

Analgesia for adult distal radius fracture manipulation in the emergency department: demand valve nitrous oxide compared with intravenous regional anaesthesia

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Introduction: This study compared demand-valve nitrous oxide (Entonox) with intravenous regional anaesthesia (IVRA) as analgesia in adults with distal radius fractures requiring manipulation and reduction (M&R) in the Emergency Department. **Materials and methods:** All adults presenting to the Emergency Department of Changi General Hospital, Singapore between August to December 2000 with closed distal radius fractures requiring M&R were enrolled. Five parameters were measured: pain perception using visual analogue scale (VAS), patient acceptance, procedure time, complication rate and failed manipulation. **Results:** Of the 67 patients enrolled, 32 received IVRA and 35 received Entonox. The average VAS was 2.2 cm for the IVRA group and 5.8 cm for the Entonox group ($p < 0.0001$). The average procedure time was 25.6 minutes for the IVRA group and 11.1 minutes for the Entonox group ($p < 0.0001$). Twenty-seven IVRA patients (84.4%) and 24 Entonox patients (68.6%) would agree to the same analgesia given similar circumstances ($p = 0.159$). Four patients who received Entonox (11.4%) experienced minor complications, while no complications were noted in the IVRA group ($p = 0.115$). Two patients who received IVRA (6.3%) and 8 patients who received Entonox (22.9%) required more than a single attempt at M&R ($p = 0.086$). **Conclusion:** The use of Entonox, compared to IVRA, was associated with significantly shorter procedure time but significantly higher pain scores, with no significant difference in terms of patient acceptance, complication rate or failed manipulation rate. Entonox is an effective analgesic alternative to IVRA in adult patients requiring M&R for distal radius fractures in the Emergency Department. Its use is ideal in situations where IVRA is unsuitable or contraindicated. (*Hong Kong j.emerg.med.* 2002;9:181-187)

Keywords: Bier's block, Colle's fracture, Entonox, pain relief, pain scores

Introduction

Adult distal radius fractures requiring manipulation and reduction (M&R) are commonly encountered in

the Emergency Department. Various methods of analgesia are used to decrease the patient's pain during the procedure. These include intravenous regional anaesthesia (IVRA), demand-valve nitrous oxide (Entonox), haematoma block, intramuscular sedation, conscious sedation and general anaesthesia.¹

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This study has been presented as an oral presentation at the 2001 American College of Emergency Physicians Research Forum in Chicago, IL, and at the 9th International Conference on Emergency Medicine in Edinburgh, UK.

Locally, the most widely used method is IVRA using 1% lignocaine. Although it is a "tried and tested" method, it is not without certain drawbacks. Not only does it require multiple painful experiences including two intravenous cannulations, exsanguination (or at least elevation) of the fractured limb and tourniquet pain, it is also time consuming, requiring the tourniquet to remain inflated for at least 15 minutes after the infiltration of the anaesthetic agent.²⁻⁴

On the other hand, nitrous oxide analgesia has been widely used in dentistry and obstetrics since the 1950s. Its use appears attractive because it is 'non-invasive' and does not require painful intravenous cannulation or the painful inflation of a tourniquet. It has a rapid onset of action and elimination, and is less time consuming as it can be immediately discontinued as soon as the fracture is reduced and the limb immobilised.⁵⁻⁷ Potential drawbacks include the need for patient cooperation with self-administration of Entonox, and its unpredictable and limited effect in certain patients.

The aim of this randomised, prospective study was to compare Entonox with IVRA as analgesia in adult patients with distal radius fractures requiring M&R in the Emergency Department. Two primary endpoints were measured: pain perception (using Visual Analogue Scale (VAS)) and procedure time. In addition, three secondary endpoints were measured: patient acceptance, complication rate and failed manipulation.

Materials and methods

This randomised, prospective study was conducted at the Accident and Emergency Department of Changi General Hospital, Singapore between August and December 2000.

The study had prior approval from the hospital's Medical Ethics Committee and informed consent was obtained from all enrolled patients.

All adult patients aged 18 years and above presenting to the Emergency Department with closed fractures of the distal radius that were clinically judged to require M&R were considered for enrolment into the study.

Exclusion criteria included those <18 years of age, those with fractures that were clinically judged not to require M&R, those who refused or were unable to give informed consent, those who received prior analgesia within the past 4 hours, those with known allergy to involved drugs and those with open

fractures. Patients were also excluded if they had severe cardiovascular or respiratory disease, pregnancy, severe hypertension, peripheral vascular disease, crush injuries, pneumothorax, bowel obstruction, middle ear disease or diving-related illness.

