

The Safe and Efficient Use of Forced-Air Warming Systems

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ABSTRACT

Maintaining perioperative normothermia is important to ensure that a patient does not experience inadvertent hypothermia and its consequences, such as increased blood loss, cardiac abnormalities, prolonged recovery, and increased risk for wound infection. Many clinical guidelines recommend the use of forced-air warming as one of several techniques to prevent inadvertent perioperative hypothermia. Safe use of forced-air warming devices includes choosing the right device, assessing the patient for risks, protecting the patient from burn injuries, appropriately maintaining the patient's body temperature, and using the device as directed by the manufacturer's recommendations. Staff members should receive education on hypothermia and warming technology on a regular basis. *AORN J* 97 (March 2013) 302-308. © AORN, Inc, 2013. <http://dx.doi.org/10.1016/j.aorn.2012.12.008>

Key words: forced-air warming, temperature management, inadvertent hypothermia, perioperative care, patient safety.

Temperature management (ie, maintaining normothermia) is an important component of perioperative patient safety and comfort. Inadvertent hypothermia in patients, however, is one of the most difficult issues for perioperative nurses to manage. Surgical patients are always at risk of losing body heat. The administration of anesthesia causes heat redistribution; ambient temperatures in the OR are intentionally kept low; and a patient's age, the duration of the procedure, and other factors can cause a drop in core body temperature.¹ A patient is considered hypothermic when his or her core body temperature is at or below 36° C (96.8° F).^{2,3} As many as 70% of surgical patients develop inadvertent hypothermia during the perioperative period.¹

Except for those situations in which induced hypothermia is required (eg, some neurological and

cardiac procedures), hypothermia should be prevented to protect the patient.¹ This article is based on a synthesis of professional organization guidelines on patient warming, a meta-analysis, systematic literature reviews, randomized and nonrandomized control trials, and case reports (Table 1). The article provides perioperative staff members with practical recommendations for using forced-air warming systems safely and effectively as a means of maintaining normothermia.

COMPLICATIONS OF HYPOTHERMIA

Inadvertent perioperative hypothermia can cause problems not only during but also after surgery. Complications associated with hypothermia include increased blood loss, arrhythmias or cardiac arrest, prolonged recovery, impaired immunity, delayed wound healing, and increased risk for wound

TABLE 1. Level of Evidence in this Article According to the National Health and Medical Research Council (NHMRC) Evidence Hierarchy¹

Type of study	Total number	Level of evidence
Meta-analysis	1	I
Systematic reviews	2	I
Randomized control trials	8	II
Nonrandomized experimental trials	4	III-2
Historical control study	1	III-3
Case reports	5	IV

1. NHMRC Levels of Evidence and Grades for Recommendations for Developers of Guidelines. 2009. NHMRC. www.nhmrc.gov.au/_files_nhmrc/file/guidelines/developers/nhmrc_levels_grades_evidence_120423.pdf. Accessed December 10, 2012.

infection.^{1,4} Unplanned hypothermia also increases costs for patients and hospitals. A meta-analysis by Mahoney and Odom⁵ showed that a drop in temperature averaging only 1.5° C (2.7° F) resulted in adverse outcomes that negatively affected the quality and even the length of patients' lives. At the same time, cumulative adverse outcomes of inadvertent hypothermia added between \$2,500 and \$7,000 per surgical patient to hospitalization costs (depending on cost assumptions of the area being studied) across a variety of surgical procedures.⁵ Although Mahoney and Odom⁵ calculated outcomes only in certain settings and costs differed by country, these costs are significant to OR administrators.

PREVENTION OF HYPOTHERMIA

Although the mechanisms of hypothermia are complicated, hypothermia can be prevented by careful temperature management. Because the body's core temperature is directly affected by the production and loss of heat, warming methods (eg, use of warmed irrigation solutions, warmed IV fluids, warming pads, forced-air warming devices) can assist in regulating both of these mechanisms. Perioperative warming has been recommended by many researchers for reducing

the complications of hypothermia.^{4,6-8} For example, a randomized control trial by Leaper⁸ showed that local, systematic warming was valuable in reducing the risk of pressure sores because it improved intraoperative cutaneous blood flow and oxygen tension, which improved tissue viability. Lower rates of pressure sores can reduce a patient's risk of infection and an associated lengthy hospital stay.⁸

With an increasing awareness and understanding of how to prevent hypothermia, professional associations have developed guidelines regarding perioperative warming.^{9,10} AORN's "Recommended practices for the prevention of unplanned perioperative hypothermia"⁹ describes forced-air warming as a safe and widely used skin surface warming method for preventing unplanned hypothermia. The American Society of PeriAnesthesia Nurses (ASPAN) Evidence-Based Clinical Practice Guideline for the Promotion of Perioperative Normothermia¹⁰ also recommends the use of forced-air warming systems.

