slight positive pressure opens the expiratory flap valve. Exhaled gas enters the room.

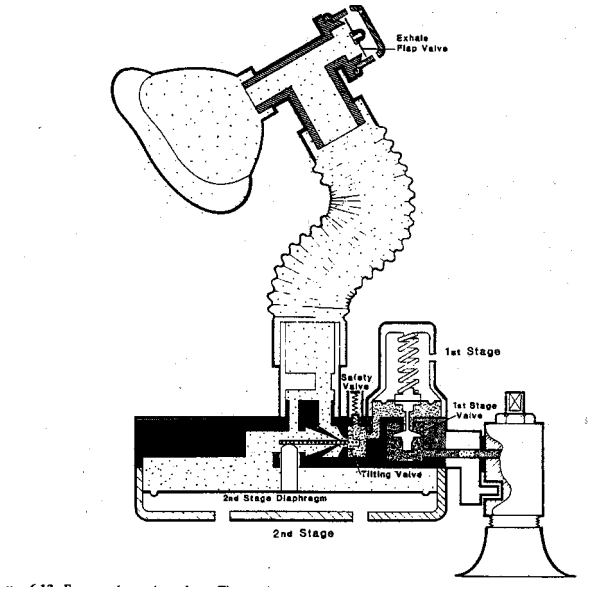

Figure 8. The Magill circuit – has an inspiratory limb, filter, mask and expiratory flap valve.

Both types of breathing circuit should be used with a new airway filter between the breathing circuit and the patient. The filter should be replaced after each case. Filters conserve heat and moisture in the patient's airway, and reduce the risk of contamination of the delivery device by the patient's expired gas. Appropriate sized filters are Pall BB25

Both types of breathing circuit can be attached to standard masks in a range of sizes, or to a mouthpiece if the patient finds this more comfortable.

OTHER EQUIPMENT

The scavenging system

Scavenging refers to the collection of exhaust gases from the patient's breathing circuit and their removal from the immediate workspace. The scavenging collection tube (corrugated pink tubing) is connected to either the scavenging valve of the Bains circuit or to a special connector placed over the flap expiratory valve of the Entonox or Midogas handpiece (see diagram). It is important to make sure this tube does not become kinked as it may apply positive pressure to the patient's breathing circuit making exhalation difficult. This collection tube is then connected to the scavenging interface ie. a large clear cylinder with holes at the bottom and a connection for suction. The interface cylinder is then connected to wall suction (20-30 L/min).

Figure 10 shows a schematic representation of active scavenging with a 'bassoon' open tube interface. This acts as both a positive and negative pressure relief system. The five parts of the overall system, the gas capturing assembly, transfer tubing, interface, gas disposal and evacuation system, are common to most active scavenging systems. The connection from the gas capturing assembly is now 30mm male. Colour coding (red) should be used for the transfer tubing to avoid confusion with the breathing hoses.

