PERFUSION INDEX DERIVED FROM PULSE OXIMETER AS A PREDICTOR OF HYPOTENSION FOLLOWING SPINAL ANAESTHESIA INELECTIVE CAESAREAN DELIVERY

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Background and Aims: It is important to predict and prevent post-spinal hypotension in lower segment cesarean section (LSCS). Peripheral vascular tone can be monitored as a perfusion index (PI) from a pulse oximeter. We aimed to study baseline PI as a predictor of post-spinal hypotension in LSCS.
Material and Methods: Prospective observational study conducted in a tertiary care teaching public hospital on patients posted for elective LSCS under spinal anesthesia. Baseline PI and hypotension were compared. A receiver operating characteristic (ROC) curve was plotted and data were analyzed using SPSS version 20.
Results: Baseline PI correlated with the degree of decreases in systolic and mean arterial pressure (r¼0.664, P,0.0001 and r¼0.491, P¼0.0029, respectively). The cut-off PI value of 3.5 identified parturients at risk for spinal anaesthesia-induced hypotension with a sensitivity of 81% and a specificity of 86% (P,0.001). The change of PI in parturients with baseline PI≤3.5 was not significant during the observational period, while PI in parturients with baseline PI.3.5 demonstrated marked decreases after spinal injection.
Conclusion: Baseline PI >3.5 was associated with significant post-spinal hypotension and vasopressor administration in LSCS. We established baseline PI >2.9 can predict post-spinal hypotension with high sensitivity and specificity. PI is simple, quick, and non-invasive and can be used as a predictor for post-spinal hypotension in parturients undergoing LSCS so that prophylactic measures can be considered in at-risk patients for better maternal and fetal outcomes.
Keywords: Lower segment cesarean section (LSCS), perfusion Index (PI)

INTRODUCTION

Spinal anaesthesia-induced hypotension during Caesarean delivery is the result of decreased vascular resistance due to sympathetic blockade[1] and decreased cardiac output due to blood pooling in blocked areas of the body.[2–4] Although baseline volume status is known to affect the degree of hypotension,[5] baseline peripheral vascular tone may also have influence. Peripheral vascular tone has been shown to be decreased in parturients at term, especially in those who are multiparous.[6–9] Decreased peripheral vascular
tone results in blood volume being trapped in the extremities even before spinal anaesthesia, and the sympathetic blockade with spinal anaesthesia would further increase the blood pooling.[10] Therefore, parturients with low baseline vascular tone may be at an increased risk of developing hypotension
after spinal anaesthesia.Spinal anaesthesia leads to hypotension during Caesarean delivery, which is due to the result of combination of decreased vascular resistance due to sympathetic blockade and decreased cardiac output due to blood pooling in blocked areas of the body.

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Baseline volume status is already known to affect the degree of hypotension, but baseline peripheral vascular tone may also have significant influence. Peripheral vascular tone has been found to be decreased in parturients at term, especially in those who are multiparous. This decrease in peripheral vascular tone leads to trapping of blood volume in the extremities even before spinal anaesthesia, and the sympathetic blockade due to spinal anaesthesia will further increase the blood pooling. Therefore, parturients with low baseline vascular tone may be at an increased risk of developing hypotension after spinal anaesthesia. Non-invasive blood pressure(NIBP) measurement is used as standard method of monitoring intraoperative and post operative haemodynamics. But the limitation is that, beat to beat variation is not measured by this method. Perfusion index is nothing but the ratio of pulsatile blood flow and non-pulsatile component of blood in the peripheral tissue. This can be used to assess the peripheral perfusion dynamics that are caused due to changes in peripheral vascular tone.2

MATERIAL AND METHODS

This is a Prospective, double-blinded, observational study conducted at obstetrics and gynaecology operation theatre, department of anaesthesiology. This study was done in 120 patients who underwent elective lower segment caesarean section. Ethical committee approval and informed written consent from patients involved in this study are obtained before starting this study.

