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Evaluation of perfusion index as an indicator of postoperative pain in parturients undergoing caesarean section: an observational study

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ABSTRACT

Objective. Perfusion index (PI) is a non-invasive measure of peripheral perfusion. Previous studies have evaluated PI as an objective tool of pain assessment peri-operatively. Against this background, the present study aimed to evaluate PI as an objective indicator of pain assessment in parturients undergoing lower segment caesarean section and also to observe any correlation of PI with Visual analogue scale (VAS), heart rate (HR) and mean arterial pressure (MAP).

Materials and Methods. This prospective observational study was conducted in 40 parturients scheduled to undergo caesarean section under spinal anaesthesia. After surgery, patients were shifted to post anaesthesia care unit. Pulse co-oximeter probe was attached to the middle fingertip of the hand along with standard routine monitors. HR, MAP, VAS and PI were recorded at first request of analgesia (T1) by the patient and at 30 minutes after administration of analgesia (T2) in the form of 1 g paracetamol i.v.

Results. There was a statistically significant increase in PI from T1 to T2 (3.62 ± 2.36 to 8.51 ± 9.36 ; $p < 0.05$). This increase was associated with statistically significant decrease in HR (93.08 ± 12.71 vs 85.65 ± 10.63 beats/min), MAP (96.60 ± 11.606 vs 91.55 ± 10.86 mmHg) and VAS (6.23 ± 1.23 vs 2.53 ± 1.06) at T2 as compared to T1. A statistically significant negative correlation was observed between PI and HR/MAP/VAS from T1 to T2 ($r_s = -0.433$, $p < 0.001$; $r_s = 0.896$, $p < 0.001$; $r_s = -0.231$, $p = 0.016$, respectively).

Conclusions. PI can be used as an additional and objective indicator of pain assessment in post anaesthesia care unit.

INTRODUCTION

Post-operative pain management is important, particularly in context of enhanced recovery after surgery as it relieves suffering, leads to earlier mobilisation, shortened hospital stay, reduced cost and increased patient satisfaction [1]. Adequate man-

agement of pain is vital in parturients undergoing lower segment caesarean section (LSCS) as it influences the capacity of the mother to take care of the new born and initiate breastfeeding [2]. Also, pain assessment should be appropriate owing to considerable physiologic changes (hormonal and emotional) in mother due to pregnancy and arrival

of baby. Visual analogue scale (VAS) is the most commonly used pain assessment tool in post-operative period in adult patients. It is easy, less time consuming and more sensitive to small changes than other descriptive ordinal scales. However, it is highly subjective and it cannot be used in patients with impaired cognitive, psychological and neurological functions and in those who are unable to express themselves verbally [3].

The perfusion index (PI), which is the ratio between the variable pulsatile alternating current (AC) and non-pulsatile direct current (DC) signals, is an indirect and non-invasive measurement of peripheral perfusion. It is calculated by means of pulse oximetry by expressing the pulsatile signal (during arterial flow) as a percentage of the non-pulsatile signal (AC/DC×100), both of which are derived from the amount of infrared (940 nm) light absorbed. The PI may decrease due to increased vasomotor tone and the contraction of peripheral blood vessels when the sympathetic nervous system is activated by pain. The PI may also increase when pain is relieved by the use of adequate analgesics [4-9]. There are a few previous studies which have evaluated PI as an objective tool of pain assessment peri-operatively and in critically ill patients [5-7, 9]. It eliminates psychological factors such as personality, age, gender, fear, anxiety, depression, anger etc for pain assessment. However, the literature is scarce regarding the same when it comes to obstetric patients who are going through emotional turmoil and levels of fear and anxiety are running high. Therefore, the present study was planned to evaluate PI as an indicator for post-operative pain in patients undergoing lower segment caesarean section. The null hypothesis was that there will be no change in PI with pain. Primary objective was to observe the change in PI with pain and administration of analgesia. Secondary objectives were to observe any correlation of PI with Visual analogue scale (VAS), heart rate (HR) and mean arterial pressure (MAP).

