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Clinical Trial

An Observational Study of Efficacy of Infraclavicular Brachial Plexus Block for Arterio-Venous Fistula Surgeries- Comparison of Two Techniques Using Ultrasound and Ultrasound with Peripheral Nerve Stimulation

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Abstract

Background: Success of the brachial plexus block depends equally on the performer's skill and the availability of specific equipments. Here, the efficacy of infraclavicular brachial plexus block was assessed using two different techniques.

Material and Methods: In 72 patients divided in equal groups, the time taken to perform the block, onset and degree of sensory and motor blockade, complications and supplements, if required were noted in patients undergoing arterio-venous fistula creation. An infraclavicular brachial plexus block was performed either with ultrasound only (group-A) or with ultrasound and nerve stimulation (group-B). Collected data underwent rigorous statistical analysis.

Results: Onset of sensory, motor blockade and block success achieved in both groups was statistically insignificant. Time taken for block administration and the mean time for complete sensory blockade were statistically significant.

Conclusion: Though time taken for the block administration was longer and complete sensory blockade was earlier by dual guidance, the block success rate and the degree of block were comparable in both the techniques. Dual modality blocks are challenging in view of obtaining an evoked motor response and visualization of the needle at the same time.

Keywords: Infraclavicular brachial plexus block, Sonosite, Peripheral nerve Stimulator

Introduction

Maintenance hemodialysis through an arteriovenous fistula (AVF) is the gold standard for chronic kidney disease (CKD) patients as a bridge to renal transplant till they get a donor. The co-existence of several systemic diseases and altered pharmacokinetics of anesthetic drugs, add up to the risk of general anaesthesia.

Regional anaesthesia for vascular access surgery ensures intraoperative patient comfort, minimize anaesthesia complications, optimize surgical conditions and post-operative state by avoiding prolonged sedation and reduce requirement for strong post-operative analgesics. Moreover, regional anaesthesia provides good hemodynamic stability, peri-operative analgesia and decrease the need for systemic analgesics. The resultant regional sympathectomy improves the blood flow through the limb and the fistula, helps to maintain the patency, lowering the failure rate and shorter maturation times.

Since the commonest site chosen is upper limb, brachial plexus block is the choice of regional anaesthesia. Out of its various techniques, intra-clavicular approach is easy, effective and faster. Techniques of nerve localization include paresthesia, peripheral nerve stimulation, ultrasound (US) guidance and combination of ultrasound with peripheral nerve stimulator (USNS).

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This study compares block efficacy of two different guidance techniques of performing infraclavicular brachial plexus block (ICBPB) viz. using US (to visualize the structures advance the needle to the exact location of administration and visualize the U-shaped distribution of anesthetic agent around the artery) and USNS (where in addition to Ultrasonic guidance, electrical neurostimulation is used to elicit a motor response, as an end point to identify) for AVF surgeries.

Methods

This prospective, observational, longitudinal study was undertaken after institutional ethics committee approval [ISEB CODE-C-3/01/2014]. Seventy-two consecutive CKD patients (ASA-III) of either sex between 18 and 70 years undergoing AVF surgeries under ICBPB using either with US or with USNS were included after a written informed consent. Patient with significant coagulopathy, preexisting motor or sensory deficit in the operative limb, previous contralateral pulmonary resection, infection at the puncture site, history of allergy to local anesthetics, pregnant and lactating females were excluded from the study.

Sample size calculation- Based on the literature, it was observed that after giving ICBBP, 86% of patients in US group had complete sensory block compared to 57% of patients in USNS group. Expecting the proportion of patients in US to be 85% and 55% in USNS, we require 72 subjects to achieve 80% power with 5% level of significance. $n = (Z\alpha/2+Z\beta)^2 (p1(1-p1)+p2(1-p2))/(p1-p2)^2$, where $Z\alpha/2$ is the critical value of the normal distribution at $\alpha/2$ (e.g. for a confidence level of 95%, α is 0.05 and the critical value is 1.96), $Z\beta$ is the critical value of the Normal distribution at β (e.g. for a power of 80%, β is 0.2 and the critical value is 0.84) and p1(85%) and p2 (55%) are the expected sample proportions of the two groups. $n= (1.96+0.84)^2 (0.85(1-0.85+0.55(1-0.55)) / (0.85-0.55)^2 =$ 33 per group, However, a total sample size of 72 patients with 36 per group recommended to allow for drop outs or incomplete data collection.

