Should Patients Undergoing Ambulatory Surgery with General Anesthesia Be Actively Warmed?

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Citation

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Abstract

We compared active warming (convective and IV fluid warming) with routine thermal care (RTC) in 383 adults. At the end of surgery, core temperature was higher in the actively warmed group compared with RTC (mean ± SD: 36.4 ± 0.5 vs 35.8 ± 0.6 oC, P < 0.0001). More patients in the RTC group were hypothermic (< 36°C) at the end of surgery compared with active warming (53 vs. 17%, P < 0.001). More patients shivered and required interventions for shivering and hypothermia in the RTC compared with the actively warmed group (20 vs 3%, P < 0.001). There was no difference in time to discharge between groups (114-115 min) or in patient satisfaction with their anesthetic at 2 weeks (92-95% good or excellent ratings). Only 1 patient (RTC) recalled shivering. Costs were higher with active warming compared with RTC ($26.26 vs. $6.70 per patient).

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INTRODUCTION

Hypothermia (core temperature < 36 °C) often occurs during general anesthesia because of impaired thermoregulation, redistribution of heat from the core to the periphery, infusion of room temperature IV fluids, decreased metabolic heat production, and heat loss to a cold operating room environment [1,2,3] In patients undergoing surgeries requiring postoperative hospitalization, intraoperative hypothermia has been shown to increase blood loss and transfusion requirements, wound infections, adverse cardiac outcomes, and the duration of hospitalization. [4,5,6] Other complications of hypothermia include prolonged recovery room stay, enhanced anesthetic drug effect, shivering, and impaired immune function. [7,8,9,10,11,12,13] In an effort to avoid hypothermia, it has become routine anesthetic practice to actively warm inpatients undergoing major surgeries with convective warming (forced-air). Convective warming is routinely combined with IV fluid warming if the surgery is accompanied by major fluid shifts.

In patients undergoing ambulatory surgery, however, the choice of whether to apply active warming methods is often made arbitrarily since the risk of blood transfusion, wound infection, adverse cardiac outcomes, and hospitalization is low. Moreover, it has been our impression that non-warmed outpatients frequently receive many warm hospital bath blankets by nursing and anesthesia personnel in addition to postoperative radiant heat, meperidine, and other measures to improve patients' thermal comfort level and promote patient satisfaction. Use of these techniques may, in turn, increase costs.

Intraoperative hypothermia during ambulatory surgery can be minimized by prewarming the patient in the holding area prior to induction of anesthesia and by infusing warm IV fluids. [14,15] The effectiveness of prewarming is due to the reduction or elimination of the normal core to peripheral temperature gradients that exist in the awake state, which in turn minimizes heat loss from the core to the periphery. [16] The effectiveness of warming IV fluids is due to the high specific heat of water. The negative thermal balance of infusing 1-1.5 liter of 21°C crystalloid into a normothermic patient is -16 to -24 kcal and is sufficient to decrease body temperature in a 70 kg patient by about 0.25- 0.38°C. [17]

The purpose of this study was to evaluate the incidence, severity, costs, and complications of hypothermia in two groups of patients undergoing ambulatory surgery requiring general anesthesia: group 1- active pre and intraoperative warming and group 2- routine thermal care (RTC). The

hypotheses were that compared with RTC, actively warmed patients would have a decreased incidence of hypothermia and shivering, and shorter recovery room stay.

MATERIALS AND METHODS

The protocol was approved by the Institutional Review Board and written informed consent was obtained. ASA physical status 1-3 adults, undergoing elective ambulatory gynecologic, orthopaedic, urologic and general surgery scheduled to last > 30 minutes were studied. Exclusion criteria were emergency surgery, age < 18 or > 85 years, indication of abnormal clot formation properties or bleeding as determined by patient or family history, use of coumadin, family or personal history of malignant hyperthermia, pre-operative temperature >38°C or ≤35°C, chemotherapy within the past 3 months, major surgical procedure within the past 3 months, surgical procedure scheduled to last <30 min, use of immunosuppressive drugs or corticosteriods 2 weeks prior to surgery, known cold agglutinins and cold induced vasospasm (e.g., Raynaud's disease), and pregnancy. Patients were identified through the presurgical evaluation clinic and the daily surgical schedule. A random number generating algorithm was used to randomize the subjects to either active warming, n =191, or RTC, n= 192.

