

Evaluation of Perfusion Index as a Predictor of Hypotension Following Spinal Anaesthesia in Lower Limb Orthopaedic SurgeriesSanket Site¹, R.P. Kaushal², Twinkle Kewalramani¹, Rajkumar Ahirwal³¹Junior Resident, Department of Anaesthesiology, Gandhi Medical College, Bhopal, Madhya Pradesh, India²Professor & H.O.D., Department of Anaesthesiology, Gandhi Medical College, Bhopal, Madhya Pradesh, India³Associate Professor, Department of Anaesthesiology, Gandhi Medical College, Bhopal, Madhya Pradesh, India

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Conflict of interest: Nil

Abstract:**Introduction:** Subarachnoid block (SAB) is commonly used for lower limb and abdominal surgeries due to its benefits like reduced bleeding and good operative conditions. However, it can cause side effects like hypotension and bradycardia due to sympathetic blockade, reduced cardiac output, and peripheral blood pooling.

Non-invasive blood pressure (NIBP) monitoring has limitations in detecting beat-to-beat perfusion variations. Perfusion index (PI), measured via pulse oximetry, assesses perfusion dynamics and may predict hypotension after subarachnoid block (SAB). This study aimed to determine if a baseline PI >3.5 predicts hypotension following spinal anesthesia.

Perfusion index (PI), measured by pulse oximetry, reflects peripheral blood flow and vasomotor tone, influenced by factors like sympathetic tone, pain, and temperature. It indicates variations in blood volume and sympathetic vascular tone. PI changes with vasodilation and regional blocks, serving as a non-invasive marker of perfusion and sympathetic activity.

Aims and Objectives: To evaluate the correlation between baseline perfusion index and incidence of hypotension following subarachnoid block in Lower limb orthopedic surgeries.**Methodology:** The study was conducted in Department of Anesthesiology, Gandhi Medical College Bhopal for a period of 1.5 years. This observational prospective cohort study involved 60 patients (aged 15-60, ASA grade I/II) undergoing lower limb orthopedic surgeries. Preoperative perfusion index (PI) was recorded, and various vital parameters were monitored during surgery. Subarachnoid block with 0.5% bupivacaine was administered, and blood pressure changes were compared to preoperative PI. Hypotension episodes were analyzed to assess PI's predictive value for intraoperative hypotension.**Result:** Demographic variables like age, weight, and surgery indication were similar across both groups and did not affect results. A significant difference in intraoperative blood pressure (SBP, DBP, MAP) was observed, with the PI >3.5 group showing a greater drop. Hypotension occurred in 73.3% of PI >3.5 patients versus 16.7% in PI <3.5 patients. Surgery duration and nausea/vomiting incidence were similar in both groups, with no respiratory distress or pruritus reported.**Conclusion:** The study found that a preoperative perfusion index (PI) >3.5 correlates with a higher incidence of intraoperative hypotension in lower limb orthopedic surgeries under spinal anesthesia compared to PI <3.5.This is an Open Access article that uses a funding model which does not charge readers or their institutions for access and distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>) and the Budapest Open Access Initiative (<http://www.budapestopenaccessinitiative.org/read>), which permit unrestricted use, distribution, and reproduction in any medium, provided original work is properly credited.**Introduction**

Subarachnoid block (SAB) is commonly used for lower limb and lower abdominal surgeries due to its advantages, such as excellent relaxation, reduced bleeding, and a good operative field. However, common side effects of SAB include hypotension and bradycardia, resulting from sympathetic blockade and reduced cardiac output. Additionally, peripheral blood pooling associated with this technique can cause severe hypotension. The incidence of intraoperative hypotension after spinal

anesthesia ranges from 8-33%, depending on the criteria used to define it. Risk factors for hypotension include high-level block (above T5), elderly age, female gender, obesity, low baseline blood pressure, and comorbidities like diabetes and hypertension.[1]

Non-invasive blood pressure (NIBP) monitoring is a standard method for tracking blood pressure during surgery but is limited in detecting beat-to-beat

variations in perfusion dynamics. Perfusion index (PI), a measure derived from pulse oximetry, can assess perfusion dynamics by calculating the ratio of pulsatile to non-pulsatile blood flow in peripheral tissue. PI provides real-time feedback on blood flow and sympathetic vascular tone, making it a potential tool for detecting the risk of hypotension following SAB.[2,3]

Recent studies have shown that PI increases during successful spinal anesthesia, indicating vasodilation and peripheral blood flow changes. A low PI can signal acute illness or circulatory disruption, making it a reliable indicator for monitoring patient condition. However, there is limited data on using PI to predict hypotension resulting from central neuraxial blockades.[4]

Aims and Objectives

To evaluate the correlation between baseline perfusion index and incidence of hypotension following subarachnoid block in Lower limb orthopaedic surgeries.

