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Comparison and evaluation of perfusion index with two volumes of 0.75% ropivacaine with 4 milligrams of dexamethasone in supraclavicular brachial plexus block for upper limb surgeries under ultrasound guidance: A randomised clinical study

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Abstract
Background: The Perfusion index (PI) is an objective tool used to assess successful nerve block. The blockade of sympathetic fibres after successful regional anaesthesia results in increased local blood flow and vasodilation, eventually increasing PI.
Aims: The objective is to analyse, contrast, and appraise the Perfusion index of the limb prior to and during the attainment of full motor block using 15ml and 20ml of 0.75% Ropivacaine with 4mg Dexamethasone in an ultrasound-guided supraclavicular brachial plexus block for upper limb procedures.
Materials and Methods: A randomised, single-blinded study was carried out in the Department of Anaesthesiology at BGS Global Institute of Medical Sciences between August 2022 and April 2023. A total of eighty patients, classified as ASA (American Society of Anaesthesiologists) I or II, and of any gender, who were undergoing upper limb procedures with US-guided Supraclavicular brachial plexus block, were included in the study. The patients were randomly assigned to two groups. Group I (n=40) received a 15ml dose of 0.75% Ropivacaine + 4mg Dexamethasone, whereas group II (n=40) received a 20ml dose of 0.75% Ropivacaine + 4mg Dexamethasone. The Perfusion Index (PI) was measured at the beginning of the experiment (before the block), every 2 minutes until 10 minutes, and then every 5 minutes until 30 minutes after the block. The PI ratio was determined by dividing the PI at 10 minutes by the baseline PI. The duration of pain relief and any observed adverse effects were recorded. The statistical analysis was conducted using SPSS version 21. Student's t-test and Chi-square test were conducted as required.
Results: The average age, sex ratio, and BMI were similar in both groups. In Group I, the average Perfusion index after 0 minutes was 1.72±0.58, whereas in Group II it was 1.59±0.58. After 10 minutes, the Perfusion index in Group I was 6.29±0.67, while in Group II it was 7.17±0.64. The mean perfusion ratio in Group I was 4.17±1.54, while in Group II it was 5.21±2.16. In group I, the duration of analgesia was 8.48±0.88 hours, but in group II it was 10±1.2 hours ($P < 0.001$). No negative consequences observed.
Conclusion: The perfusion index is a dependable indicator for evaluating the effectiveness of supraclavicular brachial plexus block using a small volume of 15ml of 0.75% Ropivacaine with 4mg Dexamethasone for procedures involving the upper limb. Nevertheless, there was a 15% reduction in the duration of pain relief when the volume of the Local Anaesthetic medication was decreased from 20 ml to 15 ml.

Keywords: Regional anaesthesia, sympathetic block, analgesia

Introduction

Peripheral nerve blockade is a well-accepted concept for comprehensive anaesthetic care. From the operative suite, the role of peripheral nerve blockade is expanded for management of postoperative pain and chronic pain [1] Peripheral nerve block administered with higher volume of local anaesthetics helps to prolong the length of analgesia, however, may also increase the risk of occurrence of local anaesthetic's systemic toxicity. The advent of ultrasonography in the field of regional anaesthesia aides in accurate placement of the drug in the perineural sheath by real-time visualization of the nerves, thus enabling lower volume

of the drug to be administered [2].

Ropivacaine is a long-acting local anaesthetic agent, that acts by preventing the influx of sodium, and blocking Brachial plexus block is a useful substitute for general anaesthesia for upper limb surgeries. It not only helps in avoiding the untoward effects of general anaesthetic drugs and upper airway instrumentation [3], it also aides in achieving ideal operating conditions by producing complete muscular relaxation, maintaining stable intraoperative hemodynamics, and associated sympathetic block. The sympathetic block decreases postoperative pain, vasospasm and oedema [4]. Certain complications such as pneumothorax, accidental intravascular injection of the local anaesthetic drug, phrenic nerve injury [5], Horner's syndrome, and neuropathy could be avoided with the advent of ultrasound and administration of lower volume of the local anaesthetic drug [6]. Sensory and motor function are typically used to evaluate the effectiveness of peripheral nerve blocks. Nevertheless, this method is subjective, time-consuming, needs patient's cooperation. Assessment of these parameters become futile in patients who are unconscious or those who are unable to provide input due to general anaesthesia, deep sedation, dementia or other conditions [7].