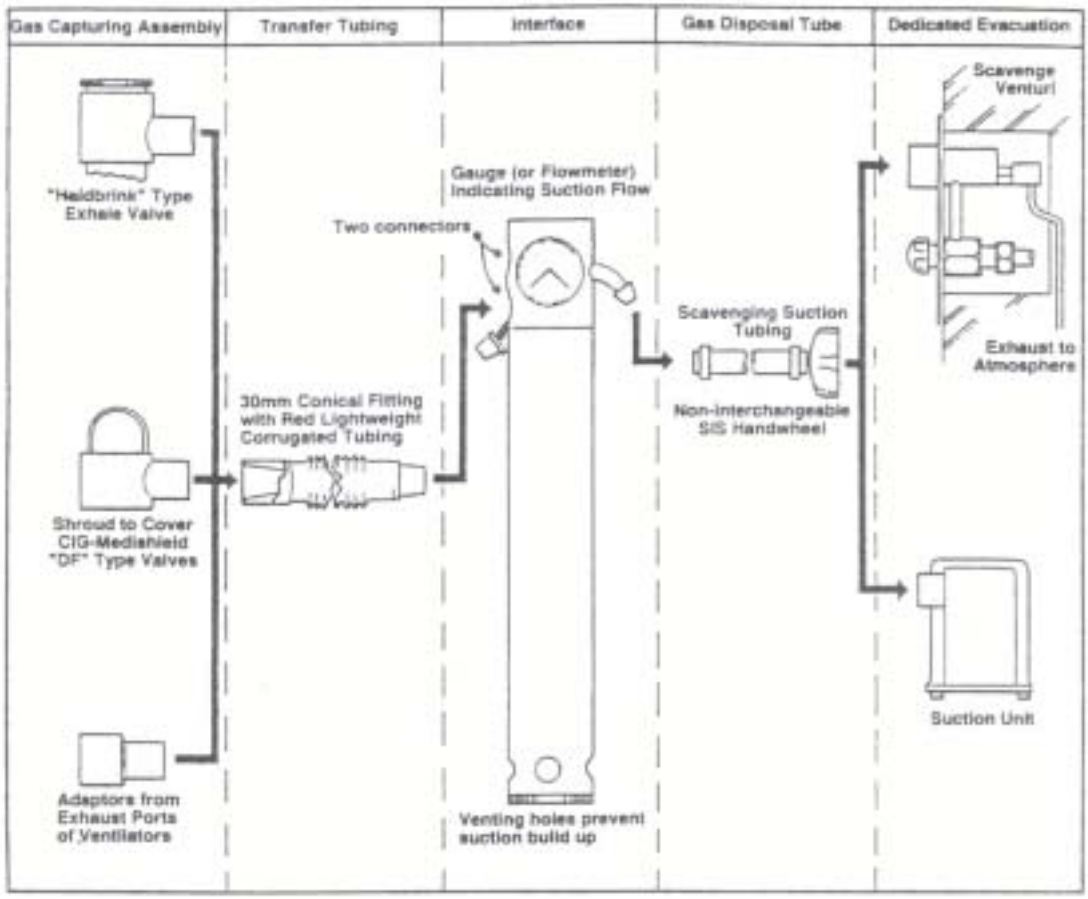

Figure 9. A schematic representation of active scavenging.

Monitoring equipment

The most important monitor is you. You need to ensure that there is adequate lighting to observe your patient (colour, distress, level of consciousness), and that you are in a position to see the flowmeters and your monitoring equipment. Pulse oximetry should be used throughout inhalation analgesia and recovery. You should turn on the pulse tone and set alarms to sound if O_2 saturation falls below 94%.

Suction and emergency resuscitation equipment

The following should always be available and checked prior to commencing the procedure:

- Suction apparatus within easy reach to remove vomitus from the child's airway
- An alternate O_2 supply in the room (eg. a second wall outlet or a full O_2 cylinder) for use in case of machine failure
- An appropriately sized Laerdel bag and mask available in the room
- Standard paediatric resuscitation equipment available and close-by on the ward
- Some mechanism for alerting staff outside the room if emergency help is needed

ACTIVITY 4

Johnny's mother consented to you administering nitrous oxide inhalation analgesia.

a) Which delivery system(s) would Johnny be able to use?

b) Pick one delivery system you plan to use and describe the other equipment you will need.

PROCEDURE FOR ADMINISTERING INHALATION ANALGESIA.

1. Obtain / check the prescription

- Nitrous oxide / oxygen inhalation analgesia must be prescribed by a medical officer prior to administration. Ward staff may request that it be prescribed.
- The prescription should specify the relative percentages of nitrous oxide / oxygen to be used, and should be written on the medication chart, signed, and dated.
- The administrator (if not an anaesthetist) must be accredited according to the policy and is responsible for ensuring the patient is correctly fasted.
- Any other agents that are to be given as a 'premed' or adjunct to inhalation analgesia should be charted and the timing of their administration should be specified (eg. EMLA applied 1 hour prior, paracetamol and oral midazolam to be given 30 minutes prior).
- Both the prescriber and the administrator are individually responsible for identifying contra-indications prior to charting or administering any drugs.
- The person administering the nitrous oxide must sign the chart following administration, noting the duration of administration and percentage of nitrous oxide that was used.
- Advice regarding planning and prescription can be obtained by contacting the Acute Pain Service Registrar (pager 2101) or the Duty Anaesthetist (contact Theatres). [NOTE: They should not be contacted for assistance *during* administration. If an adverse event occurs, institute the emergency protocol and call the arrest team for help]

2. Obtain / check the consent

- Consent for the painful procedure must be obtained from parent, parent and child or child (depending on age).
- Consent for inhalation analgesia must also be obtained. The proceduralist or the prescriber may not have done this. It remains the responsibility of the person administering the nitrous oxide to ensure that informed consent is obtained and documented prior to commencing the procedure.
- The child should be a willing participant.

