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Assessing Efficacy of Ultrasound Guided Supraclavicular Block Using Perfusion Index in Pulse Oximeter

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Abstract:
Background*: Supraclavicular block is usually conducted on brachial plexus to facilitate surgical anesthesia in most of upper limb surgeries. The assessment of success of peripheral nerve blocks is time consuming and subjective in nature like evaluation of motor and sensory functions. There are some objective methods as well but are time and resource consuming. Owing to these facts, the present study has researched on the use of perfusion index (PI) for assessment of ultrasound guided supraclavicular block.*
Materials and Methods*: 52 patients between 18 years and 65 years of age, ASA grade 1 and grade 2 physical status undergoing upper limb orthopaedic surgeries were included in the study after obtaining clearance from the college ethics committee. The block was considered successful when brachial plexus dermatomes (C5–T1) were completely blocked. The PI was measured using pulse oximeter probe applied on the thumb. The PI was recorded at baseline and at 10,20, &30minutes after injection in both blocked and non-blocked limbs. In every patient, a comparison between the blocked and unblocked limb was performed. The positive predictive value and negative predictive value were calculated for both the PI at 10min and PI ratio.*
Results*: Both the PI and the PI ratio at 10 min after injection showed sensitivity and specificity of 100% for block success at cut-off values of 5.1 and 4.7respectively. Thus, the study concluded that PI provides an earlier, more objective, and more sensitive indicator to assess the onset of supraclavicular brachial plexus block.*
Key Word*:*

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I. Introduction

The upper limb is a large and flexible joint in the body which is often prone to many physical damages and diseases revolving around inflammation. Owing to this, surgeries of upper limb has become very common[1]. Supraclavicular block is usually conducted on brachial plexus block to facilitate surgical anesthesia in most of upper limb surgeries.

Figure 1: Expected sensory distribution of the supraclavicular brachial plexus block.
Source: Bendtsen et al., (2020)[2]

Herein, the concern arises owing to the close vicinity of the brachial plexus to the pleura and chest cavity. Brachial plexus is firmly structured as a bunch at the point where supraclavicular approach has to be

administered. This causes quicker commencement and dense block.[3] Supraclavicular brachial plexus block decreases the rate of hemi –diaphragmatic paresis[4], reduces the neurologic complications and Horner's syndrome.[5] Still some complications are still attached to supraclavicular brachial plexus block like it can cause pneumothorax[6], recurrent laryngeal nerve blockade, vascular punctures[7] and is considered inefficient in blocking the suprascapular nerve[1] to name a few. Recently, ultrasound-guided supraclavicular block has been considered as a potential solution to these complications associated with supraclavicular brachial plexus block. This is because ultrasound-guidance helps in avoiding pneumothorax[6] and can image both the lung and pleura at the same time using advancement in needle.[8] Thus, for anesthesia in upper limb surgeries, the use of ultrasound in supraclavicular block has increased.[9]

The assessment of success of peripheral nerve blocks is time consuming and subjective in nature like evaluation of motor and sensory functions.[10] There are some objective methods as well, available for evaluation of success of peripheral nerve blocks like use of sympathetic block and resulting physical changes.[11]These objective methods are again time consuming and many a times require sophisticated equipment there by making these resource consuming. Owing to these facts, the present study has researched on the use of perfusion index (PI) for assessment of ultrasound guided supraclavicular block.

PI is a non-invasive method which uses the mechanism of evaluating the changes in finger peripheral perfusion.[12] This is done through a pulse Oximeter. PI can be defined as the non-pulsatile flow rate of the pulsatile flow.[13] It is a prompt pointer of fluctuations in microcirculation. This can facilitate the anesthetists to access the instabilities in circulation.[14] Thus, the present research has been focused on assessing efficacy of ultrasound guided supraclavicular block using perfusion index in pulse Oximeter.

In the last decade, researchers have conducted many studies on ultrasound-guided supraclavicular brachial plexus block for upper extremity surgery.

