



A Comparative Study of Intravenous Regional Anesthesia using Forearm Versus Upperarm Tourniquet

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Abstract

Aim of the Study: To evaluate the efficacy of forearm tourniquet in comparison with upperarm tourniquet in Intravenous Regional Anesthesia on the quality of the block and the post operative pain relief.

Materials and Methods: This prospective, randomized comparative study, was done in 30 patients each in the control group (upperarm intravenous regional anesthesia) using 40ml of 0.5% lignocaine and the study group (forearm intravenous regional anesthesia) using 20ml of 0.5% lignocaine

Statistical Tools: Using Epidemiological Information Package (EPI 2002) and Kruskal Wallis chi-square test was used to test the significance of difference between quantitative variables. A 'p' value less than 0.05 is taken to denote significant relationship.

Conclusion: Intra Venous Regional Anesthesia using forearm tourniquet in comparison with upperarm tourniquet, has increased margin of safety, by allowing fifty percent reduction in the drug dosage, provides adequate intraoperative analgesia, offers longer duration of sensory blockade after tourniquet deflation, provides, prolonged post operative analgesia, provides lesser degree of motor blockade which is useful in certain tendon surgeries.

Keywords: Intravenous Regional Anesthesia, Forearm tourniquet, Hand Surgeries.

Introduction

IVRA (Intravenous Regional Anesthesia) is a safe and effective technique for providing anesthesia as well as bloodless field during hand surgery. Traditionally, an upperarm tourniquet has been used for these procedures. However, upperarm IVRA does have some disadvantages including the potential for local anesthetic toxicity,

Tourniquet pain and lack of postoperative analgesia. Toxicity may be caused by leakage past the tourniquet because of high venous pressures or tourniquet failure. Adverse reactions have also been reported upon tourniquet release, especially when larger doses of local anesthetic are used.

The application of a Forearm tourniquet offers several advantages to the use of an upperarm

tourniquet. Forearm IVRA allows the dose of LA to be decreased by upto 50 %, without affecting the quality of analgesia^{[1][2]}. In addition, the forearm tourniquet can be tolerated longer and was consistently rated less painful when compared with the upperarm tourniquet. Finally, using a forearm tourniquet 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 and fixation of hand fractures.

Aim of the Study

To evaluate the efficacy of forearm tourniquet in comparison with upperarm tourniquet in Intravenous Regional Anesthesia on the quality of the block and the post operative pain relief.

Materials and Methods

This is a prospective, randomized comparative study conducted at our hospital. After approval by the ethical committee 60 patients of ASA grade I and II age between 15-50 years who came for hand surgeries which lasted for less than 45 minutes were included in the study.

Patients with history of allergy to local anesthetics, sickle cell disease, raynaud's disease, scleroderma, local infection, paget's disease and patients with inadequate starvation <6 hours were excluded from this study. Preanesthetic evaluation was done.

No patients were premeditated. Resuscitation equipment and drugs were kept ready. Pulse rate, Blood Pressure and Oxygen saturation were estimated continuously. 18G iv cannula was started in the non operative hand.

The equipment required for IVRA includes:

- ❖ Pneumatic tourniquet (checked for leaks before the procedure) and a pressure gauge.
- ❖ Esmarch bandage or Rhys-Davis exsanguinator
- ❖ Local anaesthetic solution
- ❖ Resuscitation equipment and drugs.

Upperarm Intravenous Regional Anesthesia Group (Control Group)

A 22G cannula was placed intravenously in the arm to be anesthetized. The double tourniquet was applied on the arm with generous layers of padding, ensuring that no wrinkles are formed and the tourniquet edges do not touch the skin. The arm was exsanguinated by using Esmarch bandage. If this was impossible, exsanguination was achieved by elevating the arm for 2-3 minutes while compressing the axillary artery. Tourniquet pressure of systolic plus 100mmHg was used. Circulatory isolation of the operative arm was confirmed by inspection of the hand and by absence of the radial pulse. A standard volume of 40ml of 0.5% Lignocaine containing 200mg was used. Venous access is established in the opposite arm to allow administration of fluids or drugs if necessary. The distal tourniquet is inflated to at least 100mmHg higher than the patient's systolic blood pressure (250-300mmHg)^[11]. The proximal tourniquet is inflated to the same pressure. After ensuring inflation, the distal cuff is deflated.

Before injecting local anaesthetic it must be confirmed that no radial pulse is palpable. The local anaesthetic is then injected slowly. A standard volume for injection into the upper limb is 40ml, which can be increased to 50ml in a fit, large adult. If the injection is too rapid, the venous pressure may exceed the tourniquet pressure and the local anaesthetic solution may escape into the systemic circulation. Surgical Anesthesia is usually achieved within 15 minutes. The distal tourniquet, which overlies part of the anaesthetized arm, can then be inflated and the proximal one deflated to relieve tourniquet pain.

