Original Article

Subarachnoid Block Anesthesia as a Predictor of Perioperative Hypothermia in Cesarean Deliveries: A Clinical Study

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Abstract

Background: Hypothermia, defined as a decrease in core body temperature below normal levels, is a common perioperative complication in patients undergoing surgical procedures, including cesarean section (CS). Subarachnoid Block (SAB) anesthesia has been identified as a contributing factor due to its thermoregulatory effects.
Objective: This study aimed to evaluate the impact of SAB regional anesthesia on the occurrence of perioperative hypothermia in patients undergoing cesarean section.
Methods: A pre-experimental study with a pretest-posttest design was conducted involving 60 cesarean section patients receiving SAB anesthesia at Al Fuadi General Hospital, Binjai. Body temperature measurements were taken before and after SAB administration. Data were analyzed using paired sample t-tests.
Results: Prior to the administration of SAB anesthesia, the majority of patients (91.7%) exhibited normal body temperature, with a mean pretest temperature of 36.8°C (±0.3172). Following SAB administration, all patients (100%) developed hypothermia, with a mean posttest body temperature of 34.9°C (±0.4873), reflecting an average temperature decrease of 1.9°C. Statistical analysis indicated a significant effect of SAB anesthesia on the incidence of perioperative hypothermia ($p = 0.000$, $p < 0.05$).
Conclusion: The administration of SAB regional anesthesia significantly increases the risk of perioperative hypothermia in cesarean section patients. Preventive strategies in clinical practice should include continuous monitoring of patient body temperature before, during, and after SAB administration to enable early detection and intervention, thereby reducing hypothermia-related complications.

Keywords: Subarachnoid, anesthesia, hypothermia, secarean section, perioperative

INTRODUCTION

Hypothermia is a condition that can occur in patients undergoing surgery. Hypothermia happens in perioperative patients, where the core body temperature drops below 36°C. It can be caused by thermoregulatory disturbances induced by anesthesia, fluids used during

surgery, and exposure to cold in the operating room environment (1). The complication of hypothermia include heart arrhytmias, delayed surgical wound healing and increased infection risk (2). Hypothermia during cesarean section with SAB anesthesia is primarily caused by a combination of factors. One of the most significant contributors is the vasodilation induced by the spinal block, which results in the redistribution of blood from the central to the peripheral circulation. Additionally, exposure of the abdominal cavity, the administration of cold intravenous fluids, and the often lower operating room temperatures exacerbate heat loss.

Hypothermia during surgery is partly caused by the effects of SAB anesthesia (Subarachnoid Blok) and the sedation technique using general anesthesia. This is suspected to occur because anesthetic agents may disrupt the thermoregulatory center, leading to a decrease in core temperature in the form of hypothermia (3). The relevance of hypothermia during cesarean sections is critical, as it can lead to several adverse outcomes for both the mother and neonate. Maternal complications may include shivering, discomfort, increased oxygen consumption, and a higher risk of wound infection and coagulopathy. Furthermore, hypothermia can negatively affect the neonate, increasing the risk of hypoglycemia, poor thermoregulation, and respiratory distress (2).

Spinal anesthesia can lower the shivering threshold to hypothermia during the first hour after the procedure, with a temperature decrease of about 1-3°C. This is related to the redistribution of body heat from the core to the periphery, where spinal anesthesia causes vasodilation (4). In a cesarean section, in addition to the influence of anesthetic drugs, hypothermia is also caused by the temperature of the operating room, infusion fluids, abdominal surgery, and rinsing of the abdominal cavity with cold fluids (5).

Existing studies report that the incidence of perioperative hypothermia can be as high as 78.6%, with hypothermia occurring within two hours in 56.6% of patients and nearly 100% after two hours if preventive measures are not taken (6). In elective cesarean sections, nearly one-third of women experience perioperative hypothermia, with 40% reporting thermal discomfort and 33% experiencing shivering postoperatively (7). Other studies have indicated that approximately 80% of patients undergoing anesthesia experience some degree of hypothermia, increasing the risk of bleeding, myocardial ischemia, delayed anesthetic recovery, impaired wound healing, and infection (8).

