Original Article

Infraclavicular block in children: Is blocking lateral or posterior cord equally successful?

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Abstract

Background and Aims : The most effective approach for infraclavicular brachial plexus block in adults is to target the posterior cord, usually situated posterior to axillary artery. However, we do not know if this can be extrapolated in children. Our primary objective was to compare the clinical success rate of ultrasound guided infraclavicular brachial plexus block in children with local anesthetic injection aimed at two targets. These were posterior to axillary artery (posterior cord) and lateral to axillary artery (lateral cord). The secondary objectives involved need for intraoperative rescue analgesia, evaluation of duration of analgesia, incidence of complications such as pneumothorax and arterial puncture, comparison of postoperative pain scores and fluoroscopic dye spread pattern was also observed.

Material and Methods: It was a randomized, prospective pilot study. Forty children undergoing forearm and hand surgeries were randomized to two groups, in accordance with the target site of the block. Target sites of Group P (20 patients) and Group L (20 patients) were posterior and lateral to the axillary artery, i.e., posterior and lateral cord respectively. Aforesaid objectives were assessed. SPSS (Version 15.0) statistical package was used. Comparison between Group L and P was by using student's unpaired *t* test for age and weight. Fisher's exact probability test was applied to compare percentages between groups.

Results: Blocks of both groups were equally successful. No patient required intraoperative rescue analgesia. Duration of analgesia was comparable. Both groups had no major complications and similar postoperative pain scores.

Conclusions: The success rate of infraclavicular brachial plexus block by aiming at the lateral and posterior cord was similar.

Keywords: Brachial plexus block, nerve block, pediatrics, regional anesthesia, ultrasonography

Introduction

The favorable use of effective single shot infraclavicular brachial plexus block (IBPB) in children is known.[1,2] Nonetheless, it possesses a risk of pneumothorax, arterial puncture and nerve injury.[3] The application of ultrasound (US) decreases the possibility of damage to these surrounding structures, especially pleura.[2,4] With ultrasonography, the pleura appears closer to posterior cord, usually located posterior to axillary artery. The lateral cord, in contrast, is located relatively lateral and superficial to the artery.[5] Thus, targeting the lateral cord might be technically easier. Moreover, needle passage near the pleura is eluded, intuitively making this approach safer than the posterior cord approach. Unlike adults, the brachial plexus sheath in children is thinner,[6] permitting easy diffusibility of local anesthetic (LA) across the compartments. Consequently, the LA injection aiming

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at posterior or lateral cord may yield similar success rates. Our study pivots around this finding.

We hypothesized that the success rate of IBPB with LA injection targeting the lateral or posterior cord is similar. The aim was to compare the success rate of IBPB with LA aimed at two targets. The first target was posterior to the axillary artery, presumed to be the posterior cord. The second target was lateral to the artery, presumed to be the lateral cord. The secondary objectives involved evaluation of duration of analgesia, need for intraoperative rescue analgesia, incidence of complications such as pneumothorax and arterial puncture in both techniques and comparison of postoperative pain scores. Fluoroscopic dye spread pattern was also observed in both groups.

Material and Methods

This prospective, randomized pilot study was approved by institutional review board (IRB Number EC/01/02/2016). This trial was conducted from August 2017 to January 2018. It was carried out in line with the principles of Declaration of Helsinki Written informed consent was obtained from parents of all subjects participating in the trial. Registration (CTRI/2017/08/009264) of the clinical trial occurred prior to start of trial and before patient enrolment at clinicaltrials.gov.

The surgical list was reviewed one day prior to the surgery. Patients meeting the inclusion criteria were identified. Written informed consent was confirmed again on the day of surgery. Children between 7 months to 12 years of either gender belonging to ASA physical status 1 or 2 scheduled for upper extremity surgery of the forearm and hand were included in this study. Exclusion criteria included patients with a history of severe cardiac, renal, neurological or pulmonary disease, coagulopathy, local infection, documented allergy to local anesthesia and parents unwilling to consent for regional anesthesia.

Forty patients were randomly divided into two groups of 20 each, namely Group L and Group P. This was in accordance to the drug injection target site. In Group L, needle tip and LA was placed lateral to axillary artery (lateral cord) under US guidance. In Group P, needle tip and LA was placed posterior to the axillary artery (posterior cord) under US guidance. The *post hoc* power analysis and method of randomization is detailed in Appendix I and II.

