

Original Research Article

Pulse Oximeter Perfusion Index as an Early Predictor of Successful Ultrasound-Guided Axillary Brachial Plexus Block: A Prospective Observational Study

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ABSTRACT

Background: Objective assessment of ultrasound-guided axillary brachial plexus block (AXB) success is challenging due to the subjective nature of conventional sensory and motor evaluations. The perfusion index (PI), a non-invasive marker derived from pulse oximetry, may provide an early, objective indicator of block efficacy.

Methods: This prospective study included 30 adult patients (ASA I-II) undergoing upper limb surgery with ultrasound-guided AXB. PI measurements were taken on the middle finger of the blocked arm at baseline, every 2 minutes up to 10 minutes, and every 5 minutes up to 30 minutes post-block. PI ratio was calculated as PI at 10 minutes divided by baseline PI. Sensory and motor blocks were evaluated at 5-minute intervals for 30 minutes. Statistical analysis used ROC curve assessment to determine optimal PI cut-off values for predicting block success.

Results: Successful AXB was achieved in the majority of patients. PI values significantly increased from baseline as early as 5 minutes post-block in successful cases ($p < 0.001$). At 10 minutes, mean PI and PI ratio were significantly higher in successful blocks. ROC analysis identified optimal cut-offs of $PI \geq 2.6$ and $PI \text{ ratio} \geq 1.9$ at 10 minutes, with high sensitivity (96% and 93.3%) and specificity (94% and 100%), and AUROC values of 0.97 and 1.0, respectively.

Conclusion: PI and PI ratio are reliable predictors of successful ultrasound-guided AXB, reflecting sympathetic blockade-induced vasodilation. Incorporating PI monitoring may enhance block assessment, improve operating room efficiency, and reduce reliance on subjective tests.

Keywords: Ultrasound-Guided Axillary Brachial Plexus Block, Perfusion Index (PI), Block Success Prediction, Peripheral Nerve Block.

INTRODUCTION

Peripheral nerve blocks are widely used in regional anesthesia to provide effective perioperative analgesia and anesthesia for upper limb surgeries. Ultrasound-guided axillary brachial plexus block (AXB) is a commonly employed technique due to its precision in local anesthetic deposition and favorable safety profile.^[1] However, objective assessment of block success remains challenging, as conventional sensory and motor evaluations are subjective, time-consuming, and require patient cooperation. Early and

reliable indicators of block efficacy are essential to optimize operating room efficiency and improve patient outcomes.

The perfusion index (PI), derived from pulse oximetry, reflects the ratio of pulsatile to non-pulsatile blood flow in peripheral tissues and serves as a non-invasive marker of peripheral vasodilation.^[2,3] Sympathetic blockade following successful nerve block leads to vasodilation and increased PI values in the blocked limb.^[4] Recent studies have suggested that PI and its relative change from baseline (PI ratio) may serve as early, objective predictors

of peripheral nerve block success.^[5,6] These parameters offer a continuous, real-time, and operator-independent assessment method, potentially complementing clinical evaluation. Despite promising evidence, data on the predictive accuracy of PI in ultrasound-guided AXB remain limited, particularly in smaller, prospective cohorts. This study aims to evaluate the role of PI and PI ratio as early predictors of successful ultrasound-guided axillary brachial plexus block in a prospective observational design with a sample size of 30 adult patients. By establishing reliable cut-off values, this research seeks to enhance block assessment protocols and contribute to improved clinical decision-making.

Aim & Objectives

This study aims to evaluate the role of PI and PI ratio as early predictors of successful ultrasound-guided axillary brachial plexus block.

The study has two primary objectives: first, to evaluate the role of the perfusion index (PI) as an early predictor of successful ultrasound-guided axillary brachial plexus block (AXB); and second, to assess the effectiveness of the PI ratio-calculated as the PI at 10 minutes divided by the baseline PI-in predicting the success of the block. These objectives aim to establish PI and PI ratio as reliable, objective, and early indicators of block efficacy, thereby enhancing clinical decision-making and optimizing the assessment process for AXB success.