While the association between general anesthesia and perioperative hypothermia is well-documented, there is a notable gap in the literature specifically examining hypothermia related to Subarachnoid Block anesthesia in cesarean sections, particularly within the Indonesian healthcare context. Most studies have focused on general surgical populations or compared different anesthesia types, without isolating the direct effects of SAB on perioperative temperature regulation in obstetric surgery. Additionally, there is limited local data on the incidence, severity, and clinical consequences of hypothermia in cesarean section patients receiving spinal anesthesia. Therefore, the novelty of this study lies in its focused investigation of the impact of SAB anesthesia on perioperative hypothermia specifically among cesarean section patients in Indonesia. By addressing this gap, the study aims to provide context-specific evidence on the prevalence, severity, and clinical relevance of hypothermia induced by SAB anesthesia, thereby supporting improved perioperative care and the development of targeted preventive strategies.

This study aims to evaluate the effect of Subarachnoid Block (SAB) anesthesia on perioperative hypothermia in cesarean section patients, focusing on the incidence, severity, and potential clinical implications of temperature reductions during and after surgery.

METHODS

Study Design

This study utilized a pre-experimental pretest-posttest design to evaluate the effect of Subarachnoid Block (SAB) anesthesia on perioperative hypothermia among cesarean section patients.

Sample

The study population comprised all patients undergoing cesarean section (CS) surgery with regional anesthesia (SAB) at Al Fuadi General Hospital, Binjai, during the data collection period. The hospital's monthly records indicated an average of 150 cesarean section procedures performed with SAB anesthesia. A systematic

random sampling method was employed to select participants from the eligible population. Every second patient scheduled for elective cesarean section during the data collection period was approached for participation. A total of 60 respondents were recruited based on inclusion and exclusion criteria. Inclusion criteria were emale patients undergoing elective cesarean section with regional anesthesia (SAB), aged between 18 and 45 years, willing to provide informed consent, and body temperature within normal limits (36–37.5°C) before surgery. Exclusion criteria were patients with pre-existing febrile conditions or systemic infections, patients requiring conversion to general anesthesia during surgery, and patients with diagnosed hypothyroidism or other metabolic disorders affecting thermoregulation.

Sample size calculation was conducted based on an expected medium effect size (d = 0.5), a significance level (α) of 0.05, and a statistical power of 0.80 using G*Power 3.1 software. The calculation indicated a minimum required sample of 54 participants. To account for potential dropouts or incomplete data, the sample size was increased to 60 participants.

Instrumentation

Temperature Measurement Instrument was measure using Digital Clinical Thermometer (Standardized hospital-grade model). Core body temperature was recorded preoperatively and at 15-minute intervals intraoperatively until the end of surgery. The unit was Degrees Celsius (°C). Normothermia: ≥ 36.0°C, Mild, Hypothermia: 35.0°C–35.9°C, Moderate Hypothermia: 32.0°C–34.9°C, Severe Hypothermia: < 32.0°C. Digital thermometers used had an accuracy margin of ±0.1°C and were calibrated regularly according to hospital standards.

General Characteristics Questionnaire covering patient age, parity, gestational age, BMI, ambient operating room temperature, and fluid infusion volume. Demographic variables were categorized and described using frequencies and percentages.

Procedure

Following ethical approval, eligible patients scheduled for cesarean section with SAB anesthesia were approached, and informed consent was obtained. Baseline body temperature was recorded preoperatively using a digital thermometer. Patients then received SAB anesthesia as per hospital protocol. Intraoperative body temperature measurements were recorded every 15 minutes during surgery. Observations included documentation of intraoperative fluids administered, ambient operating room temperature, and duration of surgery. Data collection occurred from March 16, 2023, to April 16, 2023, in the operating room of Al Fuadi General Hospital, Binjai. The independent variable was the administration of SAB anesthesia, and the dependent variable was the occurrence and severity of hypothermia.

