Effectiveness of strategies for the management and/or prevention of hypothermia within the adult perioperative environment

Sandeep Moola BDS MHSM (Honours) and Craig Lockwood RN BN GradDipClinNurs MNSc
The Joanna Briggs Institute, The University of Adelaide, Adelaide, South Australia, Australia

Abstract

Background Inadvertent hypothermia is common in patients undergoing surgical procedures with a reported prevalence of perioperative hypothermia ranging from 50% to 90%. Hypothermia within the perioperative environment may have many undesired physiological effects that are associated with postoperative morbidity. There are different options for treating and/or preventing hypothermia within the adult perioperative environment, which include active and passive warming methods. This systematic review was undertaken to provide comprehensive evidence on the most effective strategies for prevention and management of inadvertent hypothermia in the perioperative environment.

Objective The objective of this review was to identify the most effective methods for the treatment and/or prevention of hypothermia in intraoperative or postoperative patients.

Inclusion criteria Adult patients ≥18 years of age, who underwent any type of surgery were included in this review. Types of interventions included were any type of linen or cover, aluminium foil wraps, forced-air warming devices, radiant warming devices and fluid warming devices. This review considered all identified prospective studies that used a clearly described process for randomisation, and/or included a control group. The primary outcome of interest was change in core body temperature.

Review methods Two independent reviewers assessed methodological validity of papers selected for retrieval and any disagreements were resolved through discussion.

Results Nineteen studies with a combined 1451 patients who underwent different surgical procedures were included in this review. Meta-analysis was not possible. Forced-air warming in pregnant women scheduled for caesarean delivery under regional anaesthesia prevented maternal and foetal hypothermia. Intravenous and irrigating fluids warmed (38–40°C) to a temperature higher than that of room temperature by different fluid warming devices (both dry and water heated) proved significantly beneficial to patients in terms of stable haemodynamic variables, and higher core temperature at the end of the surgery.

Water garment warmer was significantly (P < 0.05) effective than forced-air warming in maintaining intraoperative normothermia in orthotopic liver transplantation patients. Extra warming with forced air compared to routine thermal care was effective in reducing the incidence of surgical wound infections and postoperative cardiac complications.

Passive warming with reflective heating blankets or elastic bandages wrapped around the legs tightly were found to be ineffective in reducing the incidence or magnitude of hypothermia.

Conclusion There are significant benefits associated with forced-air warming. Evidence supports commencement of active warming preoperatively and monitoring it throughout the intraoperative period. Single strategies such as forced-air warming were more effective than passive warming; however, combined strategies, including preoperative commencement, use of warmed fluids plus forced-air warming as other active strategies were more effective in vulnerable groups (age or durations of surgeries).
Implications for practice

• Use active warming strategies
• Commence warming preoperatively
• In extended surgeries or aged patients use multiple active warming strategies
• Warm fluids designated for intraoperative administration
• Consider pharmacotherapeutic strategies in preference to no treatment/prevention

Implications for research

Future research should focus on large, high quality randomised controlled trials looking at long-term clinical outcomes, operating temperature forced-air warming devices, different body sites and percentage of body coverage area of active warming.

Background

Inadvertent hypothermia is common in patients undergoing surgical procedures with a reported prevalence of perioperative hypothermia ranging from 50% to 90%. Inadvertent hypothermia is common in patients undergoing surgical procedures. Hypothermia within the perioperative environment may have many undesired physiological effects that are associated with postoperative morbidity, some of which include bleeding, platelet dysfunction and shivering which increases oxygen consumption. Inadvertent hypothermia is different from therapeutic or induced hypothermia, which is defined as deliberate induction of hypothermia. Therefore, maintaining a state of normothermia is both beneficial to the patient in terms of morbidity and/or mortality and the health service in terms of resource allocation and length of stay.

There are different options for treating and/or preventing hypothermia within the adult perioperative environment, which include active and passive warming methods. Passive warming methods include the use of unwarmed linen or aluminium blankets and head covers. Active warming methods include the use of forced-air warming devices, fluid warmers and radiant heaters.

This systematic review was undertaken to provide comprehensive evidence on the most effective strategies for prevention and management of inadvertent hypothermia in the perioperative environment.