Choudhary et al., 2019[15] conducted a research to compare the performance of single-point and double-point injection technique for ultrasound-guided supraclavicular block. The study took into consideration the parameters like success rate, start and length of sensory and motor block, time taken to complete the procedure and complications. The results found and double-point injection technique to be more effective than the single-point injection technique. Similar study was conducted by Arab et al., (2014)[16]on ultrasound-guided supraclavicular brachial plexus block in upper limb surgery and compared the single and triple injection technique for the procedure. The study found that triple injection technique to be more effective and to provide more complete sensory block than when compared with single injection technique at 20 minutes.

Mathew et al., 2018[17] stated that ultrasound-guided supraclavicular brachial plexus block has better onset, improved quality and spell of the block leading to better outcomes and reduced complications. Similarly, Brattwall et al., (2016)[18] stated that ultrasound-guided supraclavicular brachial plexus block has improved the performance and increased the safety of the anesthetic procedure in upper extremity surgeries. Further, it provides early postoperative and effective intraoperative analgesia.

Again in 2014, Gamo et al.[19] conducted a research for accessing the outcomes and satisfaction of the patients ultrasound-guided supraclavicular brachial plexus block in upper limb surgery. The study found the use of ultrasound-guided supraclavicular brachial plexus block in upper limb surgery safe as only 10% of the total patients in the study developed Horner's syndrome which was then fixed spontaneously. No side effects like systemic anesthetic toxicity, nerve injury, arterial puncture or pneumothorax were reported. Further, 96.7% of the patients were found to be satisfied with the process.

In 2011, Amiri & Espandar[20] conducted a research on younger children undergoing ultrasound-guided supraclavicular brachial plexus block for upper extremity surgery. The study found ultrasound-guided supraclavicular brachial plexus block to be safe, effective and convenient anesthesia process for children undergoing upper limb surgery.

Thus, it can be inferred from the above discussion that supraclavicular brachial plexus block is a successful process which is being adopted rapidly as a topic of research to test its effectiveness. Further, it is being adopted as a trusted process in surgeries as well. Owing to popularity and increased usage of ultrasound-guided supraclavicular brachial plexus block, it becomes important to test the success of the block.

Kim et al., (2020)[21] used PI as a tool to assess the success of the block. Further, the study tested the influence of Epinephrine on the PI values for the ultrasound-guided supraclavicular brachial plexus block. The study found use of PI values to test the success of block to be an effective method but Epinephrine was found to have no impact on the PI values. Kingslin, (2019)[22] also used PI as a tool to assess the success of the supraclavicular brachial plexus block and found similar positive results for PI to predict and assess the success of the block.

Abdelnasser et al., (2017)[9] stated the conventional methods like objective methods including change in the temperature of skin, blood flow and resulting physiological changes to be time consuming. Thus, the researcher used PI instead to evaluate the success of the block and found it to be an effective method.

Kus et al., (2013)[23] conducted a similar research and stated PI as an effective tool to test the success of brachial plexus block for upper extremity.

As can be inferred from the above discussion that ultrasound-guided supraclavicular brachial plexus block for the upper extremities is a successful procedure. Further, it was found that use of PI to assess the efficacy of a block to be a popular method since it less consumes lesser time and resources and is also minimally invasive. Many researches were found specifically focused on assessing efficacy of supraclavicular block using PI but very limited researches were found to test the efficacy of Ultrasound Guided Supraclavicular Block Using PI even though ultrasound method is minimally invasive possess lesser complications. Thus, the present research will mend this gap and will contribute to the existing literature by conducting a study on assessing efficacy of ultrasound guided supraclavicular block using PI.

II. Material And Methods

The present research is a prospective observational study based on primary data collected from target sample. The sample was selected based on some pre-defined exclusion and inclusion criteria. The criteria for conducting the study and sampling design have been presented in the subsequent section.