Actively warmed patients received preoperative convective warming (Snuggle Warm Convective Warming System, SIMS, Irvine, CA). The upper or lower body warming blanket was applied over approximately 40% anterior body surface area in the preoperative holding area, and forced air was delivered at the medium setting (40± 1°C hose end temperature). The warming unit draws ambient room temperature air through an ultra fine glass inlet filter. Filtered air is passed through a 0.2 micron outlet filter and delivered through a hose to the disposable blanket.. Duration of prewarming was targeted at 30 min based on the observation that arm and leg heat content increases by 69 kcal during the first 30 min of warming, an amount similar to heat loss due to redistribution in healthy volunteers. [16]During surgery, the convective blanket was applied using coverage appropriate for the given surgical procedure. At the end of surgery, the convective blanket was removed and the patient was covered with a standard hospital bath blanket. Intraoperatively, IV fluids were infused via a fluid warmer (Hotline with L-70 disposable, Level 1 Technologies, Inc, Rockland, MA). The fluid warming device heated water to a 42°C setpoint, and the warm water was then circulated through the L-70 disposable which had a central lumen for IV fluid administration surrounded by an outer layer through which the warm water circulated down one side and then back up to the heated reservoir. This method of heat exchange has been shown to heat room temperature IV fluids to ~ 38-39°C at clinically relevant flow rates.[18] At the end of anesthesia, the fluid warming disposable was disconnected and the patient was transported to the post anesthesia care unit (PACU) with a standard IV administration set. Any patient developing intraoperative core temperature > 37°C had the convective warming unit turned off to avoid overheating.[19]

RTC patients received intraoperative convective and/or IV fluid warming at the discretion of the anesthesiologist. The temperature setting of the convective blanket was not dictated by protocol. In both groups, warm hospital blankets were applied to the patient prior to induction of anesthesia by the circulating nurse according to patient need.

Premedication was with midazolam 1-2 mg. All patients underwent general anesthesia. Choice of anesthetic agent was at the discretion of the attending anesthesiologist and not dictated by protocol. Anesthesia was induced with propofol or thiopental, and fentanyl or remifentanil. Anesthesia was maintained with isoflurane, sevoflurane, or propofol, supplemented with opioids and/or N2O. Neuromuscular relaxants were used as indicated. Anesthetic gases were delivered via a tracheal tube or a laryngeal mask airway (LMA) using a circle system, heat and moisture exchanger (Humid-Vent, Gibeck Respiration, Upplands Vasby, Sweden) and CO_2 sodalime absorber. The heat and moisture exchanger was placed between the Y-piece of the circle system and the breathing tube. The ambient room temperature was set at 21 °C. Fluids were infused as clinically indicated to maintain normovolemia. Prophylactic antibiotics were given according to surgeon preference.

Sublingual temperatures were measured with an electronic thermometer (IVAC Temp Plus II thermistor, IVAC Corp., San Diego, CA) preoperatively and in the PACU postoperatively. Sublingual placement and mouth closure was carried out during all measurements by nurses experienced in the use of this device. Intraoperatively, distal esophageal (tracheally intubated patients) or nasopharyngeal (LMA patients) temperatures were measured at 15 minute intervals following induction until the end of surgery using an 18 or 9 Fr esophageal stethoscope with thermocouple sensor (Respiratory Support Products, Inc., SIMS, Irvine, CA). The temperature was continuously displayed on a two channel monitor (Bi-Temp, Model TM-200D, Respiratory

Support Products, Inc.).

Postoperative data were recorded within 5 min of arrival (initial) to the PACU, and after 30 and 60 minutes in the PACU by a nurse who was unaware of patient group. Data consisted of vital signs, sublingual temperature, presence or absence of shivering, severity of shivering, medication requirements, time to discharge, and use of heating devices such as radiant heat and warm hospital blankets. Presence or absence of shivering was determined by visual examination, and shivering was recorded as mild if it did not interfere with monitoring and did not require treatment with meperidine, and severe if meperidine treatment was required for patient discomfort or interference with monitoring of vital signs. [20] Radiant heat lamps and warm blankets were used per protocol to treat mild postoperative shivering and/or sublingual temperature < 35.5 °C. Standardized discharge criteria were used to determine PACU stay.