3. Plan for all appropriate personnel to be available

- Inhalation analgesia should only be performed by anaesthetists or by registered nursing or medical staff who have satisfied the requirements for accreditation in inhalation analgesia.
- The administrator of the nitrous oxide is allocated to this task only and is not performing the procedure for which the nitrous oxide is being given.
- If play / music /distraction therapy is planned then a separate person may be needed to provide this.
- The proceduralist should be confident and competent, or supervised by someone who is, in order to minimise procedural time and discomfort.

4. Check the patient

- Double-check that no contra-indications exist.
- Check that fasting is adequate ie. No solids or milk for 4 hours prior, and no clear fluids for 2 hours prior.
- Check that the child and parent understand what will happen (via interpreter if necessary).
- The child should be allowed to practice using the airway and gas before the painful procedure starts.
- If using a patient-held demand-valve system, check that the child is comfortable holding the mask or mouthpiece and can form a seal around it with their lips.

5. Give the pre-med / adjuncts

- These should be given at appropriate times prior to the procedure so that they will be working when the procedure commences.
- If using opioids or sedating medications, their sedative effects should be observed prior to commencing inhalation analgesia.
- The efficacy of the concurrent medications should be evaluated before and during the procedure and documented.

6. Assemble / check the equipment

- Check the gas supplies:
  - When using wall oxygen check that it is properly connected at the wall outlet.
  - When using cylinders of oxygen, nitrous oxide or Entonox, identify which cylinders are present by their colour-coding. Check that the cylinders contain sufficient for the procedure.
- Connect the gas supply(ies) to the delivery device.
- Connect the appropriate breathing circuit to the delivery device.
- Attach an appropriately sized filter and mask or mouthpiece to the circuit. The mask should fit snugly on to the child's face over the nose and mouth. This allows adequate seal and avoids air entrainment and dilution of inspired nitrous oxide concentration.
- Connect the scavenging system to the expiratory valve of the circuit, and turn on low suction for scavenging.
- If using the Bain circuit, test it for leaks.
- If using the Entonox system, turn the Entonox cylinder on and prime the administration circuit by pressing the test button on the back of the demand valve.
- Check wall suction and attachments are set up.
- Check that the pulse oximeter is present, working and that the pulse and alarm tones are on.
- Check that the following are available in the room:
  - An emergency call system to summon help
  - An alternate oxygen supply (wall or cylinder)
  - An appropriately sized self-inflating resuscitation bag
  - Appropriate suction equipment
- Check that the following are available close-by on the ward:
  - An appropriate range of face masks, airways, endotracheal tubes
  - Standard paediatric resuscitation trolley.

7. Administer inhalation analgesia

- Always wear your personal protective equipment at all times during a procedure.
- Attach the pulse oximeter to the child.
- If using a continuous flow device, select the appropriate flow rate and mixture. If using Entonox turn the Entonox flow meter to 6-8 litres.
- Stand at the head of the child so that you can see the patient, the flowmeters, the pulse oximeter reading and the progress of the procedure.
- Offer the mask or mouthpiece to the child. If they have chosen the mask they should hold it over their nose and mouth, maintaining an airtight seal and breathing normally. If they chose the mouthpiece they should hold it between their teeth and breath through their mouth only.
- Speak in a calm, clear voice and instruct the child to breath normally. Give reassurance about the effects, safety and progress as needed.
- Allow inhalation to continue for 3 minutes before allowing the proceduralist to start any painful procedure.

8. Monitor the child

- Observe and communicate with the child throughout the procedure to determine
  - Level of pain and distress
  - Degree of sedation
  - The presence of any side-effects
- Pulse and Oxygen saturation should be monitored throughout the procedure.
- Care must be taken to avoid contact between monitoring equipment and water.

