Plethysmography Variability Index as a Guidance for Intraoperative Fluid Management in Cesarean Section Delivery under Spinal Anesthesia: A Pilot Study

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Abstract

Background: Plethysmography variability index (PVI) is a measure of the dynamic changes in the perfusion index (PI) that occur during one or more complete respiratory cycles. This study was designed to investigate the accuracy of PVI in guidance of fluid management in parturient undergoing cesarean section surgery under spinal anesthesia.

Methods: This randomized clinical trial was performed on 21 consecutive patients who were candidate for cesarean section surgery under spinal anesthesia at Shariati Hospital in Tehran, Iran, between April 2015 and April 2016. The patients were randomly assigned to one of the PVI or conventional group. In all patients, serum level of lactate, mean arterial pressure (MAP), total amount of infused intraoperative fluids, urine output, and duration of surgery were recorded.

Results: In total, 21 patients (10 in PVI group and 11 in control group) were assessed. The trend of the change in MAP was significantly different between the two groups with a downward trend in PVI group and a fluctuated trend in the conventional group ($P = 0.003$). The mean amount of infused fluid was 2565.00 ± 563.74 ml in PVI group that was significantly lower than control group (3122.73 ± 321.99 ml) ($P = 0.011$). Although urine output was numerically higher in PVI than in control group (425.00 ± 274.12 ml vs. 322.00 ± 121.82 ml), it was not statistically significant ($P = 0.292$). In PVI group, the primary value of PVI was 23.80 ± 6.93 that reached to 12.20 ± 1.75 at the end of surgery indicating a significant reduction ($P < 0.001$).

Conclusions: Regarding clinical and hemodynamic stability as well as fluid therapy responsiveness (less requiring fluids within surgery), PVI monitoring seems to be superior to the conventional method.

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Introduction

Intravenous fluid therapy plays an important role in the outcome of patients undergoing surgery. Hypovolemia may lead to decreased circulatory volume resulting in decreased oxygen delivery and consequently causing organ dysfunction and shock (1). Therefore, administration of fluid therapy should be adjusted patient by patient (2,3).

Fluid therapy is guided by understanding the basis of human physiology and measuring basic cardiovascular parameters such as heart rate and mean arterial pressure during surgery (4). Nonetheless, many factors not related to the circulatory status such as pain, surgical stress, and body temperature affect these parameters (5,6). Therefore, the use of more advanced and sophisticated cardiovascular parameters such as stroke volume variation or pulse pressure variation (PPV) are recommended for the monitoring of circulatory status (7,8). Mentioned parameters may

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accurately predict fluid responsiveness, but they are invasive and costly (9). Non-invasive dynamic measures such as PPV and variation of the plethysmographic waveform of pulse oximetry (ΔPOP) have also been proposed, but they are not easily calculated from the pulse oximetry display (10-12).

Plethysmography variability index (PVI) is a measure of the dynamic changes in the perfusion index (PI) that occur during one or more complete respiratory cycles (13). PI is the ratio of non-pulsatile to pulsatile blood flow through the peripheral capillary bed (14,15). This pilot study was designed to investigate the accuracy of PVI in guidance of fluid management based on the changes observed in lactate levels during surgery, in parturient undergoing cesarean section surgery under spinal anesthesia.

Materials and Methods

This randomized clinical trial was performed on 21 consecutive patients' candidates for cesarean section surgery under spinal anesthesia at Shariati Hospital in Tehran, Iran, between April 2015 and April 2016. All patients aged higher than 18 years with ASA I-II and body mass index < 30 kg/m^2 were included in the study. The exclusion criteria were: history of cardiovascular, renal or hepatic disorders, and prolonged surgery (longer than 3 h). All patients gave written informed consent before this study. The Human Ethical Committee at Tehran University of Medical Sciences approved the study. The study was registered at Iranian clinical trials registry before the start of the study (IRCT2016010525856N1).

