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REVIEW PAPER

Preventing perioperative hypothermia: an integrative literature review

Prevenir a hipotermia no perioperatório: revisão integrativa da literatura
Prevenir la hipotermia perioperatoria: revisión integradora de la literatura

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Abstract

Context: During surgery, many patients become hypothermic. Health complications resulting from hypothermia lead to longer hospital stays and increased healthcare costs.
Objective: To identify in empirical research results the active warming systems that proved to be most effective in the pre and intraoperative periods to prevent perioperative hypothermia.
Methodology: The search was performed using the following keywords: Hypothermia, perioperative nursing, anaesthesia and rewarming. Publications from the last five years (2007-2012), with full text, and written in English, Spanish or Portuguese were included. Articles on pregnant women, neurocritical patients, induced hypothermia and the variables affecting hypothermia were excluded.
Results: A total of 30 articles were obtained, seven of which were selected for analysis.
Conclusion: Active warming methods are effective measures for the prevention of hypothermia; the combination of warming methods is more effective than an isolated use; and, finally, the forced-air system and circulating water garments proved to be the most effective active warming methods.

Keywords: hypothermia; perioperative nursing; anaesthesia; rewarming.

Resumo

Contexto: Durante uma cirurgia, muitos utentes ficam hipotérmicos. As complicações do estado de saúde decorrentes da hipotermia resultam em internamentos prolongados e maiores custos em cuidados de saúde.
Objetivo: Identificar, nos resultados das investigações empíricas, os sistemas de aquecimento ativo que se revelaram mais eficazes no pré e intraoperatório para a prevenção da hipotermia no perioperatório.
Metodologia: A pesquisa foi realizada com recurso às palavras-chave: hipotermia, enfermagem perioperatória, anestesia e reaquecimento. Incluíram-se publicações dos últimos cinco anos (2007-2012); com texto completo; em inglês, espanhol ou português. Excluíram-se artigos relativos a grávidas e utentes neurocríticos; estudos em que a hipotermia era induzida ou focavam-se nas variáveis que condicionam a hipotermia.
Resultados: Obtiveram-se 30 artigos e destes selecionaram-se sete para análise.
Conclusão: Os métodos de aquecimento ativo são medidas eficazes para a prevenção da hipotermia; a associação de métodos de aquecimento é mais eficaz que a sua utilização isoladamente; e por último o sistema de ar forçado e as roupas com circulação de água revelam-se os métodos de aquecimento ativo mais eficazes.

Palavras-chave: hipotermia; enfermagem perioperatória; anestesia; reaquecimento.

Resumen

Contexto: Durante un acto quirúrgico, muchos pacientes se quedan con hipotermia. Las complicaciones del estado de salud derivadas de la hipotermia llevan a estancias hospitalarias más largas y mayores costes de atención sanitaria.
Objetivo: Identificar en los resultados de las investigaciones empíricas los sistemas de calentamiento activo que han sido más eficaces en el pre e intraoperatorio para la prevención de la hipotermia en el perioperatorio.
Metodología: Para la investigación se recurrió a las palabras clave: hipotermia, enfermería perioperatoria, anestesia y recalentamiento. Se incluyeron publicaciones de los últimos cinco años (2007-2012); con el texto completo, en inglés, español o portugués. Se excluyeron artículos relativos a mujeres embarazadas y pacientes neurocríticos, estudios en que la hipotermia fue inducida o que se centraban en las variables que condicionan la hipotermia.
Resultados: De los 30 artículos obtenidos, se seleccionaron siete para analizarlos.
Conclusión: Los métodos de calentamiento activo son medidas eficaces para la prevención de la hipotermia; la asociación de métodos de calentamiento es más eficaz que usarlos por separado y, finalmente, el sistema de aire forzado y las ropas con circulación de agua prueban ser los métodos de calentamiento activo más eficaces.

Palabras clave: hipotermia; enfermería perioperatoria; anestesia; recalentamiento.