Data Analysis

Data analysis was conducted using IBM SPSS Statistics version 26.0. Descriptive statistics (means, standard deviations, frequencies, percentages) were used to present demographic characteristics and baseline clinical parameters. The Kolmogorov-Smirnov test was conducted to assess the distribution of temperature data, and normality was confirmed ($p > 0.05$). Paired sample t-tests were used to assess pre- and post-anesthesia temperature differences within participants. A p-value of <0.05 was considered statistically significant.

Ethical Considerations

The study protocol was reviewed and approved by the Health Research Ethics Committee of STIKes Kepanjen, Malang Regency, under ethical clearance certificate number No. 316/S.Ket/KEPK/STIKesKPJ/III/2023. Written informed consent was obtained from all participants prior to their involvement in the study. Participants were assured of the confidentiality and anonymity of their data and informed of their right to withdraw at any point without affecting their medical care. The study adhered to the ethical principles outlined in the Declaration of Helsinki.

RESULTS

Table 1. General Data of Respondents (n=60)

Data	f	%
Age		
< 20 years	6	10,0
20-35 years	32	53,3
> 35 years old	22	36,7
Education		
Basic	11	18,3
Secondary	37	61,7
Higher	12	20,0
IMT		
Normal	3	5,0
Obesity	57	95,0
Operation time		
<1 hour	28	46,7
1-2 hours	30	50,0
2-3 hours	2	3,3

Based on table 1, it is known that most respondents are aged 20-35 years as many as 32 people (53.3%), a small number of respondents aged <20 years as many as 6 people (10%). Most respondents have secondary education (high school / vocational high school), as many as 37 people (61.7%), a small number of respondents have primary education (elementary/junior high school), and as many as 11 people (18.3%). Most respondents with BMI category obesity, as many as 57 people (95.0%), and a small number of respondents with normal BMI, as many as 3 people (5.0%). Most of the length of cesarean section operation is 1-2 hours for as many as 30 people (50.0%), and a small number of operation duration is 2-3 hours for as many as 2 people (3.3%).

Table 2. Frequency Distribution Data of Respondents' Body Temperature (Pre-post test)

Body Temperature	f	%	Mean±SD	Min- Max
Pre-test				
Hypothermia (<36.5°C)	5	8,3	36.8±0.3172	36.6-37.4
Normal (36.5°-37.5°C)	55	91,7		
Post-test				
Hypothermia(<36.5°C)	60	100,0	34.9±0.4873	34.1-36.1
Normal (36.5°-37.5°C)	0	0,0		

In table above, it is known that the body temperature of patients with cesarean section before administration of regional anesthesia SAB (pre-test) is in the normal category of 55 people (91.7%), a small number of respondents experienced hypothermia (body temperature <36.5°C) of 5 people (8.3%). At the same time, the body temperature of patients with cesarean section after administration of regional anesthesia SAB (post-test) is entirely in the hypothermia category of 60 people (100.0%).It shows the body temperature before administration of SAB regional anesthesia (pre-test) in 60 respondents with an average (mean) and standard deviation of 36.8 ± 0.3172, minimum body temperature of 36.6 ° C, and maximum body temperature of 37.4 ° C. The body temperature after administration of SAB regional anesthesia was measured in 60 respondents with an average (mean) and standard deviation of 34.9 ± 0.4873, minimum body temperature of 34.1 ° C, and maximum body temperature of 36.1 ° C.

The significant temperature reduction highlights the thermoregulatory impact of SAB anesthesia, warranting proactive monitoring during caesarean sections. Furthermore, a normality test was carried out using the Kolmogorov-Smirnov test on the body temperature data of patients with the cesarean section before and after the administration of SAB regional anesthesia. A normal distribution was obtained because the p-value was> 0.05 (pre-test p = 0.181 and post-test p = 0.138). So, you can use the paired t-test.

