# Summary of Research Supporting Air-Free HotDog® Patient Warming

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PATIENT WARMING

Augustine Surgical Inc.
*Making Surgery Safer*

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Air-Free • Better Warming • Cost Effective

# Letter from Anesthesiologist and Inventor Dr. Scott Augustine

Dear Medical Professional,

When I became a doctor I took an oath, and the most important part of that oath is to first do no harm. I take that oath very seriously. The essence of “do no harm” is to always look out for the best interest of the patient—the patient who has trusted me with their life. Do No Harm is always at my core which may explain my obsession with patient safety.

I’m a physician, a scientist, and an inventor. Helping others by developing products that make a real difference in healthcare is what drives me every day. I believe there is always an opportunity to improve patient care, patient safety and surgical outcomes. That’s why my team and I invented a breakthrough technology for safely maintaining normothermia: the HotDog® Patient Warming System.

HotDog Patient Warming has become the world’s most used air-free/water-free patient warming system. It has been extensively studied all around the world, and it has consistently demonstrated its superior value on the metrics of effectiveness and safety.

This Research Summary is organized into four sections:

1. Effectiveness of Warming
    a. HotDog Patient Warming Effectiveness
    b. Comparison: Forced-air Warming Effectiveness
2. Clinical Benefits of Intra-Operative Normothermia
    a. Outcomes
    b. Cost of Hypothermia-Caused Complications
3. Safety of Air-Free Warming versus Forced-Air Warming
    a. Forced-air Warming Blowers Contaminated
    b. Waste Heat Causes Contamination
    c. Waste Heat Linked to Infection
    d. Forced-Air Warming Discontinued: Infection Rates Drop
4. Other Benefits
    a. Cost Effectiveness
    b. Environmental Impact

Thank you for entrusting us to safely provide your patients with the important therapeutic benefits that come from normothermia.

Sincerely,

Scott Augustine MD

Scott Augustine MD
CEO, CTO, CMO
Augustine Surgical Inc.

The HotDog® Patient Warming System utilizes a semi-conductive polymer fabric to safely and effectively provide perioperative warming to surgical patients without blowing air. The proprietary technology is most often referred to as Conductive Fabric Warming. Other researchers have called it Resistive-Polymer Warming, Radiant Warming, Conductive Blankets, Conductive Fabric Heating, and Electric Warming.

# HotDog Effectiveness

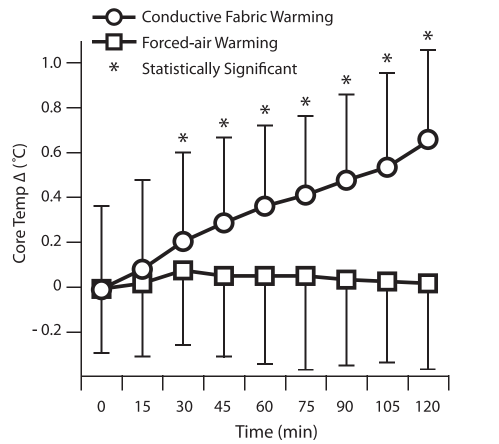
## Relative Clinical Heat Transfer Effectiveness: Forced-air Warming vs. Conductive Fabric Electric Warming, a Randomized Controlled Trial[1]

Sugai, H.; Koizumi, T.; Sumita, S.; Yamakage. *Journal of Anesthesia and Surgery.* Vol 5(2). Available online. *| No Company Support*

**SUMMARY:** The heat transfer capability for patient warming technologies is largely determined by two factors: 1.) conductive vs convective; and 2.) surface area of warming. [HotDog] conductive fabric electric warming (CFW) relies on conductive heat transfer and roughly doubles the body surface area in contact with the heat by utilizing over-body blankets and underbody mattresses.

In this prospective randomized controlled trial, conductive fabric warming (HotDog) showed significantly higher warming rates than forced-air warming (FAW) (0.35˚C/hr vs 0.01˚C/hr), when all other relevant variables were held constant. The temperature difference between the two groups was statistically significant at each data point after 30 minutes.

The authors' conclusion: "We conclude from these data that the clinical heat transfer effectiveness of [HotDog warming] is significantly greater than FAW convection. This is due to the combination of conductive heat transfer and the larger surface area of simultaneously heating from above and below the patient."

