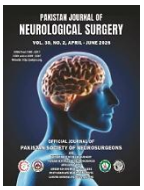

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Original Research

Correlation between Perfusion Index and Hypotension Following Spinal Anesthesia during Cesarean Section

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ABSTRATCT

Objective: To explore the predictive strength of baseline Perfusion index (PI) for hypotension during cesarean sections (CS). This study was designed to analyze the relationship between baseline PI >3.5 and the number of episodes of hypotension during cesarean section in spinal anesthesia.

Material & Methods: This correlational study was conducted at the Department of Anesthesiology, Lahore General Hospital. A sample of 65 primigravida women planned for elective CS were included in this study after informed consent. The procedure was performed as per the standard protocol of the hospital. Main variables like PI, mean arterial pressure, systolic blood pressure, and number of episodes of hypotension during surgery were recorded.

Results: Study findings reported that the mean age and BMI of patients were 28.48±5.74 years and 28.14±3.84 kg/m2, respectively. Among the 35 participants with a PI ≤3.5, 18 (53.3%) experienced hypotension, while in the PI >3.5 group, a significantly higher proportion, 31 (88.6%), developed hypotension (p = 0.002) with OR 6.13, CI 95% (1.77-21.3). Those with a baseline PI >3.5 have a significantly higher number of episodes as compared to those with a PI ≤3.5 (p = 0.000). Further, correlation analysis also showed a significant correlation between PI and hypotension.

Conclusion: In conclusion, this study demonstrates a significant association between baseline PI and the development of hypotension during CS under spinal anesthesia. Patients with a baseline PI >3.5 are at notably higher risk of hypotension.

Keywords: Cesarean Section, Hypotension, Maternal Outcomes, Perfusion Index, Predictive Marker, Spinal Anesthesia.

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INTRODUCTION

Anesthetists prefer Spinal anesthesia (SA) in cesarean section (CS) due to its ease of application and low incidence of severe perioperative challenges.[1] However, a complication called maternal Hypotension is common in SA, and its prevalence is reported between 7.4% to 74.1%.[2] This induced hypotension is observed due to a reduction in cardiac function, which is an outcome of blood pooling in blocked areas. Further, pregnant women are more sensitive to SA and present with low mean arterial blood pressure (MAP), but less sensitivity to vasopressor drugs.[3] Commonly, SA is preferred during lower-segment cesarean section (LSCS) unless any contraindication is present. Therefore, a high frequency of hypotension can be observed while performing LSCS in spinal neuraxial blockade,[4,5], and a timely assessment of this condition is essential.

Perfusion index (PI) is a noninvasive, cheap, and commonly available method for assessing the blood flow in extremities. It is the measure of the percentage of pulsatile to non-pulsatile blood flow in the extremities. It has various functions like continuous monitoring of hypotension, hypothermia, depth of anesthesia, adequacy of blood flow in newborns, and response to fluid therapy intraoperatively.[6,7] The role of PI can be vital in assessing hypotension, especially in CS procedures, due to its continuity and non-invasiveness. However, there is a need to validate its potential to assess hypotension and also need some cut-off values of PI which can help to decide the presence of hypotension, considering sensitivity and specificity as a tool.

There is vast literature that can guide in this condition; however, population-based characteristics can influence these findings, which need to be verified before the application. A pioneer study reported that there is a strong relationship between the baseline value of PI and the incidence of hypotension.[4, 8] Further, this study also categorized the patients considering a value of 3.5 as a threshold, and groups were ≤ 3.5 and > 3.5. Despite the high prevalence of hypotension, there is a scarcity in local literature that can confirm the correlation between PI and hypotension. This gap highlights the need for research to understand how PI, a marker of peripheral perfusion, relates to the development of hypotension during CS. By elucidating this relationship, tailored interventions can be developed to optimize maternal and fetal outcomes during cesarean deliveries.

The main objective of the study is to analyze the effectiveness of PI as a determinant of hypotension by having a relationship between baseline PI and hypotension during SA. In addition to this main objective, this study also assesses the efficacy of thresholds of PI, ≤ 3.5 and > 3.5, by comparing the prevalence of hypotension and its episodes in these two PI groups.

PATIENTS AND METHODS

Study Design & Settings

This study followed a prospective observational study design and was conducted at the Department of Anesthesiology, Lahore General Hospital, Lahore, over 6 months after the approval of the synopsis from 06/12/2023 to 06/06/2024.