Patients were divided into two groups of 36 each as group-A receiving ICBPB using only US and group-B receiving ICBPB using USNS at discretion of the anesthesiologist administering the block.

Adequate counselling and informed consent were performed prior to day of surgery. Intravenous access was secured with 20G cannula. Patient's heart rate (HR), arterial blood pressure (ABP), oxygen saturation, respiratory rate (RR) and ECG were monitored throughout the surgery. Oxygenation was done with Hudson's mask at 6L/minute.

Technique

Patient was positioned supine with the neck turned away from the side to be blocked and the arm was placed in abduction. Medial clavicular head and coracoid process were identified and midpoint of line connecting them was marked. The area was prepared sterile. The sterile linear probe (3-12mHz (M-turbo Fuji Sonosite)) was positioned in parasagittal plane medial to the coracoid process at the marked point and was adjusted to obtain a cross section of the axillary artery. At the marked point, immediate cephalad to the probe a 5 ml of 2% lignocaine was injected. Under direct visualization, with the needle in line with the probe, a 22 Gauge 100 mm Teflon coated insulated needle was advanced from cephalad to caudal and posteriorly towards the neuromuscular space.

In group-A, the local anesthetic (LA) was injected in a U-shaped distribution posterior and to each side of the axillary artery with needle positioned appropriately.

In group-B, the needle was attached to peripheral nerve stimulator and was grounded with an electrode. US guided neuromuscular space was approached with the needle. Upon electrical stimulation at 1Hz 0.1ms stimulation and a current at 1.5 mA, distal motor response, like a discrete finger or hand movement were anticipated. Once the desired response of flexion, extension of the wrist and fingers, stimulation of posterior cord at a current of 0.2 to 0.5 mA was obtained, a LA (15 ml of 0.5% bupivacaine and 15 ml of 2% lidocaine) was injected. The site of injection and cross-section of axillary artery along with spread of LA around it was imaged.

Parameters like time taken for the block (interval between placement of the ultrasound probe to completion of LA administration), onset of sensory blockade (interval between the end of LA injection to reduction of pin prick or loss of cold sensation at the site of surgery), onset of motor blockade (interval between end of LA injection to development of motor weakness), degree of motor blockade (ascertained by forearm flexion, wrist extension, and thumb opposition), degree of loss of cold sensation were noted. In case of failure of block (inadequate anaesthesia), additional LA infiltration, intravenous analgesics, rescue/supplemental block procedure, or conversion to GA was provided. The block was said be totally effective, if the procedure was completed without the need of any supplementation.

Sensory blockade was graded as I- No difference, II- Some difference but cold still sensed in blocked arm, III- No cold sensation in blocked arm (checked with ether-soaked swab). Axillary, musculocutaneous, radial, median, ulnar nerves were checked over lateral side of the arm, lateral side of the forearm, dorsum of the hand over the second metacarpo-phalangeal joints, thenar eminence and little finger,

respectively. Sensory and motor blockade was graded after the exit of the needle, at the interval of 5 minutes for the first 30 minutes. Motor blockade was graded as 0-no contraction, 1-flicker or trace of contraction, 2-active movement with gravity eliminated, 3-active movement against gravity, 4-active movement against gravity and resistance, 5-normal power. Musculocutaneous, radial, median and ulnar nerves were tested for flexion of arm, extension of the flexed arm & wrist, flexion of wrist and opposition of the thumb to 2nd & 3rd fingers, and flexion 4th & 5th fingers, respectively. Monitoring of hemodynamic parameters including HR, ABP and oxygen saturation were done every 10 minutes till the end of surgery. Complications like pneumothorax, nerve injury, accidental intravascular injection, local anesthetic toxicity, if occurred, were noted. Post-operatively, sensory and motor blockade was graded before shifting the patient out of the operating room. Patient was observed for 24 hours after the block to determine any nerve injuries or pneumothorax.

