PEER-REVIEWED RESEARCH

Preoperative warming with a forced-air warming blanket prevents hypothermia during surgery

Surgical patients are exposed to heat loss, which can lead t o complications such as increased oxygen demand, higher infection risk and cardiovascular problems.

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ABSTRACT

Background: Surgical patients are exposed to heat loss. It is important to prevent accidental hypothermia in surgical patients in order to avoid unnecessary complications such as increased oxygen demand, higher infection risk and cardiovascular problems.

Objective: To generate new knowledge about the effect of using forced-air warming blankets as a means of preventing accidental hypothermia in elective surgery patients under general anaesthesia.

Method: We conducted an updated systematic literature search in the databases CINAHL (EBSCO), Embase (Ovid), Cochrane Register of Controlled Trials (Wiley), MEDLINE (Ovid) and ScienceDirect for material published between January 2011 and February 2016 in order to complement existing systematic reviews. Randomised controlled studies published in English and Scandinavian languages were included. We made a critical assessment of the studies with regard to the risk of systematic bias and presented aggregate findings in a narrative analysis.

Results: We identified 624 references and included a total of 10 articles in the analysis. Eight of the ten studies show a positive effect from preoperative warming with a forced-air warming blanket. The majority of these studies show statistically significant results and have a low bias risk.

Conclusion: The results indicate that preoperative warming with a forced-air warming blanket has a significant effect on preventing accidental hypothermia in adult elective surgery patients under general anaesthesia. Continuing to warm patients perioperatively can also be beneficial.

Hypothermia is a complication that often occurs in connection with surgery, and preventing it can be a challenge. Hypothermia is defined as a core temperature below 36.0°. The body temperature of patients about to undergo surgical procedures under general anaesthesia generally drops by 2–3° if preventive measures are not taken (1).

Prognostic factors such as age, body mass index (BMI), morbidity rate (American Society of Anaesthesiologist (ASA) classification) and length of operation can all affect the extent to which the patient is exposed to hypothermia.

Patients arriving at the operating theatre are immediately exposed to heat loss due to low temperatures in theatres, removal of clothes and disinfection of the surgical site with cold liquids.

Infusing cold liquids and transferring the patient from the hospital bed to the operating table lead to further heat loss. During the induction of anaesthesia, the body reacts with vasodilation, and the natural thermoregulation does not function as normal. During surgery, the patient lies still on the operating table, and heat production is thus by means of basal metabolism.

Muscle blockade also prevents the body from compensating for heat loss by shivering. The body redistributes heat from central to peripheral parts of the body, causing the core temperature to fall. Surgical patients also lose heat through vaporisation from the skin, operation wounds and respiratory tracts (2, 3).

Shared responsibility for preventing hypothermia

The entire surgical team is concerned with preventing hypothermia, and it is a shared responsibility. This responsibility is given as a separate item in the checklist for safe surgery. The checklist aims to prevent unnecessary complications and injuries from occurring during surgery (4).

«Nurse anaesthetists have a special responsibility to observe and measure temperatures as well as initiate measures to prevent hypothermia.»

If the surgical patient becomes hypothermic, the risk of various anaesthetic-related complications increases. These include increased oxygen demand, bleeding risk, infection risk and unnecessary discomfort during and after surgery. Hypothermia may also prolong the effect of the anaesthetic agents (3). According to Bozimowski (2), hypothermia can also lead to undesired cardiovascular events.

Nurse anaesthetists have a special responsibility to observe and measure temperatures as well as initiate measures to prevent hypothermia (5). The nurse anaesthetist's responsibility for preventing complications and implementing pre-, intra- and post-anaesthetic measures is set out in the nurse anaesthetist's job specification (6).

Preoperative warming

Preoperative warming is defined as the heating of patients' peripheral tissue or skin surface using various warming methods prior to surgery. This contributes to a peripheral increase in temperature. The heat is redistributed from core to peripheral parts of the body, thereby reducing heat loss (7).

The research literature shows that active warming with a forced-air warming blanket is the most effective warming method for preventing accidental hypothermia in surgical patients. When using a forced-air warming blanket, warm air is blown from a heat source into a thin disposable blanket placed over the patient (8).

We conducted preliminary searches in relevant databases prior to our literature search and found a systematic review from 2012 and a review article from 2013. These articles indicate that active preoperative warming of surgical patients can prevent accidental hypothermia in such patients (9, 10).