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Introduction

Most patients submitted to a surgical procedure under anaesthesia become hypothermic due to changes in thermoregulation. These result not only from the anaesthesia, which is responsible for a 20% reduction in metabolic heat production, but also the cold environment of the operating room. Hypothermia results when body temperature is below 36ºC (Galvão, Liang, & Clark, 2010).

Core body temperature is one of the most strictly controlled physiological parameters of the human body. The human thermoregulatory system allows ranges from 0.2ºC to 0.4ºC around 37ºC to maintain its metabolic functions (Galvão et al., 2010). When the temperature is not within this range, the hypothalamus and, consequently, its thermoregulation mechanisms are activated. These include vasoconstriction or vasodilation of peripheral arteriovenous shunts, nonshivering thermogenesis (involuntary muscle contraction) or increase in heat production of the brown adipose tissue particularly in children, shivering, and sweat (Campbell, 2008). However, according to Burns, Piotrowski, Caraffa, and Wojnakowski (2009), these compensatory mechanisms are not enough in 50% to 90% of surgical procedures, thus resulting in hypothermia.

Hypothermia may lead to severe consequences, such as decreased blood flow, cardiac arrhythmias, increased oxygen needs, decreased metabolism, changes in the platelet function, and increased susceptibility to surgical wound infections. Shivering (involuntary somatic motor response that occurs in skeletal muscles to produce heat during exposure to cold environments or during the development of fever) is a minor complication, but rather frequent during anaesthesia and surgery, and referred to as uncomfortable by the patients. The existence of complications will imply longer hospital stays, the need to stay in intensive care units and, as a result, increased healthcare costs (Hong-Xia, Xbi-jian, Hong, & Zhiqing, 2010; Burns et al., 2009).

At induction of anaesthesia, the vasoconstriction mechanism responsible for maintaining temperature is inhibited. Hence, vasodilation occurs, blood flow to the extremities is increased, body heat is lost much more quickly and the patient becomes hypothermic. In the case of locoregional anaesthesia, a peripheral blockade of vasoconstriction is observed below the level of blockade, which also results in body heat loss. The combination of these two types of anaesthesia leads to an even more significant temperature deregulation (Campbell, 2008; Burns et al., 2009; Kamal & Hussein, 2011).

This heat loss mechanism goes through three phases. First, anaesthetics cause a rapid decline in core temperature (1ºC-3ºC), resulting in a sudden redistribution of blood from the core to the periphery. Within the next 2 to 3 hours, the heat loss continues, but there is a gradual decrease in core temperature. Finally, core temperature stabilizes and reaches a plateau, which is characterized by an ongoing metabolic heat production and is able to restore the normal gradient between the several compartments (Burns et al., 2009).

In the perioperative period, the risk factors for hypothermia need to be taken into consideration. The following risk factors are presented in the literature: age (children and elderly people), low body mass index, patients with trauma, sepsis and burns, preoperative systolic blood pressure below 140 mmHg, anaesthetic techniques, operating room temperature, length of surgery, among others (Hooper et al., 2010; Torossian, 2008; Burns et al., 2009). However, according to Hooper et al. (2010), the risk factors for hypothermia imply correlation but not necessarily causation, *i.e.*, patients may have risk factors and not develop hypothermia.

In view of the above, monitoring of body temperature, as a Nursing intervention, in the perioperative period is essential. It may be measured in the body core or at more easily accessible peripheral sites, in which temperature values are close to the core temperature. According to the recommendations of the American Society of PeriAnesthesia Nurses (Hooper et al., 2010), temperature should always be measured via the same route, as there are small differences of values depending on the measurement site.

When body temperature decreases, it is necessary to warm the patient to prevent hypothermia. The identification of the most effective methods of perioperative warming will lead to improved patient comfort, decreased hemodynamic changes, decreased length of stay in the Post-Anaesthesia Care Unit (PACU) and, consequently, lower costs with patients undergoing surgery (Burns et al., 2009). As an integral part of the operating room team, nurses play a key role in maintaining normothermia.