FORCED-AIR WARMING SYSTEMS

Various types of forced-air warming devices are available from different manufacturers. These warming systems generally consist of a power unit that generates warmed air and a fan that blows the warmed air through a hose into a disposable blanket that has direct contact with the patient. Manufacturers make blankets classified for intraoperative, postanesthesia care unit, adult, and pediatric use, and the blankets vary in size and shape according to the body part to be covered (eg, upper body, lower body, full body). Special designs are also available for certain types of surgery (eg, cardiac surgery blankets).¹¹

Choosing the Right Device

The first step in warming a patient with forced air is to choose the appropriate device. A study by Bräuer et al¹² showed that the design and quality of the blanket may be the key factor that determines the efficacy of a forced-air warming system. A

well-designed blanket should have an even temperature distribution.¹² The smaller the temperature gradient between the highest and the lowest temperatures provided by the blanket, the better its efficiency.¹² A study by Shorrab et al¹³ that included data from pediatric epidural and general anesthesia surgeries suggests that there is similar heat loss between lower and upper body blankets of equal surface areas. Because of this, both upper body blankets and lower body blankets were effective in preventing intraoperative hypothermia; the choice between a lower body blanket and an upper body blanket depends mainly on the surgical site and procedure.¹³

Temperature Monitoring

The decision to use perioperative warming should always be based on monitoring a reliable measurement of the patient's core temperature. Among various temperature monitoring sites, core temperature can be evaluated in the nasopharynx, the pulmonary artery, the tympanic membrane, and the distal esophagus.^{9,14} How core temperature is monitored depends on the clinical setting and, in surgery, on what procedure is planned.¹⁴

A survey on intraoperative temperature management by Torossian et al¹⁵ concluded that in Europe intraoperative temperature monitoring is not commonly conducted during every surgery. The survey indicated that staff members in European ORs did not use active warming methods like forced-air warming in time to prevent hypothermia and that this may be the result of an absence of temperature monitoring and insufficient assessment of patients.¹⁵

Prewarming

Andrzejowski et al¹⁶ found that when patients were warmed preoperatively with forced-air warming devices for 60 minutes, they had smaller intraoperative decreases in core temperature and less inadvertent hypothermia. Prewarming, however, has not yet become a routine part of preoperative preparation.¹⁶ Stoneham et al¹⁷ found that a period

of active preinduction warming is needed to avoid the common decreases in core temperature seen during general anesthesia induction.

A randomized controlled trial by Melling et al¹⁸ also supported the use of a preoperative warming method. Researchers compared the infection rate of patients after clean surgeries. They divided the patients into two groups, one with standard warming (nonwarming before surgery) and one with prewarming for at least 30 minutes before surgery. This study found that warming patients before surgery seemed to help in the prevention of postoperative wound infection. Furthermore, traditional warming by using warmed blankets has proven to be less effective than using a forced-air warming system in maintaining patients' core temperatures throughout the perioperative period.¹⁹

SAFE USE OF FORCED-AIR WARMING SYSTEMS

Although forced-air warming systems have been used for more than 20 years, these systems still present risks. These risks include

- burn injuries,²⁰
- fire,²¹
- risk for contamination of the surgical site,²²⁻²⁴ and
- anesthesia monitoring interference.²⁵

Risk for Burns

Bräuer and Quintel²⁰ found that burn injuries associated with forced-air warming systems rarely happen if the manufacturer's instructions are well followed. Misuse was the main cause of burn injuries according to 15 reports submitted to the US Food and Drug Administration in 1994.^{26,27} These reports showed that five types of operator error were responsible for the burns:

- warming of patients with nonperfused or poorly perfused skin,
- direct contact of the heated plastic blanket with the patient's skin,
- use of the forced-air delivery hose unattached to a warming cover,²⁷