A pulse oximeter Perfusion Index (PI) is a novel, uncomplicated, indirect, and non-invasive method for evaluating peripheral perfusion. It is employed to determine the effectiveness of central neuraxial and peripheral nerve blocks [8]. The value can be quantified as a percentage or an absolute measure and is obtained by dividing the ratio of pulsatile arterial blood flow to non-pulsatile blood flow, which includes venous, capillary, and tissue blood flow. It is used to study the changes in blood flow in the peripheral arteries caused by alterations in vascular tone. The value of PI lies in its ability to accurately assess the efficacy of regional anaesthesia-induced sympathetic block, which results in vasodilation and enhanced blood circulation.[9] Therefore, it can be utilised as a standalone measure to evaluate the effectiveness of the block. The objective of this study was to determine if lesser amounts (15ml) of 0.75% Ropivacaine, compared to higher volumes (20ml), were equally effective for successful supraclavicular brachial plexus block (SCBPB) under ultrasound guidance. The criterion used to measure effectiveness was the performance index (PI). Additionally, 4 milligrams of dexamethasone were administered.

Materials and Methods

A single blinded randomised clinical study was conducted in BGS Global institute of medical sciences, Bengaluru for a period of 9 months from August 2022 to April 2023. The study protocol was approved by Institutional Review Board/Ethical Committee (BGSGlMS/ ll C/App/Feh/2022/012- IEC) and registered under Clinical Trails Registry-India. (CTRI/2022/07/044159 [Registered on: 20/07/2022]). Written Informed Consent was obtained from all the patients.

Inclusion criteria: 80 Patients of the age group 20-40years, of either sex, with body mass index (BMI) between 18-30kg/m2 belonging to ASA physical status I and II, undergoing elective upper limb surgeries.

Exclusion criteria: 32 Patients with peripheral neuropathy, coagulopathy, local site infection, hypersensitivity to the study drug, respiratory insufficiency, pregnant lady and lactating mothers were excluded from study.

Sample size calculation

For seed outcome variable on incidence of success rate derived from previous literature [1] for a comparative two group clinical study with minimum success rate of 15.0%, 90% statistical power and 5% level of significance, the sample size 80 (40 in each group) is adequate.

The sample size was estimated using the formula:

$$N = \frac{Z\alpha/2\sqrt{2p\,(1-p)} + Z1-\beta\, p1\sqrt{(1-p1)p2\,(1-p2)}}{(p1-p2)^2}$$

Where p1 and p2 are the proportion of event of interest (outcome) for group I and group II, and p is

$p=\frac{(p1-p2)^2}{2}$, $Z_{\alpha/2}$ is normal deviate at 1-β power with β% of type 2 error, normally type 2 error is considered 20% or less.

Method of Randomisation: Computer generated randomisation.

Procedure

After obtaining ethical committee approval, written and informed consent from 80 ASA I and II patients belonging to the age group of 20-40 years undertaking upper limb surgeries were included in this study. They were randomly divided in to two groups by computer randomization of 40 each.

The patients alone were blinded to the volume of drug used. All patients were kept fasting for 8 hours. Tab Alprazolam 0.25mg was given night before the day of the surgery. Inj. Pantoprazole 40mg and Inj. Ondansetron 4mg intravenously was given on the day of the surgery preoperatively. On arrival to the operating room, intravenous access was secured. Non-Invasive Blood Pressure, Pulse oximetry and electrocardiogram was connected. The baseline Systolic and Diastolic blood pressures, Heart Rate and Oxygen Saturation was recorded. A reconnaissance scan was conducted utilising a linear high frequency probe (12 MHz-ANO36 Portable Ultrasound) on the supraclavicular area to exclude any anatomical anomalies, such as malformed blood vessels. With strict sterile measures in place, a skilled anaesthesiologist conducted a supraclavicular brachial plexus block technique using a high frequency (12 MHz) linear probe and an echogenic needle, following an in-plane approach guided by ultrasound. The needle tip placement was aimed at the corner pocket located between the brachial plexus and subclavian artery.

Group I: 15 ml of 0.75% Ropivacaine + 4mg Dexamethasone

Group II: 20 ml of 0.75% Ropivacaine + 4mg Dexamethasone

Half the drug was injected into the nerve plexus, other quarter portions into the cords on either side of the nerve plexus.

Outcomes: The primary outcome of the study was to assess

the Perfusion index of the limb before and after achieving complete motor block. The secondary outcome was to assess the duration of analgesia / the time to post-operative rescue analgesic and to assess the safety profile of the drug and complications if any.

After the completion of SCBPB, PI was measured using Masimo radical-7 SET pulse oximeter applied on the middle finger of the ipsilateral arm. PI was recorded at baseline (before block) and 10 minutes following completion of SCBPB.