There are several active and passive warming methods. Examples of passive methods are cotton blankets, heated surgical drapes, space blankets, and increase of temperature in the operating room, among other less common methods. The forced-air system, heating blankets, circulating hot water mattresses and garments, radiant heaters, and adjuvant measures (warmed intravenous and irrigation fluids or heated and humidified anaesthetic gases) are the current active warming measures being used (Torossian, 2008; Hooper et al., 2010).

Thus, a wide variety of interventions, described in various studies, is available to be implemented in Nursing practice in three different moments: preoperative, intraoperative and postoperative periods (Burns et al., 2009).

To better understand the results obtained in this integrative literature review, our reference was the Evidence-Based Clinical Practical Guideline for the Promotion of Perioperative Normothermia elaborated in 2009 by the American Society of PeriAnesthesia Nurses (Hooper et al., 2010). This protocol classifies the strength and quality of evidence using a specific scale. Evidence-rating scales guide clinicians in evaluating the robustness and quality of research on a particular issue under study. Criteria of interest include the feasibility and risk versus benefit of implementing the recommendation in practice. Stetler (2001, cited by Hooper et al., 2010) ranks the strength of evidence from a level I, which consists of a systematic statistical review of multiple controlled studies (for example, meta-analysis), to a level VIII, which consists of the consensus opinion of respected authorities (for example, a nationally known guideline group). The quality of the evidence is also rated as A through D, with A reflecting the highest quality study and D representing findings derived from low quality studies. Thus, in line with the ASPAN's guidelines (Hooper et al., 2010), active warming measures are needed: In the preoperative phase, if the patient is hypothermic (Class IIb, level B). In the postoperative phase, if the patient is hypothermic, in addition to normothermic interventions, the forced-air system should be applied (Class I, level A); consider adjuvant measures: warmed intravenous fluids (Class IIb, level B) and humidified warm oxygen (Class IIb, level C). In the intraoperative phase, procedures of less than 30 minutes of aesthetic time if the patient is hypothermic before induction of anaesthesia and/or has risk factors for the development of hypothermia; active warming measures should be implemented (Class I, level A). There is evidence to suggest that alternative active warming measures may maintain normothermia when used alone or in combination with forced-air warming (Class IIb, level B). These warming measures include: warmed IV fluids (Class IIa, level B); warmed irrigation fluids (Class IIb, level B); circulating water garments/mattresses (Class IIb, level B); radiant heat (Class IIb, level B); gel pad (Artic Sun); surface warming (Class IIa, level B); and resistive heating (Class IIa, level B).

This issue arose in the context of our professional practice as nurses in the Operating Room setting, aiming at contributing to the quality of the care provided to patients and optimising healthcare management. Thus, the following question was formulated: what are the most effective active warming methods to prevent perioperative hypothermia? The purpose of this study was, thus, to assess the effectiveness of the active warming systems in preventing perioperative hypothermia in both pre and intraoperative periods.

Methodological Procedures of Integrative Review

"The ultimate benefit of research lies not only in the generation of new knowledge, but also in its uptake through the translation of knowledge into technologies, interventions and strategies effectively and appropriately delivered to the end-users (...)" (World Health Organization, 2005; cited by ARS Norte I.P., 2012).

In methodological terms, an integrative literature review was performed using scientific material published in various databases. We sought to summarize the evidence related to the topic under study, rearranging data and information, and interpreting its meaning. The search was performed in the CINAHL and MEDLINE databases using the EBSCO search engine, from February to September, 2012. The following keywords were searched in the text: hipotermia (*hypothermia*), enfermagem perioperatória (*perioperative nursing*), anestesia (*anaesthesia*), and reaquecimento (*rewarming*). The Boolean operators available in the search engines were used to combine descriptors, and filters were used to exclude articles prior to 2007. Articles published over the last five years (2007-2012), with full-text, and written in English, Spanish or Portuguese were included in the review. Moreover, articles related to pregnant women and neurocritical patients; articles on hypothermia as an induced condition and focused on the variables affecting hypothermia; opinion articles, protocols and ongoing studies were also excluded. Finally, articles on the strategies for the prevention of unintentional perioperative hypothermia were selected. The following table illustrates the inclusion and exclusion criteria of articles (Table 1).