Study Design: Prospective observational study
Study Location: Narayana Medical College and Hospital, Nellore.
Study Duration: February 2018 to May 2018.
Sample size: 52 patients.
Sample size calculation: The patients who came in Narayana Medical College and Hospital, Nellore lying in the age group of 18 years and 65 years, ASA grade 1 and grade 2 physical status undergoing upper limb orthopaedic surgeries between February 2018 to May 2018, were included in the study after obtaining clearance from the college ethics committee.

Inclusion criteria:
1. Patients aged between 18-65 years.
2. ASA I-II
3. Scheduled for upper limb orthopaedic surgeries.

Exclusion criteria:
1. Patients under 18 years of age and over 65 years
2. Patients with local anesthetic allergy
3. Patients with injection site infection
4. Patients who do not accept / consent for the procedure.
5. Patients with altered coagulation profile.

Procedure methodology

After written informed consent was obtained from the ethical committee, the study was conducted. The procedure of research was initiated in the operating room with the arrival of patient. On arrival in the operating room, an 18G/20G cannula was secured in the opposite limb of the patient. Patients were monitored (PHILLIPS EFFACIA CM100) by three-lead ECG, automated non-invasive blood pressure, and pulse oximetry & vitals were recorded. Pulse oximeter was connected to both the thumbs and baseline perfusion index was recorded. The block was given in the supine position, with the head of the patient turned away from the side to be blocked.

The supraclavicular nerve block was performed under guidance of ultrasound linear transducer (8–14MHz; SONOSITE M TURBO) over the supraclavicular fossa in the coronal oblique plane immediately superior to the midclavicular point. The brachial plexus was identified as a compact group of nerves, hypo-echoic, round or oval, located lateral and superficial to the pulsatile subclavian artery and superior to the first rib. A 22-gauge insulated block needle was inserted in-plane (lateral to medial) to the ultrasound probe. A volume of 30 ml of local anesthetic (bupivacaine 0.5%, 15ml and lignocaine 2%, 15ml) was injected. The limb was evaluated for block success, both for the sensory block and for the motor block. Sensory function was assessed using pinprick in the dermatomal areas supplied by the four main nerves (median nerve, radial nerve, ulnar nerve, and musculocutaneous nerve). Motor block was assessed by the ability to flex the elbow and the hand against gravity. The block was considered successful when brachial plexus dermatomes (C5–T1) were completely blocked.

The PI was measured using pulse oximeter probe (Philips efficia CM10) applied on the thumb. The PI was recorded at baseline and at 10 minutes, 20 minutes and 30 minutes after injection in both blocked and non-blocked limbs. The PI ratio was calculated as the PI after 10 minutes divided by the PI at the baseline. In every patient, a comparison between the blocked and unblocked limb was performed.

Statistical analysis

Both categorical and continuous data was used in the study. The data was collected by observing the patient. For conducting the descriptive analysis, categorical data was analyzed using frequency analysis while continuous data was analyzed using mean analysis by presenting the standard deviation.

Further, predictive value analysis was conducted wherein positive predictive value (PPV) and negative predictive value (NPV) were calculated for both the PI at 10 minutes and PI ratio to understand the success of the block. Further, significance level has been considered to be 1% (p-value=0.001).

III. Result

The ultrasound-guided supraclavicular nerve block was provided to a total of 52 patients received. The gender wise distribution of the patients has been presented in Figure 2.