The PI value is calculated from pulse oximetry data and is derived from the extent of absorption of red and infrared light. As a marker of peripheral perfusion, the PI is expressed as the ratio of the pulsatile component of light (i.e., the arterial compartment (AC)) to the non-pulsatile component of light (i.e., the direct current (DC) in other tissue) reaching the pulse oximetry sensor, and this value is independent of patient oxygen saturation.

The PI can be expressed by the following formula: PI = (AC/DC) x 100%

Based on a study done in 2021 by Jatin Lal *et al.* [9] a PI of >3.03 is considered as an indicator of successful ultrasound-guided supraclavicular brachial plexus block.

The proposed surgery was carried out. Patient was monitored throughout the surgery and the PI and PI ratios in both the group were recorded and compared. Following successful completion of surgery, the patient was shifted out to post-operative anaesthesia care unit.

Statistical Analysis:

All the data collected were compiled and entered into Microsoft excel worksheet. Descriptive statistics like mean, median, mode, standard deviation, Interquartile range, proportions were calculated. The data was analysed using statistical software (SPSS version 20.0 or 22.0). Students T test and Chi square test was used where deemed necessary.

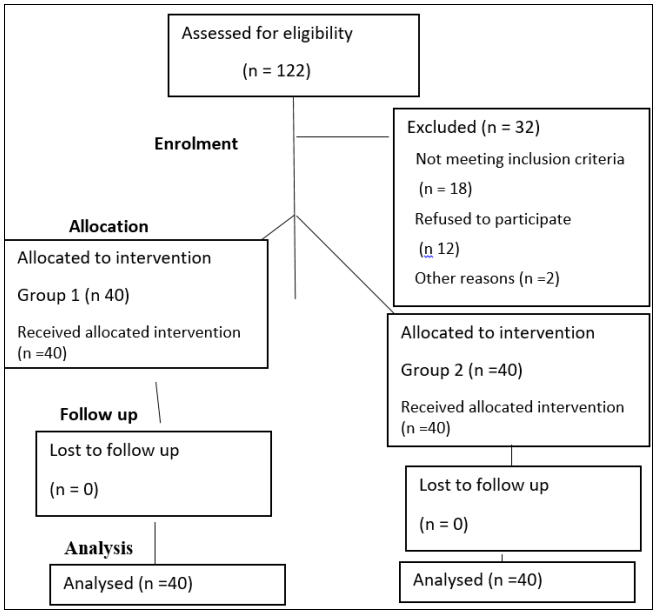

Fig 1: Consort Diagram for the Study

Results

In Group I mean age was 32.25±9.33 years, in Group II mean age was 28.33±11.88 years. The mean age in the two groups were comparable (p=0.270) [Table 1] The total number of male patients in both the groups were 28, while the female patients were 12 in each group. The sex ratio of the two groups was comparable (p= 0.806). [Table 1] In Group I mean BMI was 24.14±2.93 Kg/m², in Group II mean BMI was 24.10±3.44 Kg/m². The mean BMI of the two groups were comparable (p=0.964). [Table 1].

Table 1: Demographic Data

Demographics	variables	GROUP I	GROUP II	Total
Age groups	<20	0 (0%)	0 (0%)	0 (0%)
	20-30	11 (27.5%)	21 (52.5%)	32 (40%)
	>30	29 (72.5%)	19 (47.5%)	48 (60%)
Sex	Female	12 (30%)	12 (30%)	24 (30%)
	Male	28 (70%)	28 (70%)	56 (70%)
BMI	<18.5	0 (0%)	1 (2.5%)	1 (1.3%)
	18.5-24.9	25 (62.5%)	23 (57.5%)	48 (60%)
	25.0-29.9	15 (37.5%)	16 (40%)	31 (38.8%)
	>30.0	0 (0%)	0 (0%)	0 (0%)

The mean PI at 0minutes (prior to procedure) in Group I was 1.72±0.58, and in Group II was 1.59±0.58. The mean PI at 0 minutes of the two groups were comparable (p=0.340). No significant difference in mean PI at 0minutes between the two groups was noted. The mean PI achieved at 10miuntes after procedure in Group I and II were 6.29±0.67 and 7.17±0.64, respectively, and the difference was statistically significant (p<0.001). [Table 2]

Perfusion Ratio is calculated by dividing PI at 10 minutes by the baseline PI (0 minutes). Mean Perfusion ratio in Group I and II are 4.17±1.54 and 5.21±2.16 respectively, and the difference is statistically significant (p=0.016). [Table 2]