However, the quality of the methodology in the studies in these articles is considered to be variable, and the findings were inconclusive. These review articles also cover different types of preoperative warming methods, and anaesthesia methods vary across the studies.

Objective of the study

The purpose of the study was to generate new knowledge about the effect of using forced-air warming blankets as a means of preventing accidental hypothermia during surgery.

We formed the following research question:

'What effect can preoperative warming with a forced-air warming blanket have on preventing accidental hypothermia in elective surgery patients under general anaesthesia?'

Method

This article is a systematic literature review – a systematic summary of knowledge gleaned from relevant research articles that can help answer the research question. Systematic literature reviews are often regarded as the core of evidence-based practice and can lead to conclusions that may be useful in practice (11).

Before we started the literature search and review, we drew up a methodological plan for how we would conduct our study. This plan is described in a separate protocol in the form of a project plan. The protocol can be obtained by contacting the first author. We used the PRISMA checklist throughout our work to quality assure the reporting of our systematic review (12).

In 2012 and 2013, a systematic review article and a general review article were published with the aim of clarifying whether preoperative warming can prevent accidental hypothermia in surgical patients (9, 10). Following a critical review of the articles using the PRISMA checklist, we chose de Brito Poveda et al. (9) in preference to Roberson et al. (10).

We chose this article because the study by de Brito Poveda et al. (9) is a systematic review based on randomised controlled trials (RCT). We believe it is necessary to update the work of de Brito Poveda et al. (9) since they use the Jadad quality tool and present inconclusive results.

The Cochrane Collaboration advises against using the Jadad quality tool, as the scoring scale is not considered to be a reliable instrument for measuring validity, and no clear indication is given of the basis for assessment. In addition, the tool does not include any checks to establish whether the randomisation process is properly concealed (13).

Literature search and search terms

In the study by de Brito Poveda et al. (9), the systematic literature search was conducted in several databases, and different variations of subject terms and key words were used (see appendix). The search string is not specified. The inclusion criteria for this systematic review were as follows: RCT studies published between January 1990 and November 2011 that tested whether preoperative warming can prevent hypothermia in elective surgery patients over the age of 18.

Language delimitation was English, Spanish and Portuguese, and in total, this included 14 articles. On the basis of the aforementioned considerations, we chose to perform an updated literature search based on the systematic review article by de Brito Poveda et al. (9).

Prior to the literature search, we devised a search strategy based on the PICO model as well as search terms from the study by de Brito Poveda et al., which we chose to update (9). The PICO model is a good tool for creating the correct structure and combination of search terms (14). In a new, updated literature search, we used subject terms and key words in different combinations for population, intervention and outcome goals.

We used the same search terms as de Brito Poveda et al. (9), but we also added new, relevant terms. The updated literature search in various databases took place between October 2015 and February 2016 (see appendix). As we were building on a literature search already conducted by other researchers, we searched for studies published from January 2011 to February 2016.

Individual searches and citation searches

In addition, we performed individual searches in the selected articles' reference lists, as well as citation searches. The inclusion criteria for the systematic review were as follows: RCT studies published in English or a Scandinavian language that tested the effect of preoperative warming with a forced-air warming blanket as a means of preventing accidental hypothermia.

The studies involved adult surgical patients between the ages of 18 and 85 who were to undergo elective surgery procedures under general anaesthesia. We excluded studies using regional anaesthesia or other warming methods. The outcome goals we were looking for were the patients' core temperatures and cases of sustained normothermia, i.e. a core temperature of over 36°.

Selection and assessment

The two authors carried out the selection process independently of each other. Initially, we assessed the title and summary in relation to the inclusion and exclusion criteria. We then obtained full-text versions of all potentially relevant articles, and finally we considered whether to include or exclude them. The two authors also performed data extraction independently and concluded the process by collecting relevant data in two descriptive tables (Tables 1 and 2 under Results).

First, we carried out a critical review of the studies selected using the checklist for RCT studies, which was prepared by the Norwegian Knowledge Centre for the Health Services (15). We then assessed the risk of systematic bias using the validation tool 'Cochrane Collaboration's tool for assessing risk of bias (RoB)'. Seven key points reflect different features of the study that could pose a risk of systematic bias (13).

The two authors independently assessed the risk of systematic bias in the studies selected. The different points in the validity tool (RoB) were graded as low, high or indeterminate risk of systematic bias. Based on these assessments, we provided an overall evaluation of the entire study. The assessments were then entered into the RevMan computer programme, which presents tabular summaries showing the risk of systematic bias (13).