Materials and Methods

Place of Work: Department of Anaesthesiology, Gandhi Medical College and associated Hamidia Hospital, Bhopal

Duration: August 2022 to December 2023

Design of Study: Observational prospective cohort study (after getting permission from Institutional ethic committee).

Inclusion Criteria

1. Patients of ASA grade-I and ASA grade II
2. Age group 15-60 years of either sex.
3. All patients undergoing lower limb orthopaedic surgeries

Exclusion Criteria

1. Patient refusal or not giving consent.
2. Patient with history of cardiac, respiratory, renal or hepatic disease
3. Psychological disorders
4. Respiratory distress
5. Allergy to the local anaesthetics
6. Coagulation abnormalities

Study Protocol

The study was conducted after obtaining approval from institutional ethics committee. Sixty patients of ASA grade I and II were included in the study and divided into two groups of 30 each on the basis of baseline PI- 30 patients having PI >3.5 and 30 having PI <3.5.

Methodology

This observational study included 60 patients (aged 15-60 years, ASA grade I or II) scheduled for lower

limb orthopedic surgeries. Informed consent was obtained, and patients were kept nil by mouth for 6 hours before surgery. An intravenous line was established, and Ringer Lactate was infused. Preoperative perfusion index (PI) was recorded using a finger probe. Monitoring of vital signs, including heart rate, BP, SpO₂, ECG, MAP, and PI, was conducted throughout the surgery. Subarachnoid block was administered with 0.5% bupivacaine heavy. Blood pressure changes were compared to preoperative PI to investigate its correlation with intraoperative hypotension.

Technique: Emergency drugs and equipment were prepared before the procedure. Spinal anesthesia was administered using a Quincke's 25-gauge needle at the L3-L4 interspinous space, with 0.5% hyperbaric bupivacaine, under strict asepsis. Sensory block level was assessed 5 minutes after the injection, and once an adequate block was achieved, the patient was handed over to the surgeon. Intraoperative monitoring of vital signs, including heart rate, mean blood pressure, and oxygen saturation, was performed at 30-minute intervals for 150 minutes. The average of these measurements was statistically analyzed. Oxygen was delivered via face mask at 5 l/min throughout the procedure.

Parameters that were Observed:

- Demographic data- age and weight
- Preoperative baseline values-PI, SBP, DBP, MAP, HR, SPO₂
- Intraoperative values of PI, SBP, DBP, MAP, HR, SPO₂ immediately after induction, at 15 min, at 30 min, and every 15 minutes thereafter till 150 minutes.
- Incidence of hypotension
- Post-operative nausea and vomiting

Statistical Analysis: The presentation of the categorical variables was done in the form of number and percentage (%). On the other hand, the quantitative data were presented as the means \pm SD. The following statistical tests were applied for the results:

1. The comparison of the variables which were quantitative in nature were analysed using unpaired t-test.
2. The comparison of the variables which were qualitative in nature were analysed using Pearson Chi-Square test.

The data entry was done in the Microsoft EXCEL spreadsheet and the final analysis was done with using Epi info software.

For statistical significance, p value of less than 0.05 was considered statistically significant.

Sample Size Calculation: Sample size was calculated using the formula,

$$n = \{(Z \alpha/2 + Z1-\beta) * \sigma / (\mu1 - \mu2)\}^2$$

The sample size for each group can be calculated using the above formula.

Here $\mu1$ is the mean of group one and $\mu2$ is mean for group two. σ is the pooled standard deviation of two groups.

For $\alpha = 0.05$, $Z \alpha/2$ is 1.96

For power = 0.80, $\beta = 0.20$, $Z\beta = 0.84$

From previous literature, it was found that the mean baseline blood pressure between the two groups was statistically significant from 4th to 10th minutes with a mean SBP of 120+/-56.91 in low PI group and that of 90.21 +/- 8.58 in high PI group.