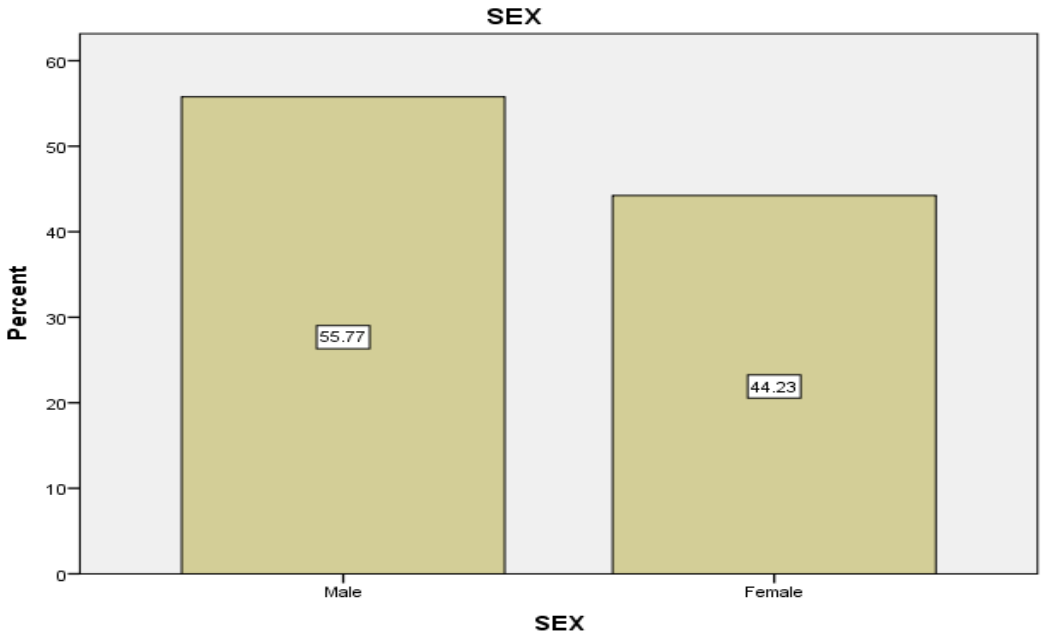

Figure 2: Gender-wise distribution of Patients

It can be observed in Figure 2 that number of male patients (55.77%) is more than number of female patients (44.23%). The descriptive results of the study have been presented in Table 1 discussing the age, Hemoglobin percentage (HB %) and duration of the surgery. It can be observed that male.

Table 1: Descriptive Analysis of Patient Characteristics

Descriptive Statistics	N	Mean	Std. Deviation	Minimum	Maximum
AGE	52	38.08	11.840	22	68
HB%	52	11.7308	1.3791	9.00	15.00
DURATION OF SURGERY	52	54.77	10.532	40	90

It can be observed from Table 1 that in the present research, the average HB% is 11.73% and average duration of surgeries was 54.77 minutes. Further, the average age of patients is 38.08 years. Thus, it can be stated that the patients considered in present research are usually middle aged. The graphical presentation of age wise distribution has been presented below-

