Guo et al. BMC Surgery (2025) 25:101
https://doi.org/10.1186/s12893-025-02816-w

BMC Surgery

RESEARCH

Open Access

Application of chain body temperature management checklist in robotic surgery for urology: a randomised controlled trial

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Abstract

Objective To explore the management effect of a chain temperature management checklist in preventing hypothermia in patients undergoing urological robotic surgery during the perioperative period.

Methods A total of 152 patients undergoing urological robotic surgery were enrolled in this study between March and September 2021 and again between March and September 2022. All patients were randomly divided into the control group ($n = 76$) and the intervention group ($n = 76$). The incidence of hypothermia and chills were compared between the two groups of patients, as well as implementation omission rates, thermal comfort scores and nurse satisfaction scores, following the construction and implementation of a chain temperature management checklist.

Results The incidence of hypothermia and chills in the intervention group (10.5% and 13.2%, respectively) was lower than that in the control group (38.2% and 40.8%, respectively). The implementation omission rate in the intervention group (1.3%) was also lower than that in the control group (30.3%). The thermal comfort score in the intervention group (8.76 ± 1.31) was higher than that in the control group (5.78 ± 1.43). Additionally, the nurse satisfaction score was higher in the intervention group (98.89 ± 2.43) than in the control group (89.57 ± 3.75). The differences were all statistically significant ($p < 0.05$).

Conclusion Using a chain temperature management checklist in the temperature management of patients undergoing urological robotic surgery can reduce the incidence of low body temperature and shivering, decrease the rate of implementation omissions and improve patient thermal comfort and nurse satisfaction.

Keywords Urological surgery, Robotic surgery, Chain management, Low body temperature, Checklist management

Introduction

Perioperative hypothermia occurs when the central body temperature (CBT) falls below 36℃ [1] during and after surgery. It is a common complication of surgery and has various causes. Research indicates that patients receiving general anaesthesia have a high incidence of hypothermia, 50%–70% in the US and approximately 44.5% in China [2]. During surgery, the body is exposed to cold environments, and anaesthetic agents can impair the hypothalamic response to temperature changes. Additionally, factors such as skin exposure, perfusion changes and using intravenous fluids at room temperature further contribute to heat loss. The mechanisms of hypothermia can be categorised as conductive, convective and evaporative heat loss [3]. Conductive heat loss occurs through direct contact with cold surfaces, whereas convective heat loss occurs when the air movement around the patient facilitates heat

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dissipation. Evaporative loss increases with the exposure of moist skin and respiratory surfaces to ambient air. Complications arising from hypothermia include an increased risk of intraoperative bleeding caused by coagulopathy, prolonged recovery from anaesthesia and an increased incidence of postoperative complications such as wound infections and shivering. Shivering itself can elevate metabolic demand and discomfort for patients, complicating postoperative care. Moreover, hypothermia may lead to adverse cardiovascular events, including arrhythmia and increased oxygen consumption [4].

Low body temperature increases the risk of intraoperative bleeding, prolongs anaesthesia recovery time and increases the incidence of shivering [3]. Therefore, managing perioperative body temperature effectively is vital. In recent years, robotic surgery has been widely used in urological surgery and has become a key minimally invasive treatment method, with advantages such as minimal trauma, reduced bleeding and faster postoperative recovery [4]. However, in robotic surgery, compared with traditional laparoscopic or open surgery, once the robotic arms are docked and the surgery begins, it is difficult to change the patient's position or implement additional external measures to raise body temperature, making it more challenging to manage low body temperature [4]. Scholars have researched low body temperature in robotic surgery, but most studies focus on intraoperative management, lacking systematic and continuous research on temperature management in various perioperative areas and stages [5, 6]. Building on previous research, such as the study by Chen [7] on temperature management during da Vinci robotic procedures, our objectives include assessing the impact of a chain temperature management checklist on the maintenance of CBT and analysing its correlation with postoperative outcomes, including recovery time and patient satisfaction. The significance of this study lies in its potential to enhance patient care and safety in robotic surgeries, offering evidence-based strategies for effective perioperative temperature management. Therefore, this study aims to construct a checklist for perioperative hypothermia management in urological robotic surgery based on the different characteristics of each operating room and stage. This paper describes the process and reports the positive results achieved.