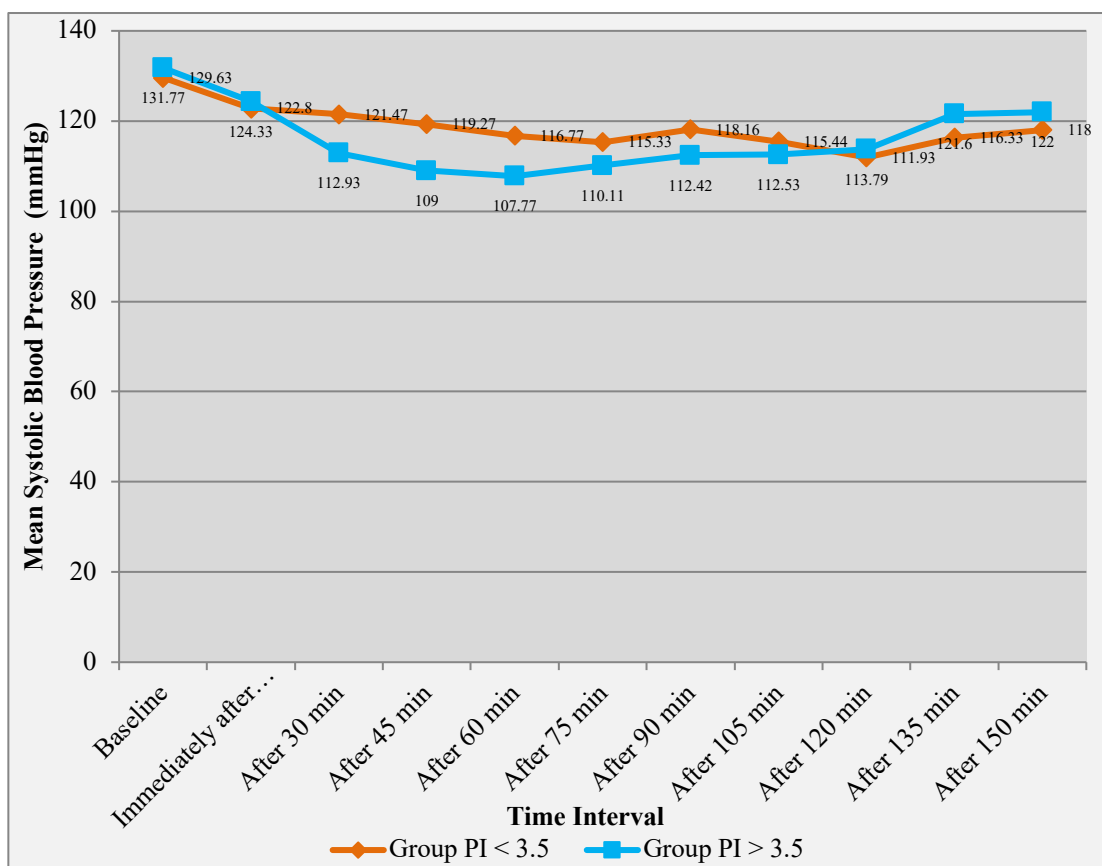
Putting the values in the above formula the sample size came out to be 30 in each group.

Result

Table 1: Comparison of Systolic Blood Pressure Between the Two Groups

Time Intervals	Groups		T value	P value
	PI<3.5 [Mean ± SD]	PI>3.5 [Mean ± SD]		
Baseline	129.63±10.79	131.77±13.94	-0.662,df=58	0.510
Immediately after induction	122.8±10.8	124.33±11.37	-0.535,df=58	0.594
At 30 min	121.47±9.81	112.93±11.3	3.1235,df=58	0.003
At 45 min	119.27±12.54	109±12.31	3.1998,df=58	0.002
At 60 min	116.77±10.34	107.77±11.89	2.9998,df=54	0.004
At 75 min	115.33±10.49	110.11±11.62	1.6102,df=46	0.114
At 90 min	118.16±12.33	112.42±9.9	1.5813,df=36	0.123
At 105 min	115.44±10.93	112.53±11.26	0.7516,df=31	0.458
At 120 min	111.93±11.82	113.79±12.13	-0.416, f=27	0.680
At 135 min	116.33±14.17	121.6±14.59	-0.605, df=9	0.560
At 150 min	118±15.02	122±0.00	-0.246, df=5	0.815

Unpaired ‘t’ test applied. P value <0.05 was taken as statistically significant.