Objective

The objective of this review was to identify the most effective methods for the treatment and/or prevention of hypothermia in intraoperative or postoperative patients.

Search strategy

A three-step search strategy was undertaken (Fig. 1). Step one consisted of a limited search of Medline using the terms hypothermia, surgical, perioperative, randomised controlled trial, adult treatment and/or prevention. Step two consisted of a full search of all databases using all the key words identified. Step three consisted of the review of reference lists of all included papers for further references and searched grey literature for unpublished studies. Some of databases included in the search included CINAHL, MEDLINE, Cochrane Central Register of Controlled Trials (CENTRAL), EMBASE, Current Contents, Scopus, TRIP database, The Database of Abstracts of Reviews of Effectiveness, The Networked Digital Library of Theses and Dissertations (NDLTD) and Proquest Dissertations and Theses.

Inclusion criteria and data sources

Adult patients ≥18 years of age, who underwent any type of surgery were included in this review. Patients who were subjected to deliberate hypothermia such as those for cardiac or neurosurgical interventions were excluded. Types of interventions included were any type of linen or cover, aluminium foil wraps, forced-air warming devices, radiant warming devices and fluid warming devices. Interventions not included in this review were: forms of warming reliant upon microwave warming of fluids, electric blankets and humidified inhalation gases. This review considered all identified prospective studies that used a clearly described process for randomisation, and/or included a control group. The primary outcome of interest was change in core body
temperature. Rectal temperatures were not considered as internal placement can affect the accuracy of readings. Papers written in languages other than English were excluded, the search was not limited by date, and all included databases were searched from their date of inception.

**Review methods**

Two independent reviewers assessed methodological validity of papers selected for retrieval prior to inclusion in the review using the standardised critical appraisal instruments from the Joanna Briggs Institute Systems for the Unified Management, Assessment and Review of Information package (JBI-SUMARI). Appraisal was based on assessing risk of bias in the following four domains: allocation, performance, detection and attrition. Data were extracted from papers included in the review using standardised data extraction tools from the JBI-SUMARI and disagreements were resolved through discussion. As there were no comparable randomised controlled trials found for this review, and as the data were unable to be statistically combined, the data extracted from the included studies were synthesised into a narrative summary.

**Results**

One hundred and thirty studies potentially eligible for inclusion in our review were identified. On final assessment, 19 studies (Appendix I) were identified as fulfilling all of our criteria for inclusion giving a combined total of 1451 patients who underwent different surgical procedures. Fourteen studies were identified for background and discussion. Ninety-seven studies did not fulfil our criteria for inclusion.

This review focused on interventions to prevent and manage hypothermia perioperatively. Inclusion criteria were strictly adhered to, which ensured that the review focused on randomised clinical trials (with a description of randomisation process) of active and passive warming techniques in patients aged over 18 years. Patient groups within the included studies in this review did not differ significantly on baseline demographic characteristics, duration and type of surgery or length of anaesthesia. Patient ages ranged from 18–80 years with most being older than 40 years.

The review found that the definitions of hypothermia were not consistent across studies. There was limited reporting of pre-specified secondary outcomes. Most of the included studies in the review had small sample sizes, fewer than 100 patients. In all the studies, the interventions were used intraoperatively, but some included warming in preoperative and postoperative phases. Not all studies distinguished clearly between these phases when describing their interventions and/or results.

Forced-air warming in pregnant women (with high risk of bleeding, difficulty with wound healing and cardiac problems) scheduled for caesarean delivery under regional anaesthesia prevented maternal and foetal hypothermia.1 In arthroscopic knee surgery patients, forced-air warming did not result in a decrease in the incidence of postoperative shivering indicating that it was not effective or feasible to extend active warming into recovery in this patient population.2 Intravenous and irrigating fluids warmed (38–40°C) to a temperature higher than that of room temperature by different fluid warming devices (both dry and water heated) proved significantly beneficial to patients in terms of stable haemodynamic variables, and higher core temperature (core T) at the end of the surgery (transurethral prostatectomy and orthopaedic surgery).3,4 However, prewarming irrigation fluids in knee arthroscopy patients did not prove beneficial in maintaining normothermia.5