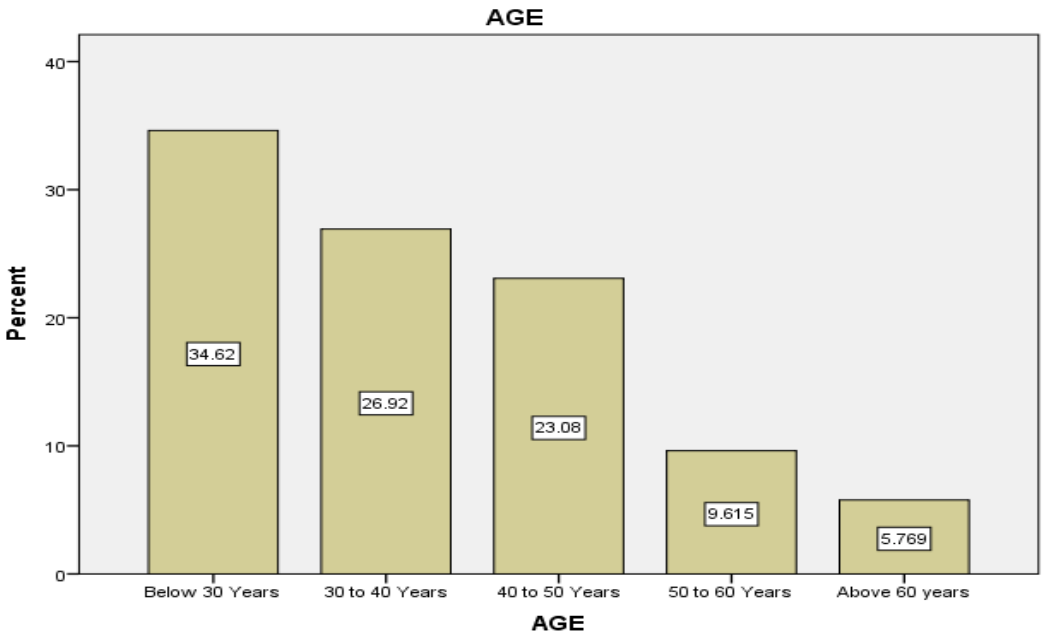

Figure 3: Age-wise distribution of Patients

It can be inferred from Figure 3 that a maximum number of patients that is 34.62% belong to age group of less than 30 while minimum number of patients that is 5.76% belongs to age group of above 60 years. Further, the age-wise gender distribution of patients has been presented in Table 2.

Table 2: Age-wise Gender Distribution of Patients

AGE	SEX				Total
	Male		Female		
	Number	Percentage	Number	Percentage	
Below 30 Years	11	37.93	7	30.43	18
30 to 40 Years	5	17.24	9	39.13	14
40 to 50 Years	8	27.59	4	17.39	12
50 to 60 Years	3	10.34	2	8.70	5
Above 60 years	2	6.90	1	4.35	3
Total	29	100	23	100	52

