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Original Research Article

A STUDY TO EVALUATE THE CHANGE IN PERFUSION INDEX AS AN INDICATOR OF SUCCESSFUL ULTRASOUND-GUIDED SUPRACLAVICULAR BLOCK

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ABSTRACT

Background: This study evaluated changes in the Perfusion Index (PI) as an objective indicator of successful ultrasound (USG)-guided supraclavicular block (SCB), correlating PI dynamics with sensory and motor block onset. **Materials and Methods:** An observational study was conducted on 50 patients aged 18–60 years who were scheduled to undergo upper limb procedures under SCB. Using a pulse oximeter, PI values were recorded at baseline and set intervals post-block for up to 30 min. The block was performed using 25 mL of local anaesthetic (0.5% bupivacaine and 2% lignocaine) under USG guidance. Sensory block was assessed via pinprick using a 3-point scale, and motor block was evaluated using the modified Bromage scale. The block was considered successful based on sensory loss at the surgical site 30 min after the injection. **Result:** The mean age was 33.6 ± 14.5 years, with most patients <39 years old. The mean baseline PI was 1.1, increasing to 7.6 at 6 min, and peaking at 11.8 by the 15th min. It remained stable at 11.8–11.9 for up to 30 min. Sensory block showed a rapid progression, with the mean grade rising from 0.2 ± 0.4 at 2 min to 2.0 by 10 min, sustaining until 30 min. Motor block was slower in onset, achieving a grade of 0.1 ± 0.3 at 6 min and a full grade 2 at 20 min. **Conclusion:** PI is a reliable, objective, and noninvasive marker for evaluating the success of USG-guided SCB in upper-limb surgeries. A consistent rise in the PI strongly correlates with the success of SCB, particularly for the early identification of sensory block.

INTRODUCTION

Effective pain management is the basis of recent surgical practice. Anaesthesia procedures, such as nerve blocks, play an important role in achieving this goal, particularly for upper extremity surgeries. The supraclavicular regional block, which targets the brachial plexus nerves at the base of the neck, offers a reliable and safe anaesthesia technique and analgesia in the arm, forearm, wrist, and hand.[1] The older technique of assessing the success of a supraclavicular block (SCB) was based on subjective measures, such as sensory testing and motor function evaluation. However, these methods can be tedious, subject-dependent, and unreliable in the early stages of the block.[2]

The SCB aims at the brachial plexus, by injecting local anaesthesia near the brachial plexus under ultrasound (USG) guidance, the block anaesthetises the entire upper extremity.2 The SCB has become a commonly used technique for various upper extremity surgeries, including: Fracture repair, Arthroscopy, Soft tissue repair, and Pain management for chronic conditions.[3] USG techniques offer several advantages over landmark-based methods by enabling real-time visualisation of nerves, blood vessels, and surrounding structures, thereby reducing the risk of nerve injury, pneumothorax, and inadvertent vascular puncture. This approach facilitates accurate needle placement, ensuring proper distribution of anaesthetics and contributing to a faster onset of action. USG guidance allows for precise injection, resulting in a more reliable and effective block.[4]

Pain after upper extremity procedures can significantly impair functional recovery, reduce patient satisfaction, and negatively impact overall outcomes. Inadequate pain control may result in heightened pain levels, which can delay wound healing, increase the risk of infections, and limit