MATERIALS AND METHODS

The present prospective, observational study was carried out in the Department of Anaesthesiology and Critical Care at Pt. B.D. Sharma PGIMS, Rohtak following approval from Institutional Ethics Committee (IEC) vide letter no. BREC/Th/20/Anesth16 dated 02/04/2021 with CTRI no.

CTRI/2022/03/041169 from March to September, 2022. Forty pregnant females belonging to American Society of Anaesthesiologist’s (ASA) class II, scheduled to undergo lower segment caesarean section under regional anaesthesia were enrolled. Patients with age <18 years, history of neurological, psychological, or any chronic pain disorder, drug allergy, any contraindication to regional anaesthesia and conversion to general anaesthesia were excluded from the study.

Sample size

Mohammad *et al.* reported the mean change in PI value 30 minutes after rescue analgesia compared to baseline as 0.86 ± 0.96 [5]. Assuming these as references values, the minimum required sample size at power of 80% and type 1 error of 5%, number of participants required in the study were 40. Hence by using following formula:

$$N = 2 \times \frac{(Z_{\alpha/2} + Z_{\beta})^2}{(\delta_0)^2} \times SD^2$$

- N = size per group
- SD = Standard Deviation = 0.6
- δ = mean difference = 0.96
- Z_{α/2} = Z_{0.05/2} = Z_{0.025} = 1.96 — From Z table at type I error of 5
- Z_β = Z_{0.20} = 0.842 — at 80% power

$$N = 2 \times \frac{(Z_{\alpha/2} + Z_{\beta})^2}{(\delta_0)^2} \times SD^2$$

$$= 2 (1.96+0.84)^2 (0.96)^2 / (0.6)^2$$

$$= 15.68 * 0.92 / 0.36$$

$$=14.59/ 0.36$$

$$=40.52$$

$$=40$$

Statistical analysis

The data was compiled and entered into Microsoft Excel spread sheet. The quantitative variables such as HR, MAP, PI, VAS, temperature, duration of surgery, height and weight of patients were expressed as mean ± SD and were assessed for normality using Kolmogorov Smirnov non parametric test. The qualitative variables such as age type of surgery level of block) were expressed as frequencies/ percentages and compared using chi square test. The paired t-test was used to compare normally distributed paired data. A P-value < 0.05 was con-



Figure 1. PI measurement using Masimo Radical 7; Masimo corp, Irvine, CA, USA.

sidered statistically significant. Test data Analysis was done using SPSS version 20 (IBM SPSS Statistics inc, Chicago Illinois, USA) Windows software program. Descriptive statistics included computation of percentages, means and standard deviation.

Patient and public involvement

Informed witnessed consent for participation in the study was obtained from the patients. Preoperative fasting of 6 hours prior to surgery was ensured. Patients were trained to express their level of pain using VAS to increase the familiarity with the scale. We showed them a 10 cm line with “no pain” at one end and “worst pain imaginable” at the other, and asked them to mark a spot that best represents their current pain level that can range from 0 to 10. A standardised routine protocol was used for anaesthesia in all patients. After shifting the patient to operation theatre, ASA standard monitors including lead II electrocardiography, pulse oximetry, and NIBP measurement was instituted. HR and MAP were recorded on the operation theatre table prior to any intervention. An intravenous access was established and co-loading with 15 ml/kg Ringers’ lactate infusion was initiated. Under all aseptic precautions, subarachnoid block was performed at L3-L4 or L4-L5 interspace with patient in sitting position, using 12.5 mg of hyperbaric bupivacaine (0.5%). After spinal block, patients were placed in supine position with a wedge underneath left buttock and oxygen was provided via a facemask.