Inclusion Criteria

This study has the following important thresholds for selection of patients for this study: (a) all female patients who were greater than 18 and less than 40 years of age at the time of study; (b) undergoing elective lower segment cesarean section; (c) ASA II physical status; (d) gestational age >36 weeks and <41 weeks.

Exclusion Criteria

In addition to these inclusion criteria, it is important to describe the exclusion criteria. This criterion is generally further confirmation of the inclusion criteria. Those patients who had (a) contraindication for spinal anesthesia (b) Body

mass index (BMI) > 40 (c) Cardiovascular disease (d) Cerebrovascular disease (e) Preeclampsia or Placenta Previa (f) Emergency LSCS (g) requirement of greater than 5 international unit (IU) of oxytocin (g) who fail to achieve sensory level blockade less than T7 after 5 minutes of spinal anesthesia (h) and any history of previous cesarean section, have been excluded from the study.

Ethical Approval

This study was approved by the Ethical Review Committee of Lahore General Hospital, Lahore.

Data Collection

This study chose a sample of 65 patients through a well-defined procedure, using 95% confidence interval and 5% margin of error, and at PI >3.5, the number of episodes of hypotension was r_s 0.416 [4]. The study sample was selected through purposive sampling, which is a type of non-random or non-probability sampling technique. This type of technique is preferred when the researcher wants to choose such people whose sampling frame is not available or accessible. Generally, it is associated with well-defined inclusion and exclusion criteria.

The main variables of the study have been measured through the following methods: Baseline PI was measured through the highest value recorded before preloading the patient. A pulse oximeter was used for this purpose and was attached to the monitor. Baseline systolic blood pressure (SBP) was measured through the averaging of the first three readings of SBP of patients after entering Operation Theater. Baseline Diastolic Blood Pressure (DBP) was computed through the mean of the first three readings of DBP. Baseline Mean Arterial Pressure (MAP) was the mean of the first three readings of MAP. Lastly, an episode of Hypotension was defined as MAP < 65 mmHg, assessed every two minutes for the first 20 minutes and then every 5 minutes till end of surgery. The episodes were noted.

A total of 65 primigravida women were recruited for elective LSCS after obtaining approval from the institutional ethical review board. A preoperative anesthesia assessment was done one day prior, and written informed consent regarding the SA procedure was obtained. On the day of surgery, after receiving the patient in the pre-operative holding area, NPO status was confirmed, and baseline MAP and PI were recorded. PI >3.5 was also noted. An intravenous line was secured, and 500 mL of Ringer's was given as a preload for all patients. Ondansetron 4 mg was given as premedication. After preload and premedication, patients were taken to OT and an electrocardiograph (ECG) and a pulse oximeter. PI and NIBP monitors were attached. SA was performed by a consultant anesthesiologist using a 25-gauge Quincke's spinal needle in the sitting position in the intervertebral space L4-L5. Hyperbaric bupivacaine 10 mg, 0.5% was also given to the patients. Then, patients were shifted to the supine position with a left lateral tilt of 15° for uterine displacement. After 5 minutes of spinal anesthesia, the sensory blockade level was assessed using a sprit swab. Those who failed to achieve sensory blockade to the level of T7 were excluded from the study and managed as per hospital protocol.

After delivery of the baby, 5 IU oxytocin was given to all. Those who required a greater dose of oxytocin were excluded, as it may change blood pressure. Maintenance fluid was continuously infused, and blood loss was replaced with Ringer's lactate or, if needed, blood products accordingly. Hypotension was managed with a bolus of phenylephrine 100 microgram per milliliter, and bradycardia was treated with atropine 0.6 mg bolus.

Data Analysis

A special form was devised to record all required information, which was later entered into SPSS 25

for analysis purposes. Age, BMI, PI, and MAP were originally recorded as quantitative variables and reported in the form of mean and standard deviation. However, qualitative variables like the presence of hypotension, thresholds of PI, and episodes of hypotension were presented in frequency and percentages. Further, the Chi-square test of association, Spearman's rank correlation, and odds ratio (OR) were computed to assess the relationship between baseline PI, its two categories, and the actual status of hypotension. Spearman's rank correlation was employed due to the non-normal behavior of baseline PI and hypotension values. Further, the relationship between several episodes of hypotension and two categories of PI was also assessed through the Chi-Square test of association. A two-sample independent t-test was also performed to assess the significant difference between age and BMI in the two groups based on thresholds of PI. Confounding effects of age and BMI were controlled through stratification.

