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ORIGINAL STUDY

A comparison of ketamine sedation and general anaesthesia for manipulation of paediatric forearm fractures

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The study was conducted at the University Hospitals Coventry & Warwickshire

The purpose of the study was to compare the use of ketamine sedation and general anaesthesia for manipulation of paediatric wrist and forearm fractures. A retrospective analysis was performed of patients under 16 years treated at our centre between October 2014 and October 2015. Exclusion criteria were open fractures and fractures with complete displacement. Outcomes measured were fracture reduction, the quality of the cast, fracture redisplacement, further surgical intervention and use of theatre time. 66 children were manipulated over the study period; 31 received ketamine sedation and 35 general anaesthesia. No statistically significant difference was found in the rate of re-intervention (p=0.48), quality of reduction (p=0.39), quality of cast (p=0.14 and p=0.21), or redisplacement (p=0.87). Those undergoing general anaesthesia used on average 50 minutes of theatre time and one third required an overnight admission. We conclude that ketamine sedation achieves comparable treatment outcomes to general anaesthesia whilst using fewer resources.

Keywords : forearm fracture ; wrist fracture ; paediatric ; sedation ; ketamine ; reduction.

INTRODUCTION

Forearm fractures are among the commonest skeletal injuries in childhood *(6)*. The majority of displaced fractures undergo closed reduction and cast immobilisation *(2,10)*. The key to achieving a successful outcome is the ability to obtain an adequate reduction *(17,20)* and maintain this in a well-moulded cast with three-point fixation *(2,5,20)*. Numerous measurements of cast quality are available, including the cast and gap index *(7,12)*. Manipulation is commonly performed under general anaesthesia, although reduction under conscious sedation is an alternative method *(14)*. Conscious sedation is appealing as this allows fracture reduction to be performed at the time of presentation, potentially minimising the use of health care resources.

The use of ketamine for paediatric sedation in the emergency setting has previously been reported for various procedures *(8,16)*. A review of 11,589 paediatric cases reported ketamine could provide rapid and consistent paediatric sedation with a predictable onset and recovery time with a very low

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Table I. — Local guidelines on Contraindications to ketamine sedation in paediatric patients

Contraindications
Age less than 12 months
A high risk of laryngospasm (active respiratory infection, active asthma)
Active upper or lower respiratory tract infection
Patients with severe psychological problems such as cognitive or motor delay or severe behavioural problems
Significant cardiac disease (heart failure, malignant hypertension)
Recent significant head injury or reduced level of consciousness
Intracranial hypertension with CSF obstruction
Intra-ocular pathology
Previous psychotic illness
Uncontrolled epilepsy
Hyperthyroidism or Thyroid medication
Porphyria
Prior adverse reaction to Ketamine

risk of aspiration and laryngospasm *(9)*. Ketamine provides a state of profound amnesia and analgesia whilst preserving respiratory and cardiovascular function *(9,19)*. A systematic review concluded that ketamine was more effective and had fewer adverse events than fentanyl or propofol *(11)*. The use of ketamine sedation for reduction of paediatric forearm and wrist fractures has recently been introduced in our Emergency Department. The aim of this study was to assess whether reduction of paediatric wrist and forearm fractures under ketamine sedation would give comparable results to general anaesthesia, in terms of redisplacement and further surgical intervention.

METHODS

A retrospective analysis was performed of all patients aged under the age of 16 years who presented with an angulated or displaced distal radius or forearm fracture to our Emergency Department between October 2014 and October 2015. The study was retrospective and required no patient contact, therefore formal ethical approval was not sought but the study was registered with the local research department. Patients were included if the fracture was deemed to require manipulation by the treating paediatric orthopaedic surgeon. Exclusion criteria were open fractures, fractures with complete displacement and those treated by any mode of fixation (Kirschner wires, elastic nails or plate fixation).

Patients were divided into those manipulated under ketamine (MUK group) and those reduced under general anaesthetic (MUA group). The decision whether to perform a manipulation in the Emergency Department under ketamine or in theatre under general anaesthetic was made by the attending surgeon in conjunction with the Emergency Department clinician. Determining factors were the availability of a monitored paediatric bed and an Emergency Department clinician competent to perform ketamine sedation. Specific local guidelines on the use of ketamine in paediatric patients are in place and include a number of contraindications to its use, see Table I.

