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ORIGINAL RESEARCH

# To evaluate the changes in perfusion index in the lithotomy position during spinal anaesthesia

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**Background:** Spinal anaesthesia induces lumbosacral sympathetic blockade. The lithotomy position is an add-on to spinal anaesthesia vasodilation, which further compromises tissue perfusion. This study aimed to identify the changes in perfusion index (PI) in the upper and lower limbs in the lithotomy position following spinal anaesthesia. A comparison of PI changes in the upper and lower limbs was a secondary objective.

**Methods:** A total of 100 patients, aged 18–60 years, with an American Society of Anesthesiologists (ASA) physical status of 1 and 2, and scheduled for surgery under spinal anaesthesia in the lithotomy position, were included. Baseline PI was measured using a specific pulse oximeter probe (Masimo Radical-7® Pulse CO-Oximeter®, Masimo Corp., Irvine, United States), one at the fingertip and another at the toe. The lithotomy position was made after 10 minutes of spinal anaesthesia. The PI was noted subsequently at different time periods at both sites. Mean arterial pressure (MAP), heart rate (HR), and $SpO_2$ were also recorded.

**Results:** The mean PI value measured in the toe increased immediately after spinal anaesthesia, and reached a peak at 10–15 minutes, then decreased progressively in the lithotomy position. In the postoperative period, PI increased immediately after positioning the patient supine, and subsequently decreased, reaching near-baseline values. These changes in PI in toe at all the time periods were clinically significant. Conversely, PI values measured in the fingertip at all the time periods were clinically insignificant.

**Conclusion:** PI can be used to estimate circulatory states. Therefore, its use is recommended to prevent circulatory compromise in the lower limbs following spinal anaesthesia and the lithotomy position.

**Keywords:** perfusion index, spinal anaesthesia, lithotomy, pulse oximetry, tissue perfusion

## Introduction

Spinal anaesthesia induces lumbosacral sympathetic blockade, leading to vasodilatation of the lower limbs.[1] This leads to decreased vascular resistance and cardiac output due to blood pooling in blocked areas of the body. Vasodilation in the limbs due to spinal anaesthesia compromises tissue perfusion to some extent.[2] This may be further exaggerated by bleeding and fluid flux (from extracellular space to intravascular) during surgery.[3]

Knowledge of possible physiological effects of various positions, like supine, prone, sitting, lithotomy, Trendelenburg or reverse Trendelenburg, is important to conduct anaesthesia safely.[4] The lithotomy position is a supine position with bilateral elevation of the legs. It is an add-on to spinal anaesthesia vasodilation, which further compromises tissue perfusion.[5] Therefore, it is important to monitor tissue perfusion after the lithotomy position.

Recently, the pulse oximetry signal has been used to measure changes in peripheral perfusion by measuring perfusion index (PI).[6] It is a noninvasive, quick, and easy method that gives the ratio between pulsatile and nonpulsatile components of the pulse oximetry signal (i.e. it is the nonpulsatile flow rate of the pulsatile flow). It works by measuring changes in finger peripheral perfusion through a pulse oximeter. It is a rapid indicator of microcirculatory changes and may help the anaesthesiologist detect circulation disturbances.[1]

However, limited studies are available in the literature regarding the effect of the lithotomy position during spinal anaesthesia on PI. Hence, we planned this study to observe these changes. Accordingly, we hypothesised that PI correctly indicates and correlates with the amount of vasodilation and any further perfusion compromise in the limb during spinal anaesthesia. This observational study aimed to identify the changes in PI in the upper and lower limbs in the lithotomy position following spinal anaesthesia. A comparison of PI changes in the upper and lower limbs was a secondary objective.

## Material and methods

The present prospective, observational study was conducted according to STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines at the Department of Anaesthesiology and Critical Care, Pandit Bhagwat Dayal Sharma University of Health Sciences, Rohtak, from December 2020 to November 2021, after approval from the Institutional Biomedical Research Ethics Committee (IEC/Th/19/Ans22). The study was registered before patient enrolment at CTRI/2021/03/032289.

A predefined pro forma was used as a tool for data collection. The study population consisted of 100 patients of either sex, aged 18–60 years, with an ASA physical status of 1 and 2, scheduled for surgery under spinal anaesthesia in the lithotomy position.

Figure 1: Perfusion index noted with a pulse oximeter (Masimo Radical-7®)

Patients with contraindications to spinal anaesthesia, heart block/dysrhythmia, morbid obesity, a history of neuromuscular disease in the lower extremities, and chronic pain syndromes were excluded from the study.

