

Original Article

The related factors and countermeasures of hypothermia in patients during the anesthesia recovery period

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Abstract: Objective: This research aims to explore and analyze the risk factors that lead to hypothermia in patients in the post-anesthesia care unit (PACU) and to investigate the heat preservation effects of the various heat preservation measures. Methods: A total of 224 patients who entered the PACU from February 2018 to October 2018 after anesthesia surgery in our hospital were recruited as the research cohort. Among them, 46 had hypothermia and 178 did not. The patients' general and surgical data were recorded, and the risk factors for hypothermia in the PACU patients were analyzed using logistic regression. Another 68 hypothermia patients admitted to the PACU in our hospital were also recruited for this study. The patients in the routine group (RG) were insulated using quilts, while those in the observation group (OG) were insulated using inflatable warming blankets. The heat preservation effects of the two heat preservation methods on the PACU patients were compared. Results: Age >60 years old, an intraoperative infusion volume >1500 ml, an intraoperative blood loss >300 ml, major surgery, and an operation time >2 h were the risk factors for hypothermia in the PACU patients. The heat preservation times, the PACU retention times, and the patients' awake times in the OG were shorter than they were in the RG, and the incidence of complications related to hypothermia in the OG was lower than it was in the RG. In addition, the degree of satisfaction in the OG was higher than it was in the RG. Conclusion: Age >60 years old, an intraoperative infusion volume >1500 ml, an intraoperative blood loss >300 ml, major surgery, and an operation time >2 h are risk factors for hypothermia in PACU patients. Inflatable warming blankets have a better heat preservation effect and bring higher patient satisfaction than traditional quilts.

Keywords: PACU, hypothermia, risk factors, heat preservation

Introduction

Body temperature is an important physiological index of the human body, and having a normal body temperature is a necessary condition for maintaining normal life activities [1]. Humans, a species of warm-blooded animals, maintain a normal body temperature of 36.5-37.5°C. However, 20% to 70% patients will have hypothermia during the perioperative period (a core temperature <36°C) [2]. Hypothermia causes many adverse effects in patients, such as an increased risk of infection, prolonged hospitalization times, high medical expenses, and coagulation dysfunction [3, 4]. It is reported that maintaining a normal body temperature can reduce the hospitalization times of surgery patients and reduce their risk of infections at the surgical site [5]. Therefore, the medical

staff needs to actively carry out insulation treatment to prevent hypothermia in patients during the perioperative period to prevent the adverse effects.

The post-anesthesia care unit (PACU) is the place for postoperative waking up and for the recovery of patients who just underwent anesthesia, and hypothermia is one of the most common complications in the PACU [6]. At present, PACU patients can undergo many kinds of heat preservation measures, and these are mainly divided into passive and active heating [7]. The effects of the different heat preservation measures are very different, and a safe and effective heat preservation method needs to be found. There are many controversial cases of hypothermia after surgery. For example, Vural and his colleagues reported that [8] hypo-

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thermia is related to the operating room temperature, but Inaba et al. reported that there is no significant connection [9]. Therefore, more research is still needed to identify the risk factors that may lead to hypothermia in patients undergoing surgery, so that medical personnel can formulate targeted prevention or heat preservation programs [10].

We established a regression model to analyze the risk factors leading to hypothermia in PACU patients and explored the heat preservation effects of the different heat preservation measures. This research may help people better identify the risk factors for hypothermia in PACU patients and find a safe and effective insulation method.

Materials and methods

The research cohort

Altogether 224 patients who entered the PACU after anesthesia surgery in our hospital from February 2018 to October 2018 were recruited as the research cohort. Among them, 46 had hypothermia (hypothermia group, core temperature $<36^{\circ}\text{C}$) and 178 did not (non-hypothermia group, core temperature $\geq 36^{\circ}\text{C}$). The inclusion criteria were: patients who underwent general or intraspinal anesthesia for non-cardiac surgery, and patients at least 18 years old. The exclusion criteria were: patients with a pre-operative fever or hypothermia, patients with hypothermia during their surgeries, patients with incomplete clinical data, and patients with abnormal thermoregulation. This study was approved by the Ethics Committee of our hospital, and the patients and their families signed an informed consent form.