Water garment warmer was significantly (P < 0.05) effective than forced-air warming in maintaining intraoperative normothermia in orthotopic liver transplantation patients.6 Extra warming with forced air compared to routine thermal care was effective in reducing the incidence of surgical wound infections and postoperative cardiac complications, as well as shortening the length of hospital stay.7 Passive warming with reflective heating blankets or elastic bandages wrapped around the legs tightly were found to be ineffective in reducing the incidence or magnitude of hypothermia.8 Low-flow anaesthesia with active forced-air warming was effective in stabilising patient’s core T during surgical procedures.9 Only one study that included medication as an intervention showed that intraoperative intravenous infusion of phenylephrine in the first hour of anaesthesia in patients who underwent minor oral surgery was associated with significantly less heat loss.9

**Discussion**

Inadvertent or unintended perioperative hypothermia is common during anaesthesia and surgical procedures resulting in severe postoperative complications and is thought to prolong hospitalisation.10 Inadvertent hypothermia during general anaesthesia results from a combination of impaired thermoregulation and exposure to the cold environment of the operating room.10,11 Shivering threshold in epidural and spinal anaesthesia is lesser than in general anaesthesia.11 Core T usually decreases after the first hour of anaesthesia because body’s heat loss exceeds the metabolic production of heat and after 3–5 h of anaesthesia, the core T stops decreasing.12 Early intervention in the operating room and recovery room is vital to maintain normothermia. In addition, continual perioperative monitoring of patient’s body temperature is warranted.13 Intravenous infusion of phenylephrine may be beneficial in preventing heat loss in patients during minor oral surgery; however, phenylephrine is associated with potential adverse effects that may affect the patient’s cardiovascular system.9

**Translation into practice – implementing preventative and management strategies for inadvertent perioperative hypothermia**

As the evidence from a recent systematic review illustrates, inadvertent perioperative hypothermia is associated with a range of negative health outcomes intraoperatively and
postoperatively. While the review identified evidence on which interventions are effective, and most of the techniques and strategies have been previously identified through primary research, surgical patients continue to experience unplanned perioperative hypothermia.

The evidence suggests hospital costs could be reduced by between $2500 and $7000 per surgical patient and that morbidity and mortality could be decreased by promoting good perioperative management to maintain normothermia. However, a lack of intervention during the perioperative phase of patient care continues to place patients at risk of unplanned hypothermia.

Current guidelines and professional standards for prevention of perioperative hypothermia are based on either consensus or earlier reviews and do not include recent recommendations that inform how practice should change, nor do they effectively facilitate change based on current evidence. The Centre for Disease Control in their 1999 ‘Guideline for prevention of surgical site infection’ did not provide recommendations to prevent inadvertent perioperative hypothermia because of a lack of randomised controlled trials related to surgical site infections.

Joanna Briggs Institute systematic reviews take a ‘best available’ rather than ‘best or nothing’ approach to systematic reviews, meaning wider forms of evidence are identified and included, enabling reviewers to generate recommendations for practice in the absence of randomised controlled trials rather than conclude that the evidence is inadequate.

Current guidelines include a range of decision algorithms and generalised statements that can inform practice and are framed in the context of preoperative, intraoperative and postoperative care. The National Institute for Health and Clinical Excellence guidelines, for example, suggest a range of interventions depending on preoperative temperature for different phases of the perioperative period. One has to ask why then, perioperative management of unplanned hypothermia remains problematic.

Doreen Wagner, in a paper entitled ‘Unplanned perioperative hypothermia’ makes the following observation of standards and guidelines for preventative strategies for management of hypothermia: ‘...practitioners can track improvements and outcomes, redesign processes for providing standardised care, and commit to using current science to improve patient care.’

This then is an area where further work is required. The evidence on which interventions is effective is clear. The benefits to the patient and the health system are also unequivocally clear. What is now needed is a range of resources to enable and facilitate the translation of review findings into recommendations for practice that can be implemented and evaluated at the local level.

The evidence is in favour of active warming that is initiated preoperatively; this should be built into care pathways and consideration given to routinely including information on prevention of perioperative hypothermia in patient education as an expected standard of treatment.

