NOVA

University of Newcastle Research Online

nova.newcastle.edu.au

Cobbe, Kerry-Anne; Di Staso, Renatta; Duff, Jed; Walker, Kim; Draper, Nicole "Preventing inadvertent hypothermia: comparing two protocols for preoperative forced-air warming". Published in Journal of PeriAnesthesia Nursing Vol. 27, Issue 1, p. 18-24 (2012)

Available from: <http://dx.doi.org/10.1016/j.jopan.2011.10.005>

© 2012. This manuscript version is made available under the CC-BY-NC-ND 4.0 license
<http://creativecommons.org/licenses/by-nc-nd/4.0/>

Accessed from: <http://hdl.handle.net/1959.13/1334015>

Preventing inadvertent hypothermia: A pilot study comparing two protocols for preoperative forced air warming

ABSTRACT

Preoperative forced air warming is one way of preventing inadvertent perioperative hypothermia. There is scant evidence, however, on the best method to use, or the acceptability of these methods to patients. This pilot study compared two warming protocols; one which commenced at maximum temperature and was titrated down as requested (A) and one that commenced at near body temperature and was titrated up as tolerated (B). A crossover design was used where each participant (n=10) received both protocols sequentially. The mean device temperature and length of time spent at maximum settings were greater for protocol A ($43^{\circ}\text{C} \pm 0$ versus $41^{\circ}\text{C} \pm 1$, $p=0.003$; and $60\text{min} \pm 0$ versus $41.5\text{min} \pm 2.8$, $p=0.004$). There was no difference in thermal comfort scores, participant temperature or sweating between the two protocols. When asked, participants preferred protocol A over B (70% to 30%). Starting at higher device settings appears the more favorable of the two approached.

BACKGROUND

Inadvertent perioperative hypothermia - defined as a core temperature below 36°C - is a common, yet widely under acknowledged perioperative occurrence.¹⁻³ On average patients undergoing surgery will have a core temperature heat loss of between 1°C and 3°C .⁴ Three principle factors are said to contribute to this occurrence: Reduced metabolic heat production due to the impact of general anesthesia; heat loss due to the cold perioperative environment and exposed body surfaces; and impaired thermoregulation with subsequent core to periphery thermal redistribution.⁵

Although a common problem, inadvertent perioperative hypothermia is not a benign one. It has, in fact, been shown to have a considerable impact on clinical outcomes, patient experience, and healthcare expenditure.¹ A large body of research demonstrates the clear link between inadvertent perioperative hypothermia and serious physiological adverse outcomes such as myocardial ischemia, surgical site infection, and intraoperative bleeding.^{1, 6-9} There are also serious psychological consequences associated with perioperative hypothermia that are more serious than just feeling uncomfortably cold. As nurses, we are aware that a person's temperature is an integral component of their overall perception of well-being. Research has shown that memories of thermal discomfort during the perioperative period significantly affect a patient's overall surgical experience.¹⁰⁻¹² These physiological and psychological adverse effects can, and do, result in prolonged recovery times, lengthier hospital stays, and increased resource use which in turn translates into greater overall healthcare costs.^{8, 9, 13}

The evidence-based clinical practice guidelines on the promotion of perioperative normothermia¹⁴ from the American Society of Peri-anesthesia Nurses (ASPN) recommend that the active warming of patients should be considered preoperatively to reduce inadvertent perioperative hypothermia in at-risk patients (level B recommendation). There are a number of potential methods for actively warming perioperative patients including the use of forced air warming devices, circulating water mattresses, resistive heating blankets, radiant warmers and negative pressure warming systems.⁵

Forced air warming has been shown to be one of the most effective methods for preoperative warming, consistently demonstrating higher core temperatures in preoperative normothermic patients compared to other warming techniques.^{1, 15-17} The

warming of the peripheral tissues preoperatively reduces the impact of core to periphery thermal redistribution caused by anesthetic-induced peripheral vasodilatation.⁴ As a result patients experience less post-induction temperature loss and recover from any loss at a faster rate intraoperatively.¹⁸⁻²¹

Eliminating or reducing a patient's core temperature drop should, theoretically, reduce the adverse physical and psychological outcomes associated with perioperative hypothermia. Unfortunately, there are only a limited number of studies testing this hypothesis. What evidence there is tells us that patients who are preoperatively warmed experience significantly less blood loss intra and post-operatively²² and require fewer transfusions of blood products.²³ They are also more likely to report thermal comfort²⁴⁻²⁶; experience less perioperative anxiety; and have higher overall satisfaction with their surgical experience than patients who are not preoperatively warmed.²⁵ As a result preoperatively warmed patients can spend up to half the time in the post anesthetic care unit^{22, 23} which in turn results in savings of approximately 24% of the total costs for anesthetic and post anesthetic care.²³

There is clear evidence that preoperative forced air warming prevents or reduces inadvertent perioperative hypothermia¹; there is some evidence that this reduces adverse outcomes^{17, 27}. There is little evidence, however, on the most effective and acceptable method for undertaking preoperative forced air warming. For example, there is no consensus in the literature on such things as the recommended temperature settings or appropriate duration of therapy for awake, normothermic patients. Nor is there much evidence on the acceptability of the treatment to patients.

