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ORIGINAL ARTICLE

Use of Pulse Oximeter Perfusion Index During Ultrasound Guided Supraclavicular Brachial Plexus Block With or Without Epinephrine in Upper Extremity Surgery: a Randomized Comparative Study

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Abstract

Background: **Ultrasound (US) -guided supraclavicular block (SCB) has the benefit of the widest sensory blocking of all of the brachial plexus techniques, including the single puncture method, due to the concentration of the plexus components at this site.**

Objectives: **To assess the use of pulse oximeter perfusion index (PI) changes in the assessment of success SCB in upper extremity surgery and to evaluate the impact of adrenaline on pulse oximeter perfusion index changes.**

Patients and methods: **A prospective, randomized, double-blind, comparative research was done on 90 cases between June 2022 to January 2023, at Al- Faculty of Medicine, Al—Al-Azhar University.**

Results: **There was a substantial distinction among the groups in Diagnostic accuracy of PI and PI ratio for the prediction of potent obstruct, change in HR in the time interval, Change in MAP in the time interval and Time to need analgesics in the time interval.**

Conclusion: **Pulse oximeter perfusion index changes and PI ratio can be used as reliable predictors of the success of SCB in upper extremity operation. However, epinephrine produces no difference in perfusion index compared to local anesthetic alone.**

Keywords: Epinephrine, Oximeter perfusion index, Supraclavicular brachial plexus block, Ultrasound, Upper extremity surgery

1. Introduction

US-guided SCB is one of the most frequently utilized peripheral nerve blocks for anesthesia in upper extremity procedures.[1] When contrasted to other brachial plexus procedures, involving the single puncture approach, this one delivers the most complete sensory blockage because of the close proximity of the plexus components at this point.[2]

The sensory and motor functions are frequently employed to evaluate the efficacy of peripheral nerve blocks. Nevertheless, this method is subjective, laborious and infeasible for cases under general anesthesia (GA), and deep sedation.[3]

The PI is a noninvasive tool for evaluating the relative importance of pulsatile vs non-pulsatile blood flow using a pulse oximeter.[4] It is influenced by variations in the volume, elasticity, and pressure of the blood within the body's blood vessels. As a result, it corresponds to modifications in blood volume and fluctuates in value based on the compressibility of vascular walls and pulse

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pressure. When a nerve is properly blocked, sympathetic nerve fibres are disabled, leading to an increase in local blood flow, vasodilation and, finally, a higher PI.[5]

An observational trial found a median (quartiles) normal value of PI of 4.3 (2.9–6.2), but the estimated normal range for PI is 0.2–20 %. PI is typically utilized for subsequent interactions in relation to each person's baseline readings (a metric known as the PI ratio) due to ‘its elevated skewed values.[6]

The effectiveness of central neuraxial and peripheral nerve blocks may now be assessed with a very simple, objective, and nonintrusive approach called PI.[2]

We sought to assess the use of pulse oximeter PI changes in assessment of success SCB in upper extremity surgery and to evaluate impact of adrenaline on pulse oximeter perfusion index changes.

2. Patients and methods

This prospective randomized double blind comparative research was done on 90 cases who are planned for elective upper limb surgeries to evaluate the usage of pulse oximeter PI changes in assessment of success of SCB and to evaluate the impact of epinephrine on pulse oximeter PI changes at Al-Azhar university hospitals from June 2022 to January 2023.

Patients aged between 21 and 60 years for each Sex with ASA physical status classification I and II plan to undergo optional surgeries on their upper extremities were participated in this research.

Cases undergoing operations involving the upper limb are candidates for a SCB guided by US.

Patients with Diabetes mellitus, Peripheral vascular disease, Contraindications of supraclavicular nerve block, Patients with a documented hypersensitivity to local anesthetics, bleeding disorders and neuromuscular disease were excluded.

2.1. Randomization and blinding

Using a computer-generated randomization sequence and a 1:1 ratio using sealed, opaque envelope procedures, the cases were randomly allocated to one of two groups: a non-epinephrine group or an epinephrine group.

Study medicines were manufactured by a technician who did not perform the SCB or evaluate the results.

Until the trial was over, neither the assigned groups nor the clinical patient data were revealed to the researchers.

