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Comparison of Variation in Perfusion Index of Upper Limb and Lower Limb and Its Correlation with Intraoperative Hypotension and Sensory Block Following Subarachnoid Block in Femur Surgeries: A Prospective Observational Study

Sandeep Kumar[1], Vandana Pandey[2], Jain Shikha[3*], Koovakattil Akhil kuttan[4], Vaishli Waindeskar[5], Harish Kumar[6], Zainab Ahmad[7],

[1]MD (Anesthesia), Assistant Professor, Department of Anesthesia, AIIMS Bhopal (MP), India.
[2]MD (Anesthesia), Assistan Professor, Department of Anesthesia, Gandhi Medical College, Bhopal (MP), India.
[3]MD (Anesthesia) EDAIC (European Diploma in Anesthesiology and Intensive Care), Assistant Professor, Department of Anesthesia, AIIMS Bhopal (MP), India.
[4]MD (Anesthesia), Senior Resident, Department of Anesthesia, AIIMS Bhopal (MP), India.
[5]MD (Anesthesia), Professor, Department of Anesthesia, AIIMS Bhopal (MP), India.
[6]MD (Anesthesia), Assistant Professor, Department of Anesthesia, AIIMS Bhopal (MP), India.
[7]MD (Anesthesia), Additional Professor, Department of Anesthesia, AIIMS Bhopal (MP), India.

Email: itzshikhahere@gmail.com,

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ABSTRACT:

Background: Hypotension is commonly encountered following spinal anaesthesia, resulting from sympathetic blockade and decreased cardiac output. Perfusion index (PI) is a valuable objective during anaesthetic-practice for early prediction of hypotension. This study aimed to compare variations in upper limb and lower limb PI following subarachnoid block in femur surgeries and also investigate its correlation with intraoperative hypotension and sensory blockade.

Methods: In this prospective observational study, 100 American Society of Anaesthesiologists (ASA) I & II, aged 20-50 years, patients scheduled for elective femur surgeries were enrolled. PI and blood pressure were noted at baseline, at every minute for five minutes, and every five minutes till 30 minutes in both upper limb and lower limb, after administration of subarachnoid block tailored according to patient's weight and duration of surgery. Incidence of hypotension was noted at all observation time points. Spearman's rank correlation coefficient was used to assess correlation between baseline PI and the number of episodes of hypotension and onset of sensory blockade. A Receiver Operating Characteristic (ROC) curve was obtained for baseline PI compared with hypotension episodes of 100 patients and a p-value of <0.05 was considered as statistically significant.

Results: The incidence of hypotension is higher with baseline preoperative PI >3.2. The intraoperative increase in PI of lower limb is associated with a simultaneous decrease in PI of the upper limb and increased incidence of episodes of hypotension at various time intervals. Also, there was no correlation between sensory block time and perfusion index.

The ROC curve revealed that PI discriminated well between patients who developed hypotension versus those who did not; it yielded a new baseline PI value of 3.2 as cut-off point for predicting hypotension in patients undergoing femur surgeries under subarachnoid block with a sensitivity and specificity of 82%and 79% respectively.

Conclusion: PI > 3.2 at baseline has a higher risk of hypotension following subarachnoid block in femur surgeries.

Keywords: Perfusion index, subarachnoid block, hypotension.

1. Introduction

Spinal anaesthesia is the preferred method of anaesthesia for lower limb surgeries, as it is devoid of systemic pharmacologic side effects, and provides good post-operative analgesia. However, hypotension is its most common side effect due to sympathetic blockade and decreased cardiac output [1]. It leads to selective vasodilatation of lower limbs and relative vasoconstriction of upper limbs.

Non-invasive blood pressure (NIBP) measurement is the standard method of monitoring intra-operative haemodynamics. However, its usefulness is undermined by its failure to record beat to beat variation and promptly predict intraoperative hypotension.

Perfusion index (PI) is a relatively new parameter to predict hemodynamic responses during spinal anaesthesia and is calculated using infrared spectrum as part of plethysmography waveform processing. It is a simple, cost effective and non-invasive method of assessing peripheral perfusion and is determined by percentage of pulsatile to non- pulsatile blood flow in the extremities based on amount of infrared light absorbed. [2] It indicates the status of the microcirculation which is densely innervated by sympathetic nerve, and therefore, is affected by multiple factors responsible for vasoconstriction or vasodilatation of the microcirculation.