All patients were subjected to a detailed history, as well as a complete physical and systemic examination before surgery. The purpose and protocol of the study were explained to patients, and informed, written consent was obtained. Patients were kept nil per os (NPO) for six hours prior to the scheduled time of surgery. They were premedicated with tablet omeprazole 20 mg orally two hours before surgery, and tablet alprazolam 0.25 mg the night before and two hours before surgery.

Upon arrival at the operating room, standard monitoring, including electrocardiogram, noninvasive blood pressure, and $SpO_2$, was established. Baseline PI was measured by an anaesthesiologist who was not involved in the further intraoperative monitoring of the patient, using a specific pulse oximeter probe (Masimo Radical-7Ò, Masimo Corp., Irvine, United States), one at the fingertip and another at the toe (Figure 1). Spinal anaesthesia was administered and, after ensuring the desired level of anaesthesia, PI was noted. The supine position was maintained for 10 minutes, after which the lithotomy position was made. PI readings were noted at both sites after 10 minutes of spinal anaesthesia. Thereafter, a PI reading was noted every 15 minutes till the end of the surgery.

The patient was made supine on completion of the procedure and later moved to the post-anaesthesia care unit. PI readings were continued to be noted every 15 minutes till one hour postoperatively. HR, MAP, and $SpO_2$ were recorded at baseline and at an interval of five minutes after spinal anaesthesia for the first 20 minutes, and then every 15 minutes till one hour postoperatively. Hypotension was defined as a fall of > 20 mmHg from basal MAP. Hypotension was managed with an intravenous (IV) injection of ephedrine 5 mg bolus. HR < 50 bpm or < 20% of basal value was recorded as bradycardia and was treated with an injection of glycopyrrolate 0.2 mg bolus. Episodes of nausea and vomiting were recorded and treated with an injection of ondansetron 4 mg IV.

### *Sample size calculation*

The sample size was calculated based on the previous study by Hyuga et al.[7] The minimum required sample size at a 5% level of significance and 80% power is obtained in at least 98 patients; we included 100 patients during the study period.

