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ASSESSMENT OF SUPRACLAVICULAR BRACHIAL PLEXUS BLOCK SUCCESS USING PERFUSION INDEX: A PROSPECTIVE OBSERVATIONAL STUDY

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ABSTRACT **Introduction:** The supraclavicular approach to the brachial plexus block is a well-established regional anesthesia technique for surgical interventions on the upper extremities. Traditional methods of assessing block success, primarily reliant on motor and sensory evaluations, can be subjective and impractical in certain clinical situations. The Perfusion Index (PI) serves as a non-invasive, objective method to measures peripheral perfusion and can function as a dependable parameter for analysing the effectiveness of nerve blocks. **Aim and Objectives:** Supraclavicular brachial plexus block achievement through the usage of the perfusion index. The primary objective was to assess the trend in perfusion index with time (at 1, 5, 10, 15, 20, and 30 min) after giving a supraclavicular brachial block within the blocked arm. The secondary objective became to evaluate a comparison of perfusion index in the blocked and unblocked limb after the supraclavicular brachial plexus block. **Materials And Methods:** This study was designed as a prospective observational analysis at a tertiary care centre from January 2019 to December 2020, this research involved a total of 86 participants aged between 18 and 50 years, categorized as ASA Grade I or II, and scheduled for elective procedures on the upper limb. Patients with contraindications for the block were excluded. Pre-anesthetic evaluations, routine investigations, and informed consent were obtained. The procedure was conducted using ultrasound guidance, and the Perfusion Index was recorded at baseline and post-block at specified intervals. The study analyzed demographic data, block success rates, and the relationship between PI values and block efficacy. **Results:** The Perfusion Index was found to be significantly elevated in the successful block group. The optimal cut-off values were determined to be 1.1 for the PI ratio and 3.35 for the absolute Perfusion Index, both demonstrating high sensitivity and specificity for predicting block success. No complications occurred during the procedure. **Conclusion:** The Perfusion Index Ratio provides a more precise indication of block success than the absolute value of the Perfusion Index. The findings in favour of the use of PI as a valuable, non-invasive and economical method for evaluating the success of supraclavicular approach to the brachial plexus blocks.

KEYWORDS : Brachial plexus block, Perfusion Index, Regional anesthesia, Ultrasound-guided technique, Block success.

INTRODUCTION:

The supraclavicular approach to the brachial plexus block is recognized as one of the most frequently employed regional anesthesia techniques for surgeries involving the upper extremity. The effectiveness of a brachial plexus block is determined by evaluating both motor and sensory responses, even when ultrasound guidance is used for the supraclavicular approach. Motor and sensory function tests are subjective and cannot be assessed during general anesthesia and if the patient is in deep sedation or if the patient is unable to communicate [1]. There are many objective methods to evaluate the physiological changes like vasodilation, increased blood flow, and raised temperature that consequently occur after a successful sympathetic blockade.[2] All objective methods are comparatively high in cost and sophisticated to use.

The Perfusion Index (PI) is one of the objective methods used to determine the success of a peripheral nerve block. This is a non-invasive, continuous method that offers a direct evaluation of peripheral perfusion at specific monitoring locations, such as the hand, finger, or foot. [3] The Perfusion Index (PI) is determined by calculating the ratio of Pulsatile flow (arterial blood) to Non-pulsatile (the combined flow of venous, capillary, and tissue blood) PI is mainly used to check out the dynamics of peripheral perfusion, which vary with a change in peripheral vascular resistance. A dedicated pulse oximeter is no longer required to measure the Perfusion Index (PI), as this functionality is now built into standard monitoring devices. [4] Previously, the Perfusion Index (PI) has been utilized to assess various vasodilation-related conditions, including the effectiveness of stellate ganglion blocks, epidural blocks, and thoracic sympathectomy and the induction of anesthesia.[5]

The Perfusion Index (PI) offers a quick, straightforward, and easy-to-use option compared to other quantitative methods for assessing the effectiveness of a nerve block. Early and precise detection of block success allows for timely intervention, either by enhancing the block or transitioning to general anesthesia. This proactive approach can reduce operating room time and significantly enhance patient satisfaction. We hypothesized that the assessment of PI is an easy, quick, reliable, and safe objective parameter for a successful supraclavicular plexus block.