Ketamine sedation was performed in the paediatric resuscitation area of the Emergency Department. This area has immediate access to full resuscitation facilities and standard monitoring including electrocardiogram, blood pressure, respiration, pulse oximetry and end tidal carbon dioxide measurement. At least three members of staff were required to be present: a doctor to manage the sedation and airway, an orthopaedic surgeon to perform the procedure and an experienced nurse to monitor and support the patient, carers and clinical staff. The doctor managing the ketamine sedation

and airway was suitably trained and experienced in ketamine use and paediatric airway management. For the procedure to be performed the child had to be fasted; no water for 2 hours, no breast milk for 4 hours and no solids for 6 hours prior to starting sedation. The dose of ketamine was 1.0 mg/kg by slow intravenous injection over at least one minute and supplemental doses of 0.5mg/kg by slow IV injection were administered if required. After ketamine sedation, the attending orthopaedic surgeon manipulated the fracture and a full plaster of Paris cast was applied and moulded. As the procedure was performed in the Emergency Department, no immediate imaging facilities were available and this manipulation was performed without the aid of an image intensifier. After the conscious sedation had worn off formal radiographs were obtained to ascertain if a satisfactory reduction had been achieved. Children undergoing general anaesthesia were splinted in the Emergency Department using a backslab. Instructions were provided to return the following day fasted in preparation for surgery. The type of general anaesthetic given was dependent upon the treating anaesthetist. The procedure was performed in a theatre setting with the use of an image intensifier and a full moulded plaster of Paris was applied.

For both groups, the surgeon performing the procedure was an orthopaedic trainee of at least 4 years post-graduate experience. For those cases performed in theatre, this was under the supervision of an orthopaedic consultant but those under ketamine sedation were typically performed independently. The amount of padding and the technique of application were subject to individual surgeon technique. A repeat radiograph was performed between 5 and 10 days post-operatively to check for redisplacement. Further radiographs were performed between 3 and 6 weeks dependent upon the fracture pattern, patient's age and discretion of the treating orthopaedic surgeon.

Patient's age and gender were collected from electronic records. The degree of fracture angulation and percentage of translation were recorded on admission, post-reduction and final follow up radiographs. Fracture reduction was deemed acceptable when residual translation was less than 10% and angulation less than five degrees in the sagittal or coronal plane *(1)*. Radiographic redisplacement was defined as more than 20 degrees of angulation or greater than 50% translation *(18,20)*. The quality of cast was estimated using the cast and gap indices. The cast index and gap index were measured on initial radiographs according to the techniques described by Chess *et al*. and Malviya *et al*. respectively *(7,12)*. The need for further surgical intervention, overnight admission and theatre time for the MUA group were also recorded. Theatre time was defined as the interval between arrival in the anaesthetic room and entering the recovery area. Statistical analysis was performed using GraphPad Prism 5 (GraphPad Software, Inc., La Jolla, CA).

RESULTS

66 children were manipulated over the study period, 35 in the MUA group and 31 in the MUK group. Patient demographics and fracture details for each group are illustrated in Table II. There were no statistically significant differences between the groups. An acceptable reduction was achieved in a higher proportion of patients in the MUA

Table II. — Comparison of patient demographics and fracture pattern

	MUA	MUK	P Value
Number of children	35	31	n/a
Sex distribution (M:F)	18:17	23:8	0.057[a]
Mean age (years (95% C.I.))	8.6 (7.7-9.5)	9.0 (7.7-10.2)	0.60[g]
Angulation on presentation (degrees (95% C.I.))	27.7 (24.7-30.6)	28.6 (24.5-32.6)	0.71[g]
Displacement on presentation (units (95% C.I.))	17.9 (10.7-25.0)	19.5 (8.3-30.7)	0.80[g]
Fracture site (wrist:forearm)	22:13	18:13	0.69[a]

a - chi-square test, g - t-test

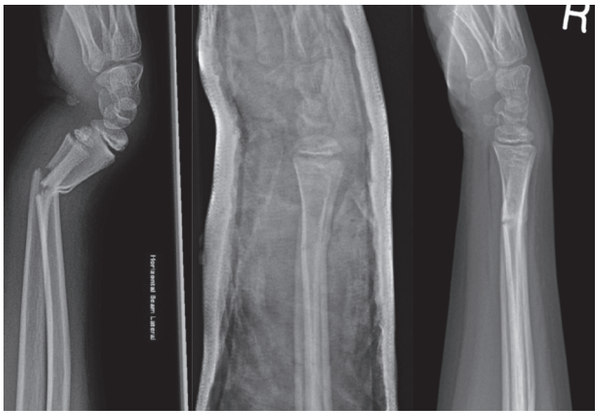

Fig. 1. — Example case of distal radius fracture treated successfully with manipulation under ketamine 1) Initial plain lateral radiograph 2) Lateral radiographs after reduction under sedation 3) Final lateral radiograph at 4 weeks

group (26 patients 74%) than the MUK group (20 patients 61%), although this difference did not reach statistical significance (p=0.39). An example case of distal radius fracture successfully treated with reduction under ketamine is shown in Figure 1. The reduction achieved in two cases in the MUK group was deemed unacceptable by the treating surgeon and these patients required a further manipulation under general anaesthesia. During follow up, no further patients in the MUK group required a second procedure. In the MUA group, one patient suffered a redisplacement deemed unacceptable at one week and underwent percutaneous Kirschner wire fixation, as illustrated in Figure 2. Although the requirement for further general anaesthesia was slightly higher in the MUK group than the MUA group this did not reach statistical significance (p=0.48). Radiographic redisplacement was seen in four patients in the MUK group and five children in the MUA group which was not statistically significant (p=0.87), although as described, in total only three patients actually required further surgical intervention.

