

# Incidence of intraoperative hypothermia

## *Adopting protocol for its prevention*

Ali S. Al-Qahtani, DLO, KSUF, Farouk M. Messahel, DA, FRCA.

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### ABSTRACT

**Objective:** To determine the incidence of hypothermia during surgical procedures when adequate methods of preserving normothermia are applied.

**Methods.** A prospective study in which patients ASA I-IV presented for surgery at the Armed Forces Hospital, Wadi Al-Dawasir, Kingdom of Saudi Arabia during the period from July 2000 until February 2003, in whom body core temperature was between 35-37°C, were included. Ambient temperature of the operating room was thermostatically adjusted to record 26°C and 24°C if patients were <10 year-old or above. Depending on type of surgery; the patients were provided with space blankets and were lying on warm mattresses. Fluid or blood warmers and forced-air surface warming were used when needed.

**Results:** There were 3886 surgical patients operated upon during the period of the study. Their average age was 34.5 years (range 15 days to 104 years). Sixty patients (1.54%) developed intraoperative hypothermia (core temperature

<35°C) and were admitted to the intensive care unit for monitoring and gradual rewarming. There was no mortality amongst them. Out of those 60 patients, 17 (28.3%) expressed dissatisfaction on this part of the service, but the overall patient's satisfaction scored 99.6%.

**Conclusion:** Aggressive measures must be adopted to preserve normothermia as prevention of intraoperative hypothermia improves patient's outcome. All patients should have their core body temperature monitored during surgery. However, application of available methods of keeping normothermia reduces the incidence of intraoperative hypothermia but does not abolish it completely. Hypothermic patients should be closely monitored during gradual rewarming, preferably in the intensive care setting. A protocol for prevention of intraoperative hypothermia must be adopted by all operating theaters.

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**H**ypothermia is defined as core temperature of <35°C.<sup>1</sup> In the surgical patient it is often recognized and yet can progress to a fatal outcome. Prevention of hypothermia improves patient's outcome, and unless hypothermia is intraoperatively induced (for example, in cardiac or neurosurgery) all steps should be taken to preserve normothermia. The prevailing hot climate in the Kingdom of Saudi Arabia (KSA) gives the impression that hypothermia is

unlikely to occur. However, the use of air conditioning systems inside the operating rooms (OR) subjects anesthetized patients, particularly those at extreme age groups (the very young and the elderly), to hypothermia. Humans are homeothermic namely, the core temperature is kept constant against ambient temperature variations. Under anesthesia, patients become poikilothermic; namely, the body temperature follows environmental temperature. Children are at a

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From the Department of Surgery (Al-Qahtani) and the Department of Anesthesia and Intensive Care (Messahel), Armed Forces Hospital, Wadi Al-Dawasir, Kingdom of Saudi Arabia.

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Address correspondence and reprint request to: Dr. Ali S. Al-Qahtani, Chief of Surgery, Department of Surgery, Armed Forces Hospital, PO Box 228, Wadi Al-Dawasir 11991, Kingdom of Saudi Arabia. Tel. +966 (1) 7842779. Fax. +966 (1) 7842779 Ext. 4623. E-mail: dralient@hotmail.com

disadvantage due to their high surface area in relation to body mass, and in the elderly, the response to a fall in ambient or body temperature is impaired. In the anesthetized paralyzed patient, the homeostatic heat preserving mechanisms cannot be activated (for example increase metabolic rate, shivering or exercise). Anesthesia lowers the activation levels for a hypothermic response by 2.5°C due to depression of the thermoregulatory central control in the hypothalamus. Therefore, patients show no reaction to a falling body temperature until the new level is reached.<sup>2</sup> In addition, infusion of one litre of crystalloid solution at room temperature decreases mean body temperature by approximately 0.25°C.<sup>3</sup> Other factors contributing to decrease body temperature are: exposure of the patient, combining general anesthesia with neuraxial analgesia (spinal or epidural), low ambient theatre temperature, fluid and blood transfusion without the use of fluid or blood warmer, cold irrigating fluids, and the use of certain drugs for example, the phenothiazine.<sup>4</sup> Hypothermia has multitude of adverse effects on the body including: slowing down of metabolism, unavailability of oxygen to tissues (shift of oxygen dissociation curve to the left), myocardial ischemia, delayed recovery from anesthesia and neuromuscular blockade, postoperative shivering, thermal discomfort, coagulopathy, delayed wound healing, wound sepsis, and patient dissatisfaction. We conducted this prospective study to demonstrate the incidence of intraoperative hypothermia when necessary precautions are taken to prevent its occurrence. It was conducted as part of the ongoing quality improvement program established in our Hospital in 1997 and boosted recently by the Total Quality Management in the Military Health Service of the Saudi Armed Forces, Riyadh, KSA.

