

# Hypothermia on arrival in the intensive care unit after surgery

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Intraoperative hypothermia is common and is associated with morbidity.<sup>1-3</sup> Studies of active warming of patients during surgery, including randomised trials,<sup>1</sup> have shown an association between warming and decreased intraoperative and postoperative complications.<sup>4,5</sup> Active intraoperative warming, particularly using forced air warmers, has become increasingly common over the past 10 years.<sup>1</sup> Despite this evidence-based change in operating room practice, few studies have been published on postoperative hypothermia in the intensive care unit and the possible advantages of warming.<sup>6-9</sup> Of these, both Abelha et al from Portugal<sup>6</sup> and Kongsayreepong et al from Thailand<sup>7</sup> found that hypothermia was common in patients admitted to the ICU after non-cardiac surgery. During cardiac surgery, patients are actively warmed while on cardiopulmonary bypass and may be warmer on arrival in the ICU than patients who undergo non-cardiac surgery.<sup>10</sup> There are no reports of the incidence of postoperative hypothermia in Australian and New Zealand ICUs, nor are there any direct comparisons of patient temperature on arrival in the same ICU after cardiac versus non-cardiac surgery.

We conducted an audit in an Australian ICU to test the hypotheses that many patients arrive in the ICU with hypothermia and that patients are warmer after cardiac surgery than after non-cardiac surgery.

## Methods

We conducted a prospective audit of ICU patients at the Austin Hospital, a tertiary referral hospital affiliated with the University of Melbourne, Melbourne, Victoria. Data were collected as part of routine postoperative assessment and did not identify the patients. The Austin Health Human Research Ethics Committee waived the need for informed consent.

We audited all postoperative patients admitted to the ICU over a 2-month period between July and August 2006. We collected demographic data, including age and sex, type and duration of surgery, and American Society of Anesthesiologists (ASA) score for physical status.<sup>11</sup> Patients were classified as cardiac or non-cardiac.

An experienced ICU nurse measured each patient's temperature as part of routine monitoring immediately on arrival in the ICU, using an infrared tympanic membrane thermometer (Genius R Model 3000A, Sherwood Medical Company, St Louis, Mo, USA). This has an accuracy of  $\pm 0.03^\circ\text{C}$  in the range  $32.2\text{--}40.6^\circ\text{C}$ .<sup>12</sup> The thermometer was

## ABSTRACT

**Objective:** Minimising perioperative hypothermia is a priority for anaesthetists. However, there are few studies of postoperative hypothermia in intensive care units. We tested the hypotheses that many patients arrive in the ICU with hypothermia and that patients are warmer after cardiac surgery than after non-cardiac surgery.

**Methods:** We undertook a prospective audit of the temperature of all patients who arrived in the ICU from the operating suite of a university-affiliated tertiary referral hospital between July and August 2006. Temperature was measured with infrared tympanic membrane thermometers. We compared arrival temperatures and proportion of patients with hypothermia (defined as temperature  $< 36.0^\circ\text{C}$ ) after cardiac versus non-cardiac surgery.

**Results:** 171 consecutive surgical patients were assessed. Their median temperature on arrival in the ICU was  $36.0^\circ\text{C}$  (95% CI,  $35.4\text{--}36.5^\circ\text{C}$ ). Almost half (48%; 95% CI, 41%–55%) had hypothermia. Patients who underwent cardiac surgery ( $n = 49$ ) had worse ASA physical status and spent twice as long in the operating room as those who underwent non-cardiac surgery ( $n = 122$ ), but a smaller proportion were hypothermic (31% [95% CI, 18%–44%] v 55% [95% CI, 47%–64%]). The difference (24%; 95% CI, 8%–41%) was significant ( $P = 0.004$ ).

**Conclusions:** Hypothermia is common among postoperative patients admitted to our ICU. We suggest that ICU staff should routinely expect to actively warm postoperative patients, particularly after non-cardiac surgery, and should have sufficient resources to do so.

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calibrated in accordance with the manufacturer's guidelines. Hypothermia was defined as a tympanic temperature less than  $36.0^\circ\text{C}$ , and severe hypothermia as a tympanic temperature less than  $35.0^\circ\text{C}$ .<sup>13</sup>

## Statistical analysis

We compared the cardiac and non-cardiac groups using Mann–Whitney tests (for ICU arrival temperature and time in the operating room) or Fisher's exact test (for proportions). We compared the proportions of patients with ASA scores 1–2, or ASA scores 3–4, and the proportion of patients with

hypothermia. The differences and their 95% confidence intervals were calculated. We used GraphPad Prism version 4 software (GraphPad Software, San Diego, Calif, USA). A  $P < 0.05$  was considered statistically significant.

