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Role of perfusion index in early detection of hypotension following spinal anesthesia for cesarean section

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ABSTRACT

Background: The most common drawback of spinal anesthesia (SA) is hypotension, which has adverse effects on both mother and fetus; consequently, early detection and management of spinal hypotension have been considered a very important topic in obstetric anesthesia. Additionally, the capability to ultimately diagnose hypotension could permit initiation of adequate treatment. The standard method to estimate blood pressure during cesarean section is noninvasive blood pressure measurement. However, periods of hypotension could be missed within a reasonable time frame.

Methods: Perfusion index (PI) and blood pressure were measured in 100 pregnant women during elective cesarean section under SA.

Results: PI had a significant negative correlation with the change occurred in systolic blood pressure (SBP) ($r = -.432$, $p < .0001$); by using univariate linear regression analysis, the PI explains 20.2% of variability in SBP as PI significantly predicts the change occurred in SBP ($F = 24.8$, $p < .0001$), as each one unit increase in PI, accompanied by a significant decrease in SBP by 2.089 (mm/hg), as (b, t, p) (−2.089, −4.987, .0001), respectively. There was a significant difference in SBP and PI before and after giving oxytocin bolus [($z = -1.9$, $P = .05$) and ($z = -4.3$, $P < .0001$), respectively]. By comparing PI before vs. after taking ephedrine bolus, there was a significant decrease in median of PI [median of PI before 10 (5.5–15) vs. median of PI after 7.5 (6–15.5) ($z = -6.6$, $P < .0001$)].

Discussion: After SA with sympathetic blockade, peripheral vascular tone declined and therefore PI increased.

Conclusion: PI could anticipate the incidence of hypotension during cesarean delivery with SA. Ephedrine effect could be evaluated rapidly by the alteration in the PI so that further need can be judged. Oxytocin has a significant impact on vascular tone with 5 international unit bolus, although it does not have a significant effect on blood pressure.

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Anesthesia; hypotension; obstetric; perfusion index; pulse oximeter

1. Introduction

The most common technique of anesthesia in parturient for cesarean delivery is spinal anesthesia (SA) [1]. The rate of cesarean section imposed under SA has marked expansion in the last two decades [2].

The most common drawback of SA is hypotension, which has adverse effects on maternal and baby sequel. Consequently, early detection and management of spinal hypotension have been considered a very important topic in obstetric anesthesia. Additionally, the standard method to estimate blood pressure during cesarean section is noninvasive blood pressure (NIBP) measurement. However, periods of hypotension could be missed within a reasonable time frame.

Perfusion index (PI) is a noninvasive continuous estimation of peripheral perfusion based on pulse oximeter. It is the proportion of pulsatile and fixed non-pulsatile flow of blood in peripheral tissue like a fingertip which adds more convenient details in different clinical conditions [3]. PI could assess peripheral perfusion that can be related to vascular tone, which has a major effect on hypotension [4]. Previous research by Toyamo et al. proposed that, after SA for cesarean delivery, PI >3.5 could predict the incidence of hypotension [5].

It was hypothesized that changes in PI after SA could help in early detection of hypotensive episodes. It also detects response to ephedrine bolus after hypotensive episode; therefore, it can help in early detection and management.

2. Aim of the work

The primary aim of this study was to establish whether the trend of the perfusion index detects hypotension before the changes in NIBP values.

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The secondary aim was to detect oxytocin bolus impact on the PI and the effectiveness of ephedrine dose during hypotensive episodes on PI and whether PI can assess the response to ephedrine [6,7].

3. Methods

In El Shatby Hospital, Alexandria, 100 elective cesarean deliveries were done in prospective observational study after taking a consent from pregnant female from November 2021 till November 2022 after acceptance of ethical committee in monthly meeting of 20 January 2022 with serial number 0305448.