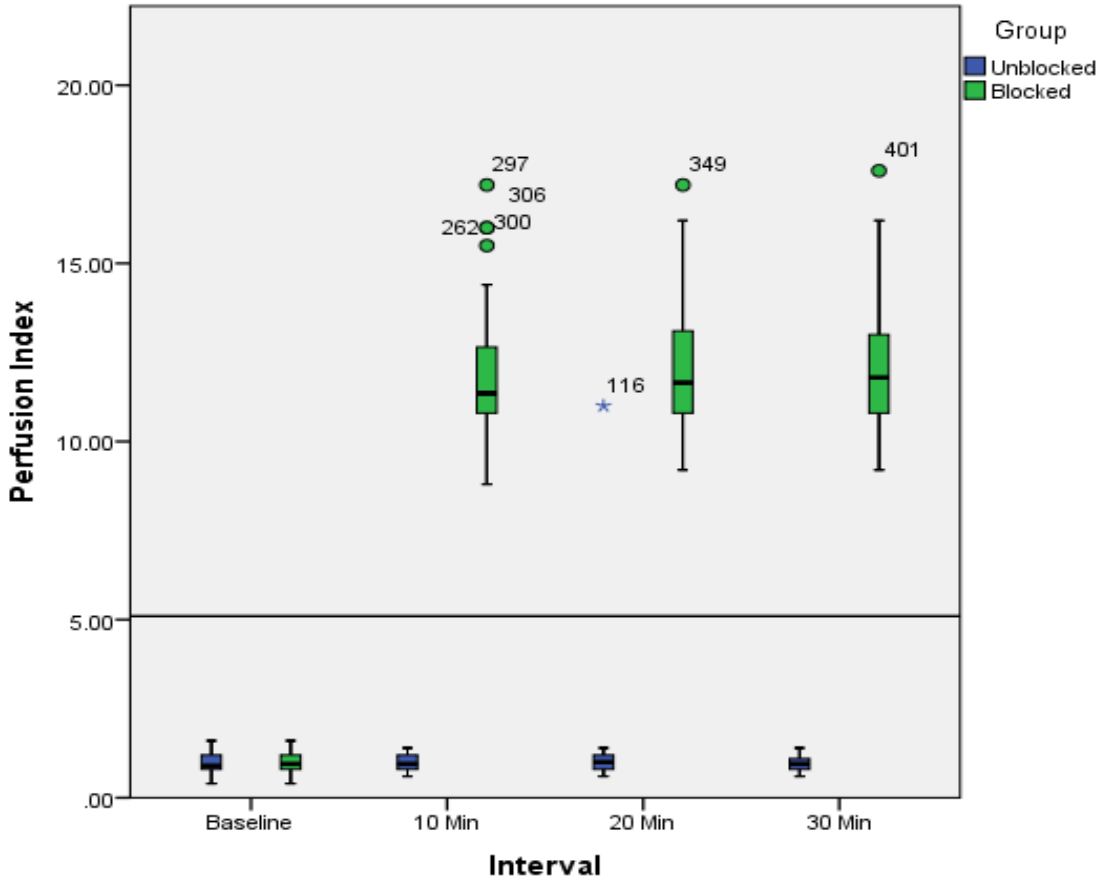

Figure 4: Perfusion index values at different time intervals in patients with blocked and unblocked limbs. A reference line at PI 5.0 is provided.
[PI=perfusion index, Boxes= Quartiles, Whiskers =Ranges, Horizontal Lines =Medians]

Table 3: Descriptive Analysis of PI

Perfusion Index	Parameters	Blocked	Unblocked	P-value
Baseline	Median (Range) (IQR)	0.950 (0.40-1.60) (0.800-1.200)	0.900 (0.40-1.60) (0.800-1.200)	0.725
	Mean (SD)	0.965 (0.275)	0.946 (0.279)	
10 Min	Median (Range) (IQR)	11.350 (8.80-17.20) (10.800-12.675)	0.950 (0.60-1.40) (0.800-1.200)	<0.001*
	Mean (SD)	11.809 (1.846)	0.990 (0.245)	
20 Min	Median (Range) (IQR)	11.650 (9.20-17.20) (10.800-13.150)	1.000 (0.60-11.00) (0.800-1.200)	<0.001*
	Mean (SD)	12.026 (1.842)	1.180 (1.407)	
30 Min	Median (Range) (IQR)	11.800 (9.20-17.60) (10.800-13.000)	0.950 (0.60-1.40) (0.800-1.100)	<0.001*
	Mean (SD)	12.044 (1.83)	0.978 (0.224)	
PI RATIO	Median (Range) (IQR)	12.550 (7.90-33.00) (10.150-14.000)	1.000 (0.88-1.50) (1.000-1.125)	<0.001*
	Mean (SD)	13.149 (4.371)	1.072 (0.146)	

It can be inferred from Table 3 that the baseline PI in blocked limb was as good as in unblocked limbs. The baseline value in blocked limb was found to be 0.950 (0.40-1.60) while that is unblocked limb was 0.900 (0.40-1.60) thereby registering a difference of only 0.050. But since the p- value of baseline was beyond the decided significance level (0.001<0.725) of the research, these results cannot be considered to be statistically significant.

The PI values for both blocked and unblocked limbs have been calculated at three intervals that is 10 minutes, 20 minutes, and 30 minutes. In the blocked limb, an increase in PI value was observed at all the three intervals, when compared with the baseline reading (Figure 4, Table 3). While, in the unblocked limb, though an increase was observed (when compared with baseline value) but the increase was very small in comparison to the PI values of blocked limb for all the three intervals.

Table 4: Receiver operating characteristics (ROC) for the ability of PI to detect the block success. [AUROC = Area under the Receiver Operating Characteristics Curve, NPV= negative predictive value, PPV= positive predictive value, PI= Perfusion Index]

Parameter	AUROC (95%CI)	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Cut-off Value
PI at 10min	1.0 (1.0-1.0)	100	100	100	100	>5.1
PI Ratio	1.0 (1.0-1.0)	100	100	100	100	>4.7

The AUROC value lies between 0 to 0.1 wherein 0 means that the test/ methodology predicted all the values wrong that is the actual success rate was predated to be a failure and failure rate to be success rate[24]. Table 4 presents the ROC for the ability of PI to detect the block success. 10 minutes was after the anesthetic injection was given to the patient, the AUROC curve for the PI value was 1 (0.95–1.00). Further, the cut-off value for this was found to be >5.1. The AUROC curve for the PI ratio was 1 (0.95–1.00), with a cut-off value >1. Further, both the PI and the PI ratio at 10 min after injection showed a sensitivity and specificity of 100% for block success at cut-off values of 5.1 and 4.7 respectively. Similarly, PPV and NPV also registered 100% block success each.