9. Complete inhalation analgesia

- Administer 100% O_2 for a full 3-5 minutes after cessation of nitrous oxide to prevent diffusion hypoxia. Continue to supplement oxygen until saturations remain above 95% in room air.
- Deliver your patient to staff responsible for monitoring their recovery, or remain with the patient yourself until they are fully recovered. Checking equipment and cleaning up can be done once the patient is safe.
- After use, check the cylinder gauges for contents:
  - If N_2O or Entonox cylinders are less than ¼ full, arrange to have the cylinder replaced
  - If N_2O or Entonox are ½ full, check that a new cylinder has been ordered
- Turn off the cylinder(s) and depressurise the system fully by operating the test button on Entonox or leaving the flows running on continuous flow machines
- Ensure cylinders are stored in a secure environment – attached to a wall or trolley and away from patients when not in use.
- Clean the equipment:
  - Multi-use face masks and mouthpieces must be autoclaved at 121°C. Single use airway equipment must be discarded.
  - Filters are for single patient use and must be discarded. They may be labelled and kept by the patient's bed if they are going to use Entonox again within the next day.
  - If there was no filter between the patient and the breathing circuit, or if contamination of the breathing circuit is suspected, then the breathing circuit should be sent for sterilization.
  - The external surfaces of the delivery machine and administration set must be cleaned with an alcohol-impregnated wipe.
- Check on the supply of cylinders, disposable or reusable masks, filters and circuits. Arrange to reorder if necessary.

10. Record inhalation analgesia

- Document your administration of inhalation analgesia in the child's progress notes.
- Details should include:
  - Relevant assessment findings
  - Reason for administration
  - Equipment used
  - Nitrous oxide concentration and any other drugs used
  - Start and finish times
  - Representative pulse rate and oxygen saturations
  - Efficacy of analgesia and sedation
  - Any adverse events, their duration, management and outcome.
- Also fill in the Nitrous Oxide Audit Form which you will find attached to the delivery device.
- If you think the plan should be changed for next time, please notify the patient's admitting team to assist them in planning repeat procedures.

11. Supervise recovery and discharge

- Sedated patients should be placed in the left lateral position until awake.
- A staff member who is continuously responsible for observation, able to initiate resuscitation, and able to call for help, should remain with the child (especially during transport) until they meet discharge criteria.
- Oxygen, suction, Guedel airway, mask and self-inflating bag should remain with the child (especially during transport) until they meet discharge criteria.
- Monitor and document the 5 vital signs hourly until discharge criteria are met.
- Continuous pulse oximetry should be monitored for the same period of time.
- Discharge criteria for return to general ward / general nursing care:
    - Cardiovascular function and airway patency are satisfactory and stable
    - The child is rousable and protective reflexes are intact (swallow, cough)
    - Absence of respiratory distress
    - Minimal pain.
- Discharge criteria for out-patients:
    - Cardiovascular function and airway patency are satisfactory and stable
    - The child can talk (if age-appropriate)
    - The child can sit up unaided (if age-appropriate)
    - The child has returned to his / her pre-sedation level of responsiveness
    - The state of hydration is adequate
    - There is no respiratory distress
    - There is not more than minimal pain
    - There is no significant nausea, vomiting or dizziness.
- Patients should not walk around unaided until any dizziness or disorientation has gone.
- Adolescent and adult patients should be advised not to drive, use machinery or perform other demanding psychomotor tasks until 12 hours after inhaled analgesia (24 hours if additional sedative drugs are used).
- A responsible adult must accompany the child to observe for complications after discharge.

TECHNICAL PROBLEMS	
If any of the following technical problems occur, the equipment should be clearly labelled with a warning and reported to biomedical engineering or your service technician immediately: • Equipment not delivering gas • Leak at joint between regulator and cylinder valve • Demand valve leaks or does not shut cleanly • Demand valve does not stop giving flow after test button is released	To ensure equipment is safe and in good working order

ACTIVITY 5

Half way through the procedure and during your administration of nitrous oxide, you notice that Johnny's O_2 saturation is falling slowly.

a) What action do you take?

b) Despite your action Johnny lets the mask fall and looks like he is going to vomit. What is your next action?

c) Johnny's mother is very anxious and appears quite pale and sweaty. What will you do?

d) Your actions in treating this situation are successful and the medical officer wishes to complete the procedure. Where to from here?

e) How will you conclude this procedure and what documentation will you complete?