MATERIALS AND METHODS

This study was conducted in a tertiary care institute from February 2024 to January 2026. About 30 patients of either sex, aged 18-60 years, belonging to American Society of Anesthesiologists (ASA) physical status I and II posted for upper limb surgery under US-guided AXB were included. The sample size was calculated using the effect size of 0.85 (obtained from the mean perfusion index values in the study conducted by Bozdogan et al.), power of 90%, alpha (Type I error) of 0.05, the required minimum sample size obtained was 29 patients, which was rounded off to 30. Patients with diabetes mellitus, peripheral vascular disease, allergy to local anaesthetics (LAs), use of medications like alpha and beta blockers, local site infection and refusal to give consent were excluded from the study. All the patients were examined during the preoperative visit on the day prior to surgery. The purpose and protocol of the study was explained to the

patients and informed written consent was obtained. They were kept nil per orally for 6 hours prior to the scheduled time of surgery and were premedicated with alprazolam 0.25 mg the night before and oral ranitidine 150 mg 2 hours prior to surgery.

Using a Sonosite M-Turbo ultrasound device equipped with a high-frequency (10–13 MHz) linear array probe, a US-guided AXB was conducted. The ultrasound-guided axillary brachial plexus block is performed with the patient in a supine position, the arm abducted to 90 degrees and externally rotated to facilitate transducer placement and needle advancement. The axillary artery is identified first, typically 1–3 cm below the skin surface on the medial aspect of the proximal arm, appearing as a pulsatile, hypoechoic, spherical structure that is not readily compressible. The transducer is placed in the short axis orientation over the axillary fold, allowing visualization of the neurovascular bundle, including the axillary artery and surrounding nerves. The local anesthetic is injected in a perivascular manner, often dorsal to the axillary artery (at the 6 o'clock position), to ensure adequate spread around the terminal branches of the brachial plexus.^[7] A multipoint injection method was employed to administer a total of 25 ml of LA, consisting of 12.5 ml of 0.5% bupivacaine and 12.5 ml of 2% lignocaine.

Peripheral perfusion index (PI) was assessed using a Masimo radical-7 SET pulse oximeter placed on the middle finger of the same arm. Measurements were taken initially (prior to local anesthetic administration), every 2 minutes up to 10 minutes, and then every 5 minutes until 30 minutes post-block. The PI ratio was determined by dividing the PI at 10 minutes by the baseline PI. Sensory and motor blocks were evaluated at 5-minute intervals for up to 30 minutes following the block. Sensory block was tested using a pin prick with a blunt 23 G hypodermic needle, rated on a 3-point scale (0 for normal sensation, 1 for loss of prick sensation [analgesia], and 2 for loss of touch sensation [anesthesia]), and compared to the same test on the opposite arm.^[8] Motor block assessment employed a modified Bromage 3-point scale (0 for normal motor function with full elbow, wrist, and finger movement, 1 for reduced motor strength with movement of fingers and/or wrist only, and 2 for complete motor block with no finger movement).^[9] After at least 30 minutes, patients were moved to the operating room. In the operating theater, the block's effectiveness was checked by pinching

the surgical site with a plastic clamp. If no sensation was detected at the surgical site, the block was deemed successful. If pain was present, the block was considered unsuccessful, and additional analgesia or conversion to general anesthesia was considered based on the patient's needs. Complications such as signs or symptoms of local anesthetic toxicity were monitored.

Statistical Analysis

Data analysis was performed using the Statistical Package for Social Sciences (SPSS) version 22, (International Business Machines SPSS Statistics Inc., Chicago, Illinois, USA). For quantitative variables, descriptive analysis involved calculating the mean and standard deviation, while frequency and proportion were used for categorical variables. The Chi-square or Fisher's Exact test was applied to categorical data, and the Mann-Whitney test was used for continuous data. To assess the ability to

identify successful and unsuccessful block, a receiver operating characteristics (ROC) curve was created. A P value of less than 0.05 was deemed statistically significant.