**Methods.** The study was approved by the hospital Research and Ethics Committee of Armed Forces Hospital, Wadi, Al-Dawasir, KSA. Consent from patients was waived as intraoperative temperature monitoring is standard and preservation of normothermia represents part of the overall patient care. Other basic intraoperative monitoring was applied.<sup>5</sup> ASA I-IV patients presented for surgery in our hospital between July 2000 and February 2003 were included in the study. Elective surgical cases received oral benzodiazepine (midazolam for patients <40 kg body weight and diazepam for >40 kg body weight). The type and site of surgery together with patients' preference (if there was a choice) determined whether they received general anesthesia (GA) or neuraxial (spinal or epidural) anesthesia. Induction of GA was either by inhalation for infants and small children or intravenous route for older children and adults. Depending on the site of surgery the core body temperature was measured either from the esophagus or rectum, and continuously displayed and printed in degrees celsius using the temperature module of AS/3

anesthetic delivery unit (Datex-Ohmeda, Finland). Otherwise, core temperature was measured every 5 minutes from the tympanic membrane (Infrared tympanic thermometer, First Temp, Genius, USA).<sup>6</sup> Infants and small children were connected to non-rebreathing anesthetic circuits while closed low-flow anesthetic circuits were used in all procedures, whether patients were breathing spontaneously or ventilated (Datex-Ohmeda AS/3, Finland). The temperature inside the OR is thermostatically adjusted to keep theater's ambient temperature at 24°C if the patient is >10 years old or 26°C for neonates and children up to 10 years old. All operating tables are provided with warming mattresses containing heating coils with thermostatically controlled temperatures between 36-38°C (Thermomaquet 2000, Germany). One or more of the available methods of heat-preservation during surgery were applied to each patient depending on the position of patient for surgery and the extent of the exposed cutaneous area. Once the patients are positioned on the operating table, they are provided with a warm cotton blanket drawn from a thermostatically controlled warming cabinet at 40°C (Olympic Warmette, Olympic Medical, Seattle, USA), or are wrapped with space blanket (MPI Outdoors, Windham, USA). Forced-air surface warming (Bair Hugger Model 500, Augustine Medical, Inc, USA) was applied as a standard to children below 10 years or adults above 55 years old, and to patients with estimated surgical time of 2 hours or more. Warm IV crystalloid fluids (if less than 1000 ml were infused) and bladder irrigation fluids for transurethral prostatectomy were drawn from the warming cabinet, otherwise, fluid or blood warmer was used (Anemic AM 4, Elltec Co. Ltd, Japan). Intravenous fluids and blood used were all warmed to a temperature between 37-38°C.

**Results.** All patients with preoperative body temperature of <35°C or >37°C were excluded from the study. There were 3886 patients during the period of study. Their average age was 34.5 years (range 15 days to 104 years). There were 2215 males and 1671 females with male to female ratio of 1.3:1. They included 6 newborns (<4 weeks), 89 infants (one month to one year), 1013 children (one year-14 years) and 2778 adult (>14 years). The average length of surgery was 2 hours 20 minutes (range 25 minutes to 13 hours and 40 minutes). There was no mortality. Sixty patients developed intraoperative temperature less than 35°C (37 were under GA, 19 received spinal and 4 combined GA and spinal), and were all admitted to the intensive care unit (ICU) for observation and gradual rewarming. Twenty-six of them had other indications for ICU admission including monitoring of cardiovascular status (n=14), monitoring of renal function (n=6), management of transurethral prostatectomy syndrome (n=2), and postoperative elective ventilation (n=4). The maximum patient's

stay in the ICU was 15 hours. Seventeen out of the 60 patients admitted to the ICU expressed their dissatisfaction (0.44% of the total cases). This dissatisfaction had arisen from the occurrence of shivering, thermal discomfort and from the routine restrictions imposed in an ICU setup. The final patient satisfaction of this part of the service scored 99.6%.