Graph 1: Comparison of systolic blood pressure between the two groups

The above table and graph compared systolic blood pressure (SBP) at various time intervals between

two groups based on their perfusion index (PI). At baseline, there was no significant difference in SBP

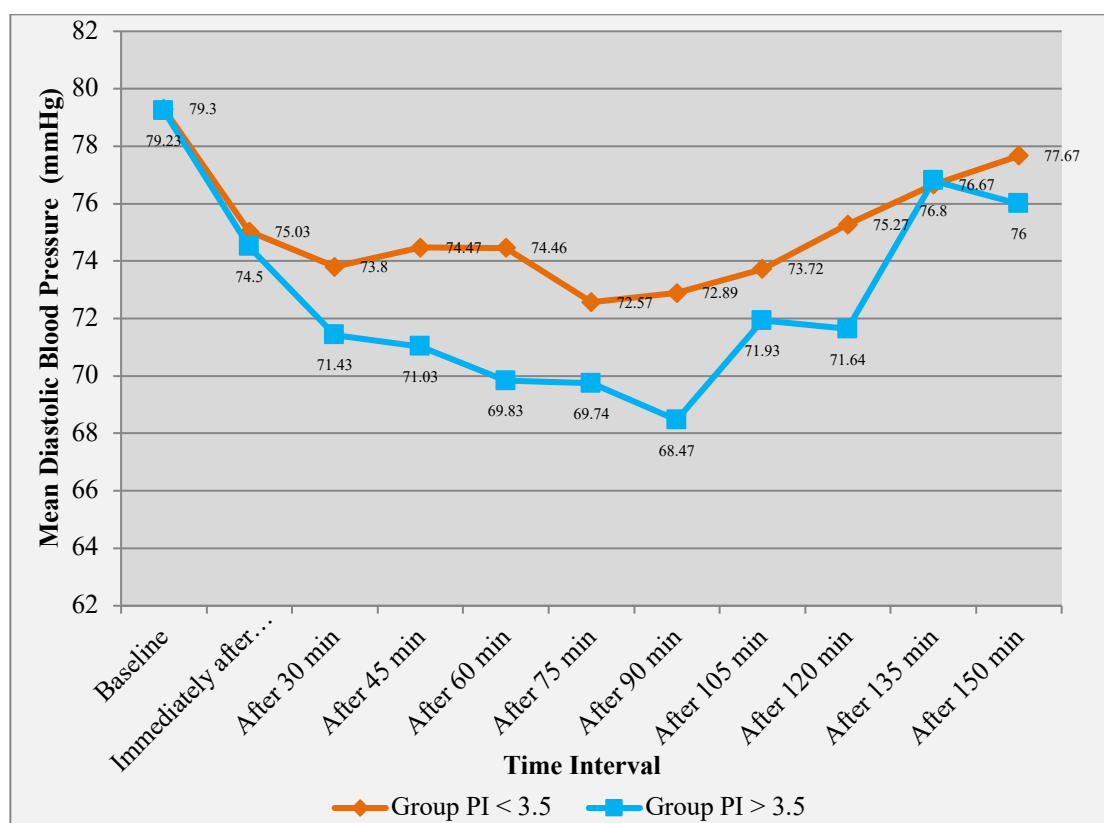
between the groups. However, significant differences emerged at 30, 45, and 60 minutes after induction, with Group PI < 3.5 showing higher SBP compared to Group PI > 3.5. At 30 minutes, the SBP for Group PI < 3.5 was significantly higher (121.47 mmHg vs. 112.93 mmHg), with a p-value of 0.003. Similar trends were observed at 45 minutes (119.27

mmHg vs. 109 mmHg, p = 0.002) and 60 minutes (116.77 mmHg vs. 107.77 mmHg, p = 0.004). No significant differences were found at 75, 90, 105, 120, 135, and 150 minutes. These findings suggest that SBP variations related to PI are most evident during the early post-induction period, particularly at 30, 45, and 60 minutes.

