

Evaluation of Success Rate of Brachial Plexus Block by Selective Cord Stimulation

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Abstract

Aims and Objectives: The aim is to study and compare the success rate of brachial plexus block achieved by stimulation of individual cord, that is, medial, lateral, and posterior cord.

Introduction: Infraclavicular block is indicated for surgery of the forearm, wrist, and hand. It is performed by localizing one cord of the brachial plexus and injecting the local anesthetic solution at that location. In this study, we compare the success rate of brachial block achieved by stimulating individual cord, that is, posterior, medial and anterior. The approach used with the help of nerve stimulator at a stimulator current of 0.4 mA or less infraclavicular vertical brachial plexus block approach.

Materials and Methods: A total of 108 patients who were planned to undergo forearm or hand surgeries were divided into three groups. Infraclavicular brachial plexus block (ICPB) was performed using 50-mm insulated nerve stimulator needle and B. Braun Stimuplex RC nerve stimulator with an initial stimulator current of 1.0 mA with 2 Hz frequency. The patients belonging to the respective groups would receive ICPB after attaining the evoked muscle response.

Result: After prospective, randomized comparative study which was carried out in 108 patients, result achieved was that in comparison to the lateral and medial cord, posterior cord blockade was associated with rapid onset of motor block and sensory block with selective cord stimulation and this also decreased the incidence of block failure.

Key words: Infraclavicular brachial plexus block, Lateral cord, Medial cord, Nerve stimulator, Posterior cord

INTRODUCTION

Anesthesia began with “rag and bottle”. Whether the rag was the sponge that Morton used, or the folded pocket handkerchief used by Simpson to turn a liquid into a vapor by draining it from a bottle into a “rag.” This was the first method of inhalational anesthesia. Then, there was the era of unending endeavors to control pain, The “Fifth Vital Sign”! The efforts to manage pain have evolved from the simple topical application of cocaine, through the use of sedation analgesia - the “twilight sleep” and techniques of neuraxial blockade, to the development of nerve blocks

that are still in use today, in one form or another and with one eponymous name or another.

Regional anesthesia is preferred to avoid the complications of general anesthesia. However, supraclavicular and axillary routes of brachial plexus block have presented with various complications and unpredictable cases of failure bringing back the use of the infraclavicular route. Thus, despite being not so common in use, the infraclavicular block has its own advantages to offer.^[1]

In this study, we evaluate the success rate of brachial plexus block by selective cord stimulation through infraclavicular approach.

Aims and Objectives

Focused aims of the study

1. Time taken for onset of complete motor and sensory block
2. Duration of sensory block

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3. Duration of analgesia
4. To study and compare the success rate of brachial plexus block achieved by stimulation of individual cord, that is, medial cord, lateral cord, and posterior cord.

Primary objectives

- To assess and compare the success rate of block by evaluating
- The extent of block (as assessed by the motor block in the number of nerves)
- The effectiveness of sensory block in each group.

Secondary objectives

1. To observe hemodynamic changes (if any)
2. To look for side effects (if any).

MATERIALS AND METHODS

The present study was undertaken in indoor patients admitted in Orthopaedics Ward in NSCB Medical College and Hospital, Jabalpur, Madhya Pradesh.

Sample Size

The adequate required sample size was estimated using following formula

$$n = z^2pq/d^2$$

Where

n = sample size

z = 1.96 (considering 0.05 alpha, 95% confidence limits, and 80% beta)

q = 1-p

d = marginal error (precession)

To calculate the adequate required sample size, we have taken assumption suggested by previous literature review that 15–45% (15% relative precision) difference between the groups would be observed.

Sample size is 36 from the above formula. Therefore, minimum 36 subjects in each group will be adequate in number. Therefore, minimum 36 subjects in each group will be adequate numbers.

Sampling Method

Considering the best of the patients by reviewing the previous records of this health facility to achieve the maximum sample size, we will screen all the patients who fulfill the inclusion and exclusion criteria and ready to give the written informed consent.

