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Reduction of forearm diaphyseal fractures in children under haematoma block in emergency: A prompt and cost-effective approach

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Abstract
Introduction: Closed reduction of a diaphyseal forearm fracture, either radius or ulna, under haematoma block in the emergency department has been demonstrated to provide cost-effective, timely care. There has not been a considerable amount of research into the efficacy of haematoma or regional block and reducing such fracture types. This study describes the epidemiology and outcomes associated with closed reduction of the fractures of either radius or ulnar diaphysis under haematoma block in our hospital's emergency department for the age group 5-11yrs.
Methods: All children (5-11yrs old) with either radius or ulnar diaphysis fractures presenting to our hospital's emergency between July 2019 and January 2020 were included in our study. Patients were followed up for 1year records were maintained to determine diagnoses, treatments, and outcomes. The rate of repeat intervention after successful reduction under haematoma block and rate of changes in management and the need for reduction under procedural sedation and further surgical intervention after morning case review rounds was calculated.
Results: Closed reduction under haematoma block was performed on a total of 20 patients covering these fracture types during our study, with both bone forearm diaphyseal fractures (n = 14, 70%) comprising the majority of cases. A total of 4 cases (20%) lost alignment and required repeat intervention, consisting of 3 cases (15%) that required repeat surgery and 1 (5%) that required cast wedging. There was one case of malunion noted (5%).
Conclusions: Closed reduction under haematoma block provides an alternative to general anaesthesia for many paediatric trauma injuries without compromising patient outcomes.

Keywords: Closed reduction, haematoma block, paediatric, orthopaedic, forearm fracture

Introduction
Diaphyseal forearm fractures comprise 3–5% of pediatric fractures [1, 2]. Most cases can be managed successfully with closed reduction and cast immobilization [3-12]. The loss of function can be minimized by restoring normal alignment [7]. Historically, most of these fractures have been treated with non-operative management relying on closed reduction and casting.
The acceptable degree of displacement to achieve successful outcomes is controversial, leaving much of the decision on treatment to the treating physician's judgment [7, 12]. Indications for surgical treatment of a diaphyseal forearm fracture include open fractures, unstable fractures, irreducible fractures, and fractures that fail to maintain reduced [8, 9, 11, 13, 15].
Few researchers have depicted the efficacy of haematoma or regional block and reducing diaphyseal fractures in the forearm. This study aimed to describe the epidemiology and outcomes associated with closed reduction of the fractures of either radius or ulnar diaphysis under haematoma block in our hospital's emergency department for the age group 5-11years.
We hypothesized that the haematoma block provides a safe method of analgesia during closed reduction maneuvers for these types of fractures that may or may not require surgical intervention at a later stage.

Materials and methods
All patients, 5-11 years old, presenting with a diaphyseal forearm fracture at our institution from July 2019 and January 2020, were included in our prospective study.

A total of 20 patients presented to the emergency department with acute injury to the forearm suggestive of a diaphyseal forearm fracture. The treating orthopaedician made treatment decisions, whether to go for conservative or operative management in each case. The patients planned for conservative management underwent closed reduction under haematoma block. We excluded all patients who were initially treated at an outside facility or who did not undergo closed reduction maneuvers in our emergency department, including those taken straight to the emergency operating theatre and those who underwent surgery alone.

Procedure details

Patients presenting to our emergency with acute forearm pain following trauma and a suspected radius or ulna diaphysis fracture were treated with a preliminary splint. Cold fomentation and elevation of the forearm was done. X-rays of the injured forearm were taken in anteroposterior and lateral views. Additional neuro-vascular examinations of the forearm, wrist, and hand were performed. They were classified according to the AO/OTA system after the radiological diagnosis of radius, ulna, or both diaphyseal bones fracture, and they were classified according to AO/OTA system [15]. The indication of surgical treatment for forearm fractures was based on instability and the patient's wish.

Haematoma block

For the haematoma block, 10 mL of local anaesthetic, lignocaine 2% (20mg/mL), was aspirated into a syringe, and the fracture site was identified by palpation along diaphysis of the bone. The identified site was then cleaned with a disinfecting solution and draped in a sterile manner. The needle was inserted transcutaneously into the fracture site at a 30° angle, pointing from proximal to distal. The needle's correct location was confirmed using a C-arm image intensifier, and fracture haematoma was aspirated. 5-10 mL of lignocaine was then injected into the region of fracture haematoma itself [16]. In the case of both bone fracture cases, 5ml local infiltration with lignocaine was given into different fracture site haematomas each.

