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PULSE OXIMETRY PERFUSION INDEX VERSUS PERFUSION INDEX RATIO, BETTER TOOL FOR EVALUATION OF ULTRASONOGRAPHY GUIDED SUPRACLAVICULAR BRACHIAL BLOCK SUCCESS: A COMPARATIVE STUDY

Anaesthesiology

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ABSTRACT

Background: The supraclavicular brachial plexus block (SC-BPB) is a widely used regional anesthesia technique for upper limb surgeries. Traditional methods of evaluating SC-BPB success rely on subjective assessments, which can be challenging in non-cooperative patients. This study aimed to compare the efficacy of pulse oximeter-derived perfusion index (PI) and PI ratio as objective indicators for assessing ultrasound-guided SC-BPB success. **Methods:** This prospective observational study was conducted in a tertiary care hospital, including 80 patients aged 20-60 years, classified as ASA-PS Grade I or II, undergoing elective upper limb surgery. Patients received SC-BPB with 0.5% Bupivacaine and 2% Lignocaine under ultrasound guidance. PI and PI ratio were measured at baseline, 5, 10, 15, 20, and 30 minutes post-block. Statistical analyses included t-tests and ROC curve analysis. **Results:** Significant increases in PI values were observed in the blocked arm compared to the unblocked arm, demonstrating effective perfusion changes. ROC analysis indicated high diagnostic accuracy for PI and PI ratio, with cut-offs showing strong sensitivity and specificity for block success. **Conclusion:** The study concluded that PI and PI ratio are reliable, non-invasive measures for evaluating SC-BPB success, offering improved accuracy over traditional methods. These findings support the use of PI-based assessment in clinical anesthesia to enhance block evaluation.

KEYWORDS

Brachial Plexus Block, Perfusion Index, Regional Anesthesia, Ultrasound Guidance, Peripheral Nerve Block

INTRODUCTION

The supraclavicular brachial plexus block (SC-BPB) is a popular regional anesthesia technique for upper limb surgeries, offering effective pain management and a preferable alternative to general anesthesia.[1,2] It provides numerous benefits, including excellent intraoperative analgesia, stable hemodynamics, and reduced postoperative complications.[3] Traditional methods for administering SC-BPB, however, often rely on a "blind" technique, which carries risks such as pneumothorax, vascular punctures, and nerve injuries.[4,5] With advancements in medical imaging, ultrasound-guided SC-BPB has become the standard approach, allowing for precise visualization of nerves and surrounding structures, thereby minimizing complications and enhancing block success.[6,7]

Evaluating the effectiveness of a brachial plexus block can be challenging, especially in sedated or unconscious patients. Traditional methods rely on assessing motor and sensory responses, which can be subjective, time-consuming, and impractical.[8,9] Recent developments have introduced objective techniques, including the use of pulse oximetry to measure the perfusion index (PI). The PI provides a non-invasive, real-time measure of blood flow in peripheral tissues, reflecting the physiological changes associated with successful nerve blocks.[10] More specifically, the perfusion index ratio (PI ratio) has been explored as a potential tool for evaluating the degree of sympathetic blockade, based on blood flow changes between pre- and post-block conditions.

This study aimed to compare the pulse oximetry perfusion index with the perfusion index ratio in assessing the success of ultrasound-guided SC-BPB. By evaluating the two metrics side by side, it seeks to identify which measure offers greater reliability, ease of use, and accuracy in determining block effectiveness. Establishing a superior tool between the PI and PI ratios is intended to refine clinical practice and enable anesthesia providers to assess SC-BPB success with greater confidence and precision. Ultimately, this comparative study strives to enhance pain management in upper limb surgeries, supporting patient safety and optimizing outcomes in regional anesthesia.

MATERIAL AND METHODS

Study Design and Setting

This prospective observational study was conducted from August 1, 2022, to March 1, 2024, in the Department of Anaesthesiology and Critical Care Medicine at Heritage Institute of Medical Sciences, Varanasi, Uttar Pradesh.

Participants and Criteria

The study included patients aged 20–60 years, weighing between 50–90 kg, and classified as ASA-PS grade I or II, scheduled for elective below-elbow upper limb surgery under ultrasound-guided supraclavicular brachial plexus block (SC-BPB). Exclusion criteria included refusal to consent, diabetic neuropathy, upper limb ischemia, peripheral vascular disease, coagulopathy, ASA-PS grade III and IV, and skin infection at the block site. Convenient sampling was employed, with a sample size of 80 patients.