The presence of factors that potentially made M&R difficult (e.g. impacted or comminuted fractures, obese patients) did not influence the selection process.

A consecutive series of patients meeting the inclusion criteria were assigned to 2 study groups in an alternating fashion, such that odd numbered patients received IVRA and even numbered patients received Entonox.

The methods of administration of the 2 agents are discussed below.

In both study groups, analgesic effect was assumed to be adequate when the patient could allow simple palpation of the fracture site without indicating pain.

IVRA: The affected arm was elevated to promote venous drainage. The pneumatic tourniquet was inflated to approximately 100 mmHg above systolic blood pressure up to a maximum of 250 mmHg. This was followed by the intravenous injection of 2 mg/kg of 1% lignocaine and diluted to 20 mls with normal saline into the affected arm. The M&R was carried out only after a wait of 5 minutes for the onset of analgesia. In patients with inadequate analgesia, top-up doses of lignocaine could be given up to a maximum of 3 mg/kg, but in practice, this was not required. After reduction and immobilisation of the limb, the tourniquet was deflated, having ensured that it had been in place for at least 15 minutes.

Demand-valve 50% Nitrous Oxide (Entonox): The patient is instructed on the proper use of the demand-valve mask. A proper seal to the face and proper breathing technique is ensured. Entonox was inhaled for a minimum of 3 minutes before (to achieve adequate analgesic effect) and during the M&R and immobilisation, after which it is discontinued. Patients in whom analgesia was inadequate were allowed to

continue inhalation of the Entonox beyond 3 minutes until adequate analgesia was achieved.

The following parameters were measured:

Procedure time: For IVRA, procedure time was measured from the first attempt to establish intravenous access to the time that the tourniquet was deflated. It should be noted that this is an artificial endpoint because, for safety reasons, the tourniquet has to be in place for a minimum of 15 minutes before it can be deflated.

For Entonox analgesia, procedure time was measured from the time the gas was first administered to the time that the gas was discontinued after the immobilisation of the limb.

Pain perception: After the procedure was completed and success of manipulation was confirmed, the patient was asked to complete a visual analogue pain scale (VAS). This consisted of a horizontal line 10 cm long. One end of the line was labelled 'No Pain' while the other end was labelled 'Worst Pain'. The patient was instructed to place a single mark on the line corresponding only to the amount of pain experienced during the M&R.

Patient acceptance: As a measure of patient acceptance of the method of analgesia, patients were also asked whether, given similar circumstances, they would agree to have the same method of analgesia again.

For patients given Entonox, care was taken to ensure that the patient was no longer under the effect of Entonox and was fully conscious and alert before the VAS was scored and the above question asked.

Failed manipulation: Success of the M&R was based on the operator's review of the check radiograph. If in doubt, the senior staff on duty was consulted. Inability to achieve successful reduction of the fracture at first attempt was considered a failed manipulation. Such patients underwent a second M&R using the same method of analgesia after the VAS was recorded on the first manipulation.

Complications: In both groups, the patients were observed for complications for a minimum period of 30 minutes before appropriate disposal. Potential complications of lignocaine toxicity include seizures, cardiac arrhythmias and minor neurological symptoms such as giddiness, dizziness and tinnitus. Complications expected after Entonox inhalation include drowsiness, nausea/vomiting and oxygen desaturation. All complications were documented and appropriate treatment was given as and when necessary.

The results were compared using Fisher's exact test for categorical data and Wilcoxon Rank-Sum test for continuous data. A *p* value of less than 0.05 was considered significant.

Results

Ninety patients were eligible for enrollment: 2 were unable to give consent, 19 refused consent and 2 received prior analgesia.

A total of 67 patients (74.4% of those eligible) were enrolled: 32 received IVRA and 35 received Entonox (1 patient who was supposed to receive IVRA was mistakenly enrolled into the Entonox group instead).

Table 1 shows the demographics and the fracture type of both groups of patients. There was no significant difference between the 2 groups in terms of age, sex, race and fracture type.

Table 1. Demographic data and fracture type of study patients.