**Discussion.** There are 2 potentially lethal conditions connected to anesthesia, which necessitate monitoring patients' core temperature during surgical procedures: 1) malignant hyperthermia and 2) hypothermia. This study was about incidence of intraoperative hypothermia when precautionary steps are taken to preserve normothermia. General anesthesia causes vasodilatation, which facilitates heat loss by the different known mechanisms: conduction, convection, radiation and evaporation. This cause alone results in a fall of body temperature equivalent to 0.1°C/5 minutes and the heat lost during the first hour of surgery may be sufficient to make most patients hypothermic.<sup>5</sup> This is due to a core-to-peripheral distribution of body heat after induction of anesthesia.<sup>7</sup> In neuraxial (namely, spinal or epidural) analgesia the central autonomic thermoregulatory control is impaired.<sup>8,9</sup> This is related to the extent of the regional block produced.<sup>10</sup> It also impairs behavioral thermoregulation with the result that patients, who are usually awake, often do not complain of cold as they cannot perceive their hypothermia.<sup>11,12</sup> Typically, there is a decrease of 0.5-1°C in core temperature following redistribution of body heat during neuraxial analgesia. The use of closed breathing circuits during surgery warms cold anesthetic gases, vapors, and compensates for any heat loss from the respiratory tract. The use of fluid or blood warmer should be a routine if more than one litre of fluid or one unit of blood is transfused and it should be a compulsory during massive blood transfusion. The heat required to raise the temperature of a unit of blood from 4°C to 37°C (100 kJ/litre) represents 1/10th of hourly heat production in a young awake patient and even more in the elderly.<sup>13</sup> The environmental OR temperature should be adjusted to reach a compromise between preventing heat loss from patients and a reasonably comfortable working atmosphere for OR personnel. However, OR personnel working frequently in pediatric theaters are usually used to stand a warm OR ambient temperature. Thermostatically controlled warm mattress on the operating table helps in preventing heat loss from the back of patients in the supine position during surgery. These mattresses use either heating metal coils or circulating warm water. To prevent skin burn, the temperature range of this warming mattress is set between 36-38°C. Different sizes for adults and children are available. However, its role is limited in surgical positions where there is less patient's contact with the operating table. Any exposed part of the patient must be properly covered before spreading

sterile drapes. Space blankets are also useful in preserving body temperature. Changes in intraoperative core temperature are reported to delay recovery of neuromuscular function, which may delay recovery of spontaneous breathing after reversal of residual paralysis at end of surgery. As hypothermia decreases the mechanomyographic twitch of the adductor pollicis muscle,<sup>14-17</sup> it is recommended to maintain skin temperature above 32°C while monitoring neuromuscular blockade during surgery.<sup>18,19</sup> Oxygen extraction from hemoglobin is reduced when core body temperature decreases. This is due to the shift of the oxygen dissociation curve to the left.<sup>20,21</sup> Cold stress can trigger ischemic cardiac problems. Heat loss during the first hour of surgery triples the incidence of cardiac events.<sup>22</sup> Patients are 2-3 times more likely to develop early postoperative myocardial ischemia during recovery when core temperature drops below 35°C. In one study, the incidence of perioperative morbid cardiac events was shown to be 300% higher in hypothermia.<sup>23</sup> A core temperature less than 35.5°C following surgery causes increases in norepinephrine, vasoconstriction, and arterial blood pressure. Cold also slows the heart rate and disrupts the electric conduction system, producing a variety of cardiac dysrhythmias, of most concern is ventricular fibrillation, to which a hypothermic heart is extremely susceptible. Such lethal condition can be precipitated by routine maneuvers carried out in anesthesia such as insertion of an airway, tracheal intubation or central venous cannulation. Rough handling of hypothermic patients may also precipitate ventricular fibrillation.<sup>24</sup> Hypothermia impairs the function of platelets, probably due to reduced levels of thromboxane at the site of tissue injury. The activity of coagulation factors in the coagulation cascade is also reduced. This may result in more perioperative blood loss than in normothermic patients.<sup>25</sup> Wound healing is impaired and the incidence of wound infection increases by 3-folds during hypothermia. This cause alone is responsible for delayed discharge of patients from the hospital by an average of 2.6 days.<sup>26</sup> Hypothermic patients develop shivering in the immediate postoperative period, which is one of the indications of administration of oxygen. The average increase in oxygen consumption is 40%.<sup>27</sup> Furthermore, shivering causes discomfort and usually leads to patient dissatisfaction. Studies have also shown that applying forced surface-warming air during surgery is found to be the most effective than other passive methods of skin warming devices (for example, cotton blankets or space blankets). This is because cutaneous heat loss is the predominant element and skin surface warming is the most effective intraoperative protective method.<sup>28</sup> In fact, forced-air warming was found to be the most efficient among 3 warming methods in maintaining perioperative normothermia.<sup>29</sup> However, cutaneous warming may be limited if the available skin surface to be warmed is restricted. It may also produce skin burn

if warm air is blown directly without using the appropriate blanket. If hypothermia persists at the end of surgery, it is advisable to admit the patient to the ICU for monitoring purposes and gradual rewarming. For this, appropriate equipment must be available. They are cost-effective as they help in reducing morbidity and mortality outcomes in surgical patients. One of the most clinically relevant measures of outcomes is patient's satisfaction, which is considered as a useful indication of quality of care that can contribute to a balanced evaluation of the structure, process and outcome of services.<sup>30-32</sup> Measures to guard against fall in intraoperative body temperature must be well planned and adopted from the start. These measures may appear elaborate but they are essential, cost-effective and represent part of the overall patient care. Suggested guidelines include: Adjusting OR environmental temperature in particular during pediatric and geriatric surgery, availability of warm mattress and space blanket to each patient (depending on type of surgery), and administration of warm intravenous fluid or blood, and the use of forced-air surface warming device, should be part of the intraoperative management of patients.

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