Insulation methods

The inclusion and exclusion criteria of the 68 hypothermia patients who entered the PACU in our hospital were the same as those described above. They all were treated in the same PACU for heat preservation. The RG was treated with conventional heat preservation, i.e., their bodies except for their heads were covered by a 2 kg quilt. In the OG, inflatable warming blankets were used for heat preservation, i.e., the blankets were applied to cover the whole trunk below the neck for heating, and the heating temperature was set to 43°C , so as to carry out targeted scald prevention nursing.

Outcome measures

The patients' vital signs in the RG and the OG were recorded every 5 min until their signs were stable and they were conscious and returned to the ward. The heat preservation times, the PACU retention times, and the patients' waking up times in both groups were recorded.

One hour after each surgery, 5 ml of peripheral blood was taken as a sample, and the angiotensin II (Ang-2) levels were determined using radioimmunoassays, and the adrenaline (AD) and norepinephrine (NE) levels were determined using high performance liquid chromatography.

The occurrences of hypothermia complications such as chills, agitation, and nausea and vomiting during the PACU retention were recorded.

After the patients returned to the ward, we evaluated their degree of satisfaction with the heat preservation operation using the self-made "nursing satisfaction questionnaire", an instrument that measures patient attitude, degree of comfort, wearing, operation proficiency, etc. There were 20 questions, each worth 5 points, and a total score less than 70 points indicates unsatisfactory, 70-89 indicates basically satisfied, and ≥ 90 indicates satisfactory. Satisfaction = (Satisfaction + Basic satisfaction)/Total cases $\times 100\%$.

Statistical analysis

The data were statistically analyzed using SPSS 21.0 (IBM Corp, Armonk, NY, USA), and the figures were drawn using GraphPad Prism 7. The counting data were compared with Chi-square or Fisher exact tests, and the measurement data were compared with independent-samples T tests. The hypothermia risk factors in the PACU patients were analyzed through a multivariate logistic regression. $P < 0.05$ represents a statistically significant difference.

Results

Comparison of the general data between the RG and OG

Comparing the clinical data of both groups, we found there were no significant differences in terms of gender, age, operation times, intraop-

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Table 1. Comparison of the general data between the routine group and the observation group

Group	Routine group (n=30)	Observation group (n=38)	χ^2	P
Gender			0.911	0.340
Male	20 (66.67)	21 (55.26)		
Female	10 (33.33)	17 (44.74)		
Age (year)			0.355	0.552
>60	16 (53.33)	23 (60.53)		
≤60	14 (46.67)	15 (39.47)		
Operation time (h)			0.154	0.695
≤2	12 (40.00)	17 (44.74)		
>2	18 (60.00)	21 (55.26)		
Intraoperative infusion volume (ml)			0.185	0.666
>1500	15 (50.00)	17 (44.74)		
≤1500	15 (50.00)	21 (55.26)		
BMI (kg/m ²)			0.081	0.822
>25	7 (23.33)	8 (21.05)		
≤25	23 (76.67)	28 (78.95)		
Intraoperative blood loss (ml)			0.580	0.446
<300	17 (56.67)	18 (47.37)		
≥300	13 (43.33)	20 (52.63)		
Type of surgery			0.272	0.602
Middle and small types	23 (76.67)	27 (71.05)		
Major types	7 (23.33)	11 (28.95)		
Anesthesia methods			0.546	0.460
General anesthesia	10 (33.33)	16 (42.11)		
Local anesthesia	20 (66.67)	22 (57.89)		