Routine clinical audit of surgical processes should include auditing of the provision of patient education included awareness of preoperative warming as a key metric, particularly where surgery is likely to be of an extensive timeframe.

Clinically, the expectation should be that all at-risk surgical patients will be warmed preoperatively, and that intraoperative fluids will be warmed prior to administration. These should be standardised, measurable processes where routine clinical audit can establish compliance with best practice recommendations.

Passive warming should be clearly understood to be an ineffective intervention, and not seen as a viable alternative to active warming methods.

Conclusion
The majority of the trials included in this review evaluated active warming techniques, more specifically forced-air warming methods. There are significant benefits associated with forced-air warming in terms of better outcomes such as higher core temperatures, reduced incidence of shivering and morbid cardiac events, increased thermal comfort, reduced blood loss, and reduced surgical site infections and shorter length of hospital stay. Evidence supports commencement of active warming preoperatively and monitoring it throughout the intraoperative period. Single strategies such as forced-air warming were more effective than passive warming; however, combined strategies, including preoperative commencement, use of warmed fluids plus forced-air warming as other active strategies were more effective in vulnerable groups (age or durations of surgeries).

Implications for practice
The systematic review indicated that active warming techniques (forced-air warming) were effective in preventing and managing hypothermia in the perioperative environment and based on the results from the review consideration should be given to the following recommendations to prevent and manage inadvertent hypothermia in the perioperative environment:

- Use active warming strategies
- Discontinue passive warming in vulnerable groups
- Commence warming preoperatively
- In extended surgeries or aged patients use multiple active warming strategies
- Warm fluids designated for intraoperative administration

Implications for research
Most of the included studies in the review had small sample sizes, fewer than 100 patients. Future research should focus on large, high quality randomised controlled trials looking at long-term clinical outcomes, operating temperature forced-air warming devices (not just maximum set temperature), different body sites and percentage of body coverage area of active warming for efficient management of intraoperative hypothermia.
Acknowledgements

The authors would like to extend their thanks to Robert McCann, Clinical Lecturer, The University of Adelaide and Lyll Brougham, Clinical Service Coordinator, Royal Adelaide Hospital for their valuable input during the course of this review and Mrs Maureen Bell, Research Librarian, The University of Adelaide for her help with search strategy.

