

Nurse administered relative analgesia using high concentration nitrous oxide to facilitate minor procedures in children in an emergency department

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Emerg Med J 2003;20:410-413

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Accepted for publication 22 May 2003

Aims: To describe the experience of using high concentration nitrous oxide (N₂O) relative analgesia administered by nursing staff in children undergoing minor procedures in the emergency department (ED) and to demonstrate its safety.

Method: Data were collected over a 12 month period for all procedures in the ED performed under nurse administered N₂O sedation. All children greater than 12 months of age requiring a minor procedure who had no contraindication to the use of N₂O were considered for sedation by this method. The primary outcome measure was the incidence of a major complication namely respiratory distress or hypoxia during the procedure. Secondary outcome measures were minor complications and the maximum concentration of N₂O used.

Results: Data were collected for a total of 224 episodes of nurse administered N₂O sedation over a 12 month period. In 73.2% of children no complications were recorded. One major complication was recorded (respiratory distress) and the most common minor complication was mask intolerance in 17%. The mean maximum concentration of N₂O used was 60.2%.

Conclusions: N₂O is a safe analgesic in children over the age of 1 year undergoing painful or stressful procedures in the ED. It may safely be administered in concentrations of up to 70% by nursing staff after appropriate training.

Many ill and injured children attending emergency departments (EDs) require sedation and analgesia for brief procedures that are painful or anxiety provoking but that do not justify a general anaesthetic.¹ In our ED these procedures include cannulation, wound repair, minor fracture manipulation, lumbar puncture, bone marrow aspiration, and removal of foreign bodies from ears and noses. Choosing a safe and efficacious sedative agent for these procedures that is suitable for use in the ED is a daily consideration for emergency physicians.

Procedural sedation has been defined by the American College of Emergency Physicians as "a technique of administering sedatives or dissociative agents with or without analgesics to induce a state that allows the patient to tolerate unpleasant procedures while maintaining cardiorespiratory function..."² Relative analgesia refers to this state of analgesia and sedation.

Nitrous oxide (N₂O) has a number of advantages that make its use preferable to other agents for relative analgesia in the ED. It provides analgesia within three minutes of inhalation and this analgesic effect disappears less than four minutes after cessation.³ The physical properties of N₂O account for its efficacy as a short acting agent. Because it is not metabolised, N₂O is almost completely eliminated by the lungs in an unchanged state. It does not bind to any carrier proteins during transport and therefore avoids the difficulties of drug interactions.⁴

Previous studies have demonstrated that N₂O may safely be used, when administered by doctors, at concentrations of up to 50% in children for a wide variety of procedures.³⁻⁵⁻¹⁰ Our hospital has developed a programme to train nurses in the administration of N₂O in concentrations of up to 70%. Hospital policy allows the administration of N₂O to children by staff who have undergone the appropriate training and accreditation and who have applied to and have been approved by the director of clinical services. The accreditation process consists

of attendance at an introductory lecture on the technique and successful completion of a nitrous accreditation package, followed by a demonstration of practical ability in using the technique. This includes three observed N₂O administrations under the guidance of an educator or clinical nurse specialist. To maintain an acceptable level of skill, annual attendance at a review lecture on the technique and re-accreditation is required if staff are not administering N₂O on a regular basis (that is, two per month). This programme was initially implemented on the wards and after its success¹¹ has been developed to permit relative analgesia using this technique in the ED.

The aim of this paper is to report our experience using nurse administered N₂O and to demonstrate its safety when used to facilitate minor procedures undertaken in the ED.

METHODS

Setting

This prospective descriptive study was conducted over 12 months from 1 July 2001 to 30 June 2002 on all consecutive patients receiving nurse administered N₂O relative analgesia presenting to the ED of the Children's Hospital at Westmead. The Children's Hospital is the tertiary paediatric centre for the western area of Sydney (feeding population of 2 million) and the western region of NSW as well as parts of the South Pacific and the paediatric burns' referral centre for NSW. The ED during the time this study was undertaken had a patient census of around 45 000 presentations.

Population

Any child over 12 months of age requiring relative analgesia for a minor procedure in the ED was eligible for consideration for inclusion in the trial. Children were excluded from the study if they had a longstanding disease, acute respiratory infection, upper airway obstruction, asthma, previous anaesthetic reactions, recent middle ear surgery, penetrating eye

Table 1 Study procedures (n=224)

Procedure undertaken	Number (%)*
Wound examination and closure (tissue glue/steri-strip/suturing)	81 (36.2)
Investigative procedure (intravenous cannulation, venepuncture, lumbar puncture, bone marrow aspirate)	74 (33.0)
Application of dressings (wounds and burns)	19 (8.5)
Orthopaedic (manipulation of fractures and dislocations)	18 (8.0)
Miscellaneous (removal of foreign body, urinary catheterisation and change of gastrostomy tube)	32 (14.3)
Total	224 (100)

*Column percentage.

injury, or undrained pneumothorax. In addition ED nurses may not administer N₂O to children who have received intravenous opioids or sedatives although nurses on the pain team may do so.