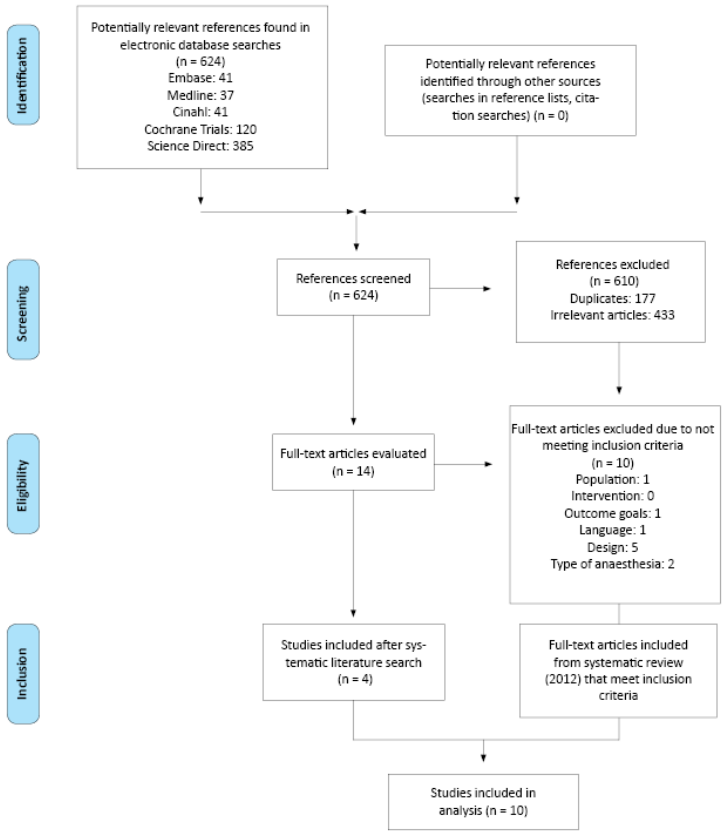
As indicated in the project plan, we initially intended to perform a meta-analysis. However, after the literature search, we considered this method to be unsuitable since the degree of heterogeneity between the studies selected was too high. This was due to variations in intervention duration, heat strength, measuring instruments and outcome goals between the studies. We therefore performed a narrative analysis in order to provide an overarching description of the results.

Both authors close read the selected articles and classified them into two categories with subthemes. This provided us with a structured description and comparison of the results of the studies.

Results

We identified a total of 624 references through our systematic literature search. Of these, we printed 14 for close reading. After assessing these articles in relation to our inclusion and exclusion criteria, we excluded ten of them (Figure 1). Four further studies were included from a new, updated literature search (16–19). We also assessed all of the articles by de Brito Poveda et al. (9) for inclusion and exclusion, and included six studies (20–25). In total, we were left with ten articles that were relevant for further analysis.

Figure 1: Flowchart for selecting studies



Searches from 2011–2016 based on literature searches in systematic review in 2012.

The number of participants in the studies ranged from 27–383, with an average age from 40–60 years, and an average BMI of 25 among participants. All participants underwent elective surgery under general anaesthesia, and the majority had an ASA classification of ≤ III. The ASA classification is an indication of a patient's morbidity rate and reflects their physiological state prior to the induction of anaesthesia (2). Table 1 shows the distinctive features of the studies selected.

