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RESEARCH

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Intraoperative temperature management during emergency cesarean section: a retrospective observational study

Ran Zhang[1], Qiang Zhou[2] and Hongli Guan[1*]

Abstract

Background Intraoperative hypothermia is a common complication during cesarean section (C-section) and associated with the high maternal mortality and morbidity. This study aimed to explore the risk factors associated with the incidence of intraoperative hypothermia in women who underwent emergency C-section deliveries.

Methods We retrospectively enrolled women who underwent emergency cesarean deliveries from August 2022 to Dec 2023 at Suzhou Municipal Hospital of Anhui Province. Baseline characteristics, thermal status, and perioperative information were extracted. Hypothermia was defined as the onset of a core temperature below 36 °C. Data were compared between patients with and without a hypothermia during surgery. Logistic regression analyses were performed to determine the risk factors for low-temperature-status.

Results Overall, 87 patients were included, and 30 underwent hypothermia during surgery. For women with a normal temperature status, women in the hypothermia group had a lower incidence of receiving active warming methods (52.6% vs. 30%, $P = 0.044$). In the logistic regression model involving core temperature, a pre-surgery core temperature < 36.5 °C (OR 4.22, 95% CI 1.13–15.63, $p = 0.032$) and a long surgery duration (per 10 min, OR 1.97, 95% CI 1.24–3.11, $p = 0.004$) were associated with a high probability of hypothermia. Administering active warming methods to women can reduce the risk of experiencing a hypothermia during emergency C-sections (OR 0.19, 95% CI 0.05–0.63; $p = 0.007$).

Conclusions Hypothermia is common in emergency C-section deliveries. It is recommended that active warming methods should be applied to parturient undergoing emergency C-sections more proactively, especially for women who have a low baseline core temperature (< 36.5 °C) and are expected to have a long surgery duration.

Keywords Intraoperative hypothermia, Warming method, Emergency, Cesarean section

*Correspondence:
Hongli Guan
119166728@qq.com
[1]Department of Nursing, Suzhou Municipal Hospital of Anhui Province, Suzhou Hospital of Anhui Medical University, Anhui Province, China
[2]Department of Anesthesiology, Suzhou Municipal Hospital of Anhui Province, Suzhou Hospital of Anhui Medical University, Anhui Province, China

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Background

Hypothermia is commonly observed in parturient undergoing cesarean section (C-section) with neuraxial anesthesia, and its prevalence is much higher in the case of emergency C-sections for inadequate preoperative preparations [1–3]. The adverse effects of hypothermia, such as increased blood loss, prolonged recovery, and increased risk of wound infection and patient discomfort, have been well recognized [4–6]. Therefore, it is important to identify risk factors and preventive measures for hypothermia during emergency C-sections as a way to optimize perioperative management.

Intraoperative hypothermia during neuraxial anesthesia has various etiologies, primarily caused by altered thermoregulation and a reduced threshold for vasoconstriction and shivering [7, 8]. Procedures, including the use of insulation to retain patients' existing body heat, which is passive warming (PW), and the use of external devices to actively generate heat for patients, which is active warming (AW), have been proven to be effective in improving patient body temperature [7, 9]. However, their relative effectiveness specifically in emergency C-section surgeries remains uncertain. Determining which method performs better in mitigating hypothermia risk could enhance perioperative care. Therefore, we aimed to identify the prevalence of hypothermia and the risk and protective factors associated with hypothermia during emergency C-sections. Additionally, evaluating the efficacy of PW and AW is one of the crucial aspects in this study.

Methods

The Ethics Committee of Suzhou Municipal Hospital of Anhui Province approved this study and waived the need for informed consent from participants.

Patients

We retrospectively enrolled women who underwent emergency cesarean deliveries from August 2022 to Dec 2023 at Suzhou Municipal Hospital of Anhui Province. Patients were excluded if they had less than 37 weeks of gestation, an American Society of Anesthesiologists (ASA) classification of III or higher, coagulation abnormalities (including the use of anticoagulants or antiplatelet agents), received epidural or general anesthesia, used intravenous anesthetic agents, or had a history of thyroid disease.

