



ENTONOX® GUIDELINE


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1.0 Introduction

Entonox® is a ready-to-use gas mixture consisting of 50% nitrous oxide and 50% oxygen. Nitrous oxide is a colourless, sweet smelling gas with powerful analgesic properties which takes effect within 2 minutes of inhaling the gas. Nitrous oxide is administered by inhalation, absorbed by diffusion through the lungs, and eliminated via respiration. The patient's level of consciousness determines his/her ability to maintain gas flow. Thus, there is little risk of overdose. Due to its low fat solubility, it does not accumulate within the body. The elimination half- life of nitrous oxide is approximately 5 minutes (Glasper et al, 2010, BOC Healthcare 2010). Entonox® is particularly suitable for acute pain associated with injury, trauma, and therapeutic and investigative procedures.

Entonox® should only be used for painful procedures. Procedures that are primarily frightening in nature should be managed using psychological input and sedation/anxiolytics as appropriate.

2.0 Definition of Guideline

This Guideline provides standardised instructions about how to ensure high quality service for the safe delivery and supervision ^{by} competent registered nurses to children self-administering Entonox® for the relief of procedural pain.

3.0 Definition / Terms


- **Entonox®** is a gaseous analgesic agent composed of nitrous oxide and oxygen in equal proportions of 50% Oxygen and 50% Nitrous Oxide (BOC Medical, 2010).
- **Inhalation:** the drawing of an aerolised drug into the lungs with the breath (Dorland's Pocket Medical Dictionary, 2004).
- **Pain Service:** Consultant Anaesthetist lead Dr Kevin McCarthy, Advance Nurse Practitioner (ANP) and Advanced Nurse practitioner candidate (ANPc). Clinical Nurse Specialist practitioner (CNSp),

4.0 Applicable to

- Applies to nursing staff, who have successfully completed the BOC Entonox® on-line training resource (*the compulsory module pain management and the paediatric specific module*) and has been deemed competent in the delivery of self-administered Entonox®.
- Staff members must maintain up to date PILS/APLS training.

A list of the staff that has been trained in the use of Entonox® should be kept on each ward.

- The Pain Control Service may be able to administer Entonox® in clinical areas where staff have not been trained in its use.

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5.0 Objectives of Guidelines

The main purpose of the guideline is to apply standardised best practice to all areas identified in the guideline, where there are children and young people over the age of 6 years who would benefit from the self-administration of Entonox® for the management of painful procedures.

All health care professionals should be trained in the use of Entonox® before administering it.

6.0 Guideline

6.1 Storage and use of Equipment- See SOP for preparation of Entonox® equipment.

- The Portable Entonox® cylinder **is stored in the nitrous oxide gas room in PICU Floor 1** (between the entrance of Operating Theatre and PICU floor 1 area).
- Spare mouthpieces can be sourced from the nursing staff on the pain service. Only remove the cylinder and regulator from the storage area immediately prior to use.
- Ensure cylinder must not be used if too cold, it will automatically be remixed for use by storing it above 10°C for at least 24 hours.


6.2 Health and Safety

- Entonox® supports combustion and must not be used near an ignition source (BOC, 2014)
- **No smoking is permitted in the area where Entonox® is stored or used.**
- **Maximum exposure limits:** Entonox® is excreted unaltered via the patient's breath. In the UK and Ireland, the maximum exposure limits for nitrous oxide is set at 100ppm over an 8 hour period (BOC 2013). This level is significantly below the concentrations where any detrimental effect will be caused.
- Thorough ventilation or scavenging of waste gases should reduce atmospheric room levels of ambient nitrous oxide to a level below 100ppm. (BOC, 2013, Messeri et al ,2016).
- **Scavenging equipment is recommended for prolonged and continuous use** and individual clinical areas will need to assess potential use of Entonox® and ventilation requirements (Messeri et al, 2016).

****** The evidence base for what constitutes a well ventilated area is sparse but literature and anecdotal evidence from practitioners experienced in the use of Entonox® suggest areas with air conditioning or open windows are adequate for occasional to regular use******

6.3 Risk Assessment: A risk assessment (see appendix1) should be carried out by the practitioner to ensure ventilation is adequate and action should be taken to move the patient to a well ventilated area if necessary.

