Clinical Trial/Experimental Study

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Effects of air-heated blankets on hypothermia and quality of recovery in patients undergoing radical resection for endometrial cancer

A randomized trial

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Abstract

Background: Perioperative hypothermia is a common complication in patients undergoing major abdominal surgery. The aim of this study was to explore the effects of air-heated blankets on perioperative hypothermia and quality of recovery in patients undergoing radical resection for endometrial cancer.

Methods: A total of 80 patients who underwent radical resection for endometrial cancer were enrolled and randomly divided into the control group (Group C) and experimental group (Group A) (n = 40). Routine nursing measures were used in Group C. Patients in Group A were continuously kept warm with an air-heated blanket (38°C) from the induction of anesthesia until the end of surgery. The core body temperature, intraoperative blood loss, extubation time, eye-opening time and post-anesthesia care unit (PACU) stay were recorded. The incidence of hypothermia, postoperative agitation, shivering, postoperative nausea and vomiting and delayed awakening was observed.

Results: The incidence of hypothermia was significantly lower in group A (2.5% vs 45%, $P = .001$), and the body temperature 30 minutes after the induction of anesthesia and 1 hour after the beginning of the operation were significantly higher than that in the group C ($P < .05$). Intraoperative blood loss was reduced in group A that in the group C (135.8 ± 38.8 vs 155.8 ± 48.7 mL, $P < .046$). The extubation time, eye-opening time, and PACU stay were shorter in group A that in the group C (all $P < .05$). The incidence of postoperative shivering was lower than that in Group C (2.5% vs 20%, $P < .024$).

Conclusion: The use of air-heating blanket could reduce the incidence of intraoperative hypothermia and postoperative shivering, shorten the extubation time and eye-opening time, and reduce intraoperative blood loss in patients undergoing radical resection for endometrial cancer.

Abbreviations: ASA = American Society of Anesthesiologists, HR = heart rate, I:E = inspiration/expiration, PACU = post-anesthesia care unit, $P_{ET}CO_2$ = end-tidal carbon dioxide partial pressure, SpO_2 = pulse oxygen saturation, TOF = train-of-four.

Keywords: air-heated blanket, gynecology, hypothermia, quality of recovery

1. Introduction

Perioperative hypothermia, defined as a core body temperature below 36°C during surgery,[1] is a common complication in patients undergoing major abdominal surgery. During open surgery, the body temperature of the patient can be lowered by prolonged exposure of the abdominal organs, anesthesia-induced vasodilatation, and rehydration.[2,3] It has been reported in the literature that the incidence of hypothermia in surgical patients is as high as 70%.[4] Hypothermia can lead to a decrease in myocardial contractility. Decreased prothrombin activity results in prolonged bleeding and coagulation times, prolonged drug metabolism, decreased immunity, and even increased incidence of surgical incision infection, which may seriously affect patient prognosis.[5] To prevent hypothermia, it is therefore important to maintain a constant body temperature during surgery. In clinical practice, air-heated blankets have been widely used as a warming device.[6–8] The aim of this study was to evaluate the effect of air-heated blankets on perioperative hypothermia and quality of recovery in patients undergoing radical resection for endometrial cancer.

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The datasets generated during and/or analyzed during the current study are publicly available.

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2. Materials and methods

2.1. Study subjects

The study was approved by the Women and Children's Hospital of Jiaxing University Ethics Committee on Jan 2, 2024 (Approval Number. 2024Y-005), and written informed consent obtained from all subjects participating in this trial. The trial was registered before patient enrollment in the Chinese Clinical Trial Registry (Registry number: ChiCTR2400080803). From January 2024 to July 2024, 80 patients who underwent radical resection for endometrial cancer, ASA I to II, aged 30 to 75 years old, were enrolled in this study. They were divided into the control group (Group C) and the experimental group (Group A) using the computer-generated randomized numerical table method. The exclusion criteria were as follows: abnormal preoperative body temperature (higher than 38.0°C or lower than 36.0°C), severe cardiovascular and cerebrovascular diseases and hyperthyroidism. Randomization was carried out by opening a sealed envelope containing a serial number. The allocation sequence was generated using random permuted block randomization. The study medications were prepared by a nurse who was blinded to this study. The investigators, anesthesiologists, surgeons, and patients were blinded to the group assignment.