Selection of Cases

After obtaining institutional and ethics committee approval and written informed consent, 108 patients of

both sexes in the age group of 15 years–65 years, body weight between 45 and 75 kg belonging to Class 1 and 2 of ASA classification posted for elective surgeries on the forearm, hand, and wrist were enrolled for the study. A detailed history, thorough physical examination, routine investigation, or any special investigation if required were done for the study.

Exclusion Criteria

- Patient refusal
- Local infection at needle insertion site.
- Patient using anticoagulants drugs.
- Patient with hypertension, pregnancy, chronic obstructive pulmonary disease, coronary artery disease, diabetes mellitus I and II, or pre-existing neuropathy involving the surgical limb.

Study Design

This was a prospective, randomized, double-blinded, comparative study.

For the purpose of the study, the patients were randomly allocated by random number table into three groups of 36 patients each.

Group L: Stimulation of lateral cord of brachial plexus was inferred by the motion of muscles supplied by the median nerve.

Group M: Stimulation of medial cord of brachial plexus was inferred by the motion of muscles supplied by the ulnar nerve.

Group P: Stimulation of posterior cord of brachial plexus was inferred by the motion of muscles supplied by the radial nerve.

Equipments in material and methods [Figure 1]

- Sterile tray
- Sterile towel
- Sterile swabs
- Sponge holding forceps
- Betadine solution and spirit
- 2 ml and 10 ml syringe
- B Braun Stimuplex nerve stimulator
- Braun Stimuplex insulated needle.

Drugs

Injection ropivacaine 0.75% (plain)

Patients received 0.75% ropivacaine (plain) as the drug for the infraclavicular block. The quantity of the drug depended on patient's body weight (0.5 ml/kg). Maximum 30 ml of the drug was injected.

In Case of any Emergency or Complications

- Emergency drugs
- Intubation kit
- Resuscitation equipment.

Technique

The patient was placed on the operation table in supine position. Before starting the procedure, all the monitoring equipment (NIBP cuff, pulse oximetry probe, and electrocardiogram) were attached to the patient and baseline value of blood pressure (BP), heart rate, SpO₂, and respiration rates (RR) were recorded, and an IV cannula 18 G was inserted. Pre-medication of any kind was not given.

Technique for Vertical Infraclavicular Block

- Under all aseptic precautions, after painting and draping, the infraclavicular brachial plexus block (ICPB) was performed using 50-mm insulated nerve stimulator needle and B. Braun Stimuplex RC nerve stimulator with an initial stimulator current of 1.0 mA with 2 Hz frequency.
- The patient was placed in supine position with the head rotated away from the site to be blocked. The arm was rested on the side with the wrist supinated if possible. The main landmarks for this block were as follows:
 1. Middle of the sternal notch
 2. Puncture site
 3. Coracoid process
 4. Head of humerus
 5. Anterior part of acromia.

The puncture site is halfway between the middle of the sternal notch and the anterior part of acromion.

Figure 2 shows the landmarks for vertical infraclavicular brachial plexus block

A skin wheal was raised just above the puncture site with 2 ml of 2% lignocaine with a 24 G needle.

- Insulated needle was inserted just above the puncture site in a vertical direction to maximum depth not more than 4 cm. Figure 3 shows the technique of vertical infraclavicular brachial plexus block.
- The needle was advanced until an evoked motor response of the hand muscles

Group L

Stimulation of lateral cord of brachial plexus was inferred by the motion of muscles supplied by the median nerve, especially,

- Flexor carpi radialis (abduction and flexion of wrist joints and of flexor pollicis longus (flexion of thumb)
- Lateral two lumbricals - flexion at metacarpophalangeal joints of index and middle fingers and extension of interphalangeal joint



