ORIGINAL RESEARCH

The Effects of Active Warming on Patient Temperature and Pain After Total Knee Arthroplasty

Study findings support the use of patient-controlled, forced-air warming gowns.

Total knee arthroplasty (TKA) is an increasingly common procedure as more and more patients opt for this surgery to replace worn-out joints and to deal with the pain of arthritis. This procedure is often associated with inadvertent perioperative hypothermia and significant postoperative pain.

Hypothermia occurs during and after surgery as a result of inhibition of the thermoregulatory system induced by anesthesia and exposure to a cool environment.[1,2] It's estimated that perioperative hypothermia is experienced by 50% to 90% of patients undergoing minor and major procedures.[3-5] Even mild hypothermia can lead to numerous complications, including lowered resistance to surgical wound infection, coagulopathy, and ventricular tachycardia and other life-threatening cardiac events.[2] There is a significant risk of hypothermia with TKA, because of both the older age of many patients having this procedure and the large surface area exposed during surgery.[6]

Another common sequela of TKA is postoperative pain; indeed, the surgery is reportedly one of the most painful orthopedic surgeries.[7-9] Factors affecting TKA pain include the extent of muscle tissue destruction, the amount of tissue renovation required, the occurrence of reactive hyperemia after tourniquet release, and the intensity of postoperative physical therapy.[10,11]

The inadequate treatment of postoperative pain may lead to undue suffering, complications, and delay in discharge, thereby resulting in increased health care costs.[12,13] Despite advances in research, pain continues to be undertreated in surgical patients. It's likely that more effective pain relief during the initial postoperative period would result in both improved knee function and greater patient satisfaction.

Hypothermia may have an effect on the pain experienced by patients who undergo TKA. However, the link between hypothermia and pain isn't well understood. Studies in animals and humans offer conflicting evidence as to how hypothermia affects pain and opioid disposition.[14-17]

The aim of this randomized controlled trial was to determine the efficacy of a patient-controlled, forced-air warming gown in optimizing patients' perioperative body temperature and in diminishing postoperative pain after TKA. As this research was experimental in design, four hypotheses were developed to help guide analysis of the data.

- Patients who are warmed with a warming gown will achieve normothermia more effectively (their oral temperatures will be higher and thus closer to normal) than patients warmed with a standard cotton blanket.
- Patients who are warmed with a warming gown will report different intensities of pain in the first 24-hour postoperative period than patients warmed with a standard cotton blanket.
- Patients who are warmed with a warming gown will use different quantities of opioid during the first 48-hour postoperative period than patients warmed with a standard cotton blanket.
- Patients who are warmed with a warming gown will report more satisfaction than patients warmed with a standard cotton blanket.

The underlying framework. Good and Moore's theory of pain alleviation, which they called "a balance between analgesia and side effects," guided

ABSTRACT

Background: Total knee arthroplasty (TKA) is a procedure with associated risks of inadvertent perioperative hypothermia and significant postoperative pain. Hypothermia may affect patients' experience of postoperative pain, although the link is not well understood.

Objective: The aim of this prospective, randomized controlled trial was to determine the efficacy of a patient-controlled active warming gown in optimizing patients' perioperative body temperature and in diminishing postoperative pain after TKA.

Methods: Thirty patients who would be undergoing TKA received either a standard hospital gown and prewarmed standard cotton blanket (n = 15) or a patient-controlled, forced-air warming gown (n = 15).

Results: Although pain scores were not significantly different in the two groups ($P = 0.08$), patients who received warming gowns had higher temperatures ($P < 0.001$) in the postanesthesia care unit, used less opioid ($P = 0.05$) after surgery, and reported more satisfaction ($P = 0.004$) with their thermal comfort than did patients who received standard blankets. These findings indicate that patient-controlled, forced-air warming gowns can enhance perioperative body temperature and improve patient satisfaction. Patients who use warming gowns may also need less opioid to manage their postoperative pain.

Conclusions: Nurses should ensure that effective patient warming methods are employed in all patients, particularly in patients with compromised thermoregulatory systems (such as older adults), and in surgeries considered to be exceptionally painful (such as TKA).

Keywords: active warming, forced-air warming gown, hypothermia, pain, total knee arthroplasty

this study.[18] The model framework predicts the most effective combination of treatments to use for acute pain. Eight interventional concepts form the building blocks for the theory's three propositions (statements), which assert that[18]

- giving adequate, potent pain medication along with pharmacologic and nonpharmacologic adjuvants contributes to achieving a balance between analgesia and adverse effects.
- regular pain and adverse effects assessments; identification of unrelieved pain and unacceptable adverse effects; and a process of intervention, reassessment, and reintervention contribute to achieving that balance.
- patient teaching and goal setting for pain relief contribute to achieving that balance.