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participation in physiotherapy. Furthermore, uncontrolled acute pain can progress to chronic pain syndromes, causing long-term functional limitations and psychological distress. Poorly managed pain also substantially reduces patient satisfaction with the surgical experience.[5,6] Therefore, selecting a safe and effective regional anaesthetic procedure and having reliable assessment tools for assessing the effectiveness of the anaesthetic procedure are vital for optimal pain management in upper limb surgeries. The perfusion index (PI) is a noninvasive method used to evaluate how well a SCB is working. It collects readings through a pulse oximeter sensor attached to the fingertip. PI reflects the proportion between arterial (pulsatile) and non-arterial (venous and tissue) blood flow.[7] The logic behind using the PI lies in the physiological changes that occur after a good SCB. Blockade of sympathetic nerve fibres results in vasodilation of the blocked extremity. This increased blood flow leads to an increase in the PI value. Research suggests that PI changes can be a valuable indicator of successful block placement.[8] Advantages of using PI over other techniques, such as skin temperature and laser Doppler: PI provides a quantitative measure, reduces subjectivity, and makes the procedure painless and comfortable for the patient. The PI can be continuously monitored throughout the procedure, allowing for real-time evaluation of block efficacy. Changes in PI may be obvious even before the sensory or motor block is fully established, which allows for the early identification of an incomplete block.[9] However, there are only a few studies available that suggest PI as an effective indicator for assessing the success of peripheral nerve blocks. Hence, this study aimed to evaluate the role of the PI in assessing the success of USG-guided SCB.

Objectives

This study focused on observing changes in PI values following SCB and evaluating the levels of sensory and motor block, along with any related side effects.

MATERIALS AND METHODS

This observational study was conducted on 50 patients aged 18-60 years, scheduled to undergo upper limb surgery under USG-guided SCB at the Department of Orthopaedics and Plastic Surgery at Government Rajaji Hospital, Madurai, for 1 year.

Inclusion Criteria

Patients aged 18–60 years, classified as American Society of Anesthesiologists (ASA) physical status I or II, scheduled for elective upper limb surgery under SCB, and who provided informed consent, were included.

Exclusion Criteria

Patients were excluded if they refused to provide consent, had coagulopathy, local infection at the injection site, peripheral vascular disease, diabetes mellitus, known allergy to local anaesthetics, or were on medications such as alpha or beta blockers.

Sample size: The sample size was calculated using the following formula: $n = [Z^2_{1-\alpha/2}\, pq]/[d^2]$, where $Z = 1.96$, $p = 7.7\%$, $q = 100\text{-}p$, and $d = 20\%$ of p. Thus, providing $n = 46$, which is rounded off to 50.[7]

Methods

USG-guided SCB was carried out using a Sonosite M-Turbo machine equipped with a high-frequency linear probe (10–13 MHz). Patients were placed in a supine position with the head-end of the bed slightly raised and the head turned away from the side to be blocked.

After preparing the area aseptically, the ultrasound probe was placed transversely just above the midpoint of the clavicle. The probe was then angled downward to visualize a cross-section of the Subclavian Artery. The parietal pleura and first rib appeared as bright linear structures located laterally and beneath the diaphragm. The brachial plexus appeared as multiple round, dark nodules situated above and to the side of the artery. A total of 25 ml of local anesthetic was injected using a multipoint technique comprising 12.5 ml of 0.5% bupivacaine and 12.5 ml of 2% lignocaine.

PI values were obtained using a Masimo Radical-7 SET pulse oximeter attached to the middle finger on the same side as the block. Measurements were taken before giving the local anesthetic (baseline), every 2 minutes for the first 10 minutes, and then every 5 minutes until 30 minutes after the block. The PI ratio was calculated by dividing the 10-minute PI value by the baseline reading.

Sensory and motor functions were examined at 5-minute intervals for 30 minutes post-block. Sensory evaluation used a pinprick with a blunt 23 G needle and was rated on a 3-point scale (0: normal, 1: loss of prick sensation, 2: loss of touch), compared against the opposite arm. Motor assessment followed the modified Bromage scale (0: full movement at elbow, wrist, and fingers; 1: limited movement of fingers or wrist only; 2: complete loss of movement).

After 30 minutes, patients were moved to the operation theatre. The block's effectiveness was confirmed by pinching the surgical area with a plastic clamp absence of pain indicated success. If pain was reported, the block was considered unsuccessful, and additional analgesia or conversion to general anesthesia was done as needed. Any signs of local anesthetic toxicity or pneumothorax were also observed. Data analysis was performed using IBM SPSS Statistics (version 25). Quantitative variables are presented as mean and standard deviation.