4. Indications for elective cesarean section

- Breech presentation (at term) – planned cesarean sections for breech presentation at term have increased significantly since the "Term Breech Trial" [Lancet, 2000].
- Other malpresentations – e.g., unstable lie (a presentation that fluctuates from oblique, cephalic, transverse, etc.), transverse lie, or oblique lie.
- Maternal request – this covers a variety of reasons from previous traumatic birth to "maternal choice".

Inclusion criteria were ASA (American Society of Anesthesiologists) II elective cesarean section of a single baby and 39-weak gestational ages or above.

Exclusion criteria were contraindication to SA, allergy to medication used, obese with BMI ≥35 kg/m^2, and height out of the range from 150 cm to 180 cm.

Preoperative pregnant patients were assessed carefully. Sodium citrate (30 ml) was given as prophylactic antacid in operating room after 5 minutes of rest, with the table tilt of 15 to 30 degree left lateral. Large cannula 18G was put after lidocaine 2%, a local anesthesia. Basic monitors were attached. Basal reading of heart rate, blood pressure, and PI was done by averaging of three consecutive readings. Heart rate and PI were monitored using pulse oximeter, and blood pressure (systolic mean diastolic) was monitored using automated noninvasive device (Biolight M69, Biolight Meditech®, Zhuhai, China).

In the sitting position spinal anaesthesia was delivered under full sterilization. After skin local anaesthetic injection with lidocaine 2% 2 ml at the L3-L4 or L4-L5 vertebral interspace. At L3-L4 or L4-L5 intervertebral space, local anesthetic, 2.2 ml of 0.5% hyperbaric bupivacaine, with 25 µg (0.5 ml) fentanyl was given (total volume 2.7 ml) with Quincke spinal needle after confirmation of free flow of cerebrospinal fluid, and then the basal posture was restored.

As regards fluids, Ringer's lactate coload was started with the injection of local anesthetic for the first 1 L. The bag of fluid was suspended at 1 m height above operating table midpoint. Maintenance fluids (10 ml/kg/hour) were given till the end of operation [8,9].

Block adequacy was assessed by anesthesiologist, and surgery could be started. Ice swap was used for block height and deemed adequate if T4 level. Bromage score was employed for motor block, and grade IV must be reached. In case of inappropriate sensory or motor level, the patient was excluded. Oxytocin 5 international unit IU as intravenous bolus was given after delivery of the baby then 2 international units. Hemodynamic monitors – (systolic, diastolic, and mean) blood pressure, heart rate, and PI – were measured every 1 minute till delivery and then every 3 minutes till the end of surgery.

The definition of hypotension was a decrease from the basal systolic blood pressure (SBP) by >20%, which is the most common definition in research study. Treatment with 10 mg ephedrine was given intravenously when mean blood pressure was below 65 mmHg [10].

Atropine 0.5 mg was given intravenously when heart rate was <60.

Oxygen was delivered by face mask to maintain oxygen saturation more than 95%.

5. Sample size calculation

Based on this study [11], a sample size of 100 achieves 80% power that detects effect size of 30% with a target significance level at 5%. NCSS 2004 and PASS 2000 program were used for sample size calculation.

6. Statistical analysis

The Statistical Package for the Social Sciences version 25 was used for data coding.

According to the distribution of variables using Kolmogorov–Smirnov test, data were summarized by median as measures of central tendency and range as measures of dispersion for quantitative not normally distributed, while for quantitative normally distributed variables, we summarized it using mean and standard deviation.

The strength and correlation course of PI and hypotension was estimated by Spearman correlation.

Univariate linear regression analysis was used to predict the sequel of PI on SBP. Wilcoxon test was used to detect significant difference in median quantitative variables among SBP, mean arterial blood pressure (MABP), and PI before and after giving oxytocin bolus.