The primary objective was to compare block efficacy between the two groups.

Statistical Methods- The categorical (frequency counts, percentages and significance) and ordinary data were analyzed using Chi-square/Fisher's exact and non-parametric tests like wilcoxon-mann-whitney test. The numeric data was summarized by descriptive statistics like; n, mean, standard deviation, median, minimum and maximum. For statistical significance of numeric data, t-test was used. Qualitative data (groups, sex, complications, need of supplementation, etc.) was represented in form of frequency and percentage. Association between groups and qualitative variables were assessed by Chi- Square test, with Continuity Correction for all 2X2 tables and by Fisher's Exact test for all 2X2 tables where Chi-Square test was not valid due to small counts. In presence of small counts in tables with more than two rows and/or columns, adjacent row &/or Column data was pooled & Chi-Square Test reapplied. Continuity Correction was applied for all 2X2 tables after pooling of data. Fisher's Exact test was applied for all 2X2 tables where p-value of Chi-Square test was not valid due to small counts, in-spite of pooling of data (E.g. Association between need of supplementation and group categories (A & B)). Quantitative data (age, weight, time taken for block administration, time for onset of sensory blockade and motor blockade, pulse at various time intervals, systolic BP at various time intervals, etc.) was represented using Mean ± SD and Median & IQR (Interquartile range). Its analysis was done using Unpaired t-test if the data passed 'Normality test' or by Mann-Whitney Test if data failed 'Normality test'. (E.g. Time of achieving Motor Block G0 & G1 (min) vs. & group categories (A & B)). Results were graphically represented where deemed necessary.

Appropriate statistical software, including MS Excel & PSPP version 0.8.5 was used for statistical analysis. Graphical representation was done in MS Excel 2010.

Results

Patient demographics (in terms of age and gender) were comparable between groups. The mean time taken for block administration was 9.69 +/- 6.93 minutes in group-A versus 14.72 +/- 6.98 minutes group-B. Mean time taken for onset of sensory blockade was 5.83 +/- 5.38 minutes versus 5.19 +/- 6.82 minutes and for onset of motor blockade was 2.69 +/-3.85 minutes versus 2.08 +/- 4.28 minutes in group-A and group-B respectively. Mean time taken to achieve complete sensory blockade was 11.67 +/- 5.65 minutes in group-B compared to 16.92 +/- 8.13 minutes in group-A. Time taken for achieving complete motor blockade was 21.43 +/- 8.02 minutes and 14.44 +/- 8.82 minutes in group-A and group-B respectively. (Table 1)

Table 1: Comparison of age, weight, time variables between Group-A & Group-B

Variables	Gr	Mean	+/-SD	Median	IQR	Z value	P value
Age (years)	A	56.31	16.04	61.5	20	-0.541	0.589
	B	59.61	12.79	61	16	Difference is insignificant	
Weight (kg)	A	66.36	14.84	65.5	25.2	-2.305	0.021
	B	75.88	16.9	75	20.3	Difference is **significant**	
Time to administer block	A	9.69	6.93	7	7	-3.361	0.00078
	B	14.72	6.98	15	12	Difference is **significant**	
Onset of Sensory block	A	5.83	5.38	5	10	-0.94	0.347
	B	5.19	6.82	0	10	Difference is insignificant	
Onset of motor block	A	2.69	3.85	0	5	-1.234	0.217
	B	2.08	4.28	0	1	Difference is insignificant	
Time of achieving complete sensory Block III (min)	A	16.92	8.13	15	15		
	B	11.67	5.65	10	5	Difference is **significant**	
Time of achieving Complete Motor Block (min)	A	21.43	8.02	25	15		
	B	14.44	8.02	10	10	Difference is insignificant	