- use of one manufacturer's warming cover with a unit belonging to another company, and
- use on anesthetized patients of a model with a higher heat output and a higher thermostat setting intended for use on conscious patients.^{26,27}

The most common misuse of forced-air warming devices is the practice of "hosing" (ie, blowing warm air directly on patients without using a blanket).^{27,28} In a case in Turkey related by Uzun et al,²⁸ a staff member did not connect the nozzle of a forced-air warming device to the blanket, and hot air (ie, 40° C to 43° C [104° F to 109.4° F]) was blown directly onto the patient's legs for nearly two hours during surgery, causing a third-degree burn of 12.5 cm in diameter on the patient's ankle.²⁸

It is important for the nurse to perform a complete nursing assessment of a patient before warming him or her with forced-air warming devices. This includes noting any history of vascular disease, the patient's perfusion and cardiac output status, and the length of the planned procedure. Based on these assessments and in consultation with the surgeon and anesthesia care provider, the use of a forced-air warming device may not be appropriate.

Manufacturers' recommendations usually include asking users not to set the blanket to its maximum temperature when a patient has compromised circulation or when the patient requires warming for an extended period of time.²⁹ In the United States, for example, Truell et al³⁰ reported that multiple factors caused skin hypoperfusion in a three-year-old boy who sustained third-degree burns from a forced-air warming device used when he underwent surgical correction of transposition of the great arteries.

Risk for Fire

Fire is a major risk in the OR because, under normal circumstances, all factors that can lead to a fire (ie, oxygen, fuel, ignition sources) are present. Williams et al²¹ used manikins to evaluate whether use of a forced-air warming blanket could affect the ignition or increase the risk of fire caused by

a fiberoptic light source.²¹ They concluded that, although forced-air warming accelerated the production of the initial smoke seen in this study, the blanket of the warming system offered protection to the patient's skin from the fire.²¹ In my review of the literature from the past 10 years, I could find no reports of fire related to the use of forced-air warming systems.

Risk for Contamination

It is unclear whether forced-air warming devices pose a risk for contamination in the OR. A study by Albrecht et al²² indicated that there is questionable design in the blowers of some forced-air warming systems that may lead to internal contamination of the equipment itself and emission of airborne contamination into the OR. Even though contamination was found inside the forced-air warming devices, these researchers were not able to provide evidence of a link to surgical site infection rates.²²

Another study showed that warm-air convection heaters produced a small increase in the number of colony forming units in ultra-clean air ORs (ie, laminar flow rooms), but the levels most likely were not clinically significant.²³ A nonrandomized controlled study by Huang et al²⁴ indicated that use of a forced-air warming system did not increase bacterial OR air contamination and was unlikely to adversely affect the surgical field. Further study is needed on this issue; however, manufacturers recommend using single-use blankets so that the risk of potential contamination of surgical sites from inadequately cleaned, reusable blankets is reduced.^{31,32}

Anesthetic Monitoring Interference

The use of forced-air warming may be related to interference with anesthetic monitoring. Hemmerling and Fortier²⁵ discuss case reports and experiments that indicate that the interpretation of bispectral index readings (ie, a system used to measure the effects of specific anesthetic medications on the brain and to track changes in the patient's level of sedation or hypnosis³³) and their

use to titrate anesthesia can be severely impaired by forced-air flow use.²⁵ Bispectral index readings have been reported to be abnormally high, without relevant clinical signs in the patient when forced-air warming systems are in use.²⁵ Therefore, when the monitoring sensor is near the forced-air system, it may be difficult to determine an accurate bispectral index.²⁵

WET BLANKETS

Keeping forced-air warming blankets dry when in use is important because use of large amounts of irrigation fluid can easily wet the drape around the surgical site as well as the warming blanket, if an adhesive surgical drape was not carefully sealed around the surgical site. An experimental study by Lin et al³⁴ compared the temperature decline among three groups of fluid bags (ie, a control group, a group of bags kept dry and warmed by forced-air warming devices, and a group of bags wet by irrigation fluid and also warmed by forced-air warming devices) and concluded that wet forced-air warming blankets were inefficient in maintaining normothermia.