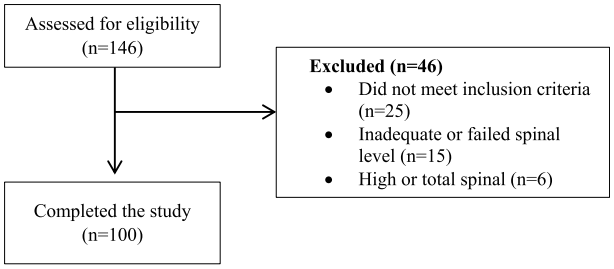

Table 1. Correlations between changes that occurred in the systolic blood pressure and in perfusion index.

		Correlations	
		Systolic BP	Perfusion index
Systolic BP	*R*	1	−.439*
	P		<.0001*
	No.		100

Note: *R*; Spearman correlation.
*Statistically significant.

7. Results

Study was done on 100 pregnant females; their mean age was 28.34 ± 5.1 years (ranged from 19 to 39 years), and the mean of their BMI was 28.13 ± 2.5 (ranged from 23 to 34). As regards gravida G, G2 constituted the majority (30%), followed by G3 (23%), then G1 and G4 were the same percent (20%), and G5 (8%) was the least. As regards parity P, P1 constituted the majority (34%), followed by P0 (26%), then P2 (19%), and P4 (9%) was the least. As regards gestational age GA, GA39 constituted the majority (42%), followed by GA40 (39%), and GA41 (19%) was the least. Basal mean PI was 3.7 ± 1.08 (ranged from 2 to 6.4).

Gravida ranged from 1 (20 cases), 2 (30 cases), 3 (23 cases), 4 (20 cases), and 5 (8 cases); parity ranged from 0 (26 cases), 1 (34 cases), 2 (19 cases), 3 (12 cases), and 4 (9 cases); and gestational age ranged from 39 weeks (42 cases), 40 weeks (39 cases), and 41 weeks (19 cases). Basal mean PI was 3.7 (ranged from 2 to 6.4). Figure 1 illustrates mean changes that occurred in PI, MABP, and SBP starting from baseline to 60 minutes.

Spearman correlation revealed that the change that occurred in PI had a significant negative correlation with the change that occurred in SBP ($r = -.432$, $p < .0001$) (Table 1 and Figure 2).

Using univariate linear regression analysis, the model including PI explains 20.2% of variability in SBP as PI significantly predicts the change occurred in SBP ($F = 24.8$, $p < .0001$), as each one unit increase in PI, accompanied by a significant decrease in SBP by 2.089 (mm/hg), as (*b*, *t*, *p*) (−2.089, −4.987, .0001), respectively (Table 2).

Table 3 and Figure 3 show diagnostic ability of PI in the prediction of hypotension that occurred during cesarean section as change in PI can *; statistically significantly detect hypotensive cases with AUC was .92 (0.859 to 0.970) ($P < 0.0001$), the cutoff point of PI change with highest sensitivity (95% CI) and specificity (95% CI) [(>2.127, 73.7 (56.9–86.6) and 98.7 (94.2–100), respectively].

There was a significant difference in SBP and PI before and after giving oxytocin bolus [($z = -1.9$, $P = .05$) and ($z =$

Table 2. Univariate linear regression analysis to predict the effect of PI on SBP.

	Unstandardized coefficients		Standardized coefficients			
	B	Std. error	Beta	*t*	*p*	95% Confidence interval
(Constant)	−10.646	.883	-	−12.057	<.0001*	(−12.39 to −8.89)
PI	−2.089	.419	−.450	−4.987	<.0001*	(−2.920 to −1.258)

Note: Dependent variable: SBP.