Materials and methods

Participants and study design

Participants

This study is a randomised controlled trial that was performed with 152 patients undergoing urological robotic surgery between March and September 2021 and again between March and September 2022 due to the COVID-19 pandemic. The inclusion criteria were as follows: (1) patients undergoing robotic surgery in urology, (2) those with an American Association of Anaesthesiologists condition grade of I to III, (3) those undergoing surgery lasting 2–7 h, (4) those receiving general anaesthesia, (5) those aged 18–80 years and able to communicate effectively and (6) those who understood the study and agreed to participate. The exclusion criteria were as follows: (1) a previous history of severe organ dysfunction or mental illness, (2) a previous history of hypothermia or a recent history of fever or infection, (3) abnormal blood clotting function, abnormal liver or kidney function, an allergy to narcotics or a history of long-term alcohol consumption or opioid abuse, (4) transfer to the intensive care unit because of a critical condition after surgery, (5) an inability to provide informed consent, (6) any contraindications to the use of the hypothermia management checklist and (7) a history of surgery within the previous month. This study was registered with the ISRCTN registry under the registration number ISRCTN18308293 (https://www.isrctn.com/ISRCTN18308293) (Fig. 1).

Randomisation and blinding

All patients were randomly divided into two groups using computer-generated random numbers: the control group ($n=76$) receiving standard postoperative care without the hypothermia management checklist and the intervention group ($n=76$) receiving the hypothermia management checklist developed by our specialised team. To mitigate potential bias, a blinding procedure was implemented throughout the study. Participants were blinded to their group assignments, and clinicians administering treatment were also unaware of group allocation. Outcome assessors who evaluated the results post-treatment were similarly blinded to the participants' group status. This approach helped maintain the integrity of the data and the objectivity of the findings.

Sample size measurement

A previous pilot study formed the basis of this research. The pilot study assessed the feasibility of the hypothermia management checklist and was conducted with a smaller cohort of 30 patients over 2 months using the same eligibility criteria as the main study. It aimed to evaluate the effectiveness of various temperature management strategies and gather preliminary data on patient outcomes. The results indicated a significant reduction in hypothermia incidents, which informed the development of the hypothermia management checklist used in the current study. Insights gained from the pilot study also shaped the design of the main trial, including adjustments to the selection criteria and data collection methods to ensure robustness and reliability in measuring outcomes. By providing this context, the reader's understanding of