After completion of surgery, patients were shifted to PACU where following monitors were attached to the patient: ECG, NIBP, temperature probe. To monitor the PI, pulse co-oximeter probe (Masimo Radical 7; Masimo corp, Irvine, CA, USA) as shown in **Figure 1** was attached to the middle fingertip of the hand contralateral to the site of blood pressure monitoring and was wrapped in a sheet to decrease heat loss and interference by ambient light [4, 5]. Baseline values of HR, MAP, PI, peripheral oxygen

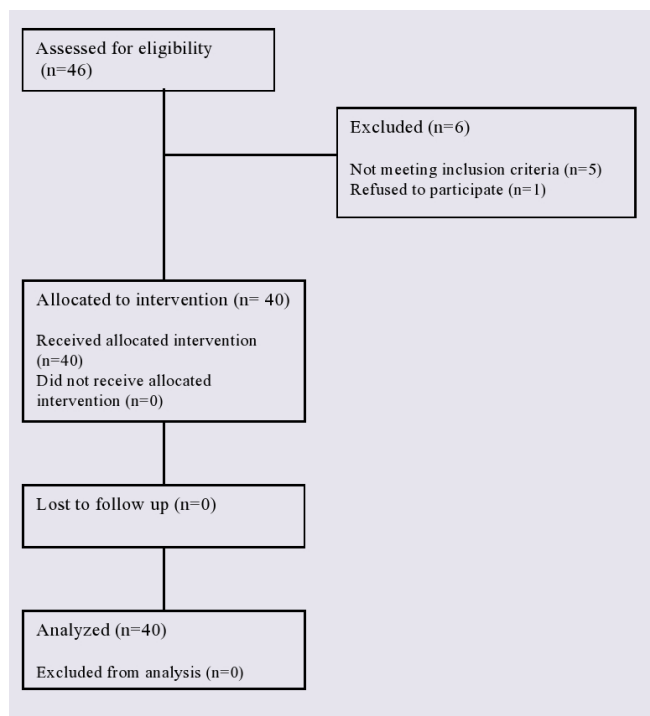


Figure 2. Consort diagram.

saturation (SpO_2) and level of block were recorded as soon as the patient was shifted to recovery room (T0). An oxygen mask was applied if $SpO_2 < 95\%$. The patients were kept warm with woollen blankets, warm i.v. fluids, and a warm environment. All patients were observed till the end of study period in PACU. The person recording the parameters was blinded to the timings of analgesia requirement and administration.

Time of the first request for analgesia (T1): When patients complained of pain in PACU and requested for analgesia, VAS, PI, HR, MAP, SpO_2 and temperature were noted. For all patients, analgesia was given with injection paracetamol 1g i.v.

Thirty minutes after analgesic administration (T2): after 30 minutes of first administration of rescue analgesia, second measurements of the above-mentioned parameters were noted in all the patients: VAS for pain intensity, PI, HR, MAP, SpO_2 and temperature.

RESULTS

Total 40 patients were analysed who were in age group of 18 to 39 years (**Figure 2**). Mean age of the patients was 25 ± 3.78 years. Mean height of the patients was 155.48 ± 5.14 cm and mean weight was 49.15 kg. Mean duration of surgery was 1.71 ± 0.37 hours. Mean temperature was 36.52 ± 0.06 °C,

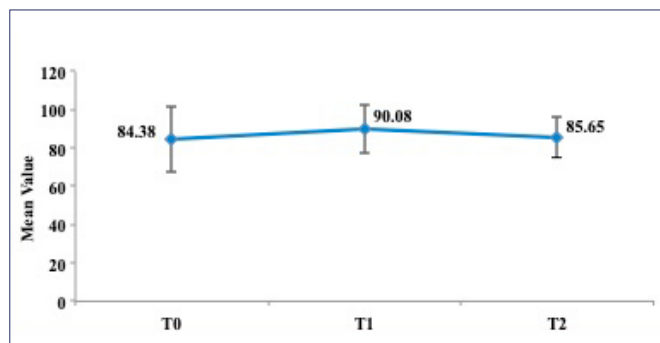


Figure 3. Mean HR at various time points.