## Results

We analysed data from 171 consecutive postoperative patients admitted to the ICU. Forty-nine were admitted after cardiac surgery, and 122 after non-cardiac surgery. The types of surgery in the cardiac group were coronary artery bypass grafting, 24 (49%); valve surgery, 12 (24%); and mixed or other surgery, 13 (27%). The types of surgery in the non-cardiac group were general, 58 (48%); orthopaedic, 16 (13%); thoracic, 16 (13%); and other, 32 (26%). Anaesthetic techniques in the non-cardiac group were general alone, 97 (80%); general plus regional, 20 (16%); and regional alone, 5 (4%).

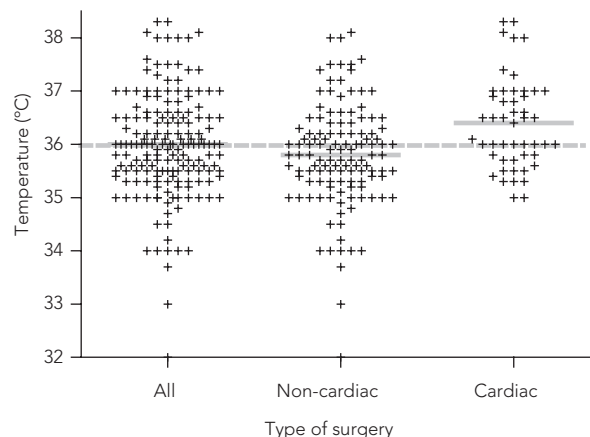
Age ranges were wide in each group (Table 1) but similar between groups: median age was 69 years for the cardiac group and 67 years for the non-cardiac group (difference, 1 year; 95% CI, -4 to 5 years;  $P = 0.80$ ). The cardiac surgery group had worse ASA scores for physical status (Table 1): all cardiac patients had an ASA score of 3 or 4, compared with 66% of the non-cardiac patients (median difference, 35%; 95% CI, 27%–45%;  $P < 0.001$ ). The cardiac patients were in the operating room twice as long as the non-cardiac patients (Table 1) (median difference, 150 minutes; 95% CI, 100–195 minutes;  $P < 0.001$ ).

**Table 1. Comparison of cardiac and non-cardiac surgery patients\***

	Non-cardiac (n = 122)	Cardiac (n = 49)
Age (years) <sup>†</sup>	67 (26–89)	69 (24–80)
Sex (no. of men)	81 (66%)	35 (71%)
Emergency cases	38 (31%)	5 (10%)
ASA score		
1	8 (7%)	0
2	34 (28%)	0
3	72 (59%)	47 (96%)
4	8 (7%)	2 (4%)
Operating room time (mins) <sup>†</sup>	165 (40–850)	333 (100–855)
Cardiopulmonary bypass		
No. of patients	0	43 (88%)
Time (mins) <sup>†</sup>	0	119 (52–542)

ASA score = American Society of Anesthesiologists' score for health status. \* All figures are number of patients and percentage unless otherwise indicated. † Median (range).

**Figure 1. Tympanic temperature of patients on arrival in the ICU after cardiac (n = 49) or non-cardiac (n = 122) surgery\***



\* Horizontal bars represent median temperature. Hypothermia was defined as a temperature less than 36.0°C (dotted line).

For the two groups combined, the median temperature on arrival in the ICU was 36.0°C (95% CI, 35.4–36.5°C) (Figure 1). For patients who underwent cardiac surgery, median temperature was 36.4°C. This was greater than the median temperature of 35.8°C for patients after non-cardiac surgery (median difference, 0.5°C; 95% CI, 0.3–0.8°C;  $P < 0.001$ ).

Of the 171 patients, 82 (48%; 95% CI, 41%–55%) were hypothermic with an arrival temperature less than 36.0°C; and 14 (8%; 95% CI, 4%–12%) had more severe hypothermia with a temperature less than 35.0°C. After cardiac surgery, 15 of the 49 patients (31%; 95% CI, 18%–44%) were hypothermic. A greater proportion of patients, 55% (95% CI, 47%–64%), or 67 of 121, were hypothermic after non-cardiac surgery. The difference of 24% (95% CI, 8%–41%) was significant ( $P = 0.004$ ). No patient had a temperature less than 35.0°C after cardiac surgery, but 12% (15/121) of patients had more severe hypothermia after non-cardiac surgery. This difference of 12% (95% CI, 3%–18%) was significant ( $P = 0.01$ ).

## Discussion

We tested the hypotheses that many patients arrive in the ICU with hypothermia and that patients are warmer after cardiac surgery than after non-cardiac surgery. Our study of 171 consecutive patients arriving in the ICU after surgery found that about half had hypothermia (defined as a tympanic temperature less than 36.0°C), and that one in 12 had more severe hypothermia (a tympanic temperature less than 35.0°C). Further, we found that cardiac patients were

warmer than non-cardiac patients, and that a significantly smaller proportion of patients had hypothermia after cardiac surgery than after non-cardiac surgery.