$= 2\,(1.96 + 0.84)^2\,(0.5)^2 / (0.2)^2$

$= 15.68 * 0.25 / 0.04$

$= 98$ = round off to 100

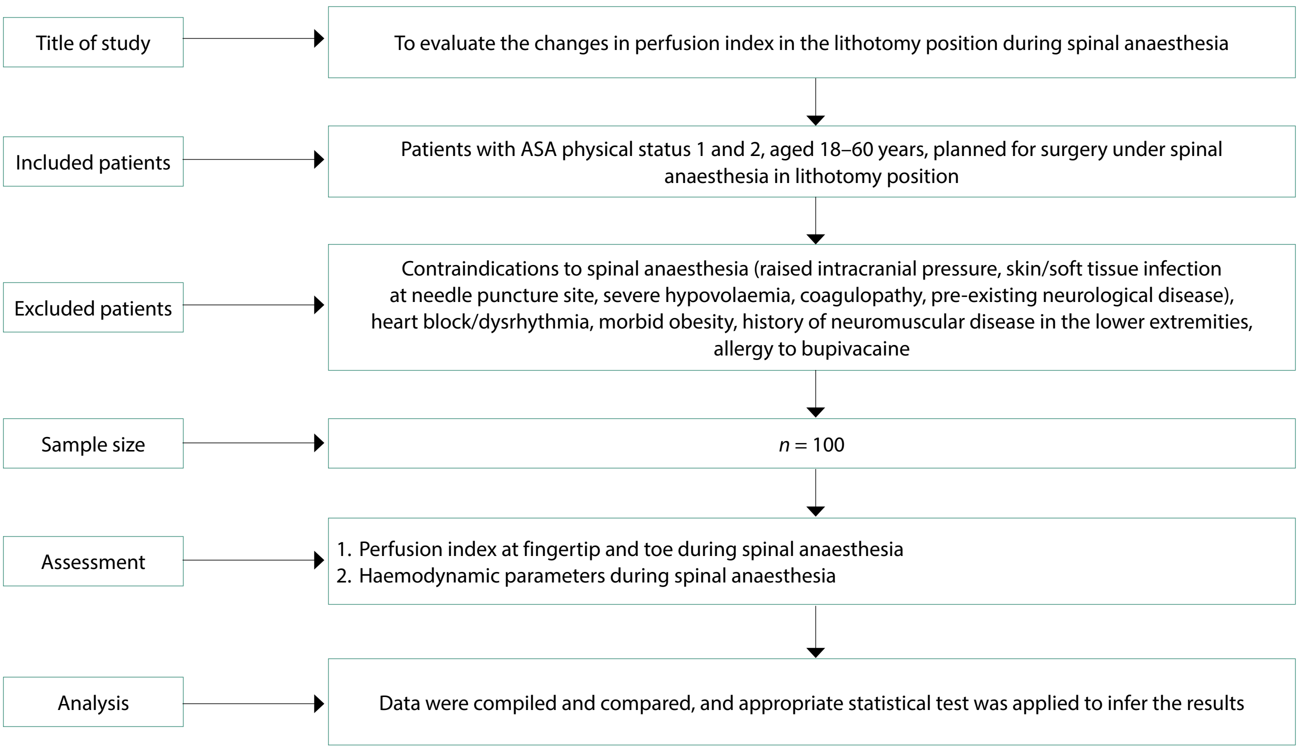


Figure 2: CONSORT (Consolidated Standards of Reporting Trials) diagram
ASA – American Society of Anesthesiologists

### *Statistical analysis*

All statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) version 22.0 software (SPSS Inc., Chicago, United States). All data were summarised as mean ± standard deviation for continuous variables, numbers and percentages were used for categorical variables. A $p \leq 0.05$ was accepted as statistically significant. A paired t-test was used for quantitative data analysis.

$$n = \frac{2(Z_a = Z_{1-\beta})^{2\sigma 2,}}{\Delta^2}$$

## Results

A CONSORT (Consolidated Standards of Reporting Trials) diagram is shown in Figure 2. Table I summarises the demographic characteristics of the studied patients. PI comparison of the fingertip and toe from baseline to subsequent time periods is shown in Table II. We observed that the mean PI value measured in the toe increased immediately after spinal anaesthesia, reaching a peak at 10–15 minutes, and then decreased progressively in the lithotomy position.

In the postoperative period, PI increased immediately after positioning the patient supine, and it subsequently decreased, reaching near-baseline values. These changes in PI in the toe at all time periods were clinically significant. Conversely, PI values measured in the fingertip at all time periods were clinically insignificant.

A comparison of MAP from baseline to subsequent time periods is shown in Figure 3. We found a significant fall in MAP after spinal anaesthesia up to 20 minutes. Thereafter, MAP gradually increased, reaching up to baseline values. Figure 4 summarises the comparison of HR from baseline to subsequent time periods. The mean HR was near baseline at all time periods. Also, $SpO_2$ did not vary and was near baseline throughout the procedure.

## Discussion

PI is a simple and reliable indicator of tissue perfusion. The present study observed that mean PI values in the fingertip did not vary significantly throughout the procedure and in the postoperative period. Thus, indicating no change in perfusion of the upper limb in the postoperative period. The mean PI value in the toe increased significantly ($p = 0.0001$) immediately after spinal anaesthesia and peaked at 10–15 minutes, followed by a progressive decrease in perfusion after the lithotomy position was made, which was statistically significant ($p = 0.0001$). This indicated an increase in perfusion of the lower limb after the patient was given spinal anaesthesia, probably due to vasodilation. The mean PI value measured in the toe postoperatively increased immediately after the supine position was made and subsequently reached baseline values. This indicated an increase in perfusion of the lower limb after the patient was made supine, probably due to increased circulation following the change from the lithotomy position.

Table I: Demographic characteristics

| Variable | | *n* = 100 | |
|---|---|---|---|
| Age (years) | Mean ± SD<br>Range | 43.56 ± 13.69<br>18–60 | |
| BMI (kg/m²) | Mean ± SD<br>Range | 21.61 ± 3.61<br>15.5–30.7 | |
| **Variable** | | **Number of patients** | **%** |
| Gender | Male | 79 | 79.0 |
| | Female | 21 | 21.0 |
| ASA status | 1 | 45 | 45.0 |
| | 2 | 55 | 55.0 |

ASA – American Society of Anesthesiologists, BMI – body mass index, SD – standard deviation