A PI ratio of <3.03 is noted in 25% patients in Group I and 7.5% in Group II, while a PI ratio of >3.03 is noted in 75% in Group I and 92.5% patients of Group II. [Table 3]

Table 2: Perfusion Index and Perfusion Ratio

Variables	GROUP I	GROUP II	P Value
Perfusion index (0 minutes)	1.72±0.58	1.59±0.58	0.340
Perfusion index (10 minutes)	6.29±0.67	7.17±0.64	<0.001**
Perfusion Ratio	4.17±1.54	5.21±2.16	0.016*

Table 3: Perfusion Index (p<0.016* using Student's t test)

Perfusion ratio	Group I	GROUP II	Total
<3.03	10(25%)	3(7.5%)	13(16.3%)
>3.03	30(75%)	37(92.5%)	67(83.8%)
Total	40(100%)	40(100%)	80(100%)
Mean±SD	4.16±1.54	5.20±2.15	4.68±1.93

The mean duration of analgesia achieved in group I and II was 8.48±0.88 hours and 10±1.2hours, respectively, and the difference was statistically significant (p<0.001). There was a 15% decrease in the duration of analgesia with a decrease in volume of 0.75% ropivacaine from 20 ml to 15 ml. [Table 4]

Table 4: Mean duration of analgesia (p<0.001** using student t test)

Variables	GROUP I	GROUP II	P Value
Duration of Analgesia (hours)	8.48±0.88	10±1.2	<0.001**

No adverse effects noted with respect to the drug and the procedure during intra-operative and post-operative period in both the groups.

Discussion

The PI is an objective tool used to assess successful nerve block. The blockade of sympathetic nerve fibres after successful nerve block results in increased local blood flow and vasodilation, eventually increasing the PI [9] The PI measures the pulsatility of blood, and not a measure of blood flow[10] Every vasoconstrictor stimulus or sympathetic nervous system activity lowers the PI because it lowers the height of the pulsatile portion of the curve. Contrarily, every vasodilator stimulation, parasympathetic nervous system activation, or sympathetic nervous system inhibition raises the PI because it increases the height of the pulsatile section of the curve. When regional anaesthesia is administered to patients, a sympathetic block occurs initially, then a sensory and motor block. Due to peripheral vasodilatation in the extremity brought on by sympathetic block, PI increases. Our study population comprised of individuals of either sex with 30% females and 70% males in both the groups (P=0.806) with an age group ranging from 20 to 40 years with the mean age in groups I and II were 32.25±9.33 years and 28.33±11.88 years respectively (P=0.270). Patients had a mean BMI of 24.14±2.93 Kg/m² in group I and 24.10±3.44 Kg/m² in group II respectively (P=0.964). There was no significant difference noted among the groups with respect to the age, gender and BMI of the patients.

Perfusion index

The mean PI at 0 minutes (prior to procedure) in Group I was 1.72±0.58, in Group II was 1.59±0.58. The mean PI at 0 minutes of the two groups were comparable (P=0.340). No significant difference in mean PI at 0 minutes between the two groups was noted. The mean PI achieved at 10 minutes after procedure in Group I and II were 6.29±0.67 and 7.17±0.64, respectively, and the difference was statistically significant (P<0.001). Perfusion Ratio is calculated by dividing PI at 10 minutes by the baseline perfusion index (0 minutes). Mean Perfusion ratio in Group I and II are 4.17±1.54 and 5.21±2.16 respectively, and the difference is statistically significant (P=0.016). In the present study, a PI ratio of <3.03 is noted in 25% patients in Group I and 7.5% in Group II, while a PI ratio of >3.03 is noted in 75% in Group I and 92.5% patients of Group II.

In the study conducted by Lal J *et al.* which included 65 individuals who were having arm surgery under supraclavicular block, the baseline mean of PI was 1.19±0.7. After the block, mean PI continued to rise from the starting point and peaked at 10 minutes. When a block was successful, the median PI began to rise two minutes after the block and rose linearly until 10 minutes had passed; when a block was unsuccessful, the mean PI barely rose at all. The median PI ratio was 7.50 in this study. It was 8.3 in blocks that were successful and 1.28 in blocks that weren't. This difference between successful and unsuccessful blocks' PI ratios was statistically significant (P< 0.001). This study is comparable to study wherein the mean PI and PI ratio proved a successful block in both the groups and the difference was statistically significant [9].