On admission to the operative room, parturient was monitored continuously for assessment of vital signs and an 18-gauge cannula was inserted on dorsum of non-dominant hand. All patients were monitored with PVI probes (Pooyandegan Saadat). Before any intervention, a blood sample was extracted and sent to laboratory to measure serum lactate level. Then, parturient was randomly (using a computerized random sampling table) assigned to one of the PVI or conventional group.

In the PVI group, 5 cc/kg of crystalloid fluid was infused, then, with the parturient in the sitting position, using an aseptic technique, a 25-gauge pencil point needle was inserted intrathecally through a midline approach into the L3-4 or L4-5 interspace and 15 mg of bupivacaine were injected. The parturient was asked and helped to lie down immediately, and the bed was positioned to obtain the desired level of anesthesia. After the parturient lied down 2cc/kg/hour of fluid was started; once PVI > 13 %, a 250 ml colloid, or crystalloid was rapidly infused and repeated for every 5 minutes until PVI < 13%.

In the control group, 5 ml/kg crystalloid was infused, and spinal anesthesia was performed similar to the PVI group. Maintenance fluid was administered with the 4-2-1 rule: 4 cc/kg/hour for the first 10 kg, 2 cc/kg/hour for the second 10 kg, and 1 cc/kg/hour for every kg above 20. Deficit fluid was also administered based on the NPO time. Blood loss was also replaced with 3 times volume of crystalloid.

In both groups, if mean arterial blood pressure (BP) < 65 mmHg, 10 mg of ephedrine was given to keep mean arterial BP above 65 mmHg. In all patients, the following measurements were documented: (1) The serum level of lactate on admission as well as at the end of surgery, (2) mean arterial pressure before spinal anesthesia as well as 1, 2, 3, and 5 min following spinal anesthesia, (3) the total amount of intraoperative fluids infused, (4) the amount of urine output within surgery, and (5) the duration of surgery.

For statistical analysis, results were presented as mean ± standard deviation for quantitative variables and were summarized by absolute frequencies and percentages for categorical variables. Normality of data was analyzed using the Kolmogorov-Smirnov test. Categorical variables were compared using chi-square test or Fisher's exact test when more than 20% of cells with expected count of < 5 were observed. Quantitative variables were also compared with t-test or Mann–Whitney U-test. For the statistical analysis, the statistical software SPSS version 16.0 for Windows (SPSS Inc., Chicago, IL, USA) was used. P values of 0.05 or less were considered statistically significant.

Results

Twenty-one parturients (10 in PVI group and 11 in control group) were included in this study. There was no difference in mean age (29.60 ± 4.01 years vs. 31.27 ± 3.66 years, P = 0.330) and mean weight (75.60 ± 7.69 kg vs. 75.27 ± 9.87 kg, P = 0.934). Regarding MAP, no difference was found in this parameter before and also at different time points after spinal anesthesia; however, the trend of the change in MAP was significantly different between the two groups, with a downward trend in the PVI group and a fluctuated trend in conventional group (P = 0.003) (Figure 1). Regarding volume of infused fluid, the mean amount of fluid was 2565.00 ± 563.74 ml in PVI group that was significantly lower than in control group (3122.73 ± 321.99 ml) (P = 0.011). Difference in urine output in PVI group compared to the control group (425.00 ± 274.12 ml vs. 322.00 ± 121.82 ml) was not statistically significant (P = 0.292). The mean duration of operation was 1.42 ± 0.41 h in PVI group and 1.40 ± 0.37 h in the conventional group with no difference between groups (P = 0.900). Mean serum level of lactate at baseline in PVI and control groups was 1.29 ± 0.75 and 1.85 ± 0.92, respectively, with no meaningful statistical difference (P = 0.143). Similarly, the mean serum level of lactate at the end of operation

was 1.28 ± 0.57 and 1.53 ± 0.43, respectively, with no meaningful difference (P = 0.272).