Figure 1: Equipments used

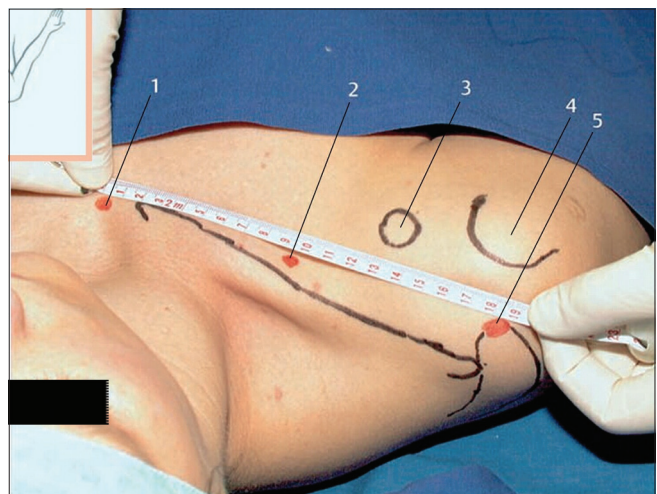


Figure 2: Landmarks of the Vertical Infraclavicular block



Figure 3: Technique of vertical infraclavicular brachial plexus block

- Adductor pollicis brevis (thumb abduction)
- Flexor pollicis brevis (flexes metacarpophalangeal joints of thumb)
- Opponens pollicis (opposes thumb toward fingers).

Group M

Stimulation of medial cord of brachial plexus was inferred by the motion of muscles supplied by the ulnar nerve, especially

- Flexor carpi ulnaris, that is, wrist flexion and adduction
- Medial two lumbricals flexion of metacarpophalangeal joint of ring and little finger and extension of interphalangeal joint
- Adductor pollicis (thumb adduction)
- Interossei of hand
- Abductor digiti minimi (abducts little finger)
- Flexor digiti minimi (flexes little finger).

Group P

Stimulation of posterior cord of brachial plexus will be inferred by action of triceps, extensor carpi radialis, that is, elbow extension and wrist extension.

- Once the desirable evoked motor response was obtained, the needle was stabilized, negative aspiration for blood or air was done and the calculated drug volume was injected
- After complete injection of drug, the observation was made by another observer to make the study double-blinded
- Immediately after injection of local anesthetic, the patient was observed for signs of local anesthetic toxicity and intravascular injection
- Time of administration of drug was noted.

Evaluation

- Onset of sensory and motor block was assessed every 5 min after injection up to 30 min using below-mentioned scale.

Motor Block Evaluation

- Musculocutaneous nerve - elbow flexion
- Median nerve - thumb and index finger opposition
- Radial nerve - wrist extension
- Ulnar nerve - little finger flexion

Scale

- Normal motor function - 0
- Decreased motor strength - 1
- Complete block - 2

Sensory block assessment was done by cold sensation loss to ice cube application at the region of sensory supply of each nerve.

Sensory Block Evaluation

- Musculocutaneous nerve - lateral aspect of forearm
- Median nerve - Thenar eminence
- Radial nerve - Dorsum of hand (web between thumb and index finger)
- Ulnar nerve - Palmer and dorsal aspect of little finger.

Scale

- Sensation in response to cold - 0
- Lesser degree of cold compared to that on contralateral side - 1
- No recorded cold sensation - 2
- The block was considered failed if the patient complains pain during surgical intervention
- Time to achieve onset of sensory block was defined as the time interval between the administration of drug and sensation absent to cold
- Time to achieve complete motor block was defined as the time interval between administration of the drug and complete loss of muscle function
- Surgery was permitted only when block was complete; general anesthesia was instituted whenever block was inadequate
- Duration of sensory block was defined as the time interval between onset of complete sensory blockade to return of normal sensation to cold
- Duration of motor block was defined as the time interval between onset of complete motor blockade to recovery of normal muscle function
- Duration of analgesia was defined as the time interval between the onset of the complete sensory block to the post-operative visual analog scale (VAS) score >4.