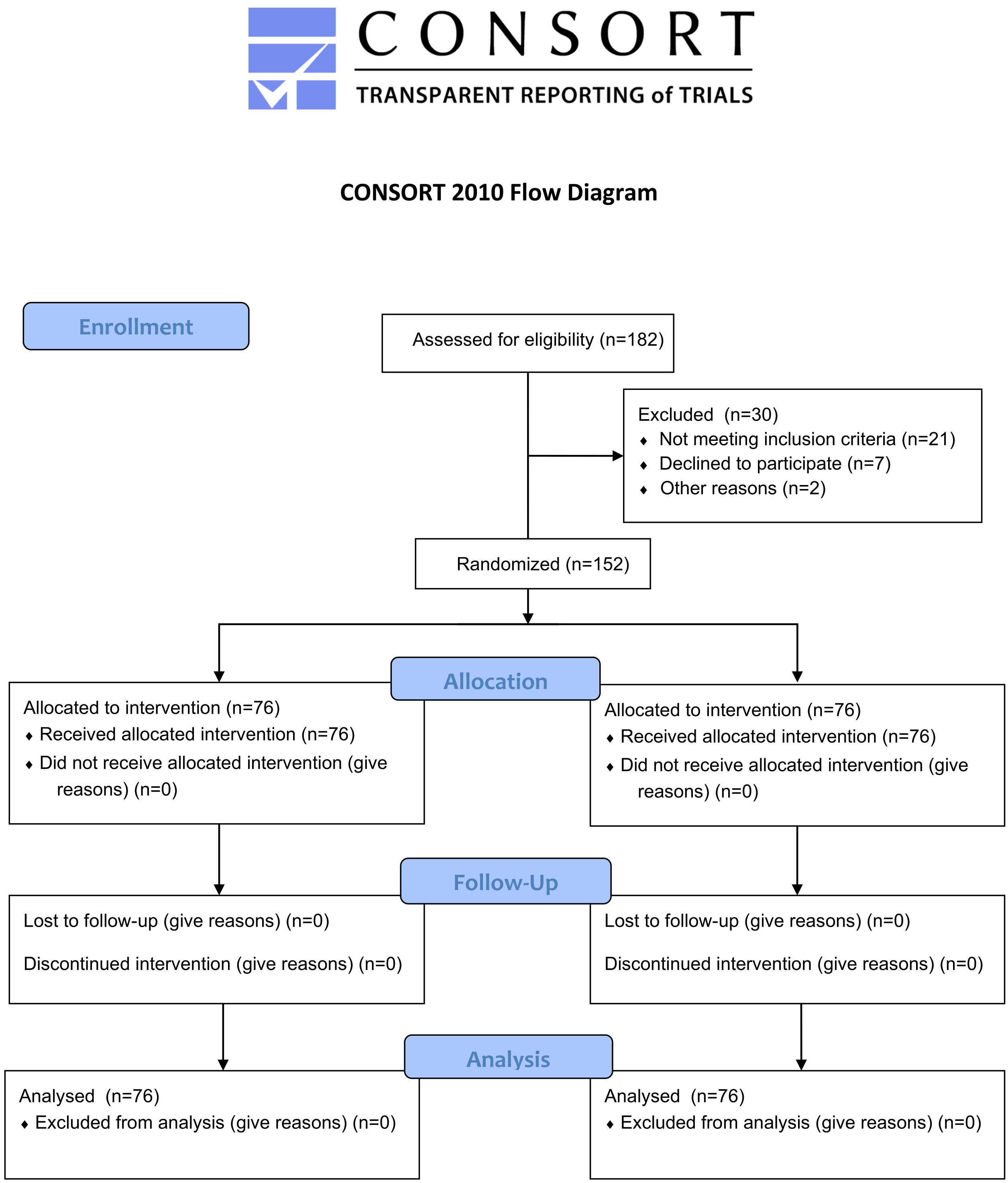

Fig. 1 The flow diagram of this study

how the pilot study underpinned the current research was enhanced. The sample size was calculated based on the incidence of postoperative hypothermia. The sample size estimation formula for comparing two sample rates was used, with a two-sided significance level of $\alpha = 0.05$ and a power of $1 - \beta = 0.8$. The incidence of hypothermia was 10.43% in the intervention group and 31.17% in the control group, according to a previous pilot study.

According to the above results, the number of patients to be enrolled in this study was 59 in each group, and the total number of patients in the two groups was 118. Considering a dropout rate of 10%, the number of patients to be enrolled in each group was at least 65, and the total number of patients to be enrolled was at least 130. A total of 182 patients underwent urological robotic surgery between March and September 2021 and again between March and September 2022 due to the COVID-19 pandemic. According to the strict inclusion and exclusion criteria, 152 patients were finally included, with a final inclusion rate of 83.5%.

Intervention methods

Routine warming measures were implemented in the control group. Room temperature was adjusted to 21–25℃, passive warming was performed and active warming was provided using an inflatable warming blanket based on the patient's temperature and surgical duration, as well as the warming of fluids, blood transfusions and irrigation solutions.

The observation team adopted a body temperature management checklist to manage body temperature. The specific measures were as follows.

Establishment of a perioperative hypothermia prevention and management team

The team consisted of 10 members, including the head of the department of anaesthesiology and the operating room head nurse, who acted as the project team leader responsible for the coordination and scheduling of the overall design, organisational training and the project implementation management of this study. A urologist, an anaesthesiologist, the head nurse of the anaesthesiology department and the ward head nurse guided the research design and supervised the project implementation process. An operating room robotics specialist team leader participated in the formulation of the checklist and implementation details and provided the quality control of the project implementation details. Two operating room nurses were responsible for document retrieval, inventory preparation and data collection and analysis.

Formulation of a list of perioperative temperature management

1) The group members performed a literature search. PubMed, MEDLINE, Web of Science, China National Knowledge Infrastructure, Wanfang and China Biomedical Literature Database were searched systematically to select relevant literature as reference materials for low body temperature, robotics, urological surgery and perioperative-related keywords in both Chinese and English. Relevant guidelines and expert consensus, such as the *Expert Consensus on the Prevention and Treatment of Low Body Temperature in Perioperative Patients (2017)* [8], *Operating Room Nursing Practice Guidelines (2022)* [9] and *ERAS China Expert Consensus and Pathway Management Guidelines (2018): Radical Prostatectomy Section* [10], were consulted. Combined with the actual situation of urological robotic surgery and temperature management in the operating room, a systematic understanding and summary of the current status and intervention measures of temperature protection for patients undergoing robotic surgery were obtained. Based on this, an initial version of the standardised management plan for perioperative chain urological robotic sub-specialty temperature protection was formed. After discussion and modification in group meetings, the final draft was transformed into a checklist for temperature management of patients undergoing urological robotic surgery.