Table 3. Results of the Paired Sample T-Test on the Relationship between SAB Regional Anesthesia Administration and the Incidence of Hypothermia in Caesarean Section Patients

Body Temperature	*Mean* dan SD	*p-value*	t-test	t-table
Pre-test	36,8±0,3172	0,000	34,219	1,671
Post-test	34,9±0,4873			

DISCUSSION

The result for sthudy showing that there is a effect of administration of SAB regional anesthesia and the incidence of hypothermia in post-cesarean section patients at Al Fuadi Binjai General Hospital with a p-value = 0.000 <0.05 and a calculated t value = 34.219> t table = 1.671. Hypothermia is when a person's body temperature drops below the normal limit below 36.5 ° C (95 ° F). This occurs when the body loses heat faster than it can produce it, often in response to a cold environment (6). Hypothermia in surgery is caused by the effects of SAB (Subarachnoid Block) anesthesia and anesthesia with general anesthesia techniques. This is thought to be because anesthetic drugs can interfere with the thermoregulatory center, so there is a decrease in core temperature in the form of hypothermia (3). Spinal anesthesia can lower the shivering threshold to hypothermia in the first hour after spinal anesthesia with a decrease in temperature of about 1-3 ° C, this is related to the retribution of body heat from the core compartment to the periphery where the spinal causes vasodilation (4).

There are many undesirable effects of hypothermia, hypothermia can interfere with myocardial contraction, cause arrhythmias, and can cause coagulopathy in injured patients. Hypothermia can increase the risk of pneumonia. Hypothermia can also increase mortality or morbidity, possibly due to the effect of hypothermia on hemostatic function. Randomized trials have shown that hypothermia also causes increased bleeding during surgery (7).

Regional anesthesia Sub Arachnoid Block (SAB) is one of the anesthesia methods used in cesarean section procedures. This procedure involves injecting local anesthetic into the subarachnoid space around the spinal cord to stop sensation in the lower body, allowing surgery to be performed without pain (8). However, SAB has a potential impact on the patient's body temperature. This is related to changes in blood circulation and disruption of the body's mechanisms that regulate temperature. SAB often causes vasodilation, where peripheral blood vessels widen, allowing body heat to be lost faster than it can be produced (9).

In this study, the administration of SAB regional anesthesia in patients with cesarean section was shown to cause a decrease in body temperature (hypothermia) (10). A decrease in body temperature after administration of Sub Arachnoid Block (SAB) regional anesthesia in patients undergoing cesarean section is a possible complication (11,12). There are three causes of hypothermia with spinal anesthesia. First, spinal anesthesia causes a redistribution of internal heat from the core to the peripheral compartment. Second, with the loss of thermoregulatory vasoconstriction below the level of the spinal block, there is increased heat loss from the body surface. Finally, there is a change in thermoregulation in spinal anesthesia, characterized by a decrease in vasoconstriction and a shivering threshold of 0.5 ℃ (13).

Redistribution of body heat is the main initial cause of hypothermia in patients with neuraxial anesthesia. Neuraxial anesthesia also inhibits central thermoregulatory control and inhibits peripheral sympathetic and motor nerves, thereby preventing thermoregulatory vasoconstriction and shivering. Core temperature decreases by 0.8 ± 0.3℃ in the first hour of neuraxial anesthesia. Redistribution during neuraxial anesthesia accounts for 89% of the initial decrease and is usually limited to the limbs (12,14,15). After the initial decrease, sufficient core hypothermia will trigger vasoconstriction and shivering in the unoccluded area. However, shivering in the upper body is relatively ineffective and insufficient to prevent further hypothermia (13). According to the researchers, the results of this study prove that cesarean section patients at Al Fuadi Binjai General Hospital experienced a decrease in body temperature (hypothermia)

after the administration of SAB regional anesthesia. This decrease in body temperature can make patients more susceptible to hypothermia during and after surgery. The average decrease in body temperature during the pretest of 36.8°C decreased to 34.9°C during the posttest, or there was a decrease in body temperature of 1.9°C in respondents.

