

Warming infusion improves perioperative outcomes of elderly patients who underwent bilateral hip replacement

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Abstract

Background: This prospective, randomized, and controlled study was performed to determine the benefits of prewarmed infusion in elderly patients who underwent bilateral hip replacement.

Methods: Between September 2015 and April 2016, elderly patients who underwent bilateral hips replacement that met the inclusion and exclusion criteria were included in this study. After inclusion, patients were randomized into one of the study groups: in the control group, patients received an infusion of fluid kept at room temperature (22–23°C); in the warming infusion group, patients received an infusion of fluid warmed using an infusion fluid heating apparatus (35°C). Postoperative outcomes, including recovery time, length of hospital stay, visual analogue scale (VAS) score, and postoperative complications rate of patients from both groups, were compared.

Results: A total of 64 patients were included in our study (71.2 ± 7.6 years, 53.1% males), with 32 patients in the control group and 32 patients in warming infusion group. No significant difference was found in terms of demographic data and intraoperative blood transfusion rate between 2 groups ($P > 0.05$). Patients receiving a prewarmed infusion had a significantly shorter time to spontaneous breath, eye opening, consciousness recovery, and extubation than the control group ($P < 0.05$). In addition, significant differences were found in Steward score and VAS score between 2 groups ($P < 0.05$). Moreover, warming infusion group also showed an obviously decreased incidence of shivering and postoperative cognitive dysfunction ($P < 0.05$).

Conclusion: A prewarmed infusion could reduce the incidence of perioperative hypothermia and improve outcomes in the elderly during bilateral hip replacement.

Abbreviations: BIS = bispectral index, BMI = body mass index, POCD = postoperative cognitive dysfunction, SD = standard deviation, VAS = visual analogue scale.

Keywords: bilateral hip replacement, elderly, perioperative fluid infusion, perioperative hypothermia

1. Introduction

Hip replacement is one of the most effective therapies for bilateral hip diseases caused by osteonecrosis, slipped capital femoral epiphysis, hip dysplasia, and trauma.^[1] With the improvement of both knowledge and skills in orthopedic surgery, hip replacement

has been developed as a routine operation with a mature technology and good outcomes.^[1] However, bilateral hip replacements always need a relatively long operation period and large operation scope.^[2] Additionally, several factors, such as skin disinfectant evaporation, long surgical exposure time, and anesthetic drugs use, would affect the regulation of body temperature and eventually lead to hypothermia.^[3] Perioperative hypothermia is found associated with an increased rate of perioperative complications, such as bleeding, wound infection, prolonged duration of anesthetic drugs effects, delayed post-anesthetic recovery, and patient shivering and discomfort.^[4–6] Due to the importance of normothermia maintenance, an increasing number of researches focusing on this issue have been performed.

During bilateral hip replacement, a high volume of blood transfusion is necessary; therefore, the risk of intraoperative hypothermia increases, especially in elderly patients.^[3] A previous study indicated that the body temperature of an adult drops with 0.25°C, with every liter of infused liquid with ambient temperature or transfused blood after cold storing at 4°C.^[7] Thus, to prevent perioperative hypothermia, transfused blood and infused liquids are usually prewarmed clinically. Present prospective, randomized, and controlled study was performed to determine the benefits of warmed liquids infusion compared with infusion of liquids kept at room temperature in elderly patients

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during hip surgery. The outcome measures included time to recovery, length of hospital stay, Steward score, visual analogue scale (VAS) score as well as postoperative adverse events rate.

2. Methods

2.1. Patients

This prospective, randomized, single-blind, and controlled trial included patients who underwent bilateral hip arthroplasty at the Second Hospital of Jilin University between December 2015 and April 2016. Enrolled, patients were aged at least 60 years and were in American Society of Anesthesiologists classes I, II, or III. This study was approved by medical ethics committee of the Second Hospital of Jilin University. Informed consent was obtained from all patients before inclusion.