All children were fasted as per standard fasting guidelines. Premedication was done with oral midazolam 0.5 mg/kg 20 to 30 minutes before surgery. Standard American Society of Anesthesiologists (ASA) monitors, which included pulse oximetry, electrocardiogram, and non-invasive blood pressure, were attached to the patient. Anesthesia was induced with inhaled sevoflurane in oxygen and nitrous oxide. After achieving an adequate depth of anesthesia, an appropriate intravenous (IV) access was established and propofol 2 mg/kg was administered IV to facilitate laryngeal mask airway (LMA) placement. Anesthesia was maintained with 3 to 4 mg/kg/hour propofol infusion. Subsequently, US guided IBPB was administered depending on the patient's group.

The block procedure was similar in both groups except the drug deposition end point. The blocks were performed under aseptic precautions in supine position, with the arm adducted and kept along the side of the patient to be blocked. Infraclavicular area was scanned with linear high frequency (6-13 Hz) ultrasound probe (Micromax, Sonosite Inc, Bothell, WA, USA) in the parasagittal plane. The probe was placed below the coracoid process, with the orientation marker towards the clavicle. The scan showed from superficial to deep, pectoralis major and minor muscles respectively, axillary artery, axillary vein and the brachial plexus cords.[7] The lateral cord was usually visualized on the lateral and superficial (anterior) aspect of the artery while the posterior cord was usually visualized posterior (deeper) to the artery.[5] A 22G 35 mm Stimuplex needle B Braun™ Germany was inserted in an in-plane approach for both groups.

In Group L – The needle tip was placed lateral to the axillary artery (lateral cord) under US guidance. 0.5 ml/kg of 0.25% Bupivacaine tagged with 0.2 ml/kg radio-opaque dye Iohexol, OMNIPAQUE™ 350 mg I/ml was injected. In Group P – The needle tip was placed posterior to the axillary artery (posterior cord) under US guidance. 0.5 ml/kg of 0.25% Bupivacaine tagged with 0.2 ml/kg Radio-opaque dye Iohexol was injected. This was visualized by fluoroscopic imaging with the help of C arm in operation room (OR). Fluoroscopy was done immediately after injection of the LA.

Complications like pneumothorax and vascular puncture, if present, were noted. Distribution of contrast via fluoroscopic guidance inside OR aided by the c-arm was noted in the neurovascular space, below level of clavicle as described in literature.[8,9] It was assessed by an anesthesiologist who would conduct the case and the operating orthopedic surgeon, who was blinded to the study group. Ideally the contrast should spread below the clavicle along the neurovascular space of infraclavicular brachial plexus. This space is typically restricted to the infraclavicular region and did not extend into the supraclavicular space.

Surgery commenced with a minimum interval of 20 minutes after administration of the block.

Success rate was assessed in both groups. A block was considered successful if the pulse rate was unchanged on surgical incision or change was within the acceptable range of 20% from baseline. Increase in heart rate over 20% of baseline was defined as block failure. Intravenous Fentanyl (2 microgram/kg) was reserved as rescue analgesic intraoperatively in the event of block failure Duration of analgesia was defined as time between the administration of IBPB and first dose of analgesic administered in postoperative period.

The routine pain regimen was as follows. All patients received IV paracetamol 15 mg/kg every 6 hourly after first complain of pain. The younger children received oral ibuprofen syrup 1 mg/kg every 8 hours and tablet ibuprofen 200 mg was prescribed twice a day for children who could swallow tablets.

Acute pain service staff blinded to the patient's group managed the patients postoperatively. The pain scores were systematically recorded and pain regimen was followed as per the institutional protocol. Children and infants postoperative pain score (CHIPPS) in children less than 6 years of age and visual analogue score (VAS) for 6 years and above was noted at 1, 6, 12, 18, 24, 30, 36, 42 and 48 hours postoperatively. In conjunction with a study by Beltramini *et al.*,[10] the therapeutic threshold for CHIPPS score was considered as 4 or more and for VAS was 4.[11]

In case of persistently high pain scores despite administration of usual pain regimen, intravenous tramadol 2 mg/kg in the ward was reserved. In our study none of the patients, however, required tramadol.

Statistics

Sample size calculation

Sample size of 20 subjects in each group (L and P) was taken in this pilot study. Efficacy variable was taken as success rate. It was anticipated that both groups will have similar success rate. After study was completed, *post hoc* power calculation was performed using SAS9.2 package. *Post hoc* power calculation revealed power of 84.1% by equivalence test. Details are enclosed in Appendix I.