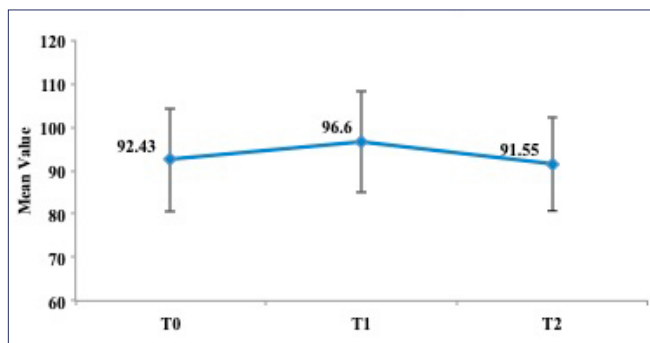


Figure 4. Mean MAP in mmHg at observed time points.

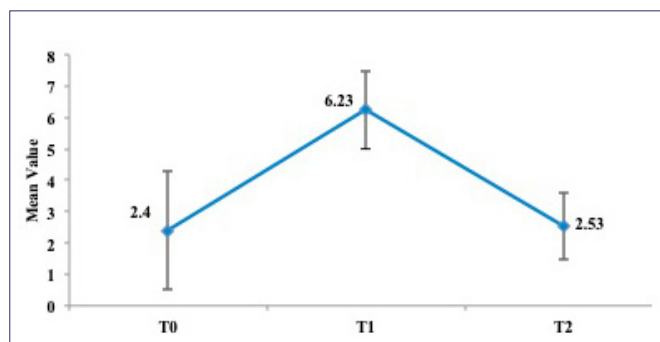


Figure 5. Mean VAS at various time points.

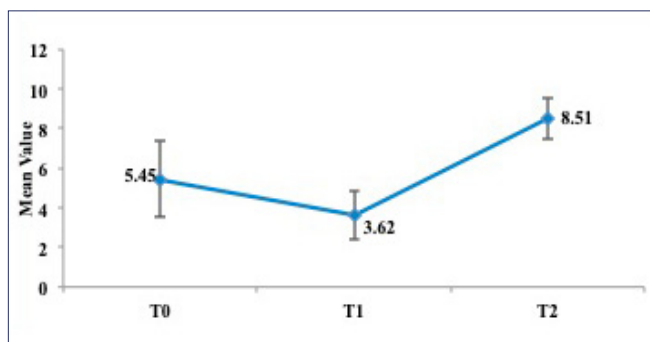


Figure 6. Comparison of mean PI at observed time points.

36.505 ± 0.07 °C and 36.51 ± 0.06 °C at T0, T1 and T2 respectively (p = 0.640). The average length of PACU stay was 2.5 hours in our study. All patients made analgesia request during the course of their PACU stay. Mean T0 to T1 interval was 60 ± 10.5 minutes. Mean values of HR, MAP, VAS and PI at T0, T1 and T2 is shown in **Figures 3, 4, 5 and 6** respectively. HR increased significantly from T0 to T1 with a mean difference of 6.225 (p = 0.001), while it decreased significantly from T1 to T2 with mean difference of 7.425 (p = 0.001) (**Figure 3**). It was observed that MAP increased from T0 to T1 with mean difference of 4.175 which was statistically significant (p < 0.001); it decreased from T1 to T2 with mean difference of 7.325 which was statistically significant (p = 0.006) (**Figure 4**). VAS increased from T0 to T1 with a mean difference of 3.825 which was statistically significant (p = 0.001), while it decreased significantly from T1 to T2 with a mean difference of 3.700 (p = 0.001) (**Figure 5**). This signifies that there was a significant increase in HR, MAP and VAS values with pain while a significant decrease was observed after analgesic administration. PI decreased from T0 to T1 with mean difference of 1.828, this finding was found to be statistically non-significant (p = 0.489). PI increased from T1 to T2 with a mean difference of 4.888 which was statistically significant (p = 0.001)

Table 1. Correlation of percentage change among study variables from T0 to T1.