PURPOSE

This study was conducted as part of preparatory work for a randomized controlled trial assessing the effect of preoperative forced air warming on nurse sensitive indicators such as thermal comfort. Since there was no clear consensus in the literature, the research team recognized the need to identify an effective and acceptable preoperative warming protocol. This study was designed to compare the effectiveness and acceptability of two warming protocols; one that commences at maximum device temperature (43°C) and titrates down as required by the participant and one which commences at near body temperature (38°C) and titrates up as tolerated.

METHOD

Design

The study was conducted using a crossover design. Two different warming protocols (A & B) were provided sequentially (with a 24 hour washout period) to each of the 10 participants. This design was chosen because it is an effective and efficient way of comparing two treatments as each participant acts as their own control, thereby reducing the influence of extraneous variables.²⁸ Figure 1 illustrates the crossover design used in this study.

Figure 1: Illustration of study crossover design.

Setting

The study was conducted by nurse researchers in the day surgery unit of a large private hospital in metropolitan Australia. The project was approved by the hospital human research ethics committee.

Participants

A convenience sample of 10 healthy volunteers was recruited to the study. Inclusion criteria were ASA physical status classification I or II; 18 years of age or older; and able to communicate in English.

Procedure

Participants were asked to change out of their street clothing and into a standard hospital gown. They were then seated in a reclining chair in the preoperative area of the day surgery unit and a lower body disposable warming blanket was applied to

approximately 50% of their anterior body surface with a hospital sheet placed on top. Participants were randomly assigned to receive one of two warming protocols (either A or B). They were then warmed for 60 minutes with a forced air warming device (Bair Hugger brand model no.775). After a 24 hour washout period, participants returned to receive the alternate warming protocol. Outcome measures were recorded at regular intervals during both warming periods. All of the participants were blinded to the warming protocols and the warming device was placed behind a screen out of their line of sight. The researchers collecting the data were not blinded to protocol allocation.

Warming protocols (A & B)

Protocol A: The warming device was commenced at 43°C high-fan. The device temperature and fan speed were then titrated to the participants' thermal comfort which was assessed by the researchers at 15 minute intervals. If a participant complained of thermal discomfort the fan speed and or device temperature were gradually reduced in three stages.

1. Device fan speed decreased to low and participant monitored.
2. Device temperature decreased one level and participant monitored.
3. Device temperature decreased another ~~one~~ level and participant monitored.

Protocol B: The warming device was commenced at 38°C low-fan. The device temperature and fan speed were then titrated to the participants' thermal comfort which was assessed by the researchers at 15 minute intervals. The device fan speed and or temperature were gradually increased in three stages as tolerated.

1. Device fan speed increased to high and participant monitored.
2. Device temperature increased one level and participant monitored.

3. Device temperature increased another ~~one~~ level and participant monitored.

The desired outcome for both protocols was to ensure that the forced air warming device remained on at the highest possible setting for the entire 60 minutes. At any time during either warming protocol the participants could ask to have the warmer device removed completely.

Data collection

Outcome measures were collected by a trained research nurse and recorded on a data collection form. Data collected included device temperature; thermal comfort; body temperature; sweating; and participant preference of protocol. The device temperature was recorded as the set temperature displayed on the console. The time that the temperature was increased or decreased was also recorded. Thermal comfort was measured with a self-rated thermal comfort score that has been used in previous research.^{24, 26} Participants were asked to score how comfortable they were with their body temperature on a scale from 0 to 10 with zero being very comfortable (neither too hot nor cold) and 10 being very uncomfortable (too hot or cold). Body temperature was measured with a tympanic thermometer (Welch Allyn Braun Thermoscan Pro 4000). The thermometer was calibrated by the clinical engineering department as per the manufacturer's instructions. Thermal comfort scores and body temperature were measured at 15 minute intervals over the hour of warming. Participants were also asked if they experienced any excessive sweating during their warming. After experiencing both protocol A and B, participants were asked to choose their preferred warming protocol.