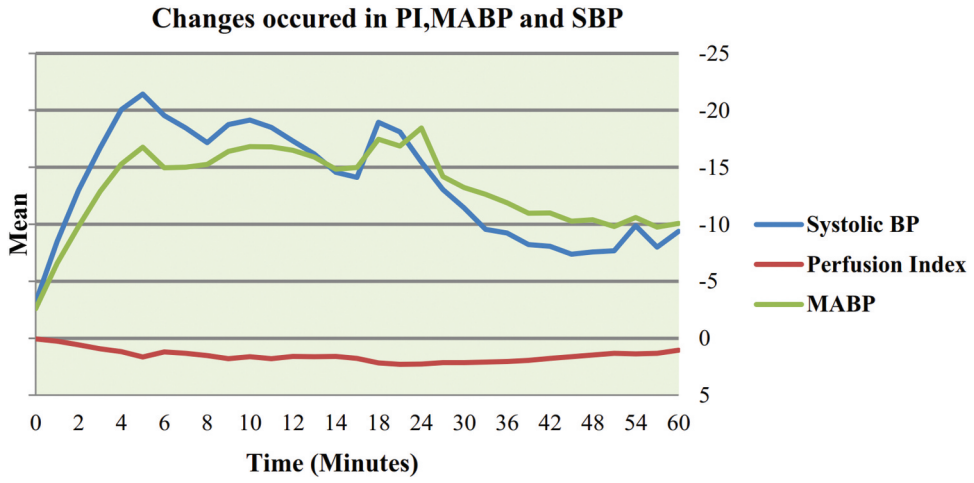

Figure 1. Line graph describes mean changes that occurred in PI, MABP, and SBP starting from baseline to 60 minutes of cesarean section.

Table 3. Diagnostic ability of PI in prediction of hypotension during cesarean section.

NPV (95% CI)	PPV (95% CI)	Specificity (95% CI)	Sensitivity (95% CI)	Cutoff point	*P* value	AUC (95% CI)	
86.1 (75.9–93.1)	100 (87.2–100)	98.7 (94.2–100)	73.7 (56.9–86.6)	>2.127	<.0001*	.92 (0.859–0.970)	PI

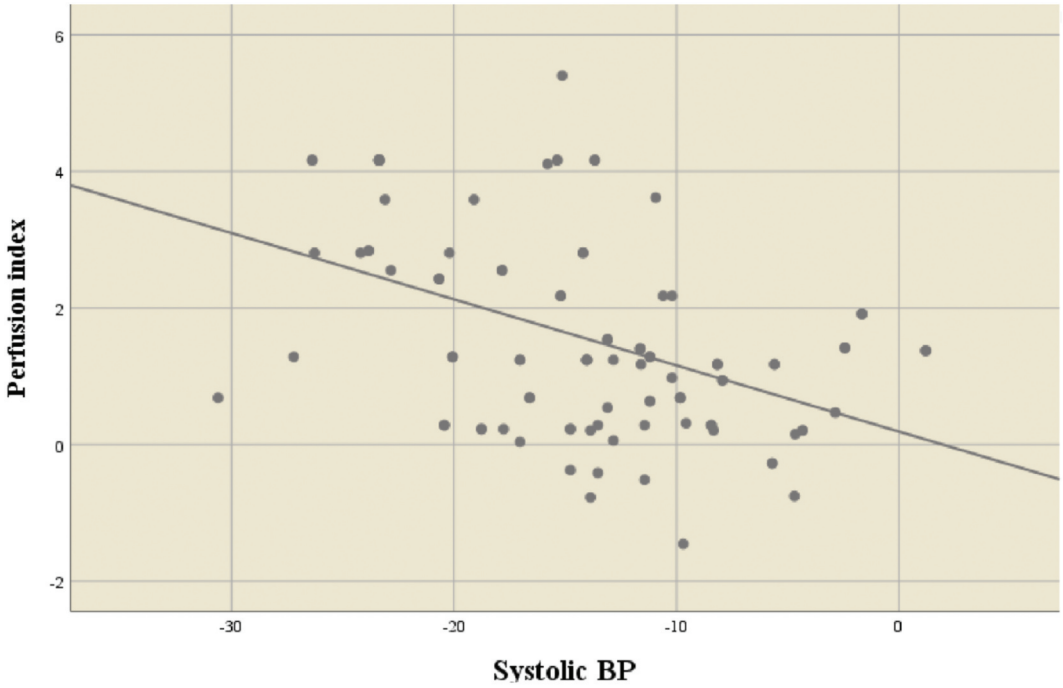

Figure 2. Correlation between change in PI and change in systolic blood pressure during spinal anesthesia for cesarean delivery.

