Perfusion Index and Positional Blood Pressure Changes as Preoperative Predictors for Post-Spinal Hypotension in Caesarean Section: An Observational Study

Zainab M. Attia, Essam F. Abdelgalel, Ramy M. Alsewe*, Naglaa Fathy Abdelhaleem
Department of Anesthesia, Intensive Care and Pain Management,
Faculty of Medicine, Zagazig University, Zagazig, Egypt
***Corresponding author:** Ramy M. Alsewe, **Mobile:** (+20) 01013088656, **E-Mail:** ramy23m@gmail.com

ABSTRACT

Background: Spinal anesthesia (SA) remains the most popular anesthetic technique for caesarean sections (CS), as it abolishes the possible risks of pregnant airway management. The ability to anticipate the episodes of hypotension following spinal anesthesia will enable anesthesiologists to interfere early and provide better patient management. **Objective:** The aim of the current study was to evaluate the perfusion index and the blood pressure positional changes in the prediction of hypotension after SA in CSs. **Patients and methods:** A prospective cohort study was conducted at the Obstetrics and Gynecology Department of Zagazig University Hospitals. A total of 80 pregnant women who were prepared for elective CS delivery, aged from 18 to 40 years with ASA-II (American Society of Anesthesiologists Status), were recruited in the current study. **Results:** The mean perfusion index (PI) pre-spinal was 5.81 and immediately after spinal was 4.65 with a statistically significant decrease (P<0.001). There was also a statistical difference between the mean of mean arterial pressure (MAP) of the studied cases pre-spinal at the lateral position (91.76 mmHg) and mean MAP in the supine position (83.29 mmHg) with P-value <0.001, with a mean difference of 8.48 mmHg. PI cut-off >4 had a sensitivity of 85.9%, specificity of 75%, and accuracy of 83.8% in the prediction of hypotension. The positional change in blood pressure at cut-/off >5 mmHg had a sensitivity of 82.8%, specificity of 75%, and accuracy of 81.3% in the prediction of hypotension among cases. **Conclusion:** The preoperative PI and positional blood pressure change can predict spinal anesthesia induced hypotension during caesarean deliveries.

Keywords: Caesarean section, Spinal anesthesia, Perfusion index.

INTRODUCTION

The safety of the patient is an established anesthetic priority and should always come first**,** so anesthesiologists should be aware of the perioperative physiological changes, appropriate anesthetic approaches and expected anesthetic complications [(1)]. The spinal anesthesia (SA) remains the most popular anesthetic technique for caesarean deliveries, as it eliminates the possible risks related to pregnant airway control. However, intraoperative hypotension is a common association in such groups of patients after spinal anesthesia that account for 70% to 74% of patients [(2,3)]. Important contributors to the onset of hypotension include aortocaval compression brought on by the gravid uterus, and a reduction of systemic vascular resistance caused by the sympathetic block that associated with SA. Following SA, hypotension may result in fetal acidosis, nausea, vomiting, and wooziness in the mother [(2,4)]. At term, mean arterial pressure (MAP) is lower in pregnant women and is highly sensitive to the local anesthetics and less reactive to vasopressors. Blood pressure during caesarean sections is typically measured using non-invasive blood pressure measurement (NIBP). However, because NIBP is sporadic, it might not be able to anticipate episodes of hypotension [(5,6)]. The perfusion index (PI), which is measured in peripheral tissues like a patient's fingertip, toe, or ear lobe, is the ratio of pulsatile blood flow to static, non-pulsatile blood flow. Accessing a continuous, non-invasive monitoring of tissue perfusion, which may be altered by peripheral vascular tone, is possible using PI. The average PI's values are from 0 points to 2% for a highly faint pulse to 20 % for a very strong pulse [(7-9)]. Intraoperative hypotension correlates with elevated sympathetic activity prior to spinal anesthesia. The high degree of variation in hemodynamics following positional changes suggests increased sympathetic activity. In light of that, post-spinal hypotension can be anticipated [(10,11)]. To the best of our knowledge, it was the first investigation to evaluate both PI and the positional MAP changes as preoperative predictors of hypotension after SA in CSs.