2.2. Patients were split into two groups at random

Group A (non-epinephrine group): 50 patients who were injected with local anesthesia only without adrenaline. The injection formed of 25 ml of local anesthetic (12.5 ml bupivacaine 0.5%- and 12.5-mllidocaine 2 %) and 1 ml normal saline.

Group B (epinephrine group): 50 patients were injected with local anesthesia with adrenaline. The injection will be formed of 25 ml of local anesthetic (12.5 ml bupivacaine 0.5%- and 12.5-ml lidocaine 2%) and 1 ml saline containing 5 mcg epinephrine.

2.3. Methods

All patients were subjected to the followings:

Preoperative assessment: Every case was examined before operation by complete history taking and clinical evaluation.

Operative Technique: Hemodynamics such as heart rate (HR), mean arterial blood pressure (MAP), and oxygen saturation (SPO_2) were documented each 5 min via electrocardiogram (ECG), automated non-invasive blood pressure monitoring (NIBPM) and upon arriving in the operating room, cases are given premedication in the form of midazolam (0.03 mg/kg), and a venous cannula is placed using 18-gauge tubing in the contralateral hand.

2.4. Ethical considerations

The Ethics Committee of Al-Azhar University's Faculty of Medicine approved the investigation. There were adequate safeguards in place to protect participants' privacy and the confidentiality of their data, as detailed below: Patients were given the option to withdraw out of the study if they did not wish to participate. Prior to enrollment in the research, written informed permission was acquired from all cases, the purpose of the research was explained to each case, code numbers were assigned to each participant, and their names and addresses were kept in a separate file, the cases' identities were concealed when the research was used, and the findings of the research were used solely for scientific purposes and not for any other purposes.

2.5. Statistical analysis

After collecting data, a code sheet was developed. SPSS v26 (IBM Inc., ARMONK, IL, USA) was used for data organization, tabulation, presentation, and analysis. Using the Shapiro-Wilks test and histograms, the normality of data distribution was verified. Quantitative parametric data were shown as mean and standard deviation (SD). Quantitative non-parametric data were shown as median and interquartile range (IQR). The qualitative variables were shown as frequency (%).

Comparison between the two groups was done using unpaired Student's t-test or Mann-Whitney test when appropriate. Contrast between readings in the time interval in each group was done using paired *t*-test or Wilcoxon rank test when it's needed. Qualitative variables were analyzed utilizing the Chi-square test or Fisher's exact test when appropriate. The overall diagnostic performance of PI and PI ratio was assessed by ROC curve analysis, A perfect test is a curve that extends from the lower left corner to the upper left corner and proceed to the upper right corner. The area under the curve (AUC) measures the overall performance of a test. A two-tailed P value below or equal to 0.05 was deemed to be substantial Fig. 1.

3. Results

This prospective, randomized double-blind research was done on 90 cases planned for elective upper limb surgeries to determine the application of pulse oximeter PI changes in the evaluation of the success of SCB and to evaluate the effect of epinephrine on pulse oximeter PI changes.
Table 1.

There was no substantial variance in baseline characteristics (age, Sex, BMI, and ASA classification) among the researched groups Table 2.

Regarding the change in PI in the time interval after local anesthetic injection, there was no substantial distinction in PI at baseline, after 10, 20, and 30 min afterward local anesthetic injection between the two studied groups. In both studied groups, PI at 10, 20 and 30 min afterward local anesthetic injection were significantly higher compared to PI at baseline ($P < 0.001$) Table 3.