COST CONSIDERATIONS

According to a 2010 report from the National Health Service in Britain, the average cost per patient for use of a forced-air warming system was £15 (\$24.14).³⁵ Studies and manufacturer's data indicate that forced-air warming systems, in turn, can reduce patients costs from hypothermia by \$2,500 to \$7,000 per patient.^{5,36-38} Although clinical guidelines support and many research studies have confirmed "perioperative normothermia to be beneficial to the patient and the surgical institution, keeping patients warm is not often a high priority for surgical team members."^{2(p340)}

In considering the net cost of implementing the ASPAN Normothermia Clinical Guideline,¹⁰ a study by Berry et al³⁸ endorsed the implementation of the guideline as an effective and efficient strategy for achieving or maintaining normothermia during the perioperative period and noted the use of

passive warming techniques (eg, blankets, socks head coverings, limited exposure) and active warming techniques (eg, use of forced-air warming systems, raising room temperature).

Kabbara et al³⁹ studied the use of forced-air warming systems and focused on whether replacing the disposable commercial blanket with a traditional cotton blanket would cut costs or have any effect on patients' temperatures. Although the effectiveness of keeping patients warm was similar in both groups, other factors that can increase the risk of using cotton blankets cannot be ignored (eg, hospital cotton blankets are not fire resistant like commercial forced-air warming blankets, cross contamination from reuse).³⁹ New kinds of warming technology emerge every day; however, there is a paucity of cost comparison between the widely used forced-air warmers and new devices available for use.

EDUCATION

Although the topic of hypothermia is included in most surgical textbooks, results of studies indicate that there is inadequate knowledge among surgical team members about the implementation of warming techniques and about which warming techniques work best or are most cost effective for surgical patients.^{1,13} Perioperative educators must highlight the risks of hypothermia for staff members and provide education to fill knowledge gaps about hypothermia, techniques to effectively warm patients, and instructions for using warming devices. It is the responsibility of educators and preceptors to teach inexperienced nurses how to reduce patients' risks for unplanned hypothermia and to familiarize them with all techniques available at the facility for preventing hypothermia.

RECOMMENDATIONS

Safe and effective use of forced-air warming systems requires that care providers review the literature to determine the method that currently appears to provide the best means of warming patients and to follow recommendations made by both researchers and product manufactures.

Manufacturers' recommendations for use of any piece of equipment should always be followed to ensure safe patient outcomes. Safe recommendations include the following:

- Choose the forced-air warming device that has
 - the lowest temperature gradient in one blanket (ie, the temperature difference between various points on the blanket should differ as little as possible).¹²
 - a blanket that covers the largest area of skin possible without interfering with the surgical site.¹²
- Assess the patient for risks before using a forced-air warming system.^{2,9,10}
- Provide forced-air warming systems to patients with higher risks for hypothermia when the number of devices is limited.²
- Prewarm patients 30 to 60 minutes before anesthesia induction because forced-air warming increases a patient's mean-skin temperature by approximately 2° C (3.6° F).^{16,18,19,40}
- Monitor the patient's core body temperature during use of the warming device. If necessary, forced-air warming devices may be used in combination with other warming methods such as warmed irrigation liquid or warmed IV fluids.^{2,9,10}
- Never use a forced-air warming system to warm a patient without using an attached blanket. The substitution of commercial blanket with hospital cotton blankets is not recommended.^{28,30}
- Keep the blanket dry.³⁴
- Assess the condition of patients' skin and the connection between the hose and blanket during use. Patients undergoing major surgeries can experience large amounts of blood loss or have other risks that lead to poor perfusion, which places the patient at risk for thermal injury from the blanket. Many units do not have alarms that sound when a disconnection occurs between the hose and blanket, therefore, the nurse should check the connecting points regularly during use.^{2,9,10}
- Use single-use blankets to reduce the risk of cross contamination.³¹
- Use caution to interpret bispectral index readings whenever the monitoring sensor is near a forced-air warming blanket.²⁵
- Use forced-air warming devices in the post-anesthesia care unit.²
- Educate staff members about hypothermia and warming technology on a regular basis.^{2,9,10}

CONCLUSION

Maintaining normothermia is important to positive patient outcomes and requires the careful use of perioperative patient warming measures. Adopting the recommendations from this article may improve the quality of perioperative care related to maintaining normothermia by using forced-air warming systems. **AORN**

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