PATIENTS AND METHODS

A prospective cohort study was conducted at the Obstetrics and Gynecology Department of Zagazig University Hospitals. A total of 80 pregnant women who were prepared for elective CS delivery, aged from 18 to 40 years and with a body mass index (BMI) ≤35kg/m^2 with ASA-II (American Society of Anesthesiologists Status), were recruited in the current study. While, the pregnant women with gestational diabetes, preeclampsia, eclampsia, hypertension, placenta previa, or comorbidities like cerebrovascular, cardiovascular diseases and contradicting to regional anesthesia as allergy, coagulation abnormalities or infection in site of injection were ruled out from the investigation. **Sample Size calculation:** Based on the study of **Jeon *et al.*** [(12)], and those who had hypotension were more likely to have a higher blood pressure drop while changing positions (171±0 mmHg) than those who did not (12±5 mmHg). At 80% power and 95 % CI, the estimated sample was 80 cases. A total of 129 female patients were tested for eligibility to be enrolled in this study. Forty-six were excluded as 34 patients didn't fulfill the inclusion criteria and 12 patients refused the participation. The rest 83 cases were included, and 80 patients continued to be analyzed. Only 3 patients were excluded from analysis because the spinal block didn't reach to T4 level as shown in the flow chart (**Figure 1**).

Received: 30/09/2022
Accepted: 03/12/2022

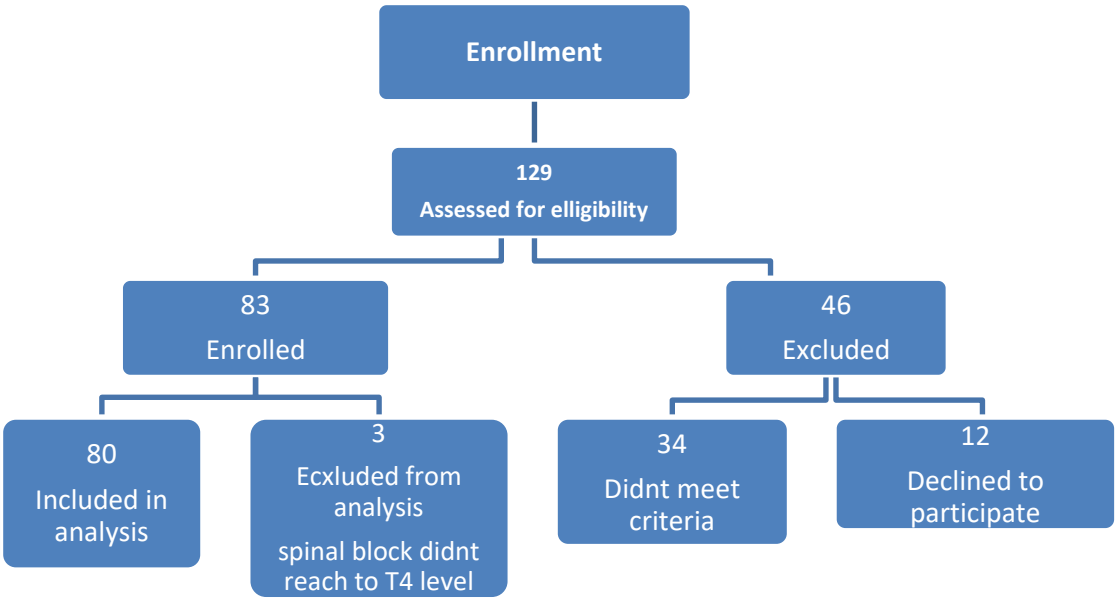

Figure (1): Consort flow chart of study.

Clinical assessment: To rule out the presence of any contraindications like infection, mass, or vertebral column deformity, each patient underwent a history taking, physical examination, and examination of the site of intrathecal injection.

Procedure steps: All patients were assessed by PI and positional hemodynamic changes.

- The left arm was used for the continuous NIBP and ordinary pulse oximetry while the right hand was used for PI monitoring using the specific pulse oximeter probe (Promise M170).
- Prior to SA, PI was reported as a baseline value, and it was then measured again right after SA.
- MAP was measured twice and averaged before SA: the first reading was while the patients lying at supine position whereas the second was after switching to the right lateral position.
- The difference in MAP values between the lateral and the supine positions is referred to as the positional blood pressure change.