The mean cast index was higher in the MUK group, 0.81 (CI 0.77-0.85) versus 0.77 (CI 0.73-0.80). The mean gap index was similarly higher in the MUK group, 0.25 (CI 0.23-0.3) versus 0.23 (CI 0.21-0.26). Although the trend was towards improved cast quality under general anaesthesia, neither the difference in cast index (p = 0.14) or gap index (p = 0.21) reached statistical significance as demonstrated in Figure 3. The mean time utilised in theatre for the MUA group was 50.8 minutes (range 26-80) and 31% of these children required overnight admission following the procedure as illustrated in Figure 4.

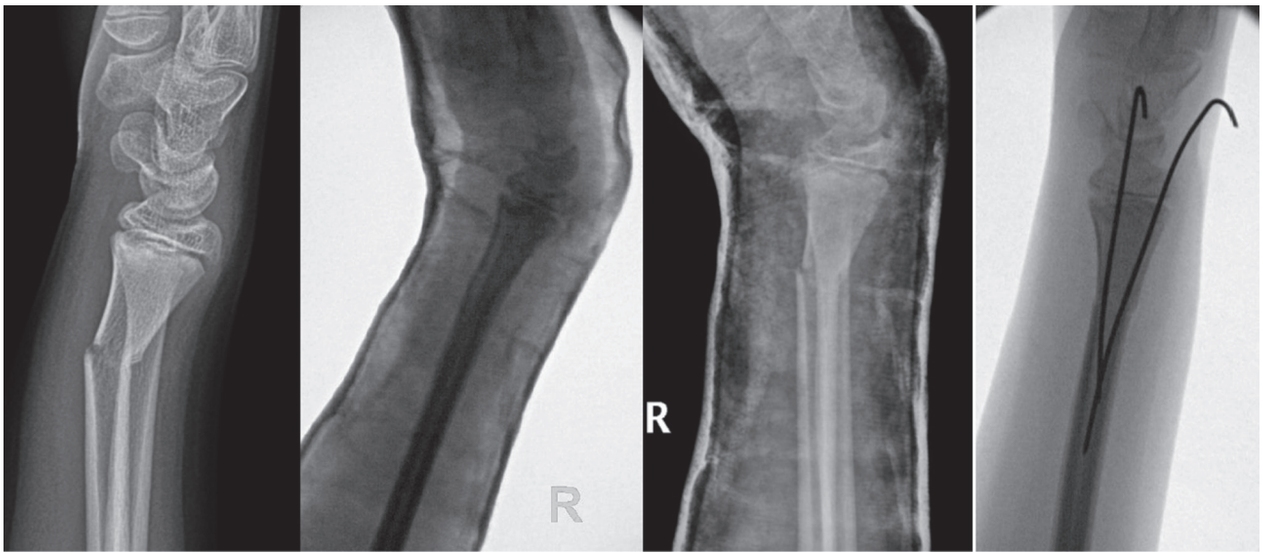

Fig. 2. — Example case of failed manipulation under general anaesthesia; 1) Initial plain lateral radiograph 2) Reduction intra-operatively 3) Redisplacement at 6 days 4) Position after percutaneous Kirschner wires