Our study focused mainly on the first statement of the theory; that is, on how potent pain medication (bupivacaine spinal with intrathecal morphine), along with pharmacologic (oral or intravenous opioids) and nonpharmacologic (warming) adjuvants, could contribute to a balance between achieving analgesia and adverse effects.

Good and Moore's theory has been used in previous research on adults undergoing abdominal surgery,[19] as well as in the development of a prescriptive theory of acute pain management for infants and children.[20] But we could find no evidence of its use in patients undergoing TKA.

METHODS

This prospective, randomized controlled study was conducted at a western Canadian community hospital, following approval by both the hospital's ethics committee and the associated university's research ethics board. Staff of the preadmission clinic, day surgery area, operating room (OR), postanesthesia care unit (PACU), and orthopedic unit areas were informed of the study's methodology and use of a forced-air warming gown; the principal researcher (EEB) also received in-service training on the gown from the manufacturer's representative. Data were collected from January through April of 2009.

Sample. A convenience sample of 44 patients who would be undergoing TKA was recruited. Inclusion criteria were age 18 years or older, an American Society of Anesthesiologists physical status classification system (www.asahq.org/clinical/physicalstatus.htm) rating of 1 to 3, and the ability to adequately read and speak English. Exclusion criteria were revision TKA surgery, allergy to opioids, regular opioid use, or reported or known dependency on alcohol or drugs. A power analysis determined that a sample size of 30 was needed to detect a 0.2°C difference in temperature and a 5-mg difference in opioid consumption, with a power of 90% and a 0.05 significance level.

Patients were randomized to one of two study groups by simple random draw. Thirty colored

tickets—15 white and 15 purple—were placed in an envelope and then drawn, indicating which group each participant would be enrolled in. If a patient subsequently had to be excluded (because of use of general anesthetic, cancellation of surgery, or early removal of warming gown by staff), that patient's ticket went back into the envelope and was redrawn. Care was taken to replace any excluded patient with a new recruit randomized to receive the same method, thus ensuring an equal number of patients in each group. Of the initial 44 patients, those 30 receiving bupivacaine spinal anesthesia with intrathecal morphine were used in the final analysis; 14 patients were excluded. Six different surgeons performed the surgeries.

Of the 30 patients used in the final analysis, 15 received a hospital gown and a prewarmed standard cotton blanket, and 15 received a single-use, forced-air warming gown connected to a portable warming unit capable of generating up to 1,000 BTUs per hour (Bair Paws patient adjustable warming system, Arizant Healthcare, Eden Prairie, MN; gown model 81001, unit model 875). (The patients in the warming gown group also received a standard blanket, but it was not prewarmed and was used only in the PACU.) The temperature of the warming gown can be adjusted using a handheld controller; settings range from low heat and low airflow to high heat and high airflow, and temperatures range from room temperature to 43°C (109°F) (the highest temperature setting is accurate to within 3°C [5.4°F], according to the manufacturer).[21]

Pre- and intraoperative treatment. Patients were invited to participate in the study at the preadmission clinic appointment. Those who agreed then met with one of us (EEB), who gave a brief explanation of the purpose, risks, and methodology of the study. Patients were required to read and sign a consent form. Chart identification of study patients was done in the preadmission clinic: yellow heart-shaped stickers indicated to staff which patients were to receive a prewarmed standard cotton blanket, and purple heart-shaped stickers indicated which were to receive a warming gown. Each group retained the same warming method throughout the perioperative period (defined here as from the time of preoperative preparation in the day surgery through to discharge from the PACU).

Patients who received a warming gown were taught how to adjust the gown's temperature using the handheld controller. Patient temperatures were not recorded while patients were in the OR; but the OR's ambient temperature was obtained using a designated digital room thermometer (Springfield Precision Instruments, model 91551). Preoperatively, patients adjusted the temperature; in the OR and the PACU, the staff did so based on verbal feedback from the patients. Upon patients' return to an orthopedic unit, the warming gown was removed and replaced with a standard hospital gown.

