Original 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 and Aims: Perfusion index (PI) is a new simple, objective and non-invasive method for evaluation of the success of central neuraxial and peripheral nerve blocks. So, we conducted a study with an aim to evaluate PI as an indicator for success of ultrasound-guided supraclavicular block (SCB). **Methods:** 65 patients of either sex, age 18–60 years, American Society of Anesthesiologists physical status I and II posted for upper limb surgery under ultrasound (US)-guided SCB were included. PI was recorded at baseline every 2 minutes till 10 minutes and then every 5 minutes till 30 minutes after block. PI ratio was calculated as the ratio between PI at 10 minutes and baseline PI. Sensory and motor blocks were assessed at 5-minutes intervals up to 30 minutes. Descriptive analysis was applied by mean and standard deviation for quantitative, frequency and proportion for categorical variables. **Results**: Mean PI increased continuously from baseline and reached the maximum at 10 minutes and then slightly decreased up to 30 minutes, but values at subsequent time intervals were quite high as compared to baseline. In case of successful blocks, median PI started increasing 2 minutes after the block and then increased in a linear fashion till 10 minutes, whereas in case of failed blocks, it only increased minimally. **Conclusion:** PI is an objective and faster indicator for evaluating success of US-guided SCB. A cut-off value of 3.25 for PI and 3.03 for PI ratio showed a fairly good ability with high sensitivity and specificity for predicting the success of SCB.

Key words: Brachial plexus block, perfusion index, peripheral nerve block, ultrasound guided

INTRODUCTION

Ultrasound (US)-guided supraclavicular block (SCB) is one of the commonly used peripheral nerve blocks for anaesthesia during upper extremity operations. It has the advantage of the most widespread extent of sensory blockade among all the brachial plexus approaches and also single puncture technique because of the tight location of the plexus elements at this location.[1] The success of peripheral nerve blocks is usually assessed by sensory and motor function. But this method is subjective, time consuming and cannot be done in patients under general anaesthesia (GA), deep sedation or otherwise unable to provide feedback. Various objective methods like thermographic temperature measurement, laser Doppler perfusion imaging and skin electrical resistance have been developed. These methods depend on evaluation of sympathetic block and consequent physiological changes such as vasodilation, change in blood flow and skin temperature.[2] However, most of these objective methods require sophisticated and expensive equipment.

Perfusion index (PI) is a simple, objective and non-invasive method for evaluation of the success

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of central neuraxial and peripheral nerve blocks. It is calculated by dividing the ratio of arterial blood flow (pulsatile) to venous, capillary, and tissue blood flow (non-pulsatile blood flow) and is shown as a percentage or absolute value.[3] It is used to assess peripheral perfusion dynamics due to change in peripheral vascular tone and requires a special pulse oximeter for measurement. But nowadays, it is available on other monitors as well.[4]

As very few studies are available in literature for PI as an indicator for evaluating the success of peripheral nerve blocks,[2,5] we planned the present study with the aim to evaluate PI as an indicator for assessing success of US-guided SCB. Our primary objective was to analyse the variations in PI value after SCB. The secondary objectives were to calculate the cut-off value of PI for a successful SCB, compare the change in PI value between successful and unsuccessful SCBs, to assess grades of sensory/motor block and "complications", if any.

METHODS

The present prospective, observational, single-arm study was approved by the institutional ethics committee and trial was registered in Clinical Trial Registry- India (CTRI/2020/03/02396). This study was conducted in a tertiary care institute from January 2020 to March 2021. About 65 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 SCB were included. 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 oral ranitidine 150 mg and alprazolam 0.25 mg the night before and 2 hours prior to surgery.

US-guided SCB was performed using a Sonosite M-Turbo ultrasound machine with a high frequency (10–13 MHz) linear array probe. The block was performed with the patient in the supine position and with slight elevation of the head-end of the bed with the patient's head turned away from the side to be blocked. Using aseptic technique, the probe was positioned in the transverse plane immediately superior to the midpoint of the clavicle. The transducer was tilted caudally to obtain a cross-sectional view of the pulsating subclavian artery. Parietal pleura and the first rib were seen as linear hyperechoic structures immediately lateral and deep to it. The brachial plexus was seen as a bundle of hypoechoic round nodules (grapes) just lateral and superficial to the artery.[6] A multipoint injection technique was used to inject a total volume of 25 ml of LA (12.5 ml of 0.5% bupivacaine and 12.5 ml of 2% lignocaine).