The cuff should not be deflated until 20 minutes after local anaesthetic injection because systemic toxic doses of local anaesthetic may occur. After 20 minutes, 30% of the injected drug is fixed within the tissues and is unavailable for immediate release into the systemic circulation. Cuff deflation should be performed in cycles with deflation / inflation times of less than 10 seconds until the patient no longer exhibits signs of

systemic toxicity (e.g. tingling of the lips, tinnitus, drowsiness). Severe signs of systemic toxicity include bradycardia, hypotension, ECG abnormalities, seizures and loss of consciousness. The patient should be monitored closely for 30 minutes following tourniquet release.

Ten minutes after cuff deflation, blood levels will be less than 2 micrograms/ml, when Lignocaine is used in a dose of 2.5 – 3 mg/kg.

If severe CNS intoxication occurs, appropriate resuscitation guidelines should be followed. Emergency drugs must be readily available and 100% oxygen should be administered.

Forearm Intravenous Regional Anesthesia Group (Study Group)

Here the double tourniquet was positioned 1cm below the medial epicondyle. A standard volume of 20ml of 0.5% Lignocaine containing 100mg of Lignocaine was used.

IVRA solution was administered slowly via the cannula for 3 minutes. The distal tourniquet was used as a safety measure, it was not inflated in any patient.

After injection of the IVRA solution, sensory block was assessed at thenar eminence (median nerve), hypothenar eminence (ulnar nerve) and first web space (radial nerve) at 30 seconds interval. The cuff was not deflated until 20 minutes after local anesthesia injection even if surgery was completed before 20 minutes. Cuff deflation was performed in cycles of deflation/inflation times of less than 10 seconds until the patient no longer exhibits signs of systemic toxicity. Patients were observed 60 minutes after surgery.

Sensory regression was assessed at the same sites at 30 seconds interval, after tourniquet deflation. Postoperatively, pain was assessed by using verbal analog pain scale between '0' and '10' with '0' representing no pain and 10 representing the worst imaginable pain.

Intraoperatively the following parameters were noted:

Pulse rate, blood pressure, Oxygen saturation were monitored regularly at frequent intervals

- Sensory and Motor blockade onset times.
- Duration of surgery
- Mean tourniquet time
- Mean Tourniquet Pressure
- Modified Lovett's Scoring to assess the motor power.
- Intraoperative verbal analog scale
- Verbal analog scale after deflation
- Field of surgery
- Sensory and motor blockade regression time

Statistical Tools

The information collected regarding all the selected cases were recorded in a Master Chart. Data analysis was done with the help of computer using Epidemiological Information Package (EPI 2002).

Using this software, range, frequencies, percentages, means, standard deviations, chi square and 'p' values were calculated. Kruskal Wallis chi-square test was used to test the significance of difference between quantitative variables. A 'p' value less than 0.05 is taken to denote significant relationship.

Results and Observations

The difference between the groups with groups with respect to the mean arterial pressure and pulse rate at 5 minutes interval during the procedure and after cuff deflation was not statistically significant

The difference between the groups with respect to the Tourniquet pressure used is not statistically significantly. Hence the groups were comparable with respect to the tourniquet pressure. The sensory block onset time in the study group and control group were 2.77 minutes and 2.7 minutes respectively. The difference in the sensory block onset time was not statistically significant.

The motor block onset time in the study group and control group were 5.93 minutes and 1.53 minutes respectively, the difference of which is statistically significant.

Sensory block regression time in the study group and control group were 8.97 minutes and 1.06 minutes respectively, the difference of which is statistically significant. Motor block regression time in the study and control group were 7.87 and 1.22 minutes, the difference of which is not statistically significant.

The field of surgery in the study group was excellent in the study group was excellent in 56.7%, good in 36.7%, and oozing was present in 6.7%. in the control group it was excellent in 70%, good in 26.7% and oozing was present in 33% of the cases.

The mean duration of surgery in the study group and control group were 37.5 and 37.43 minutes, the difference of which is not statistically significant.

Table 1: Onset time

Onset time	Forearm IVRA		Upperarm IVRA		'p'
	Mean	S.D.	Mean	S.D.	
Sensory Block	2.77	0.68	2.7	0.75	0.6348 Not Significant
Motor Block	5.93	1.38	7.17	1.53	0.0025 Significant

The sensory block onset time in the study group and control group were 2.77 minutes and 2.7 minutes respectively. The difference in the sensory block onset time was not statistically significant.

The motor block onset time in the study group and control group were 5.93 minutes and 1.53 minutes respectively, the difference of which is statistically significant.