This Australian study is one of the few studies to examine the incidence of postoperative hypothermia in the ICU. Kongsayreepong et al reported data collected in 2001 in Thailand.<sup>7</sup> They found that 57% of 194 general surgical patients had a tympanic temperature less than 36°C, and 28% had a temperature less than 35°C. We found a similar proportion of patients (55%) had hypothermia after non-cardiac surgery, but a lower rate of more severe hypothermia (less than 35°C). In a 2004 study in Portugal, Abelha et al<sup>6</sup> collected data on 185 patients who underwent non-cardiac surgery. They found that 58% had a tympanic temperature less than 35°C, considerably more than our proportion of 12% of patients with more severe hypothermia after non-cardiac surgery. In a study conducted over 20 years ago, before the widespread use of active intraoperative forced air warming,<sup>1,13</sup> Slotman et al<sup>14</sup> found that 53% of patients admitted to a surgical ICU had a temperature less than 36.1°C (97°F).

Our study also compared patients after cardiac and non-cardiac surgery. The cardiac patients were warmed before separation from cardiopulmonary bypass.<sup>3,10</sup> Compared with patients who underwent non-cardiac surgery, a significantly smaller proportion of patients (33% versus 55%) were hypothermic after cardiac surgery. This is despite the cardiac patients having longer operations and worse ASA physical status — both risk factors for postoperative hypothermia in non-cardiac surgery.<sup>6,7</sup> This finding is comparable to that of Insler et al who found, in a study of over 5000 patients after coronary artery surgery in the United States, that 28% were admitted to the ICU with a temperature less than 36°C.<sup>3</sup>

Our study had some limitations. It was conducted in a single centre in a large teaching hospital with a sample of fewer than 200 patients. This may limit its generalisability, but its size and nature were comparable to the other recently reported studies of general surgical ICU patients.<sup>6,7</sup> Another potential limitation of our study, as well as those of Kongsayreepong et al<sup>7</sup> and Abelha et al,<sup>6</sup> is that all three used infrared tympanic thermometers. The reliability of these thermometers has been questioned.<sup>15</sup> Bland–Altman analyses comparing the “gold standard” of a thermistor in a pulmonary artery catheter<sup>15</sup> with infrared tympanic thermometers showed that the tympanic thermometers have a bias (mean difference) of 0.1°C to 0.4°C less than thermistors.<sup>16</sup> Therefore, infrared tympanic thermometers may overestimate the frequency of hypothermia compared with pulmonary artery thermistors. Further, based on the limits of agreement (precision) estimates of Bland–Altman analyses, tympanic thermometers are

thought to be less precise than thermistors.<sup>16</sup> However, a limitation of these comparisons is that the proportion of bias and imprecision due to either tympanic thermometers or thermistors cannot be separated. Nevertheless, thermistors are likely to contribute less to bias and imprecision than infrared tympanic thermometers.<sup>16</sup> If the largest reported bias between thermistors and tympanic thermometers (0.4°C) is applied to our data, the incidence of hypothermia decreases from 48% to 33%. This is still a large proportion of our patients. However, currently the risk–benefit comparison of accuracy, safety (and cost) between non-invasive tympanic thermometers and thermistors in pulmonary artery catheters or urinary catheters<sup>16</sup> is unclear.

In non-cardiac surgery, intraoperative active warming is associated with decreases in cardiac complications, bleeding, infection, shivering, and duration of stay in the post-anaesthesia care unit (recovery).<sup>1</sup> There are only limited data on postoperative hypothermia in the ICU and no controlled trials of active warming on arrival in the ICU. In the two recent studies, neither Kongsayreepong et al<sup>7</sup> nor Abelha et al<sup>6</sup> showed that hypothermia on arrival in the ICU was associated with increased mortality. However, there were several confounding factors. First, Abelha et al<sup>6</sup> actively warmed hypothermic patients, which may decrease complications associated with hypothermia, while the approach of Kongsayreepong et al<sup>7</sup> to warming was unclear. Second, the factors that both groups found to be important to mortality, including patients being sicker and having prolonged surgery, were also risk factors for hypothermia; this may have resulted in the elimination of hypothermia from their multivariate analyses. These results contrast with the finding of Insler et al<sup>3</sup> in a study of cardiac patients that hypothermia was strongly associated with mortality. However, more recent research concluded that mild hypothermia after cardiopulmonary bypass is associated with improved neurological outcome and is not associated with increased complications.<sup>17</sup>

We conclude that hypothermia is common among postoperative patients admitted to our ICU and is more likely in patients who undergo non-cardiac surgery. The rate of hypothermia that we found was similar to, or lower than, that reported in other recent studies.<sup>6,7</sup> Further study is required on the most appropriate way to measure temperature in the ICU, as well as the effects of hypothermia in ICU patients after surgery and possible benefits of active warming. However, given the available evidence of adverse outcomes associated with intraoperative hypothermia and the apparent benefits of intraoperative warming,<sup>1</sup> we suggest that ICU staff should routinely expect to actively warm postoperative patients, and should have appropriate resources to do so. Further, greater efforts are needed to

reduce intraoperative hypothermia. The role of hypothermia in cardiac surgery appears to raise even more questions than its role in non-cardiac surgery.

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