PI was measured using Masimo radical-7 SET pulse oximeter applied on the middle finger of the ipsilateral arm. PI was recorded at baseline (before LA administration), at every 2 minutes till 10 minutes and then every 5 minutes till 30 minutes after the block. PI ratio was calculated as the ratio between PI at 10 minutes and baseline PI. Sensory block and motor block were assessed at 5-minute intervals up to 30 minutes after the block. Sensory block was assessed by pin prick test with a blunt 23 G hypodermic needle, using a 3-point scale (0 -normal sensation, 1 -loss of sensation of prick [analgesia] and 2 -loss of sensation of touch [anaesthesia]) and compared to same stimulation on contralateral arm.[7] Assessment of motor block was done by modified Bromage 3 -point score (0-normal motor function with full flexion and extension of elbow, wrist and fingers, 1-decreased motor strength with ability to move fingers and/or wrist only and 2-complete motor blockade with inability to move fingers.[8] After a minimum of 30 minutes, patients were shifted to the operating room. In the operation theatre, the block was assessed by pinching the surgical area with a plastic clamp. When no sensation was felt at the site of the surgical area, the block was considered successful. If there was pain at the surgical site, the block was considered as a failed block and supplemental analgesia or conversion to GA was considered as per requirement of the patient. Complications like signs/symptoms of LA toxicity and pneumothorax were monitored.

Based on a previous study, both PI at 10 minutes and PI ratio showed a good ability to predict block success with cut-off values of 3.3 and 1.4, respectively.[9] To

detect a moderate correlation (r = 0.35), a sample of 62 subjects was calculated to provide 80% power to discover that the correlation is significantly different from there being no correlation at the 0.05 level. To compensate for any dropout or exclusion, 65 patients were enroled in the study. Analysis was done using Statistical Package for Social Sciences (SPSS) version 22 (International Business Machines SPSS Statistics Inc., Chicago, Illinois, USA) windows software program. Descriptive analysis was carried out by mean and standard deviation for quantitative variables, frequency and proportion for categorical variables. Chi-square/Fisher's Exact test was used for categorical data and Mann–Whitney for continuous data. A receiver operating characteristics (ROC) curve was constructed to predict the ability to detect the successful and failed blocks. A P value of <0.05 was considered statistically significant.

RESULTS

Sixty-five patients undergoing arm surgery under SCB were enroled into the study. Block was successful in 60 patients (92.3%). It failed in five (7.7%) patients and general anaesthesia was administered to them. The number of patients with failed blocks was not sufficient to allow statistical comparison between successful and unsuccessful blocks; yet the data is presented. Mean age and weight of the patients was 33.43 ± 13.58 years and 62.89 ± 8.81 kg, respectively. More than 50% of patients underwent surgery for fracture humerus and radius [Tables 1 and 2].

The mean of PI at baseline in the study population was 1.19 ± 0.7 with a minimum of 0.1 and a maximum of 3 (95% CI 1 to 1.4). After the block, mean PI increased continuously from baseline and reached maximum value at 10 minutes and then slightly decreased up to 30 minutes but the values at subsequent time intervals were also quite high as compared to baseline [Figure 1]. In case of successful blocks, median PI started increasing 2 minutes after the block and increased in a linear fashion till 10 minutes, whereas in the case of failed blocks, it only increased minimally [Figure 2].

Both PI at 10 minutes and PI ratio showed a good potentiality to predict the success of the block. The ROC curve yielded 3.25 as an appropriate cut-off value for PI at the tenth minute and 3.03 as cut-off value for PI ratio. This cut-off value had excellent predictive

Table 1: Demographic profile	
Characteristics	**Values**
Patients (*n*)	65
Age (years)	33.43±13.58
Sex (Male/Female)	52/13
Height (cm)	169.4±7.68
Weight (kg)	62.89±8.81
ASA (I/II)	41/24

Data are mean±standard deviation (SD) or total numbers. BMI: body mass index; ASA: American Society of Anesthesiologists

Table 2: Type of upper limb surgeries in the study population		
Diagnosis	**Number of patients**	**Percent**
Elbow deformity	4	6.15%
Forearm deformity	7	10.77%
Hand deformity	7	10.77%
Humerus fracture	23	35.38%
Radius fracture	12	18.46%
Ulna fracture	6	9.23%
Wrist deformity	6	9.23%

validity in predicting success of the block, as indicated by area under the curve of ROC [Tables 3 and 4].