Table 1: Distinctive features of RCT studies selected

Study, year, country, (reference)	Population (no. of participants, description)	Outcome goals	Type of surgery	Age (SD) in years/ BMI (SD) in kg/m2	RoB score
Fettes S, Mulvaine M., Van Doren E, 2013, USA (16)	n = 128 (18–85 years) English-speaking surgical patients with an ASA of 1–3	Primary: body temperature pre-, intra- and post-operatively Secondary: resting time in postoperative ward	Exploratory laparotomy, colorectal surgery, prosthesis surgery, spinal and breast surgery, hysterectomy and robot-assisted surgery in urinary tract	58,4/32,3	High
Perl T, Peichl LH, Reyntjens K, Deblaere I, Zaballos JM, Brauer A, 2014, Germany (17)	n = 68 (18–70 years) surgical patients to undergo elective surgery with an ASA of 1–3, BMI 20–30	Primary: core temperature and cases of hypothermia Secondary: core temperature in postoperative ward, thermal comfort and shivering	Abdominal surgery, lower and upper limbs, thoracic surgery and head and neck surgery	43 (+/–16) / 25 (+/–3)	Low
Horn EP, Bein B, Bohm R, Stenfath M, Sahili N, Hocker J, 2012, Germany (18)	n = 200 (>18 years) surgical patients to undergo elective surgery with a surgery time of 30–90 mins., ASA 1–3	Primary: core temperature pre-, intra- and post-operatively and cases of hypothermia Secondary: degree of shivering and thermal comfort	Laparoscopy, thoracic surgery, orthopaedic and ENT surgery	54/26,7	Low
Nicholson M, 2013, USA (19)	n = 66 (>18 years) surgical patients to undergo elective procedure with preoperative warming > 30 min.	Primary: body temperature pre-, intra- and post-operatively	Colorectal procedure	Range from 18–89 / 18.5 > 30	High
Camus Y, Delva E, Sessler D, Lienhart A, 1995, USA (20)	n = 16 (>18 years) surgical patients to undergo elective surgery with an ASA of 1–2	Primary: core temperature pre-, intra- and post-operatively Secondary: skin surface temperatures and postoperative shivering	Laparoscopic cholecystectomy	46 (+/–4) / 24,8	Low
Fossum S, Hays J, Henson MM, 2001, USA (21)	n = 100 (>18 years) surgical patients with an ASA of 1–3 and surgery time of 60–180 mins.	Primary: core temperature pre-, intra- and post-operatively Secondary: thermal comfort, postoperative shivering, postoperative nausea/vomiting and need for pain relief	Gynaecological, orthopaedic and urological	47 (+/–16) / not specified	High
Kim JY, Shinn H, Oh YJ, Hong YW, Kwak HJ, Kwak YL, 2006, Korea (22)	n = 40 (>18 years) surgical patients to undergo elective surgery	Primary: skin and core temperature pre-, intra- and post-operatively	Coronary artery bypass surgery	64 (+/–8) / not specified	Unclear
Andrzejowski J, Hoyle J, Turnbull D, 2008, England (23)	n = 76 (>18 years) elective surgical patients with an ASA of 1 or 2	Primary: core temperature and cases of accidental hypothermia Secondary: nausea, vomiting and shivering	Spinal stenosis surgery	54 / 28,4 (+/–3,8)	High
De Witte JL, Demeyer C, Vandemaele E, 2010, Belgium (24)	n = 27 (>18 years) surgical patients to undergo elective surgery with a BMI of 18–28	Primary: core, skin and body temperatures Secondary: perspiration	Laparoscopic colorectal surgery	66 (+/–12) / 23 (+/–2)	Low
Smith C, Sidhu R, Lucas L, Mehta D, Pinchak A, 2006, USA (25)	n = 383 (18–85 years) elective surgery patients with an ASA of 1–2 and surgery time of >30 mins.	Primary: core temperature Secondary: vital signs, cases and degree of shivering, use of medication, use of warming equipment postoperatively and resting time in postoperative ward	Out-patient surgery in gynaecology, orthopedy and urology	40 (+/–13) / 28,3	Low

RCT = Randomised controlled trial
ASA = American Society of Anesthesiologists (system for grading risk in connection with anaesthesia)
BMI = body mass index
SD = standard deviation
RoB score = risk of shivering
ENT surgery = ear, nose and throat surgery
Age and BMI are specified in the prewarmed group. The values are given as they appear in the literature (average, standard deviation and range).
Article nos. 1–4 are from a new systematic literature search from 2011–2016, article nos. 5–10 are from de Brito Poveda et al. (2012).

All studies selected tested the effect of preoperative warming with a forced-air warming blanket. We classified the studies in two categories: studies that tested preoperative warming, and studies that tested preoperative warming where active warming continued perioperatively. Table 2 describes the intervention in more detail.