Table 2: Comparison of Diastolic Blood Pressure Between the Two Groups

Time Intervals	Groups		T value	P value
	PI<3.5 [Mean ± SD]	PI>3.5 [Mean ± SD]		
Baseline	79.3±8.34	79.23±8.95	0.0298,df=58	0.976
Immediately after induction	75.03±8.29	74.5±8.62	0.2442,df=58	0.808
At 30 min	73.8±6.4	71.43±9.6	1.1235,df=58	0.266
At 45 min	74.47±8.05	71.03±8.36	1.6198,df=58	0.111
At 60 min	74.46±6.75	69.83±7.41	2.4290,df=54	0.018
At 75 min	72.57±8.99	69.74±7.89	1.1606,df=46	0.252
At 90 min	72.89±7.9	68.47±7.66	1.7508,df=36	0.088
At 105 min	73.72±7.61	71.93±10.35	0.5715,df=31	0.572
At 120 min	75.27±9.3	71.64±9.92	1.0154,df=27	0.319
At 135 min	76.67±7.87	76.8±10.35	-0.024, df=9	0.981
At 150 min	77.67±7.94	76±0.00	0.2815, df=6	0.788

Unpaired ‘t’ test applied. P value <0.05 was taken as statistically significant.



Graph 2: Comparison of Diastolic Blood Pressure between the Two Groups

The above table and graph compared diastolic blood pressure (DBP) at various time intervals between two groups based on their perfusion index (PI). At baseline and immediately after induction, there was no significant difference in DBP between the

groups. At 30 and 45 minutes, no significant differences were observed. However, a significant difference emerged at 60 minutes, with Group PI < 3.5 showing higher DBP (74.46 mmHg) compared to Group PI > 3.5 (69.83 mmHg), with a p-value of

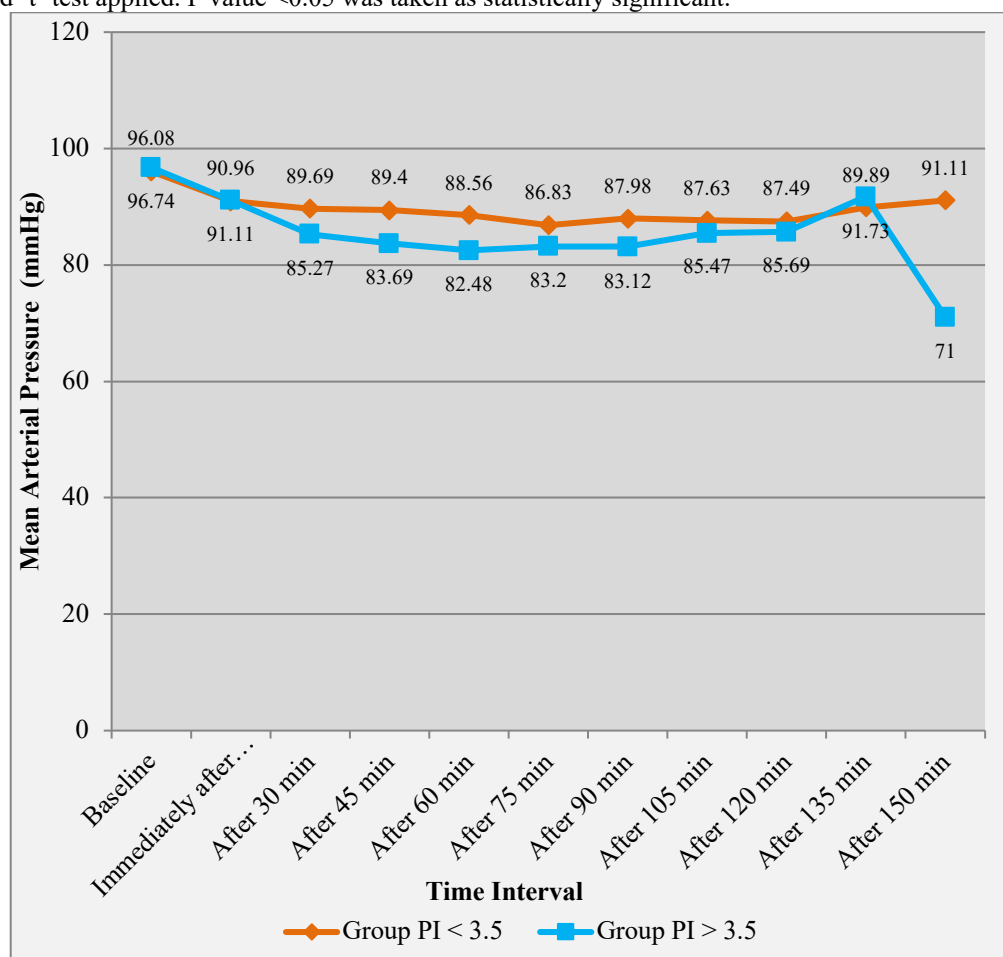
0.018. No significant differences were found at subsequent time points (75, 90, 105, 120, 135, 150 minutes). These findings suggest that DBP variations related to PI are most noticeable 60 minutes post-induction, with Group PI < 3.5

showing less decrease in DBP compared to Group PI > 3.5. The initial post-induction period was crucial for observing significant DBP changes linked to the perfusion index.