Posttreatment outcome measures. An oral thermometer (Welch Allyn, model 690) was used to measure patient temperature. Oral temperature was taken preoperatively in the day surgery area and postoperatively in the PACU on admission, at 30 minutes after admission, at 60 minutes after admission, and upon discharge from the PACU. Hypothermia was defined as an oral temperature less than 36°C (96.8°F), a common definition.[4, 6, 22]

Postoperative pain was measured using a 0-to-10 verbal numeric rating scale (VNRS), with 0 indicating "no pain" and 10 indicating "the worst pain imaginable." In addition to standard postoperative pain monitoring, patients in this study were specifically asked to rate their pain at 12 and 24 hours after surgery. A score of less than 4 was considered to reflect adequate pain management.[23] An equianalgesic table in the Canadian Pharmacists Association's *Compendium of Pharmaceuticals and Specialities 2009* was used to convert each of the opioids used in study patients during the first 48 hours to its morphine equivalent.[24]

Patient satisfaction with the thermal comfort provided by their assigned warming method was

Table 1. Perioperative Data by Group

Characteristic	Standard blanket group, mean ± SD (n = 15)	Warming gown group, mean ± SD (n = 15)	*P*
Preoperative oral temperature (°C)	36.7 ± 0.3	36.8 ± 0.3	0.5
Operating room temperature (°C)	20.6 ± 1.5	20.5 ± 0.9	0.6
Total anesthetic time in minutes	87.8 ± 20.6	92.9 ± 15.9	0.5
Total surgery time in minutes	60.1 ± 13.5	61.9 ± 14.2	0.9
Total PACU time in minutes	71 ± 22.1	77.2 ± 29.3	0.4

PACU = postanesthesia care unit.

assessed using a 1-to-5 Likert rating scale, with 1 representing "very unsatisfied" with the warming method and 5 representing "very satisfied." This assessment took place in the PACU just before discharge to the orthopedic unit. The scale was developed by one of us (EEB); although it was not tested for validity or reliability, it was modeled on the classic Likert scale.

Statistical analysis. Data were analyzed using SPSS software, version 17. The *t* test was used to measure between-group differences for demographic and perioperative data, and total opioid consumption. A *t* test for repeated measures (an analysis of variance, or ANOVA) was used to examine significant between-group differences for temperature and pain intensity. The Wilcoxon signed rank test was used to assess for between-group differences in patient satisfaction.

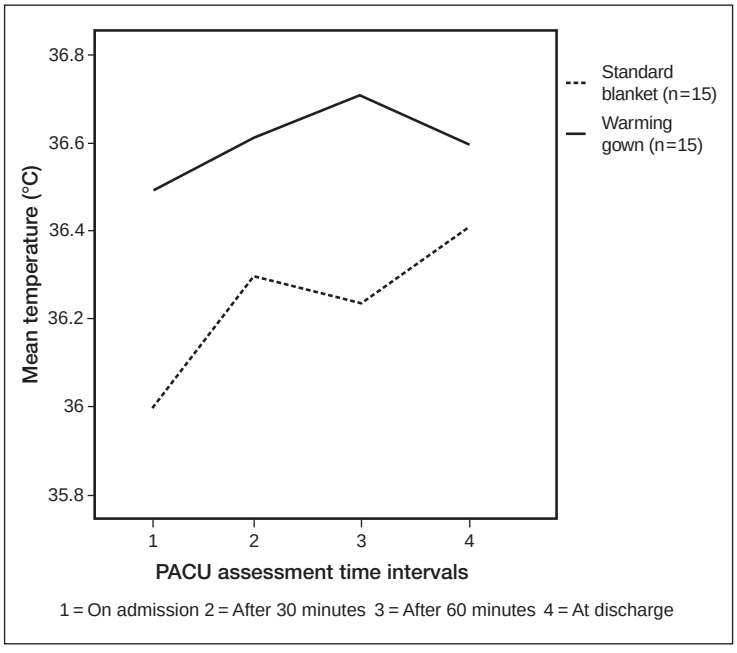
RESULTS

The final study sample consisted of 12 men and 18 women (five men and 10 women in the standard blanket group, seven men and eight women in the warming gown group). For patients in the standard blanket and warming gown groups, mean age was 68.5 years and 68 years, respectively, and mean body mass index was 32.9 and 33.2, respectively. Statistical analysis of the demographic and perioperative data (including preoperative oral temperature, total anesthetic time, total surgical time, and total PACU time) revealed no significant differences between the standard blanket and warming gown groups (see Table 1).

At each of the four PACU assessment time intervals (on admission, 30 minutes after admission, 60 minutes after admission, and at discharge), mean oral temperatures were significantly higher in the warming gown group than in the standard blanket group ($P = 0.009$) (see Figure 1 and Table 2). On admission to the PACU, one patient in the warming gown group was hypothermic (35.9°C), as were three patients in the standard blanket group (34.5°C, 34.6°C, and 34.7°C). Overall, patients in the warming gown group had significantly higher oral temperatures in the PACU than did patients in the standard blanket group ($P < 0.001$).