Table 2: Description of the intervention

Study, year (reference)	Type of intervention	Comparison (control group)	Duration of intervention	Heat strength	Measuring instrument	Stage when temperature measured	Room temperature	Result
Fettes S, Mulvaine M, Van Doren E, 2013 (16)	Preoperative + perioperative warming with a forced-air warming blanket	Warm cotton blankets preoperatively	Ca. 60 mins.	Medium strength (37.8°)	Infrared temporal scanner thermometer	Pre-, intra- and post-operatively	Not specified	The intervention had no effect on postoperative body temperature.
Perl T, Peichl LH, Reyntjens K, Deblaere I, Zaballos JM, Brauer A, 2014 (17)	Preoperative + perioperative warming with a forced-air warming blanket	1. Hospital duvet 2. Thermal suit (no warm air)	30–60 mins.	Max. strength peri-operatively	Sublingual temperature measurement pre- and post-operatively, and oesophageal temperature measurement perioperatively	Preoperatively at ward and before induction of anaesthesia, every 10 mins. postoperatively. Every 15 mins. perioperatively	20,6 (+/–0,9)	The intervention raises the core temperature under anaesthesia and after surgery.
Horn EP, Bein B, Bohm R, Steinfath M, Sahili N, Hocker J, 2012 (18)	Preoperative warming with a forced-air warming blanket + perioperative warming with a cotton blanket. Forced-air warming blanket on upper body if temp. <36°.	Passive/no preoperative warming	3 groups: 10, 20 and 30 mins.	High strength (44°)	Ear thermometer with aural probes	Measured continuously from arrival at preoperative ward until 60 minutes after arrival at postoperative ward	22,9 (+/–0,7)	The intervention in periods of 10, 20 or 30 minutes significantly reduced the risk of perioperative hypothermia and postoperative shivering.
Nicholson M, 2013 (19)	Preoperative + perioperative warming with a forced-air warming blanket	Cotton blanket	75 mins. (+/– 56 mins.)	Not specified	Electronic oral thermometer pre- and post-operatively.	Preoperatively after 30 mins. warming, after induction of anaesthesia and every 15 mins. postoperatively	19,9	The intervention did not reduce cases of accidental hypothermia.
Camus Y, Delva E, Sessler D, Lienhart A, 1995(20)	Preoperative warming with a forced-air warming blanket	Wool blanket	61 mins. (+/–1 mins.)	High strength	Oesophageally, rectally or temperature measured in urinary catheter perioperatively	Preoperatively and continuing with intervals of 15 mins. until end of surgery	21 (+/–0,1)	The intervention before induction of anaesthesia has an effect on the reduction of accidental hypothermia.
Fossum S, Hays J, Henson MM, 2001 (21)	Preoperative warming with a forced-air warming blanket	Warm cotton blanket	45 min.	(41°)	Ear thermometer linked to aural probes and electronic measuring instrument with probes linked to the body	Preoperatively with intervals of 15 mins., immediately before arrival at the theatre and every 15 mins. postoperatively	Not specified	The intervention had a positive effect on the patient's core temperature perioperatively
Kim JY, Shinn H, Oh YJ, Hong YW, Kwak HJ, Kwak YL, 2006 (22)	Preoperative warming with a forced-air warming blanket + perioperative warming with a heated mattress	2 cotton blankets	49,7 min. (+/–9,9 min.)	Medium strength (ca. 38°)	Infrared ear thermometer	Upon arrival at the theatre, immediately before induction of anaesthesia and 30, 60 and 90 mins. after induction of anaesthesia	20,0 (+/–0,9)	The intervention has an effect and reduces cases and the degree of hypothermia.
Andrzejowski J, Hoyle J, Turnbull D, 2008 (23)	Preoperative + perioperative warming with a forced-air warming blanket	Blanket without warm air	72 mins.	38°	Infrared temporal scanner thermometer pre- and post-operatively, oesophageal thermometer perioperatively	Preoperatively, perioperatively with intervals of 20 mins.	20,7 +/–1,5)	Intervention durations of 60 minutes reduce cases of accidental hypothermia.
De Witte JL, Demeyer C, Vandemaele E, 2010 (24)	Preoperative warming with a forced-air warming blanket (or carbon fibre) + perioperative warming with a forced-air warming blanket	Cotton blanket	30 mins.	42°	Ear thermometer with aural probes pre- and post-operatively, oesophageal thermometer perioperatively	Continuously from 10 mins. before preoperative warming and until discharge from postoperative monitoring	20,0 (+/–0,3)	The intervention should be considered as part of the anaesthesia management of patients at risk of postoperative hypothermia
Smith C, Sidhu R, Lucas L, Mehta D, Pinchak A, 2006 (25)	Preoperative + perioperative warming with a forced-air warming blanket	Standard procedure, not specified	42 mins. (+/– 38) mins.	Medium strength (ca. 40°)	Electronic sublingual thermometer and oesophageal thermometer	Preoperatively, every 15 mins. perioperatively and 5, 30 and 60 mins. after arrival at postoperative monitoring	21,0	The intervention has an effect on preventing accidental hypothermia.