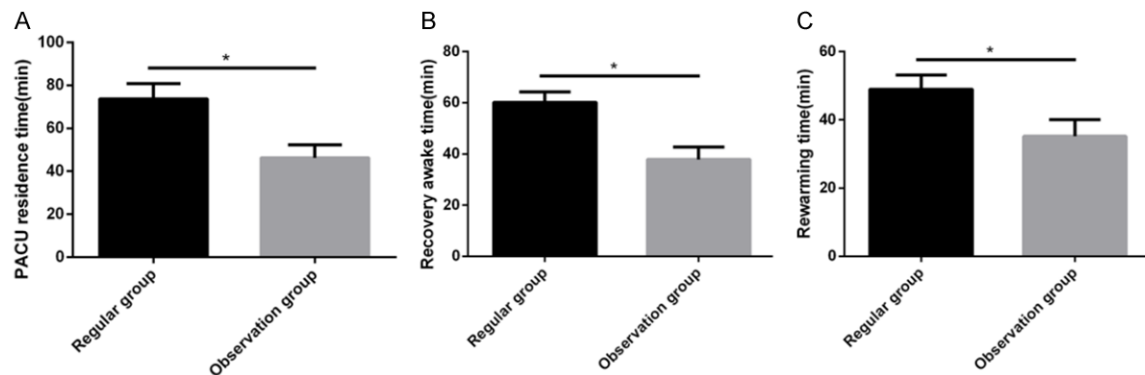


Figure 1. Comparison of the insulation of the PACU patients. A. Comparison of the patients' heat preservation times. B. Comparison of the patients' retention times in the PACU. C. Comparison of the patients' waking up times. Note: * represents $P < 0.05$.

erative infusion volumes, BMI, intraoperative blood loss, surgery types, or anesthesia methods ($P < 0.05$) (Table 1).

Comparison of the patients' PACU insulation

Comparing the PACU insulation of all patients, we found that time of heat preservation, the PACU retention times, and the conscious-

ness times in the OG were shorter than they were in the RG ($P < 0.05$) (Figure 1).

Comparison of the patients' stress response indexes

We found that the Ang-2, AD, and NE levels in the OG were lower than the corresponding levels in the RG (Figure 2).

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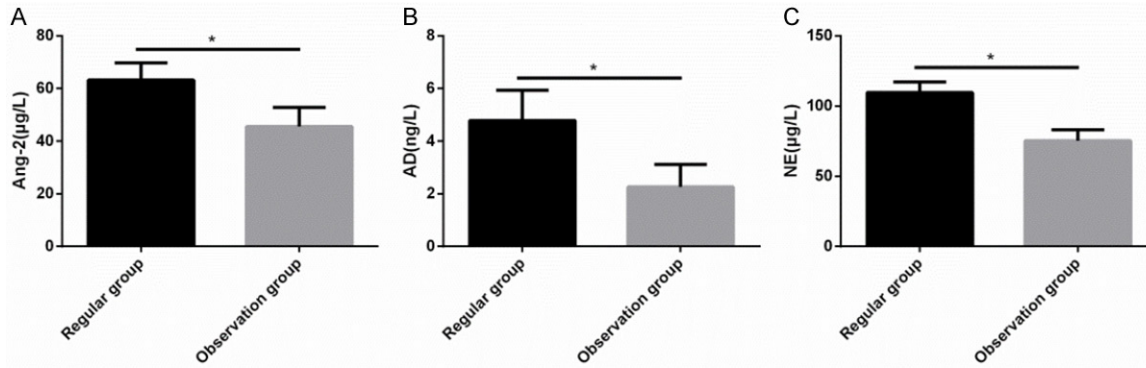


Figure 2. Comparison of stress response indexes in the patients' peripheral blood. A. Comparison of the Ang-2 levels in the patients' peripheral blood. B. Comparison of the AD levels in the patients' peripheral blood. C. Comparison of the NE levels in the patients' peripheral blood. Note: * represents $P < 0.05$.

Table 2. Comparison of the incidences of chills, restlessness, and nausea and vomiting

Group	Routine group (n=30)	Observation group (n=38)	χ^2	P
Chills	6 (20.00)	1 (2.63)	5.477	0.019
Restlessness	5 (16.67)	1 (2.63)	4.105	0.042
Nausea and vomiting	3 (10.00)	0	3.975	0.046
Total number of people affected	10 (33.33)	2 (5.26)	9.089	0.003

Table 3. Patient satisfaction with the two heat preservation methods

Group	Very satisfied	Basically satisfied	Dissatisfied	Satisfaction
Routine group (n=30)	7 (23.33)	12 (40.00)	11 (36.67)	19 (63.33)
Observation group (n=38)	13 (34.21)	20 (52.63)	5 (13.16)	33 (86.84)
χ^2	-	-	-	5.149
P	-	-	-	0.023

Comparison of incidence of chills, restlessness, nausea and vomiting

The hypothermia complications during the PACU stays were recorded, and the incidence of hypothermia complications such as chills and restlessness in the OG was significantly lower than it was in the RG ($P < 0.05$) (Table 2).