Mean oral temperatures were significantly higher in the warming gown group than in the standard blanket group.

Figure 1. Mean PACU Temperatures by Group



PACU = postanesthesia care unit.

Figure 2 depicts each group's mean scores for postoperative pain intensity, assessed using the 0-to-10-point VNRS. Patients in the standard blanket group had higher mean postoperative pain scores at 12 hours (4.4) and 24 hours (5.8) after surgery than did those in the warming gown group at 12 hours (3.4) and 24 hours (3.6) after surgery; however, these differences did not reach statistical significance ($P = 0.08$). There were also nonsignificant differences in the proportions of each group experiencing postoperative pain at an intensity of 4 or greater. At 12 hours postoperatively, 60% of the standard blanket group and 43% of the warming gown group reported a mean pain score of 4 or greater ($P = 0.36$). At 24 hours postoperatively, 87% of the standard blanket group and 57% of the warming gown group reported a mean pain score of 4 or greater ($P = 0.08$).

Figure 3 depicts the mean opioid consumption in both groups from the time patients arrived on the orthopedic unit to 48 hours postoperatively. The 48-hour unit total opioid consumption ranged from 18.3 mg to 143.7 mg in the standard blanket group and from 12 mg to 50.2 mg in the warming gown group. The standard blanket group used more total opioid on average than the warming gown group (53.6 ± 37.9 mg versus 31.9 ± 11.7 mg, respectively; $P = 0.05$) during the first 48 hours postoperatively on the unit ($P = 0.05$; Levene's Test for Equality of Variances was performed and corrections applied).

Table 2. PACU Temperatures by Group

Time interval	Standard blanket group				Warming gown group			
	n[a]	Temperature, mean ± SD (°C)	Temperature, minimum–maximum (°C)	Percent of patients with temperature ≥ 36°C	n[a]	Temperature, mean ± SD (°C)	Temperature, minimum–maximum (°C)	Percent of patients with temperature ≥ 36°C
On admission	15	36 ± 0.8	34.5–36.6	80	15	36.5 ± 0.3	35.9–37	93.3
At 30 minutes after admission	13	36.3 ± 0.6	34.6–37.4	92.3	13	36.6 ± 0.2	36.4–36.9	100
At 60 minutes after admission	12	36.2 ± 0.5	34.8–36.5	92	13	36.7 ± 0.2	36.3–37	100
At discharge	15	36.4 ± 0.8	36.3–36.6	100	15	36.6 ± 0.3	35.9–37	100

PACU = postanesthesia care unit.
[a] Where n is less than 15, one or more patient responses were missing.

Patient satisfaction with thermal comfort, assessed using the 1-to-5-point scale, differed significantly between the two groups. Scores of 4 or 5 (that is, "satisfied" or "very satisfied" with thermal comfort) were reported by 21% of patients in the standard blanket group and by 83% of patients in the warming gown group. Mean satisfaction scores for patients in the standard blanket and warming gown groups were 3 ± 0.8 and 5 ± 0.9, respectively ($P = 0.004$).

DISCUSSION

This randomized controlled trial found that the patients in the warming gown group had higher mean oral temperatures in the PACU than did those in the standard blanket group. Compared with patients who received the standard blanket, patients who received the warming gown required less opioid during the first 48 hours after surgery to maintain comparable levels of analgesia. The patients with a warming gown also gave higher satisfaction scores to their thermal comfort than did those receiving a standard blanket.

On average, the warming gown group had significantly higher overall temperatures and higher interval temperatures than the standard blanket group. The differences in mean temperatures between the groups at each of the four PACU time assessment points were 0.5°C, 0.3°C, 0.5°C, and 0.2°C, with the warming gown group consistently demonstrating the higher mean temperature. A clinical practice guideline on the management of inadvertent perioperative hypothermia commissioned by the National Institute for Health and Clinical Excellence (NICE) states that a temperature difference of 0.2°C (0.36°F) or more between any intervention and control group is of clinical significance in hypothermic patients[25]; therefore, the differences in mean temperatures in our study were clinically significant.

Research has shown forced-air warming blankets to be an effective and common method of warming patients, but little is known about the effectiveness of forced-air warming gowns.[26-28] We found two previous studies that specifically tested the use of warming gowns made by Arizant Healthcare Inc. One study examined their use preoperatively in relation to patients' perceptions of thermal comfort and anxiety.[29] The treatment group received a warming gown and, if desired, a nonwarmed cotton blanket; the control group received a standard gown and a warmed cotton blanket. The patients in the treatment group reported less anxiety and more thermal comfort than did those in the control group.