Hence, PI can be used to assess peripheral perfusion dynamics and is being considered as a

non- invasive method to detect the likelihood of development of hypotension following subarachnoid block (SAB).[3] It is a valuable indicator during anaesthetic practice to predict the hemodynamic responses to anaesthetic drugs, techniques and intra operative stimuli. However, there is limited data regarding its use for prediction of incidence of hypotension occurring as a result of central neuraxial blockade.
This study was aimed with primary objective to assess a correlation between perfusion index and intraoperative hypotension and also to assess the relative change in perfusion index of upper limb and lower limb following subarachnoid block in femur surgeries. The secondary objective of the study is to determine a correlation between PI and sensory block following subarachnoid block in femur surgeries.

$$PI = \frac{AC_{IR}}{DC_{IR}} \times 100$$

2. Material and methods

After approval by the Institutional Human Ethics Committee and written informed consent, this prospective observational study was conducted at our tertiary care Institute in the Department of Anaesthesiology. We recruited 100 American Society of Anaesthesiologists (ASA) I & II patients of either sex, aged 20 to 50 years, posted for elective femur surgeries under subarachnoid block.
Emergency surgeries, patients with medical co-morbidities like hypertension, diabetes mellitus, liver, cardiac or neurological disease; pre-existing haematologic or coagulation disorder; infection of skin over the back; neuropathy; presence of spinal deformity; patients on any anticoagulants were excluded from the study.
Patients underwent preoperative assessment and were kept nil per oral for 6 hours for solids and 2 hours for clear liquids. Standard monitoring with electrocardiography (ECG), non-invasive blood pressure (NIBP) and pulse oximetry (SpO_2) was performed for baseline values and intraoperative monitoring. The ambient OT temperature was maintained at 22-26°C.After securing intravenous (IV) access, patients were co-loaded with ringer lactate (10 ml/kg).
Next, perfusion index of upper limb and lower limb was recorded using MINDRAY 562A pulse oximeter in supine position. In the upper limb, probe was placed on thumb of the arm with IV cannula and for lower limb on the great toe of the non-operative limb. Proper care was taken to avoid bodymovement, any excess pressure over sensor and contamination by ambient light by covering the oximeter probe with a drape.
Spinal anaesthesia was given according to standard practice with 25G Quincke's needle in a sitting position at L3-L4 or L2-L3 interspace using hyperbaric Bupivacaine (0.5%) with all aseptic precautions tailored according to the patient's weight and duration of surgery. The sensory blockade was assessed using the spirit swab method and the dermatome level was assessed every one minute until the level got stabilised. Measurement of HR, SBP, DBP, MAP and PI of both upper and lower limbs were noted at every minute till 5 minutes, followed by every 5 minutes till 30 minutes.
Intra-operative hypotension was defined as a drop in systolic BP to less than 30% of baseline or mean arterial pressure less than 60 and was treated with IV mephentermine (6mg) and other side effects such as bradycardia (defined as heart rate<50/ minute was treated with Atropine 0.6 mg). Any other adverse effects such as nausea and vomiting were noted and managed. Oxygen was not routinely given unless the arterial oxyhaemoglobin saturation obtained from the pulse oximeter decreased to<95%.

Statistical analysis

Sample size

Statistical analyses were performed by using SPSS software version 21. Statistical analysis was performed using the chi-square test, and independent sample t-test. Regression analysis with Spearman's rank correlation coefficient was done to assess the correlation between baseline PI with other parameters like onset of sensory blockade and episodes of hypotension. A Receiver Operating Characteristic (ROC) curve was obtained for baseline PI compared with the hypotension episodes of 100 patients and a p-value of <0.05 was considered as statistically significant.

3. Results

A total of 109 patients were assessed in the study. Nine patients were excluded from the study due to inadequate levels of the sensory blockade and conversion to general anaesthesia. Thus, a total of 100 patients were included in the study. Analyzed (N=100)