		MAP % increase	VAS % increase	PI % decrease
% change in HR (beats/min)	Spearman Correlation	0.539	0.649	0.474
	P-value	< 0.001**	< 0.001**	< 0.001**
% change in MAP (mmHg)	Spearman Correlation	1	0.548	0.756
	P-value		< 0.001**	< 0.001**
% change in VAS	Spearman Correlation		1	0.258
	P-value			0.009*

HR: heart rate; MAP: mean arterial pressure; VAS: visual analogue scale; PI: perfusion index.

(**Figure 6**). PI values decreased with pain and increased after analgesic administration. The increase in HR from T0 to T1 showed a negative correlation with decrease in PI from T0 to T1, with a spearman correlation coefficient value of 0.474, which was statistically significant (p < 0.001). The increase in MAP from T0 to T1 showed a significant negative correlation with decrease in PI from T0 to T1 (spearman correlation coefficient = 0.756; p < 0.001). The increase in VAS score showed a significant negative correlation with mean decrease in PI from T0 to T1 (spearman correlation coefficient = 0.258; p = 0.009) (**Table 1**). This indicates that the

Table 2. Correlation of percentage change among study variables from T1 to T2.

		MAP % decrease	VAS % decrease	PI % increase
% change in HR (beats/min)	Spearman Correlation	0.423	0.537	0.433
	P-value	< 0.001**	< 0.001**	< 0.001**
% change in MAP (mmHg)	Spearman Correlation	1	0.678	0.896
	P-value		< 0.001**	< 0.001**
% change in VAS	Spearman Correlation		1	0.231
	P-value			0.016*

HR: heart rate; MAP: mean arterial pressure; VAS: visual analogue scale; PI: perfusion index.

increase in HR, MAP and VAS observed with pain was significantly correlated with decrease in PI values at that time.

The decrease in HR from T1 to T2 showed a significant negative correlation with increase in PI from T1 to T2, with spearman correlation coefficient of 0.433 which was statistically significant ($p < 0.001$). The mean decrease in MAP from T1 to T2 was negatively correlated with increase in PI from T1 to T2, with a correlation coefficient of 0.896 ($p < 0.001$). The decrease in VAS was negatively correlated with increase in PI from T1 to T2 (spearman correlation coefficient = 0.231; $p = 0.016$) (Table 2). This indicates that the decrease in HR, MAP and VAS observed after analgesia was significantly correlated with increase in PI values at that time.

DISCUSSION

Pain is difficult to measure due to its multifaceted and subjective nature. Obstetric patients are anxious and emotional and therefore an objective indicator of pain is required. Currently, there exists no valid and reliable method of objectively quantifying pain. PI has been reported to decrease with a noxious stimulus that causes vasoconstriction and it has also been reported to increase with vasodilation caused by pain relief [5-7,10,12]. In our study, we have evaluated perfusion index as an indicator of post-operative pain in parturients undergoing caesarean section, and its potential use as an objective indicator for quantification of pain. We observed that there was a decrease in PI values with pain which increased after pain relief. The increase in HR, MAP and VAS observed with

pain was negatively correlated with decrease in PI values at that time. The decrease in HR, MAP and VAS observed after analgesia was significantly correlated with increase in PI values at that time.

We included 40 pregnant females belonging to age group 18 to 39 years scheduled to undergo LSCS under regional anaesthesia. Age associated difference of changes in PI were evaluated in a previous study and it was observed that changes are more significant and detectable in younger age groups rather than elderly (> 60 years) [13, 14]. However, in our study we included patients of similar age group (18 to 39 years). Thus, no age-related bias was present in our study.

