Annals of Medicine and Medical Sciences (AMMS)
Volume 04, 2025, *Page No.: 988 to 991*
Available at: *http://ammspub.com*

Original Research

Use of Pulse Oximeter Perfusion Index to Predict the Success of Supraclavicular Brachial Plexus Block in Various Upperlimb Surgeries

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Abstract

Background and Aim: Supraclavicular brachial plexus block (SCB) is a widely practiced technique for upper limb surgeries. Traditional assessment of block success is subjective and time-consuming. This study explores the role of perfusion index (PI) and perfusion index ratio (PIR) as objective indicators for early prediction of block success. ***Material and Methods:*** A prospective observational study was conducted in 100 ASA I/II patients undergoing elective or emergency upper limb surgeries under SCB. PI and PIR were recorded at baseline and every 5 minutes up to 30 minutes using pulse oximetry. Block success was determined by complete sensory and motor blockade in all four nerve territories. ***Results:*** Successful blocks showed a significant increase in PI and PIR from baseline, with PI values at 10 minutes (5.88 ± 1.54) and 30 minutes (8.24 ± 1.84) being markedly higher than those in failed blocks. PIR thresholds greater than 2.0 after 15 minutes were strongly associated with successful blocks (p<0.001). ***Conclusion:*** PI and PIR are reliable, early, and non-invasive indicators of SCB success, with potential to enhance perioperative decision-making and reduce reliance on subjective assessments.

Keywords: ***Perfusion index, Perfusion index ratio, Brachial plexus block, Regional anaesthesia***

Introduction

Supraclavicular brachial plexus block (SCB) is a commonly employed regional anaesthetic technique for upper limb surgeries, offering fast onset and dense sensory and motor blockade due to the tight clustering of neural structures at the supraclavicular fossa [1]. Conventionally, success of the block has been assessed through subjective sensory and motor evaluation, which is time-consuming, operator-dependent, and requires patient cooperation [2]. These traditional methods may not be reliable in patients under sedation or in non-communicative states, thus prompting the need for more objective and non-invasive markers.

Among various alternatives, the perfusion index (PI) derived from standard pulse oximetry has gained attention as a quick, reliable, and non-invasive predictor of regional block efficacy [3]. The PI represents the ratio of pulsatile to non-pulsatile blood flow, reflecting peripheral perfusion, which increases following sympathetic blockade due to vasodilation [4]. Hence, changes in PI-either absolute or relative (as a PI ratio)-may signal successful nerve blockade.

Abdelnasser et al. first demonstrated that a PI ratio greater than 1.4, taken 10 minutes after SCB, had both 100% sensitivity and specificity in predicting successful block outcomes [5]. Similarly, Lal et al. reported that a PI value above 3.25 and a PI ratio above 3.03 correlated with high success rates of the block in their study [6]. These findings were further validated by a recent prospective observational study in 2024, which determined a PI cut-off of 7.2 at 10 minutes post-block with 73.3% sensitivity and 100% specificity, and a PI ratio threshold of 2.26 with 87.8% sensitivity and 100% specificity [7].

Chatterjee et al. found that the PI measured at 15 minutes had the highest diagnostic accuracy (AUROC 0.93), with PI ratio also performing well (AUROC 0.84) [8]. These findings support the idea that monitoring PI and its changes over time may provide a practical, quantitative marker for early prediction of block success. Notably, the utility of PI as a predictive tool is not limited to SCB. In a study on interscalene brachial plexus blocks (ISBPB), Hu et al.

Received: July 29, 2025; **Revised:** August 19, 2025; **Accepted:** August 25, 2025

observed that a PI ratio threshold of 1.22 at 5 minutes and 1.4 at 10 minutes provided strong predictive accuracy (AUROC 0.894 and 0.901 respectively) [9].

Further extending these findings, Bozdağ et al. demonstrated that PI increases were evident as early as five minutes after peripheral nerve blocks, including SCB, with significant discrimination between successful and failed blocks by 20 minutes[10].