All data failed Normality test, so Mann-Whitney test applied.
Gr= group, SD= standard deviation

The association between block success and need of supplementation is shown in Table 2. Sensory block achieved in patients from group-A and group-B was compared. Complete sensory blockade was achieved in 72.2% patients of group-B and 66.7% of group-A. Partial sensory blockade was seen in 25% patients of group-B and 33.3% of group-A. One patient (2.8%) in group-B did not develop any loss of sensations. Chi square test used showed no statistically significant association. Only seven patients in group-A and nine Patients in group-B had achieved complete motor blockade at 30 mins. Partial motor blockade was achieved in 26 patients (80.5%) in group-A and 26 patients (72.22%) in group-B.

The overall block success in the study was 69.4%. Successful blockade was achieved by 66.7% in group-A and 72.2% in

Table 2: Association between block success and need of supplement

Block success	Need of supplement	Groups		Total
		A	B	
Yes	No	24	26	50
		66.70%	72.20%	69.40%
No	yes	12	10	22
		33.30%	27.80%	30.60%
Total		36	36	72
		50%	50%	100%
Chi Square test	Value	df	P value	Association is
Pearson chi square test	0.262	1	0.609	Not significant
Continuity correction	0.065	1	0.798	Not significant

group-B. Supplementation in the form local infiltration with 5 ml of 2% lignocaine was administered in total of 22 patients with ineffective blockade (33.3% of group-A and 27.8% in group-B) (p>0.05). None of the patients required systemic analgesia, sedation or general anaesthesia.

Throughout the surgical procedure, hemodynamics in terms of HR, ABP (Graph 1 & 2) and oxygen saturation were measured and they were comparable in both groups.

One patient in group-B had a vascular puncture on manipulation to get a favourable motor response. It was identified when blood was aspirated, before the drug was injected.

All patients regained complete motor power and sensations by 24 hours after the surgery (Tables 3 & 4). No patient had residual neuro-deficit as there was no nerve injury. Since both the groups had needle manipulation under vision, pleura was not punctured. Post–block no patient developed any cough or any breathing difficulty.

2 cells (33.3%) have expected count less than 5. Row data pooled & Chi-Square Test reapplied.

Discussion

Our study demonstrates, time to administer block was shorter with US alone than dual modality and is in agreement with previous two studies [1, 2]. This can be explained by the additional time needed to establish a distal motor response to nerve stimulation in addition to ultrasonic scanning.

The onset time for both sensory and motor blocks were similar in both the groups, as was in a similar study [2]. In contrast early onset times have been reported with US alone [3], which can be explained by the inclusion of time taken to

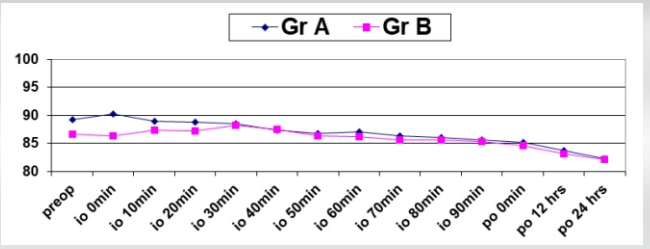

Figure 1: Comparison of Pulse at various time intervals between Group A & B

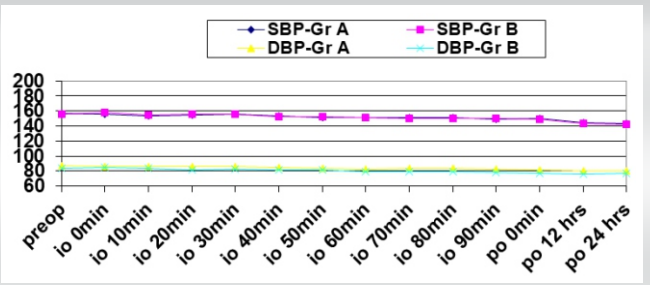

Figure 2: Comparison of Systolic (SBP) and Diastolic (DBP) blood pressure at various time intervals between Group A & B

administer the block and the onset after. However, in our study the mean time taken to achieve complete sensory blockade was shorter in USNS (group B) than in US (group-A) (p=0.022) as was observed in another study [4]. At 30th minute, a complete motor blockade was achieved in 25% and 19.4% of patients in group-B and group-A, respectively at 30 minutes. Majority of the patients had developed only partial motor blockade in either group. Conversely, two studies [1, 3] observed the larger proportion of patients from US group had complete blocks.

