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Original Article

Anaesthetic management of forearm fractures using a combination of haematoma block and intravenous regional anaesthesia

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ABSTRACT

Background: Intravenous regional anaesthesia (IVRA) has been successfully used as a sole technique for forearm fractures and has high success rates. However, it is uncomfortable for the patient when the fresh fracture is manipulated for conduct of IVRA. Haematoma block (HB) has also been demonstrated as an effective anaesthetic technique for treatment of radial fractures in the ER. Unfortunately, HB does not provide muscular relaxation and may not be sufficient for operative intervention.

Methods: An observational case series was designed with the hypothesis that a combination of HB and IVRA would overcome the aforementioned drawbacks. A standardized protocol was followed for HB with 0.1 ml/kg of 0.5% bupivacaine preceding the conduct of IVRA, which permitted adequate exsanguination of the extremity (using compression bandage). For IVRA, 0.5% lignocaine at 3 mg/kg was used with an electro-pneumatic tourniquet. Pain scores were noted after the HB, at exsanguination and during surgery.

Results: 100 cases were studied. Average time of onset of block after HB was 2 min 18 s. By the time the IVRA procedure was performed, 99% of patients had a pain score of zero. The quality of surgical anaesthesia revealed that 94% of the patients did not have any pain of incision, tourniquet or positioning at any time during surgery.

Conclusion: The use of dual technique of HB and IVRA improved patient acceptance and compliance, and the safety and efficacy of the IVRA. The combination anaesthesia was found to be easy to administer, effective and safe with no complications.

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Introduction

Fractures of forearm requiring both operative and non-operative intervention can be managed with various anaesthetic techniques such as haematoma block (HB), intravenous regional anaesthesia (IVRA), brachial plexus block, sedation and general anaesthesia (GA). GA and conscious sedation require skilled monitoring and carry a multitude of drawbacks particularly in patients with multiple co-morbidities. Brachial plexus blocks also need hospital admission and require anaesthetic expertise. HB and IVRA are commonly used for treatment of such conditions. IVRA has been successfully used as it has a high success rate, offers bloodless operating field and good muscle relaxation.^{1–3} However, besides tourniquet pain and lack of postoperative analgesia, it is uncomfortable for the patient when the fractured hand is manipulated for conduct of IVRA.⁴ On the other hand, HB has been demonstrated to be safe and simple and has been used effectively for treatment of fractures of radius in the emergency room and for immediate relief of pain.^{5–7} However, HB does not provide muscular relaxation and may not be sufficient for any operative intervention.

Against this background, it was hypothesized that a combination of HB and IVRA would overcome the drawbacks of each technique and would complement each other. Preceding IVRA with HB would allow proper conduct of IVRA. Both the techniques have been studied independently and also compared with other techniques such as sedation, brachial plexus block, etc.^{8–10} However, there is no study in the literature till date which has combined these two techniques. HB and IVRA together are also an attractive option since they do not require expertise or equipments such as ultrasound or peripheral nerve stimulator needed for brachial plexus block and hazards of GA are obviated. Thus, these techniques can prove to be potentially useful in field situations. Besides, the technique is also suitable for day care anaesthesia. In view of the above, a prospective observational case study was undertaken to evaluate the effects of a combination of HB and IVRA for anaesthetic management of fractures of distal forearm.

Materials and methods

After taking approval of Hospital Ethical Committee, the study was carried out on 100 cases over a period of 4 years in a secondary level hospital of armed forces medical services. The study was designed as an observational case series. The inclusion criteria consisted of all the patients between age group of 10 and 75 years in ASA I and II who had sustained closed fractures of distal upper extremity within 7 days of onset, requiring open or closed reduction and internal fixation and were scheduled for a procedure lasting less than 90 min.

Patients having cardiovascular co-morbidities, compound or contaminated fractures, peripheral vascular disease, sickle cell disease/trait, coagulation disorders and histories of allergy to the local anaesthetic (LA) agents were excluded from the study. Cases which had to be converted to GA, as well as those which exceeded tourniquet time (90 min) were also excluded from the study. All the patients were subjected to a thorough

pre-operative anaesthesia assessment (history, physical examination and relevant investigations).

Prior to surgery, patients were explained about the procedure and Numerical Rating Scale (NRS), and written informed consent was taken. The patients were taken up for surgery after ensuring NPO status. Pre-medication was given in the form of inj. midazolam 0.02–0.03 mg/kg IV immediately after establishing the monitoring lines in the OT and baseline assessment of pain was also done by interviewing the patient.