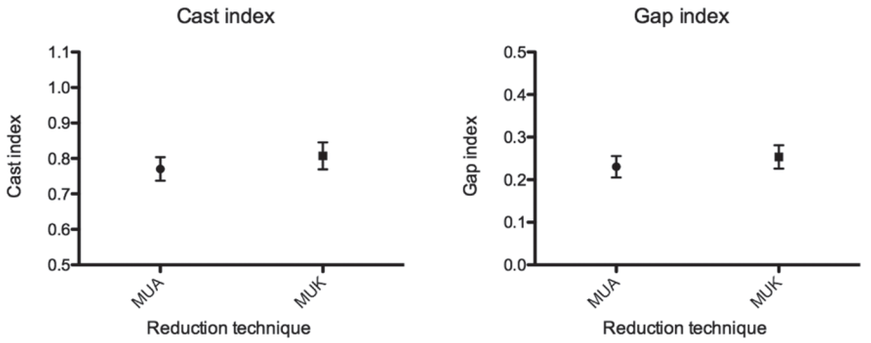

Fig. 3. — The spread of data for Cast and Gap Index between the two study groups

DISCUSSION

This study demonstrates that reduction of paediatric forearm and wrist fractures under ketamine sedation can give comparable results to reduction under general anaesthesia. There was no significant difference in the need for further procedures under general anaesthesia between the groups. This is supported by comparable rates of adequate reduction, measures of cast quality and radiographic redisplacement between the groups. Reduction under general anaesthesia required additional resources, both in terms of operating department time (a mean of 50 minutes theatre time was required for reduction under general anaesthesia) and the cost of admission to hospital (all of the MUA group were admitted to hospital and a third stayed overnight).

The reduction of paediatric fractures in the emergency department under sedation has previously been reported. Sharieff *et al*. *(18)* performed a pilot study of 20 children having forearm fractures reduced under sedation with a combination of propofol and ketamine. The authors reported a successful reduction in 95% of patients. McCarty *et al*. *(13)* presented a review of 114 children who had fractures reduced under ketamine sedation and demonstrated that 97% were successfully reduced and 99% of parents were pleased with the sedation technique. The achievement of an adequate reduction in patients receiving sedation was lower in our study than the reported literature. There were similarly lower proportions of optimal reductions achieved under general anaesthesia. We suggest that this is a result of the strict definition of an adequate fracture reduction used in this study rather than reflecting endemic poor practice in our centre. The definition that fracture reduction was only deemed acceptable when residual translation was less than 10% and angulation less than five degrees in the sagittal or coronal plane is stricter than those previously described in the literature. This explanation for the discrepancy is supported by a favourable proportion of patients requiring a further procedure after ketamine reduction compared to those figures in the literature 5-15% *(4,13)*. Although a range of re-intervention rates may result from the differing definition of what constitutes an acceptable reduction in paediatric fractures and varying thresholds of different surgeons to re-intervene.

The type of sedation used has the potential to affect the patient experience, side effects and success of the procedure. Comparative studies of sedation techniques are limited and this study adds to this body of literature. McKenna *et al*. *(14)* compared reduction of fractures under nitrous oxide and general anaesthesia and demonstrated a significantly increased need for remanipulation in the nitrous oxide group. Bear *et al*. *(3)* compared the reduction of 52 paediatric distal radius fractures under haematoma block and midazolam sedation. There was no difference in success of reduction and both groups had comparable overall satisfaction. Betham *et al*. *(4)* compared manipulation of 108 simple paediatric forearm fractures under sedation

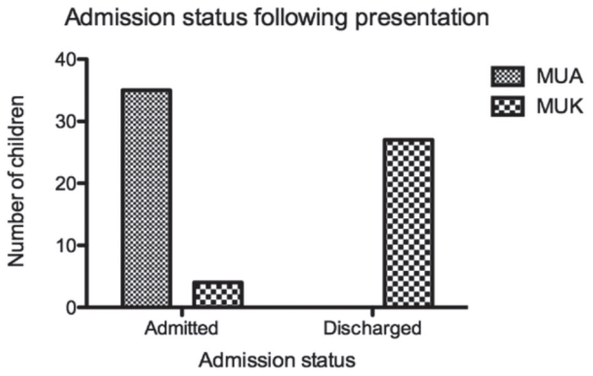

Fig. 4. — The proportion of children admitted and discharged according to group allocation

and general anaesthesia and found no difference in requirement for further intervention - 15% after sedation and 21% after anaesthesia. However, manipulation under sedation did reduce delays to definitive treatment and was associated with shorter hospital stays. A systematic review from Migita *et al*. concluded that ketamine was more effective and had fewer adverse events than fentanyl or propofol *(15)*.

The study does have limitations that the authors acknowledge. The study is retrospective and has small numbers. There is a potential for selection bias over treatment allocation, although an attempt was made to negate this by excluding those with completely displaced fracture. Furthermore, the degree of initial angulation and translation was found to be comparable between the groups. The type of sedation was not the only difference between the groups. Orthopaedic registrars did not have senior supervision or intra-procedural imaging while performing manipulations under ketamine sedation. However, these factors have the potential to reduce the rate of optimal reduction under sedation and the comparable results achieved with sedation despite these limitations further supports the conclusion that similar outcomes can be achieved.

CONCLUSION

Manipulation of paediatric forearm and wrist fractures under ketamine sedation can achieve comparable outcomes to general anaesthesia in terms of re-intervention, quality of reduction and redisplacement. This approach can reduce the use of valuable healthcare resources, although further formal evaluation of its cost-effectiveness would be required to confirm and quantify this.

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