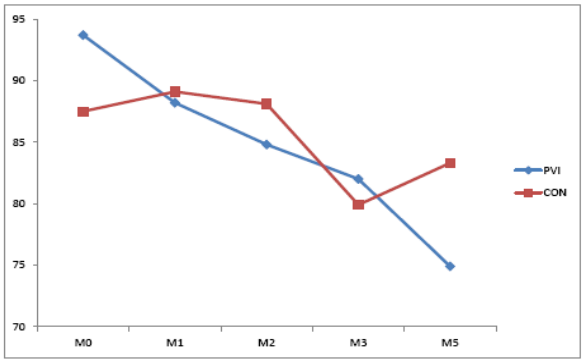

Figure 1. The trend of the change in mean arterial pressure in plethysmography variability index and control group (M = minute)

In PVI group, the primary value of PVI was 23.80 ± 6.93 that reached to 12.20 ± 1.75 at the end of surgery indicating a significant reduction (P < 0.001) (Figure 2).

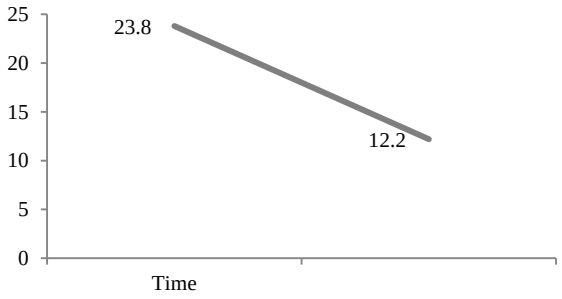

Figure 2. Mean plethysmography variability index (PVI) at baseline and at the end of operation -X-axis shows the timeline during surgery and the Y-axis shows the PVI number

Discussion

In this study, it was observed that when PVI is used for guidance of fluid management levels during cesarean surgery under spinal anesthesia, lower amount of fluid is needed compared to conventional methods with no difference in changes in serum lactate during the surgery.

In many studies, PVI for monitoring of fluid management was considered as a superior method in patients who were candidate for surgeries as compared to the conventional methods under general anesthesia. With respect to responsiveness to fluid therapy and also reducing post-operative complications, the PVI monitoring seems to be superior to classic methods. However, this has been explained mainly in surgeries performed under general anesthesia and not spinal anesthesia. The reason we chose to do a pilot study was that safety of PVI during spontaneous ventilation under spinal anesthesia in cesarean section has not been documented. One of the novelties of the present study is studying the changes in PVI and its effect on fluid management in parturient who are under spinal anesthesia with spontaneous ventilation and not mechanical ventilation. According to the increasing trend of cesarean section surgery under spinal anesthesia especially in Iran and also its related adverse consequences, the use of PVI monitoring may be very useful for achieving better surgical outcome.

Our study aimed to assess and compare the hemodynamic changes as well as intraoperative fluid therapy during cesarean section surgery in the two PVI and conventional fluid therapy methods.

It was shown that a consistent trend in MAP may be achieved within surgery in the PVI group, but the trend of the changes in the control group had an irregular fluctuation. This decreasing MAP did not require any significant vasopressor support. Second, the fluid required within operation was significantly lower in PVI group. However, the mean serum level of lactate was not different across the two groups at baseline as well as at the end of the operation. Finally, it can be concluded that regarding clinical and hemodynamic stability as well as fluid therapy responsiveness (less requiring fluids within surgery), PVI monitoring seems to be superior to the conventional method.

In previous studies, the superiority of PVI method to other plans has also been described during mechanical ventilation. In a study by Forget et al. (16), intraoperative crystalloids and total volume infused were significantly lower in the goal-directed PVI group. Lactate levels were significantly lower in the PVI group during surgery and 48 h after surgery. Similarly, in Yu et al. trial (17), the total amount of intraoperative fluids, the amount of crystalloid fluid and the 1st h blood lactate levels during surgery were significantly lower in PVI than control group. Cai et al. also revealed that there was a significant relationship between PVI before volume expansion and change in cardiac index after volume expansion (18).

This study was a pilot study and had some shortcomings. More patients should be studied to be able to get more concrete conclusions and also this monitoring is still very costly, and with reducing prices of this monitoring, it can be used more frequently.

As a conclusion, it can be concluded that although PVI is mostly used during mechanical ventilation, it can help us to guide fluid management during surgery in patients undergoing spinal anesthesia.

Conflict of Interests

Authors have no conflict of interests.

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