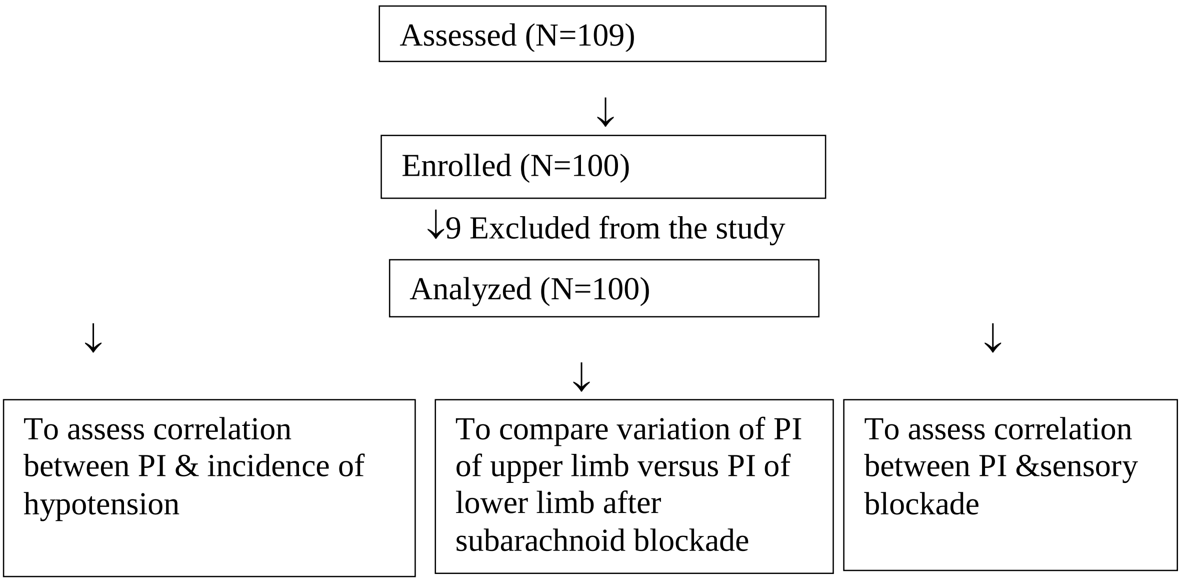

Figure 1: Consort Diagram

The demographic variables were comparable concerning age, sex distribution, weight and ASA physical status with the average of patients being 42.16±13other .11, male /female ratio of 62/38 and ASA I and II ratio of 58/42. Mean heart rate showed significant increase at 1 minute from baseline followed by significant decrease in next 20 minutes.) We noted the change of mean SBP,DBP,MAP from baseline to final follow up at 30 minutes and found that it decreased continuously. The mean blood pressure in our study falls from baseline concurrently with a continual increase in the perfusion index at different time intervals. When we correlated the percent increase of perfusion index (LL) with the percent decrease of mean blood pressure statistically it was found to be significant (p <0.01)

	MAP MEAN±SD	**Statistical significance**
BASELINE	111.33±12.76*	
1 minute	106.12±11.12*	<0.01 Significant
2 minute	105.96±14.24*	<0.01 Significant
3 minute	103.10±15.66*	<0.01 Significant
5 minute	97.33±20.12*	<0.01 Significant
10 minute	93.42±17.06*	<0.01 Significant

15 minute	92.32±14.82*	<0.01 Significant
20 minute	91.11±16.38*	<0.01 Significant
25 minute	89.14±13.76*	<0.01 Significant
30 minute	89.02 ± 13.12*	<0.01 Significant

Table: 1 Comparison of mean of mean arterial pressure (MAP) in mmHg.

	Perfusion Index of Lower Limb (Mean±Sd)	**Statistical significance**
baseline	1.42±0.86	
1minute	1.98±0.76	<0.01 Significant
2 minute	2.24±0.96	<0.01 Significant
3 minute	2.76±0.80	<0.01 Significant
5 minute	3.14±0.92	<0.01 Significant
10 minute	3.38±0.88	<0.01 Significant
15 minute	3.64±0.76	<0.01 Significant
20 minute	3.78±0.74	<0.01 Significant
25 minute	4.06±0.66	<0.01 Significant
30 minute	4.16±0.79	<0.01 Significant

Table: 2 Comparison of mean perfusion index of lower limb

Correlation of mean sensory block time with perfusion index at various time intervals
When we correlated mean sensory block time with perfusion index from baseline to 30 minutes, no significant correlation found (p>0.05).