Ethical Considerations

The Institutional Ethics Committee (IEC) approved this study, and all patients provided written informed consent before participating. This study adhered to the ethical guidelines for clinical research.

RESULTS

The majority of patients were aged between 20 and 29 years (32%), followed by equal proportions in the

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18–20 and 30–39 age groups (20% each). The mean age was 33.6 ± 14.5 years. Males (72%) predominated over females (28%). Regarding ASA classification, 60% of the patients were ASA grade II, while the remaining 40% were ASA grade I (Table 1).

Table 1: Distribution of age, gender and ASA status

	Categories	Count (%)
Age	<20	10 (20%)
	20-29	16 (32%)
	30-39	10 (20%)
	40-49	6 (12%)
	50-59	8 (16%)
Sex	Male	36 (72%)
	Female	14 (28%)
ASA	I	20 (40%)
	II	30 (60%)

The mean heart rate (HR) was 83.5 ± 11.9 bpm, systolic blood pressure (SBP) was 119.9 ± 13.4 mmHg, diastolic blood pressure (DBP) was 75.6 ± 8.7 mmHg, and mean arterial pressure (MAP) was 90.4 ± 9.2 mmHg. The mean oxygen saturation (SpO_2) was 98.3 ± 0.9%. The average body weight of the patients was 62.5 ± 10.1 kg, and the mean duration of surgery was 140 ± 44.3 min (Table 2).

Table 2: Pre-operative parameters and duration of anaesthesia

Parameters	Mean ± SD
HR (bpm)	83.5 ± 11.9
SBP (mmHg)	119.9 ± 13.4
DBP (mmHg)	75.6 ± 8.7
MAP (mmHg)	90.4 ± 9.2
SPO2 (%)	98.3 ± 0.9
Weight (kg)	62.5 ± 10.1
Duration (min)	140 ± 44.3

The mean baseline PI was 1.1, which further increased to 5.6 and 7.6 at the 4th and 6th min, respectively. By the 15th minute, the PI reached 11.8, and showed minimal variation with 11.9 at both the 20th and 25th minutes, and decreased to 11.8 at the 30th minute.

Sensory block progression was gradual and consistent, with the mean sensory grade increasing from 0.2 ± 0.4 at the 2nd minute to 1.9 ± 0.3 by the 8th min. The mean sensory grade reached 2 by the 10th minute and remained stable until the 30th minute.

The mean motor grade remained 0 until the 4th minute, and a mean of 0.1 ± 0.3 was noted at the 6th minute. A mean grade of 2 ± 0.2 was noted at the 20th minute, which remained constant at 2 until the 30th minute (Table 3).

Table 3: Mean perfusion index, sensory, and motor grade at a given time

Interval	PI	Sensory (Grade)	Motor (Grade)
Baseline	1.1	0	0
2nd min	3.6	0.2 ± 0.4	0
4th min	5.6	1.0 ± 0.1	0
6th min	7.6	1.4 ± 0.5	0.1 ± 0.3
8th min	9.6	1.9 ± 0.3	0.7 ± 0.5
10th min	11.1	2	1 ± 0.2
15th min	11.8	2	1.4 ± 0.5
20th min	11.9	2	2 ± 0.2
25th min	11.9	2	2
30th min	11.8	2	2

DISCUSSION

Our study evaluated the PI, to check if it as an effective indicator for assessing the success of USG-guided SCB by measuring changes in PI values after block administration. The PI reflects blood flow dynamics, with higher values indicating successful sympathetic blockade. In our study, the patients primarily consisted of 20-29 years (32%). The mean age was 33.6 ± 14.5 years. Males (72%) were significantly more represented than females (28%). The study population was predominantly ASA physical status II (60%) with a mean weight of 62.5 ± 10.1 kg. The average duration of anaesthesia was 140 ± 44.3 min. These findings align with a study on 40 patients by Bereket et al., who reported an average age of 36.4 years, and males were predominant in their study (72.5%).[10]