Table 3: Comparison of Mean Arterial Pressure Between the Two Groups

Time Intervals	Groups		T value	P value
	PI<3.5 [Mean ± SD]	PI>3.5 [Mean ± SD]		
Baseline	96.08±7.71	96.74±9.93	-0.290,df=58	0.772
Immediately after induction	90.96±8.1	91.11±8.89	-0.070,df=58	0.944
At 30 min	89.69±6.47	85.27±9.1	2.1697,df=58	0.034
At 45 min	89.4±7.93	83.69±8.74	2.6508,df=58	0.010
At 60 min	88.56±6.42	82.48±7.43	3.2542,df=54	0.002
At 75 min	86.83±8.72	83.2±7.23	1.5761,df=46	0.122
At 90 min	87.98±8.34	83.12±7.68	1.8684,df=36	0.070
At 105 min	87.63±7.7	85.47±10.25	0.6916,df=31	0.494
At 120 min	87.49±9.57	85.69±10.13	0.4914,df=27	0.627
At 135 min	89.89±9.66	91.73±11.75	-0.286, df=9	0.781
At 150 min	91.11±10.06	71±28.76	1.6523, df=6	0.150

Unpaired ‘t’ test applied. P value <0.05 was taken as statistically significant.



Graph 3: Comparison of Mean Arterial Pressure Between the Two Groups

The following table and graph compared mean arterial pressure (MAP) at various time points between two groups based on their perfusion index

(PI). At baseline and immediately after induction, no significant differences were observed between the groups. However, significant differences in MAP

emerged at 30, 45, and 60 minutes post-induction. At 30 minutes, Group PI < 3.5 had a higher MAP (89.69 mmHg vs. 85.27 mmHg, $p = 0.034$). This trend continued at 45 minutes (89.4 mmHg vs. 83.69 mmHg, $p = 0.010$) and 60 minutes (88.56 mmHg vs. 82.48 mmHg, $p = 0.002$), with Group PI < 3.5 consistently showing higher MAP. At later time points (75, 90, 105, 120, 135, and 150 minutes), no significant differences were found. These findings indicate that MAP variations related to PI are most pronounced during the early post-induction period, with significant differences observed at 30, 45, and 60 minutes.

Discussion

Subarachnoid block (SAB) for lower limb surgeries can cause hypotension due to sympathetic blockade, reduced cardiac output, and blood pooling. Perfusion index (PI), measured by pulse oximetry, reflects peripheral vascular tone and blood volume. High baseline PI may indicate lower vascular tone, increasing susceptibility to SAB-induced hypotension.

The overall mean age for all participants was 41.65 years, with a standard deviation of 11.73 years. The mean age for the PI < 3.5 group was 38.97 years (SD = 9.4), and for the PI > 3.5 group, it was 44.33 years (SD = 13.29).

The mean weight for patients in Group PI < 3.5 was 64.43 kg with a standard deviation of 10.43 kg. For patients in Group PI > 3.5, the mean weight was 64.40 kg with a standard deviation of 10.50 kg. The combined mean weight for all patients was 64.42 kg with a standard deviation of 10.37 kg.

The mean duration of surgery for patients in Group PI < 3.5 was 1.58 hours, with a standard deviation of 0.59 hours. For patients in Group PI > 3.5, the mean duration of surgery was 1.49 hours, with a standard deviation of 0.56 hours. The combined mean duration of surgery for all patients was 1.63 hours, with a standard deviation of 0.45 hours.

Initially, at baseline, the mean SBP for Group PI < 3.5 was 129.63 mmHg (SD = 10.79), while Group PI > 3.5 had a mean SBP of 131.77 mmHg (SD = 13.94).