Anesthesia:

SA was administered while the patient was seated and completely sterile. After injecting 2 percent lidocaine locally, a 25-gauge Quincke spinal needle was placed at the L3-L4 or L4-L5 vertebral interspace. About 10 mg of hyperbaric bupivacaine was given at a concentration of 0.5%, after free flow of cerebrospinal fluid. Up to 25 micrograms of fentanyl were also administrated for all patients. Patients were returned to supine position with uterine left lateral displacement by tilting the bed. Prior to SA, the following values were noted: MAP, oxygen saturation (SpO2), and heart rate (HR). These values were then repeated every 3 minutes after SA. Sensory block level was assessed by bilateral pin-prick sensation every 2 min until complete loss of sensation at level of thoracic 4 dermatome (T4). Hypotension was defined as a decrease of ≥20% from basal MAP. Hypotension was managed with intravenous ephedrine increments (5-20mg).

Ethical Approval:

This study was ethically approved by the Institutional Review Board of the Faculty of Medicine, Zagazig University (IRB# 9293). The study was also registered at clinicaltrials.gov (NCT# 05587153). Written informed consent was obtained from all participants. This study was executed according to the code of ethics of the World Medical Association (Declaration of Helsinki) for studies on humans.

Statistical Analysis

The collected data were introduced and statistically analyzed with Statistical Package for Social Sciences (SPSS) version for windows. Indicative of frequency and relative percentages, gravity and parity were displayed (Qualitative data). Quantitative data were tested for normality by Kolmogorov-Smirnov test. Normal distribution of variables was described as mean and standard deviation (SD). Paired sample T test was used for quantitative normally distributed data in the same group as pre and post spinal PI at different times. Repeated measure ANOVA test was utilized for assessment of differences between different readings of MAP and HR after spinal compared to pre spinal. A ROC analysis was conducted to determine the best PI and systolic blood pressure thresholds for each position. P-value $\leq$0.05 was considered significant.

RESULTS

Table 1 summarizes the demographic characteristics and gestational history of the studied patients.

Table (1): Demographic characteristics and gestational history of studied cases.

Variable		**(n=80)**	
Age (years)	Mean ± SD Range	26.66 ± 5.41 18-40	
BMI (Kg/m^2)	Mean ± SD Range	34.21 ± 3.59 28.58-44.44	
Gestational age (Week)	Mean ± SD Range	37.55 ± 1.08 36-40	
Variable		**No of patients**	**%**
Gravidity	G 2-3 G 4-5 G 6-10	54 16 10	67.5 20 12.5
Parity	P 1 P 2-3 P 4-5	36 31 13	45 38.8 16.2

The mean PI pre spinal was 5.81 and immediately after spinal was 4.65 with a statistical significance decrease compared to pre spinal (**Table 2**).

Table (2): Perfusion index (PI) among the studied cases.

Variable		**(n=80)**
Pre spinal: (PI)	Mean ± SD Range	5.81 ± 1.73 2.2-9.8
Immediately after spinal: (PI)	Mean ± SD Range	4.65 ± 1.21 2.3-7.7
Paired t test		7.23
P-value		<0.001**

There was also a significant difference between mean MAP of the studied cases pre spinal at lateral position (91.76 mmHg) compared to mean MAP at supine position (83.29 mmHg) at P<0.001, with a mean difference of 8.48 mmHg (**Table 3**).

Table (3): Positional blood pressure change among the studied cases.

Variable		**(n=80)**
Pre spinal MAP lateral position: (mmHg)	Mean ± SD	91.76 ± 8.46
Pre spinal MAP supine position: (mmHg)	Mean ± SD	83.29 ± 15.56
Student's t test	- 7.28	
P-value	<0.001**	
Positional blood pressure change: (mmHg)	Mean ± SD	8.48 ± 2.11

MAP: Mean arterial pressure.

Figure 2 demonstrates a statistical significance decrease in MAP all times after spinal compared to pre spinal (91.76 mmHg pre spinal compared to 76.68, 74.6,73.91, 72.79, 71.93, 73.41, 74.7, 75.6, 74.79 and 76.56 mmHg post spinal, respectively). Also, MAP showed decrease from 1st till 5th reading then started to increase again. While the figure (3) shows that HR 1st seventh times statistically higher after spinal compared to pre spinal (98.95 beat/min pre spinal compared to 110.28, 110.89, 105.38, 103.39, 105.41, 102.88, 101.19 beat/min post spinal, respectively).