The median PI ratio was 7.50 in the study population. It was 8.3 (5.4, 10) in successful blocks and was 1.28 (1.21, 2.04) in failed blocks. This difference in the PI ratio between successful and failed blocks was statistically significant ($P < 0.001$) .

Sensory block (loss of pain to pin prick) started 5 minutes after the needle withdrawal and reached a maximum grade of 2 after 15 minutes. Similarly, motor block started appearing at 10 minutes and complete motor blockade occurred after 20 minutes.

DISCUSSION

The conventional method to determine the efficacy of SCB is based on the presence of clinical signs on the arm-like increase in skin temperature and loss of sensation to pin prick and cold. However, these signs may be ambiguous, slow in onset and may not predict the success or failure of the block in some patients. So, objective assessment of the regional block may be important in patients under general anaesthesia, deep sedation or in those not able to provide the feedback for some other reason.

The PI is not a measurement of blood flow but rather a measurement of its pulsatility.[10] Every vasoconstrictor stimulus or activation of the sympathetic nervous system reduces the PI, because

Table 3: Receiver operating characteristics for ability of perfusion index to predict block success						
Parameter	**AUROC (95% CI)**	**Cut-off value**	**Sensitivity**	**Specificity**	**PPV%**	**NPV%**
PI at 10 min	0.995 (0.981-1.00)	3.25	96.67%	100%	100	71.44
PI ratio	1.0 (1.0-1.0)	3.03	93.33%	100%	100	83.33

AUROC Area under ROC; PPV: positive predictive value; NPV: negative predictive value ; PI: perfusion index; CI: confidence interval

Table 4: Comparison of status of block with perfusion index (PI) at 10th min and PI ratio (*n*=65)			
Parameter	**Status of block**		**P**
	Success (*n*=60)	**Failed (*n*=5)**	
PI at 10 min			
High (>3.25)	58 (96.67%)	0 (0%)	<0.001
Low (<3.25)	2 (3.3%)	5 (100%	
PI ratio			
High (>3.03)	59 (98.33%)	0 (0%)	<0.001
Low (<3.03)	1 (6.7%)	5 (100%)	

Figure 1: Mean of PI at different time intervals

the height of the pulsatile part of the curve is reduced. On the contrary, every vasodilator stimulus, activation of the parasympathetic or inhibition of the sympathetic nervous system increases the PI, because the height of the pulsatile part of the curve is increased. In patients who are administered regional anaesthesia, there is a sympathetic block first, followed by sensory and motor block. Sympathetic block results in peripheral vasodilatation in the extremity and thus an increase in PI. The role of PI in predicting the success of various peripheral nerve blocks as a parameter for fluid responsiveness and early detection of blood loss and postspinal hypotension has been evaluated in literature.[11-13] The results of the current study show that both PI and PI ratio are good predictors of successful SCB. In this study, successful US-guided SCBs are accompanied with a statistically significant increase in PI values compared to the baseline, starting as early as 2 minutes after the administration of LA drug. Patients with failed blocks showed minimal increase in PI values suggesting that increase in PI values is associated with sympathetic blockade and not with an increase in the serum level of LA. We calculated the cut-off values of 3.25 and 3.03 for PI and PI ratio, respectively. However, conventional methods like sensory and motor block began to appear in 5 and 10 minutes and reached a maximum at 15 and 20 minutes, respectively, after needle withdrawal.