There were few limitations. It was a single centre study with lack of control group and potential Hawthorne effect, thus impacting the internal and external validity of the study. Our study had a small sample size limited to a subgroup of patients *i.e.* ASA II parturients, which limits its applicability to broader patient populations, including high-risk obstetric cases or non-obstetric surgical patients. Future research involving more diverse populations groups is warranted. Another limitation of our study is that multivariate analysis was not done to adjust for potential confounders such as temperature, anxiety, or baseline hemodynamic variability.

We observed a statistically significant increase in HR at T1 as compared to baseline with mean difference of 6.225. There was a statistically significant decrease at T2 as compared to T1 with mean difference of 7.425 beats/min. Our results are similar to the previous studies [5-7, 12]. We observed a statistically significant increase in MAP at T1 as compared to baseline with a mean difference of 4.175 mmHg ($p = 0.004$). There was a statistically significant decrease in MAP at T2 as compared to T1 with mean difference of 7.325 mmHg. Nociception driven sympathetic drive causes an increase in HR and MAP, thus explaining the increase in values at T1, *i.e.* at first request of analgesia by patients, and the decrease with pain relief at T2 [15, 16]. Similar changes in MAP were observed in previous studies [4, 5, 12].

PI decreased from T0 to T1 in our study as pain causes an increased vasomotor tone due to sympathetic nervous system stimulation [17]. This leads to decreased peripheral perfusion and hence a decreased value of perfusion index. PI increased from T1 to T2 with pain relief, due to vasodilation caused by decreased sympathetic vasomotor tone caused

after analgesia administration. Similarly, Mohamed *et al.* evaluated PI as an objective indicator of pain in adult patients undergoing lumbar spine discectomy and observed a statistically significant increase in PI, 30 minutes after administration of rescue analgesic in the recovery room (1.89 ± 1.73) as compared to the PI value at first request of analgesia (1.03 ± 1.01) ($p < 0.001$) [5]. Salah *et al.* conducted an observational study in 40 postoperative patients and observed mean PI was 1.45 before analgesic administration (at request of analgesia), while it was 1.15 after analgesic administration 5 mg nalbuphine increments on patient's request ($p = 0.004$) [12]. Tapar *et al.* studied patients undergoing elective surgeries under general anaesthesia and observed statistically significant increase in PI value after the administration of rescue analgesic in post-operative area as compared to pre-analgesic values. The mean PI value increased from 2.80 ± 0.77 (pre analgesic) to 3.97 ± 0.94 (post analgesic) ($p < 0.001$) [7]. Chu *et al.* studied the utility of PI as a discharge criteria for post-operative pain assessment in PACU and recorded a statistically significant increase in PI value after analgesic administration ($p = 0.0001$) [4]. Kupeli *et al.* evaluated PI as an objective tool for assessment of pain in labour analgesia and recorded a statistically significant increase in mean PI value 5 minutes after administration of epidural analgesia as compared to the pre-epidural values (2.6 ± 1.4 vs 1.8 ± 1.1 respectively; $p < 0.05$) [9]. Lee *et al.* analysed data of 100 patients in retrospective study to evaluate correlation between perfusion index and analgesic efficacy in transforaminal block for lumbosacral radicular pain. The authors observed that in patients with $> 50\%$ reduction in pain after a successful transforaminal block (responders), the change in perfusion index > 0.27 was observed at 5 min after block when compared to non-responders ($< 50\%$ reduction in pain after transforaminal block) ($p < 0.05$) [8].

In our study, the percentage increase in HR shows a negative correlation with percentage decrease in PI from T0 to T1 ($r_s = -0.474$; $p < 0.001$). Similarly, Hasanin *et al.* evaluated PI as a tool for assessment of pain in sedated critically ill patients after the application of painful stimulus, *i.e.* changing the patient's position, which resulted in a significant increase in HR and significant decrease in PI. A weak negative correlation was observed between PI and HR values after the positioning of patient ($r_s = -0.24$; $p = 0.02$) [6].