Table 1
Inclusion and exclusion criteria for article selection

Selection Criteria	Inclusion Criteria	Exclusion Criteria	No. of articles excluded
Participants	Adults	Children	0
		Pregnant women	5
		Neurocritical patients	1
Intervention	Strategies for the prevention of unintentional hypothermia	Induced hypothermia	2
		Variables affecting hypothermia	6
Year of study	2007 - 2012	Prior to 2007	0
Study design	Qualitative or Quantitative	Protocols	3
		Opinion Articles	3
Original language	English, Portuguese, Spanish	Another language	0
Access to article	Full Text	Abstracts	0
		Ongoing studies	3
Selected articles: 7			

The identification and selection of articles was performed in three steps. The first step consisted of reading the titles of the articles identified so as to exclude those that did not meet the previously established inclusion criteria. Subsequently, the articles were selected/excluded after abstract reading. Finally, the articles which included enough information in the abstract and met the inclusion criteria, as well as the articles with incomplete abstracts or abstracts that raised doubts were fully analysed.
Two researchers independently selected and analysed the articles. As for the selection process, in the event of disagreement or doubt in any phase of the process, both researchers would analyze the abstract and, if the information was still not sufficient, they would analyze the whole article to decide its inclusion or exclusion. In the data extraction process, tables were created to facilitate article analysis. One researcher extracted data, while the other confirmed the authenticity of collected data. In the analysis of the studies, the following aspects on the article itself and the method used to develop the study were identified: study design, sampling technique, sample size, intervention, objective, and major findings.

Results and Interpretation

From the 30 articles obtained in the initial selection process, seven were selected for full analysis. Two of these articles were excluded as their objectives were not in line with the research question under study.
From the seven studies included for review, one was a meta-analysis, another was a case-control study, and five were correlational and randomized clinical trials, *i.e.* they established causal relationships between the dependent/independent variables under analysis.
Researchers analysed the effectiveness of different active warming methods and adjuvant measures (administration of warmed intravenous fluids); mostly in the intraoperative period (five studies); with only one study making reference to the use of preoperative warming methods. In relation to the anaesthetic technique, participants underwent general anaesthesia/deep sedation in six out of seven studies. The following table summarises the main aspects related to each article (Table 2).