Other data recorded included body surface area coverage of convective blanket (modified burn rule of 9, Berkow formula), change in intraoperative temperature management, number of warm hospital blankets used throughout the intraoperative period, type and volume of intraoperative fluids administered. Patients were contacted 14 days post surgery by a general clinical research center nurse blinded to patient group to answer questions about infections or complications, thermal comfort (comfortable, too warm, too cold, shivered, no memory), satisfaction (excellent, good, fair, poor), and if the patient would choose the same anesthetic again if offered the choice (yes/ no) .

Statistical analysis was with the SAS System and Statistix for Windows Version 8.0 (Tallahassee, FL). Parametric data (reported as means ± SD) were compared between groups using unpaired Student's t test. Non-parametric data were compared between groups with Chi Squared analysis, Fishers Exact test, and the Cochran- Mantel- Haenszel test. A P value < 0.05 was considered significant.

RESULTS

A total of 37 patients were excluded leaving 336 patients available for analysis (active warming, n= 156 and RTC, n=180. Reasons for exclusion were surgical factors (n= 13) such as change in date of surgery, surgery cancellation or surgeon refusal; anesthesia factors (n=15) such as use of regional, local or IV sedation instead of general anesthesia; and patient factors (n= 7) such as patient changed their mind on the day of surgery. Warming equipment problems occurred in 2 active warming patients- ripped convective

blanket in 1, and unspecified fluid warmer malfunction in the second patient. Prewarming time was 42± 38 minutes in the actively warmed group.

The groups were similar with respect to age, weight, height, gender, ASA physical status, and other factors. There were more general surgery patients in the active warming group vs RTC (22 vs 13%, P < 0.05).

Figure 1

Table 1: Patient data

Active Warming		Routine Thermal Care
Age (years)	40± 13	40± 13
Male	49 (31%)	49 (27%)
Female	107 (69%)	131 (73%)
Weight (kg)	78 ±15	76 ±16
Height (cm)	166 ±16	165± 14
Medical History		
Current Smoker	67 (43%)	72 (40%)
Diabetes	6 (4%)	6 (3%)
ASA Physical Status		
I	28 (18%)	34 (19%)
II	120 (77%)	123 (68%)
III	8 (5%)	23 (13%)
Type of Surgery *		
Gynecology	72 (46%)	82 (46%)
Orthopaedics	46 (29%)	70 (39%)
General	34 (22%)	24 (13%)
Urology	4 (3%)	4 (2%)

Data are means ± SD or number of patients (%). * P< 0.05 between groups.

In both groups, temperature decreased after induction, but to a greater extent in controls (P< 0.001, Table 2). Final temperature at the end of surgery was higher in the actively warmed group (Table 2, P < 0.001). More RTC patients were hypothermic at the end of surgery compared with the actively warmed group (Table 2, P < 0.001). Final temperature was higher in those RTC patients receiving convective warming vs those not actively warmed (36.0± 0.6, range 34.3-37.0 vs 35.8± 0.6°C, P< 0.02). Duration of anesthesia and fluid requirements were similar between groups

Figure 2

Table 2: Intraoperative data

	Active Warming	Routine Thermal Care
Anesthesia Time (min)	95± 38	93± 40
Surgery Time (min)	56± 33	56± 35
Endotracheal tube	73 (47%)	99 (55%)
Laryngeal mask	83 (53%)	81 (45%)
Crystalloid (mL)	1127± 368	1088± 414
Colloid, (mL)	0	500, n=1
Estimated Blood Loss (mL)	10± 15	11± 23
Temperature Data (°C)		
Room, initial	22.0± 1.3	21.4± 1.4
Room, final	21.7± 1.4	21.1± 1.5
Sublingual, baseline	36.6± 0.4	36.7± 0.4
Core, lowest	36.0± 0.5*	35.6± 0.6
Core, final	36.4± 0.5*	35.8± 0.6
Time to core lowest (min)	25± 19	35± 27
Final core < 35.5 °C	6 (4%)^	45 (25%)
Final core < 36.0 °C	27 (17%)^	96 (53%)

Data are means ± SD or number of patients (%). * P< 0.0001 between groups. ^P < 0.001 between groups. Core: distal esophageal or nasopharyngeal temperature.

Fifty two RTC patients received convective warming and 16 RTC patients received IV fluid warming. Ten actively warmed patients required discontinuation of intraoperative heating (Table 3).