Data collection

Intraoperative hypothermia was defined as a core temperature < 36 °C [10]. Shivering status was graded and recorded during and after the cesarean section according to the Bedside Shivering Assessment Scale [11]. The scale ranges from 0 to 3, where:

- 0 indicates no shivering, noted by the absence of palpable shivering in the masseter, neck, or chest wall.
- 1 represents mild shivering localized to the neck and/or thorax.
- 2 indicates moderate shivering, involving gross movement of the upper extremities in addition to the neck and thorax.
- 3 signifies severe shivering, involving gross movements of the trunk, as well as the upper and lower extremities."

In our institution, commonly used passive warming methods include covering body with reflective blankets, covering head and extremity with cotton blanket, and increasing ambient temperature. Active warming methods include warming intravenous fluid to 37 °C using a 3MRanger™ Fluid Warmer, applying heating pads (RC-2000III™, Computer Medical Temperature Controller, Reicheng Medical Inc., Jilin Province, PRC), and forced-air warming (Level 1 EQUATOR® Convective Warmer, Smiths Medical ASD, Rockland, USA). The temperature of the forced air warming device and heating pad is usually set at 40 °C throughout the operation.

We collected core temperature and shivering status at different timepoints (before surgery, during surgery, and after surgery). The lowest core temperature recorded during surgery, along with the first preoperative and postoperative core temperatures, were extracted for further analysis. The core temperature was measured using an infrared tympanic thermometer (PRO6000, Braun, Marlborough, MA USA 01752). In practice, nurses usually measure body temperature twice and record the average. If there is a major discrepancy between the initial two values, they will take additional measurements and average the two closest values. Hypothermia was defined as the onset of a core temperature below 36 °C. Demographic data, Apgar score, neonate weight, anesthetic and surgery information (duration, ambient temperature, fluid infusion, blood loss, etc.), and other relevant information were extracted and analyzed. In our hospital, crystalloid solutions are usually the first choice for fluids infusion. When patients require a relatively large volume of crystalloids, colloid solutions are administered to minimize the total amount of required crystalloids. Two main ways were used to calculate blood loss during C-sections: one uses a bottle with negative pressure suction, which has a scale to measure the blood loss directly; the other estimates bleeding by measuring the weight difference of sterile gauze pads before and after they have been soaked with blood.

Study outcomes

The incidence of hypothermia was the primary outcome. Secondary outcomes included the change of core temperature and shivering assessment from baseline.

Statistical analysis

Likewise-deletion method was used to handle missing data. Continuous data are presented as mean±standard deviation (Gaussian distribution) or median (interquartile range (IQR)) (non-Gaussian distribution) [12]. Categorical variables are expressed as absolute values and percentages. For the continuous variables, the data were analyzed using Student's t-test, the Mann-Whitney U test or the Kruskal-Wallis test depending on the data distribution and the number of variables. The categorical variables were analyzed using chi-square or Fisher's exact tests. Multivariable logistic regression analysis was performed with intraoperative hypothermia status as outcome. Univariable analysis was performed for each potential risk factor of intraoperative hypothermia status. We defined $P<0.2$ in univariable analysis as the threshold of a variable qualified to be included in multivariable logistic regression model. All comparisons were two-tailed, and $P<0.05$ was used to exclude the null hypothesis. The statistical analysis was performed using IBM SPSS Statistics, Version 22.0 (Armonk, NY: IBM Corp).

Results

During the study period, a total of 96 women underwent emergency cesarean deliveries. Seven patients were excluded due to gestations of less than 37 weeks, one for receiving epidural anesthesia, and one for having ASA III. Ultimately, 87 patients were included for further analyses (Fig. 1). Among them, 30 patients experienced intraoperative hypothermia.