Data analysis

For continuous variables, comparisons were conducted using a non-parametric approach for paired samples. Test statistics were calculated using Wilcoxon test for two related samples. For paired categorical data the McNemar Chi-squared test was used. Chi-squared test was used for unpaired categorical data. Qualitative responses to the question ‘how acceptable was the warming intervention’ have been presented in full in Table 3.

RESULTS

Table 1 contains the demographic characteristics of our study participants. Ten healthy volunteers were recruited to participate in the study, six women and four men. The average age of the volunteers was 33.5 years (± 10.9). The mean height of the participant group was 167.5 cm (± 7.9) and their mean body mass index was 24.2 kg/m² (± 2.8).

Table 1 Mean and (standard deviations) or ratios of participants’ demographic characteristics.

Demographic characteristics	n=10
Sex (female: male)	6:4
Age (years)	33.5 (10.9)
Height (centimeters)	167.5 (7.9)
Body Mass Index (kg/m ²)	24.2 (2.8)

The desired outcome for both protocols was to ensure that the forced air warming device remained on the highest possible setting for the entire 60 minutes without causing thermal discomfort to the participants. We used the Wilcoxon test for related samples to compare the mean device temperature and the mean time spent at the

maximum setting (highest temperature and highest fan speed) between the two protocols. We found that protocol A had a higher mean device temperature and longer mean time spent on the maximum setting than protocol B ($43^{\circ}\text{C} \pm 0$ versus $41^{\circ}\text{C} \pm 1$, $p=0.003$; and $60\text{min} \pm 0$ versus $41.5\text{min} \pm 2.8$, $p=0.004$).

We used the Wilcoxon test for related samples to compare mean thermal comfort scores and body temperatures between the two protocols. We found no significant difference between the two protocols for these two measures at any of the five time points. The mean temperatures for protocol A and B after 60 minutes of warming were $36.8^{\circ}\text{C} (\pm 0.1)$ and $36.7^{\circ}\text{C} (\pm 0.1)$ respectively. The mean thermal comfort score at 60 minutes was $3.8 (\pm 0.8)$ for protocol A and $3.8 (\pm 0.6)$ for protocol B. This was measured on a 10 point scale from 0 to 10 with zero being very comfortable (neither too hot nor cold) and 10 being very uncomfortable (too hot or cold).

No significant difference was found in participants self reports of sweating between protocol A and protocol B using McNemar's Chi-squared test for paired data. Twenty percent of participants reported sweating during protocol A compared to 60% during protocol B.

After the participants had experienced both protocols they were asked to choose which of the two they preferred. We used the Chi-squared test to compare these responses and found no significant difference in the participants' preference of protocol (70% and 30% respectively). Table 2 contains the comparison of all the project outcome measures for protocol A and B.

Table 2: Mean and (standard deviations) or percentages of study variables for protocol A compared to protocol B.

Outcome measures	Protocol		Results
	A (n=10)	B (n=10)	
Time spent at 'maximum' setting	60 (0)	41.5 (2.8)	p=0.004
Mean device set temperature	43 (0)	41 (1.0)	p=0.003
Body temperature			
@ 0 min	36.2 (0.3)	36.5 (0.4)	NS
@ 15 min	36.5 (0.3)	36.6 (0.3)	NS
@ 30 min	36.7 (0.3)	36.6 (0.4)	NS
@ 45 min	36.7 (0.2)	36.6 (0.4)	NS
@ 60 min	36.8 (0.3)	36.7 (0.4)	NS
Thermal comfort score			
@ 0 min	0 (0)	0 (0)	NS
@ 15 min	1.5 (1.2)	1.6 (1.3)	NS
@ 30 min	2.2 (1.8)	2.5 (2.5)	NS
@ 45 min	3.1 (1.9)	3.0 (1.2)	NS
@ 60 min	3.8 (2.5)	3.8 (1.9)	NS
Reported being sweaty	20%	60%	NS
Preferred protocol	70%	30%	NS

NS = non-significant difference. Time is reported in minutes with (standard deviation). Temperature is reported in °C with (standard deviation). Thermal comfort score is on a 10 point scale from 0 to 10 with zero being very comfortable (neither too hot nor cold) and 10 being very uncomfortable (too hot or cold). Protocol A commences warming at maximum temperature (43°C) and titrates to thermal comfort. Protocol B commences warming at near body temperature (38°C) and titrates to thermal comfort.

Figure 2 Comparison of mean device (Bair Hugger) set temperature during preoperative warming for protocol A and B.

Following each warming protocol participants were asked the question ‘how acceptable was this warming intervention to you? Participants’ response to this question for each of the protocols is presented in full in Table 3.