Procedure

Upon arrival in the operating room, each patient was connected to continuous monitoring (5-lead ECG, pulse oximetry, and non-invasive blood pressure) recorded every 5 minutes. The SC-BPB was administered with a 22-gauge, 5-cm insulated needle under ultrasound guidance. A total of 25 ml of 0.5% Bupivacaine and 2% Lignocaine with Adrenaline (equal volumes) was injected around the brachial plexus. The patient's sensory and motor blocks were assessed periodically, with PI evaluated at baseline, 5, 10, 15, 20, and 30 minutes. Successful blocks showed complete sensory and motor block of brachial plexus dermatomes (C5-T1). General anesthesia was administered if the block was incomplete.

Data Collection and Analysis

All patients provided informed consent, and the study received ethical approval. Data were entered into Microsoft Excel and analyzed using IBM SPSS (version 22). Categorical data were reported as numbers and percentages, while continuous data were presented as mean ± SD or median with interquartile range, depending on distribution. Analytical statistics included the Student's t-test for quantitative data and the chi-square test for qualitative data. A p-value of <0.05 was considered statistically significant.

RESULTS

Table 1 presents patient demographics and anthropometric measurements. Most patients were aged 31 to 40 years, with a mean age of 41.3 years. The majority (63.75%) were male, and 72.25% were classified as ASA-PS Grade II. Average BMI was 24.72 Kg/m², indicating an overall balanced distribution

Variable	Category	Number	Percentage (%)	Mean	SD
Age Group (years)	20 to 30	12	15.0		
	31 to 40	22	27.5		
	41 to 50	28	35.0		
	51 to 60	18	22.5		
	Total	80	100.0	41.3	8.4
Gender	Male	51	63.75		
	Female	29	36.25		
	Total	80	100.0		
ASA-PS Grade	Grade I	23	28.75		
	Grade II	57	72.25		
	Total	80	100.0		
Anthropometric Variables	Weight (Kg)			79.2	5.3
	Height (m)			1.79	0.8
	BMI (Kg/m²)			24.72	3.9

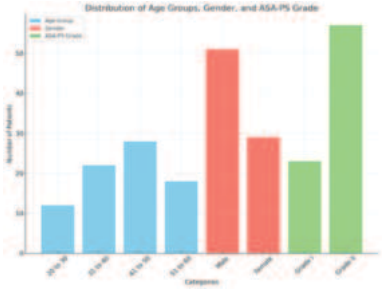


Table 2 compares the onset and duration of sensory and motor blocks. Sensory blocks have a slightly shorter onset time than motor blocks, with a longer duration, indicating sustained anesthesia effectiveness for sensory response.

Block Type	Onset (min)		Duration (hours)	
	Mean	SD	Mean	SD
Sensory Block	7.9	1.5	10.3	2.6
Motor Block	8.1	1.9	9.1	2.3

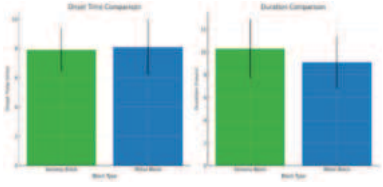


Table 3 compares perfusion index (PI) values and PI ratios between blocked and unblocked arms at multiple time intervals. PI values in the blocked arm significantly increased over time compared to the unblocked arm, showing the block's effectiveness in enhancing perfusion.

Time (min)	PI (Blocked Arm)	SD (Blocked Arm)	PI (Unblocked Arm)	SD (Unblocked Arm)	p-value
0	2.5	0.8	2.7	0.5	0.980
5	3.8	0.9	2.6	0.5	0.001*
10	6.8	1.6	2.6	0.5	0.000*
20	9.9	2.1	2.6	0.5	0.002*
30	13.8	2.9	2.6	0.5	0.000*
PI Ratio					
Overall	2.8	0.8	1.1	0.1	0.000*

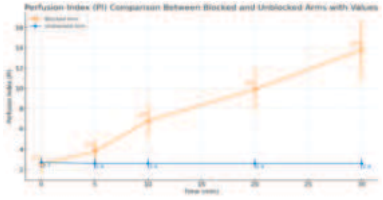
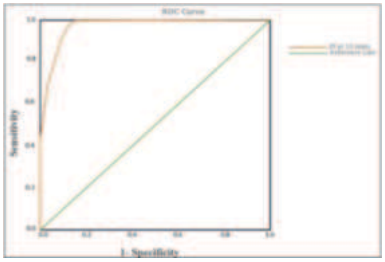
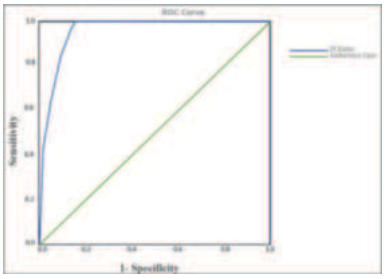


Table 4 presents the ROC analysis results for perfusion index (PI) and PI ratio at a 10-minute interval, with calculated sensitivity and specificity for each variable's optimal cut-off. Both PI and PI ratio demonstrate high diagnostic accuracy, indicating their effectiveness in predicting successful block outcomes.