2.2. Anesthesia methods

After the patient was admitted to the operating room, the room temperature was set to 24°C and the humidity was maintained between 40% and 60%. Blood pressure, electrocardiogram, pulse oximetry (SpO_2) and heart rate (HR) were continuously monitored. Intravenous access was established and Ringer solution 6 to 8 $mL{\cdot}kg^{-1}{\cdot}h^{-1}$ was infused intravenously. General anesthesia was induced with midazolam 0.03 mg/kg, propofol 2 mg/kg, fentanyl 0.4 μg/kg, and cisatracurium 0.15 mg/kg by intravenous injection. and endotracheal tube intubation was performed with direct vision laryngoscopy. Mechanical ventilation was carried out with respiratory rate of 10 to 12 breaths/min, positive end-expiratory pressure of zero, inspiration/expiration (I:E) of 1:2. and tidal volume of 8 mL/kg. The end-expiratory carbon dioxide pressure ($P_{ET}CO_2$) was maintained between 35 and 45 mm Hg by adjusting the tidal volumes. Cisatracurium 0.08 to 0.1 $mg{\cdot}kg^{-1}{\cdot}h^{-1}$ was maintained intravenously so that the train-of-four stimulus (TOF) value was < 10%. Propofol and remifentanil were used to maintain systolic blood pressure within a range of 20% of basal values during the surgery. The depth of anesthesia was maintained at a BIS value of 40 to 55 using a BIS monitor (Aspect A2000, USA). Intravenous sufentanil 0.1 μg/kg was administered for postoperative analgesia at the time of abdominal closure. The patients were transferred to the post-anesthesia care unit (PACU) at the end of surgery. Ephedrine 6 mg was given when the systolic blood pressure was <90 mm Hg. Atropine 0.3 mg was administered when the HR was <50 beats/min.

2.3. Interventions and measurements

The Group C were used routine nursing measures for keeping warm. While the Group A was used an air-heated blanket (Tyco Medical Inc., USA) for warming from the induction of anesthesia until the end of surgery, and the temperature was set at 38°C. During the operation the patient's nasopharyngeal temperature (Zhejiang Zhenxing Medical Instrument

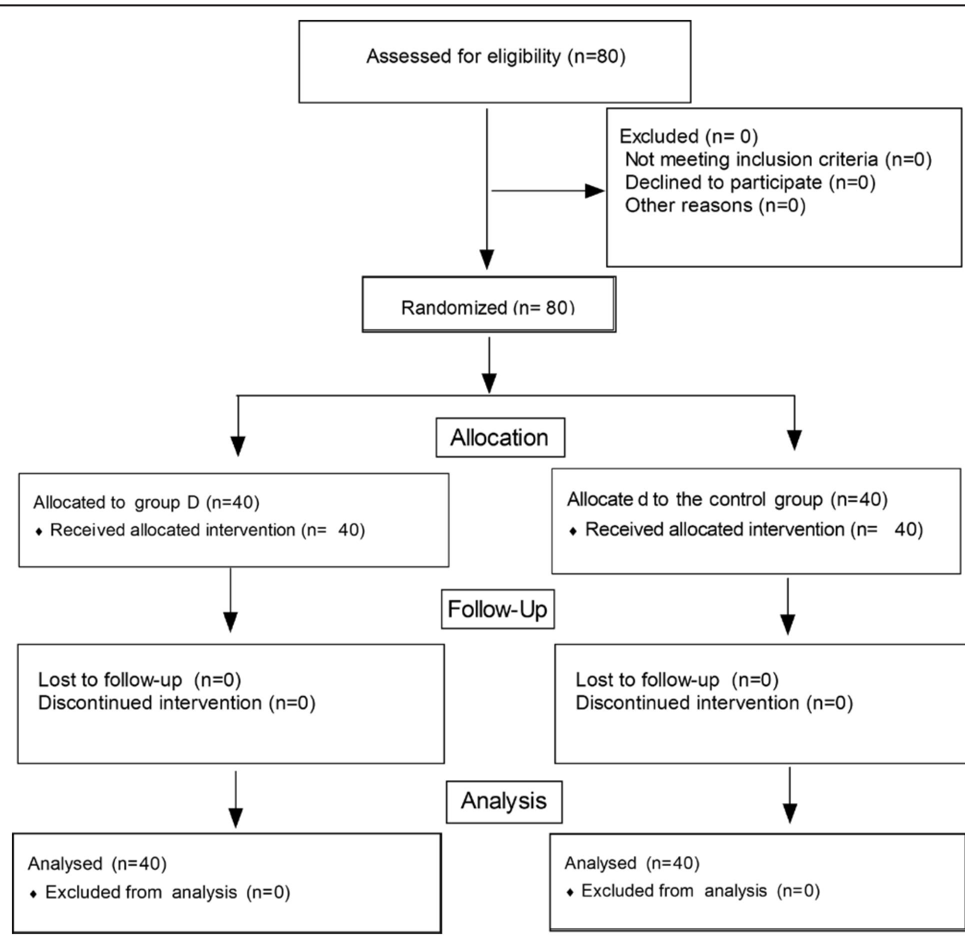

Figure 1. Flow diagram of the study.

Table 1

Data of patients (n = 40).