Statistical analysis

Data were analyzed using SPSS V15.0 (Statistical Package for Social Sciences, Version 15.0) package. Data were given as Mean, SD and N for continuous data and Number and Percentage for categorical data. Comparison of means of 2 groups were carried out by Student's unpaired *t* test for numerical normal data. Fisher Exact Probability tests were applied to compare percentages for categorical data between 2 groups. 95% Confidence Intervals were calculated for the difference. All statistical tests were two tailed. Alpha (α) Level of Significance was taken as $P < 0.05$.

Randomization

Randomization chart was prepared using SAS9.2 package for 40 subjects with 2 groups (Group L and Group P) with sample size of 20 in each group. Details of Randomization are given in APPENDIX II.

Results

The study adhered to the Consolidated Standards of Reporting Trials (CONSORT) guidelines. Patient Recruitment is illustrated in Consort flow diagram attached as Figure 1. Forty patients enrolled in the study and were included in the data analysis. No statistically significant difference was found in the demographics of both the groups as shown in Table 1 (*P* value for weight, age and gender was 0.8, 1 and 1 respectively). Table 2 depicts the block details.

All the blocks were successful. Patients in both groups had comparable duration of analgesia (*P* value = 0.1). None of the 40 cases had radiological evidence of pneumothorax. Two cases had positive blood aspirations in Group P. None had positive blood aspiration in Group L. Patients in both groups had similar pain relief post operatively as evaluated by CHIPPS and VAS score (see Figure 2a and 2b respectively which illustrate postoperative pain score for 48 hours). In group L as well as group P, CHIPPS was applied to 8 patients and VAS was applied to 12 patients. None of the patients required rescue analgesia in the intraoperative (reserved as intravenous Fentanyl) and in the postoperative period (reserved as intravenous Tramadol) apart from the routine pain regimen. Fluoroscopic dye spread pattern was similar in both groups as depicted in Figure 3a and 3b.

Discussion

Our study proves our hypothesis. Based on our findings, it is plausible to infer that IBPB with LA injected near lateral aspect of the axillary artery may not be inferior to IBPB with LA injection posterior to the artery. Few studies have been performed to study exclusively, the importance of the LA injection site in IBPB in children. The data has been habitually extrapolated from the adult concepts. Due to LA diffusion in pediatric population, the emphasis given in the adult literature regarding posterior cord injection in IBPB,[12] may not apply to children.