Patient satisfaction with the two heat preservation methods

The patients were sent back to the ward, and their satisfaction with the two methods of heat preservation was evaluated: the patient satisfaction in the OG was higher than it was in the RG ($P < 0.05$) (Table 3).

Univariate analysis of the hypothermia in the PACU patients

The patients' general data and surgical information in the non-hypothermia group and the

hypothermia group were assessed using a univariate analysis: age, operation times, intraoperative infusion volumes, BMI, and intraoperative blood loss may be the factors leading to hypothermia in PACU patients. (Table 4).

Multivariate analysis of hypothermia in the PACU patients

On the basis of the univariate analysis, the outcome measures with $P < 0.05$ were assessed using a multivariate logistic regression analysis. The results showed that age > 60 years old, an intraoperative infusion volume > 1500 ml, an intraoperative blood loss > 300 ml, major surgery, and an operation time > 2 h were risk factors for hypothermia in the PACU patients (Table 5).

Discussion

This research mainly analyzed the hypothermia risk factors in PACU patients and the heat pres-

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Table 4. A univariate analysis of the hypothermia in the PACU patients

Group	n	Non-hypothermia group (n=46)	Hypothermia group (n=178)	χ^2	P
Gender				0.596	0.440
Male	130	29 (63.04)	101 (56.74)		
Female	94	17 (36.96)	77 (43.26)		
Age (years)				5.369	0.021
≤60	62	19 (41.30)	43 (24.16)		
>60	162	27 (58.70)	135 (75.84)		
Operation time (h)				6.286	0.012
>2	129	19 (41.30)	110 (61.80)		
≤2	95	27 (58.70)	68 (38.20)		
Intraoperative infusion volume (ml)				6.784	0.009
≤1500	103	29 (63.04)	74 (41.57)		
>1500	121	17 (36.96)	104 (58.43)		
BMI (kg/m ²)				1.489	0.222
>25	65	10 (21.74)	55 (30.90)		
≤25	195	36 (78.26)	123 (69.10)		
Intraoperative blood loss (ml)				5.960	0.015
≥300	99	13 (28.26)	86 (48.31)		
<300	125	33 (71.74)	92 (51.69)		
Type of surgery				6.654	0.010
Middle and small types	94	27 (58.70)	67 (37.64)		
Major types	130	19 (41.30)	111 (62.36)		
Anesthesia methods				1.901	0.168
General anesthesia	136	32 (69.57)	104 (58.43)		
Local anesthesia	88	14 (30.43)	74 (41.57)		

Table 5. A multivariate analysis of the hypothermia in the PACU patients

Factor	S.E	β	Wald	P	OR (95% CI)
Age >60	0.789	1.815	9.453	0.013	3.782 (1.651-5.105)
Intraoperative infusion volume >1500 ml	0.915	2.359	11.254	0.003	3.542 (2.875-5.598)
Intraoperative blood loss >300 ml	0.865	1.814	9.428	0.007	1.819 (2.386-3.689)
Major types	0.435	1.321	10.325	0.001	1.691 (1.524-4.188)
Operation time >2 h	1.054	2.018	9.785	0.005	2.931 (1.184-3.615)

ervation effects of the various heat preservation measures. We found that age >60 years old, an intraoperative infusion volume >1500 ml, an intraoperative blood loss >300 ml, major surgery, and an operation time >2 h were risk factors for hypothermia in PACU patients. Compared with traditional quilts, inflatable warming blankets have a better heat preservation effect and bring higher patient satisfaction.

Hypothermia is one of the most familiar complications in the PACU, and it has serious negative

impacts on patients' health and on medical resources [11, 12]. We recorded the body temperatures of 224 surgery patients who entered the PACU and found that the body temperatures of 178 (79.46%) of them were lower than 36°C when they entered PACU. Vural et al. [8] pointed out that the incidence of postoperative hypothermia is 75.70%, which is similar to our results. Previous studies found that postoperative hypothermia in patients has several causes [13, 14]. Therefore, we should pay attention to the hypothermia risk factors in PACU patients so as to formulate targeted intervention meth-