Index	Group A	Group C	*P*-value
Age (yr)	53.8 ± 11.6	57.1 ± 10.1	.385
Weight (kg)	54.2 ± 4.8	55.5 ± 6.2	.298
Height (cm)	159.3 ± 2.9	160.4 ± 3.2	.225
ASA (I/II)	4/36	5/35	.999
Duration of operation (min)	151.6 ± 57.1	138.2 ± 44.5	.247
Duration of anesthesia (min)	158.6 ± 56.4	150.3 ± 50.7	.251
Blood loss (mL)	135.8 ± 38.8	155.8 ± 48.7	.046*
Extubation time (min)	11.3 ± 2.3	12.9 ± 1.9	.001*
Eye-opening time (min)	17.3 ± 4.0	19.5 ± 5.2	.040*
PACU stay	34.2 ± 5.6	37.8 ± 4.9	.003*
Total amount of infusion (mL)	1522 ± 75	1535 ± 63	.488

Data were presented as mean ± standard deviation or numbers.
* $P < .05$, compared with the Group C.

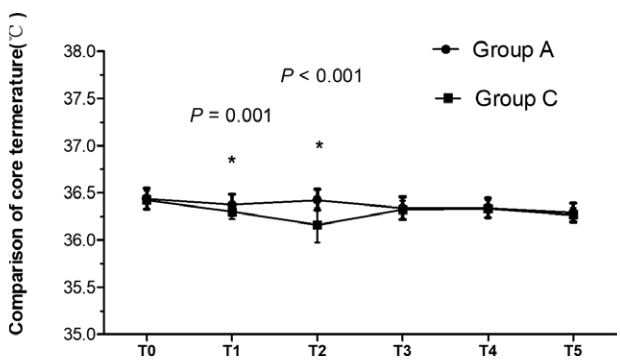

Figure 2. Comparison of the core body temperature of patients. *$P < .05$. T0: immediately before the induction of anesthesia, T1: 30 min after the induction of general anesthesia, T2: 1 h after the beginning of the operation, T3: the end of surgery, T4: 10 min after admission to PACU, T5: discharge from PACU. PACU = post-anesthesia care unit.

Company) was continuously monitored. An infrared ear thermometer (Karls Medical Inc., Germany) was used to measure the body temperature before anesthesia and after entering the PACU.

Patients' core body temperatures were recorded immediately before the induction of anesthesia (T0), 30 minutes after the induction of anesthesia (T1), 1 hour after the beginning of the operation (T2), the end of surgery (T3), and 10 minutes after admission to PACU (T4) and discharge from PACU (T5). The incidence of perioperative hypothermia (<36.0°C) was recorded. Extubation time, eye-opening time, and PACU stay were also recorded. Adverse events such as hypothermia, delayed awakening, emergency agitation, ventricular arrhythmia, respiratory depression, shivering, nausea and vomiting were noted. The tracheal catheter was removed when the patients resumed spontaneous breathing with a tidal volume > 6 mL/kg, TOF value < 0.9 and SpO_2 > 94%. Delayed awakening was defined as the inability to open the eyes within 120 minutes. Respiratory depression was defined as SpO_2 < 94% with inhaling oxygen and respiratory rate < 10 breaths/min.

2.4. Statistical analysis

Statistical analysis was conducted using SPSS 20. The quantitative variables with normal distribution were expressed as mean ± standard deviation and were analyzed by *t*-test and 1-way analysis of variance (core temperature). Categorical variables were expressed as numbers and were analyzed using the Chi-square test or Fisher exact test.

2.4.1. Sample size:. The primary outcome of this study was the incidence of hypothermia. Secondary outcomes were the extubation time, eye-opening time and duration of PACU. A pilot study with 10 patients per group shown that the incidence of hypothermia was 40% and 10%, respectively. A sample size of 33 patients was needed to detect a statistical difference between the 2 groups with an α error of 0.05 and a power of 0.8. The sample size was increased to 40 to account for dropout. Thus, a total of 80 patients were required. A value of $P < .05$ indicated statistical significance.

3. Results

3.1. Demographic data

Eighty-two patients were recruited, and then 80 patients were randomly divided into the Group A and Group C (n = 40). The flow diagram of the study is shown in Figure 1. No differences were observed in the age, ASA grade, weight, height, operative time and total amount of infusion between the 2 groups ($P > .05$), but blood loss was statistically decreased ($P < .05$, Table 1).

3.2. Core body temperature

The core body temperature was significantly higher at T1 and T2 time points in Group A compared with the Group C ($P < .05$, in Figure 2). There were no significant differences in core body temperature at other time points between the 2 groups ($P > .05$, in Figure 2).

3.3. Quality of recovery

The extubation time, eye-opening time and PACU stay were significantly reduced compared with the Group C, ($P < .05$, in Table 1).