AIM AND OBJECTIVES:

Supraclavicular brachial plexus block achievement through the usage of the perfusion index. The primary objective was to assess the trend in perfusion index with time (at 1, 5, 10, 15, 20, and 30 min) after giving a supraclavicular brachial block within the blocked arm. The secondary objective became to evaluate a comparison of perfusion index in the blocked and unblocked limb after the supraclavicular brachial plexus block.

MATERIALS AND METHODS:

This study was designed as a prospective observational analysis at a tertiary care centre between January 2019 and December 2020, received approval from the institutional ethics committee, Ethical approval letter No. 437/GMC/IEC/2018/Reg. No. 394/IEC/R-08-10-2018. A total of 86 patients were recruited, ranging from 18 to 50 years of age, including individuals of both genders, classified as American Society of Anesthesiologists (ASA) Physical Status Grade I or II, and having a body mass index (BMI) of less than 30 kg/m².

These patients were scheduled for elective upper limb surgeries under a supraclavicular approach to the brachial plexus block.

Patient refusal for the block, ASA Physical Status Grade III & IV, pre-existing significant systemic diseases, peripheral vascular disease, BMI >30 kg/m2, significant coagulopathies and other contraindications for supraclavicular brachial plexus block, neuro-psychiatric disorder, local anaesthetics allergy and those taking adrenergic blockers, such as alpha or beta antagonists, were omitted from the research. After acquiring written informed consent from each participant, a comprehensive pre-anesthetic evaluation was conducted

one day prior to surgery. Prior to surgery routine investigations were done.

Patients were given a thorough overview of the procedure in a language understood by them. As soon as the patient was brought into the operating room the American Society of anaesthesiologists standard essential monitoring was applied to the patient, and baseline parameters were recorded. An 18-gauge intravenous catheter was placed, and a ringer lactate solution was initiated. The patient was pre-medicated with an intravenous injection of Pantoprazole 40 mg, Metoclopramide 10 mg, and additional medications as needed. Ondansetron 4mg i.v. After the patient was laid supine, the head was adjusted to face the opposite direction. The arm was flexed at the elbow and supinated at the wrist. The block was administered using the supraclavicular approach under ultrasound guidance. The ultrasound device was positioned in the supraclavicular area to enhance visualization of the brachial plexus and surrounding structures, such as the subclavian artery. Upon identifying the brachial plexus on the ultrasound screen, the needle was positioned in-plane with the ultrasound beam, providing real-time visualization of the needle tip as it advanced toward the target nerves. The needle was gradually advanced toward the ipsilateral nipple with a slight posterior orientation, using ultrasound to confirm its position. Once the needle was appropriately positioned, paraesthesia was observed or a motor response became apparent, evidenced by the contraction of the arm and forearm muscles. A 22-gauge needle was used, and A total of 25 ml of local anesthetic, comprising 12.5 ml of 2% lignocaine and 12.5 ml of 0.5% bupivacaine was administered under continuous ultrasound guidance to ensure proper distribution around the brachial plexus.

A pulse oximeter was attached to the index finger of the hand undergoing the procedure on to monitor the Perfusion Index (PI). The baseline Perfusion Index (PI) was measured and documented for both the blocked and unblocked arms, just before injecting the local anaesthetic agent. PI was recorded after giving the block at 1, 5, 10, 15, 20, and 30 min in the blocked arm and at 10, 20, and 30 in the unblocked arm. Pinprick sensation with the 23-gauge hypodermic blunt needle was used to assess sensory block by using 3-level scales, normal-0, loss of sensation of pinprick -1, loss of touch sensation -2 [1] at a different time interval. Motor function was evaluated using the Modified Bromage scale: 0 indicated normal motor function with full flexion and extension of the elbow, wrist, and fingers; 1 indicated reduced motor strength, where the patient could only move their fingers and/or wrist; and 2 represented a complete motor blockade, where the patient was unable to flex their fingers. [6] The effect of the block was evaluated 30 minutes later by pinching the surgical site, if the patient having pain, the effect of the block was considered failed and mode of anaesthesia was converted to general anaesthesia. If a patient did not have pain, the block was considered adequate and the patient was handed over to the surgeon.