Table 2
Summary of the evidence found

Article 1	Identification of study (Author, year, Title/ type of publication, year/volume/ number)	Method	Warming method(s) under study	Participants/ Sample	General aim
	Hong-xia, X., Xbi-jian, Y., Hong, Z., & Zhiqing, L. (2010). Prevention of hypothermia by infusion of warm fluid during abdominal surgery. *Journal of PeriAnesthesia Nursing*, *25*(6), 366-370. China	Quantitative study; Randomized clinical trial.	Administration of warm IV fluids at 37ºC (Hotline system) *Vs* Administration of intravenous fluids at room temperature (24ºC)	30 participants: control group (n=15); test group (n=15).	To evaluate the efficacy of warm fluids in maintaining core temperature during the intraoperative period and in preventing post anaesthetic shivering.
Main conclusions	The administration of warm IV fluids in abdominal surgeries is effective in maintaining core temperature (nearly normothermia) and may decrease the incidence of postaneasthetic shivering. Authors advocate the association of this IV fluid warming system with other techniques to minimize the occurrence of hypothermia. The additional cost of the fluid warming system - Hotline - is low. Moreover, its effectiveness in preventing perioperative hypothermia has been confirmed.				
Article 2	Galvão, C., Liang, Y., & Clark, A. (2010). Effectiveness of cutaneous warming systems on temperature control: Meta-analysis. *Journal of Advanced Nursing, 66*(6), 1196-1206. Brazil	Quantitative method; Meta-analysis.	Active warming methods	Out of the 329 studies initially identified, 23 were selected (n=23);	To identify the effectiveness of different types of cutaneous warming systems in temperature control for patients undergoing elective surgery.
Main conclusions	Circulating water garments (CWG) are more effective in maintaining temperature in people undergoing surgery and improving hypothermia prevention than forced-air, radiant heat or carbon-fibre warming systems. However, forced-air warming systems (convection) are more effective than passive warming systems and the radiant heat or carbon-fibre warming systems. The abovementioned aspect is enough to confirm the cost-effectiveness of forced-air systems in relation to passive warming systems, such as blankets, but not enough to demonstrate the advantage of CWG.				
Article 3	Bernardis, R., Silva, M., Gozzani, J., Pagnocca, M., & Mathias, L. (2009). Uso da manta térmica na prevenção da hipotermia intraoperatória. *Revista da Associação Médica Brasileira*, *55*(4), 421-426. Brazil	Quantitative study; Experimental	Forced-air blanket at 38ºC	60 participants: Gcont (n=15) – patients were not warmed with a forced-air blanket ; Gpre (n=15) – forced-air blanket for 30 min. before anaesthetic induction; Gintra (n=15) – forced-air blanket after anesthetic induction up to 120 minutes; Gtotal (n=15) – forced-air blanket before and after anaesthetic induction.	To assess the efficacy of using a forced-air blanker in different periods as a method to prevent intraoperative hypothermia. The secondary objective is to assess the adverse effects of using a forced-air blanket at 38ºC.

Main conclusions	The forced-air blanket is effective to prevent intraoperative hypothermia in orthopedic surgeries when applied for a period ranging from 30 min before anaesthetic induction to 120 min after anesthetic induction; Under the conditions of the study, no adverse events were observed as a result of using a forced-air blanket at a moderate intensity (38ºC).				
Article 4	Pagnocca, M. L., Tai, E. J., & Dwan, J. L. (2009). Controle de temperatura em intervenção cirúrgica abdominal convencional: Comparação entre os métodos de aquecimento por condução e condução associada à convecção. *Revista Brasileira de Anestesiologia*, *59*(1), 56-66. Brazil	Quantitative study; Randomized clinical trial.	Circulating water mattress at 37ºC *Vs* Circulating water mattress associated with warm air blanket at 42ºC	43 participants: n=24 – circulating water mattress, on the back (Conduction); n=19 – circulating water mattress associated with warm air blanket over the thorax and upper limbs (Conduction+Convection)	To assess the efficacy of the association of conductive and convective warming methods in the prevention of hypothermia and its effects during postoperative recovery.
Main conclusions	The effectiveness in preventing hypothermia in the intraoperative period by associating conductive and convective methods was greater than that achieved by the isolated use of the conductive method, thus delaying the onset of hypothermia and reducing the intensity of its adverse condition. In addition, only the association of both methods was able to prevent the onset of hypothermia in the post-anaesthetic recovery period.				
Article 5	Wagner, K., Smith, C., & Quan, K. (2010). Prevention of hypothermia during interventional cardiology procedures in adults. *The Internet Journal of Anesthesiology*, *24*(1). United States of America	Quantitative study; Randomized clinical trial; Prospective.	Gel pad heated by a water warming unit with high flow rate (at 42ºC) *Vs* Routine thermal care, such as hospital gown and sheet (room temperature – 21ºC)	95 participants: control group, no active warming system, with routine thermal care (n=45); test group, gel pad warming (n=45)	To evaluate the ability of a reusable gel pad system to maintain perioperative normothermia.
Main conclusions	The gel pad warming group had higher temperature and lower incidence of hypothermia than the control group; The heat exchange coefficient of convective warming systems is considerably lower than those of the conductive warmer method, which results in lesser amounts of heat transfer depending on characteristics of the convective warming system such as nozzle temperature, air flow, temperature distribution inside the blanket, contact area, and other factors; The use of the conductive warming system - gel pad - also serves to eliminate heat loss due to conduction, reduce the risk of pressure sores, and decrease the need for additional warming measures, such as convective warming, intravenous fluid warming, or increased ambient temperature; Full body gel pad warming resulted in higher procedural temperatures and a lower incidence of hypothermia compared with controls.				