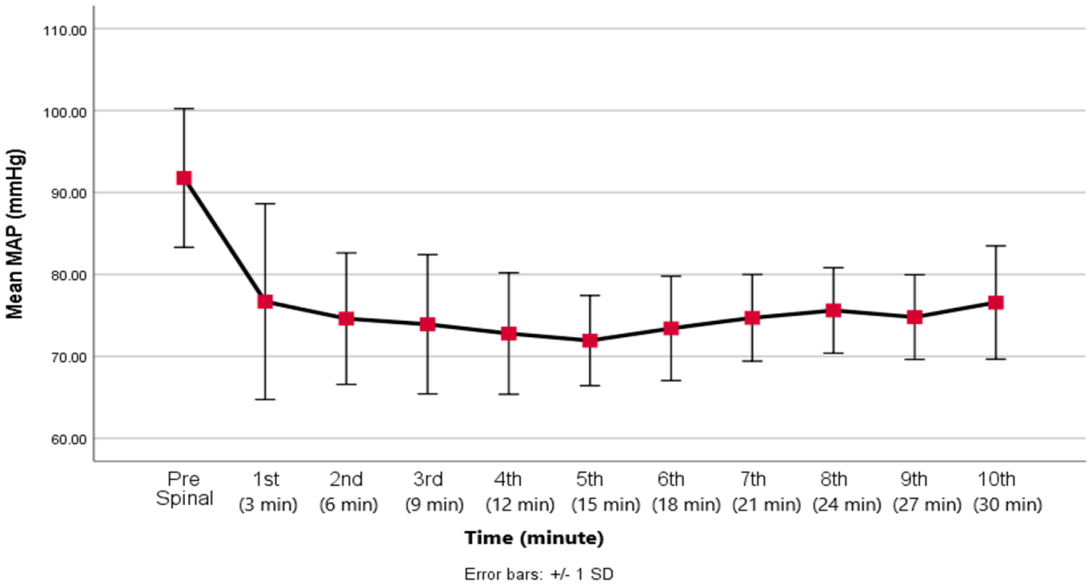

Figure (2): MAP at different times among the studied cases.

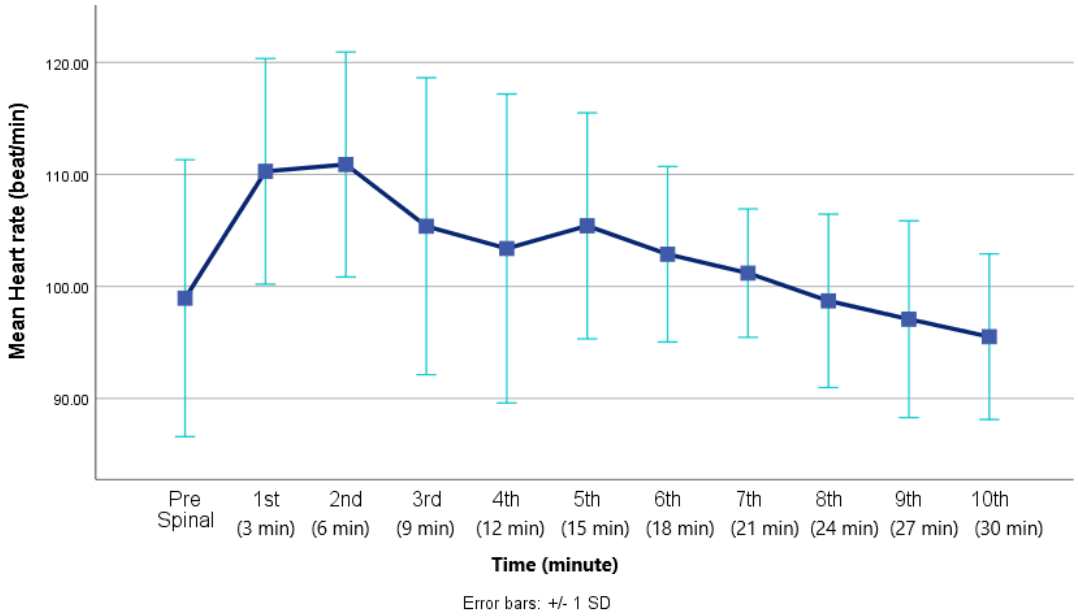

Figure (3): Heart rate at different times among the studied cases.

