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## Combining infusion warmer and automatic infusion pressure bag to stabilize blood pressure and body temperature in caesarean section

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### Abstract

**Background:** Patients undergoing caesarean section (CS) with spinal anaesthesia are at risk of hypotension and hypothermia due to peripheral vasodilation and decreased venous return. These conditions may be exacerbated by the administration of room-temperature intravenous fluids (21–23°C) and manual pressure infusion. Using a fluid warmer can help prevent hypothermia, while an automatic infusion pressure bag can accelerate fluid delivery, potentially maintaining blood pressure and body temperature stability. However, these interventions have not yet been studied as a combined approach.

**Purpose:** To evaluate the effect of using a fluid warmer in combination with an automatic infusion pressure bag on blood pressure and body temperature in patients undergoing caesarean section.

**Method:** This quasi-experimental study used a pre-test and post-test with control group design and included 64 patients undergoing CS, divided into intervention and control groups. The intervention group received warmed fluids (37–39°C) administered through an automatic infusion pressure bag from the sign-in phase until discharge from the recovery room. Measurements were taken at four time points: preoperatively during sign-in, intraoperatively at 15 and 30 minutes after anaesthesia induction, and postoperatively 15 minutes in the recovery room.

**Results:** There was no statistically significant difference in blood pressure between groups ( $p > 0.05$ ), although a small clinical effect was observed ( $\eta^2 = 0.01–0.06$ ). Body temperature showed statistically and clinically significant differences at all measurement points ( $p < 0.05$ ,  $\eta^2 > 0.14$ ), indicating a strong effect of the intervention.

**Conclusion:** The use of a fluid warmer combined with an automatic infusion pressure bag is clinically effective in maintaining blood pressure stability and statistically and clinically effective in stabilizing body temperature during caesarean section procedures.

**Keywords:** Automatic Infusion Pressure Bag; Blood Pressure; Body Temperature; Caesarean Section; Fluid Warmer.

### INTRODUCTION

The prevalence of deliveries via caesarean section (CS) continues to rise globally, including in Indonesia. The Special Region of Yogyakarta has been reported as the province with the second highest CS rate in the country, accounting for 38.1% of all births (Ministry of Health of the Republic of Indonesia, 2024). Caesarean procedures are commonly performed under spinal anaesthesia, which physiologically can lead to a decrease in blood

pressure (hypotension) and body temperature (hypothermia) due to peripheral vasodilation and reduced venous return (Afrida, Nurwidiyanti, & Marfiah 2021; Algarni, Albakri, Albakri, Alsharif, Alrajhi, Makki, & Alsharif, 2023). These risks are exacerbated when intravenous fluids are administered at room temperature (21–23°C) and delivered manually without stable pressure control. Sustained hypotension can impair perfusion to vital

organs, potentially leading to tissue ischemia and organ dysfunction (Alemayehu, Berhe, Getnet, & Molallign, 2020; Kim, Kim, Yoo, & Kim, 2021; Shaikh, Shaikh, Bhurgri, Narejo, & Ahed, 2024). Meanwhile, intraoperative hypothermia is associated with complications such as shivering, increased bleeding, wound infections, pain, cardiovascular disturbances, and prolonged hospital stay (Qi, Chen, Li, Cao, Yan, Li, & Li, 2022; Thorburn, Monteiro, Chakladar, Cochrane, Roberts, Hughes, & Harper, 2021).

An infusion warmer is a device used to heat intravenous fluids to body temperature (37–39°C), thereby reducing the risk of intraoperative hypothermia. Meanwhile, an automatic infusion pressure bag enables rapid and consistent fluid delivery without the need for repeated manual pumping (Alley, Taylor, Owens, Goodin, Rasnake, Daley, & Clark, 2020; Martin, Fisher, Meledeo, Wampler, Nicholson, Raczek, & Schauer, 2021). The combination of these two devices has the potential to meet the need for rapid fluid replacement due to vasodilation, while also helping to maintain the patient's core body temperature during surgery. While previous studies have examined the effects of warmed fluids independently (Lax, Mustola, Repo, Järvinen, Bayoro, Cataldo, & Waldmann, 2023; Shaikh et al., 2024), and the role of pressure bags in accelerating infusion rates (Alley et al., 2021), no studies to date have evaluated the simultaneous use of both devices as an integrated intervention, particularly in CS patients under spinal anaesthesia. This presents an opportunity for a novel, preventive, non-pharmacological nursing intervention.