Room temperature and surgery time are quoted as an average +/– SD (standard deviation).
The first four articles are from a new systematic literature search from 2011–2016, while the last six articles are from de Brito Poveda et al. (2012).

Preoperative warming with a forced-air warming blanket

Three of the studies involve only preoperative warming with a forced-air warming blanket to prevent accidental hypothermia (20–22). In the article by Camus et al. (20), the results showed that one hour of preoperative warming before the induction of anaesthesia reduces accidental hypothermia in surgical patients. Fossum et al. (21) and Kim et al. (22), who reported on interventions of a short duration, demonstrate results that support the claim that preoperative warming reduces accidental hypothermia.

The results are significant in all three of these studies ($p < 0.05$), but we found that the two latter studies contained a high and indeterminate risk of bias respectively. This assessment is mainly based on the incomplete description of whether distribution of the groups was concealed and whether the outcome goals were blinded for the intervention.

Nor is there any explanation of the participant drop-out rate in the study. Fossum et al. (21) also used an inaccurate measuring instrument, which was a determining factor in our assessment. We considered Camus et al. (20) to have a low risk of bias.

Preoperative warming combined with perioperative warming with a forced-air warming blanket

Seven of the studies involved preoperative warming combined with perioperative warming with a forced-air warming blanket (16–19, 23–25). In the study by Horn et al. (18), the results showed that preoperative warming for periods of 10, 20 and 30 minutes reduced the risk of perioperative hypothermia and postoperative shivering. The core temperature was significantly higher in the intervention groups compared to the control group ($p < 0.05$).

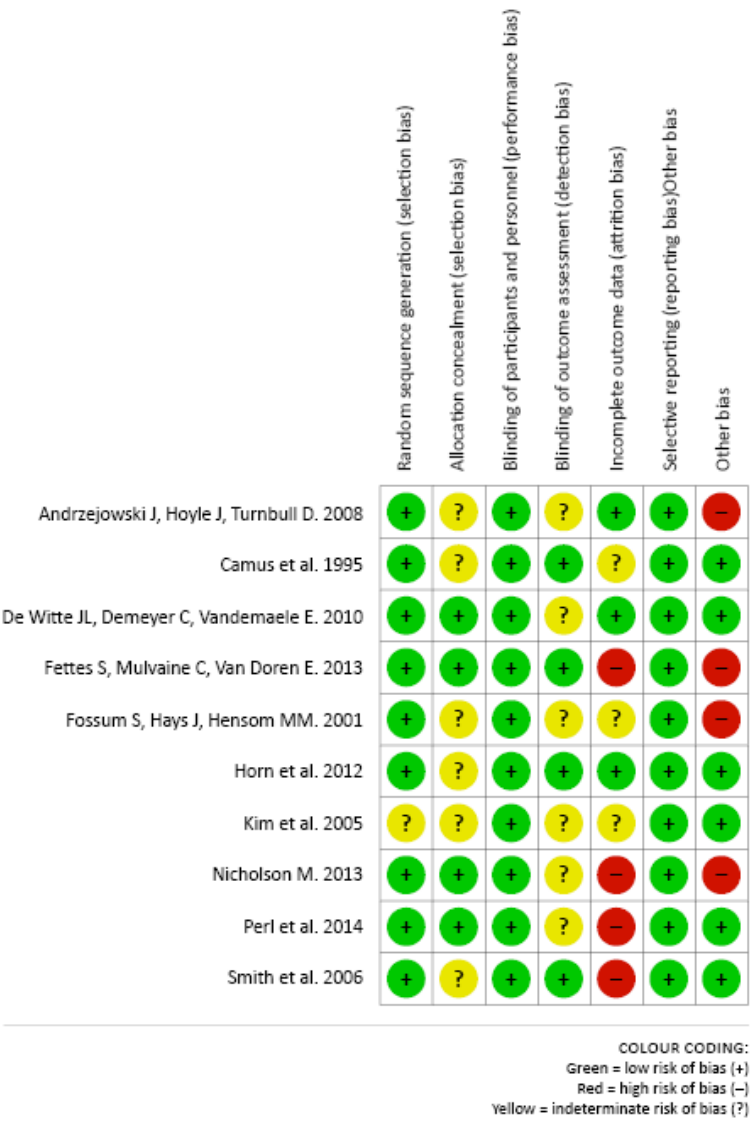
Perl et al. (17) did not specify p-values, but nevertheless concluded that the core temperature was significantly higher in the intervention group compared to the control groups. De Witte et al. (24) found no significant differences in core temperature between the control group and the intervention group that received preoperative warming from a forced-air warming blanket. Nevertheless, the study concludes that active preoperative warming has a significant effect.