Table 4 showed that the cut off of PI >4 had sensitivity 85.9%, specificity 75% and accuracy 83.8% in prediction of hypotension, while Positional change in blood pressure at cut off >5 mmHg had sensitivity 82.8%, specificity 75% and accuracy 81.3% in prediction of hypotension among cases.

Table (4): Validity of PI and positional blood pressure change in prediction of hypotension.

Variable	Cut off point	AUC (95% CI)	Sensitivity	Specificity	PPV	NPV	Accuracy	P-value
PI	>4	0.81 0.61-0.95	85.9%	75%	93.2%	57.1%	83.8%	<0.00**
Positional BP Change	>5 mmHg	0.80 0.70-0.90	82.8%	75%	93%	52.2%	81.3%	<0.00**

AUC: Area under curve. CI: Confidante interval. PPV: +ve predicted value, NPV: -ve predicted value. **Highly significant (P<0.001).

DISCUSSION

Despite hypotension being a commonly encountered complication during CS vasopressors should be cautiously used for hypotension prophylaxis due to the risk of associated maternal tachycardia and fetal acidosis. If it is possible to anticipate the episodes of hypotension following SA, the management will be earlier and more efficient. In this context: the perfusion index and the positional blood pressure changes were investigated throughout the current work, as preoperative predictors of post-spinal hypotension in cesarean sections. Eighty pregnant women were monitored using PI perioperatively, while BP was assessed with position change from supine to right lateral pre-spinal anesthesia. Our results indicated that the incidence of hypotension was 80% among the studied patients. The current results were close to the findings of **Lee *et al.*** [2] and **Klohr *et al.*** [3], who reported that intraoperative hypotension is approximately 70% to 74% of CS.

The current findings showed that mean PI pre-spinal anesthesia was 5.81 (SD 1.73) and immediately after spinal anesthesia mean was 4.65 (SD 1.21) with a statistically significant decrease compared to the pre-spinal value. The present findings were in accordance with **Toyama *et al.*** [13] who concluded that baseline PI pre-spinal in pregnant women ranged from 0.7 to 8.6, with a mean value of 4.0. By the same way, **Mallawaarachchi *et al.*** [15] reported that in pregnant women the mean PI value was 4.17 (SD 2.60).

Current findings regarding positional blood pressure reported that mean MAP of the studied cases pre-spinal at supine position was 83.29 (SD 15.56) mmHg while in right lateral position was 91.76 (SD 8.46) mmHg with mean difference 8.48 (SD 10.41) mmHg. Present results were in competence with **Jeon *et al.*** [12] who reported that the mean MAP in supine position was 75 (SD 7) mmHg, and the mean MAP in right lateral position was 87 (SD 9) mmHg. An average of 11 (3-29) mmHg was seen in blood pressure as a result of changing body position.

In our study MAP decreased significantly all times after spinal anesthesia compared to pre spinal. Also, MAP showed decrease from first till fifth readings then started to increase again. Present results were in competence with **Toyama *et al.*** [13] who reported a marked decreases in MAP after spinal injection in parturient with both high and low baseline PI.

Respecting HR at different times in our study HR 1st seven times significantly increased after spinal anesthesia compared to pre spinal anesthesia (98.95 beat/min pre spinal compared to 110.28, 110.89, 105.38, 103.39, 105.41, 102.88, 101.19 beat/min post spinal, respectively, P-value >0.001).

Current results agreed with the results of **Hanss *et al.*** [14] who found that the mean baseline HR was 91 (78/103), the mean HR at 5 min post spinal was 96 (75/144), and the mean HR at 15 minutes after spinal anesthesia was 88 (64/131).

The present study found that PI cut off >4 had a highly statistically significance in prediction of hypotension among cases (P>0.001) Also, in agreement with our findings **Mallawaarachchi *et al.*** [15] who reported that the PI correlated with the decreases in systolic and mean arterial pressure. In the same line with our results **Nandini *et al.*** [16] showed that pregnant women with high baseline PI had a significantly higher incidence of hypotension after spinal anesthesia administration.