Variable	Area under ROC Curve	95% Confidence Interval	Cut-off Value	Sensitivity (%)	Specificity (%)	p-value
PI	0.938	-	3.3	90.4	97.3	0.000
PI Ratio	0.890	-	1.4	92.3	98.7	0.000





DISCUSSION

The study evaluates the effectiveness of ultrasound-guided supraclavicular brachial plexus block (SC-BPB) for upper extremity surgeries by assessing the utility of the perfusion index (PI) and PI ratio. Traditional methods for evaluating block success, like the pin-prick test and Modified Bromage Scale, depend on subjective assessments, whereas PI, which measures the ratio of pulsatile to non-pulsatile blood flow, offers a more objective and reliable measure. PI reflects physiological changes due to sympathetic blockade and is indicative of vasodilation, a hallmark of successful SC-BPB.

In this study, 35% of patients were aged 31 to 40, with a mean age of 41.3 years. The majority were male (63.75%), and 72.25% were classified as ASA-PS Grade II. The average BMI was 24.72 kg/m², indicating a relatively balanced and healthy population.

Avcı O et al. [11] found similar patient demographics in their study, with a mean age of 43.67 years and a predominantly male population (60%). Veena et al. [12] reported a comparable mean age of 39.28 years and a slightly lower male proportion at 56.84%. Abdelnasser A et al. [13] reported a mean age of 34.9 years, and in Reddy et al.'s study, the average age was 37.98 years, with males comprising 75% of participants. In anthropometric data, Veena et al. [12] observed a mean weight and height of 61.8 kg and 1.63 m, respectively, while Abdelnasser et al. [13] noted a mean BMI of 23.7 kg/m², closely aligning with this study's values.

The onset of sensory and motor blocks in this study averaged 7.9 and 8.1 minutes, respectively, with sensory blocks lasting 10.3 hours and motor blocks 9.1 hours. In a study by Avcı O et al.[11], sensory block onset and duration were similar, at 8.83 minutes and 8.51 hours. Motor block onset was faster in Avcı's study (6.7 minutes), with a duration of 7.46 hours, highlighting SC-BPB's effectiveness in providing extended anesthesia.

This study observed a significant increase in PI over time in the blocked arm, with values reaching 13.8 by 30 minutes, while PI in the unblocked arm remained stable around 2.6. These results mirror Veena et al.'s[12] findings, where PI values significantly increased post-block, peaking at 10, 15, and 20 minutes in the blocked arm. Reddy et al.[14] also reported elevated PI values at each interval, consistent with the current study, while Sebastiani et al. confirmed that PI was a reliable marker for block success. Abdelnasser A et al.[13] observed similar trends, noting that PI and PI ratio were both significantly higher

in the blocked arm, supporting the use of PI for evaluating SC-BPB success.

The mean PI ratio in the blocked arm was 2.8, significantly higher than the unblocked arm's 1.1. Veena et al.[12] reported a PI ratio difference of 3.7 versus 1.04 between the blocked and unblocked arms. Abdelnasser A et al.[13] and Reddy et al.[14] also observed increased PI ratios in the blocked arm, with values of 2.4 and 2.64, respectively, reinforcing that PI ratio is an effective measure for block success due to its correlation with vasodilation and blood flow changes.

In this study, the ROC curve analysis for PI at 10 minutes showed an AUROC of 0.938 with a 3.3 cut-off, providing 90.4% sensitivity and 97.3% specificity. The PI ratio had an AUROC of 0.890 with a 1.4 cut-off, offering 92.3% sensitivity and 98.7% specificity. Abdelnasser et al.[13] also found high predictive accuracy, with an AUROC of 1 at a 3.3 cut-off for PI, highlighting PI's reliability as an indicator of SC-BPB success. Galvin et al.[15] observed a PI increase by 1.55 as a predictor of block success, aligning with our cut-off for PI ratio, while Kim et al.[16] and Narasimhan MK et al.[17] further supported PI's utility with high sensitivity and specificity.

Supporting this study's findings, other research has shown PI's broader application beyond SC-BPB. Klodell CT et al.[18] demonstrated PI's sensitivity in identifying successful thoracic sympathectomy through significant PI increases, while Sahin OF et al.[19] validated PI's role in assessing stellate ganglion block efficacy in treating Raynaud's disease. These studies, alongside current findings, confirm PI's value as an objective, reliable tool for evaluating nerve block success across various clinical applications.