In our opinion, these three studies have a low risk of bias. In the studies by Andrzejowski et al. (23) and Smith et al. (25), the results show that the average core temperature in the intervention group was significantly higher than in the control group. However, due to the large variation in intervention duration, we found that the study by Andrzejowski et al. (23) has a high risk of bias.

In two of the studies, the results show that preoperative warming does not reduce cases of accidental hypothermia in surgical patients (16, 19). Neither of these studies show significant results, and the risk of systematic bias is high in both studies.

This assessment is largely based on the high drop-out rate among participants. In addition, participants received different treatment prior to the measure being studied. Nicholson (19) used various measuring instruments, which could pose a high risk of bias. Figure 2 summarises the risk of bias in the studies.

Figure 2: Summary of risk of systematic bias in the studies



Discussion

The purpose of the study was to generate new knowledge about the effect of using forced-air warming blankets as a means of preventing accidental hypothermia in elective surgery patients under general anaesthesia. The main findings in this systematic review indicate that preoperative warming with a forced-air warming blanket has a positive effect on the core temperature of surgical patients and can help maintain normothermia.

This study shows that it is possible to reduce the rate of hypothermia by using a forced-air warming blanket. The different outcomes show the positive trends and suggest that complications of hypothermia can be prevented.

The effect of preoperative warming

Maintaining normothermia in surgical patients can be a challenge even where a forced-air warming blanket is used to warm the patient during surgery (7). According to Lange (1), patients consider hypothermia to be one of the most uncomfortable factors associated with surgery. Thus, it is also important to prevent hypothermia in order to ensure the well-being of the patient.

Under general anaesthesia, patients are in a particularly vulnerable situation and are not in a position to express their needs (26). During surgery under anaesthesia, the patient's body temperature can fall by 2–3° if preventive measures are not taken (1). Therefore, it is crucial that the nurse anaesthetist has knowledge about the consequences of hypothermia and is able to prevent its occurrence, and by so doing, protect patient safety.

The responsibility for implementing preventive measures where complications are expected is explained in the nurse anaesthetist's job specification (6). As hypothermia can lead to unnecessary complications in surgical patients, we believe that prevention is a natural requirement for professionally responsible conduct (27).

«It is also important to prevent hypothermia in order to ensure the well-being of the patient.»

Sessler (28) indicates that active warming aids the body's ability to maintain its core temperature when subjected to heat loss. It can therefore be envisaged that surgical patients would benefit from preoperative warming with a forced-air warming blanket. Of the ten studies we included, eight show that preoperative warming with a forced-air warming blanket has a positive effect and can prevent hypothermia in surgical patients (17, 18, 20–25).

The majority of these studies show significant results and have a low risk of bias (17, 18, 20, 24, 25). The low risk of bias makes the results more credible, as they are more likely to reflect reality (11). The findings in the two remaining studies suggest that preoperative warming has no effect, but the results were not statistically significant (16, 19).

These studies also have a high risk of bias, which may imply that their results do not match reality (13). Our analysis of the risk of bias across the studies showed that the risk is low in most of the seven main points. However, two main points stood out as having the highest risk of bias: 'drop-out bias' due to the drop-out of participants from the study, and 'other bias' due to different measuring instruments being used (Figure 2).

Factors that may have affected the results

In intervention studies, several factors can impact on the effect of a measure. Prognostic factors such as age, weight and illness can, in many cases, affect the outcome. Such factors among the participants should be equally distributed between the groups (13). The average population age in the studies selected may imply that there was a large variation in the age of participants.

Some of the participants had a high BMI, which may have had a positive effect on the results since overweight patients are less exposed to heat loss than slim patients (3, 28).

The intervention durations in the studies differ. A long intervention means a higher core temperature in surgical patients. Horn et al. (18), however, show that a short intervention duration of 10 minutes has a significant effect on preventing hypothermia. This finding is new in relation to the recommendations by de Brito Poveda et al. (9), and can be explained by the high heat strength used.

The conflated findings show a clear correlation between high heat strength and positive effects of the measure. In light of this, we found that it was beneficial to use a high heat strength. However, the high heat strength must not cause discomfort to the patients. Short warming times can also be more practical and cost effective.

We believe that the focus should not only be on efficacy, but on the prioritising of patient safety and quality. Healthcare personnel have a duty to ensure quality in the work performed, including focussing on the patient (29).