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ods. This research analyzed the risk factors of hypothermia in PACU patients and found that age >60 years old, an intraoperative infusion volume >1500 ml, an intraoperative blood loss >300 ml, major surgery, and an operation time >2 h were the risk factors for hypothermia. Tracing it to its causes, they may be due to the following points: (1) Most of the liquid drugs used in the operations are refrigerated, so the patients' core temperatures will decrease when they are injected with a large amount of these liquid drugs [15]. (2) It is generally understood that among perioperative patients, if the operation time is more than 2 h, then the incidence of hypothermia among the patients is higher [16]. (3) Excessive blood loss during the operation will take away some of the patients' heat, thus causing hypothermia [17]. (4) Compared with small operations with less trauma such as laparoscopy, patients undergoing major operations involving open chests or abdomens use more liquid drugs, take longer to complete, and lose more blood during the operation, so hypothermia is more common among such patients. (5) When people get old, they suffer from metabolic decline, vascular contractility decline, subcutaneous fat reduction, and other phenomena, so they are prone to hypothermia [18]. Medical personnel can carry out targeted intervention on the above-mentioned risk factors. For example, heat retaining articles such as quilts and hot water bags can keep the patients warm in non-surgical areas during an operation; the liquid medicine used in the operation can be heated in a water bath in advance; for elderly patients undergoing surgery, active pre-heating before the surgery or active heat preservation during the surgery can reduce heat loss.

Perioperative hypothermia is a preventable surgical complication. Clinically, in order to prevent perioperative heat loss and hypothermia, the medical staff adopts active or passive methods to warm the patients [19, 20]. However, despite the application of some insulation measures during the perioperative period, hypothermia still occurs frequently [21]. Thus, more effective measures are still needed. Previous studies found that compared with passive warming, the effect of active warming during perioperative period is better [22]. This research compared and analyzed the heat preservation effects of traditional quilts and inflatable warming blankets on PACU hypothermia patients. Our results

showed that the time of heat preservation, the PACU retention and waking up times of the patients in the OG were shorter than they were in the RG, and the stress response index levels were better. In addition, the incidence of complications related to hypothermia in the OG was lower than it was in the RG. This shows that inflatable warming blankets have a better heat preservation effect on PACU hypothermia patients than traditional quilts. Tracing it to its causes, it may be that inflatable insulation blankets continuously deliver warm air with an appropriate temperature to blankets through its pipelines. Not only can they effectively raise patients' skin temperatures, they can also effectively prevent their body temperature from accelerating to spread to the periphery, thus reducing heat loss and maintaining the body temperature within the normal range. As people's living standards improve, more and more people have higher requirements for the quality of nursing. Patients will feel discomfort due to postoperative hypothermia, thus reducing their satisfaction with hospital services [23]. After the patients are returned to the ward, we evaluated their satisfaction with the two insulation methods and found that those in the OG were more satisfied than those in the RG. This revealed that people had a strong demand for better insulation methods.

There are some limitations to our research. First of all, patients under the age of 18 were not included, so the results in this article are only applicable to adult patients. Secondly, all the subjects included come from the same hospital, so the results may be regional.

To sum up, age >60 years old, an intraoperative infusion volume >1500 ml, an intraoperative blood loss >300 ml, major surgery, and an operation time >2 h are risk factors for hypothermia in PACU patients. Inflatable warming blankets have better heat preservation effects and bring higher patient satisfaction than traditional quilts.

Disclosure of conflict of interest

None.