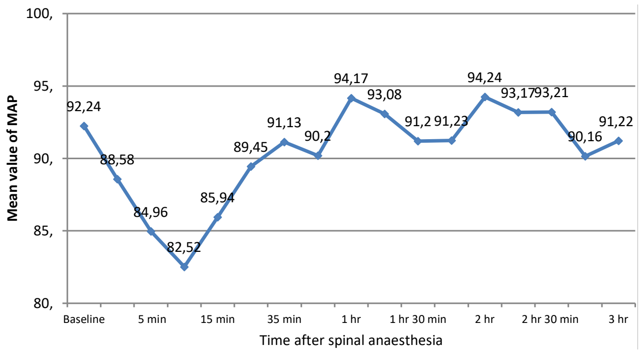


Figure 3: Comparison of MAP (mean arterial pressure) from baseline to subsequent time periods

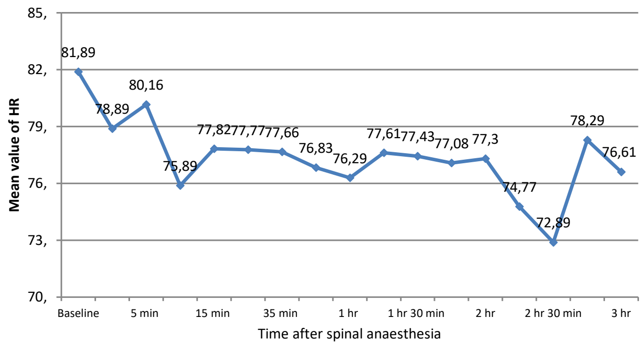


Figure 4: Comparison of HR (heart rate) from baseline to subsequent time periods

Our study results agree with the study by Hyuga et al.,[7] who studied the changes in PI at the finger, toe, and groin after spinal anaesthesia in patients undergoing endoscopic urologic procedures. They concluded that the PI at the toe increased soon after spinal anaesthesia induction and reached a plateau within five minutes; however, PI at the finger and groin remained constant after spinal anaesthesia, which corroborates our findings.

Lima et al.[6] observed that peripheral PI can be used to monitor peripheral perfusion in critically ill patients. Ginosar et al.[1] concluded that PI was an earlier, clearer, and more sensitive indicator of epidural-induced sympathectomy than either skin temperature or MAP. Similar to our study, these studies concluded that PI changes quickly in response to vasodilation after spinal anaesthesia, suggesting that PI is an important tool in estimating the circulatory state.

**Table II:** Comparison of PI in toe and fingertip from baseline to subsequent time periods

| | In toe | | | In fingertip | | |
|---|---|---|---|---|---|---|
| **Time period** | **PI (mean ± SD) %** | **Mean change** | ***p*-value** | **PI (mean ± SD) %** | **Mean change** | ***p*-value** |
| Baseline | 4.679 ± 2.56 | - | | 4.611 ± 2.62 | - | - |
| Immediately after spinal anaesthesia | 7.855 ± 3.48 | 3.176 ± 1.401 | 0.0001* | 4.618 ± 2.57 | 0.007 ± 0.173 | 0.68 |
| Lithotomy position at 0 min | 8.383 ± 3.51 | 3.704 ± 1.42 | 0.0001* | 4.607 ± 2.62 | 0.004 ± 0.129 | 0.75 |
| Lithotomy position at 15 min | 7.971 ± 3.416 | 3.292 ± 1.28 | 0.0001* | 4.617 ± 2.63 | 0.006 ± 0.124 | 0.63 |
| Lithotomy position at 30 min | 7.459 ± 3.286 | 2.78 ± 1.21 | 0.0001* | 4.610 ± 2.63 | 0.001 ± 0.11 | 0.92 |
| Lithotomy position at 45 min | 7.038 ± 3.198 | 2.362 ± 1.15 | 0.0001* | 4.601 ± 2.66 | 0.005 ± 0.115 | 0.66 |
| Lithotomy position at 1 hr | 6.778 ± 3.097 | 2.02 ± 1.07 | 0.0001* | 4.701 ± 2.72 | 0.021 ± 0.123 | 0.12 |
| Lithotomy position at 1 hr 15 min | 6.273 ± 2.63 | 1.667 ± 1.18 | 0.0001* | 4.473 ± 2.31 | 0.13 ± 0.108 | 0.5 |
| Lithotomy position at 1 hr 30 min | 6.252 ± 3.01 | 1.6 ± 1.35 | 0.0001* | 4.567 ± 2.71 | 0.057 ± 0.137 | 0.22 |
| Lithotomy position at 1 hr 45 min | 5.347 ± 2.839 | 1.466 ± 0.818 | 0.0001* | 3.733 ± 2.61 | 0.02 ± 0.11 | 0.36 |
| Lithotomy position at 2 hr | 5.317 ± 2.962 | 1.3 ± 0.555 | 0.0001* | 3.911 ± 3.17 | 0.03 ± 0.103 | 0.46 |
| Preoperative | 4.679 ± 2.56 | - | - | 4.611 ± 2.62 | - | - |
| Postoperative at 0 min | 6.817 ± 2.89 | 2.138 ± 0.98 | 0.0001* | 4.62 ± 2.60 | 0.01 ± 0.12 | 0.26 |
| Postoperative at 15 min | 6.516 ± 2.92 | 1.837 ± 1.01 | 0.0001* | 4.62 ± 2.62 | 0.01 ± 0.13 | 0.46 |
| Postoperative at 30 min | 6.022 ± 2.88 | 1.343 ± 1.02 | 0.0001* | 4.62 ± 2.61 | 0.01 ± 0.11 | 0.17 |
| Postoperative at 45 min | 5.66 ± 2.78 | 0.981 ± 0.98 | 0.0001* | 4.60 ± 2.63 | 0.01 ± 0.11 | 0.36 |
| Postoperative at 1 hr | 5.308 ± 2.83 | 0.629 ± 1.05 | 0.0001* | 4.61 ± 2.62 | 0.007 ± 0.10 | 0.49 |