The present study found that PI cut off >4 had sensitivity 85.9%, specificity 75% and accuracy 83.8% in prediction of hypotension in prediction of hypotension among cases groups. **Toyama *et al.*** [13] therefore, it was determined that a cutoff value of 3.5 for the baseline perfusion index would be useful in identifying pregnant women at risk for this type of hypotension. The sensitivity of the PI was 81%, and the specificity was 86%.

Additionally, **George *et al.*** [17] in their study, revealed that pregnant women whose baseline PI was higher had a higher incidence and severity of hypotension, PI cut off points >3.6 had a sensitivity of 80% and a specificity of 40% for predicting hypotension in pregnant women undergoing CS.

While, **Mehandale and Rajasekhar** [18] showed that a low PI at baseline was associated with an increased risk of hypotension (sensitivity 93%, specificity 71%). Patients having general anesthesia had PI used as a predictor of hypotension after propofol induction, which contradicts the findings of the current investigation.

On the contrary, **Yokose *et al.*** [19] hypotension in pregnant women getting SA for a caesarean delivery was not predicted by PI. Possible explanations for the discrepancy between the current study and the prior one include differences in methodology, such as the definition of hypotension which was defined as the patient's systolic blood pressure was less than 80 mmHg, they rapidly co-loaded with hydroxyethyl starch 6%, and they administered 10 mg of hyperbaric bupivacaine 0.5% and 10 micrograms of fentanyl while the patient was in the lateral position.

The present study found that positional blood pressure changes from supine to lateral positions at cut off >5 mmHg had sensitivity 82.8%, specificity 75% and accuracy 81.3% in prediction of hypotension among cases (P>0.001).

The current findings were in line with **Jeon *et al.*** [12] who reported a significant association between positional blood pressure change and hypotension after SA, they investigated 66 pregnant women for positional MAP and HR variations while the cases at supine and lateral positions. They concluded that the higher the positional blood pressure change, the more reduction of MAP in patients after SA. Also, current results agreed with **Elfeil *et al.*** [11] as they found that the greater blood pressure variations related to position change from supine to lateral can predict post spinal hypotension.

In contrast to our results, **Frölich and Caton [20]** did not find an association between positional blood pressure variations and post spinal hypotension. This may be explained by the different measurement methods. **Frölich and Caton [20]** averaged 5 blood pressure values obtained every minute after positional change from the supine to a standing position.

Also, **Kinsella *et al.* [21]** concluded that the post spinal hypotension could not be predicted by preoperative blood pressure variations with position change. The results of that study were inconsistent with that of ours, which might be due to the difference of methodology or relative smaller sample size (27 cases), they defined hypotension as a decrease of greater than 25% from the baseline, and they used 15 mg hyperbaric bupivacaine 0.5% and 0.15 mg morphine. While we studied 80 cases who anesthetized using 10 mg of hyperbaric bupivacaine 0.5% with fentanyl 25 ug and hypotension was defined as a decrease of ≥20% from basal MAP.

CONCLUSIONS

The preoperative PI and positional blood pressure change can predict SA hypotension during CS. PI with cut off >4 showed a relatively better sensitivity and accuracy in prediction of hypotension than the positional blood pressure changes with cut off >5.

Supporting and sponsoring financially: Nil.
Competing interests: Nil.