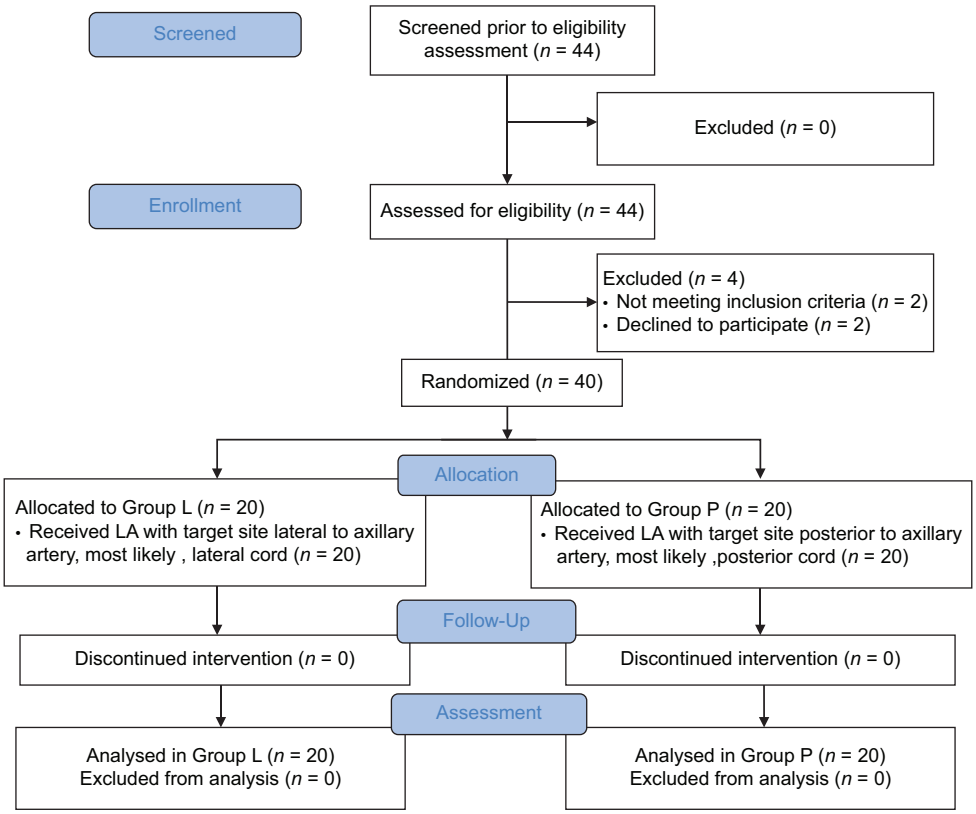

Figure 1: Denotes the consort flow diagram. Participant eligibility, enrolment, and analysis are depicted. CONSORT indicates Consolidated Standards of Reporting Trials

Table 1: Illustrates the demographic data

Variable	Group L (*n*=20)	Group P (*n*=20)	*T* test	*P* (Significance)	Difference with 95% CI
Weight in kg, mean±SD	24.25±10.10	23.65±7.06	0.2	0.800 (NS)	0.60 (-4.98,6.18)
Age in years, mean±SD	7.55±4.19	7.55±3.36	0.0	1 (NS)	0.00 (-2.43,2.43)
Gender					
Male *n* (%)	M=13 (65%)	M=14 (70.0%)	F=1.0,	1 (NS)	NA
Female *n* (%)	F=7 (35.0%)	F=6 (30.0%)	Df=1		

No Significant difference between 2 groups for all above variables like weight, age, and sex. Data expressed as Mean±SD (standard deviation) or Number (%). Group L – Lateral cord group, Group P – Posterior cord group, n=number of subjects, t – statistical test value, CI – Confidence interval M=Males, F=Females, Df – Degrees of freedom, NS – not significant

Table 2: Illustrates block characteristics

	Group L (*n*=20)	Group P (*n*=20)	*P*
Success rate	20 (100%)	20 (100%)	NA*
Duration of analgesia (in hours)	8.60±0.66	8.62±0.57	0.100
Need for rescue analgesia intraoperatively	0	0	NA*
Post op complications			
Pneumothorax	0	0	NA*
Arterial puncture	0	2	NA*

**The P value cannot be calculated*

We would also like to elucidate our stance on the methodology of identification of the respective cords. The lateral and posterior cords were located with US guidance [Figure 4a and 4b] as per conventional anatomical location described in literature.[5] Identification of cord position with the respective neurostimulation end motor responses could have served as corroborative evidence. However, our study population consisted of significant number of cases of radial club hand repair, known to alter the end motor response owing to congenital defects in musculature.[7] This explains our modality chosen to identify the respective cords.

The blocks in our study population yielded a 100% success rate, which is similar to the success rate proffered in literature.[2] During the intraoperative period, none of the patients required IV fentanyl. As per our initial concord we had reserved IV tramadol as a rescue analgesic in addition to the routine regime of PCM and Ibuprofen. Our rationale behind protocolizing IV Tramadol was based on the fact that these were orthopedic procedures known to produce intense pain. In case the routine pain regime failed to lower pain scores, IV Tramadol would deliver pain relief. However, on the floors, it was noted that