The second study examined the warming gown's efficiency in reducing intraoperative hypothermia by using it to prewarm patients.[30] Both groups wore the warming gown intraoperatively; the treatment group also received about 60 minutes of preoperative warming, but the control group did not. The treatment group demonstrated smaller decreases in core temperature intraoperatively and had less perioperative hypothermia than the control group. The researchers postulated that prewarming with the gown increased patients' core and peripheral temperatures and reduced the impact of temperature redistribution.

Our study found that, on average, the warming gown group had lower pain scores at 12 and 24 hours postoperatively than the standard blanket group, although the difference was nonsignificant. This finding is similar to those of earlier studies on the effects of forced-air warming, which also found no significant differences in pain severity scores between control and treatment groups.[15, 31] That said, however, this finding may need to be

further considered within the context of group differences in analgesic use.

In our study, the standard blanket group used significantly more opioid, on average, during the first 48 hours postoperatively than the warming gown group. This difference in total opioid consumption was observed even though mean pain intensity scores were not significantly different between the groups. The implication is that the patients in the standard blanket group required more opioid to achieve adequate pain relief.

These findings counter those of two earlier studies. One study of the pharmacokinetics of morphine in dogs found that hypothermia was associated with a sustained increase in plasma levels of morphine, which would enhance its pharmacotherapeutic effects[14]; in the other study, conducted in mice, acute cold potentiated morphine's antinociceptive effects.[17] But both studies involved colder temperatures and were performed in animals; our study was performed in humans in the clinical setting.

Patient satisfaction with thermal comfort was found to be significantly different between the groups. This difference might be attributed to the belief that thermal comfort is integral to a patient's perception of well-being. Being warm enough tends to enhance one's sense of contentment. Indeed, an earlier study found that patients who were preoperatively warmed with a forced-air blanket "expressed positive comments about being warm and comfortable," as well as about reduced anxiety.[31] Moreover, patients in the warming gown group in our study were able to preoperatively adjust the temperature of the gown with the handheld controller. Maintaining some degree of control is important to surgical patients.[32] Yet often, from the preoperative through the postoperative periods, very little is under their control. Our study allowed the patients in the warming gown group to have some control over this one small aspect of their care (thermal comfort), albeit for a short period.

A surgical patient's feeling of loss of control may also be related to preoperative anxiety and postoperative pain.[33-36] Anxiety has been found to be predictive of pain; thus the use of anxiety reduction strategies may be helpful.[37] Although we did not assess anxiety, both the ability to control gown temperature and the resulting thermal comfort could be considered as anxiety reducing.

Finally, patients in the standard blanket group may have felt less satisfaction than those in the warming gown group because of a phenomenon known as "compensatory rivalry," which is said to exist when control group participants believe they are receiving inferior treatment.[38] This was observed by some of the day surgery nurses, who told one of us (EEB) that a few standard blanket participants had expressed a desire to have the warming gown and were disappointed that they received the standard blanket.

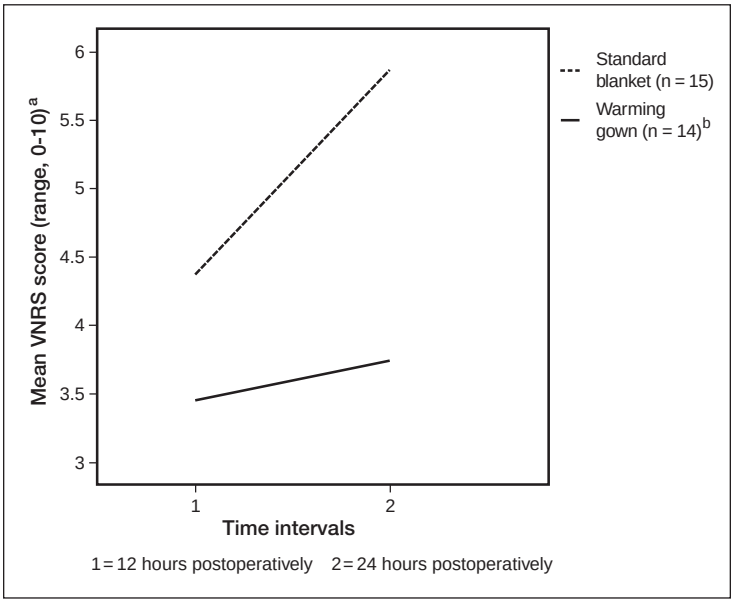
Limitations. There were five limitations of our study worth noting. First, this was not a blinded study. Study patients were aware of which warming method they received, as were the nurses and physicians who cared for them. It would have been impossible to blind the patients and staff to these methods. Because the study wasn't blinded, conscious bias may have affected both patients' responses and the care provided by staff.