2.2. Groups and treatment

After enrollment, patients were randomized according to sequential order of sealed envelopes into one of the study groups: the control group or the warming infusion group. In the control group, patients received infusion of fluid kept at room temperature (22–23°C), while patients in the warming infusion group received infusion of fluid warmed at 35°C with an infusion fluid heating apparatus (ANIMEC AM301, ELLTEC Co Ltd, Nagoya, Japan). Computer-generated allocation sequences were used to randomize patients (SPSS version 22.0, SPSS, Chicago, IL).

After entering the operating room, patients' heart rate, blood pressure, and oxyhemoglobin saturation were monitored. Venous access was established and continuous invasive arterial blood pressure monitoring was performed before anesthesia. Patients received intravenous infusion of 0.3 mg/kg midazolam, 3 µg/kg fentanyl, 3 mg/kg etomidate, and 0.15 mg/kg cisatracurium for general anesthesia induction, and mechanical ventilation by endotracheal intubation. Ephedrine or methoxamine was used to patients to normal blood pressure. Subsequently, central venous catheterization was performed. The anesthesia status was maintained using total intravenous anesthesia with propofol and remifentanyl. Bispectral index (BIS) monitoring was performed to control the infusion speed of anesthetic drugs. BIS values were maintained between 45 and 55 for all patients. Patients received blood transfusion based on the time of fasting and water deprivation, as well as intraoperative blood loss, central venous pressure was maintained between 6 and 10 cm H₂O during surgery. After surgery, drugs were withdrawn. Endotracheal tube was extracted when patients presented spontaneous breathing, normal reflexes, recovered consciousness, and stable oxyhemoglobin saturation above 93%.

2.3. Definition

Body mass index (BMI) was calculated using the following formula: BMI = weight (kg)/height (m)². Low-body weight was defined as BMI < 18.5 kg/m², normal body weight was defined as 18.5 kg/m² ≤ BMI < 24.0 kg/m², overweight was defined as 24.0 kg/m² ≤ BMI < 28.0 kg/m², and obesity was defined as BMI ≥ 28.0 kg/m² as described previously.^[8] Postoperative cognitive dysfunction (POCD) referred to neurological complications occurring in elders after surgery, characterized by insanity, anxiety, personality change, and memory impairment. POCD was evaluated based on the duration of metal symptoms and clinical manifestations of patients within 48 hours after surgery. Pain was assessed by VAS ranging from 0 (no pain) to 10 (most violent pain).

2.4. Indicators

Patients from both groups were assessed for awaking time, length of hospital stay, as well as incidence of adverse events including shivering during extubation, nausea and vomit and POCD.

2.5. Statistical analysis

All the data were included into database using Epidata 3.1 (EpiData Association, Odense, Denmark) and were analyzed using SPSS 22.0 software (SPSS Inc, Chicago, IL). Continuous variables were presented as mean ± standard deviation (SD) and were compared using independent *t* test; noncontinuous variables were presented as percentages and were compared using χ^2 test. A *P* value < 0.05 was considered statistically significant.

3. Results

3.1. General data of patients

A total of 64 elderly patients (53.1% males) with average age of 71.2 ± 7.6 years (range, 60–68 years) who underwent bilateral hip arthroplasty were included in the present study. Demographic data of patients from both groups were presented in Table 1. No significant differences were found between the 2 groups in terms of sex, age, and BMI (*P* > 0.05).

3.2. Comparison of intraoperative outcomes between control group and warming infusion group

As shown in Table 2, no significant difference was observed in terms of blood loss, transfusion volume, and blood transfusion volume between control group and warming infusion group

Table 1
Demographic data of included patients.

Items	Control group (n=32)	Warming infusion group (n=32)	χ^2	<i>P</i>
Sex	Male	18 (56.3)	0.251	0.616
	Female	14 (43.8)		
Age, y	≥ 60	13 (40.6)	5.627	0.060
	≥ 70	10 (31.3)		
	≥ 80	9 (28.1)		
BMI, kg/m ²	<18.5	14 (43.8)	0.155	0.985
	≤ 18.5 and < 24.0	2 (6.3)		
	≤ 24.0 and < 28.0	12 (37.5)		
	≤ 28.0	4 (12.5)		
		5 (15.6)		

BMI = body mass index.