Prevention of hypothermia in patients undergoing surgery or receiving regional anesthesia (SAB) must be considered (16,17). Measures like warming can help reduce the risk. Warming for fifteen minutes after epidural catheter placement and before starting general anesthesia reduces the incidence of postoperative hypothermia. Warmed IV fluids are also known to keep the core temperature of surgical patients about half a degree warmer than participants given room-temperature IV fluids (18). In addition, mechanisms to prevent hypothermia can include monitoring the patient's body temperature before, during, and after surgery, increasing the environmental temperature, and providing warm blankets. Removing wet clothes, blankets, and socks from the patient (10,19). Protecting the patient from wind and further heat loss. Move to a warm and dry room as soon as possible, and if necessary, the patient should use extra clothing (6,20).

Implications

The results underscore the critical role of proactive temperature monitoring and management during cesarean sections conducted under spinal anesthesia. Integrating standardized warming protocols into surgical and anesthesia procedures could significantly reduce the incidence of hypothermia-related complications. Nursing and anesthesia teams should incorporate active warming strategies and routine thermal assessments to enhance patient safety, improve surgical recovery, and protect neonatal health. Future clinical guidelines should emphasize perioperative thermal care as an essential component of obstetric anesthesia management.

Limitations

This study has several limitations. First, the use of a pre-experimental design without a control group limits the ability to establish causality definitively. Second, the relatively small sample size (n = 60) may affect the generalizability of the findings. Third, core temperature was measured non-invasively using digital thermometers, which, although practical, may not be as precise as esophageal or bladder thermometry. Additionally, external factors such as variations in room temperature and individual patient physiology were not fully controlled. Future research should utilize randomized controlled designs, larger sample sizes, and multiple sites to strengthen the evidence base regarding SAB-induced hypothermia.

CONCLUSION

This study confirms that the administration of Subarachnoid Block (SAB) regional anesthesia can significantly contribute to the occurrence of perioperative hypothermia among patients undergoing cesarean section. The findings emphasize the importance of vigilant monitoring of body temperature before, during, and after SAB administration. Early detection of temperature changes is essential to enable timely preventive interventions, such as warming techniques, fluid management strategies, and maintaining optimal operating room temperatures. Furthermore, this research provides valuable insights into the relationship between SAB anesthesia and perioperative hypothermia during cesarean deliveries. By identifying key contributing factors and highlighting the clinical importance of temperature management, the study supports improvements in maternal and neonatal care practices. Enhancing perioperative thermal regulation has the potential to improve maternal comfort, reduce postoperative complications, and optimize neonatal outcomes.

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Author Contribution

AWK : Conceptualization and Study Design, Methodology, Data Curation, Writing – Original Draft, Writing – Review & Editing
NR and WRN : Conceptualization and Study Design, Methodology, Formal Analysis,

WDN : Data Curation, Writing – Review & Editing, Methodology, Formal Analysis

Conflict of Interest

The authors declare no conflict of interest regarding the research, authorship, or publication of this article.

Data Availability Statement

The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request. Data sharing is subject to appropriate ethical and confidentiality safeguards.