Patient baseline characteristics, perioperative information and neonate status are presented in Table 1. Detailed information about emergency C-section. e.g., indications, comorbidities, etc., is shown in Supplement Material Table S1. No differences were observed in terms of age, Apgar score, neonate weight, indications for emergency C-section, comorbidities or required concomitant procedures.

Perioperative information

There were no differences between the two groups in terms of anesthesia method, intravenous fluid infusion, intraoperative urine output and ambient temperature. Patients in hypothermia group had longer surgery (minutes, median [IQR]: 50 [45, 55] vs. 55 [50, 65], $p=0.001$) and anesthesia duration (minutes, median [IQR]: 70 [65,80] vs. 80 [70,90], $p=0.006$).

More women in the normal-temperature group than in the hypothermia group received active warming method (52.6% vs. 30.0%, $p=0.044$). Details of (passive/active) warming methods are presented in Supplement Material Table S2. Patients in the hypothermia group experienced a longer surgery duration. A greater volume of blood loss was observed in the hypothermia group than the normal-temperature group (median [IQR]: 400 ml [300,400] vs. 400 ml [400,500], $p=0.009$). In terms of the initial thermal condition, there was no difference in the core temperature between the two groups before surgery. However, the shiver assessment scale was higher in hypothermia group than the normal-temperature group before surgery. The change in core temperature throughout the operation was visualized and is shown in Fig. 2. More details of perioperative information are presented in Table 1.

Logistic regression models

The univariable logistic regression outcomes for intraoperative hypothermia are presented in Table 2. Finally, variables including surgery time, warming method, core temperature before surgery, and shiver assessment scale before surgery were considered for inclusion in

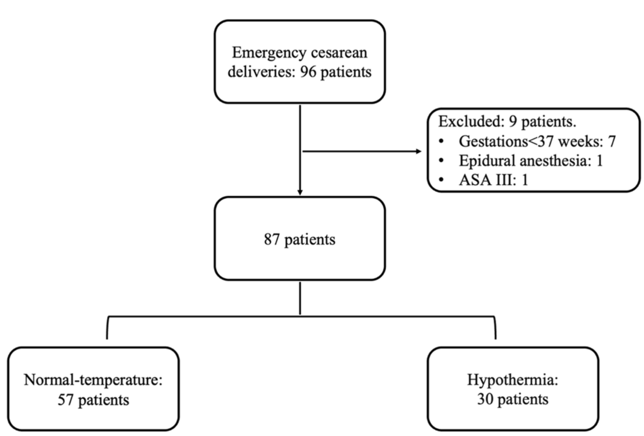

Fig. 1 Diagram showing the enrollment of patients. ASA: American Society of Anesthesiologists Classifications

Table 1 Baseline characteristics and perioperative information of women who underwent emergency C-sections