	IVRA n=32	Entonox n=5
Sex (M/F)	8/24	7/28
Average age (y)	62±16.5 (22-87)	61.5±16 (21-84)
Ethnicity		
Chinese (%)	25 (78.1)	26 (74.3)
Malay (%)	6 (18.8)	7 (20)
Others (%)	1 (3.1)	2 (5.7)
Type of fracture		
Dorsal angulated (%)	31 (96.9)	32 (91.4)
Volar angulated (%)	1 (3.1)	3 (8.6)

Continuous variable expressed as mean±SD (range)

The average VAS was 2.2 cm (SD, 2.3; range, 0-8.7) for the IVRA group and 5.8 cm (SD, 2.8; range, 0.9-10) for the Entonox group. This was statistically significant (p value <0.0001 , power 100%). The mean difference in VAS was 3.6 cm (95% CI, 2.3 to 4.9 cm). (Table 2)

Twenty-seven patients in the IVRA group (84.4%) and 24 patients in the Entonox group (68.6%) would agree to the same method of analgesia given similar circumstances. This was not statistically significant with a p value of 0.159. The mean difference was 15.8% (95% CI, -7.9 to 41.3%). (Table 3)

The average procedure time was 25.6 minutes (SD, 9.1; range, 15-55) for the IVRA group and 11.1 minutes (SD, 6.3; range, 5-35) for the Entonox group. This was statistically significant (p value <0.0001 , power 100%). The mean difference in procedure time was 14.5 minutes (95% CI, 10.7 to 18.3 min). (Table 2)

Four patients who received Entonox (11.4%) experienced minor complications, while no complications were noted in the IVRA group. This was not statistically

significant with a p value of 0.115 (95% CI, -6.5 to 36.5%). (Table 3)

Of the 4 patients, 1 experienced light-headedness, 2 experienced giddiness, and 1 patient was noted to be slightly drowsy; all these resolved spontaneously and subsequent recovery and disposal was uneventful.

Two patients who received IVRA (6.3%) and 8 patients who received Entonox (22.9%) required more than a single attempt at fracture manipulation. This was not statistically significant with a p value of 0.086. The mean difference was 16.6% (95% CI, -7.7 to 38.1%). (Table 3)

Of the 2 patients in the IVRA group, 1 patient had a successful second M&R, while the other was admitted after two failed M&R attempts.

Of the 8 patients in the Entonox group, 4 patients had successful second manipulations, 1 patient was referred (the decision of the senior staff on duty) to the outpatient clinic for review after one failed M&R.

Table 2. Pain perception and procedure time.

	IVRA	Entonox	Difference	(95% CI)	p value
Visual analogue score (cm)					
mean±SD	2.2±2.3	5.8±2.8	3.6	(2.3-4.9)	
range	0-8.7	0.9-10			<0.0001
median	1.4	6.3	4	(2.5-5.2)	
Average procedure time (min)					
mean±SD	25.6±9.1	11.1±6.3	14.5	(10.7-18.3)	
range	15-55	5-35			<0.0001
median	24.0	10.0	14	(10-16)	

Table 3. Patient acceptance, complication rate, and failed manipulation.

	IVRA n=32	Entonox n=35	Difference	(95% CI)	p value
Agree to similar analgesic method (%)	27 (84.4%)	24 (68.6%)	(15.8%)	(-7.9%, 41.3%)	0.159
Complications (%)	0 (0%)	4 (11.4%)	(11.4%)	(-6.5%, 36.5%)	0.115
Failed first manipulation (%)	2 (6.3%)	8 (22.9%)	(16.6%)	(-7.7%, 38.1%)	0.086

Three patients were admitted: 2 after both M&R attempts failed and 1 after the first failed M&R (the decision of the senior staff on duty).

Discussion

IVRA is a widely used and accepted form of analgesia for forearm fractures requiring outpatient M&R.

In a subjective study based on telephone questionnaires of accident and emergency doctors in 25 Scottish hospitals dealing with trauma, Graham et al⁸ concluded that Bier's Block may be the anaesthetic method of choice for the management of distal radius fractures both in efficiency and economic terms in Scotland.

In our hospital, it is routine practice to reduce distal radius fractures under IVRA. Our experience is that it is safe and it works well, the main drawback being the relatively long procedure time given that the tourniquet has to be in place for a minimum of 15 minutes before it can be deflated.

On the other hand, the successful use of nitrous oxide as a form of analgesia in forearm fracture manipulations has been well documented in numerous paediatric studies.

Wattenmaker et al⁹ using a verbal rating pain scale, found 50% nitrous oxide to provide very effective and safe analgesia for fracture reduction in children in the emergency room setting.

Hennrikus et al¹⁰ using the Children's Hospital of Eastern Ontario pain score (CHEOPS) scoring and VAS, found that self-administered nitrous oxide combined with use of a haematoma block is a safe and effective technique of analgesia for the outpatient reduction of fractures in children.