Article 6	Andrzejowski, J., Tunrbull, D., Nadakumar, A., Gowthaman, S., Eapen, G. (2010). A Randomised single blinded study of the administration of pre-warmed fluid vs active fluid warming on the incidence of peri-operative hypothermia in short surgical procedures. Journal of the Association of Anaesthetists of Great Britain and Ireland. United Kingdom	Quantitative study; Randomized clinical trial.	Administration of warmed intravenous fluids *Vs* Administration of IV fluids at room temperature	n=76; participants were divided into 3 groups, one group received 1L of crystalloid at room temperature, another received 1L of crystalloid warmed using an in-line warming device, and the other was pre-warmed in a warming cabinet.	To verify whether differences were found between the core temperatures of patients receiving fluids warmed with in-line devices and those of patients receiving warming cabinet fluids To verify the incidence of postoperative hypothermia in patients receiving warmed fluids and those receiving fluids at room temperature.
Main conclusions	The administration of warmed fluids results in higher postoperative temperatures and a lower incidence of hypothermia. In addition, pre-warmed fluids in a warming cabinet are comparable to those used in the in-line system. This study reinforces the NICE guidelines, according to which all IV fluids should be warmed before administration to minimize the incidence of perioperative hypothermia.				
Article 7	Kadam, V., Moyes, D., & Moran, J. (2009). Relative efficiency of two warming devices during laparoscopic cholecystectomy. *Anaesthesia and intensive care*, *37*(3), 464-468. ; Australia.	Quantitative study; Randomized clinical trial.	Forced-air *Vs* Radiant warming devices *All administered fluids were warmed at 41ºC.	N=29; 15 used forced-air and 14 used radiant warming devices;	To evaluate the efficiency of two warming methods (forced-air and radiant warming systems) in preventing hypothermia during elective laparoscopic cholecystectomy.
Main conclusions	No statistically significant difference was found in temperature between both warming methods; This study demonstrates that both the forced-air and the radiant warming systems are effective in maintaining the patient's intraoperative temperature, thus in preventing perioperative hypothermia.				

Below, we will address each active warming method: administration of warm fluids, circulating water garments, forced-air, radiation, carbon-fibre method, Gel Pad conductive warming system, thermal blanket, and resistive system (Hot Dog).

In respect to the administration of warm fluids in the intraoperative period, studies confirm it as an effective method in maintaining core temperature (nearly normothermia) (Hong-Xia et al., 2010). It also minimizes the patient's hemodynamic changes, and reduces both the prevalence of postoperative shivering and the length of hospital stay (Hong-Xia et al., 2010). Andrzejowski, Turnbull, Nandakumar, Gowthaman, and Eapen (2010) mentioned that all intravenous fluids should be warmed to minimize the incidence of perioperative hypothermia. In their study, the authors concluded that two fluid warming systems - warming cabinets and in-line warming devices - are identical. However, other researchers recommend their association with other warming measures (Hong-Xia et al., 2010).

Regarding circulating water garments (CWG), Galvão et al. (2010), concluded in their meta-analysis that CWG are a more effective method to maintain body temperature and prevent hypothermia than forced-air, radiant heat or carbon-fibre warming systems. Nevertheless, the forced-air warming system (convection) was more effective than the passive warming systems and the radiant heat or carbon-fibre warming systems. This was enough to confirm the cost-effectiveness advantage of forced-air systems in relation to passive warming systems, such as blankets, but not enough to demonstrate the advantage of CWG.