Determination of the perioperative temperature management checklist: Six experts with senior professional titles from Shanxi Province were invited to review the checklist items, including two operating room head nurses, two nursing management head nurses, one urology chief physician and one anaesthesia chief physician. The initial version of the checklist was sent to the experts via email, and all six experts provided suggestions for modification. The checklist management team summarised and discussed the suggestions, adjusting and improving the checklist according to the expert opinions. The final version of the *Checklist for Low Body Temperature Management in Patients Undergoing Urological Robotic Surgery Under General Anaesthesia* was produced, including 27 items in 4 zones (preoperative waiting area, operating room, anaesthesia recovery room and postoperative ward) and 3 link areas (preoperative waiting area–operating room, operating room–anaesthesia recovery room and anaesthesia recovery room–postoperative ward) (Fig. 2).

Training on the perioperative hypothermia management checklist

Five days before the implementation of the perioperative hypothermia management checklist, the operating room head nurse and the leader of the robotic specialty group provided training to all operating room nurses on the content and key points related to the operating room in the checklist. The head nurse of the anaesthesia department provided training to the anaesthesia department nurses on the content related to the anaesthesia recovery room in the checklist. The ward head nurse provided training to the nurses on the content related to the postoperative ward in the checklist. All nurses were required to be familiar with, understand and master the checklist. The nurses in the robotic specialty group received

Checklist for perioperative hypothermia management in general anesthesia urological robotic surgery

Operating room: ; Patient name: ; Hospital number: ; Surgical procedure:

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Area	Measures	Execution Status	Executor
Surgical Waiting Area	Temperature Monitoring: Measure and record the patient's baseline temperature before entering the room	Implemented ☐; Not implemented ☐; Not applicable☐;	
	Risk assessment: Low body temperature risk prediction model (Predictors scoring model) evaluation	Implemented ☐; Not implemented ☐; Not applicable☐;	
	Environmental management: Adjust room temperature to 21-25°C	Implemented ☐; Not implemented ☐; Not applicable☐;	
	Passive insulation: Preheat with a 42°C warming blanket	Implemented ☐; Not implemented ☐; Not applicable☐;	
	Pre-warming: Inflate warming blanket for 30 minutes before anesthesia	Implemented ☐; Not implemented ☐; Not applicable☐;	
	Pressure relief and relaxation: Animated videos, books, magazines	Implemented ☐; Not implemented ☐; Not applicable☐;	
Operation room	Environmental management: Start the clean air conditioner 30 minutes early, room temperature 24-25°C	Implemented ☐; Not implemented ☐; Not applicable☐;	
	Psychological care: forms of communication, etc.	Implemented ☐; Not implemented ☐; Not applicable☐;	
	Liquid management: blood products and liquids are heated to 37°C; rinse solution warmed to 38°C--42°C; Iodine is heated to 37°C	Implemented ☐; Not implemented ☐; Not applicable☐;	
	Passive insulation: Use U-shaped shoulder blankets and split flowers to passively insulate	Implemented ☐; Not implemented ☐; Not applicable☐;	
	Active insulation: Select special thermal clothing, thermal leg sleeves, thermal shoulder sleeves, and thermal boot covers according to different body positions and procedures.	Implemented ☐; Not implemented ☐; Not applicable☐;	
	Pneumoperitoneum heating: Carbon dioxide gas is heated to 37°C.	Implemented ☐; Not implemented ☐; Not applicable☐;	
	Temperature monitoring and dynamic management: If the body temperature is <36.1°C, set the warming blanket to 44°C in high-speed mode.	Implemented ☐; Not implemented ☐; Not applicable☐;	
	If the body temperature is 36.1~36.5°C, set the warming blanket to 40°C in high-speed mode.	Implemented ☐; Not implemented ☐; Not applicable☐;	
	If the body temperature is 36.6~37.0°C, set the warming blanket to 36°C in low-speed mode.	Implemented ☐; Not implemented ☐; Not applicable☐;	
	Temperature > 37.0°C, turn off the inflatable heating blanket	Implemented ☐; Not implemented ☐; Not applicable☐;	
	Temperature reassessment: Conduct reassessment when there are changes in the risk prediction model items	Implemented ☐; Not implemented ☐; Not applicable☐;	
Anesthesia recovery room	Environmental management: Room temperature 22-24°C	Implemented ☐; Not implemented ☐; Not applicable☐;	
	Temperature monitoring: Record every 30 minutes	Implemented ☐; Not implemented ☐; Not applicable☐;	
	Dynamic adjustment: Normal core body temperature, passive warming measures are adopted; if the temperature is <36°C, active warming measures are taken.	Implemented ☐; Not implemented ☐; Not applicable☐;	
	Centralized operation: Centralize all operations to reduce exposure.	Implemented ☐; Not implemented ☐; Not applicable☐;	
Postoperative ward.	Environmental management: Ward temperature is maintained at 22-24°C.	Implemented ☐; Not implemented ☐; Not applicable☐;	
	Temperature monitoring: Monitor core body temperature and ask the patient if they feel cold, and record the findings.	Implemented ☐; Not implemented ☐; Not applicable☐;	
	Centralized operation: Centralize all operations to reduce exposure	Implemented ☐; Not implemented ☐; Not applicable☐;	
	Dynamic adjustment: Refer to preoperative basal body temperature and adopt passive insulation measures; core body temperature ≤ <36°C, adopt active warming measures	Implemented ☐; Not implemented ☐; Not applicable☐;	
Patient transportation	Operating waiting area-Operating room: Pre-transportation assessment record; Implement insulation measures in the ten transportation standards; Use inflatable warming blanket	Implemented ☐; Not implemented ☐; Not applicable☐;	
	Operating room-Anesthesia recovery room: Pre-transportation assessment record; Implement insulation measures in the ten transportation standards; Use inflatable warming blanket	Implemented ☐; Not implemented ☐; Not applicable☐;	
	Anesthesia Recovery Room-Ward: Pre-transport assessment record; Implement the thermal insulation measures in the ten standards for transportation; Use inflatable warming blankets additionally.	Implemented ☐; Not implemented ☐; Not applicable☐;	