VAS

Pain intensity was evaluated using 10-cm visual scale where 0 represents no pain and 10 represents worst possible pain. Rescue analgesia with intramuscular diclofenac injection 75 mg was given if VAS was >4. VAS score was recorded post-operatively at 0, 4, 8, 12, 12.30, 13, 13.30, 14, 14.30, 15, and 16 h.

16 h analgesic consumption was also noted.

Complications

- Fatal arrhythmias
- Convulsion
- Vascular puncture
- Pneumothorax
- Nausea/vomiting.

Monitoring

Throughout the procedure, BP, RR, and pulse rate was monitored continuously. Vital signs were recorded at 0, 10 min, 20 min, 30 min, 60 min, 2 h, 4 h, 6 h, 12 h, and 24 h.

Observations

Table 1 shows the mean age of patients (in years) in three groups which were almost comparable ($P > 0.05$). Table 2 shows the sex-wise distribution of all the patients in various groups. Majority of patients were male in all the groups as compared to females. However, the distribution

of both males and females in each group was comparable ($P > 0.05$).

Table 3 shows the mean weight of patients (in kg) in various groups. All the groups were comparable ($P > 0.05$). Table 4 shows the number of sensory nerves blocked in three groups

In Group P, 32 (88.88%) patients out of 36 got all four nerves blocked when compared to Group L were 24 (66.66%) and Group M were 23 (63.88%) patients got all four nerves blocked.

In Group P, the effectiveness of block was significantly higher when compared to Group L ($P = 0.024$) and Group M ($P = 0.013$), respectively.

Table 5 shows number of motor nerves blocked in three groups.

In Group P, 29 (80.55%) patients had all the four nerves blocked when compared to Group L, where 19 (52.77%) and Group M, where 17 (47.22%) patients had all the four motor nerves blocked.

The extent of block was significantly higher in Group P when compared to Group L ($P = 0.012$) and Group M ($P = 0.003$), respectively.

Table 6 shows the mean time taken (in min) to achieve complete sensory block in Groups L, M, and P which was 15.96 ± 0.69 min, 16 ± 0.60 min, and 12.09 ± 0.73 min, respectively.

Table 1: Mean age of the patients in the study group

Group	L	M	P
Mean value (years)±SD	31.39±12.03	40.67±16.66	36.03±13.16

SD: Standard deviation

Table 2: Sex-wise distribution of patients in the study groups

Group	L	M	P
Male (%)	28 (77.78)	29 (88.56)	26 (72.22)
Female (%)	8 (22.22)	7 (19.44)	10 (27.78)
Total	36	36	36

Table 3: Mean weight of patients in the study groups

Group	L	M	P
Mean value (kg)±SD	54.58±7.78	59.83±10.19	63.22±9.70

SD: Standard deviation

Time to achieve complete sensory block was significantly less in Group P, (12.09 min) than in Group L, (15.96 min) and Group M, (16 min).

On statistical analysis, the difference in time taken to achieve complete sensory block in between Groups L and P and Group M and P was found to be highly significant ($P < 0.0001$) and ($P < 0.0001$), respectively.

Thus, it affirms that the onset of complete sensory block was fast in Group P when compared to Group L and M in order of $P > L > M$.

The mean time difference in onset of complete sensory block between Group P and L was 3.87 min and Group P and Group M and P was 3.91 min.

Table 7 shows the meantime (in min) to achieve complete motor block in Groups L, M, and P, which was 20.95 ± 0.71 min, 22 ± 0.71 min, and 17.83 ± 0.66 min, respectively.

Time to achieve complete motor block was significantly less in Group P, (17.83 min) than in Group L, (20.95 min) and Group M, (22 min).

On statistical analysis, the difference in time to achieve complete motor block in Groups L, M, and P was found to be highly significant ($P < 0.0001$) and ($P < 0.0001$), respectively.