RESULTS

Of the 30 patients enrolled, successful ultrasound-guided axillary brachial plexus blocks were achieved in the majority, with only three failed blocks noted in the study. The mean age of the patients was 36.74 ± 12.25 years. There was a clear male predominance, with 21 males and 9 females included in the study. The mean height of the participants was 165.90 ± 6.45 cm, and the mean body weight was 69.21 ± 5.24 kg. With respect to anesthetic risk stratification, the majority (19 patients) belonged to American Society of Anesthesiologists (ASA) physical status I while the remaining 11 patients were classified as ASA II (Table 1).

Characteristics	Values
Patients	30
Age	36.74 ± 12.25
Gender (Male/Female)	21/9
Height (cms)	165.9 ± 6.45
Weight (kg)	69.21 ± 5.24
ASA (I/II)	19/11
Outcome (Successful/Unsuccessful)	27/3

Table 1: Sociodemographic Profile of the Study Population

Perfusion index (PI) values showed a significant increase from baseline as early as 5 minutes post-block in patients with successful blocks ($p < 0.001$).

The mean PI showed a mean progressive rise from 1.2 at baseline to 5.0 at 30 minutes following axillary brachial plexus block. A rapid rise in PI is observed within the first 10 minutes, increasing from 1.2 to 3.2, indicating early

onset of sympathetic blockade. The PI value exceeds 2.6 at 10 minutes, which corresponds to the threshold predictive of successful block. Thereafter, PI continues to increase gradually, reaching a plateau towards 30 minutes, reflecting sustained vasodilation. This pattern supports the utility of PI as an early, objective, and reliable indicator of block success (Figure 1).

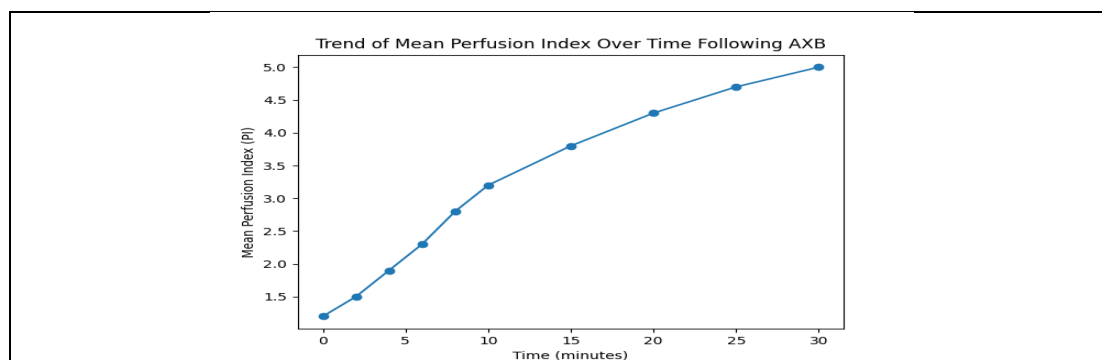


Figure 1: Trend of Mean Perfusion Index (PI) Over Time Following Ultrasound-Guided Axillary Brachial Plexus Block, Showing a Progressive Increase from Baseline (1.2) to 30 Minutes (5.0), Reflecting Sympathetic Blockade and Peripheral Vasodilation

At 10 minutes post-block, both the mean PI and PI ratio (post-block PI divided by baseline PI) were significantly higher in the successful block

group compared to the failed block group (Table 2).

Parameter	AUROC	Cut-off value	Sensitivity	Specificity	PPV%	NPV%
PI at 10 mins	0.97	2.6	96.0%	94.0%	100.0%	82.46%
PI ratio	1.0	1.9	93.3%	100.0%	100.0%	89.25%

*PI – Perfusion Index

Table 2: Receiver operating characteristics of Perfusion Index

Receiver operating characteristic (ROC) curve analysis identified a PI cut-off value of ≥ 2.6 and a PI ratio cut-off of ≥ 1.9 at 10 minutes as optimal thresholds for predicting block success.

These cut-off values demonstrated excellent diagnostic performance, with sensitivity of 96%, specificity of 94%, and an area under the ROC curve (AUROC) of 0.97 (Figures 2 and 3).