The percentage decrease in HR of patients in our study from T1 to T2 shows a statistically significant

negative correlation with percentage increase in PI from T1 to T2 ($r_s = -0.433$; $p < 0.001$). Mohamed *et al.* also observed a statistically significant negative correlation between percentage decrease in HR and percentage increase in PI after administration of rescue analgesic ($p < 0.05$) [5]. Kupeli *et al.* evaluated PI as an objective tool for assessment of pain in labour analgesia and recorded a negative and statistically significant correlation between PI and HR values 5 minutes after administration of epidural analgesia ($r_s : 0.58$; $p = 0.001$) [9]. Salah *et al.* observed no significant correlation between PI and HR values before or after analgesic administration. The results of this study are different from our study as the authors included post-operative patients admitted in ICU who were receiving continuous analgesic cover in the form of 1 g paracetamol *i.v.* 6 hourly. The change in variables was probably not significant enough to detect correlation between variables [12].

We observed significant negative correlation between percentage decrease in MAP and percentage increase in PI from T1 to T2. ($r_s = -0.896$; $p < 0.001$). Mohamed *et al.* evaluated PI as an objective indicator of pain in adult patients undergoing lumbar spine discectomy. The authors observed that the correlation between decrease in MAP and increase in PI was not statistically significant ($p > 0.05$) [5]. We observed that percentage decrease in VAS significantly correlated with percentage increase in PI from T1 to T2. The correlation was found to be statistically significant ($r_s = -0.231$; $p = 0.016$). Our findings are similar to Kupeli *et al.* and Tapar *et al.* Kupeli *et al.* evaluated PI as an objective tool for assessment of pain in labour analgesia and recorded a statistically significant negative correlation between PI and VAS at the 10, 30, 60 minutes and at 2 hours after drug administration from epidural catheter. The authors suggested that the increase in PI was associated with adequate pain relief and decrease in VAS scores [9]. Tapar *et al.* studied PI in patients undergoing elective surgeries under general anaesthesia and reported a weak negative correlation between change in VAS and PI values before and after administration of analgesia ($r_s = -0.255$; $p = 0.016$) [7].

CONCLUSIONS

We observed a statistically significant decrease in PI and increase in HR, MAP and VAS at first re-

quest of analgesia. There was a statistically significant increase in PI and decrease in HR, MAP and VAS after 30 minutes of analgesic administration. PI decreases with pain while it increases with pain relief. Also, we observed that a statistically significant negative correlation exists between change in PI with change in HR/MAP/VAS before and after analgesia.

Thus, PI is an objective complementary indicator of post-operative pain and can be used as an adjunct to standard tools like VAS in parturients undergoing lower segment caesarean section. However, we conclude that larger randomised control trials are required to establish its use in routine clinical practice.

COMPLIANCE WITH ETHICAL STANDARDS

Authors' contributions

V.A.: Conceptualization, methodology, writing - original draft, data curation, writing - review & editing. P.S.: Data collection, data curation, writing - original draft. S.K.: Conceptualization, methodology, validation, supervision. R.R., A.A.: Data collection, visualization.

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Study registration

Registered with clinical trials registry with CTRI no. CTRI/2022/03/041169.

Disclosure of interests

All authors have no financial relationships (such as employment, consultancies, stock ownership or options, honoraria, patents, and paid expert testimony), personal, political, intellectual (organizing education) or religious interests, according to the ICMJE recommendations.

The authors declare that no AI tool was used in the during the preparation of this manuscript.

Ethical approval

The present prospective, observational study was carried out in the Department of Anaesthesiology and Critical Care at Pt. B.D. Sharma PGIMS, Rohtak following approval from Institutional Ethics Committee (IEC) vide letter no. BREC/Th/20/Anesth16 dated 02/04/2021.

Informed consent

Informed witnessed consent for participation in the study was obtained from the patients after explaining the details of the study.

Data sharing

Data are available under reasonable request to the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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