The mean Modified Lovett's scoring for the motor power grading of the study and control group were 3.97 and 1.8 respectively, the difference of which was statistically significant.

Table 2: Tourniquet Time

Tourniquet Time	Forearm IVRA	Upperarm IVRA
Mean	32.47	32.37
S.D.	2.33	2.16
'p'	0.9326 Not significant	

The mean Tourniquet time of the study group and control group were 32.47 and 32.37 minutes respectively, the difference of which is statistically not significant.

Table 3: Visual Analog Score

VAS	Forearm IVRA		Upperarm IVRA		'p'
	Mean	S.D.	Mean	S.D.	
At 10 min	0.067	0.254	0	0	0.1538 Not Significant
At 20 min	0.267	0.583	0.033	0.183	0.0639 Not Significant
At 30 min	0.567	0.858	0.233	0.504	0.112 Not significant

The difference in the mean VAS during the procedure was not statistically significant. The difference in the mean VAS after cuff deflation at 10, 30, 60 minutes were statistically significant.

Discussion

Intravenous regional anesthesia uses local anesthetics administered to one particular limb occluding the arm proximally, to provide conduction blockade. Intravenous regional anesthesia was first described by August Bier in 1908^[11]. It must be safe not threatening or unpleasant to the patient. It allows adequate surgical access to the operative site and cause as little disturbance as possible to the internal homeostatic mechanisms. IVRA is used for surgical interventions on the hand, forearm or elbow that will not exceed 1 hour^[17] These include manipulation of forearm fractures, excision of ganglion, palmar fasciotomy, debriding wounds, removing foreign bodies, wrist and ankle arthroscopy, carpal tunnel decompression, repair of ruptured tendons, incision and drainage of abscesses and paronychia, podiatric surgery, microsurgical repair of limbs, suturing extensive lacerations that would otherwise require a large and possibly toxic dose of local anesthetic infiltrated into the wound edges, excision of painful scars and grafting.

Advantages of IVRA

- Speed of onset and rapid recovery
- Reliability (in the absence of local infection and with adequate equipment)
- Muscle relaxation
- Technical simplicity^[12]

Despite these advantages, conventional IVRA has some limitations, including the potential for

local anesthetic toxicity and lack of postoperative analgesia^[5]. It also has potential toxic effects which can occur despite an adequate tourniquet time.

Disadvantages and Complications of IVRA

- Poor post operative analgesia
- Limited time of surgical anesthesia (<90 minutes)
- The potential of systemic local anesthetic toxicity^[16]
- Nerve damage secondary to direct compression by the tourniquet
- Compartment syndrome and loss of limb (very rare)

In this study, we attempted to eliminate these disadvantages by using a forearm tourniquet.^[3]

Intravenous Regional Anesthesia using forearm tourniquet increases the margin of safety of the technique by allowing fifty percent reduction in the dose of Lignocaine in comparison with the conventional technique^[13,14]. Therefore, this approach reduces the risk of local anesthetic toxicity in the event of tourniquet failure.^[18,19]

The sensory block regression time was 8.97 and 2.7 minutes in the study group and control group respectively, the different of which was statistically significant. The recovery of pain sensation was rapid in the upperarm IVRA group after tourniquet deflation. Subsequent hemostasis and wound closure will be difficult. So the block must be supplement with infiltration or metacarpal block. Because IVRA using forearm tourniquet provides prolonged sensory blockade it reduces or eliminates the need to supplement the block.

The modified Lovett's score of grading of motor power was 3.97 and 1.8 in the study and control group respectively. Usage of forearm tourniquet allows for the preservation of some motor function of the long flexors and extensors of the wrist and hand which is useful in certain operations like tenolysis and tendon repair, where complete motor blockade is not needed.^[20,21]

Tourniquet tolerance was good in both the groups. Intraoperative VAS was less than 1 in all patients.

Two patients in the study group and one in the control group had tourniquet pain. The reason for this is the duration exceeded 40 minutes. So tourniquet was released and was supplemented by metacarpal block.

Patients in both the groups had adequate intraoperative analgesia. The difference in the mean VAS at 10, 20 and 30 minutes was not statistically significant in both the groups. The mean VAS at 60 minutes after tourniquet deflation in the study and control were 2.9 and 8.03 respectively the difference of which was statistically significant. Thus Intravenous Regional anesthesia using forearm tourniquet provides prolonged post operative analgesia.

Conclusion

Intra Venous Regional Anesthesia using forearm tourniquet in comparison with upperarm tourniquet.

- Has increased margin of safety, by allowing fifty percent reduction in the drug dosage.
- Provides adequate intraoperative analgesia
- Offers longer duration of sensory blockade after tourniquet deflation.
- Provides, prolonged post operative analgesia.
- Provides lesser degree of motor blockade which is useful in certain tendon surgeries.

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