



Results of intravenous regional anaesthesia with distal forearm application

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The aim of this study was to evaluate the clinical effectiveness of distal forearm intravenous regional anaesthesia (IVRA) with the tourniquet applied 3 cm above the wrist.

One hundred and twenty patients undergoing outpatient hand surgery were operated for 13 different hand problems under distal forearm IVRA, using 10 ml of a solution containing 1.5 mg/kg prilocaine. Sensory block onset time was 4.5 minutes (3.5-6.5 min.). Mean tourniquet time was 17.6 minutes (range, 7-27.5 min). Mean tourniquet pressure was 240 mmHg (range, 220-270 mm Hg). The mean VAS score for tourniquet pain was 3.8 (range, 2-10). No local or systemic side effects related to the IVRA were observed.

The study showed that distal forearm IVRA using 10 ml of a solution containing 1.5 mg/kg prilocaine provides safe, rapid and effective anaesthesia for patients undergoing outpatient hand surgery.

the dose of local anaesthetic to be decreased without affecting the quality of analgesia. In addition a forearm tourniquet can be tolerated for a longer period of time and is consistently rated less painful, compared with the upper arm tourniquet (6). Finally, it allows for preservation of some motor function of the long flexors and extensors of the wrist and hand, which is useful in certain operations such as tenolysis (2, 3, 4).

This method was unpopular in the past because it was thought that the interosseous vessels in the forearm might not be occluded by the tourniquet because of the bi-osseous structure of the forearm, but this theoretical leakage has not been substantiated in any study (5).

The aim of this study was to assess the anaesthetic efficacy of forearm IVRA with 10 ml of a solution containing 1.5 mg/kg prilocaine in 120 patients with the tourniquet applied to the distal forearm 3 cm above the wrist.

INTRODUCTION

Intravenous regional anaesthesia was first used in 1908 by Bier. It is a safe, rapid and effective method for providing anaesthesia. At the same time it provides a bloodless operative field for hand surgery. However, conventional IVRA has some disadvantages, including the potential for local anaesthetic toxicity and lack of postoperative analgesia. It also has potential toxic effects which can occur despite an adequate tourniquet time (1).

Forearm IVRA may offer several advantages over the use of an upper arm tourniquet, as it allows

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Fig. 1. — Application of forearm tourniquet

MATERIALS AND METHODS

After approval by the local research ethics committee, 120 patients with ASA physical status I-II were operated under distal forearm IVRA. The operations were performed for 13 different hand problems. Fifty five patients were male, 65 were female ; their mean age was 37.8 years (range, 18-73). The most common diagnoses were carpal tunnel syndrome and cystic hygroma (ganglion).

Patients with liver disease, renal dysfunction, cardiac conduction abnormalities, history of epilepsy, allergy to local anaesthetics, diabetic neuropathy, coagulation disorders and those who were pregnant were excluded from the study.

All of the patients were operated in an outpatient setting. Premedication and pre- or intraoperative opioids or other analgesics were not used. One cannula was inserted into a vein in the dorsum of the non-operated hand for infusion of a crystalloid solution. A second cannula was inserted into a vein on the dorsum of the operated hand.

A solution of 10 ml containing 1.5 mg/kg prilocaine was used for anaesthesia. All patients were instructed about the use of the horizontal linear visual analogue scale (HLVAS) for tourniquet pain. This is a printed graduated scale from 0 to 10 with equal increments (0 for absence of pain and 10 for excruciating pain).

A 10 cm wide single-cuff tourniquet was placed on the distal forearm 3 cm above the wrist. The patient's blood pressure was measured before tourniquet inflation. After exsanguination with an Esmarch bandage, the cuff was inflated to a pressure 100 mmHg above the systolic pressure. The mean tourniquet pressure was 240 mmHg (range, 220-270).

Prior to injection of the anaesthetic solution, radial and ulnar arterial pulses were checked manually (fig 1) to control the efficiency of the tourniquet. The local anaesthetic solution was injected over a 30-second time period. All local anaesthetics were administered by the same anaesthesiologist.

Sensation to pinching was assessed with a forceps at 30-second intervals up to 7 minutes in the thenar, hypothenar and dorsal regions of the hands for median, ulnar and radial nerves respectively. Sensory block onset time and tourniquet time were recorded.

All of the patients were reviewed on the second and fifteenth postoperative days for wound inspection and suture removal respectively.

RESULTS

Patient's age and sex, sensory block onset times, the procedures, tourniquet pressure, tourniquet time and HLVAS scores were recorded (table I).

Sensory block onset time was 4.5 minutes (range, 3.5-7).

Mean tourniquet application time was 17.6 minutes (range, 7-27.5). One patient asked for removal of the tourniquet because of severe tourniquet pain after five minutes and the tourniquet was removed at the seventh minute.

The mean HLVAS score was 3.8 (2-10). The patient who asked for removal of the tourniquet after five minutes was evaluated as 10 with the VAS pain score.

No additional anaesthetic agent was required during any of the procedures.

Significant wound haematomas, infection or any other complication were not observed in any

Table I. — Patient's age and sex, the procedures, tourniquet pressure, tourniquet time and HLVAS scores

Number of patients	120
Male/female	55 / 65
Mean age (range) in years	37.8 (18-73)
Sensory block onset time (min)	4.5 (3.5-6.5)
Mean tourniquet time (range)	17.6 min (7 min-27.5 min)
Mean tourniquet pressure (range) (mmHg)	240 (220-270)
Mean HLVAS score (range)	3.8 (2-10)
Procedures	
Carpal tunnel release	31
Ganglion excision	29
Metacarpal fracture osteosynthesis	12
Extensor tendon repair	10
Phalanx fracture osteosynthesis	8
Foreign body removal	6
Trigger thumb	6
Extensor tendon tenolysis	4
Flexor tendon tenolysis	4
Flexor tendon repair	4
Digital neuroma excision	3
Enchondroma curettage and grafting	2
Dupuytren's contracture (partial fasciectomy)	1

patient. None of the patients complained of neural dysfunction postoperatively.