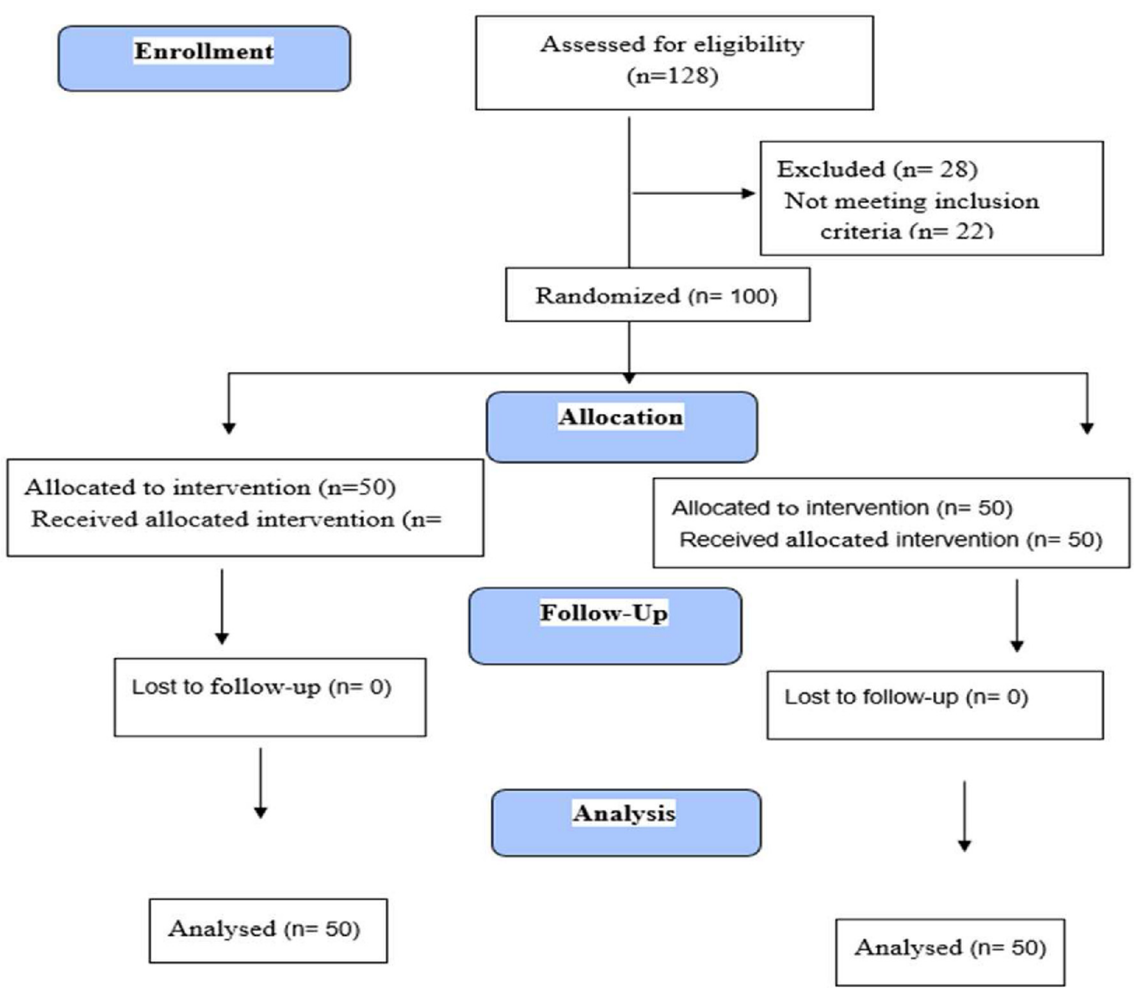

Fig. 1. ROC curve analysis of PI for the prediction of successful block in the studied patients.

Table 1. Baseline characteristics of the studied groups.

	Group I ($n = 50$)	Group II ($n = 50$)	*P* value
Age (years)			
Mean ± SD	37.11 ± 5.58	38.93 ± 4.35	0.087
Range	22–45	26–45	
Sex			
Male	46 (92 %)	43 (86 %)	0.525
Female	4 (8 %)	7 (14 %)	
BMI (kg/m^2)			
Mean ± SD	28.2 ± 2.7	28.9 ± 2.1	0.158
Range	24–34	25–33	
ASA Classification			
ASA I	32 (64 %)	28 (56 %)	0.541
ASA II	18 (36 %)	22 (44 %)	

PI at 10 min was a significant indicator of successful block (AUC: 0.836, $P < 0.001$), with a cut-off value of >9.7, sensitivity of 62.2 % and specificity of 93.3 %. PI at 20 min was a significant indicator of successful block (AUC: 0.909), at a cut-off value of >8.6, sensitivity of 75.6 % and specificity of 92.2 %. PI at 30 min was a significant indicator of successful block (AUC: 0.932), at a cut-off value of >7.5, sensitivity of 87.8 % and specificity of 87.8 %. PI ratio at 10 min was a significant indicator of successful block (AUC: 0.871), at a cut-off value of >1.6 it has a sensitivity of 91.1 % and specificity of 68.9 %. PI at 20 min was a substantial indicator of successful

Table 2. Change in PI in the time interval between the studied groups.