		Total (*n* = 87)	Normal-temperature (*n* = 57)	Hypothermia (*n* = 30)	*P*-value
Age, years		30.74 ± 4.5	30.77 ± 4.35	30.67 ± 4.87	0.921
BMI, kg/m^2		29.57 ± 3.86	29.22 ± 3.73	30.23 ± 4.09	0.264
BSA, m^2		1.80 ± 0.12	1.79 ± 0.13	1.82 ± 0.10	0.306
Gestation, weeks		39 [38,40]	38 [38,39]	39 [38,40]	0.100
Comorbidity, n(%)	Chronic HTN	2(2.3)	1(1.7)	1(3.3)	0.798
	Pregnancy-related HTN	5(5.7)	3(5.3)	2(6.7)	
	Gestational DM	16(18.4)	12(21.1)	4(13.3)	
	Arrhythmias	2(2.3)	1(1.7)	1(3.3)	
	Obesity	9(10.3)	5(8.8)	4(13.3)	
	Others	2(2.3)	1(1.7)	1(3.3)	
Warming method, n(%)	Passive	48(55.2)	27(47.4)	21(70.0)	0.044
	Active	39(44.8)	30(52.6)	9(30.0)	
Surgery time, min		50 [45, 60]	50 [45, 55]	55 [50, 65]	0.001
Anesthesia time, min		75 [65,85]	70 [65,80]	80 [70,90]	0.006
Anesthesia method, n(%)	Combined spinal-epidural	76(87.4)	50(87.7)	26(86.7)	0.888
	Spinal	11(12.6)	7(12.3)	4(13.3)	
Surgical strategy, n (%)	Fundal	18(20.7)	13(22.8)	5(16.7)	0.502
	Lower segment	69(79.3)	44(77.2)	25(83.3)	
Apgar score		9[8,9]	9[8,9]	9[7,9]	0.498
Neonate weight, kg		3.82 ± 0.69	3.87 ± 0.65	3.71 ± 0.75	0.334
Blood loss, ml		400 [300,400]	400 [300,400]	400 [400,500]	0.009
Intraoperative fluid infusion, L		1.2 [1.0,1.5]	1.2 [1.0,1.3]	1.2 [1.0,1.5]	0.168
Crystalloid solution*, mL		1000 [800,1000]	1000 [800,1000]	900[800,1000]	0.638
Colloidal solution§, mL		300[200, 425]	250[200,400]	300[250,500]	0.046
Intraoperative urine	ml	200 [200,200]	200 [200,200]	200 [200,200]	0.198
	ml/kg/h	1.87 [1.61, 2.17]	1.95 [1.60, 2.22]	1.78 [1.63, 2.05]	0.503
Ambient temperature, °C		23.0 [22.4, 24.0]	22.9 [22.4,23.8]	23.0 [22.0,24.0]	0.929
Core temperature, °C	Before surgery	36.5 [36.4,36.8]	36.6 [36.5,36.8]	36.5 [36.4,36.7]	0.134
	During surgery	36.2 [36.1,36.4]	36.3 [36.2, 36.4]	36.0 [35.8, 36.2]	< 0.001
	After surgery	36.2 [36,36.2]	36.2 [36.1,36.3]	35.8 [35.7,36.1]	< 0.001
Shivering assessment	Before surgery	0 [0,0]	0 [0,0]	0 [0,0]	0.010
	During surgery	0 [0,1]	0 [0,0]	1 [0,1]	< 0.001
	After surgery	0 [0,1]	0 [0,0]	0 [0,1]	0.031
Hospital stay, days		7 [6,8]	7 [6,8]	7 [6,9]	0.590

The data are expressed as the means ± standard deviation, medians [interquartile ranges], or numbers (%). BMI: body mass index; BSA: body surface area; HTN: hypertension; DM: diabetes mellitus

*: Commonly used crystalloid solutions include compound sodium chloride injection, lactated Ringer's solution, normal saline, 5% glucose solution. §: commonly used colloidal solutions include succinylated gelatin, human albumin

the multivariable logistic regression analysis. Given the strong associations between core temperature and shiver assessment scale before surgery, including all variables could lead to multicollinearity. To address this issue, two models were constructed: one incorporating the pre-surgery core temperature and the other involving the pre-surgery shiver assessment.

Two multivariable logistic regression models are displayed in Table 3a and Table 3b. In the model incorporating core temperature, longer surgery time (per 10 min, OR 1.97, 95% CI 1.24–3.11, $p = 0.004$), higher blood loss, and pre-surgery core temperature < 36.5 °C (OR 4.22, 95% CI 1.13–15.63, $p = 0.032$) were identified as independent factors associated with a high risk of experiencing intraoperative hypothermia. Similarly, in the model including shiver assessment, longer surgery time (per 10 min, OR 2.33, 95% CI 1.40–3.8E6, $p = 0.001$), higher blood loss, and having a shiver before surgery (OR 18.34, 95% CI 2.76–121.80, $p = 0.003$) were independently associated with a greater probability of experiencing intraoperative hypothermia. According to both multivariable logistic regression models, the use of active warming methods was associated with a reduced risk of experiencing intraoperative hypothermia (core temperature model: OR 0.19, 95% CI 0.05–0.63, $p = 0.007$; shiver assessment model: OR 0.22, 95% CI 0.06–0.73, $p = 0.013$).