Another limitation was the lack of standardization of administration of the anesthetic. Although study participants had a bupivacaine spinal anesthetic with intrathecal morphine, the dosage of intrathecal morphine used and the adjunctive medications given varied, as determined by the anesthesiologist. Because patients were randomized, however, it was anticipated that any effects of these variations would be minimal.

A specific gown temperature was not tested. Since patients could control the temperature preoperatively and could ask for adjustments intra- and postoperatively, gown temperatures likely varied over the course of use by one patient as well as from one patient to another.

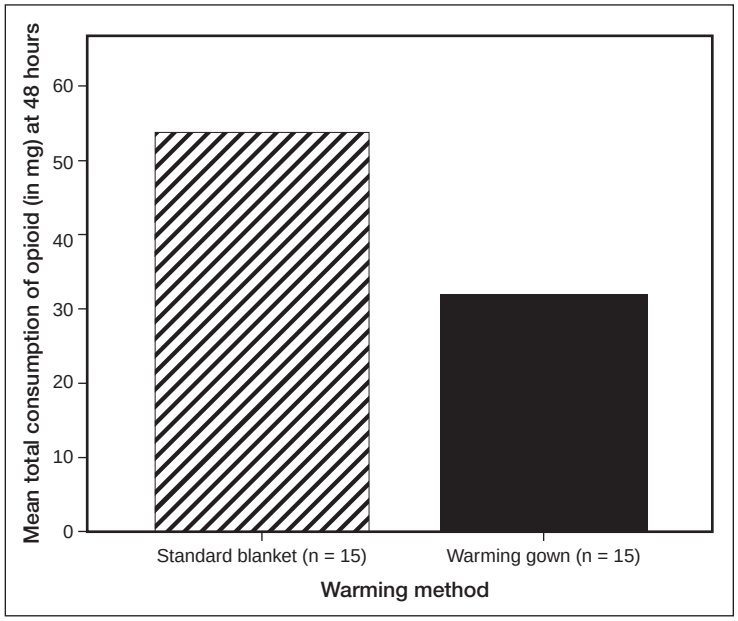
Similarly, the temperature of the standard blanket upon removal from the warming cupboard may have varied. The temperature of the warming cupboard was not monitored, and variations in blanket temperature were likely, given the opening of the cupboard door and the addition of blankets at room

Figure 2. Mean Pain Intensity Scores by Group



VNRS = verbal numeric rating scale.
[a] VNRS range is from 0, no pain, to 10, worst pain imaginable.
[b] In the warming gown group, n is 14 because one patient's responses were missing.

Figure 3. Mean 48-Hour Opioid Consumption by Group



temperature. This situation reflects real clinical practice, and such temperature variations may have been difficult to control for.

Temperature variations in the OR also occurred, and were not adjusted for. It's possible that the OR temperature affected the warming or cooling of the patient, and that the measured effects were not strictly due to the warming method used.

The intent of this study, however, was not to determine an ideal temperature for perioperative patients. Rather, it was to determine the efficacy of active warming in addressing perioperative hypothermia and postoperative pain. Perhaps future studies will examine the possibility of identifying an optimal temperature for perioperative patients.

CONCLUSIONS

This study has implications for nursing practice, education, and research. Every day, countless patients are exposed to the risk of inadvertent hypothermia and its deleterious effects. With the availability of state-of-the-art technologic devices such as the patient-controlled, forced-air warming gown, this risk could be reduced. Active patient warming should be undertaken, especially in patients whose thermoregulating mechanisms may be less effective (such as older adults). The NICE guidelines recommend active warming for surgical patients whenever the expected duration of anesthesia is longer than 30 minutes, as is the case with TKA.[25] Active warming devices (such as forced-air blankets and gowns) may be applied by nurses from the preoperative phase through the postoperative phase of care.