- As a health and safety measure it is recommended that anyone who is in the **first trimester** of pregnancy should not remain in the room/immediate area while

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Entonox[®] is being use (BOC, 2016).

- Staff administering Entonox[®] have a duty of care to ensure that those in the immediate vicinity, including the child and family members where appropriate, are aware of this risk and have the opportunity to remove themselves from the immediate area discretely if they choose.

6.4 Side effects Nitrous Oxide (the active component of Entonox[®])

General

Dry mouth, disorientation, dizziness, euphoria, loss of inhibition, feeling floaty, blurring vision, tingling sensation to lips, fingers and nose (harmless and will stop when inhalation of Entonox[®] is discontinued) and less commonly, nausea and vomiting, excessive sedation.

Discontinue use immediately if child complains of earache.

Vitamin B12

Nitrous oxide oxidizes cobalamin and thereby inactivates vitamin B12. Prolonged exposure to nitrous oxide can cause a myeloneuropathy similar to subacute combined degeneration of the cord. Acute exposure may precipitate a similar clinical syndrome in patients with pre-existing sub-clinical vitamin B12 deficiency and depression of white cell formation may also occur.

Cardiovascular effects

Nitrous oxide may cause mild increases in pulmonary vascular resistance which may be significant in patients with pulmonary hypertension, particularly mitral stenosis.


Other

Staff working with Entonox[®] should be aware it is a habit forming drug and has been subject to misuse.

6.5 Indications for use

Entonox[®] can used for a variety of painful procedures which include but are not limited to:

- Wound and burn dressing, suturing and removal of sutures (Bruce and Frank, 2000).
- Changing or removing packs and drains (Bruce and Frank, 2006).
- Invasive procedures such as urinary catheterisation, nerve conduction studies, change of gastrostomy tube (Farrell et al, 2008; Glasper et al, 2010)
- Aspiration of synovial fluid and or intra-articular administration of steroids (Weiss et al, 2010)
- Acute trauma, fracture reduction, application and removal of traction or POP (Heinrich et al, 2015).
- Bone marrow aspiration or lumbar puncture (Culshaw et al, 2003)
- Also suitable for children and young people undergoing venepuncture and insertion PICC lines (Ekbohm et al, 2011) and injections e.g. Botulinum (Botox[®]) (Brochard et al, 2011).

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6.6 Patient selection

The child and family have the right to make an informed decision about care and so must be provided with adequate information of the potential risks and benefits of Entonox[®], as well as alternative analgesia, and the opportunity to discuss these. Verbal consent/assent should be obtained prior to the procedure and documented in the child's clinical record.


The age at which a child is able to use self-administered Entonox[®] depends on a number of factors such as ability to co-operate and follow instructions. Children under 6 years are rarely able to self-administer Entonox[®] successfully.

6.7 Contraindications

- Nitrous oxide diffuses into cavities so it is not used in the following circumstances:
 - If a pneumothorax or bowel obstruction is suspected.
 - Suspected air embolism or decompression sickness
- Raised pulmonary vascular pressure e.g. pulmonary hypertension.
- Head injury.
- Alcohol and drug intoxication.
- Increased risk of airway loss e.g. acute respiratory infection or exacerbation of asthma.
- Airway obstruction or history of difficult airway management.
- Maxillofacial injuries as there is a need to grip the mouthpiece with teeth or firmly push a mask onto the face to get a good seal.
- Nasal blockage- e.g. adenoid hypertrophy or common cold.

6.8 Relative contraindication

- Toxicity may occur with prolonged use (more than one hour per day over five days).
- Megaloblastic anaemia, peripheral neuropathy, leucopenia, or thrombocytopenia may occur due to megoblastic changes in the red cells and hyper-segmentation of the neutrophils; check blood cell count if child has prolonged use.
- Entonox[®] should be used with caution in patients at risk for nitrous oxide induced bone marrow suppression, neurotoxicity or increased homocysteine levels as exposure to nitrous oxide depletes the body's stores of vitamin B12 and very rarely this can precipitate neurological complications (Culshaw, 2003).
- History of B12 or folate deficiency.
- Nutritionally compromised patients, vegetarians, children receiving synthetic diets (e.g. phenylketonuria, maple syrup urine disease) patients on H₂ blockers or proton pump inhibitors.
- Concurrent underlying serious illness, severe infection.
- Patients with metabolic diseases associated with homocysteine metabolism (methionine synthetase deficiency, homocystinuria and methylmalonic academia.
 - Children who are too drowsy to listen to instructions and use Entonox[®].