Table 4: Effectiveness of block (assessed by all four sensory nerves blocked)

Number of nerves blocked	L (%)	M (%)	P (%)
0	2 (5.55)	2 (5.55)	0
1	2 (5.55)	4 (11.11)	1 (2.77)
2	3 (8.33)	3 (8.33)	1 (2.77)
3	5 (13.88)	4 (11.11)	2 (5.55)
4	24 (66.66)	23 (63.88)	32 (88.88)

Table 5: Extent of motor block (assessed by all four motor nerves blocked)

Number of nerves blocked	L (%)	M (%)	P (%)
0	2 (5.55)	2 (5.55)	0
1	2 (5.55)	4 (11.11)	1 (2.77)
2	5 (13.88)	6 (11.11)	2 (5.55)
3	8 (22.22)	7 (19.44)	4 (11.11)
4	19 (52.77)	17 (47.22)	29 (80.55)

Table 6: Time taken to achieve complete sensory block

Groups	L	M	P
Mean value±SD (in min)	15.96±0.69	16±0.60	12.09±0.73

SD: Standard deviation

Thus, it affirms the onset of complete motor block was fast in Group P than in Group L and M in order of $P > L > M$.

The mean time difference between Group P and L was 3.12 min and between Group P and M was 4.17 min.

Table 8 shows the mean \pm standard deviation (in min) duration of analgesia in three Groups L, M, and P, which was 772.5 ± 36.74 min, 774.78 ± 35.79 min, and 772.5 ± 36.54 min respectively.

On statistical analysis, there was no significant difference in duration of analgesia in between three Groups L, M, and P.

Table 9 shows the median VAS score at 4th, 8th, 12th, 12.5th, 13th, 13.5th, 14th, 14.5th, 15th, and 16th h post-operatively in all three groups.

At 13th h post-operatively, the median VAS score was <4 and was comparable in all three groups.

At 13.5th h post-operatively, there was an increase in VAS score to 5 in all three groups.

There were no statistically significant differences in VAS score post-operatively in three groups.

DISCUSSION

The present study was conducted to evaluate the success rate of brachial plexus block by selective cord stimulation through infraclavicular approach. Our intention was to find out whether localizing the posterior cord during a single injection infraclavicular block would place the needle centrally within the infraclavicular portion of the brachial plexus and allow a uniform spread of the local anaesthetic, thereby selective cord stimulation would affect the overall time of onset of sensory and motor blockade in that respective group.

We found that the success rate was significantly higher when the injection was performed on a radial type response (80.5%) compared with the median (52.6%) or ulnar nerve (47.2%) distal motor type response as evaluated by the extent of block assessed by the motor block of all the 4 nerves within 30 min of the injection of the local anesthetic.

Our result reaffirms the outcome of the study conducted by Lecamwasam *et al.*, where they reportedly found, on the basis of complete motor block, that posterior cord stimulation has a greater success rate (73.5%) when compared to stimulation of lateral (63.5%) or medial cord (53.3%), respectively.

Table 7: Time taken to achieve complete motor block

Groups	L	M	P
Mean \pm SD (in min)	20.95 \pm 0.71	22 \pm 0.71	17.83 \pm 0.66

SD: Standard deviation

Table 8: Duration of analgesia

Groups	L	M	P
Mean \pm SD (in min)	772.5 \pm 36.74	774.78 \pm 35.79	772.5 \pm 36.54

SD: Standard deviation

Table 9: Median VAS score

Groups (h)	L	M	P
VAS AT 4	0	0	0
VAS AT 8	0	0	0
VAS AT 12	3	0	0
VAS AT 12.5	3	2	0
VAS AT 13	3	3	0
VAS AT 13.5	5	5	5
VAS AT 14	5	5	5
VAS AT 14.5	5	5	5
VAS AT 15	6	6	6
VAS AT 16	6	6	6

VAS: Visual analog scale

The effectiveness of the block as assessed by the sensory block of all the 4 nerves was found to be 66.6%, 63.8%, 88.8% in Groups L, M, and P, respectively, in our study.