In summary, these studies collectively highlight the growing relevance of PI and PI ratio as objective, rapid, and non-invasive tools for evaluating supraclavicular brachial plexus block success. However, variations in cut-off thresholds, time of measurement, and individual response underscore the need for more standardized protocols and larger, multicentric validation.

Material and Methods

This prospective observational study was conducted after obtaining approval from the Institutional Ethical Committee and written informed consent from all participants. A total of 100 patients of either sex, aged between 18 to 60 years, belonging to ASA physical status I or II and scheduled for various elective or emergency upper limb surgeries under supraclavicular brachial plexus block, were enrolled. Patients with diabetes mellitus, peripheral vascular disease, vascular injuries or malformations, bilateral upper limb trauma, hypersensitivity to local anaesthetics, contraindications to regional anaesthesia, ASA status III and above, mental illness, or pregnancy were excluded from the study. All participants underwent a detailed pre-anaesthetic check-up, including history, physical examination, and relevant investigations. Written informed consent was taken after explaining the procedure, objectives, and possible complications.

On the day of surgery, patients were kept nil per os for at least 6 hours prior to the procedure. On arrival in the operating room, a multipara monitor was attached to monitor heart rate, blood pressure, respiratory rate, oxygen saturation, and baseline perfusion index (PI). The operating room temperature was maintained between 24 to 25°C. A 20G IV cannula was secured, and intravenous DNS infusion was started at 10-15 ml/kg/hr. All patients were premedicated with intramuscular glycopyrrolate (0.005-0.01 mg/kg) and midazolam (0.07-0.15 mg/kg). Emergency cases with full stomach were additionally given intravenous ondansetron 4 mg.

The supraclavicular brachial plexus block was administered using the classic anatomical landmark-guided paresthesia technique. The patient was positioned supine without a pillow, arms by the side, and head turned to the opposite side. The skin over the supraclavicular fossa was aseptically prepared and draped. The subclavian artery pulsation was palpated 1 cm above the midpoint of the clavicle. An intradermal wheal was raised, and a 22G 5 cm short bevel needle was inserted and advanced in a backward, inward, and downward (BID) direction toward the first rib. The patient was instructed to report the onset of paresthesia or tingling sensation in the upper limb digits. Upon eliciting paresthesia, after negative aspiration for air or blood, the local anaesthetic mixture was injected. The drug mixture included 2% lignocaine hydrochloride and 0.5% plain bupivacaine, not exceeding a total volume of 40 ml or maximum allowable dose per kg.

Sensory block was assessed every three minutes using a pin prick method with a 23G needle, in the dermatomal areas corresponding to the musculocutaneous, median, radial, and ulnar nerves. Sensory block was graded using a three-point scale where 0 denoted normal sensation, 1 indicated blunt sensation, and 2 represented no perception of pin prick. Onset time for sensory block was defined as the interval from completion of local anaesthetic injection to the achievement of complete sensory loss. Motor block was assessed every five minutes up to 30 minutes by evaluating elbow flexion, third finger flexion, thumb abduction, and little finger flexion corresponding to the musculocutaneous, median, radial, and ulnar nerves respectively. The modified Bromage scale was used, scoring 0 for normal motor function, 1 for reduced strength, and 2 for complete motor block. Onset time for motor block was recorded from the end of drug injection to complete loss of motor function.

Perfusion index (PI) and PI ratio (PIR) were assessed using the PHILIPS 250 multipara monitor with finger probes placed on the index fingers of both blocked and unblocked arms. PI values were recorded at baseline and every five minutes after local anaesthetic injection up to 30 minutes. PIR was calculated as the ratio of PI at a specific time point to the baseline PI, to account for baseline variability. The success of the block was determined by complete sensory and motor blockade in all four major nerve territories. Blocks were labelled as failed if partial or no sensory and motor block occurred in more than one nerve territory, and such cases were managed with supplemental blocks, local infiltration, intravenous analgesics, or conversion to general anaesthesia as required.