Abdelnasser *et al.*[9] conducted a study on 77 patients with ultrasonography (USG) guided SCB and found a persistent increase in the mean PI from baseline (2.8) up to 30 minutes (7.1) in the blocked arm. They reported the cut-off value for PI at the tenth minute as 3.3 and PI ratio as 1.4. This
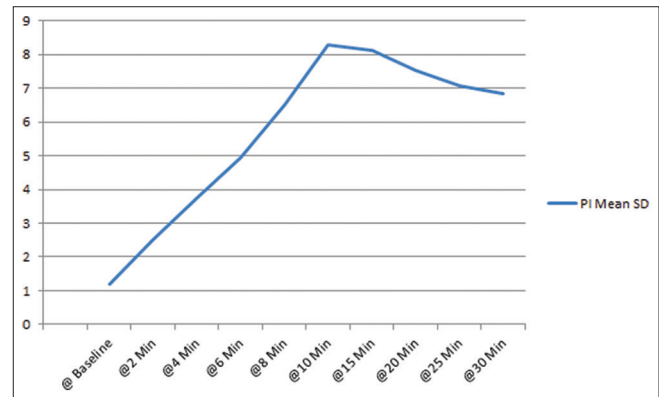
difference in cut-off value of PI ratio may be due to a higher baseline PI in the present study. Similarly, two more studies recorded continuous increase in mean PI from baseline up to 30 minutes (9.56) in blocked arm and measured median PI ratio at the 20th minute as 7.05.[14,15] This is the same as in the present study (7.5 at the 10th minute). Sebastiani *et al.*[2] reported continuous increase in PI from baseline (0.2) up to 15 minutes (2.2) with US-guided interscalene block. Kus *et al.*[5] also observed an increase in mean PI from baseline (1.8) up to 20 minutes (3.7) and then it started decreasing and continued to decrease up to 30 minutes with US-guided infraclavicular block.

Peripheral nerve blocks provide good analgesia and are also used solely for anaesthesia. These have now become a prime clinical strategy of the anaesthesiologists so as to avoid the airway during the coronavirus pandemic for all surgeries, which are feasible under regional blocks.[16] Failure of block results in unwanted stress for the patient and anaesthesiologist. Early detection of failed blocks results in earlier institution of rescue measures such as block supplementation, or general anaesthesia. PI is reported as an efficient, fast and distant measure for block evaluation. More studies with a larger population, recording PI in both blocked and unblocked arms are warranted to further confirm these cut-off values for prediction of successful USG-guided SCB.

PI ratio is considered as a more accurate measure of a successful block because of large individual
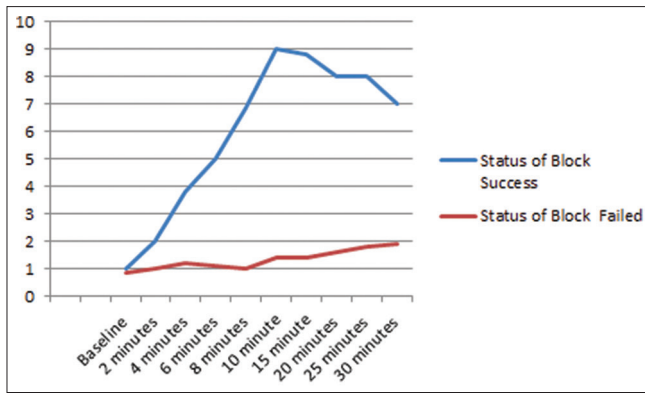
Figure 2: Median of PI in successful and failed blocks

variations in baseline PI values. This large baseline variation in PI values is well known among volunteers and critically ill patients.

There were few limitations in the present study. Firstly, we assessed PI only in the blocked arm as only one Masimo radical-7 SET pulse oximeter type PI monitor was available. So, PI was not recorded in an unblocked arm and no comparison was made. Secondly, there were a low number of failed blocks and we did not supplement these blocks. Improvement in PI with supplementation of failed blocks could have confirmed our results. Studies with a larger number of patients may involve more failed blocks, which will confirm our findings, especially cut-off values. Thirdly, we considered all failed blocks as one group without grading the degree of success (according to the number of anaesthetised segments) because we did not assess the effect in the territories of four individual nerves.

CONCLUSION

We conclude that PI is a simple, non-invasive monitor that can be considered as a faster, highly valuable and more objective tool than traditional methods for evaluation of success of USG-guided SCB. A cut-off value of 3.25 for PI and 3.03 for PI ratio at 10 min showed a fairly good ability with high sensitivity and specificity for predicting success of SCB. PI ratio was observed as a more sensitive indicator than PI at 10 min.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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