PI (lower limb)	**Mean+/- SD**	**SBT mean +/-SD**	**Correlation coefficient (r-value)**
BASELINE	1.42±0.86	3.86+/ -0.88	-0.119
1 min	1.98±0.76		-0.104
2 min	2.24±0.96		-0.89
3 min	2.76±0.80		+0.115
5 min	3.14±0.92		-0.122
10 min	3.38±0.88		+0.067
15 mins	3.64±0.76		+0.086
20 mins	3.78±0.74		+0.0268
25 mins	4.06±0.66		-0.456
30 mins	4.16±0.79		+0.074

Table: 3 Correlation of mean sensory block time with perfusion index at various time intervals

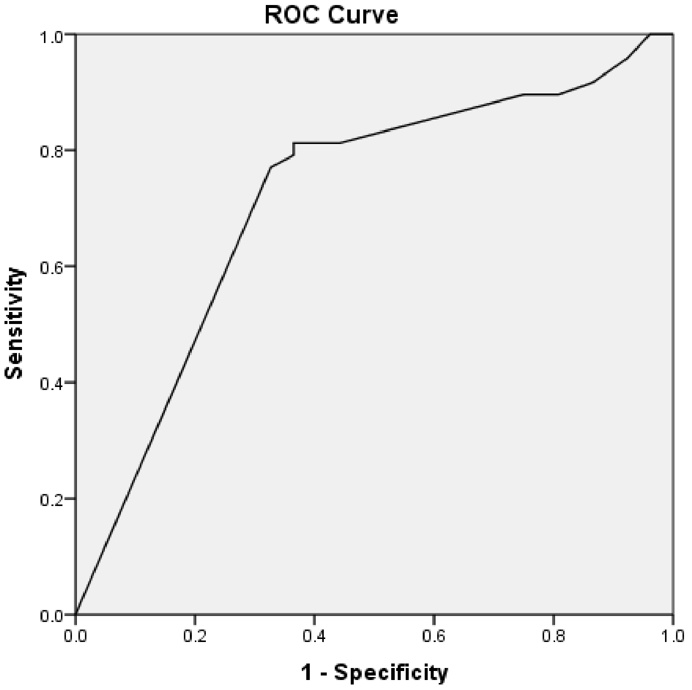

Figure 2: ROC Curve

Area	**Std. Error[a]**	**Asymptotic Sig.[b]**	**Asymptotic 95% Confidence Interval**	
			Lower Bound	Upper Bound
.716	.053	.000	.612	.819

The test result variable(s): BP has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.
a. Under the nonparametric assumption
b. Null hypothesis: true area = 0.5
To correlate the baseline perfusion index and incidence of intraoperative hypotension, a ROC curve (Receiver operating characteristic) was plotted in which cut off value of baseline perfusion index (> 3.2) was highly predictive for intraoperative hypotension with sensitivity of 76.30%, specificity of 81.2%, PPV-55.8 and NPV-62.9. Confidence interval 95% Area of ROC – 0.716

4. Discussion

In present study we found that baseline preoperative value of perfusion index (>3.2) is associated with increased incidence of intraoperative hypotension. The ROC curve revealed that PI discriminated well between patients who developed hypotension versus those who did not; it yielded a new baseline PI value of 3.2 as cut off point for predicting hypotension in patients undergoing femur surgeries under subarachnoid block with a sensitivity and specificity of 82% and 79% respectively.

Our study has shown that baseline hemodynamic variables viz. heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP) and PI in all the patients at the start of procedure were comparable with no significant difference.

In our study we found that heart rate was increased at 1 minute followed by a decreasing trend till 30 minutes. The initial tachycardia could be attributed to the anxiety regarding procedure with the heart rate settling gradually. According to Carpenter *et al*.[4] (1992) usually a decrease in heart rate occurs during spinal anaesthesia which is similar to our study except the initial 3 minutes. IclalOzdemir Kol*et al*. (Holmes,[5] 1959) also noted a decrease in heart rate after spinal anaesthesia in control group.

The SBP, DBP and MAP showed a decreasing trend till 30 minutes after subarachnoid block, similar to Klohr et al[6] (1999) who conducted a retrospective study in which they found that hypotension is most common complication during spinal anaesthesia for caesarean section.

The perfusion index of upper limb decreased till 30 minutes after SAB which indicates that our study is in concurrence with that of Hiroyuki Sumikura*et al*.[7] (2008) observed that the Perfusion Index- Finger showed a precipitous drop at 5 minutes to a value of 3.2 from the baseline value of 4.9 after the spinal anaesthesia.