Procedural protocol

(A full protocol of the procedure is available from the authors). Before the administration of the N₂O the patient was assessed by a medical officer to ensure that the administration of N₂O was appropriate and the patient was kept fasted for two hours before the procedure.

Equipment

The apparatus used to administer N₂O at a variable concentration consisted of the Quantiflex Mark II relative analgesia machine (Cyprane, Keighley, Yorkshire, UK) a Lack circuit, minimum volume antiviral, antibacterial filter (for children >10 kg), appropriate facemask, scavenger equipment, oximeter, and suction. The relative analgesia machine is a constant flow device that has a failsafe delivery of minimum 30% oxygen at all times.

Procedure for the administration of N₂O

The ED has piped N₂O in all patient clinical areas and at each procedural and resuscitation bed. The patient started breathing the gas using either the facemask or mouthpiece. Administration was started at least three minutes before any painful procedure was attempted. The N₂O/oxygen mixture was then titrated and the nitrous flow adjusted by 1 litre/min at the discretion of the administrator to a maximum of a 70% mixture of N₂O. At the end of the procedure, or at any time when the mask was removed for more than 30 seconds, the patient breathed 100% oxygen for three minutes or until the procedure was resumed.

Patient monitoring

The administrator of the N₂O relative analgesia monitored the patient, and maintained constant appropriate communication with the patient at all times. They observed and recorded the patient's state of consciousness, respiration, and airway patency. Pulse oximetry was used in all cases and any episode of desaturation (oxygen saturation <90%) was recorded and 100% oxygen administered.

Study outcome measures

All outcomes were defined a priori and applicable data collected. The primary outcome measure used in this study was the occurrence of a major adverse event. This occurred when a patient developed during or within one hour after the procedure respiratory distress (defined as tachypnoea with nasal flaring and chest retractions) or hypoxia (defined as desaturation as measured by pulse oximetry <90%). Secondary outcomes were; (a) minor adverse events—vomiting (defined as one single vomit during the procedure or an episode of vomiting in the immediate recovery period), mask intolerance (the inability or unwillingness of the child to tolerate the mask for the duration of the procedure), convulsion

(loss of consciousness associated with myoclonic movements), or dysphoria (unpleasant dreams) and (b) the maximum concentration of N₂O administered during the procedure.

Data collection

Data were prospectively collected over a 12 month period. As well as data relating to the outcome measures, we also recorded basic demographic data, the use of adjuncts such as local anaesthetics and other analgesics, the types of procedure performed, and the duration of each procedure. Data were routinely recorded on a pain management data collection form by the nurse administering the N₂O. This form was developed by the hospitals pain management committee.

Statistical analysis

Descriptive analyses were applied to the data with frequencies and percentages presented for major outcome variables.

RESULTS

Study population and procedures

Data for 224 episodes of N₂O use were collected over the period of the study. A total of 138 (61.6%) of the children were male. A total of 113 children (50.5%) were under 5 years of age, 74 (33.0%) were aged between 5 years and 10 years, and 37 (16.5%) were aged 10 years and above. A parent or other carer was present throughout the duration of the procedure in 219 (97.8%) of cases and 50 children (21.9%) had received N₂O previously.

Table 1 shows the procedures performed during the study. The length of procedures undertaken under N₂O relative analgesia ranged from 1 minute to 60 minutes with the mean duration being 13.7 minutes (95% CI 12.3 to 15.1 min) and a median duration of 10 minutes.

Outcome measures

Table 2 summarises primary and secondary outcome measures. Only one major adverse event was recorded, this was

Table 2 Study outcomes (n=224)

Outcome measure	Frequency (%)
Adverse events	
None	164 (73.2)
Major	
Respiratory distress	1 (0.4)
Hypoxia	0
Minor	
Vomiting	19 (8.5)
Mask intolerance	38 (17.0)
Dysphoria	2 (0.9)
Maximum concentration of nitrous oxide (N₂O as %)	
50%	67 (29.9)
60%	88 (39.2)
70%	69 (30.8)
	mean 60.2%
	(95% CI 59.1 to 61.2)
	median 60%

respiratory distress in an 18 month old child with a history of a recent bronchiolitis illness. He experienced a short period of tachypnoea during the procedure; however this was not associated with a fall in oxygen saturation and rapidly resolved after the withdrawal of the N₂O without the need for any intervention or treatment other than the administration of oxygen. A total of 164 children (73.2%) recorded no complications. Two procedures were abandoned however because of minor adverse events. These were a 7 year old girl undergoing a lumbar puncture who was unable to remain still for the procedure (she eventually underwent the procedure under a general anaesthetic) and a child who vomited while undergoing suturing.