Inclusion Criteria

Parturients between 20yrs and 35yrs of age posted for elective

caesarean section

Exclusion criteria

Parturients with

a. Placenta praevia
b Cardiovascular or cerebrovascular disease
c.Preeclampsia
d. Body mass index >40
e. Gestational diabetes mellitus
f. Gestational age <36 or >41weeks
g. Contraindications to regional anaesthesia
h. Those requiring emergency LSCS

Based on the baseline perfusion index, parturients are divided as follows;

Group A – Parturients with PI of <3.5

Group B – Parturients with PI >3.5

Standard monitoring as per ASA guidelines was performed for baseline values and intraoperative monitoring. Perfusion index was measured in supine position using a specific pulse oximeter probe (Masimo Radical 7®; Masimo Corp., Irvine, CA, USA). To ensure uniformity in all the parturients , PI was measured in left index finger. All the baseline values including PI was recorded in supine position by the anaesthesiologist who was not involved

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in further intraoperative monitoring of the patient. 53 Parturients with baseline PI of ≤3.5 are categorised as Group A and those with a PI of >3.5 as Group B. Intravenous (IV) access was established in the left upper limb. Every parturient was prehydrated with 500 ml of Ringer lactate over 20 min. After prehydration was over, the baseline values were recorded. During administration of neuraxial blockade, the Masimo® pulse oximeter was disconnected from the patient to prevent observer bias and oxygen saturation was recorded using a different pulse oximeter which did not showed PI. The anaesthesiologist who was blinded to the baseline PI values performed spinal anaesthesia, using 25-gauge Quincke spinal needle in left lateral decubitus position with injection 0.5% hyperbaric(heavy) bupivacaine ,10 mg at the L2–L3 or L3–L4 interspace. The parturient was returned to the supine position with a left lateral tilt of 15° to facilitate left uterine displacement. Oxygen was given at a rate of 4L/min via face mask. IV fluids were given at a rate of 100ml/min. The level of sensory block was checked at 5 min after the spinal injection with a cold swab. If aT6 sensory block level was not achieved, then these parturients were excluded from the study54 After 20mins, maximum cephalic spread was checked, heart rate, respiratory rate and SpO2 were recorded at 2 min intervals after the SAB up to 20 min and then at 5 min intervals by the same anaesthesiologist who administered Subarachnoid block till the end of surgery. If MAP was <65 mm of Hg, it was defined as hypotension and was treated with 6 mg injection ephedrine IV bolus and 100 ml of Ringer lactate(RL). The first 60 min following SAB was considered for spinal anaesthesia-induced hypotension. If Heart rate was <55 beats/min, was treated with injection atropine 0.6 mg IV bolus. After extraction of the baby, Apgar score was recorded at 1st and 5^{th} min. Injection oxytocin 10 units was given as uterotonic following baby extraction at a rate of 200 mU/min as a separate infusion. Parturients requiring extra oxytocics or any additional surgical interventions were excluded from the study. Other side effects like nausea, vomiting were also recorded.

STATISTICAL TESTS USED:

Data was entered into Microsoft Excel (Windows 7; Version 2007) and analyses were done using the Statistical Package for Social Sciences (SPSS) for Windows software (trial version 22.0; SPSS Inc, Chicago). Descriptive statistics such as mean and standard deviation (SD) for continuous variables, frequencies and percentages were calculated for categorical variables.

Table 1: Age group distribution in both groups:

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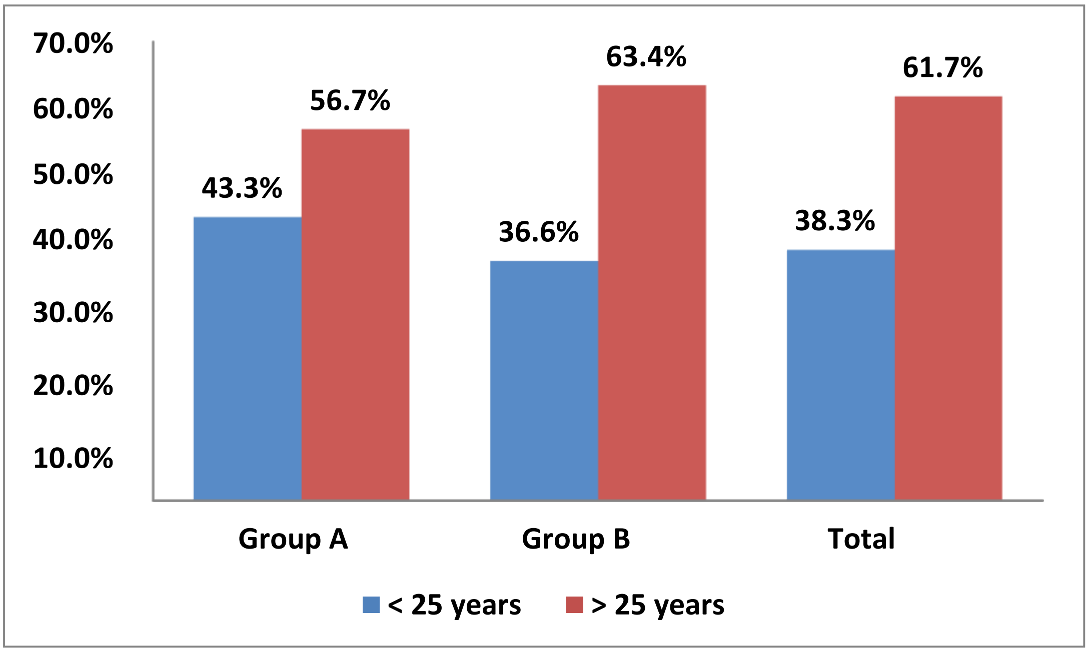

Table 2: Height and weight distribution profile in both groups:

Sex	Group A N = 60	Group B N = 60	Total N = 120	P value
Height **Mean±SD** **Range**	155.2±1.6	156±1.5	155.9±1.7	0.064
Weight **Mean±SD** **Range**	66.1±2.2	66.8±2.3	66.4±2.2	0.067

The mean height and weight in group A and B were 155cms and 66kg, 156cms and 66.8kg respectively. There was no significant difference in height and weight distribution of both groups with P value 0.067.

Table 3: ASA distribution in both groups:

ASA	Group A N = 60	Group B N = 60	Total N = 120	P value
I II	0 (0.0%) 60 (100%)	0 (0.0%) 60 (100%)	0 (0.0%) 60 (100%)	1.000

Table 4: Duration of surgery profile in both groups

Duration of surgery	Group A N = 60	Group B N = 60	Total N = 120	P value
Duration of surgery **Mean±SD** **Range**	49.2±4.4 40 – 55	49.6±3.0 46 – 57	49.4±3.8 40 - 57	0.508

There was no significant difference in the duration of surgery among both the groups. The mean duration of surgery in group A is 49.2 mins while in group B was 49.6 mins.

Table 5: Fluid requirement in both groups

Fluid requirement	Group A N = 60	Group B N = 60	Total N = 120	P value

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Mean±SD **Range**	1000.8±44.6 900 – 1050	1150±37 1000 - 1150	1010±42 900 - 1150	**0.012**

There was a significant difference in the fluid requirement of both the groups. The fluid required in group A is 1000ml while the fluid required in group B is 1150 ml this difference was statistically significant with P value0.012.

Table 6: Perfusion index in both groups

Perfusion index	**Group A** **N = 60**	**Group B** **N = 60**	**Total** **N = 120**	**P value**
Mean±SD **Range**	2±0.3 2 – 3	5.2±0.9 4 - 7	3.6±1.7 2 - 7	**0.001**

The mean perfusion index in group A is 2 and mean perfusion index in group B is 5.2. There was a significant difference in mean perfusion index of both the groups with P value 0001.

Table 7: Maximum cephalic spread in both groups:

Maximum cephalic spread	**Group A** **N = 60**	**Group B** **N = 60**	**Total N = 120**	**P value**
T2	13(21.7%)	13(21.7%)	26 (21.7%)	0.588
T4	47 (78.3%)	47 (78.3%)	94 (78.3%)	
Total	60 (100%)	60 (100%)	120 (100%)	

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The proportion of maximum cephalic spread till T2 in group A is 21.7% and group B is 21.7%. The proportion of maximum cephalic spread till T3 in group A is 78.3% and group B is 78.3%. There was no significant difference in both the groups with P value 0.588.

