

**NITROUS OXIDE** (Commentary)**How effective is nitrous oxide when used in young children?**

We owe an unacknowledged debt of gratitude to the French for doing the first really comprehensive study of the use of Entonox® (a 50:50 mixture of oxygen and nitrous oxide) to alleviate procedural pain in children. A report on its use on over a thousand occasions (Annequin *et al.*, 2000) was followed a year later by a report on its use to provide pain relief during seven and a half thousand procedures (Gall *et al.*, 2001). Serious problems (cyanosis, bradycardia, apnoea or sustained loss of verbal contact) were only encountered on twenty five occasions, and almost all of these problems occurred in children who had also had benzodiazepine sedation as well as an opiate. Even then the problem resolved within minutes once Entonox use was stopped. Entonox seemed to provide substantial pain relief for a whole range of brief but painful procedures such as suturing, burn dressing, fracture reduction, bone marrow aspiration, lumbar puncture, venepuncture, abscess drainage, biopsy procedures, bronchoscopy, gastroscopy, and cast remodelling. Infiltration with lidocaine was also employed where appropriate for procedures such as suturing. Side effects were infrequent. The commonest was brief euphoria. Four per cent suffered nausea and a few of these vomited; three per cent reported transient dizziness or hallucinations. None of these problems persisted for more than five minutes once Entonox administration was stopped. Ninety-three per cent of those old enough to be questioned said they would willingly accept Entonox analgesia again if offered it. Children old enough to cooperate often found a simple or valved mouthpiece more acceptable than a face mask.

There has been some suggestion that equipment capable of delivering up to 70% nitrous oxide in oxygen might offer even more effective pain relief (Kanagasundaram *et al.*, 2001), but there was little evidence of this in a recent very much larger study involving 762 1–17 year old children (Babl, *et al.*, 2008). If a system capable of delivering a variable amount of nitrous oxide is used a fail-safe device must be employed so that there is no risk of the child receiving less than 30% oxygen, and saturation must be checked with a pulse oximeter. The speed with which nitrous oxide delivers analgesia is a major advantage, as is the speed with which patients recover. Those who first introduced this drug's use in children used a demand valve system similar to that traditionally used by women in labour, but most children under five find this difficult to use. Continuous flow systems with scavenging, using either a mask or a mouth piece, work much better in young children, and this approach is now widely used in children of all ages (Babl, *et al.*, 2008).

Only 0.2% of the children in the French study (132/7511) and none of the 762 children in the recent study from Melbourne, Australia, were less than a year old, but there is no good reason to think that Entonox use is likely to be less effective or less safe in children younger than this. The French study showed that a nurse can administer Entonox to children more than a year old with proper training as safely and effectively as a doctor. It would be difficult to mount a study to show that Entonox can control pain in the neonate as effectively as it can in older children (any such assumption will need to be taken 'on trust'), but there is certainly a pressing need to get a study mounted to show whether use is equally safe because, while a brief pulse of IV remifentanyl (q.v.) probably provides the best strategy for managing serious short-lived procedural pain in the ventilated baby, we still know very little about how to minimise pain in a non-ventilated baby. Studies certainly suggest that nitric oxide has advantages over midazolam, or even ketamine, when trying to relieve the distress caused by painful procedures in older children (Luhmann *et al.*, 2001; 2006). Even for simple venepuncture nitrous oxide seems to be able to relieve pain just as effectively as EMLA cream (see the monograph on lidocaine) applied an hour or more before blood is due to be taken (Gall *et al.*, 1999). Propofol (q.v.) is increasingly seen as the most effective drug to use when nitrous oxide is not thought likely to produce adequate pain relief, but there is little doubt that this should only be given by a qualified anaesthetist or other clinician with intensive care experience.

**Safe use**

Upper airway obstruction is extremely uncommon when sedation is achieved using nitrous oxide, but it should never be offered in a setting where this can not be recognised promptly and overcome without delay. In 2006 the American Academy of Pediatrics and the American Academy of Pediatric Dentistry issued revised joint guidelines for the monitoring and management of children during and after sedation for diagnostic and therapeutic procedures (Coté and Wilson, 2006).

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