Besides this, success rates vary a lot between the studies ranging from 44 to 100%.^[2-7] This may be due to single or multiple neurostimulation, field of surgery, approach or technique used or the definition of successful block being used, which varies from complete (motor and sensory) involvement of all the five nerves below the elbow^[2,4-6,8] to the completion of surgery without requiring any form of supplementation.^[9,10] However, in our study, success rate among the three groups was evaluated by the extent and effectiveness of the block defined by the complete motor block (all the four nerves) and complete sensory block, respectively.

Distal motor response (flexion of the wrist or fingers) is an important predictor for better results irrespective of the approach.^[2-8,11] Borgate *et al.* reported a success rate of 44% when the proximal response was accepted for local anesthetic injection, compared to 97% when distal motor response was accepted.

It has been previously proposed that proximal response of biceps can be due to stimulation of musculocutaneous nerve, which often leaves the lateral cord at or above the level of infraclavicular region,^[2,5] while, when the distal

response is obtained, the needle is more centrally placed, resulting in even diffusion of local anesthetic.^[4,9,12]

Borgeat *et al.*^[16] reported a 97% rate of IC block success when nerve stimulation elicited a distal response consistent with central placement. Porter *et al.* visualized the block needle besides visualizing the LA spread in ultrasound-guided coracoid ICPB, and they suggested that block failure in the proximal muscle stimulation group was due to LA spread between the pectoral muscle and axillary artery.

There are some studies emphasizing that double or multiple stimulations^[5,10,13] improve the success rate of ICPB, whereas some studies suggest that stimulation of median nerve,^[11] posterior cord,^[9] or all three cords^[6] cause less chances of failure.

Sebastien Bloc obtained a significantly higher success rate with single injection ICPB when performed on a radial nerve-type response (90%) compared with the median (74%) or ulnar (68%) nerve distal motor-type response by neurostimulation. Li *et al.* found that neurostimulation of the posterior cord with Wilson's approach provided complete blockade in 78.9% and stimulating the lateral cord provided complete blockade in 53.1%.^[14]

Similar observations have been made with ultrasound-guided blocks also. Bowens *et al.* observed a significantly higher success rate of block when the drug was placed centrally^[15] with ultrasound and neurostimulation-guided techniques.

The rationale behind our study is that when the infraclavicular portion of the plexus is viewed from the angle taken by the needle, the posterior cord appears to lie central to both the lateral and medial cords; hence, LA injection at the posterior cord is more likely to reach all the three cords.

However, recent studies have shown that septa in the infraclavicular region result in inadequate spread of the Local anaesthetic.^[16] Besides, Sala Blanch *et al.* have proposed that as the cords twist around the axillary artery,^[18] their relative positions change. These might be the reasons for the observed cases of failed blocks in our study.

The onset time of sensory and motor block was faster in nerve distribution in Group P than Groups L and M. These findings are in corroboration with the findings of Lecamwasam *et al.* and Gaertner *et al.*^[6,9] Lecamwasam *et al.*^[9] observed that posterior cord stimulation resulted in less cases of block failure and rapid onset of motor block in more nerves. Gaertner *et al.*^[6] found a faster onset time of sensory and motor block in each nerve distribution with

multiple nerve stimulation when compared to single nerve stimulation. We propose that the onset time of the block may be influenced by the type of nerve stimulation used for the performance of block.

Associated complications with eliciting the distal muscle response are vascular puncture, pneumothorax, and discomfort to patients.^[12] However, in our study, no such complications were encountered. This may be attributed to the careful use of the neurostimulation technique and infraclavicular approach which has been reported to avoid neurovascular structures of the neck and diminish the possibilities of pulmonary complications and pneumothorax.

CONCLUSION

Hence, this study concludes that selective cord stimulation of posterior cord is associated with a greater effectiveness and extent of the infraclavicular block.

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