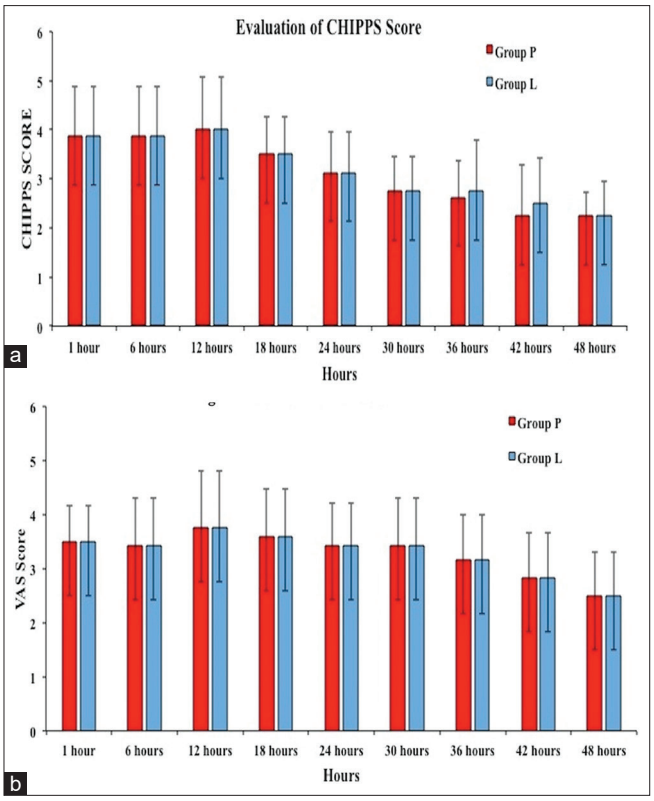

Figure 2: (a) Depicts CHIPPS Score: Children and Infants Postoperative Pain Scale (CHIPPS) scores in children aged 7 months to less than 6 years during the first 48 hours postoperatively. The box represents the 25th to 75th percentiles; the dark line is the median and the extended bars represent the 10th to 90th percentiles (b) Depicts VAS Score: VAS (Visual Analogue Scale) scores in children aged 6 to 12 years during the first 48 hours postoperatively. The box represents the 25th to 75th percentiles; the dark line represents the median and the extended bars represent the 10th to 90th percentiles

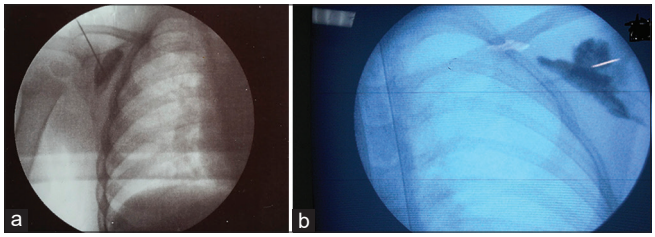

Figure 3: (a) Depicts pattern of dye spread in group L (b) Depicts pattern of dye spread in group P

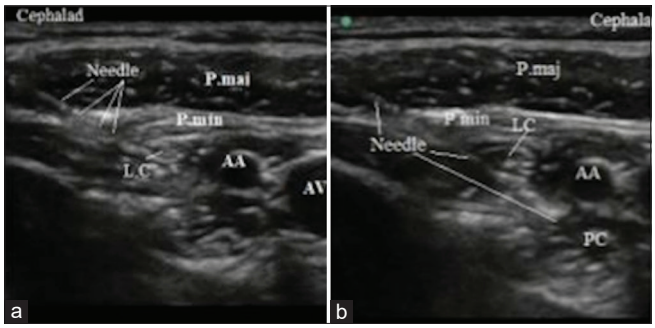

Figure 4: (a) Illustrates ultrasound picture with the needle at the lateral cord (b)Illustrates ultrasound picture while targeting posterior cord . (P. maj – pectoralis major, P. minor – pectoralis minor, AA – Axillary artery, AV – Axillary vein, LC – lateral cord)

intravenous PCM and ibuprofen were sufficient to reduce the pain scores. This explains why none of the patients required IV Tramadol.

Although we could demonstrate that the success rate of LA injection aiming lateral or posterior to axillary artery was similar, we did not notice any increased incidence of pneumothorax in group P. This did not support our premise that the incidence of pneumothorax would be more likely with posterior cord injection due to its close proximity to the pleura. Additionally, we had two incidences of arterial puncture in Group P, which doesn't seem to be of significance. We cannot comment on the impact on safety due to a limited sample size. Since pediatric anesthesiologists who are experienced in ultrasound-guided blocks performed these blocks, we may consider evaluating these complications in less experienced hands.

It is rather interesting to note the patterns of dye spread. Figure 4a and b depict the same from each group. It was similar irrespective of the injection site and was limited to the neurovascular space, below the level of the clavicle, similar to the pattern described in literature.[9] The contrast spread was chosen to add further objectivity to our findings. The concurrent benefit of detection of intravascular injection and accidental pneumothorax via fluoroscopy prompted us to use contrast in our study. Furthermore, the C arm is easily available in the orthopedic operation theatres. Nevertheless, we acknowledge it was important to analyze the pattern for an objective evidence for LA spread.