The combined approach aligns with Kolcaba's Comfort Theory, which emphasizes the importance of achieving physical and physiological comfort to support postoperative recovery (Alligood, 2013; Pomalango, 2023; Yang, Wang, Cui, Zhuan, Hu, & Chen, 2022). Minimizing hypotension and hypothermia can help reduce the risk of complications such as pain, shivering, and delays in the initiation of early breastfeeding (Ferede, Aytolign, & Mersha, 2021; Thorburn et al., 2021). This study aims to analyse the effects of using an infusion warmer and automatic infusion pressure bag on blood pressure and body temperature in CS patients undergoing spinal anaesthesia, from the intraoperative period through early post-anaesthesia care.

## RESEARCH METHOD

This study employed a quasi-experimental design using a pre-test and post-test with control group approach. The research was conducted at Bhayangkara General Hospital, Regional Police of the Special Region of Yogyakarta, and Pratama Hospital, Yogyakarta City, from January 13 to April 13, 2025. The study subjects were patients undergoing caesarean section (CS) under spinal anaesthesia who met the inclusion criteria, including full-term pregnancy, American Society of Anesthesiologists (ASA) physical status I–II, and no history of cardiovascular disorders or acute infections.

A total of 64 participants were enrolled using purposive sampling, divided equally into an intervention group (n=32) and a control group (n=32). The intervention group received crystalloid intravenous fluids using an infusion warmer set to 37–39°C, administered through an automatic infusion pressure bag. The infusion was initiated during the preoperative sign-in phase and continued until the patient was discharged from the recovery room. The control group received standard hospital protocol infusions—room temperature fluids delivered by gravity without additional pressure devices.

Blood pressure and body temperature were measured at four time points: pre-test during sign-in 15, then for post-tests in 15 and 30 minutes after anaesthesia induction, also in 15 minutes after entering the recovery room. Blood pressure was measured using a digital sphygmomanometer, while body temperature was measured using a tympanic infrared thermometer. Potentially uncontrolled factors in the experimental group included variations in ASA physical status distribution (between class I and II), as well as the volume and temperature of irrigation fluids used during surgery.

The data were analysed using univariate test to calculate mean (age and weight), then frequency (others variable) of participants. After that use Multivariate General Linear Model (GLM) repeated measures test to identify the effect of the intervention on blood pressure and body temperature across multiple time points. This study received ethical approval from the Research Ethics Committee of the Semarang Health Polytechnic, under approval number No. 1242/EA/F.XXIII.38/2024.

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## RESEARCH RESULTS

Table 1. Characteristics of the Participants (N = 64)

| Variable                                | Group                 |                        | p-value |
|-----------------------------------------|-----------------------|------------------------|---------|
|                                         | Control (n = 32)      | Intervention (n = 32)  |         |
| <b>Age (Mean±SD)(Range)(Years)</b>      | 30.68 ± 5.17 (22–44)  | 29.16 ± 5.26 (19–42)   | 0.940   |
| <b>Body Weight (Mean±SD)(Range)(Kg)</b> | 69.24 ± 11.43 (47–99) | 73.29 ± 15.41 (53–115) | 0.171   |
| <b>ASA Physical Status (n/%)</b>        |                       |                        |         |
| ASA I                                   | 25/78.1               | 25/78.1                | 0.048   |
| ASA II                                  | 7/21.9                | 7/21.9                 |         |
| <b>Duration of Surgery (n/%)</b>        |                       |                        |         |
| ≤ 30 minutes                            | -                     | 1/3.1                  | 0.741   |
| 31–60 minutes                           | 23/71.9               | 22/68.8                |         |
| 61–90 minutes                           | 8/25                  | 9/28.1                 |         |
| > 90 minutes                            | 1/3.1                 | -                      |         |
| <b>Blood Loss (&lt; 500 ml) (n/%)</b>   | 32/100                | 32/100                 | -       |
| <b>Anaesthetic Drugs (n/%)</b>          |                       |                        |         |
| Bupivacaine 12.5 mg                     | 16/50                 | 25/78.1                | 0.460   |
| Bupivacaine 12.5 mg + Fentanyl 25 mcg   | 7/21.9                | 3/9.4                  |         |
| Bupivacaine 15 mg                       | 9/28.1                | 4/12.5                 |         |