The study protocol included initial performance of HB at the fracture site. After ensuring asepsis, the fracture haematoma was localized by tactile palpation and referring to radiographs. A 24G needle attached to a 5 ml syringe was used to localize the fracture haematoma, keeping the puncture site as close to the fractured fragments as possible. Passive reflux of blood in the syringe followed by positive aspiration of blood from the fracture site was done to confirm correct needle placement. It is to be noted here that blood drawn from the haematoma and intravascular aspirate is completely different and easily identifiable. The haematoma blood being altered blood is darker (almost blackish) as it is completely deoxygenated. Also, a basic knowledge of anatomy (which most anaesthesiologist possess) will help avoid intravascular injections.

Thereafter, the drug was slowly injected, while monitoring the ECG and level of consciousness. The injection site was then sprayed with a sealant spray and pressure applied for 1–2 min. Approximately, 3–5 min time was allowed for the block to act. Pain was assessed on NRS of 0–10 (0 – no pain; 10 – maximum imaginable pain) by interviewing the patient till NRS reduced to 3, again at 5 min, at 10 min and thereafter during exsanguination of the limb. Inj. bupivacaine (plain) 0.5% was used in the dosage of 0.1 ml/kg body weight. If both forearm bones were fractured, the total volume thus calculated was multiplied by 1.5 and then divided into two parts which were injected separately into the fracture haematoma of each bone. Time for onset of block was defined as 'time required for NRS score to reduce to 3' whereas failure of block or inadequate block was defined as NRS scores of ≥ 4 , 10 min after administration of block.

After confirmation of analgesia of HB, preparations for conduct of IVRA were made. A double pneumatic tourniquet with a proximal and distal cuff (which could be inflated separately) was placed in the upper arm as proximal as possible and away from the operative site. A 20G or 22G IV cannula was used to secure an intravenous access distal to the fracture site. The limb was then exsanguinated using pressure bandage wound spirally (with $\frac{2}{3}$ overlap) from distal to proximal part of the limb. After winding the bandage, 3 min were allowed for exsanguination of the limb. The proximal cuff was then inflated to a pressure 100 mmHg above patient's systolic blood pressure or to a minimum of 250 mmHg whichever was higher. Circulatory isolation of the affected limb was confirmed by absence of radial pulse and loss of pulse oximeter trace in upper limb. Inj. lignocaine (plain) was used and the dose was calculated as 3 mg/kg body weight and diluted with 0.9% saline to form a 0.5% solution of lignocaine.¹¹ This solution was slowly injected into the exsanguinated limb. The timing of injection of lignocaine coincided nearly 10–13 min after HB.

Sensory block was determined to have developed if the patient had no response to pin prick after 3 min of the injection

Table 1 – Quality of surgical anaesthesia.

Category	Description
Category I	No pain of incision, tourniquet or positioning at any time during surgery (NRS = 0)
Category II	Experienced mild pain of tourniquet or positioning but not of incision at any time during surgery (NRS = 1–2)
Category III	Experienced mild to moderate pain of surgery or experienced discomfort or pain of positioning or tourniquet at any time during surgery (NRS = 3–4)
Category IV	No pain relief. Patient required additional/supplemental anaesthesia in the form of sedation or GA/DA (NRS ≥ 5)

and surgery was then allowed to commence. During the surgery, categorization of the quality of surgical anaesthesia was done according to the criteria as shown in Table 1. After 15 min of the injection, the distal cuff was inflated to the same pressure as the proximal cuff, and then (only after confirmation of the inflation) the proximal cuff was deflated. Subjective discomfort to tourniquet pressure was also noted and recorded by questioning the patient prior to commencement of the surgery, and thereafter at 15 min intervals.

During the procedure, constant recordings of haemodynamic parameters, sensorium and any surgical discomfort as guided by NRS were made. Special effort was made to observe any evidence of drug toxicity, i.e. tinnitus, peri-oral tingling, visual disturbances, dizziness, seizures, level of consciousness, coma, cardiac arrhythmias and hypotension. Time duration of surgery and events related to release of tourniquet after the conclusion of surgery were also noted.