In a small study utilising faces rating pain scale and VAS, Gregory et al¹¹ compared nitrous oxide with IVRA in paediatric forearm fracture manipulation and found no significant difference in amount of pain perceived by the patient for the total pain experience.

Evans et al¹² compared nitrous oxide with intramuscular sedation for the reduction of fractures in children using CHEOPS scoring and found that nitrous oxide is as effective in providing analgesia and amnesia while having a more rapid onset and a shorter recovery period with greater patient acceptance.

However, in a prospective study of 54 consecutive children utilising CHEOPS scoring, Hennrikus¹³ found that 50% nitrous oxide provided only partial analgesia for acute pain in 46% of patients and a significantly higher proportion of failures in patients with completely displaced fractures.

To date, however, there has been no study directly comparing IVRA with Entonox as analgesia for distal forearm fracture manipulations in adult patients. We therefore undertook this study to investigate whether Entonox could shorten the procedure time for M&R, yet offer the same benefits as IVRA.

Comparing procedure times of IVRA and Entonox is difficult because the two procedures are essentially different. It has been pointed out that such a comparison is unfair because IVRA procedure time is 'artificially' prolonged. However, the authors feel that this is inevitable given that it is an essential requirement (and major drawback) of IVRA. In any case, if Entonox administration was found to have a shorter recovery period, and consequently, shorter procedure time, then it is an added advantage.

Pain is a very personal and subjective experience that is much influenced by a patient's own pain threshold level, fear and even cultural background. As such, it is difficult to measure objectively. The assessment of pain experience is therefore often based on patient self-report using a visual analogue scale.¹⁴

The VAS is but one such self-reporting method of 'measuring' pain.¹⁵⁻¹⁸ It is commonly used and is simple, sensitive and reproducible. However, it is not without its drawbacks, which include difficulty in getting certain patients to understand the concept behind it. There are also doubts about the relationship of the measurement to the true pain experience.

Although some paediatric studies used pain scales (such as CHEOPS) based on observed pain behaviour, the investigators felt that this method was biased, as the operator would not be blinded to the type of analgesia used by the patient.

The investigators tried to overcome the drawbacks of trying to quantify the subjective experience of pain by assessing patient acceptance of the method of analgesia. Although still an entirely subjective assessment, it can be argued that willingness to undergo a similar procedure is actually a more accurate assessment of that procedure than simply to judge and compare its pain score.

In this study, we found that complications and side effects associated with Entonox were all minor and reversible once administration ended.

Failure of the first M&R was taken in this study to reflect the differing efficacy of the two analgesic methods influencing patient cooperation and difficulty in reduction. However, the investigators acknowledge that different fracture types and severity and patient habitus may affect the M&R result as well. These variables will be addressed in a future study.

By the nature of the study design and the procedures involved, it would not have been possible to conduct a blinded study. Nevertheless, the fact that this study is not blinded may be a cause of bias.

Without the use of end-tidal monitoring, it was not possible in this study to quantify the amount of nitrous oxide inhaled by the patient. A minimum of 3 minutes inhalation time was imposed but, even then, the amount of nitrous oxide inhaled depended on rate and depth of breathing, as well as the effectiveness of the seal of the facemask.

Other weaknesses of this study include the fact that the sample sizes of the 2 study groups were small, and that the issue of cost was not considered.

Conclusion

Both IVRA and Entonox have their own inherent limitations and drawbacks in addition to their advantages. It is up to the clinician to balance the benefits and risks of each agent for any individual patient.

This adult study shows that Entonox, compared to IVRA, required significantly less procedure time but is associated with significantly higher pain scores, with no significant difference in terms of patient acceptance, complication rate or failed manipulation rate.

In other words, although patients in the Entonox group experienced more pain, the degree of pain they experienced was not severe enough for them to be dissuaded from undergoing a similar method of analgesia given similar circumstances.

The authors thus conclude that the use of Entonox is not unsafe and may be an effective analgesic alternative to IVRA in adult patients requiring M&R for distal radius fractures in the Emergency Department.

Entonox may indeed be the ideal choice of analgesia when IVRA is unsuitable or contraindicated, e.g. patients with significant cardiac arrhythmias or severe peripheral vascular disease.

Further studies should investigate the use of Entonox for other procedures commonly performed in the Emergency Department, e.g. M&R of other fracture/dislocations, simple toilet and suture procedures and wound dressings.

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