In a study conducted on 33 ASA I and II patients by Bozdag *et al.* [7] In 32 of 33 patients who underwent brachial plexus block, our block was successful, and perfusion index measurements in the applied limb increased continuously from the 5th min over the 20-min observation period. In one patient who failed the block and in the arm group without block, no statistically significant difference was detected in the 5th, 10th, and 20th min perfusion index measurements. The findings of the present study are consistent with their study in terms of achieving adequate block with using PI as the primary parameter indicating the success of sympathetic blockade post administration of the local anaesthetic.

Duration of analgesia

The mean duration of analgesia achieved in group I and II were 8.48±0.88 hours, and 10±1.2 hours, respectively. The difference was statistically significant (p< 0.001). There was a 15% decrease in the duration of analgesia with a decrease in volume of 0.75% ropivacaine from 20 ml to 15 ml. Mamta Chadha *et al.* [1] performed a study based on 40 patients undertaking upper extremity surgery. Each group of 20 participants received 20 ml and 35 ml 0.5% ropivacaine respectively, in US-guided SCBPB. The duration of

analgesia achieved in group 20 and 35 was 575.56±104.39 and 730.75±102.09 min, respectively, and the difference was statistically significant. The duration of analgesia was 21% lesser in the patients receiving 20 ml of 0.5% ropivacaine. Similarly, our study depicts that, 15ml of 0.75% Ropivacaine with 4 mg Dexamethasone provided adequate duration of analgesia and comfort to the patient postoperatively.

Sangwan Pushpender *et al*. [11] conducted a prospective clinical study on 29 patients to estimate the minimum effective Volume of 0.5% Ropivacaine in US-guided SCBPB. The study being started with 30ml of 0.5% Ropivacaine, using step-up/step-down technique, concluded that 15ml of LA provided adequate duration of analgesia of 7.6±1.18 hours. The study also stated that the block duration did not differ between patients with successful blocks at 15ml and those who required >15 ml was 7.10±0.74 and 7.95±2.22 hours, respectively; P = 0.25). In the present study, adequate duration of analgesia was achieved but with a 15% reduction in duration of analgesia in Group I compared to Group II.

In another study which included 30 volunteer orthopaedics and traumatology patients with American Society of Anaesthesiologists (ASA) I-II, aged between 18 and 70 years, who were scheduled for hand, wrist, forearm, elbow, and arm surgery. In this prospective study, all patients received an ultrasound guided supraclavicular block using a local anaesthetic solution containing prilocaine 12.5 ml and bupivacaine 12.5 ml. Sensory block was assessed using a pin-prick test every 3 minutes, while motor block was assessed using the modified Bromage scale every 2 minutes. Haemodynamic parameters and PI values were recorded at 0^{th}, 5^{th}, 10^{th}, 15^{th}, 20^{th}, 25^{th}, and 30^{th} minutes. Significant variations were seen when comparing the measured perfusion index values. Significant variations were seen when comparing the PI values at basal and 5th min, 10 min, 15 min, 20 min, 25 min, and 30 min. The positivity time for the pin-prick test was measured to be 8.83+-2.70 minutes. The motor block onset time was found to be 6.7+-2.89 minutes, while the total motor block onset time was determined to be 10.83+-3.07 minutes. During the 5th minute, there was an average increase of 148% in PI levels compared to the basal PI values. Therefore, they deduced that supraclavicular block resulted in a more rapid sensory-motor block compared to previous blocks targeting the upper extremity. The study determined that the perfusion index is a faster, more objective, and easier technique for assessing the efficacy of a block compared to older methods. This is due to the vasodilation that occurs before the sensory and motor block [12].

Adverse reactions

No adverse reactions or complications noted with regards to the procedure or drug during our study Peripheral nerve blocks work well for providing good analgesia as well as can be used as sole anaesthetic. These are currently the anaesthesiologists' go-to clinical tactics for avoiding the airway manipulation during the coronavirus pandemic for any procedures that can be done with regional anaesthesia [13]. A block failure is an unpleasant stress both for the patient and the anaesthesiologist. Early diagnosis of failed blocks enables the quicker use of rescue treatments like block augmentation or general anaesthesia. PI is described as a reliable, quick, and remote method for block evaluation [9].

Limitations

PI value is subject to manufacturer's error of pulse oximeter as well as variations in operation room temperature.

Conclusion

Perfusion Index can be used as an independent, non-invasive parameter to assess the success of a peripheral nerve block. Ultrasound guided SCBPB for surgeries below the shoulder joint can be performed using 15ml of 0.75% Ropivacaine with 4mg Dexamethasone. PI is a quicker, more effective, reliable and objective approach for assessing the performance of US-guided SCBPBs than traditional methods.

Conflict of Interest

Not available

Financial Support

Not available

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