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7 Administration

- Prescription: Entonox[®] must be prescribed on the patient's medication kardex (OLCHC) or on Entonox[®] monitoring sheet (CUH). In the emergency department setting it is to be prescribed on the medication section of the Emergency Department sheet.
- One nurse, or trained health care professional will specifically care for the child as he or she self-administers the Entonox. The nurses' role is to assess the child's ability to self-administer Entonox[®], to observe the effectiveness and any side effects and to support and assist the child as necessary in the use of Entonox[®].


7.1 Equipment and preparation of equipment: see SOP preparation of equipment for Entonox[®]

- Entonox[®] cylinder regulator
- Blood pressure monitor
- Entonox[®] delivery unit-input hose
- Pulse oximeter
- Carnet valve and mouth piece with bacterial/viral filter
- Oxygen & suction equipment
 - Emergency equipment available and in working order prior to administration.
 - Ability to commence patient on continuous oxygen saturation monitoring.
 - Access to facemask / nasal prongs.

Competent practitioners check that the equipment is in working order before use and that access to emergency equipment (oxygen, suction, emergency trolley) is readily available.

7.2 Preparation of the Patient before the Procedure

- Carry out the pre administration check list for the patient and equipment checklist.
- The child or young person should avoid eating a large meal for an hour before the procedure to reduce the likelihood of nausea and vomiting.
- No routine monitoring is necessary but resuscitation equipment must be available. Children with abnormal airways may need continuous saturation monitoring.
- Ensure other analgesia has been administered before the procedure to optimize pain management for the procedure.
- Assess the patient's degree and level of anxiety and whether Entonox[®] is the appropriate analgesia.
- Assess the child for ability to use Entonox[®]. The child should be able to understand and be able to cooperate and follow instructions and be physically able to hold and use the mouthpiece and inhale the gas while breathing normally (Glasper et al, 2010).

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7.3 Administration to the patient

- Explain the procedure to the patient, how the Entonox® will work and what side effects may be expected.
- Allow the child to practice using the equipment and involve the play specialist if possible to ensure effective technique is established.
- Instruct the child to place the mouthpiece between their teeth and breathe through their mouth only. When used correctly a "hissing" sound will be heard. If chest expansion is too shallow, the child or young person will not inhale sufficient Entonox® to provide effective pain relief. 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 the mouth piece of the breathing circuit, and a good inspiratory effort are required to generate this negative pressure.
- Inhalation should commence for at least 2-3 minutes or more before the procedure to ensure the child or young person obtains maximum benefit from Entonox® prior to commencement of the procedure. (BOC, 2016).
- The child or young person may need considerable encouragement to start inhaling the gas. It is worth preserving as any initial reluctance usually disappears once the child realizes that the Entonox® is working (Bruce and Frank, 2000).
- The nurse should not hold the mask or mouth piece to the child's mouth to prevent over sedation (Bruce and Frank, 2000). Some children may need assistance to support the mask or tubing with a light touch.
- Once administration has commenced: The child should continue to use Entonox® as required throughout the procedure and should be encouraged to breathe slowly and deeply. If the child hyperventilates they should be encouraged to exhale slowly.
- Observe the child throughout the procedure to determine:
 - Level of pain, presence of side effects, and effective use of Entonox®

N.B. Any change in the child's observations should be immediately communicated with the physician or nurse responsible for the procedure and might require immediate intervention for airway compromise or cardiovascular depression.

- If any side effects are experienced by the patient the Entonox® must be discontinued until the side effect has resolved. Once resolved, re-evaluate the patient's level of pain for the most effective type of analgesia.

Side effects	Action
Complaint of earache	Uncommon but could be a serious side effect. Cease inhalation and offer alternative analgesia.
Dry mouth	Common but not usually distressing. Provide water and recommence inhaling
Dizziness, drowsiness or disorientation	Common after inhaling for a length of time, but not normally distressing. Cease inhalation until effects subside.
Nausea	Effects wear off, allow patient to rest for a while and recommence administration. Cease inhalation if this becomes too distressing.