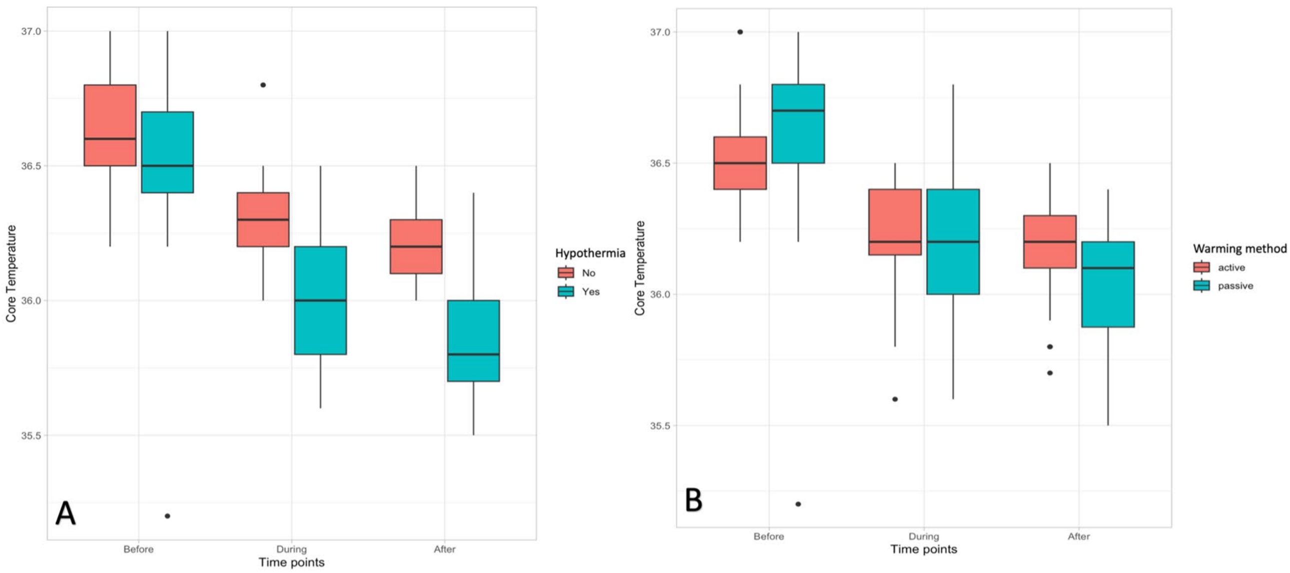

Fig. 2 Intraoperative core temperature dynamics across groups. Panel A: the core temperature change among women with and without hypothermia; Panel B: the core temperature changes between women subjected to active warming and those undergoing passive warming

Table 2 Univariable logistic regression analysis for intraoperative hypothermia

Variables	Coefficients	SE	*P*-value	OR	95% CI for OR	
					Lower	Upper
Age, year	-0.005	0.050	0.917	0.995	0.902	1.097
Parity count ≥ 2	0.132	0.540	0.807	1.141	0.396	3.288
Anesthesia method (spinal)	0.094	0.672	0.888	1.099	0.294	4.101
BMI, kg/m^2	0.069	0.060	0.247	1.071	0.953	1.205
BSA, m^2	1.815	1.918	0.344	6.141	0.143	263.560
Intraoperative fluid balance (per 100 ml) Ψ	-0.060	0.101	0.550	0.942	0.773	1.148
Surgery time Φ	*0.584*	*0.204*	*0.004*	1.793	1.202	2.675
Warming method (active)	*-0.953*	*0.047*	*0.047*	0.386	0.352	0.423
*Core temperature (< 36.5℃) **	*0.884*	*0.506*	*0.081*	2.421	0.898	6.536
*Shiver assessment (not 0) **	*2.125*	*0.839*	*0.011*	8.373	1.617	43.356
Blood loss, per 100 ml	*0.838*	*0.276*	*0.002*	1.379	1.346	3.971