Fig. 2 Checklist for perioperative hypothermia management in general anesthesia urological robotic surgery

focused training (practical exercises) and assessment, and a score of 95 or above was required to pass.

Application of the perioperative hypothermia management checklist

When the patient entered the preoperative waiting area, the nurse implemented warming measures for the patient according to the checklist and checked 'implemented', 'not implemented' or 'not applicable' in the execution column. After completing all measures, the nurse signed the form as confirmation. When the patient entered the operating room, the circulating nurse implemented various warming measures for the patient according to the checklist and checked 'implemented', 'not implemented' or 'not applicable' in the checklist execution column. After completing all measures, the circulating nurse signed the form as confirmation. After the patient arrived at the anaesthesia recovery room, the anaesthesia nurse once again implemented various insulation measures for the patient according to the contents of the list and checked 'implemented', 'not implemented' or 'not applicable' in the execution column of the list. After all measures were implemented, the nurse signed the form as confirmation. When the patient returned to the ward after surgery, all insulation measures were completed according to the contents of the list before handing over the patient, and the ward nurse signed as confirmation. The transferring party completed the insulation measures according to the contents of the list and signed as confirmation at every step of the transportation. After the contents of the four-zone three-link list were completed, the completed lists were filed in the operation archive.

Quality control

The perioperative hypothermia management checklist was implemented as part of the standard surgical protocol. Specific details regarding its use included the following. Training sessions: All surgical staff underwent training sessions to familiarise themselves with the checklist and its importance in preventing hypothermia. Real-time monitoring: Adherence to the checklist was monitored in real time by a designated nurse or surgical team member responsible for ensuring compliance during surgeries, including regular checks of patient temperature and adherence to warming protocols. Compliance audits: Periodic audits were conducted to assess compliance with the checklist, and feedback was provided to the surgical team to enhance adherence. The perioperative hypothermia management checklist was reviewed daily by the operating room head nurse to ensure the implementation of the checklist measures in the surgical area. Checklist execution was also reviewed by the anaesthesia department head nurse to ensure the implementation of the checklist measures in the anaesthesia recovery room area. The ward head nurse reviewed the checklist measures to ensure their implementation in the ward and checked the execution of the checklist. The operating room head nurse conducted periodic spot checks. If any issues were identified, on-site guidance for improvement was provided. Two months after the implementation of the checklist, the operating room head nurse held weekly meetings with the management team members to analyse the non-executed items and the reasons for non-execution. Improvement suggestions were proposed for continuous quality improvement. In the later stage, the management of the hypothermia checklist was included in the department's monthly quality control meeting for routine management.