A previous study documented an increase in perfusion index by 3.25 corresponding to an adequate block with The significance level for type 1 error was established at 0.05, while the study's power was determined to be 80%. A total of 40 patients per group was computed as the required sample size. In view of expected attrition rate of 10%, we decided to enrol 90 patients for the study. The mean and standard deviation were computed for quantitative variables, or categorical variables, the frequency and proportion were calculated. For qualitative data, the Chi-square test or Fisher's Exact test was utilized, while the Mann-Whitney test was employed for continuous data. receiver operating characteristic (ROC) curve was generated to assess the capability of identifying successful and failed blocks. A P value below 0.05 was deemed statistically significant. The data analysis was conducted using the Statistical Package for Social Sciences (SPSS), version 22 for Windows.

RESULTS:

Of the 90 patients who were originally enrolled in the stud four patients withdrew after giving consent. A total of 86 patients proceeded with surgery with the supraclavicular approach to the brachial plexus block. Table 1 presents the demographic characteristics of the patients, and the following results were derived from the study.

Among the total patients, 66 (76.7%) were male, and 20 (23.3%) were female. The mean age of the patients was 33.5 years (±9.1), with a range of 18 to 50 years.

The mean BMI of the patients was 23.5±1.6 kg/m², with a range of 20.2 to 27.1 kg/m². Of the 86 patients, 80 (93%) were classified as ASA grade I, and 6 (7%) as ASA grade II. The block was successful in 78 patients (90.7%).

Table 1- Demographic Characteristics

Characteristics	Values
Patients (n)	86
Age (years)	33.5±9.1
Sex (Male/Female)	66/20
BMI (Kg/m^2)	23.5±1.6
ASA grade (I/II)	80/6

Data are mean ± standard deviation (SD) or total numbers. BMI: Body mass index
ASA: American Society of Anaesthesiologists

In our study, the Perfusion Index was significantly greater in the group where the block was successful compared to the group where the block failed at 1, 5, 10, and 15 minutes, (Figure 1, Table 2)

Table 2: Comparison Of Mean Perfusion Index Between The Successful And Failed Blocks

Perfusion Index	Block Success (n=78)	Block Failed (n=8)	Δ (Mean ±SE)	95% C.I. of the Δ		t-value	p-value
				Lower	Upper		
1 minutes	4.2±0.7	2.6±0.6	1.6±0.3	1.0	2.1	6.045	< 0.0001*
5 minutes	6.5±1	2.7±0.5	3.8±0.4	3.1	4.6	10.558	< 0.0001*
10 minutes	7.8±1	2.8±0.5	5±0.4	4.3	5.7	14.018	< 0.0001*
15 minutes	8.6±0.8	2.9±0.5	5.7±0.3	5.1	6.3	18.600	< 0.0001*

Δ = Difference of Block (Success – Failed); *p-value < 0.05, statistically significant

In the between-limb comparison, the Perfusion Index was higher in the blocked arm group in comparison to the group of unblocked arm at 10, 20, and 30 minutes (p-value < 0.05). In the within-group comparison, a significant increasing trend in the Perfusion Index was observed from baseline to 10, 20, and 30 minutes in the blocked arm group (p-value < 0.05). (Figure 2, Table 3)

Table 3: Comparison Of Mean Perfusion Index Between The Blocked And Unblocked Arm

Group	Blocked Arm (n=86)			Unblocked Arm (n=86)			Δ_3 Mean ±SD	p - value
	Mean±SD	Δ_1 Mean ±SD	p - value	Mean ±SD	Δ_2 Mean ±SD	p - value		
Baseline	2.7±0.4	-	-	2.7±0.4	-	-	0.0±0.1	.945
10 minutes	7.3±1.7	-4.6±1.6	<0.0001*	2.7±0.5	0.0±0.1	0.024*	4.6±0.2	<0.0001*
20 minutes	8.6±1.9	-5.9±1.8	<0.0001*	2.9±0.4	-0.2±0.1	<0.0001*	5.7±0.2	<0.0001*
30 minutes	9.4±2.1	-6.7±2	<0.0001*	2.9±0.4	-0.2±0.1	<0.0001*	6.5±0.2	<0.0001*

Δ1 & Δ2: Difference from Baseline; Δ3 = Difference of Block (Success – Failed); *p-value < 0.05, statistically significant