Marhofer *et al.*[13] in their study showed that LA spreads all around the artery following single point injection in pediatric patients. Ponde *et al.*[7] described this block in patients with radial club hand, and stated that in few patients where the cords seemed indistinct they performed a periarterial injection, for successful block. Our study also consisted of similar deformity correction surgeries.

Prior research has extensively investigated the efficacy of the LA injection at all three cords. One such example is the study conducted by Sharma *et al.*[14] They compared efficacy of all three cords against posterior cord and demonstrated that success rate and onset of complete sensory block after injection of the LA posterior to the axillary artery is comparable to triple injection targeting each cord. However, this study was performed in adult population. Little research has been conducted to show such implications in pediatric population, a gap we are trying to fill by this study. We substantiated that the success rate remained the same irrespective of the site of LA deposition in children. This can be explained by revisiting anatomy. A cadaveric study done by Rudolph in 1961[6] summarized observations made by dissection

of axillary sheath of 7 cadavers ranging from premature infants to adults. It was found that the sheath is 2-3 cm in diameter in adults and 1 cm in children. In all probability, sheaths surrounding the cords, by virtue of being thinner, permit easy diffusibility of the LA across the sheath and thus single injection near the lateral cord suffices. This finding may benefit in practice in situations where high-end US machines with good resolution are unavailable. In case of suboptimal imaging, it can add assurance to know that the LA injection lateral to the axillary artery renders an equally successful block. The theoretical advantage of aiming the more superficially placed lateral cord, or injecting just lateral to the artery, is it offers a shorter trajectory, whereas, to reach the posterior cord, the needle has to pass deeper. This results in the needle tip to be in close proximity to the pleura and the artery. By injecting LA at the lateral cord level, we can avoid being close to pleura or the artery. This served as an interesting rationale for our study.

There are limitations to this study. The number of patients may not be sufficient to draw conclusive evidence about safety or complications in both groups. Future work may be performed to evaluate if continuous catheters placed at lateral cord could render similar results as the posterior cord. Moreover, a more objective method than used by authors to evaluate the fluoroscopic dye spread would further consolidate the study.

Conclusion

As per this preliminary study we may suggest that deposition of local anesthetic aiming at either the lateral or posterior cord during ultrasound-guided infraclavicular brachial plexus block in children is equally successful.

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Conflicts of interest

There are no conflicts of interest.

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APPENDIX I

Post hoc Power of the study

Power of the study calculations using SAS9.2 package after study.

Name of Pilot study: Infraclavicular Block in Children: Is Blocking Lateral or

Posterior Cord Equally Successful?

Efficacy variable: Success Rate.

2. Groups (Gr.): Gr1 = Group L, Gr2 = Group P.

Null Hypothesis H0: Mean success rate in Gr. 1 = Mean success rate in Gr. 2.

Alternative Hypothesis H1: Mean success rate in Gr. 1 not equal to Mean success rate in Gr. 2.

Mean success rate Gr1 = 100.0%, Mean success rate Gr2 = 100.0%. (Ref. Pilot study results)

Success Ratio = 100.0%/100.0% =1.0, Limits of ratio = 0.8 and 1.25, CV = 0.23 approx.;

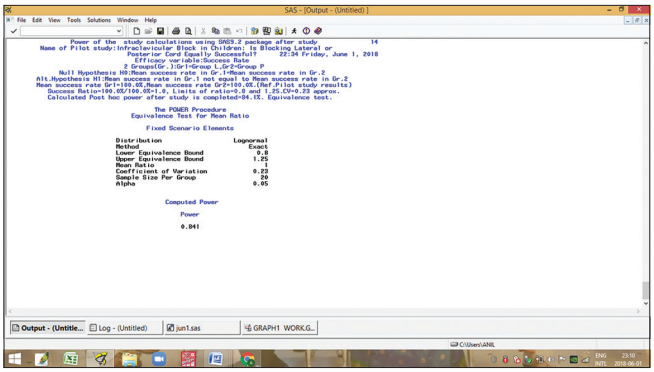
Calculated Post hoc power after study is completed = 84.1%.

Statistical test: Equivalence test

Reference.

Results of a preliminary/pilot study

Screenshot of SAS output:



APPENDIX II

Randomization Chart

Randomization chart was prepared using SAS9.2 package.

Name of Study: Infraclavicular Block in Children: Is Blocking Lateral or Posterior Cord Equally Successful?

2. Groups: 1 = Group L.2 = Group P

Sample size = 40 (20 in each group)

Screenshot of SAS9.2 Output