Evaluation methods

The primary outcomes of this study included the incidence of hypothermia during surgery, recovery time post-anaesthesia and the occurrence of postoperative complications such as shivering and wound infections. Secondary outcomes assessed patient satisfaction and the overall effectiveness of the hypothermia management checklist in improving surgical care. By evaluating these outcomes, it was hoped to establish clear evidence supporting the implementation of structured temperature management protocols in urological robotic surgeries. The core temperature was measured using a digital thermometer, providing accurate readings of the patient's body temperature. The measurements were taken at regular intervals throughout the procedure, specifically before induction, during surgery and after emergence from anaesthesia, to monitor temperature changes and ensure the effective management of hypothermia. The measurements were recorded in accordance with standard protocols to maintain consistency and reliability in data collection. Statistical evaluation of the occurrence of hypothermia in patients in the period between entering the preoperative waiting area and the postoperative return to the ward: 1) Hypothermia incidence rate: Real-time temperature monitoring was conducted on patients. When the patient's CBT was < 36℃, hypothermia occurred. The hypothermia incidence rate was calculated as follows: (number of hypothermia cases / total number of cases) × 100%. 2) Shivering incidence rate: The shivering scale [11] was used to assess whether the patient experienced shivering. A score of 0 represented no shivering, a score of 1 represented mild shivering (slight muscle tremors in the face and neck), a score of 2 represented moderate shivering (tremors in one muscle group or limbs) and a score of 3 represented severe shivering (tremors in the whole body). Scores of 1–3 indicated the occurrence of shivering, and the incidence of shivering was calculated as follows: (number of shivering cases / total cases) × 100%. 3) The implementation omission rate of temperature protection measures was calculated as follows: (number of implementation omissions / total omissions) × 100%. 4) Thermal comfort: The nurses used the visual analogue scale [12] to evaluate this aspect, with scores ranging from 0 to 10; the higher the score was, the better the comfort was. 5) Nurse satisfaction: A self-made nurse survey questionnaire was used to assess this aspect, including items related to the importance, practicality, operability and convenience of implementing a temperature checklist management for patients undergoing robotic surgery in the perioperative period. The total score ranged from 20 to 100, with higher scores indicating higher satisfaction. A satisfaction survey was conducted on a total of 26 nurses in the robotic surgery team, anaesthesia recovery room and ward (including the head nurse) before and after the implementation of the temperature checklist management in the perioperative period. The questionnaires were collected for both surveys, and all were valid.

Statistical methods

SPSS 22.0 software was used for data processing. Before applying any statistical tests, the data were assessed for normality using the Shapiro–Wilk test. For comparisons between the two groups, independent *t*-tests were employed for normally distributed data, and Mann–Whitney U tests were used for non-normally distributed data. To account for the potential risk of Type I errors due to multiple comparisons, Bonferroni correction was applied to the comparisons in Table 2. Specifically, five independent outcomes were compared between the two groups. Although these comparisons were conducted on separate variables, they were part of a broader analysis of the intervention's effects, and collectively, they contributed to the overall conclusions about the intervention. Therefore, it was necessary to control for the familywise error rate. The original significance level of $\alpha = 0.05$ was divided by the number of comparisons ($n = 5$), resulting in an adjusted significance level of $\alpha = 0.01$ for each test. This adjustment ensured that the overall Type I error rate was controlled across all comparisons [13]. Metric data were expressed as mean ± standard deviation, and intergroup comparisons were performed using a *t*-test. Count data were expressed as rates, and intergroup comparisons were performed using the chi-squared test. The significance level was set at $\alpha = 0.05$, and a *p*-value of < 0.05 was considered statistically significant.

Table 1 Comparison of General Information of Patients

Group	Control Group	Intervention Group	P
Number of cases	76	76	
Gender (cases)			0.732
Male	51 (67.1)	49 (64.5)	
Female	25 (32.9)	27 (35.5)	
Age (years, $\bar{x} \pm s$)	63.33 ± 8.67	61.42 ± 7.45	0.561
BMI ($\bar{x} \pm s$)	21.66 ± 1.43	21.35 ± 1.53	0.991
ASA classification (example)			0.929
I	7 (9.2)	8 (10.5)	
II	31 (40.8)	29 (38.2)	
III	38 (50.0)	39 (51.3)	
Clinical Diagnosis			0.929
Renal Tumor	32 (42.1)	34 (44.7)	
Prostate Tumor	9 (11.8)	8 (10.5)	
Bladder Tumor	12 (15.8)	10 (13.2)	
Other	23 (30.3)	24 (31.6)	
Surgery time (t/h, $\bar{x} \pm s$)	3.57 ± 1.23	3.61 ± 1.12	0.112
Anesthesia time (t/h, $\bar{x} \pm s$)	4.35 ± 1.42	4.41 ± 1.36	0.381
Preoperative body temperature (℃, mean ± SD)	36.56 ± 0.13	36.45 ± 0.12	0.208