IV. Discussion

Phenomenon of vasodilation is an indicator of success of brachial plexus block[25]. A comparative upsurge in pulsatile flow in circumstances of vasodilation causes an increase in the PI. This then causes PI to measure peripheral perfusion. Owing to this fact, PI is being used in the present research to test the success of supraclavicular nerve block. Lima et al., (2002)[26] also used PI as an indicator of peripheral perfusion. Further, PI ratio has been used in the present research for accurate valuation of a cut-off value. This will then aid in the clinical use of the PI for assessment of the block.

A block was considered successful if after anaesthetic injection, the PI registered an increase in the blocked limb than in the unblocked limb at 10 minutes, 20 minutes, and 30 minutes. This scenario was observed in present research thereby pointing towards the success of block in the limb.

PI ratio is a determinant of amount of escalation in PI value with successful block[9]. PI ratio was calculated and was presented as the ratio between PI at 10 minutes and baseline PI in the present research. It was found to be higher in the blocked limb than in the unblocked limb (p-value<0.001) thereby, yet again, pointing towards success of the block. Thus, it can be stated that both the parameters that is PI at 10 minutes and corresponding PI ratio are a good indicators of success of block in the blocked limb.

The perfect value (1.0) of AROC for PI at 10 minutes and PI ratio states that the all the predictions about success of block at PI 10 minutes were correct. Similarly, the PPV of 100% (both for PI at 10 minutes and PI ratio) indicate that all predicted number of successful blocks actually turned out to be successful while NPV of 100% (both for PI at 10 minutes and PI ratio) indicate that the predicted number of unsuccessful blocks actually turned out to be unsuccessful. This means that PI and PI ratio are very accurate in assessing efficacy of ultrasound guided supraclavicular block. Finally, the outcome value of 100 for sensitivity and specificity (both for PI at 10 minutes and PI ratio) present PI at 10 minutes and PI ratio as perfect predictors of assessing efficacy of ultrasound guided supraclavicular block. This is because the value of 100 for sensitivity indicate that all the successful blocks were correctly identified as successful and a value of 100 for specificity indicate that none of the successful blocks were incorrectly identified as unsuccessful. Similar results were presented by Abdelnasser et al., 2017 [9] who also tested the use of PI to predict and provide a cut-off value for ultrasound-guided supraclavicular nerve block success and reported higher PI in the blocked limb at all three-time intervals along with higher PI ratio when compared with the unblocked limb. Further, after injection, the PI and the PI ratio at 10 minutes showed a sensitivity and specificity of 100% for block success at cut-off values of 3.3 and 1.4, respectively as was registered in the present research. Thus, it can be stated that this study is in sync with the findings of the present research.

V. Conclusion

The present study found that both the PI and the PI ratio at 10 min after injection showed a sensitivity and specificity of 100% for block success at cut-off values of 5.1 and 4.7 respectively. It was further observed and proved in the study that PI provides an earlier, more objective, and more sensitive indicator to assess the onset of supraclavicular brachial plexus block. Thus, it can be stated that the PI is a suitable tool for assessment of successful supraclavicular nerve block. This result may inspire anesthesiologists to use PI to assess the efficacy of supraclavicular brachial plexus block instead of pinching, pinpricking, and other time consuming methods requiring patient consent.

The present study had some limitation of the values to be recorded at relatively longer period of time that is 10 minutes. Thus, it is recommended for the future studies to record the values at relatively shorter time

periods while testing the correlation between PI and success of block so as to get more accurate the efficient results.

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