Table 1 shows the average age in the control group was 30.68 ± 5.17 years, slightly higher than the intervention group at 29.16 ± 5.26 years. The mean body weight was also higher in the intervention group (73.29 ± 15.41 kg) compared to the control group (69.24 ± 11.43 kg). The distribution of ASA physical status was identical in both groups, with 78.1% classified as ASA I and 21.9% as ASA II. Although the homogeneity test of ASA physical status yielded a p-value < 0.05, covariate adjustment was applied in the multivariate analysis to minimize potential bias in the data. Most participants in both groups underwent procedures lasting between 31 to 60 minutes (control: 71.9%; intervention: 68.8%), and all participants experienced blood loss of less than 500 mL. Regarding anaesthetic drugs, the majority in the intervention group received 12.5 mg of bupivacaine (78.1%), while in the control group, this was observed in 50% of patients. A combination of bupivacaine and fentanyl was used more frequently in the control group (21.9%) compared to the intervention group (9.4%). Overall, the baseline characteristics of the participants were homogeneous ( $p > 0.05$ ) between the control and intervention groups and relatively comparable between groups, ensuring the validity of subsequent analyses.

Table 2. The effect of Infusion Warmer and Automatic Infusion Pressure Bag in Systolic

| Measurement Time                      | Mean (mmHg) |              | p-value | Effect Size (np <sup>2</sup> ) |
|---------------------------------------|-------------|--------------|---------|--------------------------------|
|                                       | Control     | Intervention |         |                                |
| Pre-test (adjusted)                   | 126.91      | 126.91       | -       | -                              |
| Post-test 15 minutes (intraoperative) | 118.13      | 123.43       | 0.122   | 0.034                          |
| Post-test 30 minutes (intraoperative) | 119.98      | 118.07       | 0.587   | 0.005                          |
| Post-test 15 minutes (recovery room)  | 120.03      | 126.9        | 0.116   | 0.044                          |

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Table 2 shows no significant differences in systolic blood pressure were found between the intervention and control groups at any measured time points ( $p > 0.05$ ). However, the effect size values at 15 minutes intraoperatively and at 15 minutes in the recovery room ( $\eta^2 = 0.034\text{--}0.044$ ) indicate a small but potentially clinically relevant effect of the intervention in supporting blood pressure stability.

**Table 3. The Effect of Infusion Warmer and Automatic Infusion Pressure Bag in Diastolic**

| Measurement Time                      | Mean (mmHg) |              | p-value | Effect Size ( $\eta^2$ ) |
|---------------------------------------|-------------|--------------|---------|--------------------------|
|                                       | Control     | Intervention |         |                          |
| Pre-test (adjusted)                   | 81.17       | 81.17        | -       | -                        |
| Post-test 15 minutes (intraoperative) | 68.54       | 70.26        | 0.523   | 0.007                    |
| Post-test 30 minutes (intraoperative) | 68.77       | 70.88        | 0.476   | 0.009                    |
| Post-test 15 minutes (recovery room)  | 71.98       | 76.79        | 0.094   | 0.049                    |

Table 3 shows no significant differences in diastolic blood pressure values between the two groups ( $p > 0.05$ ) across all time points. However, at 15 minutes in the recovery room, the p-value approached significance ( $p = 0.094$ ), and the effect size ( $\eta^2 = 0.049$ ) suggests a small clinical impact in favour of the intervention group.