	Group I ($n = 50$)	Group II ($n = 50$)	*P* value
PI at Baseline (%)			
Median (IQR)	6 (3–8)	7 (5–9)	0.097
Range	2–11	2–12	
PI after 10 min (%)			
Median (IQR)	12 (9–13)	10 (7–12)	0.150
Range	4–17	5–17	
PI after 20 min (%)			
Median (IQR)	11 (9–14)	10 (8–13)	0.078
Range	4–17	5–17	
PI after 30 min (%)			
Median (IQR)	11 (9–15)	9 (8–13)	0.105
Range	7–16	5–17	
P value	***P*1: < 0.001* *P*2: < 0.001* *P*3: < 0.001***	***P*1: < 0.001* *P*2: < 0.001* *P*3: < 0.001***	

Table 3. Diagnostic accuracy of PI and PI ratio for the prediction of successful block in the studied patients.

	Cut-off value	Sen	Spe	PPV	NPV	AUC	*P* value
PI at 10 min	>9.7	62.2	93.3	90.3	71.2	0.836	<0.001*
PI at 20 min	>8.6	75.6	92.2	90.7	79	0.909	<0.001*
PI at 30 min	>7.5	87.8	87.8	87.8	87.8	0.932	<0.001*
PI ratio at 10 min	>1.6	91.1	68.9	74.5	88.6	0.871	<0.001*
PI ratio at 20 min	>1.4	87.7	58.9	68.1	82.8	0.826	<0.001*
PI ratio at 30 min	>1.4	93.3	53.3	66.7	88.9	0.802	<0.001*

Table 4. Alteration in HR in the time interval among the studied groups.

	Group I ($n = 50$)	Group II ($n = 50$)	*P* value
HR at Baseline (beat/min)			
Mean ± SD	77.29 ± 8.5	79.67 ± 9.26	0.208
Range	53–98	60–98	
HR after 10 min (beat/min)			
Mean ± SD	77.07 ± 8.17	84.93 ± 9.2	<0.001*
Range	59–88	65–103	
HR after 20 min (beat/min)			
Mean ± SD	79.7 ± 11.19	85 ± 9.31	0.016*
Range	57–103	65–104	
HR after 30 min (beat/min)			
Mean ± SD	77.27 ± 8.94	85 ± 9.28	<0.001*
Range	59–102	66–103	
P value	***P*1: 0.958 *P*2: 0.236 *P*3: 0.991**	***P*1: < 0.001* *P*2: < 0.001* *P*3: < 0.001***	

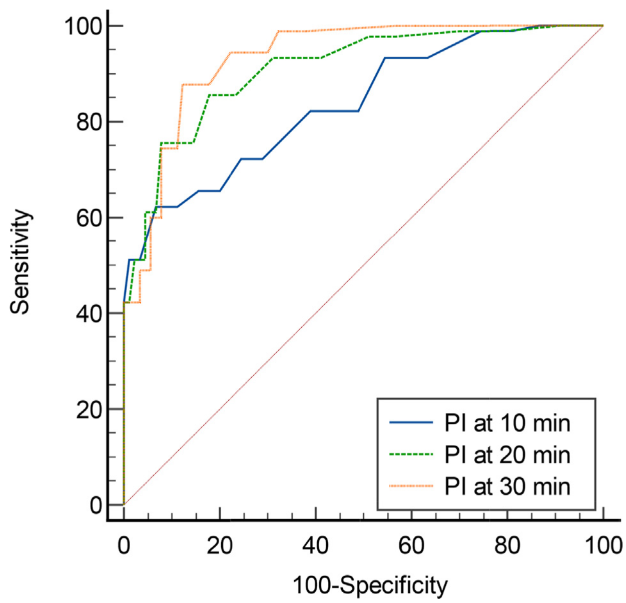

Fig. 2. Time to need analgesics in the time interval between the studied groups.

block (AUC: 0.826), at a cut-off value of >1.4 it has a sensitivity of 87.7 % and specificity of 58.9 %. PI at 30 min was a substantial indicator of successful block (AUC: 0.802), at a cut-off value of >1.4 it has a sensitivity of 93.3 % and specificity of 53.3 % Table 4, Fig. 2.