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References

- [1] Bindu B, Bindra A and Rath G. Temperature management under general anesthesia: Compulsion or option. *J Anaesthesiol Clin Pharmacol* 2017; 33: 306-316.
- [2] Ruetzler K and Kurz A. Consequences of perioperative hypothermia. *Handb Clin Neurol* 2018; 157: 687-697.
- [3] Scott AV, Stonemetz JL, Wasey JO, Johnson DJ, Rivers RJ, Koch CG and Frank SM. Compliance with surgical care improvement project for body temperature management (SCIP Inf-10) is associated with improved clinical outcomes. *Anesthesiology* 2015; 123: 116-125.
- [4] Giuliano KK and Hendricks J. Inadvertent perioperative hypothermia: current nursing knowledge. *AORN J* 2017; 105: 453-463.
- [5] Burns SM, Wojnakowski M, Piotrowski K and Caraffa G. Unintentional hypothermia: implications for perianesthesia nurses. *J Perianesth Nurs* 2009; 24: 167-173; quiz 174-166.
- [6] Poveda VB and Nascimento AS. The effect of intraoperative hypothermia upon blood transfusion needs and length of stay among gastrointestinal system cancer surgery. *Eur J Cancer Care (Engl)* 2017; 26.
- [7] Kim D. Postoperative hypothermia. *Acute Crit Care* 2019; 34: 79-80.
- [8] Vural F, Celik B, Deveci Z and Yasak K. Investigation of inadvertent hypothermia incidence and risk factors. *Turk J Surg* 2018; 34: 300-305.
- [9] Inaba K, Berg R, Barmparas G, Rhee P, Jurkovich GJ, Recinos G, Teixeira PG and Demetriades D. Prospective evaluation of ambient operating room temperature on the core temperature of injured patients undergoing emergent surgery. *J Trauma Acute Care Surg* 2012; 73: 1478-1483.
- [10] Collins S, Budds M, Raines C and Hooper V. Risk factors for perioperative hypothermia: a literature review. *J Perianesth Nurs* 2019; 34: 338-346.
- [11] Ruetzler K and Kurz A. Consequences of perioperative hypothermia. *Handb Clin Neurol* 2018; 157: 687-697.
- [12] Bilgin H. Inadvertent perioperative hypothermia. *Turk J Anaesthesiol Reanim* 2017; 45: 124-126.
- [13] Yi J, Zhan L, Lei Y, Xu S, Si Y, Li S, Xia Z, Shi Y, Gu X, Yu J, Xu G, Gu E, Yu Y, Chen Y, Jia H, Wang Y, Wang X, Chai X, Jin X, Chen J, Xu M, Xiong J, Wang G, Lu K, Yu W, Lei W, Qin Z, Xiang J, Li L, Yao M and Huang Y. Establishment and validation of a prediction equation to estimate risk of intraoperative hypothermia in patients receiving general anesthesia. *Sci Rep* 2017; 7: 13927.
- [14] Torossian A, Brauer A, Hocker J, Bein B, Wulf H and Horn EP. Preventing inadvertent perioperative hypothermia. *Dtsch Arztebl Int* 2015; 112: 166-172.
- [15] Abelha FJ, Castro MA, Neves AM, Landeiro NM and Santos CC. Hypothermia in a surgical intensive care unit. *BMC Anesthesiol* 2005; 5: 7.
- [16] Kongsayreepong S, Chaibundit C, Chadpaibool J, Komoltri C, Suraseranivongse S, Suwananonda P, Raksamanee EO, Noocharoen P, Silapadech A, Parakkamodom S, Pum-In C and Sojeoyya L. Predictor of core hypothermia and the surgical intensive care unit. *Anesth Analg* 2003; 96: 826-833, table of contents.
- [17] Schmied H, Kurz A, Sessler DI, Kozek S and Reiter A. Mild hypothermia increases blood loss and transfusion requirements during total hip arthroplasty. *Lancet* 1996; 347: 289-292.
- [18] Kenney WL and Munce TA. Invited review: aging and human temperature regulation. *J Appl Physiol (1985)* 2003; 95: 2598-2603.
- [19] Aksu C, Kus A, Gurkan Y, Solak M and Tokar K. Survey on postoperative hypothermia incidence in operating theatres of kocaeli university. *Turk J Anaesthesiol Reanim* 2014; 42: 66-70.
- [20] Alparslan V, Kus A, Hosten T, Ertargin M, Ozdamar D, Tokar K and Solak M. Comparison of forced-air warming systems in prevention of intraoperative hypothermia. *J Clin Monit Comput* 2018; 32: 343-349.
- [21] Alfonsi P, Bekka S and Aegerter P; SFAR Research Network investigators. Prevalence of hypothermia on admission to recovery room remains high despite a large use of forced-air warming devices: findings of a non-randomized observational multicenter and pragmatic study on perioperative hypothermia prevalence in France. *PLoS One* 2019; 14: e0226038.
- [22] Madrid E, Urrutia G, Roque i Figuls M, Pardo-Hernandez H, Campos JM, Paniagua P, Maestre L and Alonso-Coello P. Active body surface warming systems for preventing complications caused by inadvertent perioperative hypothermia in adults. *Cochrane Database Syst Rev* 2016; 4: CD009016.
- [23] Kurz A. Thermal care in the perioperative period. *Best Pract Res Clin Anaesthesiol* 2008; 22: 39-62.