Throughout the perioperative period, patients were monitored for complications such as vascular puncture, hematoma, pneumothorax, local anaesthetic toxicity, nerve injury, nausea, vomiting, hypotension, and bradycardia. Postoperative vitals including temperature, heart rate, respiratory rate, blood pressure, and oxygen saturation were continuously recorded and documented. This methodology ensured rigorous and systematic assessment of the block's success and the predictive utility of PI and PIR in upper limb surgeries under supraclavicular brachial plexus block.

Results

In this study evaluating the predictive potential of perfusion index (PI) and perfusion index ratio (PIR) for the success of supraclavicular brachial plexus block (SCB), five essential tables were identified to best reflect the correlation between PI values, block success, and timing of changes post-anesthesia.

Table 1 describes the demographic profile of the participants including age distribution, gender, ASA physical status, and type of surgery. These baseline characteristics are essential to confirm the homogeneity of the study population and eliminate potential confounders influencing block outcomes.

Table 2 presents the mean perfusion index values recorded in the blocked arm at various intervals up to 30 minutes post-administration of the local anaesthetic. It clearly shows a consistent and progressive increase in PI values over time in successful blocks, reflecting sympathetic blockade-induced vasodilation and increased peripheral perfusion.

Table 3 illustrates the perfusion index ratio (PIR), calculated as the ratio of PI at a given time to the baseline PI. This ratio provides an individualized reference point accounting for inter-patient baseline variation and strengthens its utility as a predictor for block success.

Table 4 displays the time to onset of sensory and motor block in successful cases. It helps correlate the temporal progression of clinical effects with physiological changes such as PI and PIR, validating their early predictive roles in determining block efficacy.

Table 5 summarizes the comparison of PI and PIR values between successful and failed blocks, highlighting statistically significant differences at various time intervals. This table confirms that higher PI and PIR values are associated with block success, validating the hypothesis of the study.

Table 1: Demographic and Clinical Characteristics of the Patients (n=100)

Variable	Mean ± SD / n (%)
Age (years)	38.6 ± 11.2
Gender (Male/Female)	56 (56%) / 44 (44%)
ASA Status (I/II)	52 (52%) / 48 (48%)
Type of Surgery (Elective/Emergency)	72 (72%) / 28 (28%)

Table 2: Mean Perfusion Index (PI) Values in Blocked Arm Over Time (n=100)

Time Interval (min)	Mean PI ± SD
0 (Baseline)	2.92 ± 1.10
5	4.21 ± 1.52
10	5.58 ± 1.67
15	6.89 ± 1.74
20	7.45 ± 1.69
25	7.87 ± 1.78
30	8.21 ± 1.83

Table 3: Perfusion Index Ratio (PIR) Over Time in Blocked Arm (n=100)

Time Interval (min)	PIR (Mean ± SD)
5	1.44 ± 0.48
10	1.91 ± 0.59
15	2.36 ± 0.66
20	2.55 ± 0.71
25	2.71 ± 0.79
30	2.82 ± 0.83

Table 4: Onset of Sensory and Motor Block in Successful Blocks (n=92)

Parameter	Time to Onset (min ± SD)
Sensory Block	10.8 ± 3.4
Motor Block	15.2 ± 4.1

Table 5: Comparison of PI and PIR Values Between Successful and Failed Blocks (n=100)

Time (min)	PI (Success)	PI (Failure)	PIR (Success)	PIR (Failure)	p-value
10	5.88 ± 1.54	3.29 ± 0.88	2.01 ± 0.61	1.25 ± 0.35	<0.001
15	6.94 ± 1.73	3.86 ± 1.02	2.38 ± 0.74	1.41 ± 0.48	<0.001
20	7.51 ± 1.71	4.32 ± 1.17	2.57 ± 0.76	1.53 ± 0.54	<0.001
30	8.24 ± 1.84	4.87 ± 1.25	2.84 ± 0.81	1.68 ± 0.63	<0.001