Table 1: Demographic Characteristics of Study Cohort

Characteristics	Total Sample n=65	Categorization as per Thresholds		p-value
		PI ≤3.5 n=35	>3.5 n=30	
Age (years)	28.48±5.74	27.71±4.09	28.65±3.51	0.331 (t-test)
18-30 years	43 (66.2%)	24 (68.6%)	19 (63.3%)	0.656
31-40 years	22 (33.8%)	11 (31.4%)	11 (36.7%)	(Chi-square test)
BMI (Kg/m^2)	28.14±3.84	28.40±5.85	28.57±5.70	0.908 (t-test)
Normal Weight	11 (16.9%)	7 (20.0%)	4 (13.4%)	0.748 (Chi-square test)
Overweight	28 (43.1%)	15 (42.9%)	13 (43.3%)	
Obese	26 (40.0%)	13 (37.1%)	13 (43.3%)	

RESULTS

Demographics

This study involved a total of 65 participants, with a mean age of 28.48±5.74 years. Among these participants, 66.2% were in the age range of 18-30 years, while the remaining sample was within the range of 31-40 years.

Clinical Information

The average BMI was 28.14±3.84 kg/m^2. Further, study participants were also classified into three categories: normal, overweight, and obese; among them, 16.9%, 43.1%, and 40% belong to these three categories, respectively. These findings are provided in Table 1. Moreover, these two basic demographics were also compared in two groups based on perfusion index (PI): ≤ 3.5 and >3.5. It was found that the average age and BMI were insignificantly different in these two groups of PI as tested through two independent samples t-test. The chi-square test of association also showed that there is no significant relationship between these two groups of PI, age groups, and weight categories.

Mean arterial pressure (MAP) was compared in two PI groups and found an insignificant difference between the groups at baseline and at 2 minutes after spinal anesthesia. However, at all other time intervals, the average MAP was significantly less in patients with baseline PI >3.5 (see Table 2).

Findings from the Chi-Square test

A chi-square test of association and an odds ratio analysis were performed to assess the potential relationship between two groups of PI and hypotension (Table 3). Results have shown that among the 35 participants with a PI ≤ 3.5, 16 (51.42%) experienced hypotension, while in the PI >3.5 group (30 participants), a significantly higher proportion, 26 (86.6%), developed hypotension (p = 0.002) with OR 6.13, CI 95% (1.77-21.30). OR and Chi-square test showed a strong association between two thresholds of PI and hypotension.

Correlations

Further, Spearman's rank correlation analysis was also performed to explore the relationship between baseline PI values and hypotension scores (see Table 4). Results have shown that there is a highly significant and positive correlation (0.393) between variables. This correlation value is significant at a 1% level of significance. It means the higher the value of baseline PI, the higher the hypotension and vice versa. This correlation analysis can be confounded with age; therefore, stratified analysis was also performed. This analysis provided a correlation between baseline PI and hypotension (0.490**) in the age group of 18-20 years. However, in the age group of 31-40 years, this correlation is weak (0.204) and insignificant. Another confounder of BMI was also considered here, which was categorized into three groups: normal weight, overweight, and obese. Correlations between baseline PI and hypotension are also positive in these groups (0.212, 0.586, and 0.243), but are insignificant except in the overweight group; 0.586**.