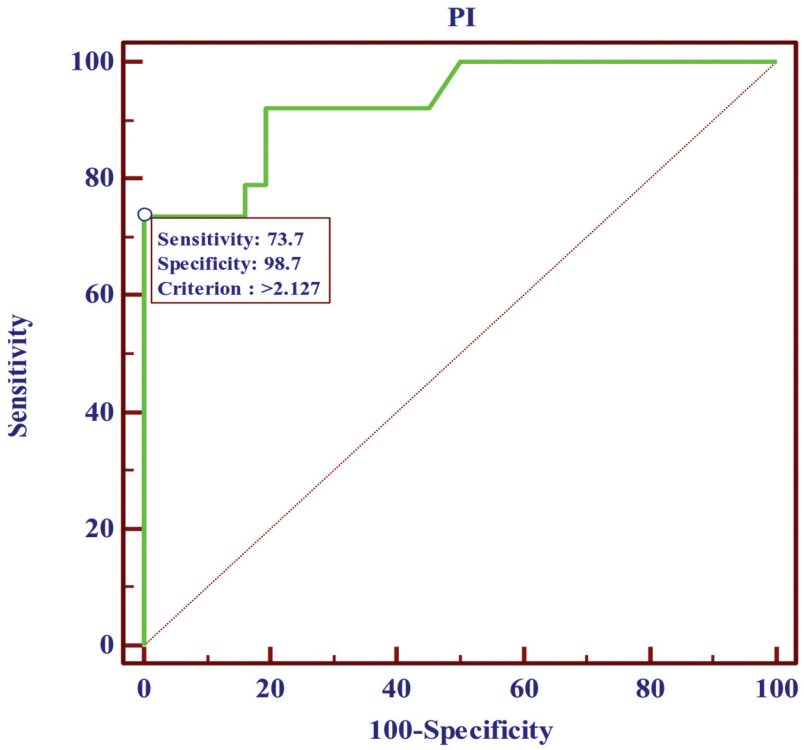

Figure 3. Diagnostic ability of PI in prediction of hypotension during cesarean section.

Table 4. Relations between the blood pressure variables and perfusion index following oxytocin bolus.

	Before oxytocin bolus (No. = 100)	After oxytocin bolus (No. = 100)	Test of significance (*P*)
SBP	103 (88–115)	105 (93–114)	($z = -1.9$, $P = .05$*)
MABP	67.33 (59–78)	69 (65–75)	($z = -.86$, $P = .38$)
PI	4.5 (2.8–12.4)	5 (2.9–11)	($z = -4.3$, $P < .0001$*)

Note: Data described by median (Min-Max).
z; Wilcoxon test.
*Statistically significant.

Table 5. Relations between perfusion indexes before ephedrine bolus vs after ephedrine bolus.

	Before ephedrine bolus (No. = 83)	After ephedrine bolus (No. = 83)	Test of significance (*P*)
PI	10 (5.5–15)	7.5 (6–15.5)	($z = -6.6$, $P < .0001$*)

–4.3, $P < .0001$), respectively], while there was no significance detected in MABP ($z = -.86$, $P = .38$), as shown in Table 4.

During operation, ephedrine bolus was given 83 times to patients as taken once in 10 cases, twice in 11 cases, thrice in 7 cases, 4 times in 5 cases, and 5 times in only 2 cases.

By comparing PI before vs. after taking ephedrine bolus, there was a significant decrease in median of PI [median of PI before 10 (5.5–15) vs .median of PI after 7.5 (6–15.5) ($z = -6.6$, $P < .0001$)] (Table 5 and Figure 4).

8. Discussion

Steady hemodynamic parameters result in better final outcome. The most frequent drawback after SA is hypotension. Intraoperative intermittent NIBP and heart rate are the main methods to detect hypotension. Invasive blood pressure or advanced monitors are needed to have continuous detection of blood pressure [4].