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7.4 Completion of the procedure

- At the end of the procedure, ensure the child is comfortable.
- Take the mouthpiece or face-mask from the child and continue to monitor and remain with the child until effects are no longer evident (at least 15 minutes).
- The administration of oxygen post the procedure maybe required.
- If the patient experiences any dizziness he/she should remain seated or on bed rest and not walk around unassisted. Monitor patient until side effects have resolved.

Documentation: The effectiveness of the Entonox® and all side effects or adverse events should be reported to the medical team and documented in the patient's Health Care Record and the sedation record to monitor the length of time the gas is used which is important if repeat procedures are performed over several days or any side effects experienced by the child.

Entonox® Cylinder: see SOP equipment preparation for Entonox®.

- Close the cylinder. Press the test button on the demand valve to remove residual gas (BOC, 2013).
- Check the remaining level of Entonox® on the gauge and if less than ¼ left order a replacement.
- The mouthpiece and filter are single patient use only. Dispose of this in Healthcare Non-Risk Waste (i.e. Household Waste).
- Return Entonox® cylinder to store room.

Decontaminate the outside of the demand valve handset and the gas supply hose with an alcohol or disinfecting wipe (BOC, 2016) or clean with Brial and disinfect with Actichlor™. If there is reason to believe that the demand valve handset is contaminated it can be disinfected using a cold disinfection process but will need to be disassembled first. Full details of how to disassemble, clean and disinfect the device can be found in the Service Manual. **Do not immerse the demand valve in water.**


7.5 Discharge Criteria

Patients may be discharged from hospital once they meet the following discharge criteria:

- Return to normal (pre-sedation) level of consciousness
- Resumption of purposeful neuromuscular activity
- Ability to ambulate (if appropriate) or able to sit without support as appropriate
- Ability to verbalize appropriate for age.

8.0 Special Considerations

8.1 Haematological monitoring: when Entonox® is used for more than a total of 24hrs, or more frequently than every four days, it must be used with close haematological monitoring (FBC) as regular or prolonged use of Entonox® can lead to depletion of vitamin B12 stores. The FBC is examined for evidence of megaloblastic change in red cells, reduced production of

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leucocytes or hypersegmentation of neutrophils (Amos et al 1984, Nunn 1987). In situations where Mean corpuscular volume (MCV) is increasing, Folinic Acid supplements may be required and should be administered as prescribed.

8.2 Methionine enriched diet: When a child is receiving Entonox® for >3 hours daily (burn injury), consider a methionine enriched diet. Consult with Haematology team and dietician. (OLHSC 2006)

9.0 Companion documents

- **SOP: Preparation of equipment for Entonox®**
- Hand hygiene policy
- Medication policy
- Pain measurement tools – (FLACC, FLACCR – Numerical – FACES).
- Entonox assessment and monitoring sheet(Appendix 1)
- Audit of Entonox® use St Annes (Appendix 2)
- Competency Assessment

10.0 Implementation Plan

- Training in the use of Entonox® will be provided by the Pain service CNSp/ANP or ANPc, or staff who have been deemed competent following successful completion of the BOC online training resource, competency assessment, and completion of PILS.
- A copy of the certificates should be sent to CNF or Pain Service nursing staff on completion of the training.
- Additional supervision and recertification of competency will be provided following return from maternity leave or prolonged absence from work.


11.0 Monitoring and/or Audit

- Adherence to this guideline will be monitored by the Pain service.
- Incident reports involving Entonox® administration will be monitored and reports will be responded to when they occur.
- Required changes in practice will be identified and actioned within 1 month. A lead member of the pain service will be identified to take change forward where appropriate.
- Lessons will be shared with all the relevant stakeholders.

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Registration is free to users.