Results

A total of 100 cases were subjected to the study. The demographic data and details of other study parameters are

given in Table 2. The age ranged between 10 and 70 years, with a mean 37.5 years. The average duration of surgery was 54 min 31 s with a range of 41–78 min. 81 patients underwent ORIF; of these, 16 patients had both bone fractures whereas 65 patients had single bone fractures. 19 were single bone fracture who underwent CRIF. The average time of onset of block after HB was 2 min 18 s and there were no instances of block failure.

Analgesia after HB was recorded on the basis of a NRS as shown in Table 3 and elucidated in Fig. 1. 88% of the patients had a NRS score of 0 at 5 min and at 10 min the 95% of patients had achieved a score of 0. However, by the time IVRA procedure was performed, 99% of patients had a score of zero and the remaining 1% had a score of 1. This degree of pain relief also resulted in patients having no discomfort at the time of exsanguination.

94% of the patients were in Category I which meant that they had a NRS of 0 and did not have any pain of incision, tourniquet or positioning at any time during surgery. Only 5% patients experienced mild pain of tourniquet or positioning but not of incision at any time during surgery. There was only one patient who fell in Category III i.e. he experienced mild to moderate pain of surgery or experienced discomfort or pain of positioning or tourniquet at any time during surgery. The duration of surgery

Table 2 – Demographic data and patient parameters.

Parameter	Mean	Std deviation	Range
Age (years)	37.5	12.52	10–70
Weight (kg)	58.52	9.87	25–82
Onset of block	2 min 18 s	39.7 s	88–280 s
Both bone vs. single bone	16 vs. 84		
ORIF vs. CRIF	81 vs. 19		
Duration of surgery	54 min 34 s	6 min 24 s	40–78 min
1st analgesic ORIF	14.3 s	5.73 s	3–25 min
1st analgesic CRIF	9 h 35 min	60 min 32 s	8 h 5 min–11 h 17 min

Table 3 – Recorded pain scores during anaesthesia and surgery.

NRS	No. of patients			
	5 min after HB	10 min after HB	During exsanguination	During surgery
0	88 (80.49–93.33)	95 (89.26–98.14)	99 (95.16–99.94)	Cat I 94
1	7 (3.11–13.35)	4 (1.28–9.36)	1 (0.05–4.83)	Cat II 5
2	4 (1.28–9.36)	1 (0.05–4.83)	0	
3	1 (0.05–4.83)	0	0	Cat III 1
4	0	0	0	
5–10	0	0	0	Cat IV 0
Total	100	100	100	

Pain scores have been calculated with 95% confidence intervals in brackets.

Fig. 1 – Recorded pain scores during anaesthesia.

for this patient was 78 min. There were no patients in Category IV and none of the patients needed any additional/supplemental anaesthesia in the form of sedation or GA.

All the patients were further followed up for assessment of postoperative analgesia. The time to first demand of analgesia was recorded. The average time for first rescue analgesic demand after CRIF was 9 h 35 min 24 s, whereas it was only 14 min and 12 s after ORIF.

All the patients remained stable haemodynamically and none of the patients had any signs of LA toxicity mentioned earlier during or after the surgery. There were also no complications such as infection, compartment syndrome, etc.

Discussion

Pain relief is of utmost importance in forearm fractures which may need manipulation immediately for reduction followed by operative intervention. Amongst various techniques, HB and IVRA are attractive options. However, while HB offers immediate and adequate pain relief, it is inadequate for operative intervention. IVRA may be difficult to perform as application of pressure bandage or elevation of the limb for exsanguination is intensely painful in recent fractures.⁴ This intense pain could be overcome with the HB and then IVRA can be performed satisfactorily. A combination of blocks is usually done to overcome the deficiencies of individual blocks and to improve operating conditions or to prolong post-operative analgesia. Based on this premise, this study focused on the combination of two very simple techniques which do not require sophisticated equipment, and hence were also possible in a situation where resources are limited.

Though IVRA has been used as a solitary technique for fracture reduction, it suffers from many limitations. Besides other factors mentioned earlier, concerns include the risk of LA toxicity and unsatisfactory exsanguination due to pain at the fracture site.⁴ Inadequate exsanguination leads to an increased risk of LA toxicity and poor quality of block.¹² On the other hand, though the HB provides excellent pain relief at fracture site, it suffers from afore-mentioned disadvantages.¹³

HB has not only been reported to be safer than GA but also faster, and less expensive with a shorter recovery time.^{13,14}

The present study has shown that the combination of the HB and IVRA can successfully overcome this problem as exsanguination of the limb was possible due to the prior use of the HB. The quality of intra-operative anaesthesia and analgesia was also good. While literature is full of studies (vide infra) demonstrating advantages of both techniques separately, there is no mention of a combination of these two techniques for anaesthesia for fracture surgery. Our study shows distinctly that the combination is safe, effective and free from any complication.