Chart 1: Maximum cephalic spread in both groups:

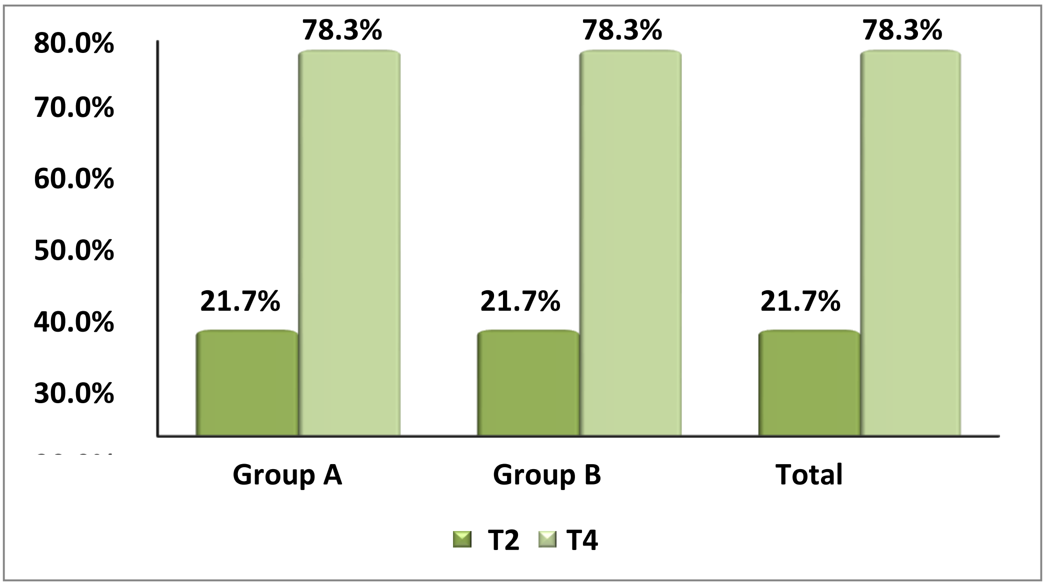

Table 8: Nausea in both groups

Nausea	Group A N = 60	Group B N = 60	Total N = 120	P value
Present	2(3.3%)	5(8.3%)	7 (5.8%)	**0.243**
Absent	58 (96.7%)	55(91.7 %)	113 (94.2%)	
Total	60 (100%)	60 (100%)	120 (100%)	

Table 9: Ephedrine dose required in both the groups:

Ephedrine dose	Group A N = 60	Group B N = 60	Total N = 120	P value
None	51(85%)	17(28.3%)	68 (56.7%)	**<0.001**
1 -2 dose	8 (13.3%)	37 (61.7%)	45 (37.3%)	

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3 – 4 dose	1 (1.7%)	8 (10%)	9 (6%)	
Total	60 (100%)	60 (100%)	120 (100%)	

In group A the percentage of not requiring ephedrine dose is 85% and group B is 28.3%. The proportion requiring 1-2 doses in group A is 13.3% and group B is 61.7%. The percentage of ephedrine dose required in group B was more compared to group Aand this was statistically significant with P value <0.001.

Table 10: Hypotension in each group:

Hypotension	**Group A** **N = 60**	**Group B** **N = 60**	**Total**	**P value**
Present	11 (18.4%)	39 (65%)	50 (41.7%)	**<0.001**
Absent	49 (81.6%)	21 (35%)	70 (58.3%)	

The incidence of hypotension in group A is 18.4% and group B is 65% this difference was statistically significant with P value< 0.001

Table 11: Hypotension episode in each group:

Hypotension	**Group A** **N = 60**	**Group B** **N = 60**	**P value**
0	49 (81.6%)	21 (35%)	**<0.001**
1	8 (13.3%)	20 (33.3%)	
2	2 (3.4%)	15 (25.1%)	

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3	1 (1.7%)	2 (3.3%)	
4	0	2 (3.3%)	

In group A, the percentage of hypotension episode is 81.6% & group B is 35%. The proportion having 1 episode in group A is 13.3% & group B is 33.3%. The proportion of having 2 episodes in group A is 3.4% & group B is 25.1%.The percentage of having 3 episodes in group A is 1.7% and group B is 3.3%. There was no one in group A with 4 episodes of hypotension. But in group B there were 2 people with 4 episodes of hypotension. The episodes were more in group B compared to group A & this was statistically significant P value <0.001.