Figure 3

Table 3: Intraoperative temperature management

	Active Warming	Routine Thermal Care
Upper body convective blanket	137 (88%)	40 (22%)
Lower body convective blanket	19 (12%)	12 (7%)
Surface area covered (%)	18± 6	17± 6
Heating change		
Turn off convective warmer (gp 1 only)	10 (6%)	N/A
Turn off fluid warmer (gp 1 only)	1 (1%)	N/A
Decrease temp of convective warmer	2 (1%)	0
Add convective warmer (gp 2 only)	N/A	52 (29%)
Add fluid warmer (gp 2 only)	N/A	16 (9%)
Increase temp of convective warmer	13 (8%)	13 (25%)
Number of warm hospital bath blankets*		
Start of case	53	284
End of case	79	248
Total bath blankets	132	532

Data are means ± SD, number of patients (%), or number of blankets. Some patients received more than 1 warm hospital blanket. N/A- not applicable. *P < 0.001 between groups.

Anesthetic agents, antiemetics, and antibiotic prophylaxis were similar between groups:

Figure 4

Table 4: Intraoperative anesthetic drugs

|	Active Warming	Routine Thermal Care
Primary agent		
Isoflurane	134 (86%)	160 (89%)
Sevoflurane	17 (11%)	16 (9%)
Propofol	5 (3%)	4 (2%)
Nitrous oxide, %	54± 7, n=142 (91%)	52± 7, n=155 (86%)
Neuromuscular relaxant	71 (46%)	100 (56%)
Induction agent		
Propofol, mg	169± 45, n=147 (94%)	172± 51,n=169 (94%)
Thiopental, mg	314± 54, n=7 (4%)	279±101,n=6 (3%)
Sevoflurane, n	2 (1%)	5 (3%)
Analgesics		
Fentanyl, mcg	221± 118, n=151 (97%)	225±126,n=173(96%)
Morphine, mg	5± 2, n=15 (10%)	7± 5, n=15 (8%)
Antiemetics		
Ondansetron, n	105 (67%)	137 (76%)
Other antiemetics, n	51 (33%)	53 (29%)
Antibiotics		
Cefazolin, n	70 (45%)	61 (34%)
Other antibiotics, n	5 (3%)	11 (6%)

Data are means ± SD and number of patients (%).Some patients received > 1 analgesic or antiemetic. There were no significant intergroup differences.

There were 2 unplanned hospital admissions to the ICU: decreased level of consciousness after hysteroscopy (active warming group, final temperature =36.3°C); cardiorespiratory problems after incisional hernia repair (RTC group, final temperature =35.9 °C).

Postoperatively, more RTC patients required warm blankets, meperidine, and radiant heat for treatment of core temperature < 35.5°C and/or shivering compared with group 1 (Figure 1, P < 0.001).

Figure 5

Figure 1: Post-anesthesia care unit treatment of core temperature < 35.5°C and/or shivering. More patients in the routine thermal care group (controls) required warm blankets, meperidine, and radiant heat compared with actively warmed patients (P < 0.001).
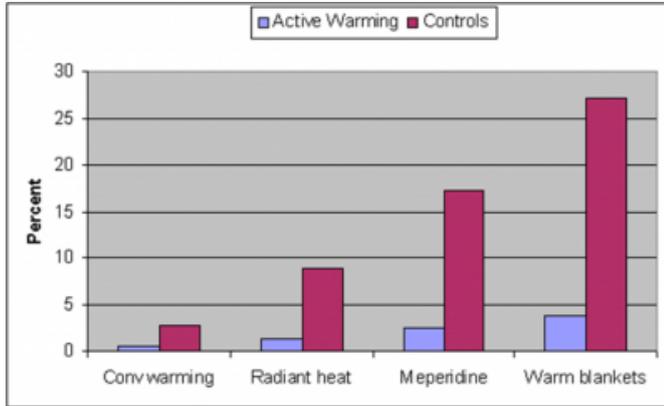
The incidence and severity of shivering was higher in the RTC group (Table 5, P < 0.001). Temperature was higher in the actively warmed group throughout the PACU stay (Table 5). Heart rate was higher postoperatively in actively warmed patients (P = 0.03, Table 5). There were no intergroup differences in opioids for pain or antiemetics for nausea/vomiting.