PI can be measured from peripheral pulse oximeter so it can be used practically as a noninvasive test [3]. During pregnancy, blood volume and cardiac output expand. On the other hand, systemic vascular resistance declines, which matches with increase in PI due to vasodilatation [3]. After SA, there is high rise in sympathetic block level than sensory block; peripheral vascular tone is declined, and there is more hypotensive effect [12].

Spearman correlation revealed that the PI had a significant negative correlation with SBP. With multiple regression model, PI significantly predicts the change occurred in SBP, as each one unit increase in PI, accompanied by a significant decrease in SBP by 2.089 (mm/hg). This can be compared with the study of Roshana Prasad et al. which found that PI was a quick predictor of the incidence of hypotension during cesarean delivery [13].

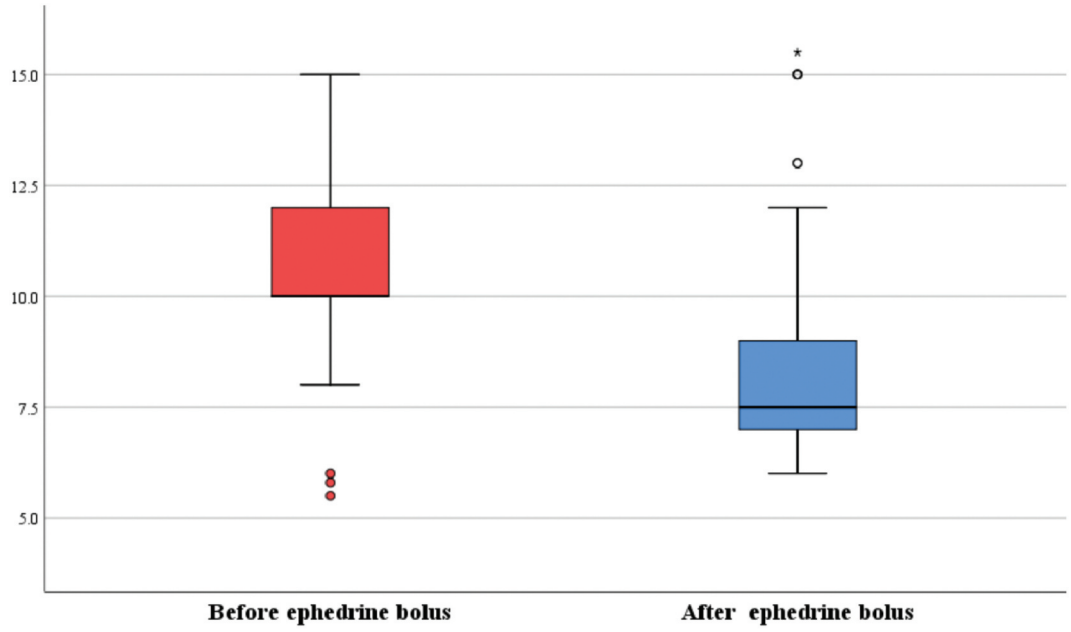

Figure 4. Relations between perfusion indexes before ephedrine bolus vs. after ephedrine bolus.

In previous studies, PI has been reported to increase following the arterial vasodilation caused by sympathetic block [11]. Furthermore, PI measurement has been shown to be effective in evaluating the success of many peripheral nerve blocks, such as axillary block, infraclavicular block, sciatic block, stellate ganglion block, and interscalene block [11,14,15]. Ginosar et al. found that, after epidural anesthesia, PI increase was a reliable marker of sympathectomy [15].

9. Conclusion

PI could anticipate the incidence of hypotension during cesarean delivery with SA. Ephedrine effect could be evaluated rapidly by the alteration in the PI so that further need can be judged. Oxytocin has a significant impact on vascular tone with 5 international unit bolus, although it does not have a significant effect on blood pressure.