Table 4: ROC Analysis for prediction of success of block by Perfusion Index at 10 minutes and Perfusion Index Ratio

Area Under the Curve					
Test Result Variable(s)	Area	Std. Error[a]	Asymptotic 95% Confidence Interval		p-value
			Lower Bound	Upper Bound	
Perfusion Index	0.958	0.017	0.925	0.992	0.0001*
Perfusion Index Ratio	0.988	0.010	0.961	1.000	0.0001*

The test result variable(s): Perfusion Index at 10 minute and Perfusion Index Ratio has at least one tie between the positive and negative actual state groups. Statistics may be biased.

a. Under the nonparametric assumption
b. Null hypothesis: true area = 0.5

***p-value < 0.05, statistically significant**

The analysis of the receiver operating characteristic (ROC) curve indicated the capacity for prediction of the ratio of Perfusion Index at 10 minutes to determine the success of the block was good (AUC = 0.988, 95% C.I.: 0.961 – 1.000) as compared to Perfusion Index (AUC = 0.958, 95% C.I.: 0.925 – 0.992). (Table 4 and Figure 3)

The optimal cut-off value for the Perfusion Index Ratio to predict block success is 1.1, demonstrating a sensitivity of 94.2%, specificity of 96.5%, positive predictive value (PPV) of 96.4%, negative predictive value (NPV) of 94.3%, and an overall accuracy of 95.4% Additionally, the optimal cut-off value for the Perfusion Index itself to predict block success is 3.35, with a sensitivity of 94.2%, a specificity of 93.0%, a positive predictive value (PPV) of 93.1%, a negative predictive value (NPV) of 94.1%, and an overall accuracy of 93.6%.

No complications were encountered during the block, such as pneumothorax, vascular puncture, intravascular injection, nerve injury, unintended nerve blockade (phrenic or recurrent laryngeal nerve), or Horner's syndrome.

DISCUSSION:

Various objective methods have been studied for the detection of successful block which includes skin electrical resistance, temperature measurement,[4] and laser Doppler perfusion imaging. [7,8]

A successful peripheral nerve block, reliant on the inhibition of sympathetic fibers, is marked by noticeable signs such as localized vasodilation, augmented regional blood flow, a mild rise in skin temperature, and diminished sensory perception in the affected limb.[9]

To commence a surgical procedure, it is crucial to assess the adequacy of the block using these parameters. However, in the demanding and often cold environment of an operating room, relying on these clinical signs to verify block effectiveness can be both inefficient and subjective, posing challenges in ensuring timely and accurate evaluations.

The perfusion index is obtained by photo-plethysmography signal and represents that PI has been considered a marker of inhibition or stimulation of the sympathetic nervous system.[10] The relevance of the Perfusion Index has been investigated as an indicator for fluid responsiveness, as well as for the early detection of blood loss and post-spinal hypotension. [11]

Various factors, including the elasticity of vascular walls, peripheral vascular resistance, and circulating blood volume, can significantly influence fluctuations in the peripheral Perfusion Index (PI). Among these, peripheral vascular resistance, predominantly governed by the autonomic nervous system, plays the most substantial role in modulating changes in PI.

An elevated PI indicates increased blood flow to the finger, reflecting improved peripheral circulation, while a reduced PI signifies diminished blood flow, suggesting restricted peripheral perfusion.[12]

In previous studies, the perfusion index has played a useful role in the Perfusion Index has been studied for effectiveness of peripheral nerve blocks.[13,14]

In our study, no patient experienced ulnar sparing, unlike Bassant Abdelhamid et al who documented ulnar sparing after supraclavicular block in 18% of the patients.[15]

We observed a statistically significant difference in the Perfusion Index (PI) ratio between the blocked and unblocked limbs (p-value < 0.05). Similarly, a study by Loretta et al demonstrated that the blocked limb exhibited a higher PI ratio than the unblocked limb.[16]