Regarding the change in HR in the time interval after local anesthetic injection:

There was no substantial variance in HR at baseline among both studied groups, but it was significantly higher at 10, 20, and 30 min afterward local anesthetic injection in group II contrasted with group I. In group I, there was no a substantial variance in HR 10, 20, and 30 min afterward local anesthetic injection compared to HR at baseline. In group II, HR 10, 20, and 30 min afterward local anesthetic injection were significant difference compared to HR at baseline ($P < 0.001$) Table 5.

Regarding the change in MAP in the time interval after local anesthetic injection:

There was no substantial variance in MAP at baseline among both studied groups, but it was significantly higher 10, 20, and 30 min afterward local anesthetic injection in group II contrasted with group I. In group I, there was no substantial difference in MAP 10, 20, and 30 min afterward local anesthetic injection compared with MAP at baseline. In group II, MAP at 10, 20, and 30 min following local anesthetic injection were significantly higher compared to HR at baseline ($P < 0.001$) Table 6, Fig. 3.

4. Discussion

The result of the present study revealed that following local anesthetic injection, there was not a substantial variance in the PI change or ratio at baseline, after 10 min, after 20 min, and after 30 min among the two groups (see Fig. 3). After local anesthetic injection, PI increased significant in both groups after 10, 20, and 30 min compared to pre-injection PI ($P < 0.001$).

Kim *et al.*[5] also found no significant difference in PI or PI ratios among the 2 groups after controlling for time interval ($P = 0.894$ and $P = 0.079$, correspondingly). Both groups' PI levels were higher at 5 min after baseline ($P < 0.001$).

The result of the present study revealed that Slowly absorbed epinephrine injected perineurally alters HR and blood pressure however has little impact on mean arterial pressure 1. Due to the importance of mean arterial pressure when evaluating the association among systemic resistance, blood flow and pressure, this can be one of the explanations for why perineural epinephrine injection has no impact on PI or the PI ratio.

Table 5. Change in MAP in the time interval between the studied groups.

	Group I ($n = 50$)	Group II ($n = 50$)	P value
MAP at Baseline (beat/min)			
Mean ± SD	76.71 ± 5.99	75.79 ± 6.81	0.5
Range	65–91	63.72–95.13	
MAP after 10 min (beat/min)			
Mean ± SD	74.58 ± 5.82	81.96 ± 6.94	<0.001*
Range	63–87	71–103	
MAP after 20 min (beat/min)			
Mean ± SD	75.98 ± 5.63	82.02 ± 6.84	<0.001*
Range	62–93	71–102	
MAP after 30 min (beat/min)			
Mean ± SD	75 ± 5.27	82.2 ± 6.9	<0.001*
Range	64–91	71–103	
P value	***P*1: 0.095** ***P*2: 0.496** ***P*3: 0.118**	***P*1: < 0.001*** ***P*2: < 0.001*** ***P*3: < 0.001***	

MAP, Mean arterial pressure.

Table 6. Time to need analgesics in the time interval among the researched groups.

	Group I ($n = 50$)	Group II ($n = 50$)	P value
Time to need analgesics			
Mean ± SD	13.56 ± 0.78	20.29 ± 1.34	<0.001*
Range	12−15	18−22	

After 10, 20, and 30 min, we found that in both groups, the blocked arm had a significant higher PI change and ratio than the unblocked arm.

Our findings are consistence with those of **Kim** ***et al.***,[5] who also found that the PI and PI ratio changed much more in the unblocked arms over time than in the blocked arms ($P < 0.001$).