* Significant
PI – perfusion index, SD – standard deviation

MAP decreased following spinal anaesthesia up to 20 minutes. Thereafter, MAP gradually increased, reaching to baseline throughout the surgery, which was statistically significant ($p = 0.0001$). Our study results are in line with the study by Arslan et al.,[8] who studied the predictive ability of PI and pleth variability index (PVI) in different positions in 90 parturients for the prediction of hypotension in caesarean delivery after spinal anaesthesia. They concluded that only post-spinal PVI was associated with spinal anaesthesia-induced hypotension in caesarean section.

George et al.[9] concluded that baseline PI > 3.6 was associated with a higher incidence of hypotension following spinal anaesthesia in elective lower segment caesarean section (LSCS). Toyama et al.[2] found that a higher baseline PI was associated with profound hypotension, and that baseline PI could predict the incidence of spinal anaesthesia-induced hypotension during caesarean delivery. In accordance with these studies, our study also concluded that there was a fall in MAP associated with an increase in PI following spinal anaesthesia, probably due to vasodilation.

In our study, the mean HR was maintained between 82 and 72 bpm throughout the procedure, likely due to individual variation of anxiety levels among the studied patients. These results were in line with Toyama et al.'s[2] study, who concluded that HR did not differ significantly between parturients undergoing elective caesarean section with high baseline PI and those with low baseline PI during the hypotensive period after spinal anaesthesia. Our study also found that mean $SpO_2$ values were comparable and near baselines throughout the procedure, which aligns with the study by Tapar et al.[10]

We concluded that PI changes quickly in response to varying perfusion of the limbs. The PI values also correlated well with the corresponding haemodynamic changes over time. Thus, PI values changed after spinal anaesthesia and with position changes, like lithotomy, which further affected limb perfusion.

### *Study limitations*

There were certain limitations to our study. Firstly, this study was only an observational study on one group of patients, and not a comparative study. Secondly, only patients with an ASA physical status of 1 and 2 were studied. Thirdly, this study did not include the paediatric and geriatric population. Lastly, other external factors, like body temperature, surgery duration, or administration of fluids and medications, which can influence results, were not studied. Further studies comparing different groups, including patients with an ASA physical status other than 1 and 2 and the paediatric and geriatric populations, are recommended in future to reinforce our results.

## Conclusion

PI is a simple and sensitive tool to evaluate limb perfusion. Its value correlates closely with quick changes in perfusion, like vasodilation, time taken, and haemodynamic changes. Thus, it can be useful to estimate circulatory states, especially following spinal anaesthesia and the lithotomy position, which further affect limb perfusion. Therefore, its use is recommended to prevent circulatory compromise in the lower limbs following spinal anaesthesia and the lithotomy position.

### *Conflict of interest*

The authors declare no conflict of interest.

### *Funding source*

None.

### *Ethical approval*

This prospective, observational study was conducted at the Department of Anaesthesiology and Critical Care, PGIMS, Rohtak, after approval from the Institutional Biomedical Research Ethics Committee (IEC/Th/19/Ans22). The study was registered prior to patient enrolment at CTRI/2021/03/032289.

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