Table 3: Participants’ responses to the question ‘how acceptable was this warming intervention to you?’

Participant	Response for Protocol A	Response for Protocol B
1	The warming was gently comfortable.	It is easy to tolerate even though I felt quite sweaty during the warming.
2	Very relaxing.	It felt more comfortable at the lower temperature. Felt sticky on the chair.
3	It was relaxing and the temperature was comfortable.	Lovely. The blanket was very acceptable.
4	Fine. Comfortable.	It felt hot towards the end.

5	This is very comfortable.	I felt sleepy most of the time.
6	Last 15 minutes a bit uncomfortable.	Felt a massive increase in temperature when the fan was turned up.
7	Very acceptable.	Got too hot. More acceptable at the lower setting.
8	Very comfortable.	Felt quite warm towards the end.
9	Very comfortable for the hour.	Relaxing.
10	Very comfortable but I'm very thirsty.	Very hot toward the end. It was better when with the fan turned down.

DISCUSSION

This study was undertaken as part of preparatory work for a randomized controlled trial evaluating the effect of various warming strategies on perioperative nurse sensitive indicators. The research team had a number of concerns involving preoperative forced air warming to address prior to large scale evaluation of this intervention: Would awake, non-anaesthetized patients tolerate 60 minutes of warming at temperatures of up to 43°C? What would be the most effective warming protocol to ensure patient comfort yet maximize the time spent at higher device settings? And what observations would assist the nursing staff to titrate the device settings to maximize patient comfort and reduce adverse effects? This study has provided some valuable evidence towards answering these questions.

Most importantly, our results clearly show that participants are able to tolerate 60 minutes of warming at a maximum fan speed and temperature setting. The mean thermal comfort score at 60 minutes for both protocol A and B was only 3.8 on a scale where zero was very comfortable and 10 was very uncomfortable. This supports

previous research which has suggested that patients can comfortably tolerate high preoperative warming temperatures for at least one hour.²⁹

Of the two protocols, protocol A was the most effective at maintaining maximal device settings while resulting in no significant increase in participant thermal discomfort or sweating. This protocol was also selected by the majority of participants when asked to choose their favored approach (70% for protocol A versus 30% for protocol B). Although this is not statistically significant it still demonstrates a strong preference, particularly when interpreted in combination with the qualitative data.

It is interesting to note that even after 60 minutes of warming at temperatures of 43°C participants' body temperature remained well within normal parameters. This supports the results of physiological warming studies which show that healthy, non-anaesthetized patients autoregulate their body temperature through peripheral vasodilatation.⁴ Implications for perioperative nurses indicate that in addition to patient's body temperature, assessment of thermal comfort and observation for signs of adverse effects such as sweating should be used to regulate the warming device settings.

Strengths and Limitations

The study was limited by its small sample size which made it difficult to identify significant differences in some project outcome measures such as participant preference and sweating. However, the use of a crossover research design, where each participant acted as their own control, did reduce the influence of extraneous variables which increased the study's rigor and the validity of the results. The study was conducted on healthy volunteers and not ~~real~~ actual perioperative patients. The aim is ~~we aim~~ to apply the lessons learnt from this study to a larger scale research project which will examine preoperative warming and its effects on perioperative outcomes.

CONCLUSION

Forced air warming at temperatures up to 43°C is well tolerated by awake, non-anaesthetized participants for at least 60 minutes. Starting the device on the maximum fan speed and temperature setting and titrating down, as necessary, appears preferable to starting at a low fan speed and temperature setting and titrating up as tolerated. Titration of settings during warming should be according to assessments of thermal comfort and signs of adverse effects, such as sweating and thermal discomfort, rather than body temperature readings.

REFERENCES

1. National Institute for Health and Clinical Excellence. *Perioperative hypothermia (inadvertent): The management of inadvertent perioperative hypothermia in adults*. London: NICE 2008.
2. Leslie K, Sessler DI. Perioperative hypothermia in the high-risk surgical patient. *Best Practice and Research: Clinical Anaesthesiology*. 2003;17(4):485-498.
3. Hegarty J, Walsh E, Burton A, Murphy S, O'Gorman F, McPolin G. Nurses' knowledge of inadvertent hypothermia. *AORN J*. Apr 2009;89(4):701-704, 707-713.
4. Sessler DI. Perioperative heat balance. *Anesthesiology*. 2000;92(2):578-590.
5. Kurz A. Thermal care in the perioperative period. *Best Pract Res Clin Anaesthesiol*. Mar 2008;22(1):39-62.