10. Limitations

Weak points in this study were found. First of all was the patient movement; therefore, PI should be measured with utmost care to avoid that. Level of anxiety must be asked as PI may decrease with anxiety.

Abbreviations

IV	intravenous
NIBP	noninvasive blood pressure
PI	perfusion index
SBP	systolic blood pressure
SA	spinal anesthesia

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Consent

Trial registration number 0305448.

Disclosure statement

The authors report that there are no competing interests to declare.

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References

[1] Riley ET, Cohen SE, Macario A, et al. Spinal versus epidural anesthesia for cesarean section: a comparison of time efficiency, costs, charges, and complications. Anesth Analg. 1995;80 (4):709–712. DOI:10.1097/00000539-199504000-00010

[2] Sufang G, Padmadas SS, Fengmin Z, et al. Delivery settings and caesarean section rates in China. Bull World Health Organ. 2007;85(10):755–762. DOI:10.2471/BLT.06.035808

[3] Masimo Corp. Clinical applications of perfusion index. USA: Masimo Corp; 2016. pp. 1–6.

[4] Hales JR, Stephens FR, Fawcett AA, et al. Observations on a new non-invasive monitor of skin blood flow. Clin Exp Pharmacol Physiol. 1989;16(5):403–415. DOI:10.1111/j.1440-1681.1989.tb01578.x

[5] Toyama S, Kakumoto M, Morioka M, et al. Perfusion index derived from a pulse oximeter can predict the incidence of hypotension during spinal anaesthesia for caesarean delivery. Br J Anaesth. 2013;111(2):235–241. DOI:10.1093/bja/aet058

[6] National Institute for Health and Clinical Excellence (NICE). Clinical Guideline CG132. Caesarean Section. London: NICE; 2011.

[7] Mercier FJ, Augè M, Hoffmann C, et al. Maternal hypotension during spinal anesthesia for caesarean delivery. Minerva Anestesiol. 2013;79 (1):62–73.

[8] Oh AY, Hwang JW, Song IA, et al. Influence of the timing of administration of crystalloid on maternal hypotension during spinal anesthesia for cesarean delivery: preload versus coload. BMC Anesthesiol. 2014;14(1):36. DOI:10.1186/1471-2253-14-36

[9] Teoh WH, Sia AT. Colloid preload versus coload for spinal anesthesia for cesarean delivery: the effects on maternal cardiac output. Anesth Analg. 2009;108 (5):1592–1598.

[10] Klöhr S, Roth R, Hofmann T, et al. Definitions of hypotension after spinal anaesthesia for caesarean section: literature search and application to parturients. Acta Anaesthesiol Scand. 2010;54(8):909–921. DOI:10.1111/j.1399-6576.2010.02239.x

[11] Mallawaarachchi R, Pinto V, De Silva P. Perfusion index as an early predictor of hypotension following spinal anesthesia for cesarean section. J Obstetr Anaest Critical Care. 2020;10(1):38–41.

[12] Chen H, Liao Z, Fang Y, et al. Continuous right thoracic paravertebral block following bolus initiation reduced postoperative pain after right-lobe hepatectomy: a randomized, double-blind, placebo-controlled trial. Reg Anesth Pain Med. 2014;39(6):506–512. DOI:10.1097/AAP.0000000000000167

[13] Chamberlain DP, Chamberlain BD. Changes in the skin temperature of the trunk and their relationship to sympathetic blockade during spinal anesthesia. Anesthesiology. 1986;65(2):139–143.

[14] Galvin EM, Niehof S, Verbrugge SJ, et al. Peripheral flow index is a reliable and early indicator of regional block success. Anesth Analg. 2006;103(1):239–243. DOI:10.1213/01.ane.0000220947.02689.9f

[15] Kus A, Gurkan Y, Gormus SK, et al. Usefulness of perfusion index to detect the effect of brachial plexus block. J Clin Monit Comput. 2013;27(3):325–328. DOI:10.1007/s10877-013-9439-4