Table 2 Comparison of the incidence of low body temperature and chills and the rate of missed implementation of measures, thermal comfort and nurse satisfaction scores in two groups of patients (%)

Group	Control group	Intervention group	p
Number of cases	76	76	
Low body temperature	29 (38.2)	8 (10.5)	< 0.001
Chills	31 (40.8)	10 (13.2)	< 0.001
Implementation omission rate	23 (30.3)	1 (1.3)	< 0.001
Thermal comfort	5.78 ± 1.43	8.76 ± 1.31	< 0.001
Nurse satisfaction	89.57 ± 3.75	98.89 ± 2.43	< 0.001

Results

Comparison of the incidence of low body temperature, chills and implementation omission rates between the two groups

The general data of the two groups of patients were compared, and the differences were not statistically significant (Table 1). The results, as shown in Table 2, indicated that in the control group, the incidence of low body temperature was 38.2%, the incidence of chills was 40.8% and the implementation omission rate was 30.3%. In the intervention group, the incidence of low body temperature was only 10.5%, the incidence of chills was 13.2% and the implementation omission rate was only 1.3%. The intervention group had significantly lower rates of low body temperature, chills and implementation omission than the control group ($p < 0.001$).

Comparison of thermal comfort between the two groups of patients

The results, as shown in Table 2, indicated that the average thermal comfort score in the control group was 5.78 ± 1.43, whereas in the intervention group, it was 8.76 ± 1.31. The thermal comfort score in the intervention group was significantly higher than that in the control group ($p < 0.001$).

Comparison of the satisfaction of the two groups of nurses

The results are shown in Table 2. The control group and intervention group each contained 76 patients. The average score for nurse satisfaction in the control group was 89.57 ± 3.75, whereas the average score for nurse satisfaction in the intervention group was 98.89 ± 2.43. Nurse satisfaction in the intervention group was significantly higher than that in the control group ($p < 0.001$).

Discussion

The main results of this study indicate that the application of a chain temperature management checklist had a significant impact on the perioperative temperature management of patients undergoing urological robotic surgery. The intervention group had a lower incidence of hypothermia and shivering than the control group, indicating significant improvement. In addition, the intervention group had better adherence to the temperature management checklist, and there was an improvement in patient thermal comfort scores and nurse satisfaction. These findings suggest that the chain temperature management checklist has a positive effect on improving perioperative temperature management in patients. Even after applying the Bonferroni correction, the p-values for all tests remained well below the adjusted threshold ($\alpha = 0.01$), with the reported p-values being < 0.001, thus reinforcing the statistical significance of the results.

This study specifically targets urological procedures due to the unique challenges posed by these surgeries, which often involve lengthy operative times and delicate anatomical structures. Urological surgeries, particularly those performed using robotic assistance, are associated with a heightened risk of hypothermia caused by factors such as extensive patient positioning, the use of cold irrigation fluids and the long duration of anaesthesia. By focusing on this specialty, we aim to address a critical gap in the literature regarding effective temperature management strategies tailored to the nuances of urological surgery.

The primary outcome of this study was the incidence of intraoperative hypothermia, defined as a CBT below 36 °C. Our findings indicated that the intervention group experienced a significantly lower incidence of hypothermia than the control group, consistent with previous research that highlighted the effectiveness of structured temperature management protocols [7, 14]. The findings are related to the application of a temperature management checklist throughout the perioperative period. These results underscore the importance of proactive temperature management in reducing hypothermia during robotic surgeries, which has been linked to improved recovery outcomes. Research demonstrates that the da Vinci surgical robot has many technical advantages, such as high levels of accuracy, low trauma, wide field of view and high levels of flexibility. It has been widely used in urological surgery in recent years [15], but factors such as ambient temperature during surgery, the establishment of artificial stomachs and extensive flushing result in low body temperature in patients. In particular, when dry low-temperature carbon dioxide gas has extensive contact with the peritoneum, abdominal organs and large blood vessels, it directly evaporates, removing the body's core energy through convection and conduction, causing the CBT to drop more rapidly [16].