The majority of the studies selected continued to actively warm patients with a forced-air warming blanket perioperatively. Based on the findings in the studies, we found that perioperative warming tended to have a positive effect on the results. Thus, it is natural to continue patient warming perioperatively as the patient is most exposed to heat loss during this period (2).

«The conflated findings show a clear correlation between high heat strength and positive effects of the measure.»

Another key element that may have affected the accuracy of the measurements is the measuring instruments that were used. The outcome goals of our study were mainly the patient’s core temperature, which is the best indicator of a patient’s temperature status (30). Which measuring instruments should be used is the topic of much debate in both the research literature and in practice.

The ear thermometer (ear drum), oesophageal thermometer, nasopharyngeal thermometer and pulmonary artery thermometer are considered to be reliable instruments for measuring the core temperature (30, 31). The ear thermometer is used in several of the studies selected (18, 20, 21, 24). This measuring instrument is considered to be reliable when aural probes are used.

Infrared thermometers, on the other hand, are regarded as inaccurate measuring instruments (31). Three of the studies used infrared thermometers (16, 21, 23). The various studies also had different measurement times. This may have affected the results, making it difficult to compare the studies.

Methodological considerations

This systematic literature review is based on RCT. Systematic literature reviews that include high-quality quantitative research are ranked highly in the evidence hierarchy (11). In order to generate new knowledge about the effect of preoperative warming, it was necessary to perform an updated literature search.

We conducted an extensive systematic literature search in relevant databases according to the recommendations of the Norwegian Knowledge Centre for the Health Services, which reinforces the validity of the study (32). Even though we did not contact de Brito Poveda et al. (9) to obtain their detailed search strategy, we nevertheless undertook a broad-based literature search where we found many articles that were relevant to our research question.

However, we recognise that the optimum approach would have been to also search for unpublished studies and reviews, known as grey literature, and are therefore aware that we may have missed relevant literature. The two authors carried out independent reviews and critical assessments of all the articles in terms of internal validity, with a view to safeguarding objectivity (11).

Another factor that reinforces the validity of our study is our use of a reliable tool – one recommended by the Cochrane Collaboration – to evaluate the study's risk of systematic bias (13). In our opinion, this validation tool provides a more solid basis for giving clear recommendations.

In relation to further research, we recommend conducting studies of children, the over 85s and patients with an ASA classification of > 3. These patient groups are more susceptible to developing hypothermia and are seldom included in the studies we found. In order to assess the effect of preoperative warming more generally, studies with preoperative warming should be carried out for several types of surgical procedures.

Patients receiving regional anaesthesia are also prone to hypothermia, and more studies should therefore be conducted where this type of anaesthesia is practised. It is crucial that future studies use measuring instruments with satisfactory psychometric properties and that the use of instruments is consistent.

In practice, more emphasis is placed on carbon fibre technology as a warming method, but research on this is limited. The benefits of carbon fibre technology as a warming method therefore need further investigation.

Clinical implications

Our systematic literature review only identifies the benefits of offering surgical patients preoperative warming with a forced-air warming blanket. Besides time spent and costs, we did not find any disadvantages or adverse side effects associated with this measure. Earlier reviews of other types of warming methods support this finding (9, 10).

> **«Besides time spent and costs, we did not find any disadvantages or adverse side effects associated with this measure.»**

Based on the results, we recommend in the strongest terms that nurse anaesthetists use preoperative warming with a forced-air warming blanket as a preventive measure. We recommend using forced-air warming blankets with a high heat strength – above 40° – and with an intervention duration of 10 to 30 minutes. We particularly recommend this measure for adult patients undergoing elective surgery under general anaesthesia, where surgery time is more than 30 minutes.

Conclusion

Maintaining normothermia in surgical patients is crucial to preventing anaesthetic-related complications and to safeguarding the quality of the work performed. Our findings clearly show that several factors can lead to a drop in a patient’s core temperature. Nevertheless, the results in this systematic review indicate that preoperative warming with a forced-air warming blanket has a significant effect on preventing accidental hypothermia in adult elective surgery patients under general anaesthesia.

The results also suggest that it may be beneficial to warm the patient perioperatively. We believe that this systematic literature review can provide a balanced picture of research findings on preoperative warming with a forced-air warming blanket and prevention of hypothermia. In addition, we believe that the study is a good source of knowledge for healthcare personnel making decisions in practice in connection with preoperative warming.

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