There was no significant change in the patients' haemodynamic variables during and after the operation. None of them experienced any local anaesthetic-related side effects.

Blood circulation in the hands was controlled one hour after the operation and all of the patients were discharged following the control.

DISCUSSION

The value of Bier's block for the manipulation of fractures and for operations on the upper limb is well recognised. It was pioneered in 1908 by Bier and became popular for limb surgery. Traditionally a forearm tourniquet was not used, because it was thought that forearm tourniquet cannot occlude the arteries located between the radius and ulna (12). However this theoretical leakage has not been substantiated in any study (5). Coleman *et al* compared the quantitative leakage and showed that leakage under the tourniquet from forearm and upper arm was similar (3).

In clinical studies to evaluate the safety and efficacy of the forearm tourniquet, forearm IVRA has been found to be safer than conventional IVRA because a larger bolus of drug enters the circulation on tourniquet release in upper arm IVRA. Therefore, forearm IVRA increases the safety margin of the technique (7, 10).

The anaesthesia onset time in our study was 4.5 minutes. Peng *et al* reported 6.5 ± 2.9 minutes for lidocaine and 8.0 ± 4.1 minutes for ropivocaine groups (8) and Reuben *et al* reported 13 ± 4 minutes for lidocaine and ketrolac in forearm IVRA when the tourniquet was applied 1 cm below the medial epicondyle (10).

In a study comparing the standard upper arm tourniquet with the forearm tourniquet in terms of discomfort, paresis and paralysis in non-anaesthetised healthy volunteers, Hutchinson and McClinton suggested that the forearm tourniquet was tolerated an average of 13 minutes longer than the arm tourniquet and no subject tolerated the arm tourniquet longer than the forearm tourniquet (6). However this study did not involve surgery. According to their clinical experience Edwards *et*

al stated that forearm and arm tourniquet tolerance time was up to 20 minutes and tolerance times were not significantly different. They recommended to use a double tourniquet for longer operations and to switch them intraoperatively if necessary (4). In the literature some authors have placed the forearm tourniquet in the most proximal part of the forearm approximately 1 cm distal to the medial epicondyle as suggested in the classic textbook description (4, 6).

Convulsions have been reported during IVRA while the tourniquet was applied, and Lawes *et al* showed Carbon 14 (C₁₄) labeled lidocaine in the circulation of dogs even while the tourniquet was inflated (11). This has been assumed to be due to spread of local anaesthetic agent via an intraosseous venous plexus. It has been shown that venous pressure had a role in leakage during IVRA (11, 12). Adverse reactions such as seizures, toxic symptoms, cardiopulmonary arrest and death have been reported while the tourniquet was inflated or upon tourniquet release, especially when larger doses of local anaesthetic were used (4, 12). Numerous medications have been used to minimize the potential for systemic toxicity but the most reliable method appears to be minimizing the dose of local anaesthetic and this can be achieved by forearm IVRA. The risks of dizziness, tinnitus and bradycardia are much lower with a forearm IVRA because local anaesthetic dispersion with blood flow after tourniquet removal is much less. Forearm IVRA allows the dose of local anaesthetic to be decreased by up to 50% without affecting the quality of analgesia, with much less postoperative pain (7, 12). Reuben *et al* stated that IVRA with forearm tourniquet provided an enhanced postoperative analgesic effect when compared with an upper arm tourniquet (10). The reason for this enhanced analgesic effect is increased binding of anaesthetics to the tissues during forearm IVRA and reduction in its clearance from the surgical site.

In a previous study to find the appropriate tourniquet pressure, it was shown that leakage was seen at tourniquet pressure 50-75 mmHg above systolic pressure, whereas slight leakage was seen in only two of 110 patients (1.8%) when pressure was 75-100 mmHg above systolic pressure (7).

One major drawback of IVRA is that haemostasis cannot be achieved satisfactorily without the tourniquet because of the rapid recovery of sensation after the tourniquet is deflated. We therefore infiltrated the wound with bupivacaine before tourniquet deflation. The volume of bupivacaine did not exceed 5 ml. This also provides analgesia for 4 to 6 hours postoperatively.

Distal forearm tourniquet is not popular in the clinical setting because it is too close to the surgical site, which may cause infection, but we have not observed infection in any of our cases.

We administered a volume of 10 ml of the anaesthetic solution with this technique. Forearm IVRA with the tourniquet applied 1 cm below the medial epicondyle, as is usually done, requires using 20-25 ml. Reuben *et al* used 20 ml (10), Peng *et al* used 0.4 ml/kg up to 25 ml (8), and Chow *et al* used 0.4 ml/kg up to 25 ml (2).

We conclude that a solution of 10 ml containing 1.5 mg/kg prilocaine provides safe, rapid and effective anaesthesia for patients undergoing outpatient hand surgery when the tourniquet is applied to the distal forearm 3 cm above the wrist.

To the best of our knowledge, clinical usage of distal forearm IVRA with 10 ml of anaesthetic solution and tourniquet application 3 cm above the radial styloid has not been reported before.

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