Table 12: Comparison of Pulse rate during the course of anaesthesia in both groups:

Heart rate(min	**Group A**		**Group B**		**P value**
	Mean	**SD**	**Mean**	**SD**	
1	75.5	7.1	76.6	6.9	0.380
2	78.6	6.5	80.1	7.1	0.237
4	81	6	82	6.7	0.410
6	82.8	5.6	84.5	6.4	0.127
8	83.5	4.1	84.7	5.0	0.159
10	82.3	6.2	83.5	5.6	0.248
12	78.4	6.2	80.3	7.3	0.126
14	77.7	6.1	78.7	5.8	0.397
16	76.7	6	77.6	6.6	0.455
18	75.9	6.2	76	5.6	0.902
20	74.9	5.9	74.9	6.0	1.000
25	73.7	6.1	74.6	5.8	0.421
30	73	6.3	73.9	6.3	0.482
35	72.8	5.3	73.5	5.3	0.517
40	72.4	4.7	72.6	4.6	0.726
45	71	4.1	71	3.9	0.946

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50	71.1	3.8	72.4	4.1	0.071
55	71.3	3.4	72.3	3.8	0.319
60	72	2.8	72.2	2.9	0.321

The mean pulse rate in both groups did not differ significantly from each other during the course of the anaesthesia. All the P value were more than 0.05

Table 13: Comparison of Mean arterial pressure during the course of anaesthesia in both groups:

MAP (min)	Group A		Group B		P value
	Mean	SD	Mean	SD	
1	86.4	7.6	85.5	7.5	0.001
2	79.9	6.6	82	6.5	0.021
4	75.9	6.6	78.8	6.3	0.817
6	72.6	5.5	72.4	6.9	0.001
8	72.3	4.5	69.1	5.5	0.001
10	73	4.1	70.2	4.7	0.045
12	73.1	4.1	70.2	4.7	0.329
14	73.8	4.4	71.2	5.2	0.252
16	73.9	4.3	73	4.7	0.360
18	74.2	3.5	73.6	4.0	0.251
20	74.8	3.1	74.4	3.4	0.490
25	74	3.2	75	3.2	0.033
30	73.9	3.6	74.7	3.6	0.204
35	73.7	3.2	75.2	4.3	0.027
40	74	3.4	74.3	3.2	0.597
45	74.2	3.0	74.7	3.3	0.349
50	73.7	2.6	74.8	3.0	0.042
55	74.3	3.1	75.4	2.9	0.132
60	73	2.1	74.5	2.2	0.015

The mean arterial pressure in both groups did not differ significantly from each other during the course of the anaesthesia on most times. In initial minutes of 1, 2, 6 and 8 mean arterial pressure of group B was higher and this difference was statistically significant with P value <0.05. All the other minutes the MAP was similar in both groups with P value were more than 0.05.

Table 14: Correlation between perfusion index and hypotension episodes and ephedrine dose

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	Hypotension episode		**Ephedrine dose**	
	Correlation coefficient	**Significance**	**Correlation coefficient**	**Significance**
Perfusion Index	**0.570**	**<0.001**	**0.732**	**<0.001**

There was significant correlation of perfusion index with hypotension episodes and ephedrine dose. They both are positively correlated. That is as perfusion index increases the number of hypotension episodes and ephedrine dose increases. There was 57% correlation between perfusion index and number of hypotension episodes which was significant with p value < 0.001. There was 73.2% correlation between perfusion index and ephedrine dose which was significant with p value < 0.001.

Table 16: Sensitivity and Specificity of Perfusion index in predicting hypotension:

Perfusion index	**Sensitivity**	**Specificity**
Cut off 3.5	65%	67%

The cut off 3.5 of perfusion index 3.5 had the best sensitivity which was 65% and specificity 67%. Hence we can conclude that using 3.5 as cut off for perfusion index is both sensitive and specific in predicting hypotension.

DISCUSSION

Hyotension after administration of spinal anaesthesia for lower segment caesarean section is very common. There is no definitive monitoring system which may help to predict development of hypotension following SAB, so that additional precautions have to be taken.