Recommendations and Limitations

Future studies should consider larger and more diverse patient populations to validate these findings across broader demographics. Incorporating additional objective measures alongside PI and PI ratio may further refine block success assessments.

This study was limited by its sample size and specific patient demographics, which may affect the generalizability of the results. Additionally, relying primarily on PI and PI ratio may overlook other physiological factors impacting block efficacy.

CONCLUSION

The study demonstrated that ultrasound-guided supraclavicular brachial plexus block (SC-BPB) was effective for upper extremity surgeries, with perfusion index (PI) and PI ratio enhancing assessment accuracy. Sensory blocks showed a shorter onset and longer duration than motor blocks, supporting their use in prolonged anesthesia. Increased PI values in the blocked arm confirmed effective perfusion and sympathetic blockade, with ROC analysis affirming PI and PI ratio as reliable, non-invasive indicators of block success in clinical anesthesia.

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Consent: Written consent from participants has been obtained and preserved.
Ethical Approval: Ethical approval was obtained and documented as per institutional guidelines.

REFERENCES

1. Maga JM, Cooper L, Gebhard RE. Outpatient regional anesthesia for upper extremity surgery update (2005 to present) distal to shoulder. Int Anesthesiol Clin. 2012;50:47-55.
2. Honnannavar KA, Mudakanagoudar MS. Comparison between Conventional and USG-Guided SC-BPB in Upper Limb Surgeries. Anesth Essays Res. 2017;11(2):467-71.
3. Brull R, Wijayatilake DS, Perlas A, et al. Practice patterns related to block selection, nerve localization and risk disclosure: a survey of the American Society of Regional Anesthesia and Pain Medicine. Reg Anesth Pain Med. 2008;33:395-403.
4. Neal JM, Gerancher JC, Hebl JR, Ilfeld BM, et al. Upper extremity regional anesthesia: essentials of our current understanding, 2008. Reg Anesth Pain Med. 2009;34(2):134-70.
5. Beach ML, Sites BD, Gallagher JD. Use of a nerve stimulator does not improve the efficacy of USG-guided supraclavicular nerve blocks. J Clin Anesth. 2006;18:580-4.
6. Delvi MB. USG-guided SC-BPB in patient with halo device. Saudi J Anaesth. 2010;4(1):20-2.
7. Mandala VK, Mendu SB, Bollaboina SKY, Kotha R Sr. Role of PI and Pulse Variability Index in the Assessment of Neonatal Hemodynamics: A Systematic Review. Cureus. 2023;15(10).
8. Sahin OF, Kilic ET, Aksoy Y, Kaydu A, et al. The importance of PI monitoring in evaluating the efficacy of stellate ganglion blockage treatment in Reynaud's disease. Libyan J Med. 2018;13(1):1422666.
9. Pramana IMD, Pradhana AP. SC-BPB Guided by USG in Pediatric Patient: A Case Report. Bioscientia Medicina. 2023;3827-3831.
10. Polcaro L, Charlick M, Daly DT. Anatomy, Head and Neck: Brachial Plexus. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2024. Available from: https://www.ncbi.nlm.nih.gov/books/NBK531473/
11. Avci O, Gündoğdu O. Evaluation of USG guided supraclavicular block with traditional methods and PI on upper extremity surgeries. Van Tip Derg. 2020;27:38-44.
12. Veena, Karthik SL, Vishwanath Ankad. Pulse Oximeter PI as a Predictor of Successful SC-BPB. Thieme IJRSMS. 2022;8:18-21.
13. Abdelnasser A, Abdelhamid B, Elsonbaty A, Hasanin A, et al. Predicting successful SC-BPB using pulse oximeter PI. Br J Anaesth. 2017;119(2):276-80.
14. Reddy NG, Sekar RG, Prathyusha K, Neha D, et al. Predicting successful SC-BPB using PI. J Cardiovasc Dis Res. 2024;15(1):1-7.
15. Galvin EM, Niehof S, Verbrugge SJ, et al. Peripheral flow index is a reliable and early indicator of regional block success. Anesth Analg. 2006;103:239-43.
16. Kim D, Jeong JS, Park MJ, et al. The effect of epinephrine on the PI during USG-guided SC-BPB: a randomized controlled trial. Sci Rep. 2020;10:11585.
17. Narasimhan MK, Kumaran NP, Vaidyanathan B. To predict the success of SC-BPB using pulse oximeter PI - a prospective observational study. Int J Acad Med Pharm. 2023;5(4):1559-63.
18. Klodell CT, Lobato EB, Willert JL, Gravenstein N. Oximetry-Derived PI for Intraoperative Identification of Successful Thoracic Sympathectomy. Ann Thorac Surg. 2005;80:467-70.