REFERENCES

1. **Borodiciene J, Gudaityte J, Macas A (2015):** Lithotomy versus jack-knife position on haemodynamic parameters assessed by impedance cardiography during anorectal surgery under low dose spinal anaesthesia: a randomized controlled trial. BMC Anesthesiol., 15:74. doi: 10.1186/s12871-015-0055-3.
2. **Lee J, George R, Habib A (2017):** Spinal-induced hypotension: Incidence, mechanisms, prophylaxis, and management: Summarizing 20 years of research. Best Practice & Research Clinical Anaesthesiology, 31(1):57-68.
3. **Klohr S, Roth R, Hofmann T *et al.* (2010):** Definitions of hypotension after spinal anaesthesia for caesarean section: literature search and application to parturients. Acta Anaesthesiol Scand., 54:909-21.
4. **Arslan M, Öksüz G, Bilal B *et al.* (2019):** Can Perfusion Index or Pleth Variability Index Predict Spinal Anesthesia-Induced Hypotension During Caesarean Section? JARSS., 27(4):251-7.
5. **Gaiser R (2014):** Physiological changes of pregnancy. In: Chestnut DH, editor. Chestnut's Obstetric Anaesthesia: Principles and Practice. 5th ed. Philadelphia: Mosby Elsevier Publishing. pp. 15-38. https://evolve.elsevier.com/cs/product/9780323358118?role=student
6. **Duggappa D, Lokesh M, Dixit A *et al.* (2017):** Perfusion index as a predictor of hypotension following spinal anaesthesia in lower segment caesarean section. Indian Journal of Anaesthesia, 61(8):649-54.
7. **Lima A, Bakker J (2005):** Noninvasive monitoring of peripheral perfusion. Intensive Care Med., 31(10):1316-26.
8. **Ginosar Y, Weiniger C, Meroz Y *et al.* (2009):** Pulse oximeter perfusion index as an early indicator of sympathectomy after epidural anesthesia. Acta Anaesthesiologica Scandinavica, 53(8):1018-26.
9. **Mowafi H, Ismail S, Shafi M *et al.* (2009):** The Efficacy of Perfusion Index as an Indicator for Intravascular Injection of Epinephrine-Containing Epidural Test Dose in Propofol-Anesthetized Adults. Anesthesia & Analgesia, 108(2):549-53.
10. **Slagt C, Malagon I, Groeneveld A (2014):** Systematic review of uncalibrated arterial pressure waveform analysis to determine cardiac output and stroke volume variation. British Journal of Anaesthesia, 112(4):626-37.
11. **Elfeil Y, Alattar A, Ghoneim T *et al.* (2021):** The Effectiveness of Non Invasive Hemodynamic Parameters in Detection of Spinal Anesthesia Induced Hypotension During Caesarean Section. Alexandria Journal of Medicine, 57:121-9.
12. **Jeon Y, Hwang J, Kim M *et al.* (2010):** Positional blood pressure change and the risk of hypotension during spinal anesthesia for cesarean delivery: an observational study. Anesthesia & Analgesia, 111(3):712-5.
13. **Toyama S, Kakumoto M, Morioka M *et al.* (2013):** Perfusion index derived from a pulse oximeter can predict the incidence of hypotension during spinal anaesthesia for Caesarean delivery. British Journal of Anaesthesia, 111(2):235-41.
14. **Hanss R, Ohnesorge H, Kaufmann M *et al.* (2007):** Changes in heart rate variability may reflect sympatholysis during spinal anaesthesia. Acta Anaesthesiologica Scandinavica, 51(10):1297-304.
15. **Mallawaarachchi P, Pinto V, De Silva P (2020):** Perfusion index as an early predictor of hypotension following spinal anesthesia for cesarean section. Journal of Obstetric Anaesthesia and Critical Care, 10(1):38-41.
16. **Nandini M, Srinivasaiah M, Jyosthna K *et al.* (2022):** Peripheral perfusion index: a predictor of post-spinal hypotension in caesarean section. Cureus, 14(6):e25699. doi:10.7759/cureus.25699.
17. **George J, Valiaveedan S, Thomas M (2019):** Role of perfusion index as a predictor of hypotension during spinal anaesthesia for caesarean section-A prospective study. J Med Sci Clin Res., 7:1208-16.
18. **Mehandale S, Rajasekhar P (2017):** Perfusion index as a predictor of hypotension following propofol induction-A prospective observational study. Indian Journal of Anaesthesia, 61(12):990-5.
19. **Yokose M, Mihara T, Sugawara Y *et al.* (2015):** The predictive ability of non-invasive haemodynamic parameters for hypotension during caesarean section: A prospective observational study. Anaesthesia, 70(5):555-62.
20. **Frölich M, Caton D (2002):** Baseline heart rate may predict hypotension after spinal anesthesia in prehydrated obstetrical patients. Canadian Journal of Anesthesia, 49(2):185-9.
21. **Kinsella S, Norris M (1996):** Advance prediction of hypotension at cesarean delivery under spinal anesthesia. International Journal of Obstetric Anesthesia, 5(1):3-7.