3.4. Postoperative complications

The incidence of hypothermia and shivering decreased significantly in Group A ($P < .05$), but there was no statistical significance in terms of hypotension, delayed awakening, respiratory depression, ventricular arrhythmia, emergency agitation, nausea and vomiting ($P > .05$, in Table 2).

4. Discussion

In this study, we found that the use of air-heating blanket could reduce the incidence of intraoperative hypothermia and

Table 2

Side effects of perioperative period (n = 40).

Index	Group A	Group C	*P*-value
Hypothermia	1	12	.001*
Nausea and vomiting	1	3	.61
Emergency agitation	0	2	.48
Hypotension	1	1	.99
Ventricular arrhythmia	0	2	.99
Respiratory depression	1	2	.99
shivering	1	8	.024*
Delayed awaking	1	3	.99

Data were presented as numbers.
* $P < .05$, compared with the group C.

postoperative shivering, shorten the extubation time, eye-opening time and PACU stay, and reduce intraoperative blood loss in patients undergoing radical resection for endometrial cancer.

The incidence of hypothermia in the experimental group was significantly lower than that in the control group, indicating that the use of air-heated blankets during the surgery could effectively reduce the incidence of hypothermia and the air-heated blankets were sufficient to maintain body temperature. Perioperative hypothermia often occurs during surgery. Anesthesia, lower operating room temperatures, open body cavities, the use of low-temperature disinfectants and washing fluid can increase the loss of patient's heat.[4] There are 2 methods for the prevention of hypothermia: passive warming and active warming. Passive warming includes various insulation measures, while active warming involves the application of external heat to the skin and surrounding tissues. The air-heated blankets put a certain temperature of hot air around the surface of the body, and have a better thermal insulation effect. At present, an air-heated blanket is widely used for the prevention of hypothermia, it is considered an effective warring measure.[7] At 30 minutes after induction of general anesthesia, there were significant differences in core body temperature between the 2 groups in this study, indicating that the core body temperature was obviously decreased 30 minutes after general anesthesia. Our study demonstrated that the air-heated blankets needed to start heating within 30 minutes after general anesthesia to maintain a constant body temperature during the long-time surgery and open surgery. Zhang et al[9] found that forced-air heating blankets could reduce the incidence of intraoperative hypothermia and shivering, and improve patients' prognosis after liposuction under general anesthesia. Moreover, it could shorten the awakening time, PACU time and extubation time. It was similar to our findings. Wang et al[10] found that more than half of the patients had been hypothermic in elderly patients with a forced-air warmer during surgery after anesthesia induction within 1 hour, indicating that anesthesia induction had a severe impact for the first-hour-onset hypothermia for elderly patients during surgery. While we also found the decrease in core temperature 30 minutes after anesthesia induction in patients without a forced-air warmer. Their results were in line with ours.

The study also found that the use of air-heated blankets could be effective in reducing the incidence of shivering in patients undergoing radical resection for endometrial cancer, while shortening the extubation time and eye-opening time. It was similar to the findings of Zhang.[9] The exact etiology of shivering is unknown, and its treatment is also not well-defined.[11] The occurrence of shivering is related to many factors, including anxiety, hypotension and hypothermia so on.[12] Postoperative shivering is related to excessive heat dissipation in the body, and the good warming measures can reduce the incidence of postoperative shivering.[13] Lower body temperature affects anesthetic metabolism, slowing anesthetic metabolism and delaying recovery in patients with hypothermia. Moreover, blood circulation accelerates when body temperature rises, which is beneficial for drug metabolism. Rodriguez-Diaz et al[14] also found that the active warming measures could reduce the incidence of hypothermia, shorten the extubation time and recovery time, which was consistent with the results of this study.

In this study, we found that intraoperative blood loss was reduced in the group A. Perioperative hypothermia can produce various adverse effects on organs. For example: it may lead to an increase in intraoperative blood loss by affecting the various thrombin activities and attenuating the platelet function.[15] Besides, hypothermia can lead to ventricular arrhythmia. The intraoperative blood loss was decreased, the possible reason might be related to the decreases in the thrombin activity and platelet function temperature in the control group. The occurrence of shivering is related to the excessive heat dissipation in the body, and the good warming effects can reduce the incidence of postoperative shivering.[13] Many factors were associated with emergency agitation. Pain and discomfort are the main causes of emergency agitation.[16,17] The cause of emergency agitation in patients with hypothermia is unknown and may be related to cold-induced discomfort.

Limitations of this study: This is a single-center, small-sample study, and the results need to be confirmed by a large-sample, multicenter study. In addition, the side effects of air-heated blankets need to be further investigated.

5. Conclusion

The use of air-heating blanket could reduce the incidence of intraoperative hypothermia and postoperative shivering, shorten the extubation time and eye-opening time, and reduce intraoperative blood loss in patients undergoing radical resection for endometrial cancer.

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Author contributions

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Investigation: Youxuan Pan.
Writing – original draft: Ying Zhang.

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