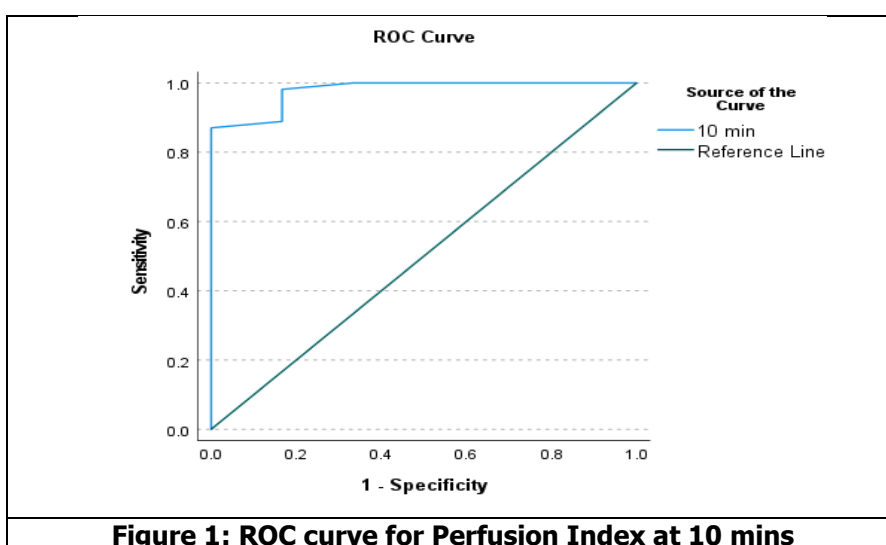


Figure 1: ROC curve for Perfusion Index at 10 mins

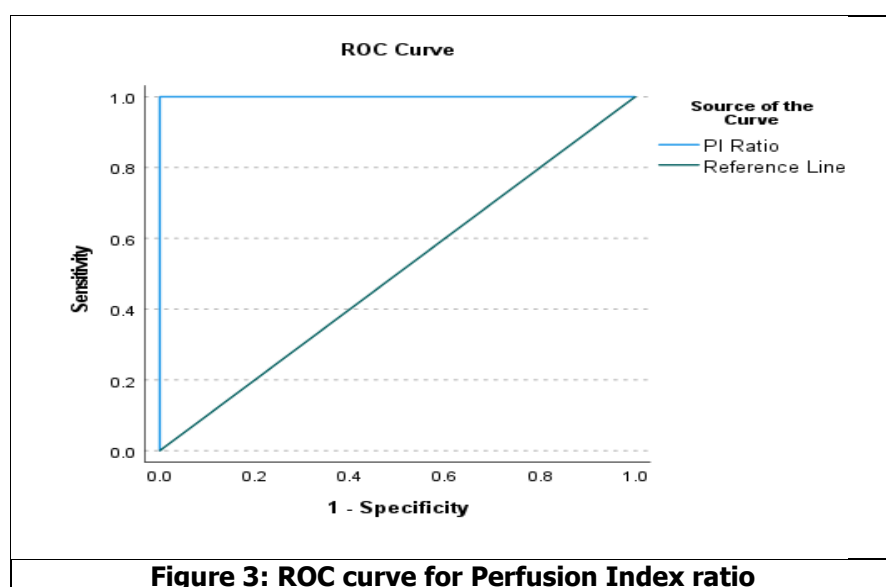


Figure 3: ROC curve for Perfusion Index ratio

These findings indicate that PI and PI ratio provide reliable, early, and objective indicators of successful axillary brachial plexus block,

correlating well with conventional sensory and motor block assessments.

DISCUSSION

The PI is not a measurement of blood flow but rather a measurement of its pulsatility.^[10] This study demonstrates that the perfusion index (PI) and its relative change from baseline (PI ratio) serve as reliable, early, and objective predictors of successful ultrasound-guided axillary brachial plexus block (AXB). The significant increase in PI values observed as early as 5 minutes post-block in successful cases aligns with the physiological basis of sympathetic blockade-induced vasodilation, which increases peripheral blood flow detectable by pulse oximetry. These findings corroborate prior research suggesting that PI is a sensitive marker for peripheral nerve block efficacy, offering a continuous and non-invasive assessment tool that complements conventional sensory and motor evaluations.^[2,3,11]