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14.1

Appendix 1

Entonox® Patient Assessment and Monitoring form


Date: _____ Weight: _____ Name _____
 Procedure _____ HCR No _____
 Entonox® Prescribed YES No (Do not proceed unless prescribed)
 Contraindications (if any Yes responses check with medical practitioner / Pain Service)

Pneumothorax- chest injury	Yes	No
Airway obstruction or history of difficult airway management.	Yes	No
Head Injury with loss of consciousness	Yes	No
Increased risk of airway loss, acute respiratory infection (URTI) , difficult airway or exacerbation of asthma	Yes	No
Severe Bullous emphysema	Yes	No
Intestinal obstruction or abdominal distension	Yes	No
Maxillofacial injuries	Yes	No
Increase in pulmonary vascular pressure e.g. Pulmonary Hypertension.	Yes	No
Middle ear occlusion / pathology	Yes	No
Any depressed conscious level e.g. alcohol or drug intoxication	Yes	No
Any recent underwater dive	Yes	No
Relative Contraindication:		
Special precautions Children who have already received sedation – In this situation, please discuss the child's care with Acute Pain Service or the Anaesthetic Consultant. (Note: the use of Opiates for analgesic effect does not out-rule the use of Entonox®) Exposure to nitrous oxide depletes the body's stores of vitamin B ₁₂ and very rarely this can precipitate neurological complications. Careful thought should be given to those: who use Entonox frequently, those with poor intake or with malabsorption syndrome, those on synthetic diets (e.g. phenylketonuria, maple syrup urine disease). Staff or parent in the first trimester of pregnancy may wish to avoid the area while Entonox® is in use		

Used Entonox previously: _____ Outcome:

Pre- Entonox®: _____ Oxygen Saturation: _____ Respiration Rate: _____ / min. Heart Rate: _____ / min

Pre Entonox® Risk Assessment (see above)	Yes	No	Comments
Allergies	Yes	No	
Analgesic administered prior to procedure if appropriate	Yes	No	
Equipment Check			
Entonox equipment in date and working	Yes	No	
Suction and oxygen available and working	Yes	No	
Pulse oximeter required (if cardiac /respiratory condition)	Yes	No	
Resuscitation Equipment & Drugs			
Area well ventilated or scavenging equipment available	Yes	No	
Adequate staff available	Yes	No	
During Procedure			
Child using Entonox® well	Yes	No	
Side effects (list) or adverse events	Yes	No	


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Observations and Sedation level monitored (see over)	Yes	No	
Post Procedure			
Patient returned to baseline level of sedation	Yes	No	
Observations within normal limits	Yes	No	
Would child use Entonox® again?	Yes	No	
Documentation in Health care Record	Yes	No	
Clean handset and tubing	Yes	No	
Entonox cylinder needs replacing (contact technical services)	Yes	No	
Entonox cylinder returned to storage area	Yes	No	

If pain score $\geq 7/10$ **STOP** procedure, encourage child to use Entonox

If sedation score of ≥ 3 **STOP** Entonox and administer Oxygen

Start Time	00	05	10	15	20	25	30	35	40	45	50	55
SpO ₂												
Respiratory rate (if appropriate)												
Heart rate (if appropriate)												
Sedation Awake and Alert =0 Minimally sedated = 1 Moderately Sedated = 2 Deep sedation = 3 Unrousable = 4												
Pain score 0-10												
Nausea												

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PAIN SCORE	NAUSEA SCORE	SEDATION SCORE
0 = NO PAIN 1-3 = MILD PAIN 4-6 = MODERATE PAIN 7-10 = SEVERE PAIN	0 = NONE 1 = NAUSEA ONLY 2 = VOMITED ONCE SINCE LAST SCORE 3 = VOMITED MORE THAN ONCE	0 = AWAKE & ALERT eyes open spontaneously 1 = EYES OPEN TO SPEECH. Patient responds to verbal commands. 2 = EYES OPEN TO SHAKE A drug-induced state of depressed consciousness with preserved airway protective reflexes. Easily roused with tactile stimulation or verbal command. 3= DEEP SEDATION may be accompanied by partial or complete loss of protective airway reflexes. Unable to respond to physical stimulation or verbal command 4= UNROUSABLE

TIME ENTONOX COMMENCED: _____ **DURATION:** _____ **OUTCOME:** _____

OTHER COMMENTS:

Name of person carrying out procedure	Name of Entonox® administrator
Date & Time	Date & Time

14.2 Appendix 2: Record of Entonox® Use St Annes

Please complete the audit form following each use of Entonox®.

Sign						
Staff in attendance at procedure						
Give details of effectiveness, pain core, side-effects, etc.						
New cylinder ordered if gauge reads < 1/4 full	No					
	Yes					
Type of procedure						
Duration of procedure	Time ended					
	Time started					
Patient HCR No.						
Date						