Kadam, Moyes, and Moran (2009) compared forced-air with radiant warming devices, and concluded that both were effective in maintaining intraoperative temperature and preventing perioperative hypothermia, with no statistically significant differences between them. However, the radiant warming system required more supervision in its application.

Patients who used the pad conductive system had higher body temperature in the intraoperative period, and lower incidence of hypothermia than patients who did not use any active warming method. It also eliminates heat loss due to conduction, reduces the risk of pressure sores, and decreases the need for additional warming measures, such as convective warming, intravenous fluid warming, or increased ambient temperature (Wagner, Smith, & Quan, 2010).

Forced-air blankets are an effective method in preventing intraoperative hypothermia when applied for a period ranging from 30 min before anaesthetic induction to 120 min after anaesthetic induction (Bernardis, Silva, Gozzani, Pagnocca, & Mathias, 2009). The combination of the forced-air blanket at 42ºC and the circulating water mattress proved to be more effective than their isolated use. In addition, only the association of both methods was able to prevent hypothermia in the post-anaesthetic recovery period (Pagnocca, Tai, & Dwan, 2009).

Based on the evidence found and in comparison with the ASPAN's guidelines (2009), some conclusions may be drawn. First, the administration of warmed IV fluids should be an adjuvant measure to maintain normothermia in all patients undergoing surgical/anaesthetic procedures from the moment they are admitted to the operating room (preoperative period) (Andrzejowski et al., 2010; Hong-Xia et al., 2010). Second, the association of active warming methods is more advantageous than the use of a single method: warmed intravenous fluids should be associated with other methods (Hong-Xia et al., 2010). Evidence on the benefits of associating conductive and convective methods (circulating water mattress with the forced-air blanket at 42ºC) was also found (Bernardis et al., 2009). The forced-air system was the most cost-effective warming method found when compared to the resistive system - Hot Dog -, the radiant warming system (electric blanket), and the circulating water garments (Kadam et al., 2009; Galvão et al., 2010). The researchers also mentioned that circulating water garments are more effective in preventing hypothermia than the forced-air system. However, the cost-benefit ratio has to be taken into account, and the data obtained in the mentioned study was insufficient.

The nurses involved in the decision-making process concerning the acquisition of warming systems should be aware of the fact that circulating water garments are the most effective method to prevent hypothermia. Further studies are needed to determine the total costs of these competitive systems (Galvão et al., 2010).

Conclusion

Perioperative hypothermia is a condition that affects most surgical patients and may lead to an increase in recovery time, length of hospital stay and costs, and also, a decrease in patient satisfaction.

Active warming systems (forced-air system, blankets, warming blankets, circulating water mattresses and garments, and radiant warming system) are commonly used to prevent hypothermia during anaesthetic/surgical procedures. These systems have proved to be more effective in maintaining body temperature than passive warming systems (cotton blankets, heated surgical drapes, space blankets, and increased temperature in the operating room).

This integrative literature review shows that all active warming methods prevent the loss of body heat; however, some are more effective than others, with circulating water garments and the forced-air system being the most effective methods.

We also observed that the association of active warming methods is more beneficial than the use of a single method.

This integrative literature review had the following limitations: only articles written in English, Spanish and Portuguese were analysed; and the fact that only articles available in the mentioned databases were used.

The healthcare professionals' knowledge, regarding the effects of hypothermia and the various methods for its prevention is essential to promote quality care, with an appropriate cost-efficiency relationship.

Further national and international studies should be conducted to analyse and compare the various active warming methods, considering that hypothermia not only affects the patients health, but also increases healthcare costs. The Cochrane Collaboration is currently conducting three systematic literature reviews, which will certainly make a major contribution to this area.

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