Figure 6

Table 5: Post-anesthesia care unit data

Active Warming		Routine Thermal Care
Vital signs on arrival		
Systolic BP, mmHg	133± 17	133± 16
Diastolic BP, mmHg	71± 12	70± 14
Heart rate, per min+	86± 14	83± 15
Respirations, per min	15± 3	15± 4
Oxygen saturation, %	97± 2	97± 3
Sublingual temperature (°C)		
On arrival	36.4± 0.5*	36.0 ±0.5
After 30 min	36.4± 0.4*	36.0± 0.5
After 60 min	36.4± 0.4*	36.2± 0.5
At Discharge	36.4± 0.4*	36.2± 0.4
Shivering^		
None	151 (97%)	144 (80%)
Mild	1 (0.6%)	5 (3%)
Severe	4 (2.6%)	31 (17%)
Meperidine for shivering, mg	25± 0, n=4	29± 17, n=31
O2 Sat < 91% on arrival	2 (1.3%)	7 (3.9%)
Airway on arrival	2 (1.3%)	3 (1.7%)
Antiemetics		
1	17 (11%)	28 (16%)
> 1	5 (3%)	7 (4%)
Time to discharge, min	114± 50	115± 59

BP= blood pressure. Airway = tracheal tube or laryngeal mask. Data are means ± SD and number of patients (%).*P < 0.0001 between groups. ^P < 0.001 between groups. +P=0.03 between groups. Two patients, one in each group, required ICU admission postoperatively. Data for these two patients are excluded.

Time spent in the PACU was similar between groups (114 ± 50 vs 115 ± 59 min, Figure 2).

Figure 7

Figure 2: Frequency distribution of discharge times for actively warmed and routine thermal care patients (controls). There were no significant differences between groups.
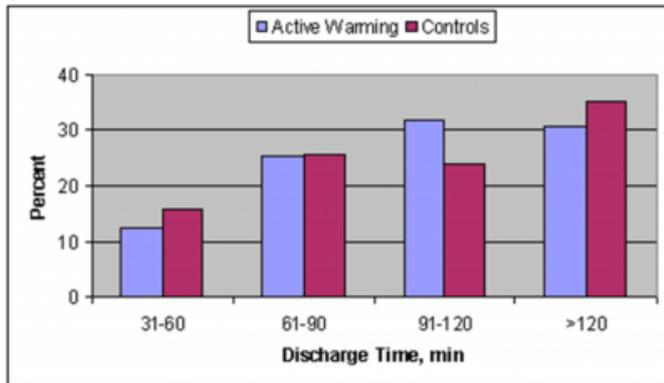
Overall, hypothermic patients spent approximately 11 minutes longer in the PACU compared to those whose temperatures were ≥ 36°C (122± 58 min vs 111± 53 min, P < 0.04).

There were no intergroup differences in patient satisfaction (Table 6). Level of thermal comfort was, however, different between groups (Table 6, P < 0.05): actively warmed patients reported feeling too warm more frequently than group 2; and RTC patients reported feeling too cold more frequently than group 1.

Figure 8

Table 6: Postoperative questionnaire

	Active Warming	Routine Thermal Care
Effective of anesthetic		
Excellent or good	83 (95%)	86 (92%)
Fair or poor	4 (5%)	6 (7%)
Don't know	0	1 (1%)
Choose same anesthetic		
Yes	81 (93%)	85 (91%)
No	6 (7%)	8 (9%)
Level of Thermal Comfort, preoperatively†		
Comfortable	68 (78%)	82 (88%)
Too warm	9 (10%)	0
Too cold	6 (7%)	9 (10%)
No memory	4 (5%)	2 (2%)
Level of Thermal Comfort, postoperatively†		
Comfortable	67 (77%)	69 (74%)
Too warm	8 (9%)	2 (2%)
Too cold	2 (2%)	9 (10%)
Had shivering	0	1 (1%)
No memory	10 (11%)	12 (13%)

Data are numbers of patients (%). 87 patients completed the telephone interview in the active warming group 1 and 93 in the routine thermal care group. †P <0.05 between groups.

DISCUSSION

The present study showed that active warming was effective in maintaining perioperative normothermia in the majority of outpatients undergoing surgery with general anesthesia. There was a low incidence of core temperature < 36°C in the actively warmed group, and a low requirement for PACU recovery room interventions for hypothermia and shivering. These results are in agreement with previous studies that have shown convective warming to be an efficient method for maintaining perioperative normothermia. [4,5,6,7, 21,22,23] For example, Kurz et al showed that convective warming maintained core temperature better than circulating water mattresses in adults undergoing major maxillofacial surgery and total hip arthroplasty.[24] Similarly, Hynson and Sessler showed that convective warming was more effective than heated humidified gases and circulating-water blankets at maintaining core temperature in patients undergoing kidney transplantation for end-stage renal disease. [25] As well, convective warming was superior to passive insulation with reflective thermoplastic-aluminum composite material in patients undergoing total hip arthroplasty.[26]