**Table 4. The Effect Infusion Warmer and Automatic Infusion Pressure Bag in Body Temperature**

| Measurement Time                      | Mean (mmHg) |              | p-value | Effect Size ( $\eta^2$ ) |
|---------------------------------------|-------------|--------------|---------|--------------------------|
|                                       | Control     | Intervention |         |                          |
| Pre-test (adjusted)                   | 36.93       | 36.93        | -       | -                        |
| Post-test 15 minutes (intraoperative) | 36.55       | 36.55        | 0.029   | 0.083                    |
| Post-test 30 minutes (intraoperative) | 36.31       | 36.31        | 0.001   | 0.170                    |
| Post-test 15 minutes (recovery room)  | 36.09       | 36.61        | 0.00    | 0.478                    |

Table 4 shows significant differences in body temperature between groups across all post-test measurements ( $p < 0.05$ ). The intervention group consistently maintained higher body temperatures. Notably, the effect sizes indicate moderate to large clinical impact at 30 minutes intraoperatively ( $\eta^2 = 0.170$ ) and especially at 15 minutes postoperatively ( $\eta^2 = 0.478$ ), confirming the intervention's strong effectiveness in preventing intraoperative hypothermia.

## DISCUSSION

Baseline characteristics of participants, including age, body weight, ASA physical status, surgery duration, blood loss, and anaesthetic drugs, were largely homogeneous between the control and intervention groups. Both groups consisted primarily of women in early adulthood (mean age ~30 years), an age range associated with optimal vascular tone and thermoregulatory function (Cho, Yoon, Lee, Jee,

Cho, & Sung, 2022; Messina, La Via, Milani, Savi, Calabrò, Sanfilippo, & Cecconi, 2022).

There is no significant different, even though the intervention group had a slightly higher average body weight ( $73.29 \pm 15.41$  kg) than the control group ( $69.24 \pm 11.43$  kg). Physiologically, individuals with lower body weight have a higher surface-area-to-mass ratio, resulting in more rapid heat loss. Thinner subcutaneous fat also reduces insulation, making these patients more vulnerable to intraoperative hypothermia during spinal anaesthesia (Shen & He, 2024; Wongyingsinn & Pookprayoon, 2023). Conversely, individuals with higher body weight may experience increased intra-abdominal pressure, potentially intensifying the spread of spinal anaesthetics and leading to greater sympathetic blockade and hypotension (Elgzar, Said, & Ibrahim, 2019).

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The majority of participants were ASA I (control: 78.1%, intervention: 87.5%), indicating a predominantly healthy population. Higher ASA classifications ( $\geq$ II) are associated with reduced cardiovascular compensation, which can increase the likelihood of intraoperative hypotension and thermoregulatory instability (American Society of Anesthesiologists, 2020; Liu & Qi et al., 2021; Nemeth, Miller, & Bräuer, 2021; Wongyingsinn et al., 2023). In this study, the distribution of ASA status was controlled during statistical analysis using covariate adjustment.

Surgical duration was between 31–60 minutes for most participants in both groups, which minimized excessive heat loss and hemodynamic disturbances (Sessler, Bloomstone, Aronson, Berry, Gan, Kellum, & Hamilton, 2019). All participants experienced blood loss below 500 mL, ruling out hypovolemia as a significant confounding factor (Pan, Song, Yao, Jiang, & Jiang, 2020). The use of bupivacaine 12.5 mg was the most common spinal anaesthetic agent. Although some patients received fentanyl as an adjuvant, the distribution was balanced between groups, and its known thermoregulatory effects were unlikely to bias results (Ebrie, Woldeyohanis, Abafita, Ali, Zemedkun, Yimer, & Mohammed, 2022).