6. Frank SM, Fleisher LA, Breslow MJ, et al. Perioperative maintenance of normothermia reduces the incidence of morbid cardiac events: A randomized clinical trial. *Journal of the American Medical Association*. 1997;277(14):1127-1134.
7. Kurz A, Sessler DI, Lenhardt R. Perioperative normothermia to reduce the incidence of surgical-wound infection and shorten hospitalization. *New England Journal of Medicine*. 1996;334(19):1209-1215.
8. Sessler DI. Complications and treatment of mild hypothermia. *Anesthesiology*. 2001;95(2):531-543.
9. Lenhardt R, Marker E, Goll V, et al. Mild intraoperative hypothermia prolongs postanesthetic recovery. *Anesthesiology*. 1997;87(6):1318-1323.
10. Fossum S, Hays J, Henson MM. A comparison study on the effects of prewarming patients in the outpatient surgery setting. *J Perianesth Nurs*. 2001;16(3):187-194.
11. Kolcaba K, Wilson L. Comfort care: A framework for perianesthesia nursing. *J Perianesth Nurs*. 2002;17:102-114.
12. Wagner VD. Impact of perioperative temperature management on patient safety. *SSM*. 2003;9:38-43.

13. de Brito Poveda V, Galvão CM, dos Santos CB. Factors associated to the development of hypothermia in the intraoperative period. *Revista Latino-Americana de Enfermagem*. 2009;17(2):228-233.
14. American Society of PeriAnesthesia Nurses. Hypothermia guideline. 2010; <http://www.aspan.org/hypothermia.htm>.
15. Vanni S, Braz J, Módolo N, Amorim R, Rodrigues G. Preoperative combined with intraoperative skin-surface warming avoids hypothermia caused by general anesthesia and surgery. *Journal of Clinical Anesthesia*. 2003;15(2):119-125.
16. Ng S, Oo C, Loh K, Lim P, Chan Y, Ong B. A comparative study of three warming interventions to determine the most effective in maintaining perioperative normothermia. *Anesthesia & Analgesia*. 2003;96(1):171.
17. Andrzejowski J, Hoyle J, Eapen G, Turnbull D. Effect of prewarming on post-induction core temperature and the incidence of inadvertent perioperative hypothermia in patients undergoing general anaesthesia. *Br. J. Anaesth.* September 26, 2008 2008:272.
18. Hynson J, Sessler D, Moayeri A, McGuire J, Schroeder M. The effects of preinduction warming on temperature and blood pressure during propofol/nitrous oxide anesthesia. *Anesthesiology*. 1993;79(2):219.

19. Camus Y, Delva E, Sessler DI, Lienhart A. Pre-induction skin-surface warming minimizes intraoperative core hypothermia. *Journal of Clinical Anesthesia*. 1995;7(5):384-388.
20. Kim J, Shinn H, Oh Y, Hong Y, Kwak H, Kwak Y. The effect of skin surface warming during anesthesia preparation on preventing redistribution hypothermia in the early operative period of off-pump coronary artery bypass surgery. *European Journal of Cardio-thoracic Surgery*. 2006;29(3):343.
21. Just B, Trévien V, Delva E, Lienhart A. Prevention of intraoperative hypothermia by preoperative skin-surface warming. *Anesthesiology*. 1993;79(2):214.
22. Mahoney C, Odom J. Maintaining intraoperative normothermia: a meta-analysis of outcomes with costs. *AANA journal*. 1999;67(2):155.
23. Bock M, Muller J, Bach A, Bohrer H, Martin E, Motsch J. Effects of preinduction and intraoperative warming during major laparotomy. *British Journal of Anaesthesia*. 1998;80(2):159.
24. Fossum S, Hays J, Henson M. A comparison study on the effects of prewarming patients in the outpatient surgery setting. *Journal of Perianesthesia Nursing*. 2001;16(3):187-194.
25. Wagner D, Byrne M, Kolcaba K. Effects of comfort warming on preoperative patients. *AORN Journal*. 2006;84(3):427.

26. Leeth D, Mamaril M, Oman K, Krumbach B. Normothermia and Patient Comfort: A Comparative Study in an Outpatient Surgery Setting. *Journal of perianesthesia nursing*. 2010;25(3):146.
27. Melling AC, Ali B, Scott EM, Leaper DJ. Effects of preoperative warming on the incidence of wound infection after clean surgery: A randomised controlled trial. *Lancet*. 2001;358(9285):876-880.
28. Portney LG, Watkins MP. *Foundations of Clinical Research: Application to Practice* 3rd ed. Sydney.: Pearsons; 2009.
29. Sessler DI, Schroeder M, Merrifield B, Matsukawa T, Cheng C. Optimal duration and temperature of prewarming. *Anesthesiology*. 1995;82(3):674-681.