Lal et al observed that the mean Perfusion Index (PI) increased steadily from baseline, reaching its peak at 10 minutes, followed by a slight decrease up to 30 minutes.[1] Sebastiani et al found in their study that the PI index values were changed significantly and increased gradually from the 5th min to the 15th min after the successful inter-scalene blockade.[12] However, we found in our trial that the perfusion index increased in an ascending fashion till 30 minutes with the maximum value reaching at 30 minutes. This is concurrent to the findings of Kus et al who documented a significant change in PI, around10 minutes after the block and the most significant changes in the Perfusion Index (PI) were observed 30 minutes after the block was performed.[13]

According to A. Abdelnasser et al. (2017), both the Perfusion Index (PI) and the PI ratio at 10 minutes demonstrated a strong capability to determine block success. At 10 minutes after the anesthetic injection, with a cut-off value of >3.3 the ROC curve for the PI was 1 (0.95–1.00). Similarly, with a cut-off value of >1.4 the ROC curve for the PI ratio was 1 (0.95–1.00).

In our study, the cut-off of Perfusion Index predicting success of block is 3.35, and the cut-off of Perfusion Index Ratio calculating the block success is 1.1. On the concurrent lines, Lal et al documented that the PI 3.25 at 10 min was considered adequate for the successful effect of the supraclavicular block. [1]

Abdelnasser et al. (2017) reported that the positive predictive value (PPV) for the Perfusion Index (PI) as an indicator of block success was 100%, accompanied by a 95% confidence interval ranging from 95% to 100%. Similarly, the negative predictive value (NPV) was also found to be 100%, with a 95% confidence interval of 57% to 100%.

In comparison, our study showed a specificity of 96.5%, PPV of 96.4%, NPV of 94.3%, and an overall accuracy of 95.4%, This aligns with the results obtained in their study.

Buono et al concluded that if the PI tripled within 5 min of giving regional anesthesia, it can be considered as a reliable indicator of successful neural blockade. [17] Lal and Abdelnasser documented PI value and PI ratio as cut-off values to indicate a successful nerve block.[1,17]

We believe that the PI ratio may serve as a more precise indicator compared to the the actual value of the Perfusion Index (PI).at any given time point, owing to the high variability in values of the Perfusion Index.

This study has some limitations that warrant consideration. Monitoring was limited to the first 30 minutes after the block, which may not capture delayed trends in the Perfusion Index (PI). Additionally, the study did not distinguish between partial and complete block failures, which could have provided a more detailed understanding of the PI's predictive value. While the findings demonstrated high accuracy, the single-center design may limit generalizability, as variations in patient demographics, equipment, and techniques across institutions could impact reproducibility. Future multicenter studies and extended monitoring are needed to address these gaps.

Our study also has strength as compared to previous studies in that the values recorded were at comparatively closer intervals of 5 minutes relative to 10-minute intervals in earlier trials. This study has highlighted the importance of the Perfusion Index (PI) and the Perfusion Index Ratio as reliable, simple, and cost-effective tools for determining the success of supraclavicular brachial plexus blocks. Unlike traditional methods that rely on assessing motor and sensory responses, which can sometimes be challenging to evaluate, these parameters provide an objective and accurate way to measure block success. The study found that a PI value of 3.35 and a PI Ratio of 1.1 are effective indicators of a successful block, with the PI Ratio proving to be even more precise. This makes it particularly useful for situations where communication with the patient is limited, such as during deep sedation or general anesthesia.

We believe that as there are several definitions of PI criteria, (including different time points, PI value, PI ratio value, and multiplication factor etc) to indicate a successful nerve blockade, high-quality systematic reviews and meta-analysis are required to provide a conclusive definition with a strong evidence base.

CONCLUSION:

The predictive capability of the Perfusion Index Ratio for determining block success was found to be better than that of the Perfusion Index at 10 minutes. The optimal cut-off value for the Perfusion Index Ratio indicating block success is 1.1, while for the Perfusion Index, it is 3.35. Additionally, the PI was significantly greater in the group with successful blocks. Incorporating Perfusion Index (PI) monitoring into

standard anesthesia practices can provide a simple, cost-effective, and reliable way to assess block success. Using the PI value and PI Ratio (within the first 30 minutes ensures early detection of block effectiveness, allowing timely intervention. This approach enhances patient safety, minimizes the need for emergent anesthesia changes, and improves overall surgical outcomes. Training healthcare providers and integrating these methods into protocols can further streamline clinical applications.

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Conflict Of Interest :- Nil

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