Analysis using the Multivariate General Linear Model (GLM) showed no significant differences in systolic and diastolic blood pressure between the intervention and control groups at any measured time point ( $p > 0.05$ ). However, small clinical effects were observed, indicated by effect sizes ( $\eta^2 = 0.01$ – $0.06$ ), suggesting the intervention played a modest role in stabilizing blood pressure.

Spinal anaesthesia commonly causes sympathetic blockade, leading to vasodilation of both arteries and veins. This reduces systemic vascular resistance and venous return, thereby lowering cardiac preload and cardiac output—resulting in hypotension. The situation is exacerbated in obstetric patients due to gravid uterine compression of the aorta and inferior vena cava (aortocaval compression), further reducing venous return (Chen, Xu, Qin, Guo, & Ni, 2023; Patel & Ninave, 2024; Sessler et al., 2019; Tome, 2024).

Additionally, the Bezold–Jarisch reflex, triggered by low intravascular volume, can result in bradycardia and profound hypotension. These physiological

mechanisms explain the common occurrence of hypotension in caesarean section patients under spinal anaesthesia (Šklebar, Bujas, & Habek, 2019).

In this context, the infusion warmer and automatic infusion pressure bag helped rapidly deliver warm crystalloid fluid, increasing intravascular volume and thereby improving preload. This action supported cardiac output through the Frank-Starling mechanism and reduced the severity of hypotension, although it could not directly restore vascular tone (Bower & Kinsella, 2020; Delicce & Makaryus, 2017; Mostafa, Hassan, & Abdelatef, 2023; Ross, Lerman, & Côté, 2019). Because earlier studies have shown that while rapid co-loading with crystalloids can reduce hypotension severity, it is more effective when combined with vasopressors such as phenylephrine (Ferré et al., 2020; Šklebar et al., 2019).

In contrast to the blood pressure findings, the intervention showed a statistically and clinically significant impact on core body temperature. The intervention group consistently maintained higher body temperatures across all intraoperative and early recovery time points ( $p < 0.05$ ,  $\eta^2 > 0.14$ ), confirming the effectiveness of the fluid warmer and pressure bag combination in preventing hypothermia.

Spinal anaesthesia impairs thermoregulatory vasoconstriction and facilitates redistribution of core heat to peripheral tissues, a process accelerated by cold ambient temperatures and administration of room-temperature fluids (Cantürk, Cantürk, Kocaoğlu, & Hakkı, 2019; Qi et al., 2022). Without intervention, this often leads to intraoperative hypothermia, which is associated with adverse outcomes including shivering, coagulopathy, and delayed recovery (Shaikh et al., 2024; Tome, 2024).

In this study, the fluid warmer maintained infused fluid temperatures at 37–39°C, reducing the need for the body to expend energy to warm the fluids. Simultaneously, the pressure bag accelerated infusion, minimizing the window for thermal loss. Together, these interventions preserved hypothalamic regulation of body temperature and maintained peripheral perfusion, reducing redistribution heat loss (Ji, Wang, Li, & Shang, 2024; Shaikh et al., 2024).

The study results in line with previous studies that warmed IV fluids reduce core temperature decline and associated with better hemodynamic. For instance,

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preoperative warming combined with warmed fluid administration has been shown to lower the incidence of intraoperative hypothermia from 64% to 29% in urological surgery patients (Cho et al., 2022), and maintain temperature within 0.3°C of baseline using advanced warming devices (Lax et al., 2023).

## CONCLUSION

Although the intervention did not result in statistically significant differences in systolic or diastolic blood pressure between the intervention and control groups, it provided a small but clinically meaningful benefit in maintaining hemodynamic stability. More notably, the combined use of warmed and pressurized intravenous fluids significantly preserved core body temperature throughout the intraoperative and immediate postoperative periods, demonstrating both statistical and clinical significance. These results underscore the physiological advantages of minimizing peripheral heat loss and optimizing intravascular volume, supporting the intervention as an effective, non-pharmacological approach to enhance perioperative thermal and cardiovascular stability in patients undergoing caesarean section.

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