In our study, the incidence and severity of hypotension, vasopressor requirement were found to be higher in parturients with baseline Perfusion index values were > 3.5. Normal pregnancy is characterised by decrease in systemic vascular resistance, increase in cardiac output and total blood volume. This reduction of the systemic vascular resistance may vary with each parturient depending on many factors. The decrease in the vascular tone will correspond to higher perfusion index values as there is increase in pulsatile component due to vasodilatation. Sympathectomy due to spinal anaesthesia(SA) will cause peripheral vascular tone to further decrease and increase blood pooling and hypotension. Parturients with high baseline perfusion index will be expected to have a lower peripheral vascular tone and thus they are at higher risk for developing hypotension following SA. The cut-off value of baseline perfusion index for predicting spinal anaesthesia induced hypotension was chosen as 3.5 based on a study conducted by Toyama et al, they did regression analysis and ROC curve

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77 analysis and concluded that a baseline perfusion index cut-off point of 3.5 could be used to identify parturients who are at risk for developing hypotension following SA. In our study, the baseline PI >3.5 and probability of hypotension were significantly correlating, which were similar to the study conducted by Toyama et al. Toyama et al. found a sensitivity and specificity of 81%and 86%, respectively, for baseline PI with a cut-off of 3.5 to predict hypotension, whereas in this study, the specificity was 65% and sensitivity was 67%. In our study, consumption of IV fluid was significantly higher than that in the study by Toyama et al. This is because we used injection ephedrine and fluid bolus for treating hypotension while they used injection phenylephrine only to treat hypotension. phenylephrine has been recently established as a first-line vasopressor during spinal anaesthesia for Caesarean delivery.[13,14,15] If low baseline vascular tone, as suggested from this study, is a major factor in producing spinal anaesthesia-induced hypotension during Caesarean delivery, prophylactic phenylephrine infusion that increases vascular tone may be a rational option to prevent spinal anaesthesia-induced hypotension in parturients with high baseline PI. Prostaglandins, methylergometrine are very powerful vasoconstrictors and hence the patients receiving these drugs were excluded from the analysis as they can influence the observations. Duggappa DR, et al conducted the study to explore the predictive ability of Perfusion index following SAB in elective lower segment caesarean section. On Spearman rank correlation, they found out a highly significant correlation between baseline PI >3.5, number of hypotensive episodes, the total dose of ephedrine required and total IV fluids given.78 A higher requirement of vasopressor was seen in parturients with baseline PI >3.5. Sensitivity was 89.29% and specificity was 69.84%, whereas in our study, the specificity was 65% and sensitivity was comparable, 67%. In our study, the consumption of IV fluid was similar to the study by Duggappa DR, et al. Mowafi et al. used PI to detect intravascular injection of the epinephrine-containing epidural test dose, so its reliability to detect vasoconstriction has been previously demonstrated successfully. Ginosar et al. demonstrated that increase in PI following epidural anaesthesia was a clear and reliable indicator of sympathectomy. A study performed by Yokose et al demonstrated that PI had no predictive value for hypotension in parturients undergoing LSCS following SAB as in this study they used colloids for co-loading and the definition of hypotension was different when compared to our study. We conclude from this study that Perfusion Index can be used for predicting hypotension in parturients undergoing elective lower segment caesarean delivery under spinal anaesthesia. Our results found out that parturients with baseline Perfusion index >3.5 are at a greater risk of developing hypotension following Spinal anaesthesia than compared to those with the baselinePI≤3.5. Since compensatory increases in sympathetic nervous system activation and systemic vascular resistance in nonblocked areas of the body to maintain systemic perfusion pressures are attenuated under high spinal anaesthesia (sensory block below Th6 or higher as used in the present study),[11,12] a decrease in PI after spinal injection seen in paturients with high baseline PI likely reflected a decrease in preload due to blood pooling in the lower part of the body rather than an increase in vascular tone due to compensatory sympathetic vasoconstriction. We conclude from this study that Perfusion Index can be used for predicting hypotension in parturients undergoing elective lower segment
caesarean delivery under spinal anaesthesia. Our results found out that parturients with baseline Perfusion index >3.5 are at a greater risk of developing hypotension following Spinal anaesthesia than compared to
those with the baseline PI ≤3.5.

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