It is well known that post-operative analgesia after IVRA is transient even though ropivacaine is likely to offer better post-operative analgesia than lignocaine.¹⁵ In our study too, there was near-absence of postoperative analgesia. However, it was interesting to note that post-op analgesia lasted for nearly 9 h in cases which were subjected to CRIF only. In our opinion, this can be explained by the fact that during CRIF the haematoma is not disturbed and the LA remains well contained as opposed to ORIF where the haematoma is washed off during the surgery. This can be taken as an additional advantage when using HB for CRIF.

Generally, lignocaine has been used for HB and use of bupivacaine for HB has been described recently.¹⁶ Dezfali et al. has described maximum recommended doses of both lignocaine as well as bupivacaine for HB.¹⁷ Researchers have used varied concentrations of 1–10% lignocaine and even prilocaine^{6,8,9,18}; however, all studies have used a fixed volume dose. There is a potential concern related to use of combination of LA and their total dose. In our study, while total doses of LA agents were kept well below the safe limit, it was also made certain that the injections were given nearly 15 min apart. This time-gap worked as a safeguard against development of additive LA toxicity. LA systemic toxicity was not seen probably as the calculated dose(s) of bupivacaine either single or combined was substantially below the toxic limit. Occurrences of LA toxicity following HB are unlikely and this fact has been supported by several studies.^{6,9,19–21} Here, it is pertinent to mention that the fracture haematoma behaves as a closed

compartment and is isolated from the rest of the circulation²²; hence, the scope for systemic absorption and toxicity is low despite angiogenesis occurring in the haematoma, during the early stage of healing, i.e. after the initial 7–10 days. This was also the reason for excluding all fractures of more than 7 days duration.

HB has been shown to provide safe and effective analgesia for manipulation of forearm and wrist fractures in adults.^{6–9} A Cochrane review in 2002 concluded that HB is much safer and can be done easily in emergency department.¹⁴ The HB is easily performed even by a non-anaesthetist and can be used effectively in a district hospital which lacks advanced anaesthesia and intensive care facilities.²³ HB when compared with sedation, GA, brachial plexus block, etc., has been found to have greater patient acceptance and more efficient with regard to time and the resources required.^{7,24,25} There has been renewed interest in HB as the technique is performed using of ultrasound for guidance and adjuncts for the HB.^{18,25} Even though HB is safe, a case of osteomyelitis and a case of compartment syndrome have been reported.^{26,27} In our study, not a single case of surgical site infection or osteomyelitis was noted during a 90-day follow-up of the cases.

IVRA by itself has been regularly used for treatment of forearm fractures. The primary advantages of IVRA are its simplicity, reliability and cost-effectiveness. However, one of the major limitations of IVRA continues to be the lack of postoperative analgesia following tourniquet deflation.³ It has been compared with HB and as noted by Kendall et al., IVRA is superior in terms of efficacy, radiological result and re-manipulation rate.²⁰ The drug of choice for IVRA is lignocaine even though a number of agents and additives have been used. According to a recent review, ropivacaine is likely to be a better alternative to lignocaine for IVRA which provides a prolonged post-tourniquet release pain relief as compared to lidocaine.^{3,15} Mohr also described IVRA to be safe, effective, reliable technique with a recommendation of using a 0.5% solution of lidocaine in a dose of 1.5–3 mg/kg.¹¹ We used a 1% solution of lignocaine at a dose of 3 mg/kg and did not come across any evidence of drug toxicity. However, in a systematic review (spanning 1950–2007) of complications of IVRA, seizures were reported with lidocaine at its lowest effective dose (1.5 mg/kg) as well as seizures occurring after tourniquet deflation were seen with a tourniquet time as long as 60 min.²⁸ However, all these events can be termed as extremely uncommon.

Conclusion

Use of HB in conjunction with IVRA with two different LAs in the dosages as described, is a safe and effective way to deal with distal upper extremity fractures of recent origin. It appears to be an attractive option to be practiced safely in field situation when it may be difficult to perform GA or equipment-guided plexus blocks.

Conflicts of interest

The authors have none to declare.

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