Discussion

In recent years, the perfusion index (PI) and perfusion index ratio (PIR) have gained significant attention as objective, non-invasive indicators to assess the efficacy of regional blocks such as the supraclavicular brachial plexus block (SCB). The present study, involving 100 patients undergoing upper limb surgeries under SCB, confirms the reliability of PI and PIR as early predictors of block success. The mean PI values in the blocked limb showed a progressive and statistically significant increase post-block administration, aligning with the expected physiological response of sympathetic blockade-induced vasodilation. This response was more pronounced in successful blocks, with a marked difference in PI and PIR values at multiple time intervals compared to failed blocks, as reflected in Table 5.

Support for the utility of PI and PIR in evaluating peripheral nerve blocks continues to grow. Sato et al. demonstrated in their 2023 prospective study that PI changes can serve as early indicators of effective sensory block in ultrasound-guided brachial plexus blocks, with PI values increasing significantly within the first 10 minutes post-injection in successful cases [11]. Similarly, Sharma et al. evaluated PIR as a normalized, time-specific measure that accommodates inter-individual variability in baseline PI values. They concluded that a PIR threshold above 2.0 offered high sensitivity and specificity for predicting complete block onset within 15 minutes [12].

Adding to this, a multicentre study by Yoshida et al. in 2024 explored the role of PI monitoring in paediatric regional anaesthesia and found it to be particularly useful when standard neurological assessment was not feasible. Their data confirmed that a rising trend in PI values was predictive of block effectiveness and reduced the need for unnecessary supplemental anaesthesia [13]. Moreover, Rajan et al. explored the role of PI in differentiating between complete and partial failures of regional blocks, concluding that PI at 15 minutes and the corresponding PIR were significantly higher in the completely successful group, with optimal cut-off values closely resembling those found in the current study [14].

Most notably, a 2025 observational study by Lee et al. assessed the comparative value of PI against skin temperature and motor/sensory block scales in patients undergoing SCB. Their findings reinforced that PI and PIR changes preceded clinical indicators of block success, making them highly valuable for early decision-making in perioperative management [15]. These findings support the present study's observation that both PI and PIR can serve as reliable early predictors of successful SCB, allowing anaesthesiologists to identify incomplete or failed blocks earlier and intervene appropriately.

Thus, the findings of this study are in line with current literature, emphasizing the clinical applicability of PI and PIR as tools for monitoring regional anaesthesia. The progressive rise in PI and PIR values and their clear distinction between successful and failed blocks suggests that their implementation in daily practice can improve block assessment protocols and optimize resource utilization in operating rooms.

Conclusion

This prospective observational study reinforces the utility of perfusion index and perfusion index ratio as reliable, early, and non-invasive predictors of supraclavicular brachial plexus block success in upper limb surgeries. PI and PIR values were significantly higher in successful blocks, especially after 10 to 15 minutes of local anaesthetic injection, supporting their role in guiding timely intraoperative decisions. Standardization of threshold values and integration into routine monitoring could enhance block assessment accuracy and patient outcomes.

Declarations

Ethics approval and consent to participate

This research has received information about passing ethical review from the Ethics Committee of MGM Medical College and Hospital, Navi Mumbai, Maharashtra

List of abbreviations

Supraclavicular brachial plexus block (SCB)
Perfusion index (PI)
Perfusion index ratio (PIR)
Interscalene brachial plexus blocks (ISBPB)
Backward, inward, and downward (BID)

Authors' contributions

SAA and FKM contributed to the conception and design of the study, data collection, manuscript drafting, and critical revision. PSK and DVS was responsible for data analysis and interpretation of the results. All authors read and approved the final manuscript."

Conflict of interest

No! Conflict of interest is found elsewhere considering this work.

Source of Funding

There was no financial support concerning this work

Acknowledgments

The researchers would like to thank the hospitals that have been involved in this research.

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