Forced-air warming devices can be expensive; but when the cost of a device is weighed against the costs of treating a patient for the consequences of hypothermia, their use may make economic sense. For example, the Bair Paws warming unit costs about $3,000, which the manufacturer usually provides at no charge when a facility also purchases the warming gown; each gown costs about $25. In comparison, Wagner and colleagues reported the average cost of a cotton blanket at about $10 per patient, which does not include warming cabinet costs.[29] A forced-air warming gown replaces both the standard cotton blanket and the need for a forced-air warming blanket in the OR (at a cost of about $14). So the direct costs are comparable. In addition, indirect or hidden costs should also be considered. Using more effective warming methods saves nurses' time that can then be used for direct patient care.

Although pain was fairly well managed in both the standard blanket and warming gown groups, as evidenced by the pain scores, pain management continues to be a challenge for nurses and other health care professionals. We believe there is a need for ongoing pain management education for nurses in the workforce as well as for nursing students. Effective pain control strategies continue to evolve. For example, our study found that opioid consumption was decreased when patients were warmed with a warming gown. This suggests that such active warming might be a simple, effective strategy in managing postoperative pain—one that might also yield further savings in drug and infusion device costs.

Ongoing education about inadvertent perioperative hypothermia and its consequences is also essential. Within the past decade or so, there has been more research in this area, as well as into the effectiveness of technologic advances such as forced-air warming. Health care organizations worldwide have begun creating evidence-based guidelines and protocols for the prevention and management of inadvertent perioperative hypothermia. These will be of great benefit in helping to increase the knowledge of nurses and other health care professionals.

This study attempted to answer some of the questions surrounding inadvertent perioperative hypothermia and postoperative pain, specifically in patients who undergo TKA. The findings provide support for the use of patient-controlled, forced-air warming gowns in reducing the need for postoperative opioids and improving patients' thermal comfort and satisfaction. Areas for further research also include the efficacy and safety of specific types of active warming devices, as well as their environmental implications. (For example, although the warming gown used in this study is single use, some components are recyclable; and although standard cotton blankets are reusable, prewarming and

cleaning them requires energy.) Further research into the costs of various warming methods and the costs associated with undertreated hypothermia and its consequences in specific patient populations would be useful. Since nurses are likely to be assessing patients for perioperative hypothermia, implementing a warming method, and addressing postoperative pain, it's essential for nurses to be involved in the relevant research. ▼

For 23 additional continuing nursing education articles on research topics, go to www.nursingcenter.com/ce.

Ember E. Benson is a surgery inpatient educator at Seven Oaks General Hospital in Winnipeg, Manitoba, Canada. Diana E. McMillan is an associate professor in the Faculty of Nursing and Bill Ong is a professor in the Department of Anesthesia, both at the University of Manitoba in Winnipeg. *This research was supported by an unrestricted educational grant from the Fort Garry Branch Royal Canadian Legion Poppy Fund. The Bair Paws warming systems were provided gratis by Arizant Healthcare Inc., and the oral thermometers were provided gratis by Welch Allyn.* *Contact author: Ember E. Benson, ebenson@sogh.mb.ca.* *The authors have disclosed no potential conflicts of interest, financial or otherwise.*