It should be noted that the use of preoperative convective warming did not completely prevent redistribution hypothermia in the active warming group, since temperature did fall maximally from 36.6 to 36.0 °C. Moreover, 17% of the actively warmed group had core temperature < 36.0°C at the end of surgery. The decrease in temperature in these patients was likely due to a combination of factors which might reduce the effectiveness of warming measures. Such factors include requirement for removal or repositioning of the convective blanket in the holding area for physical exam; turning off warming devices during transfer to the operating room and subsequent delay in turning the devices back on; removal and/or repositioning of the convective blanket during placement of monitors, surgical positioning, surgical skin preparation, and short duration of surgery. Efficacy of prewarming with convective heat can be impeded by thermoregulatory sweating provoked by high skin temperature and/or a rapid increase in skin temperature. [16]Indeed, 10% of actively warmed patients did report feeling too warm preoperatively. Efficacy of intraoperative convective warming can be impeded by short duration of surgery, since it takes time for externally applied heat to reach the core thermal compartment. The average surgery duration in the present study was less than 1 hour.

Active warming did serve to minimize redistribution hypothermia in the present study since RTC patients had, on average, a 1.1°C decrease in temperature which was substantially greater than that of actively warmed patients (0.6°C decrease). Prewarming combined with intraoperative

convective warming has previously been shown to be superior to intraoperative convective warming alone in female patients undergoing elective abdominal surgery of about 3 h duration. [27] Similarly, 15 min of prewarming combined with intraoperative warming prevented hypothermia and shivering in patients undergoing elective cesarean delivery with epidural anesthesia. [28] Convective and IV fluid warming has been shown to be superior to convective warming alone in adults undergoing major gynecologic, orthopaedic, and general surgery of approximately 2-3 h duration. [19]

IV fluid warming alone has been shown to be an important method of heat conservation.[29]For example, Patel et al demonstrated that the use of the Hotline fluid warmer during outpatient gynecologic surgeries resulted in a 0.5-0.7°C warmer core temperature as compared with room temperature fluids, and that outpatients receiving warmed IV fluids were more likely be normothermic at the conclusion of surgery and in the PACU. [14]However, delivery of 1.1 liters of IV fluids (average amount infused in our study) at 38-39°C cannot transfer enough heat to rewarm patients who are already hypothermic. Thus, in addition to administering thermally neutral fluids, covering as large a surface area as possible with a convective warming blanket during anesthesia and surgery, will minimize cutaneous heat loss, and allow internal metabolic heat production to warm the core. The average surface area available for convective warming in our study, however, was quite limited at 17-18% body surface area. Other methods such as maintaining a warm room, humidifying dry anesthetic gases, and meticulous attention to passive insulation can also minimize heat loss, especially in anesthetized patients undergoing long surgeries [30,31]

Actively warmed patients did not have a shorter discharge time compared with RTC despite the higher core temperatures and lower frequency of shivering. This is in contrast to a randomized controlled trial in which Lenhardt et al showed that normothermic patients recovering from elective major abdominal surgery with thiopental, isoflurane, N2O, fentanyl, and vecuronium of 3.2-3.4 h duration required about 53 minutes to reach fitness for PACU discharge, nearly 40 minutes sooner than hypothermic patients. [7] Although we measured actual discharge time instead of the more sensitive fitness for discharge time, it appears that core temperature may only minimally influence the time required to discharge patients from the PACU, a finding previously reported by Bissonnette and Sessler in

children after ambulatory surgery, [32] and by Fleisher et al in adults after gynecologic, plastic, orthopedic, or general surgery of at least 2 h duration. [33] Other confounding factors affecting PACU discharge times include type of anesthesia and surgery, patient demographics, pain, post-operative nausea and vomiting (PONV), medical factors, and system factors. [34] Twenty-nine percent of RTC patients did receive intraoperative convective warming at the discretion of the attending anesthesiologist which may have contributed to the negative findings.