After 5-10 min, the reduction was performed by applying manual traction by two well-trained orthopaedics residents following the longitudinal traction and counter traction principle. After maintaining traction for 15 minutes to relieve muscle tension, manual reduction and manipulation were performed by replicating the initial deformity, enabling the fracture to unlock, acquiring length, and minimizing angular/rotational deformity using a C-arm image intensifier. A forearm plaster of Paris was put after closed reduction, and post-reduction X-rays were taken to check alignment. Acceptable reduction guidelines for paediatric bone forearm fractures are stratified by age and location, summarized in Table 1.

Table 1: Acceptable reduction guidelines of Noonan and Price for paediatric both bone forearm fractures [17]

Age	Angulation	Rotation	Bayonet Apposition
Age 0–9 (0–8 girls, 0–10 boys)	<15°	<45°	Up to 1 cm
Age >9 (>8 girls, >10 boys)	<10° proximal/midshaft	<30°	Up to 1 cm
Age >9 (>8 girls, >10 boys)	<15° distal	<30°	Up to 1 cm

The patient was admitted for monitoring. The overnight events were then reviewed in the morning rounds attended by orthopaedic residents and consulting orthopaedic surgeons in which plans of care, surgical planning, and dispositions are reviewed and finalized. Following this trauma case review, residents contacted the patients and their families to inform about further plans of care and notify them of any changes in treatment or discharge of the patient.

Patient medical records were collected to determine diagnoses and treatment received, rates of changes in management, and treatment outcomes of those patients who were for and received haematoma block and reduction. We assessed for a repeat intervention involving cast wedging or surgical intervention for fractures that lost alignment after haematoma block and reduction.

Results

A total of 20 patients with forearm fractures were attended in the emergency department during our study. The patients in the study ranged in age from 5 to 11 years old, with a mean age of 8.24 years. The majority of the patients were males (13) out of 20 patients.

Both bone forearm diaphyseal fractures were the highest in number (n = 14, 70%), comprising most cases. Four patients had a radius shaft fracture, and two had an ulna shaft fracture. These fractures were classified based on the AO classification with ten fractures as 22-D/5.1, four fractures as 22-D/4.1, three fractures as 22r-D/4.1, one fracture as 22r-D/2.1, and two ulna fractures classified as 22u-D/5.1. This classification has been depicted in Table 2.

Table 2: Fractures classified based on A.O. Pediatric Comprehensive classification of Long Bones [18]

Fracture type	Number	A.O. classification
Both bone fractures	10	22-D/5.1
Both bone fractures	4	22-D/4.1
Radius diaphysis fracture	3	22r-D/4.1
Radius diaphysis fracture	1	22r-D/2.1
Ulna diaphysis fracture	2	22u-D/5.1

Of the 14 cases of both bone forearm fractures, four patients had a minimally displaced fracture of the diaphysis of both bones requiring slight manipulation after a local haematoma block at the fracture site. The rest of the 10 cases either had an angulation or bayonet apposition requiring closed reduction and manipulation post haematoma block. The radius and ulna diaphyseal fractures were also reduced to obtain acceptable reduction after administering haematoma block.

A total of 4 cases (20%) lost alignment and required repeat intervention, consisting of 3 cases (15%) that required surgery and 1 (5%) that required cast wedging. One case of malunion was noted (5%) after six months of follow-up. There were 2 cases (10%) among the ones with adequate reduction was achieved, which were recorded to have minor complications after a haematoma block, including one case that suffered from tendinitis and the other involving rash accompanied with itching at the haematoma block site. These patients were treated adequately for their complaints.

While gender did not affect complications rates, age demonstrated a disparity. Overall complications rates were significantly more common in elder patients (8-11 yrs) when

compared to their younger counterparts (5-8 yrs), including the three that required surgical intervention. The fracture type also did not affect the need for surgical intervention or complications.

Discussion

Only by knowing the physiological range of motion of the injured limb can a proper fracture reduction be accomplished. Closed reduction and casting are frequently used to achieve normal function. Because of a child's potential to rebuild, the reduction does not have to be anatomic, but it must fall within certain limitations. The authors agree upon the recommendations from Noonan and Price for considering the acceptable reduction criteria [17].

Operative intervention is recommended when an acceptable reduction cannot be obtained with closed reduction and casting. The more significant indications for surgery are unstable and irreducible fractures and refracture at a site of the previous fracture, open fractures, fractures with neurovascular compromise, pathologic fractures, and forearm fractures with associated humerus fracture ("floating elbow") [19].

While previous studies have focused on the efficacy of procedural sedation agents, agents' efficacy' efficacy has been little research into the efficacy of haematoma block and reduction from an orthopaedic trauma perspective in forearm fractures. In our study, we determined the outcomes associated with paediatric forearm fractures after haematoma block and closed reduction.