References


Appendix I

Included studies

<table>
<thead>
<tr>
<th>Study</th>
<th>Method</th>
<th>Participants</th>
<th>Intervention</th>
<th>Outcomes</th>
<th>Risk of bias/allocation concealment</th>
<th>Notes</th>
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</thead>
<tbody>
<tr>
<td>Butwick 2007</td>
<td>Randomised controlled trial (RCT)</td>
<td>Thirty healthy American Society of Anaesthesiologists (ASA) I or II pregnant women (18 and 40 years of age) undergoing caesarean delivery with spinal anaesthesia</td>
<td>Forced-air warming unit with lower body warming cover</td>
<td>Oral temperature, shivering, pain intensity and thermal comfort scores</td>
<td>No/adequate – sequentially numbered opaque envelopes. Blinded investigators assessed oral temperature, shivering and thermal comfort</td>
<td>Intraoperative lower body forced air-warming does not prevent intraoperative hypothermia or shivering in women undergoing elective caesarean delivery with spinal anaesthesia</td>
</tr>
<tr>
<td>Horn 2002</td>
<td>RCT</td>
<td>30 healthy pregnant women undergoing elective caesarean delivery epidural anaesthesia</td>
<td>Forced-air warming ((n = 15), 29 to 37 years) or to passive insulation((n = 15), 26 to 36 years)</td>
<td>Core temperature was measured at the tympanic membrane, and shivering was graded by visual inspection. Patients evaluated their thermal sensation with visual analogue scales</td>
<td>No/adequate – sequentially numbered opaque envelopes</td>
<td>Perioperative forced-air warming of women undergoing caesarean delivery with epidural anaesthesia prevents maternal and foetal hypothermia, reduces maternal shivering. The sample size of this study was based on an expected treatment effect of 1°C</td>
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<table>
<thead>
<tr>
<th>Study</th>
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<th>Outcomes</th>
<th>Risk of bias/allocation concealment</th>
<th>Notes</th>
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<tbody>
<tr>
<td>Mason</td>
<td>RCT</td>
<td>64 morbidly obese patients undergoing Roux-en-Y gastric bypass (17–59 years)</td>
<td>Control group – warmed cotton blankets, experimental group – Bair Hugger forced-air warming system</td>
<td>Blood loss, bladder temperatures, shivering</td>
<td>No/adequate – sealed opaque envelopes</td>
<td>An observer evaluating the outcomes for all study subjects was unaware of the group assignment</td>
</tr>
<tr>
<td>Smith</td>
<td>RCT</td>
<td>One hundred and twenty-seven healthy outpatients scheduled for arthroscopic knee surgery under general anaesthesia</td>
<td>Forced-air warming ($n=69$) with warmed cotton blankets ($n=58$). The forced air-warming unit (B-H model 500) was set at a high of $43.3 \pm 2.8^\circ C$</td>
<td>Core temperature was measured at the tympanic membrane. Shivering was assessed as absent or present</td>
<td>Yes/unclear</td>
<td>Only phase II of the trial was considered as it fulfilled the inclusion criteria</td>
</tr>
<tr>
<td>Elmore</td>
<td>RCT</td>
<td>One hundred patients who underwent repair of infrarenal aortic aneurysms or aortoiliac occlusive disease</td>
<td>Circulating water mattress – 50 (60 to 76 years) or a forced-air warming blanket – 50 (62 to 74 years)</td>
<td>Core temperature, postoperative length of stay, cardiac complications, and death rates</td>
<td>Unclear</td>
<td>Normothermia is protective for infrarenal aortic surgical patients; and forced-air warming blankets provide improved temperature maintenance compared with circulating water mattresses</td>
</tr>
<tr>
<td>Lee</td>
<td>Single-blind RCT</td>
<td>60 male and female patients between 18 and 80 years</td>
<td>Radiant warming (directed at the palm of the hand), forced-air warming (upper or lower body)</td>
<td>Core temperature, thermal comfort, shivering</td>
<td>No/adequate – randomisation results were concealed in opaque envelopes. Patients were blind to group assignment</td>
<td>This study was supported by a grant from Fisher and Paykel. Suntouch radiant warming was not as effective as forced-air warming in maintaining normothermia during long surgical operations</td>
</tr>
<tr>
<td>Camus</td>
<td>RCT</td>
<td>16 ASA status I and II adult patients scheduled for laparoscopic cholecystectomy under general anaesthesia. Control group – eight (38–46 years), study group – eight (42–50 years)</td>
<td>Forced-air warming for one hour before induction of anaesthesia (prewarmed group), wool blanket in control group</td>
<td>Core temperature (tympanic membrane), shivering and thermal comfort</td>
<td>No/adequate</td>
<td>Preoperative skin surface warming is particularly helpful during short procedures because redistribution hypothermia is otherwise difficult to treat</td>
</tr>
<tr>
<td>Fossum</td>
<td>Pretest/post-test experimental design</td>
<td>100 patients (ASA I, II or III) 18+ years of age scheduled for a surgical procedure that required general anaesthesia</td>
<td>Prewarming by using a forced-air warm blanket ($n=50$) or a cotton blanket ($n=50$)</td>
<td>Pre and postoperative core body temperatures with a tympanic membrane thermometer. Patients' self-report of thermal comfort. Shivering</td>
<td>No/adequate – 50 sealed packets contained a blue dot (control) and 50 sealed packets contained a red dot (treatment)</td>
<td>The investigators recommend the use of forced air prewarming for all surgical patients. Study cannot be generalised to all institutions and populations because of the limitations in patient population, length of anaesthesia time and types of surgeries performed</td>
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<tr>
<td>Study</td>
<td>Wong 2007</td>
<td>Method</td>
<td>RCT</td>
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<tr>
<td>Participants</td>
<td>One hundred and three patients over 18 years old who underwent elective major abdominal surgery were randomly allocated to either perioperative warming group (n = 47) or control group (n = 56)</td>
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<tr>
<td>Intervention</td>
<td>All patients included in this study were placed on warming mattresses 2 h before transfer to the operating theatre. However, intraoperatively the mattresses were switched on in the warming group, whereas mattresses were switched off in the control group</td>