Table 2: Comparison of MAP between the groups at various Time Intervals

Baseline PI		N	Mean	Std. Deviation	p-value
MAP_Base	>3.5	35	82.88	1.71	0.798
	=<3.5	30	83.00	1.87	
MAP_2m	>3.5	35	80.71	1.88	0.668
	=<3.5	30	80.93	2.21	
MAP_4m	>3.5	35	73.91	2.33	0.000
	=<3.5	30	76.90	2.04	
MAP_6m	>3.5	35	67.97	2.79	0.000
	=<3.5	30	72.80	1.91	
MAP_8m	>3.5	35	66.34	2.19	0.000
	=<3.5	30	70.30	2.03	
MAP_10m	>3.5	35	63.05	3.93	0.000
	=<3.5	30	68.16	1.91	
MAP_12m	>3.5	35	60.65	4.28	0.000
	=<3.5	30	66.76	1.85	
MAP_14m	>3.5	35	60.54	4.21	0.000
	=<3.5	30	65.96	1.82	
MAP_16m	>3.5	35	60.94	4.15	0.000
	=<3.5	30	65.30	2.18	
MAP_18m	>3.5	35	61.45	4.34	0.000
	=<3.5	30	66.33	2.21	
MAP_20m	>3.5	35	65.02	2.26	0.000
	=<3.5	30	68.63	1.99	
MAP_25m	>3.5	35	66.05	1.34	0.000
	=<3.5	30	70.83	2.08	
MAP_30m	>3.5	35	65.85	1.41	0.000
	=<3.5	30	71.40	1.84	
MAP_35m	>3.5	35	66.34	1.53	0.000
	=<3.5	30	72.13	1.97	
MAP_40m	>3.5	35	66.88	1.65	0.000
	=<3.5	30	72.40	2.23	
MAP_45m	>3.5	35	67.74	2.16	0.000
	=<3.5	30	72.76	2.09	
MAP_50m	>3.5	35	68.68	2.59	0.000
	=<3.5	30	73.06	2.30	
MAP_55m	>3.5	35	69.28	2.62	0.000
	=<3.5	30	73.30	2.49	
MAP_60m	>3.5	35	69.88	2.89	0.000
	=<3.5	30	74.06	3.27	

Comparisons w.r.t Hypotension

In continuation, these two groups of PI have also been explored in terms of episodes of hypotension, which could be 0 to 5 (see Table 5). Results have shown that those patients who had a baseline PI

Table 3: *Comparison of Hypotension between the Study Groups n=65.*

Hypotension	>3.5 (n=30)	PI ≤3.5 (n=35)	P-value	Odds Ratio	CI of OR
Yes	26 (86.6%)	18 (51.4%)	0.002*	6.13	1.77-21.30
No	4 (13.4%)	17 (48.6%)			

**Association is significant at the 0.01 level (2-tailed).

Table 4: *Spearman Correlation between PI and Hypotension.*

			Baseline PI	Hypotension
Spearman's Rho correlation	Baseline PI	Correlation Coefficient	1.000	.393**
		Sig. (2-tailed)	.	.001
		N	65	65
	Hypotension	Correlation Coefficient	.393**	1.000
		Sig. (2-tailed)	.001	.
		N	65	65

**Correlation is significant at the 0.01 level (2-tailed).

>3.5 experienced a higher number of episodes as compared to other groups based on PI ≤ 3.5. These findings are also significant at a 5% level of significance. These findings indicate that patients with higher levels of PI can have a significantly higher number of episodes.

Table 5: Comparison of Episodes of Hypotension between the Study Groups

Variable	Count	Baseline PI		p-value
		>3.5	≤3.5	
Episodes of Hypotension	0	4 (13.3%)	17 (48.6%)	0.000*
	1	0 (0.0%)	11 (31.4%)	
	2	1 (3.3%)	5 (14.3%)	
	3	2 (6.6%)	1 (2.8%)	
	4	9 (30.0%)	0 (0.0%)	
	5	14 (46.7%)	1 (2.8%)	

*. Association is significant at the 0.05 level (2-tailed).

DISCUSSION

This study deals with an important challenge of Hypotension during cesarean sections (CS) that can impact maternal hemodynamics and fetal perfusion [9]. It has been discussed in past studies that in almost 80% of situations, the adverse effects of hypotension need to be treated.[8] In this study, the perfusion index (PI), which is a non-invasive procedure to assess how well blood is circulating in peripheral areas of the body, is used as a marker of hypotension. The study findings suggest that the values of PI have been strongly correlated and associated with PI; therefore, it is a valid measure and can be used further.

The mean age of the patients with CS procedure in this study was 28.48±5.74 years. Previously, similar mean age patterns (28.34±5.1 years) and (27.73±4.43 years) in such studies were reported in India and Nepal, respectively.[10,11] However, a lower mean age of 24 (range 21-27.5 years) was reported by Duggappa et al, (2017) in India, and a higher mean age of 30.0±41.1 years was also reported by Kumar et al, (2023) in India.[4,12] These variations in mean age in various similar studies may reflect demographic differences and regional trends in patient populations undergoing similar medical investigations, highlighting the importance of considering age-related factors in clinical research and healthcare delivery. Similar to age-related findings, the average BMI patterns of the present study were also found to be similar to those of past studies. It was found that the mean BMI of our study is close to the mean BMI reported by Nandni et al, (2022) in India and by Zang et al, (2021) in China.[10,13]