Reduction under the analgesic effect of haematoma block in the ED has been shown to decrease time to manipulation and reduce the length of stay compared with traditional manipulation under anaesthesia, all while achieving adequate levels of reduction [20]. As a result, it would benefit both patients and hospital systems to attempt closed reduction under haematoma block effect whenever clinically appropriate.

In our series, over 75% of both-bone forearm fractures, radius diaphyseal fractures, and diaphyseal ulna fractures were treated with haematoma block and closed reduction with successful outcomes. Prior studies by Jones *et al*. concluded that forearm fractures treated with closed reduction for children from 0 to 8 years resulted in successful healing of the fractures and did not require any internal fixation in a series of 300 cases with only 22 patients requiring manipulation [21].

A study by Voto *et al*. [22] demonstrated that only 7% of pediatric forearm fractures treated by cast immobilization had reangulation or displacement.

Finally, the literature review reveals that conservative care is a familiar, safe, and effective treatment choice for paediatric forearm fractures. After removing the cast, it is common to experience stiffness in the elbow or wrist. After a few weeks, the stiffness typically goes away on its own, but in rare cases, physical therapy is required to restore motion. Because the bones are still weak after removing the cast, the patient may avoid sports and physical education for 4–6 weeks to avoid re-breaking the bone.

While haematoma block and reduction has been shown to provide benefit to the patient in the short-term with faster times to manipulation and shorter length of stay, this benefit can only be solidified if undesirable outcome rates remain low. Our series had no episodes of compartment syndrome or nonunion and only one case of malunion (5%). In addition, the overall rate of repeated intervention due to lost alignment remained low at 20%, similar to the 15% rate that Betham *et al*. [23] described for paediatric forearm fractures. Furthermore, patients that required repeat intervention with cast wedging (n=1,5%) ultimately avoided general anaesthetic in the OR, leaving the rate of lost alignment requiring surgical intervention with general anaesthetic lower at 15%.

By providing an alternative to general anaesthesia for many paediatric traumatic injuries without compromising patient outcomes, analgesia via haematoma block and closed reduction is an effective tool to utilize in the care of paediatric forearm fracture cases. Today, the number of complications arising from haematoma block infiltration at the fracture site is still debated amongst anaesthetic and orthopaedic professionals. The fear of converting a closed fracture to an open fracture equivalent dates back to the 1980s, when R.D. Case, among others, reported the theoretical risk of infecting the fracture site by the haematoma block method [24].

Our findings show no significant complications arising in cases given a haematoma block. Similarly, in a study by Johnson and Noffsinger in 1991, they found no signs of infection in patients treated with haematoma blocks. Their study compared haematoma block to general anaesthesia and intravenous regional anaesthesia [25]. Numerous publications have followed that prove the efficacy of the haematoma block and that it has a more significant and prompt pain control than other anaesthetic techniques [26, 27].

Our study demonstrated that patients suffering complications after distal radius fractures were significantly older than those without complications. This is in line with a study by Chung *et al*., who discovered that increasing age is a predictor of worse long-term results one year after surgical treatment of radius fractures [28].

A study with data gathered for the paediatric patient shows that the length of stay in the emergency department was also significantly shorter in the haematoma block group than the procedural sedation anaesthesia [29].

As with every invasive procedure, the haematoma block method bears risks, carefully evaluating and discussing the patient prior to the intervention. In every haematoma block surgery, a C-arm image intensifier may be utilized to reassure the physician that the needle is in the correct location while administering the local anaesthetic.

A minor complication arising in our study was tendinitis, which was reported as complications after sustained forearm fractures, independent of the mode of anaesthesia or reduction used [30]. Another complication that arose as a reaction to local anaesthetic can be easily prevented by giving a test dose of lignocaine prior to haematoma block infiltration.

However, since there were no significant complications and only 15% cases leading to loss of alignment after closed reduction post haematoma block, it can be stated that the haematoma block is a safe method for the pre-surgical reduction of forearm diaphysis fractures. Limitations of this study were mono-centric and smaller sample size of the cases included.

Conclusion

We conclude that closed reduction under haematoma block provides an alternative to general anaesthesia for many paediatric trauma injuries without compromising patient outcomes. It may be considered a safe method of administering analgesia during closed reductions of paediatric forearm fractures in the ED. It provides an alternative to general anaesthesia for many paediatric traumatic injuries without compromising patient outcomes, procedural sedation, and reduction with reducing hospital stay in paediatric forearm fracture cases.

Abbreviations

Yrs: Years; A.O.: *Arbeitsgemeinschaft für Osteosynthesefragen*; E.D: emergency department; OTA: Orthopaedic Trauma Association.

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