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<tr>
<td>Outcomes</td>
<td>Core temperature was monitored using a tympanic thermometer before and after surgery. Wound complications and blood loss</td>
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<tr>
<td>Risk of bias/allocation concealment</td>
<td>No/adequate – sealed opaque envelopes containing computer generated numbers. A blinded observer inspected operation site for evidence of wound complications and blood loss</td>
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<tr>
<td>Notes</td>
<td>Intention-to-treat analysis was used to evaluate outcomes</td>
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<tr>
<th>Study</th>
<th>Evans 1994</th>
<th>Method</th>
<th>RCT</th>
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<tbody>
<tr>
<td>Participants</td>
<td>Sixty-five patients, between 50–80 years scheduled to undergo transurethral prostatectomy to two groups known as standard or isothermic</td>
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<tr>
<td>Intervention</td>
<td>Patients in the standard group received ambient temperature irrigating fluid (21°C) and the patients in the isothermic group received irrigation fluid heated to 38°C</td>
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<tr>
<td>Outcomes</td>
<td>Core temperature was measured trans-oesophageally</td>
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<tr>
<td>Risk of bias/allocation concealment</td>
<td>Unclear</td>
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<tr>
<td>Notes</td>
<td>13 out of 65 patients were excluded from the final analysis due to violations of anaesthetic protocol and bladder tumour</td>
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<tr>
<th>Study</th>
<th>Kelly 2000</th>
<th>Method</th>
<th>RCT</th>
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<tbody>
<tr>
<td>Participants</td>
<td>24 adult ASA class I and II patients</td>
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<tr>
<td>Intervention</td>
<td>Patients were randomly assigned to receive warmed arthroscopic irrigation solution or room-temperature irrigation solution</td>
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<tr>
<td>Outcomes</td>
<td>Mean per cent temperature decrease from preoperative baseline. Tympanic temperatures were monitored every 15 min throughout the surgical and postanaesthesia recovery periods</td>
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<tr>
<td>Risk of bias/allocation concealment</td>
<td>Unclear</td>
<td></td>
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<tr>
<td>Notes</td>
<td>Prevention and treatment of hypothermia are important to patient safety and comfort</td>
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<tr>
<th>Study</th>
<th>Hasankhani 2007</th>
<th>Method</th>
<th>RCT</th>
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<tr>
<td>Participants</td>
<td>60 adult patients undergoing elective orthopaedic surgery (ASA status I)</td>
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<tr>
<td>Intervention</td>
<td>Patients were randomly divided into two groups according to intraoperative i.v. fluids management. In 30 patients (hypothermia group) all i.v. fluids infused were at room temperature. In the other 30 patients (normothermia group) all i.v. fluids were warmed using a dry i.v. fluid warmer</td>
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<tr>
<td>Outcomes</td>
<td>Core temperature, perioperative pulse rate, blood pressure, shivering, recovery time and intraoperative oesophageal and skin temperature were measured</td>
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<tr>
<td>Risk of bias/allocation concealment</td>
<td>Unclear. Presence or absence of shivering was recorded by a blinded assessor</td>
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<tr>
<td>Notes</td>
<td>Intraoperative i.v. fluid warming reduces perioperative changes to the hemodynamic situation, postoperative shivering and recovery time</td>
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<tr>
<th>Study</th>
<th>Janicki 2002</th>
<th>Method</th>
<th>RCT</th>
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<tbody>
<tr>
<td>Participants</td>
<td>24 adult patients (18–65 years old) enrolled in one of two intraoperative temperature management groups during orthotopic liver transplantation</td>
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<tr>
<td>Intervention</td>
<td>The water-garment group (n = 12) received warming with a body temperature (oesophageal) set point of 36.8°C. The forced-air warmer group (n = 12) received routine warming therapy using upper- and lower-body forced-air warming system</td>
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<tr>
<td>Outcomes</td>
<td>Body core temperature (primary outcome) was recorded intraoperatively and during the two hours after surgery in both groups</td>
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<tr>
<td>Risk of bias/allocation concealment</td>
<td>Yes/inadequate. Open labelled trial</td>
<td></td>
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<tr>
<td>Notes</td>
<td>The investigated water warming system results in better maintenance of intraoperative normothermia than routine forced-air warming applied to upper and lower body</td>
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</table>
Study Kurz 1996
Method Double-blind RCT
Participants Two hundred patients (18–80 years) who underwent colorectal resection for cancer or inflammatory bowel disease
Intervention Routine intraoperative thermal care (hypothermia group, n = 40) or additional warming (normothermia group, n = 40)
Outcomes Surgical wound infection, thermal comfort core temperature. Wound infections were evaluated by a blinded observer
Risk of bias/allocation concealment Adequate/yes – computer generated codes maintained in numbered, sealed, opaque envelopes
Conclusions Maintaining normothermia intraoperatively is likely to decrease the incidence of infectious complications in patients undergoing colorectal resection and to shorten their hospitalisations