In this study, MAP had an insignificant difference between the groups at baseline and 2 minutes, and it could be due to the very short time interval. However, at all other time intervals, it was significantly less in patients with PI >3.5. These findings suggest that baseline PI may influence subsequent changes in MAP, highlighting the potential clinical relevance of PI monitoring in predicting hemodynamic changes during anesthesia and surgery. Further, it indicates that at every time interval, there is a greater tendency to have low BP in the group having PI > 3.5. This is an

indirect indication that a high incidence of hypotension is associated with a high baseline PI. These findings are consistent with the literature.[8] Moreover, a very close standard deviation can also be seen in the findings, which could be due to the short time interval of reading.

Findings based on the Chi-square test and OR analysis reflected that there are higher chances of hypotension in such patients who had PI > 3.5 as compared to those in the other group, PI ≤3.5. These findings directly reflect that baseline PI is a strong determinant of hypotension. Spearman's rank correlation also augmented these findings that there is a strong relationship between baseline PI and hypotension scores. It means higher values of baseline PI increase the chances of hypotension and vice versa. These findings reflect the physiological dependence of PI on vascular tone and blood flow to the extremities. Correlation analysis after stratification based on age and BMI also produced similar results, but statistical significance could not be achieved due to the small sample size. Overall, these findings are aligned with similar studies in the literature, like Duggappa et al, (2017), 71.42% incidence of hypotension in group 1; > 3.5 PI, as compared to another group where this % is around 10.5%.[4] Similarly, George et al, (2019) reported the prevalence of 66.7% in group 1; however, they used a threshold of PI 3.6 instead of 3.5.[14] In line with these findings, another study reported a 73.3% incidence of hypotension in the group (PI > 3.5) as compared to another group, where this incidence was 40%.[8]

Lastly, another validation aspect was also observed through several episodes in participants having PI > 3.5. Among those with a baseline PI >3.5, 8.6% experienced no hypotension episodes, while 46.7% had no hypotension episodes among those with a PI ≤3.5 (p = 0.000). High frequency of hypotension at higher levels of PI indicates relative vasodilation and low peripheral vascular tone. When these patients are exposed to anesthetic agents, they cannot manage the systemic vascular resistance and report episodes of hypotension. A recent study of Thapa et al, (2022) also reported that episodes of hypotension were significantly lower in patients with baseline PI ≤3.5 as compared to those having baseline PI >3.5 ($p<0.001$). The correlation between baseline PI >3.5 and a number of episodes of hypotension was highly significant (r_s 0.78, $p< 0.01$).[11]

This study has various implications in clinical/ICU, emergency, anesthetic process, and resource-limited settings. This non-invasive marker can help in the early detection of compromised peripheral perfusion in the ICU and emergency departments. In the anesthesia process, PI can provide continuous readings that can improve intraoperative hemodynamic stability and vasopressor management. Lastly, due to its non-invasive nature, it can easily be implemented in low-resource settings as well. However, limitations include potential bias due to the single-center design and a relatively small sample size, which may impact generalizability. Future studies with larger, multicenter cohorts could further validate these findings and enhance clinical applicability.

CONCLUSION

Based on the study findings, it can be concluded that there is a strong positive association between baseline perfusion index (PI) and the incidence of hypotension during cesarean sections under spinal anesthesia. There is a significantly higher risk of hypotension in those patients who have a baseline PI >3.5 as compared to their counterparts. The findings of this study suggest that continuous monitoring through PI during CS procedure can help in identifying and managing hemodynamic changes and improving perioperative care.

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Additional Information

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AUTHORS CONTRIBUTIONS

Sr. #	Author's Full Name	Intellectual Contribution to Paper in Terms of:
1.	Muhammad Nawaz	Conception of idea, Study design, methodology, & referencing.
2.	Anum Zeb	Literature review, Paper write-up, & editing.
3.	Sidrah Batool	Data collection, Literature review, Paper write-up, & editing.
4.	Saqib Shehzad	Data collection and entry, Data Analysis, & Editing.
5.	Moazzam Butt	Data analysis & Interpretation of Data.
6.	Aslam Khan	Conception of Idea, Supervision of Work, & Editing of Work.
7.	Mudassar Aslam	Data validation, Editing, & Referencing.