COMPETENCY ASSESSMENT

Competency Assessment pre requisite

Record of attendance at Education session:

Date: **Presenter's signature**

COMPETENCY: ADMINISTRATION OF INHALATION ANALGESIA (NURSE/NON-ANAESTHETIST)

ASSUMED KNOWLEDGE
Staff are expected to demonstrate the following:

- Knowledge of the expected normal range for vital signs for children
- Knowledge and understanding of the pain assessment techniques appropriate to the child's age and ability to cooperate.
- Familiarity with Nitrous Oxide, its use and the equipment required for administration
- Familiarity with the JHCH Guidelines for the administration of Inhalation Analgesia
- Current experience in airway management and CPR

MEETS THE ASSUMED KNOWLEDGE	**Yes**	**No**	**Comment**

Element 1. Integrates knowledge and assessment findings				
Sub element	**Observable Criteria**	**Yes**	**No**	
1.1 Demonstrates knowledge, skills and judgment when assessing pain in children.	The nurse / non-anaesthetist can discuss/undertake developmentally appropriate assessment of pain in the child including assessment of: • parent and/or child self report • assessment of behaviour • assessment of vital signs • cultural factors, which may affect the assessment of pain Demonstrates knowledge and understanding of supportive and distractive pain management strategies suitable across the age continuum.			

Element 2. Safely and effectively manages the child receiving nitrous analgesia and his/her family				
Sub element	**Observable Criteria**	**Yes**	**No**	
2.1 Demonstrates knowledge, skill and judgment when preparing to administer N_2O for pain	Checks prescription on medication sheet Assesses child for contraindications Obtains/confirms consent Checks when child last had food and ensures child is correctly fasted. Gives supplementary medication as required Gathers, Correctly assembles and tests equipment and gas levels Ensures resuscitation equipment is to hand Assesses and records child's vital signs and pain level prior to undertaking the procedure Explains procedure to child and family and promotes participation Attaches cardiac and O_2 saturation monitors Liaises with person carrying out the procedure – obtains other help if appropriate			

2.2 Demonstrates knowledge, skill and judgment whilst administering N_2O for pain	Instructs the patient to hold the correctly fitting mask/mouthpiece in place Ensures that principles of OH&S and Infection control are adhered to. Correctly administers N_2O according to hospital standards and protocols Waits for N_2O to take effect before procedure is started (Approximately 2-3 minutes) Maintains verbal communication with patient Documents observations and responses throughout the procedure Continues to monitor patient till fully awake then removes monitoring equipment Responds appropriately to adverse events			
ELEMENT 3. Completes the procedure correctly				
Sub element	**Observable Criteria**	**Yes**	**No**	
3.1 Demonstrates post procedure care of patient and equipment	Ceases N_2O flow and administers O_2 100% oxygen for three 3-5 minutes Continues to monitor patient for 30 minutes post procedure and ensures that patient is comfortable and meets 'discharge' criteria Switches machine and turns cylinder (s) off and stores appropriately Discards single use equipment and cleans multi use apparatus according to infection control guidelines Documents procedure in patient's notes including outcome and on audit form (on cylinder) Initiates equipment re-ordering process as necessary			

Supervised sessions

1. Signature & Name of Assessor:
Date: / /

Participants comments:

2. Signature & Name of Assessor:
Date: / /

Participants comments:

3. Signature & Name of Participant:
Date: / /

Participants comments:

Mastery Outcome:
Assessors Comments:
1.

2.

3.

Suggested NITROUS OXIDE AUDIT SHEET John Hunter Children's Hospital

NOTE: NITROUS OXIDE SHOULD ONLY BE ADMINISTERED BY STAFF WHO HAVE HAD APPROPRIATE TRAINING

Date	Ward	Patient	Gauge reading		Procedure & Administrator	Duration	Comments. (effective? if not why not, side or adverse effects)	Sign
			Start	end				

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