Study Frank 1997
Method Stratified single-blind RCT
Participants 300 patients age greater than 60 years, scheduled for peripheral vascular, abdominal, or thoracic surgical procedures and scheduled for postoperative admission to the intensive care unit
Intervention Comparison of routine thermal care (hypothermic group) to additional supplemental warming care (normothermic group)
Outcomes Morbid cardiac event, cardiac outcomes were assessed in a double-blind fashion. Haemodynamic monitoring. Mean core temperature (eight body sites were monitored – two core sites and six skin-surface sites)
Risk of bias/allocation concealment Adequate/yes – opaque sealed envelopes
Notes In patients with cardiac risk factors who are undergoing non-cardiac surgery, the perioperative maintenance of normothermia is associated with a reduced incidence of morbid cardiac events and ventricular tachycardia

Study Sun 2004
Method RCT
Participants Sixty term pregnant women in a general hospital, ASA class I–II who underwent elective caesarian delivery under epidural anaesthesia were randomly allocated to either treatment group or control group
Intervention Thirty patients in the treatment group received leg wrapping with tight elastic bandages and 30 patients in the control group had their legs loosely covered by elastic bandages
Outcomes Core temperature and shivering
Risk of bias/allocation concealment No/adequate – random assignments were kept in sealed, sequentially numbered envelope until use
Notes Leg wrapping with tight elastic bandages has no significant benefit in terms of reducing the incidence or magnitude of hypothermia and preventing shivering

Study Whitney 1990
Method RCT
Participants 40 female patients who underwent intra-abdominal gynaecological procedures
Intervention Patients were allocated either to experimental group or control group. Patients in the experimental group had reflective drapes applied to cover maximum body surface and warmed cotton thermal blankets were used in the control group
Outcomes Core temperature was measured in all patients by oesophageal thermistor probes
Risk of bias/allocation concealment Unclear
Notes Reflective blankets are not effective than warmed cotton blankets in preventing intraoperative hypothermia during intra-abdominal gynaecological procedures

Study Berti 1997
Method RCT
Participants 30 ASA physical status I and II patients (62 to 75 years), who were scheduled for elective hip or knee arthroplasty and were free from systemic disease
Intervention Low-flow anaesthesia with additional reflective blankets, low-flow anaesthesia with active forced-air warming
Outcomes Core temperature
Risk of bias/allocation concealment Unclear
Notes Passive heat retention by means of low-flow anaesthesia alone and in combination with reflective blankets is ineffective in maintaining intraoperative normothermia and definitely inferior to active forced-air warming

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Study Ikeda 1999
Method Single-blind RCT
Participants 18 ASA physical status I–II patients undergoing minor oral surgery
Intervention Patients were randomly assigned to an infusion of 0.5 μg/kg/min phenylephrine i.v. or no treatment (control)
Outcomes Core temperature at tympanic membrane, heart rate with a three-lead ECG, haemodynamic responses and ambient temperature
Risk of bias/allocation concealment Unclear
Notes Core temperature reduction during the first hour of anaesthesia decreased less in patients given phenylephrine than in untreated controls

References to included citations
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