Ψ: the unite is 100 ml; Φ: the unit is 10 min; *: measured before surgery. SE: standard error; OR: odds ratio; CI: confidence interval; BMI: body mass index; BSA: body surface area

Table 3 **A** multivariable logistic regression analysis for intraoperative hypothermia

Variables	Coefficients	SE	*P*-value	OR	95% CI for OR	
					Lower	Upper
Surgery time Φ	0.512	0.247	0.038	1.669	1.028	2.708
Warming method (active)	-1.600	0.645	0.013	0.202	0.057	0.715
Core temperature (< 36.5℃) *	1.435	0.694	0.039	4.200	1.078	16.367
Blood loss, per 100 ml	0.630	0.285	0.027	1.878	1.074	3.282

Φ: the unit is 10 min; *: measured before surgery. SE: standard error; OR: odds ratio; CI: confidence interval; BMI: body mass index; BSA: body surface area

Discussion

This retrospective study demonstrated that a longer surgical duration, no use of an active warming method, a lower core temperature and the presence of shivering prior to anesthesia were associated with a greater risk of experiencing intraoperative hypothermia for women who underwent emergency C-sections. These findings highlight the importance of using active warming methods more proactively during emergency C-sections. Additionally, lower core temperature and shivering status before the start of anesthesia indicate the higher probability of intraoperative hypothermia for women undergoing emergency C-sections.

Table 3 **B** multivariable logistic regression analysis for intraoperative hypothermia

Variables	Coefficients	SE	*P*-value	OR	95% CI for OR	
					Lower	Upper
Surgery time Φ	0.718	0.273	0.009	2.050	1.201	3.501
Warming method (active)	-1.577	0.675	0.019	0.207	0.055	0.776
Shiver assessment (not 0) *	3.648	1.053	< 0.001	38.398	4.875	302.439
Blood loss, per 100 ml	0.937	0.340	0.006	2.552	1.311	4.970

Φ: the unit is 10 min; *: measured before surgery. SE: standard error; OR: odds ratio; CI: confidence interval; BMI: body mass index; BSA: body surface area

Most C-section procedures are elective. However, in some cases, emergency C-sections are needed, serving as a lifesaving strategy. In contrast to elective procedures, emergency procedures provide little opportunity for preoperative planning and resource optimization, which could increase the risk of mortality and morbidity for women and neonates [2]. Given the high incidence of hypothermia during emergency C-section delivery [2, 13], optimizing intraoperative temperature management and reducing the incidence of hypothermia can improve maternal health.

Warming method: passive or active

As the primary anesthesia procedure, spinal anesthesia significantly impairs autoregulation by inhibiting vasomotor and shivering responses and causes thermal redistribution from the core to peripheral tissues [8, 14]. This is the main reason for hypothermia during C-section. In our institution, passive warming is routinely implemented during C-sections, while the regulation of active warming is poorly defined. This study revealed that less than half of the women received active warming during emergency C-section delivery, and moreover, the proportion was much lower in the hypothermia group (only 30%). For women who received active warming during emergency C-section, a smaller decrease in core temperature after the start of surgery was observed when compared to those who did not receive active warming. Previous studies have shown that active warming is beneficial for improving body temperature and patients' intraoperative thermal comfort, which is consistent with our findings [7, 9, 15]. In contrast to earlier studies focused solely on elective C-Sects. [7, 10], our research established the advantages of active warming for women undergoing emergency C-sections. This population, which is at a higher risk of perioperative complications, highlights the efficacy of more proactive temperature management during C-section deliveries.