No attempt was made to control the type or amount of anesthetic agent in our study. Nonetheless, except for the use of meperidine for shivering, there were no significant intergroup differences in intraoperative anesthetic drugs or postoperative analgesia and antiemetic requirements. Only minor differences exist (5 min) in terms of home readiness and actual discharge times among the primary agents used for general anesthesia for ambulatory surgery. [35] Pavlin et al showed that maximum pain score was predictive of total recovery time in patients undergoing outpatient surgeries. [36] PACU time was substantially longer in their study [36]compared to ours, especially in patients undergoing pelvic laparoscopy (187 min) and hernia repairs (197 min). Hadzic et al showed that time to home readiness and discharge times were shorter for patients undergoing outpatient hand or wrist surgery receiving infra-clavicular nerve block compared with those receiving general anesthesia with desflurane. [37] Of note, patients in their general anesthesia group [37]had substantially longer PACU stays (218 min) than our study, whereas patients in their nerve block group had similar PACU stays (121 min) compared with our study. Active warming may reduce postoperative emergence time (not measured in our study) because hypothermia prolongs and potentiates the action of many anesthetic drugs. [9,10] Heart rate was slightly higher postoperatively in the active warming group possibly because of higher temperature in this group.

The incidence of shivering was substantially reduced in the active warming group vs RTC patients (3 vs. 20%). Shivering can double or triple oxygen consumption and carbon dioxide production, [11,38,39] although in a series of elderly patients undergoing lower extremity vascular, thoracic, or abdominal surgery with an overnight stay in the intensive care unit, Frank et al demonstrated that the increases were much smaller, on the order of 38%.[40] Shivering may aggravate postoperative pain by stretching surgical incisions, interfere with monitoring, and has been

associated with increased intraocular and intracranial pressure. [41] Shivering and feeling cold can be extremely uncomfortable for the patient. In our study, only 1 RTC patient recalled post-operative shivering and only 10% of RTC patients reported being too cold. It is likely that rapid postoperative interventions for hypothermia and shivering together with residual effects of anesthetic agents account for these results since the questionnaire was administered 2 weeks after surgery. It is acknowledged that only 54% of the study population completed the questionnaire. Further, our patient satisfaction questionnaire has not been validated in a large cohort of patients having general anesthesia. There were no intergroup differences in number of patients reporting their anesthetic experience to be good or excellent (92-95%) and the majority of patients in both groups (91-93%) would choose the same anesthetic again. High patient satisfaction scores in our study were similar to those reported in a previous study comparing convective warming with routine thermal care (86-95% satisfied). [33]

The study was not designed to detect a significant difference in rates of serious adverse events that are rare following ambulatory surgery such as requirement for hospitalization, intensive care unit admission, blood transfusion, prolonged mechanical ventilation, and adverse cardiac outcomes. We did not directly examine patient wounds or perform microbiological analysis of wounds. A previous study showed that warming patients before clean surgery (breast, hernia, and varicose veins) decreased the incidence of wound infections from 14 to 5%. [42] The risk of serious surgical wound infection in the present study was estimated to be less than 3% based on operation classification, duration of surgery, and ASA physical status. [43,44]

There is concern that actively warming ambulatory surgery patients increases costs. Hardware cost of the convective warming unit was $800, and the Hotline warmer was $1500. Amortizing hardware costs over 1 year, assuming 5 patients per day in an OR, 240 operating days per year, would be $0.67 per patient for the convective warmer and $1.25 per patient for the Hotline. Disposable costs for the convective warming blanket and fluid warming tubing were $10.50 and $13.00, respectively. Intraoperative cost of hospital bath blankets per patient (assuming $0.95 per blanket based on laundering and replacement costs) [33] were $0.84 in the active warming group and $2.80 in the RTC group. Radiant heat lamp cost was $1600. Amortizing over 1 year, assuming 5 patients per day in the PACU, 240 PACU days per year, would be $1.33 per patient. Acquisition cost of meperidine

25 mg was $0.67. Thus, cost for an actively warmed, normothermic, non-shivering patient was $26.26. Cost for a hypothermic, shivering patient in the RTC group requiring postoperative radiant heat, meperidine, and 2 warm bath blankets was $6.70.

In summary, compared with routine thermal care, convective and IV fluid warming was more effective at maintaining perioperative normothermia and reduced the incidence and severity of shivering and the use of warmed hospital bath blankets. Twenty-five percent of patients in the routine thermal care group were hypothermic at the end of surgery, and 17% required therapy with meperidine for severe shivering postoperatively. Active patient warming did not reduce duration of PACU stay, nor did it improve overall patient satisfaction, but it did increase costs.

ACKNOWLEDGEMENTS

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