Chills are involuntary tremors of rhythmic skeletal muscle caused by hypothermia. It is a protective stress response [17] to increase metabolic heat production, with an incidence of 5%–65% [18]. As a common complication after surgery, chills not only cause physical discomfort but also increase incision pain and even affect wound recovery [19]. The secondary outcomes in this study included recovery time post-anaesthesia, the incidence of postoperative shivering, wound infection rate and patient satisfaction [20]. The lower incidence of wound infections observed in the intervention group corresponded with literature suggesting that hypothermia can compromise immune function and increase infection risk [21]. Patient satisfaction scores improved significantly, reflecting the positive impact of comprehensive care strategies on the overall patient experience. In the intervention group, the nurses performed temperature list management throughout the process from the waiting area for surgery to the postoperative ward and various transportation steps, including temperature monitoring, risk assessment, environmental management, pre-heating, active heating, passive insulation, liquid heating and dynamic adjustment, to ensure the temperature protection measures during surgery were more detailed and specific. They also optimised and coordinated the measures, thus improving the patient's thermal comfort and achieving clear results, which was conducive to the patient's post-surgery recovery.

The temperature management list is based on the actual situation of the department combined with literature verification, clinical practice and expert review. The formulation process involved the use of multiple guidelines and expert consensus [22], guaranteeing the practicality and academic and scientific nature of the temperature management list. Closed loop management [23] plays a critical role in preventing hypothermia, ensures the continuity of temperature protection for patients undergoing urological robotic surgery and reduces body temperature fluctuations resulting from environmental changes and changes in caregivers [24]. Urological robotic surgical care is often implemented, and body temperature management is only part of the nursing coordination. Routine temperature management measures mostly rely on nurses' personal experience, lack organisation and focus and can easily form personalised nursing operations for nurses. Thus, nursing operations are not uniform, and the operating room work pace is fast, complex and detailed, with frequent omissions in temperature management, resulting in poor quality insulation measures during surgery [25]. The application of the body temperature implementation list not only standardises and unifies temperature protection measures in each zone and link but also highlights key time and implementation points. Nurses in each zone follow the contents of the list in a clear order to avoid omissions in the temperature protection programme and homogenise nursing procedures. Moreover, it can facilitate self-evaluation and control [26], fully guarantee the specific implementation of various temperature protection measures, considerably reduce the implementation omission rate and improve the quality of care.

The results of this study revealed a higher nurse satisfaction score in the intervention group than in the control group, which is consistent with the results of Hall et al. [27] These findings suggest that after using the temperature management checklist, nurses can complete each step and measure of temperature management in urological robotic surgery in a timely, accurate and efficient manner, ensuring patient safety. Furthermore, in urological robotic surgery, nurses have multiple steps to follow, and the application of the temperature implementation checklist allows them to easily verify and eliminate any mistakes or omissions, reducing their anxiety and fear, enhancing their confidence, strengthening surgical cooperation, improving nursing quality and increasing nurse satisfaction.

This study's strengths include its randomised controlled design, which minimises bias and enhances the reliability of the findings. Although this study is presented as a randomised controlled trial, a notable limitation is that the patients were continuously enrolled in this study due to the COVID-19 pandemic. Additionally, the study's sample size, although sufficient to detect significant differences, may limit the generalisability of the findings, and the response rate for the patient satisfaction surveys indicates potential selection bias, as those with better experiences may have been more likely to participate. Furthermore, the checklist used for hypothermia management, although developed through a quality improvement process, was not formally validated before implementation, which may affect the reliability of the results. Finally, the single-centre design may introduce site-specific biases, limiting the applicability of the findings to other settings.

Conclusion

In conclusion, this study highlights the successful construction and implementation of a hypothermia management checklist as a primary aim, demonstrating its effectiveness in reducing the incidence of hypothermia and associated complications in patients undergoing urological robotic surgery. By systematically addressing temperature management through a structured protocol, we not only improved patient outcomes but also contributed valuable insights to the ongoing discourse on best practices in perioperative care. The findings underscore the importance of such checklists in enhancing the safety and efficiency of surgical procedures, paving the way for further research and refinement in this critical area of patient management.

Acknowledgements
Not applicable.

Authors' contributions
All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Funding
Shanxi Bethune Hospital hospital-level nursing research Fund (2022YH09).

Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
This study was conducted in accordance with the Declaration of Helsinki and approved by the Research Ethics Committee of Shanxi Bethune Hospital, and informed consent was obtained from all participants. All methods were carried out in accordance with relevant guidelines and regulations.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Received: 20 February 2024 Accepted: 14 February 2025
Published online: 15 March 2025

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