The present study corroborates and extends the findings of Kus et al. and Bozdağ et al. by demonstrating that the perfusion index (PI) and its relative change from baseline (PI ratio) serve as reliable, early, and objective predictors of successful ultrasound-guided axillary brachial plexus block (AXB).^[3,11] All three studies focus on adult patients classified as ASA I–II and exclude conditions affecting peripheral circulation, with comparable sample sizes ranging from 30 to 46 patients. While the current study exclusively examines axillary blocks, Kus et al. investigate infraclavicular blocks, and Bozdağ et al. include both axillary and infraclavicular approaches, with no significant differences observed between block types in PI changes, supporting the generalizability of PI monitoring across brachial plexus block techniques.^[3,11] Methodologically, all studies employ a combination of long-acting and short-acting local anesthetics in similar total volumes (25–30 ml), though the current study uses equal volumes of bupivacaine and lignocaine, whereas the others favor a higher proportion of bupivacaine or levobupivacaine. PI measurement protocols vary slightly; the current study utilizes more frequent early measurements (every 2 minutes up to 10 minutes), allowing finer temporal resolution of PI changes, whereas Kus et al. and Bozdağ et al. measure at longer intervals or continuously but report averages at 10, 20, and 30 minutes or at 5, 10, and 20 minutes, respectively. Despite variability in baseline PI values across studies—ranging from approximately 1.2 in the current study to 3.3 in Bozdağ et al. and a wide range in Kus et al.—all consistently report significant and progressive increases in PI

following successful blocks, reflecting sympathetic blockade-induced vasodilation. (3,11) The current study uniquely establishes specific PI and PI ratio cut-off values at 10 minutes (≥ 2.6 and ≥ 1.9 , respectively) with outstanding diagnostic accuracy (AUROC 0.97 and 1.0), while Kus et al. and Bozdağ et al. demonstrate statistically significant PI increases but do not provide ROC-based thresholds.^[3,11] Block success rates are high and comparable across studies (90%–97%), with PI increases absent or minimal in failed blocks, underscoring the specificity of PI changes as indicators of effective sympathetic blockade. Sensory and motor block assessments, performed via pinch test or pinprick and Bromage scales, complement PI monitoring, which offers a non-invasive, continuous and operator-independent measure that may expedite clinical decision-making and improve operating room efficiency. The studies collectively acknowledge inter-individual variability in baseline PI and emphasize the importance of using relative PI changes (ratios or percentage increases) rather than absolute values alone. Limitations include small sample sizes and single-center designs, prompting recommendations for larger multicenter trials to validate and standardize PI cut-off thresholds for broader clinical application. Overall, these converging lines of evidence support the integration of PI monitoring as a valuable adjunct to conventional clinical assessments in the early evaluation of brachial plexus block success. The identified cut-off values of PI ≥ 2.6 and PI ratio ≥ 1.9 at 10 minutes post-block exhibited excellent diagnostic performance, with high sensitivity and specificity (96% and 94%, respectively) and an AUROC of 0.97. This level of accuracy supports the clinical utility of PI monitoring in early block assessment, potentially enabling anesthesiologists to make timely decisions regarding block adequacy and the need for supplemental anesthesia. Such objective measures can improve operating room efficiency by reducing delays associated with subjective and time-consuming clinical tests, particularly in patients who may have limited cooperation or communication ability. While previous studies have explored PI as a predictor in various peripheral nerve blocks, data specific to ultrasound-guided AXB remain limited, especially in prospective cohorts with defined sample sizes.^[12] This study adds to the growing body of evidence by providing prospective observational data in a cohort of 30 adult patients, reinforcing the generalizability of

PI monitoring in this context. Nevertheless, the relatively small sample size and single-center design may limit broader applicability, warranting larger multicenter studies to validate these cut-off thresholds and assess their performance across diverse patient populations and clinical settings.

CONCLUSION

PI and PI ratio offer valuable, operator-independent parameters for early detection of successful AXB. Incorporating PI monitoring into routine block assessment protocols could enhance clinical decision-making, optimize resource utilization, and ultimately improve patient outcomes in regional anesthesia practice.

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