Table 2
Comparison of intraoperative outcomes between control and warming infusion group.

Items	Control group	Warming infusion group	t	P
Operation time, h	3.094 ± 0.25	2.93 ± 0.22	-2.866	0.006
Blood loss, mL	418.75 ± 169.32	400.00 ± 175.98	-0.434	0.666
Transfusion volume, mL	1503.13 ± 114.96	1537.50 ± 103.95	1.255	0.214
Blood transfusion volume, U	0.72 ± 0.77	0.56 ± 0.75	-0.816	0.417

Table 3
Comparison of time to recovery and length of hospital stay between control and warming infusion group.

Items	Control group	Warming infusion group	t	P
Time of spontaneous breath, min	4.47 ± 0.84	4.06 ± 0.72	-2.080	0.042
Time of eye opening, min	8.66 ± 2.03	6.72 ± 1.73	-4.117	<0.001
Time of consciousness recovery, min	11.19 ± 1.49	9.91 ± 1.91	-2.995	0.004
Time of extubation, min	11.13 ± 1.34	10.09 ± 1.91	-2.504	0.015
Length of hospital stay, d	11.53 ± 3.37	10.50 ± 3.26	-1.244	0.218

($P > 0.05$). However, the operation time of patients who received fluid kept at room temperature was significantly longer than that of patients who received warmed infusion (3.094 ± 0.254 min vs 2.925 ± 0.216 min, $P < 0.05$).

3.3. Comparison of postoperative outcomes between control group and warming infusion group

Patients from both groups were assessed for awaking time and length of hospital stay and comparison of the 2 groups was presented in Table 3. Patients from the control group presented longer time to spontaneous breath, eye opening, and consciousness recovery than patients from the warming infusion group (spontaneous breath, 4.47 ± 0.84 minutes vs 4.06 ± 0.72 minutes, $P = 0.042$; eye opening, 8.66 ± 2.03 minutes vs 6.72 ± 1.73 minutes, $P < 0.001$; consciousness recovery, 11.19 ± 1.49 minutes vs 9.91 ± 1.91 minutes, $P = 0.004$). Additionally, the mean time to extubation in the control group was significantly longer than that in the warming infusion group (11.13 ± 1.34 minutes vs 10.09 ± 1.91 minutes, $P = 0.015$). No significant difference was found in length of hospital stay between the groups.

Patient recovery was also assessed using a Steward scale. The scores for each item in the Steward scale in both groups are shown in Table 4. A significant difference of total Steward score was found between the 2 groups (control group vs warming infusion group: 3.50 ± 1.02 vs 4.13 ± 0.61 , $P = 0.004$). Regarding each item in Steward scale, only score for respiratory patency score was significantly lower in control group than in warming infusion group (1.28 ± 0.68 vs 1.63 ± 0.61 , $P = 0.038$).

Patients were also asked to rate the level of pain using VAS. As shown in Table 4, VAS score was significantly higher in patients from the control group than that in patients from warming infusion group (8.56 ± 1.24 vs 6.13 ± 1.52 , $P < 0.001$).

3.4. Comparison of postoperative adverse events between control group and warming infusion group

A total of 29 and 11 adverse events occurred in the control and warming infusion group, respectively (Table 5). Thirteen cases of shivering during extubation occurred in the control group, and 4 in the warming infusion group. Nausea and vomit was found in

Table 4
Comparison of scores of Steward scale and VAS between control and warming infusion group.

Items	Control group	Warming infusion group	t	P
Steward scale	3.50 ± 1.02	4.13 ± 0.61	2.985	0.004
Recovery	1.09 ± 0.78	1.31 ± 0.74	1.155	0.253
Respiratory patency	1.28 ± 0.68	1.63 ± 0.61	2.125	0.038
Movement	1.13 ± 0.83	1.19 ± 0.74	0.318	0.752
VAS	8.56 ± 1.24	6.13 ± 1.52	-7.027	<0.001

VAS = visual analogue scale.

Table 5
Comparison of incidence of adverse events between control and warming infusion group.