Of the 224 children 214 (95.5%) required no other sedation. Where additional sedation was given this was midazolam in 9 (4.0%) cases and trimeprazine in 1 (0.4%) case. Similarly 215 (96.0%) children required no other oral analgesia. Where this was given the most common adjunct was paracetamol in seven (3.1%) of the cases and codeine in two (0.9%). Local anaesthesia was infiltrated in 76 (33.3%) cases.

Distraction techniques were used in 86.6% of children. These were used either by the nursing staff or the parents and were age appropriate to the child.

DISCUSSION

We have shown that relative analgesia with high concentrations of N₂O (up to 70% with oxygen) can be safely administered to children over the age of 12 months by appropriately trained nursing staff. We report only one significant (and transient) complication and despite a small number of minor complications, notably mask intolerance, all but 2 of the 224 procedures were successfully completed using this method of relative analgesia in our ED.

Our major adverse event rate (0.4%) is similar to that described in previous studies and comparable to adverse events recorded for other agents.^{12–15} Previously a 5%–15% rate of minor side effects, notably vomiting has been reported.^{5–12–14–15} We recorded 19 cases of vomiting (8.3%) of which 18 were after the withdrawal of N₂O administration. Despite the concern that emesis may place patients at risk if they are unable to protect their airways, in the absence of other sedatives clinical trials have demonstrated that the protective airway reflexes are intact.^{16–17} We also encountered a surprisingly high number of cases of difficulty with mask acceptance, 39 cases (17.1%). Of note however is that no procedures were abandoned because of difficulty with mask acceptance and in most cases it was noted that this was an initial problem that resolved quickly with distraction techniques. We believe that this number recorded reflects a “normal” response to a facemask in young children that can easily be overcome with appropriate distraction and not a true complication of the procedure.

At a time when EDs are facing an increasing workload, the role of ED nurses is evolving¹⁸ with nurse practitioners becoming an integral part of the ED team. Recommendations from France after experience with more than 7500 children have concluded that concentrations of N₂O up to 50% may be safely administered, by nursing staff after training, to children greater than 4 years of age. However, they also noted that as the incidence of side effects does not appear to be greater in the 1–4 year age group this age limit may be lowered to 1 year.¹² Our study shows that with appropriate training nurses can safely deliver relative analgesia to paediatric patients undergoing minor procedures.

Much of the previous work on the use of N₂O to provide relative analgesia has concentrated on its use in the outpatient or ward based setting.^{8–11–19–20} Within our own hospital, the pain team have already demonstrated the effectiveness of nurse administered N₂O at high concentrations during painful procedures that are carried out on the wards.¹¹ Despite the less

controlled environment in the ED, our complication rate was almost identical to the ward based studies. Where ED use has previously been studied, the N₂O has been administered in lower concentrations (ranging from 30% to 50% N₂O), to older children (ages >2) by physicians.^{5–7–9} This approach has the obvious disadvantage that two doctors are required to be present to carry out the procedure—not often a realistic prospect in most EDs.

In contrast with some previous studies,^{5–8} we have also been able to demonstrate a success with younger children. The reasons for this may include: the use of higher concentrations of N₂O (up to 70%), the use of distraction techniques such as singing and storytelling used both by the nurses administering the nitrous and the parents present, and the use of a system that does not require the child to produce large negative inspiratory pressures. Our experience compares with a similar undertaking by Vic *et al* in France.²⁰

The main limitation of our study was the lack of a validated method of measuring the pain experienced by these children. Although we collected some data on this using a linear scale, this had not been previously validated and it was felt that the information did not add to the overall content of the paper. Future studies would be helpful to address this issue. We also had no data comparing the safety of nurse administered N₂O as compared with other medical staff within our own department although we felt that this was not an important shortcoming.

Our study adds weight to the argument that N₂O is a safe agent when used for relative analgesia in children over the age of 12 months undergoing minor procedures in the ED. We have also demonstrated that after appropriate training it may be delivered by nursing staff and that this does not appear to have an effect on the adverse event rate. It has the added advantage over other sedative agents that recovery is rapid and therefore early discharge may be facilitated. We have also demonstrated that higher doses may be given successfully in the ED. That one fifth of children in the study had had N₂O for previous procedures suggests that it is acceptable to parents as a sedative agent although data on this were not formally collected.

In conclusion, relative analgesia using high concentrations of N₂O administered by appropriately trained nursing staff is a safe agent for the sedation of children undergoing minor painful or anxiety producing procedures in the ED.

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