Significant differences in systolic blood pressure were observed at 30, 45, and 60 minutes post-induction, with Group PI < 3.5 consistently showing less falling SBP. These differences were not observed at other time points, indicating that the initial period post-induction is crucial for observing SBP variations related to the perfusion index.

Our results on predicting systolic blood pressure (SBP) fall through preoperative perfusion index (PI) align with previous studies. Kiohr et al. (2010) found that different hypotension definitions impacted incidence rates.[5] Malima et al. (2019) identified

pre-spinal risk factors for hypotension in elderly patients, using a 25% fall in SBP.[6] Essam and Akram (2023) observed a significant negative correlation between PI and SBP changes in elective cesarean patients.[7]

Initially, at baseline, the mean DBP for Group PI < 3.5 was 79.3 mmHg (SD = 8.34), while Group PI > 3.5 had a mean DBP of 79.23 mmHg (SD = 8.95).

A significant difference in diastolic blood pressure was observed only after 60 minutes post-induction, with Group PI < 3.5 consistently showing less DBP. No significant differences were observed at other time points, indicating that the initial period post-induction is crucial for observing DBP variations related to the perfusion index.

Hosam M Atef et al. (2013) compared the effectiveness of perfusion index (PI) with traditional hemodynamic parameters in detecting stress responses during the insertion of I-gel, laryngeal mask airway (LMA), and endotracheal tube (ET) in elective general surgery. They found a significant correlation between increases in heart rate, systolic blood pressure (SBP), and diastolic blood pressure (DBP) with a decrease in PI, indicating a stress response.[8]

At baseline, the mean MAP for Group PI < 3.5 was 96.08 mmHg (SD = 7.71), while Group PI > 3.5 had a mean MAP of 96.74 mmHg (SD = 9.93). In our study we used MAP < 60 mmHg as cut off value to indicate an episode of hypotension.

Significant differences in mean arterial pressure were observed at 30, 45, and 60 minutes post-induction, with Group PI < 3.5 consistently showing less falling MAP. No significant differences were observed at other time points, highlighting specific periods where MAP variations related to the perfusion index are pronounced.

Shah et al. (2022) used Perfusion Index (PI) as an early predictor of hypotension during spinal anaesthesia in elective surgeries, defining hypotension as >20% decrease in MAP.[9] Ginosar et al. (2009) and Nazir et al. (2021) explored the correlation between changes in MAP, PI, and toe temperature after epidural block.[10,11] Dr. Taseen Mahvish et al. (2019) investigated PI's correlation with hypotension in elderly patients undergoing spinal anaesthesia, defining hypotension as MAP < 65 mmHg.[12] Sripada G Mehandale et al. (2017) studied PI's ability to predict hypotension following propofol induction during general anaesthesia by monitoring changes in SBP and MAP.[13]

The majority of patients in both groups did not experience nausea or vomiting: 29 patients (96.7%) in Group PI < 3.5 and 27 patients (90.0%) in Group PI > 3.5 reported no symptoms.

Majority of patients in Group PI < 3.5 (83.3%, 25 patients) did not experience any episodes of hypotension, compared to only 26.7% (8 patients) in Group PI > 3.5. This indicates more episodes of hypotension in patients with a PI > 3.5.

Conclusion

In our study the pre-operative perfusion index (PI) is found to correlate with the incidence of intra-operative hypotension in lower limb orthopaedic surgeries under spinal anaesthesia. The incidence of hypotension was more in PI >3.5 group than in PI <3.5 group. We conclude that patient undergoing lower limb orthopaedic surgeries under spinal anaesthesia having PI >3.5 have greater incidence of intra-operative hypotension than PI < 3.5.

Summary

This observational prospective cohort study aimed to evaluate the perfusion index (PI) as a predictor of hypotension following spinal anaesthesia in 60 patients undergoing lower limb orthopaedic surgery. Patients, aged 15-60 years and classified as ASA group I and II, were divided into two groups based on PI values: PI > 3.5 and PI < 3.5. The study found significant differences in intra-operative falls in SBP, DBP, and MAP, with the PI > 3.5 group experiencing greater reductions. Hypotension occurred in 16.7% of the PI < 3.5 group compared to 73.3% in the PI > 3.5 group, indicating a higher incidence in the PI > 3.5 group. The duration of surgery and incidence of nausea, vomiting, or respiratory distress were similar and not confounding factors. No patients experienced pruritus.

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