Items	Control group n (%)	Warming infusion group n (%)	χ^2	P
Shivering during extubation	13 (40.6)	4 (12.5)	6.488	0.011
Nausea and vomit	5 (15.6)	3 (9.4)	0.143	0.705
POCD	11 (34.4)	4 (12.5)	4.267	0.039

POCD = postoperative cognitive dysfunction.

5 cases in the control group and in 3 cases in the warming infusion group. POCD within 48 hours after surgery was found in 11 patients and 4 patients in the control and warming infusion group, respectively. Both incidence of shivering during extubation and POCD was statistically higher in patients who received infusion kept at room temperature than in those receiving a warmed infusion (shivering during extubation: 40.6% vs 12.5%, $P=0.011$; POCD: 34.4% vs 12.5%, $P=0.039$).

4. Discussion

Perioperative hypothermia frequently develops during hip replacement, especially the elder patients, because of a relatively long operation period and large operation scope of bilateral hip replacement causes a long period of exposure to low environment temperature and cold airflow from the air conditioning.^[2] Low body temperature of patients is always accompanied by postoperative complications such as increased blood loss, delayed recovery, and delayed wound healing.^[9] In addition, the risk of POCD is increased, especially in elderly patients.^[10] Intraoperative blood transfusion and liquids infusion has been found to influence body temperature regulation during surgery.^[10] In recent years, constant temperature infusion machines, which can warm the infusion temperature to the temperature of patients' body, have been widely used in clinical practice. They have demonstrated an effective reduction of the incidence of adverse events caused by low temperature of infusion.^[11]

In the present study, we reported the benefit of prewarmed infusion in patients who underwent bilateral hip replacement as demonstrated by the significantly shorter time to recovery (spontaneous breath, eye opening, and consciousness recovery), higher recovery score, and the lower level of pain in patients who received an infusion of fluid warmed with an infusion fluid heating apparatus (35°C) as compared with those who received an infusion kept at room temperature (22–23°C). Our results are consistent with previous description.^[12] Additionally, we compared the incidence of adverse events between 2 groups. Body temperature is controlled by 3 mechanisms: import of temperature information, information integration of information in the central nervous system, and controlled export of information regarding heat production or dissipation.^[13] Drugs used for general anesthesia such as propofol and opioids are able to block any of these 3 mechanisms of temperature regulation system.^[14,15] Additionally, skin disinfectant evaporation and long period of surgical exposure also increase the risk of hypothermia. Several adverse events such as patients shivering and discomfort can occur during operative hypothermia. In the present study, there was a significantly higher incidence of shivering during extubation which was found in patients receiving an infusion kept at room temperature than in those receiving pre-warmed infusion. These results indicated that prewarmed infusion can effectively reduce heat loss and maintain normothermia, thus decreasing the incidence of adverse events.

Previous studies demonstrated that perioperative hypothermia is an independent risk factor for POCD in patients.^[16,17] Several factors including age prolonged the duration of anesthetic drugs action, and lower educational level, reoperation, and postoperative infection were also found associated with the incidence of POCD within 1 week after surgery.^[18] Age is the only risk factor for POCD within 3 months after surgery. In the present study, we compared to the incidence of POCD between patients from both groups within 48 hours after surgery. A significantly higher incidence of POCD occurred in the control group than in

warming infusion group. These results can be explained by the fact that more patients experienced perioperative hypothermia in the control group due to prolonged anesthesia and delayed recovery in this group. Our results showed that a prewarmed infusion is beneficial for improving the POCD as well as prognosis, which was consistent with the previous description.^[16] However, we assessed the incidence of POCD in patients only during 48 hours. Furthermore, cardiovascular and coagulation system adverse events have not been documented. Thus, further studies with long-term follow-up and much more monitoring measurements are still necessary.

In summary, prewarmed infusion is beneficial for elderly patients during bilateral hip replacement, as it can shorten time for extubation, improve the quality of extubation, and reduce the incidence of postoperative shivering and POCD. The results of this study can provide a reference for clinical decision making during surgery.

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