Bleeding is the leading cause of maternal mortality and mortality after cesarean delivery in low- and middle-income countries [2, 16]. Hypothermia can cause coagulation dysfunction and more blood loss, as we observed in this study that the intraoperative blood loss volume was higher in the hypothermia group. It might indicate that warming patients may reduce the risk of hemorrhage. However, we must be cautious about the interpretations of this finding because blood loss is a result of multiple factors, for example, surgery strategy, use of vasoactive agents, and intraoperative fluid infusion [17, 18]. Future studies with more confounding factors being controlled are required to prove the causal link between hypothermia and hemorrhage during emergency C-sections.

Factors associated with hypothermia

The duration of surgery is significantly influenced by the individual conditions of patients and intraoperative circumstances. Prolonged surgical procedures are associated with a greater risk of a noticeable decrease in the patient's intraoperative core temperature, as indicated by the logistic regression model in this study. Consequently, when a lengthy surgical duration is anticipated, implementing active warming methods is advisable. Moreover, effective communication among medical staff regarding the surgical process is essential for collaborative efforts in different aspects, for example, facilitating improved body temperature management by providing the active warming method if the surgical duration is expected to be much longer than usual.

The baseline core temperature < 36.5 °C was also identified as an indicator of hypothermia during emergency C-section delivery. Usually, the human body regulates heat dissipation by adjusting the contraction and dilation of peripheral vessels. However, for patients undergoing spinal anesthesia, their ability to maintain body temperature within a normal range becomes impaired due to the influence of anesthetic drugs [19, 20]. If a patient already presents with a relatively low core temperature before surgery, promptly implementing more proactive warming measures can effectively reduce the risk of hypothermia. Therefore, pre-surgery temperature evaluation is crucial and serves as a reference for determining the timely application of active warming methods.

Limitations

This study has several limitations. Firstly, it inherits all the limitations associated with retrospective studies [21]. Secondly, only among women who received active warming methods in this study, various active methods (e.g., forced-air warming, intravenous fluids warming, etc.) were employed. We did not delve into the respective benefits of one specific active warming method due to the small sample size. Thirdly, we did not consider the conditions of parturients prior to emergency C-sections, such as the use of uterotonic agents or significant bleeding, which could influence the occurrence of perioperative hypothermia. Fourthly, although we recommend implementing active warming procedures for (emergency) C-section deliveries with a long duration, there is no explicit definition of "long duration". Fifthly, hypothermia not only affects the objective body temperature, but also affects patients subjective thermal comfort feelings. However, this study, given its retrospective property, did not assess the thermal comfort of women. Future studies on the same topic should incorporate evaluations of thermal comfort, another crucial aspect for optimizing the perioperative management of patients.

Conclusions

In women who undergo emergency C-section deliveries, intraoperative hypothermia is a frequent complication associated with spinal anesthesia. The application of active warming measures in these cases has been shown to mitigate the risk of hypothermia. Factors such as a pre-surgery core temperature below 36.5 °C and prolonged emergency C-section duration should be taken into account when deciding whether to implement active warming methods.

Abbreviations

C-section	cesarean section
ASA	American Society of Anesthesiologists
PW	passive warming
AW	active warming
SD	standard deviation
IQR	interquartile ranges
BMI	body mass index
BSA	body surface area
HTN	hypertension
DM	diabetes mellitus
CPD	cephalopelvic disproportion
ULS	uterosacral ligament suspension
SE	standard error
OR	odds ratio
CI	confidence interval

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12871-024-02730-3.

Supplementary Material 1

Acknowledgements

Nothing to declare.

Author contributions

RZ was responsible for the study design, coordination, data extraction and preparation, and statistical analysis. QZ participated in the data preparation and validation. RZ and QZ drafted and revised the manuscript. HG conceived and designed the study and assisted in drafting the paper. RZ, QZ and HG contributed to the preparation and critical review of the manuscript. All authors approved the final manuscript and the publication of it.

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Data availability

The dataset used in this manuscript is available from the corresponding author upon reasonable request.

Declarations

Ethics approval

The Ethics Committee of Suzhou Municipal Hospital of Anhui Province approved this study and waived the need for informed consent from participants.

Consent for publication

Not applicable.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as potential conflicts of interest.

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