Additionally, **Karthik and Vishwanath Ankad.**[3] conducted a related investigation on 95 cases with elective upper limb surgeries.20 mL of 0.5 % bupivacaine were injected into each patient's supraclavicular space under US guidance. Sensory and motor blocks were tested at 5-min intervals, with further tests including pinprick sensation and gravity-defying elbow and hand flexion. At pre-injection baseline and at 10, 20, and 30 min post-injection of local anesthetic, two independent pulse oximeters were used to evaluate the PI in the blocked limb and the contralateral unblocked limb. 5 min later, the blocked arm's PI had caught up with, and even surpassed, that of the unblocked arm and the initial value. PI and PI ratio in the blocked arm were both significantly distinct from zero.

The result of the present study confirmed that PI and PI ratio changes at 10, 20, and 30 min are significant indicators of effective blockage.

Similarly, **Kim** ***et al.***[5] found no significant differences in ROC curves over time by comparing the two groups. This is consistent with our findings that the PI and PI ratio were not considerably distinct among the 2 groups. Next, it was shown that both PI and the PI ratio at 5 min (PI ratio 5) were highly predictive of a successful block. With a threshold of >7.7, the AUROC for the PI was 0.89 (95 % CI 0.83−0.94), and with a threshold of >1.6, the AUROC was 0.94 (95%CI 0.90−0.98). The sensitivity and specificity of the PI ratio 5 were 0.89 (95 % CI 0.83−0.94) and 0.79 (95 % CI 0.69−0.87), consequently; the sensitivity and specificity of the PI at 5 min were 0.87 (95 % CI 0.79−0.94) and 0.89 (95 % CI 0.80−0.95), respectively.

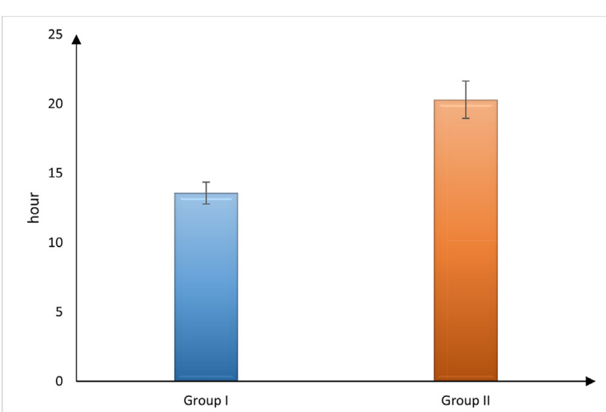

Fig. 3. CONSORT flowchart of the enrolled patients.

The result of the present study revealed that Both groups' resting HR and MAP were comparable in our investigation. However, group II's HR was significantly higher than group I's at 10, 20, and 30 min following local anesthetic administration ($P < 0.001$, 0.016, and<0.001, respectively). There was no substantial variance in HR before and after local anesthetic injection (group I) at 10, 20, or 30 min 10, 20, and 30 min following receiving a local anesthetic injection, group II had significant increase in HR and MAP than group I had at baseline.

High dosage of epinephrine added to local anesthetics increases HR and systolic blood pressure, This corroborated the outcomes of **Dogru** ***et al.***[7]

Brown ***et al.***[8] found that perineural epinephrine had no impact on arterial blood pressure.

Our results for SCB disagree with those reported by **Youssef** ***et al.***,[9] who found no substantial variance among bupivacaine alone and the inclusion of epinephrine. This difference can be explained by the varied amounts of anesthetics employed; although this research administered 20 ml of bupivacaine and 5 μg/ml of epinephrine, we utilized an injection comprising (12.5 ml of bupivacaine 0.5 % and 12.5 ml of lidocaine 2 %) and 1 ml of saline containing 5 mcg of epinephrine.

Our study had limitations such as It was a single-center study, and the results may differ elsewhere., small sample size which may produce inaccurate results. Different doses of epinephrine were not used.

4.1. Conclusion

Pulse oximeter perfusion index changes and PI ratio can be used as reliable predictors of success of SCB in upper extremity operation. However, epinephrine produces no difference in perfusion index compared to local anesthetic alone. Future multicenter studies are recommended with Larger sample size is important in future studies.

Disclosure

The authors have no financial interest to declare in relation to the content of this article.

Authorship

All authors have a substantial contribution to the article.

Conflicts of interest

The authors declared that there were no conflicts of interest.

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