REFERENCES

1. Buggy DJ, Crossley AW. Thermoregulation, mild perioperative hypothermia and postanaesthetic shivering. *Br J Anaesth* 2000;84(5):615-28.
2. Sessler DI. Mild perioperative hypothermia. *N Engl J Med* 1997;336(24):1730-7.
3. Barone CP, et al. Postanesthetic care in the critical care unit. *Crit Care Nurse* 2004;24(1):38-45.
4. Cooper S. The effect of preoperative warming on patients' postoperative temperatures. *AORN J* 2006;83(5):1073-84.
5. Kumar S, et al. Effects of perioperative hypothermia and warming in surgical practice. *Int Wound J* 2005;2(3):193-204.
6. Bitner J, et al. A team approach to the prevention of unplanned postoperative hypothermia. *AORN J* 2007;85(5):921-9.
7. Allen HW, et al. Peripheral nerve blocks improve analgesia after total knee replacement surgery. *Anesth Analg* 1998;87(1):93-7.
8. Pitimana-aree S, et al. An economic evaluation of bupivacaine plus fentanyl versus ropivacaine alone for patient-controlled epidural analgesia after total-knee replacement procedure: a double-blinded randomized study. *Reg Anesth Pain Med* 2005;30(5):446-51.
9. Singelyn FJ, et al. Effects of intravenous patient-controlled analgesia with morphine, continuous epidural analgesia, and continuous three-in-one block on postoperative pain and knee rehabilitation after unilateral total knee arthroplasty. *Anesth Analg* 1998;87(1):88-92.
10. Chelly JE, et al. Anesthesia and postoperative analgesia: outcomes following orthopedic surgery. *Orthopedics* 2003;26(8 Suppl):s865-s871.
11. Hill N, Davis P. Nursing care of total joint replacement. *Journal of Orthopaedic Nursing* 2000;4(1):41-5.
12. Pyati S, Gan TJ. Perioperative pain management. *CNS Drugs* 2007;21(3):185-211.
13. Rocchi A, et al. Canadian survey of postsurgical pain and pain medication experiences. *Can J Anaesth* 2002;49(10):1053-6.
14. Bansinath M, et al. Influence of hypo and hyperthermia on disposition of morphine. *J Clin Pharmacol* 1988;28(9):860-4.
15. Persson K, Lundberg J. Perioperative hypothermia and postoperative opioid requirements. *Eur J Anaesthesiol* 2001;18(10):679-86.
16. Puig MM, et al. Effects of temperature on the interaction of morphine with opioid receptors. *Br J Anaesth* 1987;59(11):1459-64.
17. Schlen H, Bentley GA. The possibility that a component of morphine-induced analgesia is contributed indirectly via the release of endogenous opioids. *Pain* 1980;9(1):73-84.
18. Good M, Moore SM. Clinical practice guidelines as a new source of middle-range theory: focus on acute pain. *Nurs Outlook* 1996;44(2):74-9.
19. Good M, Chin CC. The effects of Western music on postoperative pain in Taiwan. *Kaohsiung J Med Sci* 1998;14(2):94-103.
20. Huth MM, Moore SM. Prescriptive theory of acute pain management in infants and children. *J Soc Pediatr Nurs* 1998;3(1):23-32.
21. Arizant Healthcare Inc. Bair Paws model 875 warming unit operator's manual. Eden Prairie, MN. n.d.
22. Burns SM, et al. Unintentional hypothermia: implications for perianesthesia nurses. *J Perianesth Nurs* 2009;24(3):167-73.
23. McCaffery M. Using the 0-to-10 pain rating scale. *Am J Nurs* 2001;101(10):81-2.
24. Repchinsky C, editor. *CPS: Compendium of Pharmaceuticals and Specialties: The Canadian Drug Reference for Health Professionals*. 44th ed. Ottawa, ON: Canadian Pharmaceutical Association; 2009.
25. National Collaborating Centre for Nursing and Supportive Care. *Clinical practice guideline: the management of inadvertent perioperative hypothermia in adults*. London: National Institute for Health and Clinical Excellence; 2008 Apr. http://www.nice.org.uk/nicemedia/pdf/CG65Guidance.pdf.
26. Berti M, et al. Active warming, not passive heat retention, maintains normothermia during combined epidural-general anesthesia for hip and knee arthroplasty. *J Clin Anesth* 1997;9(6):482-6.
27. Kurz A. Thermal care in the perioperative period. *Best Pract Res Clin Anaesthesiol* 2008;22(1):39-62.
28. Ng SF, et al. A comparative study of three warming interventions to determine the most effective in maintaining perioperative normothermia. *Anesth Analg* 2003;96(1):171-6.
29. Wagner D, et al. Effects of comfort warming on preoperative patients. *AORN J* 2006;84(3):427-48.
30. Andrzejowski J, et al. Effect of prewarming on post-induction core temperature and the incidence of inadvertent perioperative hypothermia in patients undergoing general anaesthesia. *Br J Anaesth* 2008;101(5):627-31.
31. Fossum S, et al. A comparison study on the effects of prewarming patients in the outpatient surgery setting. *J Perianesth Nurs* 2001;16(3):187-94.
32. Costa MJ. The lived perioperative experience of ambulatory surgery patients. *AORN J* 2001;74(6):874-81.
33. Caumo W, et al. Risk factors for preoperative anxiety in adults. *Acta Anaesthesiol Scand* 2001;45(3):298-307.
34. Kain ZN, et al. Preoperative anxiety and postoperative pain in women undergoing hysterectomy: a repeated-measures design. *J Psychosom Res* 2000;49(6):417-22.
35. Ozalp G, et al. Preoperative emotional states in patients with breast cancer and postoperative pain. *Acta Anaesthesiol Scand* 2003;47(1):26-9.
36. Vaughn F, et al. Does preoperative anxiety level predict postoperative pain? *AORN J* 2007;85(3):589-604.
37. Feeney SL. The relationship between pain and negative affect in older adults: anxiety as a predictor of pain. *J Anxiety Disord* 2004;18(6):733-44.
38. Brink PJ, Wood MJ, editors. *Advanced design in nursing research*. 2nd ed. Thousand Oaks, CA: Sage Publications; 1998.