In our study, the average PI at baseline was 1.1, which rose to 11.8 by the 15-minute mark and remained steady afterward. A similar trend was reported by Abdelnasser et al. in their study involving 77 participants. They found that both the PI and the

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PI ratio measured 10 minutes after the injection had 100% sensitivity and specificity in predicting a successful block when using cut-off values of 3.3 and 1.4, respectively. Their findings also supported the use of PI as a reliable method for assessing the effectiveness of a supraclavicular nerve block, with a PI ratio above 1.4 serving as a strong indicator of block success.[11] Additionally, Bereket et al. reported a mean PI of 10.57 at the 30th minute.[10]

Similarly, Bozdag et al. conducted a study on 30 patients and continuously observed them for 20 min. The mean PI of the unblocked arm remained at 3.7 ± 2.7 at 5, 10, and 20 min, whereas it was 7.3 ± 3.6 at the 5th min and 10.9 ± 3 at the 20th min for the blocked arm.[12] These results emphasise the importance of PI as a real-time, noninvasive indicator for early evaluation of block success.

Our findings revealed a rapid sensory block progression, with the mean sensory grade reaching 2 by the 10th minute and remaining stable until the 30th min post-block. This mirrors the findings of Singh et al., who evaluated 30 patients and reported that their mean sensory grade at baseline was 1, and their highest was 1.94 ± 0.67 min at 15 min.[13] The predictable rise and stabilisation of sensory scores in our study support the utility of PI monitoring for timely sensory assessment.

Motor block initiation lagged behind sensory block, beginning with a mean grade of 0.1 ± 0.3 at the 6th minute and reaching grade 2 by the 20th minute, and then remaining constant until the 30th minute. Further strengthening our findings, Taboada et al. evaluated 50 patients and reported that the motor block onset was at 16 minutes, and it took 20 minutes for a complete block.[14] Avci et al., who evaluated 30 patients and reported that motor block onset was between 6 to 19 minutes, with a mean onset time of 10.83 ± 3.07 minutes.[15]

Hull et al. studied 21 patients and reported that the average time calculated for sensory and motor block was 4.8 ± 3.7 min and 8.4 ± 5.7 min, respectively.16 Similarly, Dangi et al. reported 3.9 ± 0.8 min as the mean for sensory block onset and 4.3 ± 1.2 min for onset of motor block.[17] Thus, indicating that motor block takes a longer onset than sensory block. The coordinated increase in the motor grade and PI supports the use of the PI as a substitute marker for motor block efficacy in the early post-block period. Further strengthening our study, Singh et al. reported that the average PIR of the blocked limb when sensory block was achieved was 1.86 ± 0.4 and motor block was 2.15 ± 0.61 ($p < 0.001$).[13] Thus, suggesting a strong association between an increase in PIR and the onset of sensory and motor block.

A consistent and significant increase in the PI following block administration was associated with the onset and progression of both sensory and motor blocks, highlighting its predictive value. Our results align well with those of previous studies, indicating early sensory block achievement and a slightly delayed motor block onset, both of which showed a strong correlation with rising PI and PIR values.

Limitations: Limitations such as the single-centre design, moderate sample size, and limited follow-up highlight the need for broader validation. Future research should focus on multicentre trials with larger samples, controlled trials, longer follow-ups, and comparisons with other nerve block techniques across diverse populations to refine its integration into clinical anaesthesia practice.

CONCLUSION

Our study demonstrated that the PI is a reliable, objective, and noninvasive marker for evaluating the success of USG-guided SCB in upper limb surgeries. The PI allows real-time monitoring of sympathetic blockade, with significant post-block increases that correlate strongly with effective sensory and motor block outcomes. Its clinical advantages include early block assessment, improved accuracy, reduced patient discomfort, and an efficient workflow by minimising the need for repeated subjective testing. Early detection of incomplete blocks enables prompt intervention, enhancing pain control and improving overall patient outcomes. Incorporating the PI into routine practice can improve block success rates, patient safety, and satisfaction with regional anaesthesia.

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