We also found that the perfusion index of lower limb increased till 30 minutes after SAB similar to Galvin et al[9] (2006) who observed an increase in PI values compared with baseline, beginning as early as 3 minutes after local anaesthetic injection and reaching statistical significance at a time of 12 minutes and 10 minutes for sciatic and axillary block respectively. They also noted that patients with failed blocks demonstrated minimal or no change in PI value suggesting that the increase in PI value is directly related to blockade than serum levels of local anaesthetic.

In our study, we found that the mean sensory block time was 3.86+/-0.88 and there was no correlation between baseline PI and onset of the sensory block as was found in the study conducted by M Chaudhary et al [10]

In the present study, we found that the baseline preoperative value of perfusion index (>3.2) is associated with an increased incidence of intraoperative Hypotension. The ROC curve revealed that PI discriminated well between patients who developed hypotension versus those who did not; it yielded a new baseline PI value of 3.2 as the cutoff point for predicting hypotension in patients undergoing femur surgeries under subarachnoid block with a sensitivity and specificity of 82%and79% respectively. Likewise, Toyama et al[11] (2013) also observed that a higher baseline perfusion index (>3.5) is associated with profound hypotension in pregnant females posted for LSCS with a sensitivity and specificity of 81% and 86%, respectively. In the study conducted by P Sridhar et al[12] a baseline PI > 3.45 was associated with a higher incidence of hypotension.

Yokose et al[13] demonstrated that the perfusion index had no predictive value for hypotension in LSCS. This was significantly due to methodological differences.

The principle of SpO_2 is based on two light sources with different wavelengths 660 nm and 940 nm, emitted through cutaneous vascular bed of finger or earlobe. The absorbance of both wavelengths has a pulsatile component, which represents fluctuations in the volume of arterial blood between the source and the detector. The non-pulsatile component is from connective tissue, bone and venous compartment. The perfusion index (PI) is the ratio of the pulsatile component (arterial) and non-pulsatile component of light reaching the detector.

The study also revealed a significant fall in systolic, diastolic, and mean blood pressure from baseline values over 30 minutes. There was significant increase in Perfusion index (PI) of the lower limb with a significant decrease of perfusion index (PI) of upper limb.

A higher PI value indicates a stronger pulsatile signal & better peripheral circulation at the sensor site. Hence an increase in PI on the site of the block may be a reliable determinant of the efficacy of regional block. Various studies (Hyuga et al [2012] and Ziferg et al 2013) showed an increase in PI following spinal and caudal block. The dose of local anaesthetic used in our study was decided by the patient's age, weight and duration of surgery as a fixed dose of bupivacaine would have contributed to bias. Also, severe hypotension defined as fall in systolic BP by 30% and absolute MAP<60mmHg was treated aggressively with fluid bolus and mephentermine as various studies have demonstrated that even transient fall in MAP<60mmhg can contribute to significant organ dysfunction.

PI is a more reliable parameter of baseline sympathetic tone and vasodilatation, which gives faster and more easily quantifiable results were studied as a potential tool for reliably and consistently marking onset of sympathetic block even before sensory block has set in. This is the perfusion index which combines simplicity, cost effectiveness, reliability and easy availability.

There are many limitations in this study. Patient movement and any stimulus increasing sympathetic activity like anxiety could easily change the PI values. In this study, we recorded baseline PI values with utmost care to avoid patient movement, especially while recording baseline values and all patients were counselled before taking them up for surgery to allay anxiety. Other variables like individual variation in perfusion index, instrument variability, any sympathetic activity and older age group where the vascular tone is altered pose a problem which is why further studies studying comparison of perfusion index with other invasive accepted hemodynamic variables are required before PI can be recommended universally as a predictor of hypotension.

However, several studies have been conducted to study the role of perfusion index such as haemodynamic response to intubating laryngeal mask [14], haemodynamic and catecholamine response to tracheal intubation[15], indicator for epidural block onset[16] , fluid responsiveness in mechanically ventilated patient [17], clinical application (sepsis) in paediatric patients [18], fluid responsiveness in major surgeries[19], caudal block onset in paediatric patients[20], in successful brachial block[21] and the screening of peripheral vascular disease.[22]

5. Conclusion

In nutshell we demonstrated that there was a significant decrease in the PI of upper limb and increase in the PI of lower limb following SAB. In our study we did not find any correlation between PI and onset of sensory block time. Also, a baseline PI cut-off value of
3.2 can be used to identify intraoperative hypotension following SAB in femur surgeries.

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Conflict of interest – None

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