The brachial cords were not visualized adequately at the infraclavicular level, a neurostimulation was not always successful, even when the stimulating needle was placed immediately adjacent to a nerve and interpreting distal motor responses at the cord level can be difficult [1].

However, LA spread posterior to the axillary artery and the presence of radial nerve type stimulation was associated with adequate ICBPB, while inconsistent block was associated with LA deposition anterior to the axillary artery and median nerve type stimulation [5].

An overall success rate of 95% in group-US, 92% in group-NSUS, and 86% in group-NS resulted after each nerve was targeted separately under US and circumferential spread was

Table 3: Association of Time of Sensory block in group-A & group-B

Time of sensory block		Groups		Total
		A	B	
Immediate postop	No.	5	10	10
	%	13.9	13.9	13.9
12 hrs	No.	21	23	44
	%	58.3	63.9	61.1
24 hrs	No.	10	8	18
	%	27.8	22.2	25
Total	No.	36	36	72
	%	100	100	100
Chi square test	Value	df	P value	Association is
Pearson chi suqare	0.313	2	0.855	Not significant

Table 4: Association of Time of Motor block in group-A & group-B

Time of Motor block		Groups		Total
		A	B	
Immediate postop	No.	6	4	10
	%	16.7	11.1	13.9
12 hrs	No.	30	31	61
	%	83.3	86.1	84.7
24 hrs	No.	0	1	1
	%	0	2.8	1.4
Total	No.	36	36	72
	%	100	100	100
Chi square test	Value	df	P value	Association is
Pearson chi suqare	1.416	2	0.493	Not significant
Pearson Chi Square	0.116	1	0.733	Not significant

obtained [6].

Two patients in our study in the group-US and three patients in the group-NSUS had pain during surgery and LA infiltration was given by the surgeon in addition to systemic analgesia with fentanyl 100 mcg.

Needle penetrated the axillary artery in one patient in our study. However, incidences of 2 to 3 vascular punctures were observed in NSUS group in two different studies [1, 2]. There were no incidences of any other complications like pneumothorax or nerve injury, LA toxicity, hoarseness, dyspnoea, residual paraesthesia or Horner's syndrome in any group in our study. Comparing the two modalities [7], paraesthesia (6%-US) compared to (45% -NS) was reported. Moreover, inadvertent vascular puncture occurred in (8%-NS) compared with none in the US [7].

This being an observational study, limitation of this study includes a potential bias. Ultrasonic visualisation depends on operator expertise and the study sample taken is relatively small though comparable to existing studies. During the block, continuously observing needle tip while trying to obtain a motor response is a challenging task and a small incidence of vascular puncture may be inevitable.

Further, randomised controlled studies may be performed to compare the dose of anaesthetic that can be reduced taking advantage of the precision obtained by these two guidance techniques on a larger sample size.

Conclusion

Dual guidance (USNS) infraclavicular brachial plexus block though time consuming gives better block success rate in terms of the need for supplementation to start the Arterio-venous fistula creation surgery for CKD patients requiring hemodialysis. Since manipulating the needle under ultrasound to get a motor response is a challenging task, adequate time should be spent in getting appropriate motor response in order to achieve a desirable block effect and a comfortable patient. In addition to above, ultrasonic visualization of local anaesthetic spread around the axillary artery is most assuring to get the action.

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Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given his/her consent for his/her images and other clinical information to be reported in the Journal. The patient understands that his/her name and initials will not be published, and due efforts will be made to conceal his/her identity, but anonymity cannot be guaranteed.

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