REFERENCES

1. Rauch S, Miller C, Bräuer A, Wallner B, Bock M, Paal P. Perioperative hypothermia—a narrative review. Vol. 18, International Journal of Environmental Research and Public Health. MDPI AG; 2021.
2. Paal P, Pasquier M, Darocha T, Lechner R, Kosinski S, Wallner B, et al. Accidental Hypothermia: 2021 Update. Vol. 19, International Journal of Environmental Research and Public Health. MDPI; 2022.
3. Bindu B, Bindra A, Rath G. Temperature management under general anesthesia: Compulsion or option. Vol. 33, Journal of Anaesthesiology Clinical Pharmacology. Medknow Publications; 2017. p. 306–16.
4. Lopez MB. Postanaesthetic shivering - from pathophysiology to prevention. Rom J Anaesth Intensive Care. 2018 Apr 1;25(1):73–81.
5. Thakur N, Balachander H, Rudingwa P, Panneerselvam S. Shivering and changes in body temperature in patients undergoing caesarean section under spinal anaesthesia with bupivacaine vs bupivacaine and fentanyl: A randomized clinical study. J Anaesthesiol Clin Pharmacol. 2023 Jan 1;39(1):67–73.
6. Simegn GD, Bayable SD, Fetene MB. Prevention and management of perioperative hypothermia in adult elective surgical patients: A systematic review. Vol. 72, Annals of Medicine and Surgery. Elsevier Ltd; 2021.
7. Kander T, Schött U. Effect of hypothermia on haemostasis and bleeding risk: a narrative review. Vol. 47, Journal of International Medical Research. SAGE Publications Ltd; 2019. p. 3559–68.
8. Abdulquadri Olawin AM, Das Affiliations JM. Spinal Anesthesia Spinal Anesthesia Continuing Education Activity [Internet]. 2021. Available from: https://www.researchgate.net/publication/351775015
9. Allen TK, Habib AS. Inadvertent Perioperative Hypothermia Induced by Spinal Anesthesia for Cesarean Delivery Might Be More Significant Than We Think: Are We Doing Enough to Warm Our Parturients? Vol. 126, Anesthesia and Analgesia. Lippincott Williams and Wilkins; 2018. p. 7–9.
10. Recio-Pérez J, Miró Murillo M, Martin Mesa M, Silva García J, Santonocito C, Sanfilippo F, et al. Effect of prewarming on perioperative hypothermia in patients undergoing loco-regional or general anesthesia: A randomized clinical trial. Medicina (B Aires). 2023;59(12):2082.
11. Indriyanti I, Sariaty S, Ferina F. Pengaruh Teknik Relaksasi Genggam Jari Terhadap Penurunan Intensitas Nyeri Pada Ibu Post Sectio Caesarea. Jurnal Kesehatan Siliwangi. 2022;2(3):751–61.
12. Dinengsih S, Suciatmi E. The influence of fingerhold relaxation technique on pain reduction of post sectio caesarea patients. International Journal nursing padjajaran. 2018;6(2):2.
13. Chung SH, Lee BS, Yang HJ, Kweon KS, Kim HH, Song J, et al. Effect of preoperative warming during cesarean section under spinal anesthesia. Korean J Anesthesiol. 2012;62(5):454–60.
14. Sugito A, Ta'adi T, Ramlan D, Pujiastuti RSE. Intervention of lavender aromatherapy and acupressure to reduce pain scale in postoperative sectio caesarea patients. Media Keperawatan Indonesia. 2023;6(2):117–26.
15. Afifah AN, Sukmawati S, Ermiati E. Penerapan Intervensi Teknik Relaksasi Genggam Jari Terhadap Nyeri Pada Pasien Post Sectio Caesarea dengan Preeklampsia: Studi Kasus. Nursing News: Jurnal Ilmiah Keperawatan. 2023;7(3):172–84.
16. Murniasih E, Natalya R, Eliawati U. Pengaruh Teknik Relaksasi Genggam Jari Terhadap Nyeri Pasien Post Sectio Caesaria Di Ruang Gardenia RSAB

Pekanbaru. Initium Medica Journal. 2021;1(1):49–56.
17. Wardani FI, Futriani ES. The Effectiveness of Fingerhold Relaxation Techniques and Lemon Aromatherapy Towards Reducing Pain Intensity in Post Section Caesarian Patients. Jurnal Keperawatan Komprehensif (Comprehensive Nursing Journal). 2022;8(2).
18. Horn EP, Bein B, Broch O, Iden T, Böhm R, Latz SK, et al. Warming before and after epidural block before general anaesthesia for major abdominal surgery prevents perioperative hypothermia. In: European Journal of Anaesthesiology. Lippincott Williams and Wilkins; 2016. p. 334–40.
19. Emmert A, Gries G, Wand S, Buentzel J, Bräuer A, Quintel M, et al. Association between perioperative hypothermia and patient outcomes after thoracic surgery: A single center retrospective analysis. Medicine. 2018;97(17):e0528.
20. Gash MC, Matthew ;, Affiliations V. Physiology, Muscle Contraction [Internet]. 2019. Available from: https://www.researchgate.net/publication/331110563