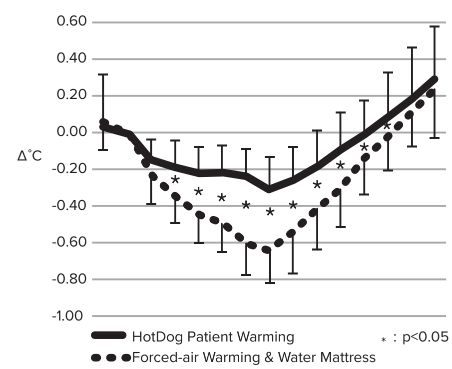



## Normothermia is Best Achieved by Warming Above and Below with Pre-warming Adjunct: A Comparison of Conductive Fabric Versus Forced-air and Water.[2]

Ohki K, et al. *Surg Technol Int.* 2019 May 15; 34:40-45. *| No Company Support*

**SUMMARY:** Thirty-five patients undergoing total knee arthroplasty were prospectively randomised into two groups to test the relative therapeutic effectiveness of combined above- and below-warming therapies: 1) forced-air warming/water mattress (FAW/WM), treated with WarmTouch® upper body forced-air warming and a Normotemp® underbody water mattress or 2) conductive fabric warming (CFW), treated with HotDog® electric upper body blanket and HotDog underbody mattress.

The CFW group had significantly warmer core temperatures compared with the FAW/WM group during most of the surgical procedure. During the period from 5–90 minutes after induction, the difference in core temperatures between the groups reached statistical significance ($p<0.05$). These results were largely due to superior pre-warming during preoperative preparations in the CFW group and thus reduced redistribution temperature drop following induction of anaesthesia. Both groups achieved 100% normothermia by the end of surgery, showing the effectiveness of simultaneous above and below warming.




## Safety and efficacy of resistive polymer versus forced air warming in total joint surgery[3]

Sandoval, M.; Mongan, P.; Dayton, M.; Hogan, C. *Patient Safety in Surgery* (2017) 11:11. *| No Company Support*

**SUMMARY:** This study compared the capabilities of patient warming between two different devices that use different mechanisms of warming: forced-air warming and air-free warming. The authors were motivated by patient safety. "Patient safety in healthcare includes the use of devices and technology that minimize potential adverse events to patients."

One hundred twenty patients undergoing total hip or total knee arthroplasty received patient warming via a forced warming device or an air-free HotDog®. Both groups achieved similar results in maintaining the core temperature of patients undergoing total knee or hip arthroplasty. Operating room staff observed that HotDog was less noisy. The authors preferred the air-free system for safety reasons, noting that "Quality improvement efforts aimed to enhance patient safety should include the implementation of healthcare equipment with the least known or suspected risk."

> "The potential for airflow disruption is present with the forced-air warming device and does not exist with the non-forced air device. The disruption of laminar airflow may be associated with surgical site infections."

## Resistive-Polymer Versus Forced-Air Warming: Comparable Heat Transfer and Core Rewarming Rates in Volunteers[4]

Kimberger, O.; et al. *Anesth Analg* 2008;107:1621-26 *| Company Support*

**SUMMARY:** The full body HotDog blanket was compared with full body forced-air warming blankets in re-warming anesthetized hypothermic volunteers in a controlled cross-over study. The warming rates of the two technologies were virtually identical.[5]

## Resistive-polymer Versus Forced-air Warming: Comparable Efficacy in Robot-assisted Laparoscopic Radical Prostatectomy[5]

Katsuda, Y.; et al. *Presented at American Society of Anesthesiologists Annual Meeting 2016*. A4039. | *No Company Support*

**SUMMARY:** In Trendelenburg position, hypothermia is common. This study compared the efficacy of two patient warming systems, forced-air (FAW) and resistive-polymer (RP) systems, in a prospective, randomized clinical study during robot-assisted laparoscopic radical prostatectomy (RALP).

Thirty-nine patients scheduled for RALP were randomized to either FA or RP warming groups. The two groups were equally effective at warming the patient in RALP. The authors' noted that the Near Surgeon Temperature was 3.9˚C warmer in the FA group than the RP group, showing the significance of waste heat, which resulted in thermal discomfort for the surgeons.

NOTE: This study did not utilize the HotDog underbody warming mattress. In Trendelenburg, we recommend the use of the HotDog underbody warming mattress along with WaffleGrip™ Warm & Secure to prevent patient movement. That will help achieve superior effectiveness.

## Utility of HotDog Patient Warming System™ in Thoracic Surgery[6]

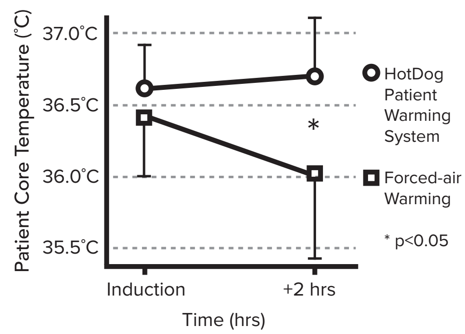
Ikeda, R.; Fujimoto, K.; Honma, N. *Japanese Society of Medical Instrumentation Program 2018.* | *No Company Support*

**SUMMARY:** The authors' noted that their hospital had used forced-air warming blankets in thoracic cases requiring a lateral position and that such warming was ineffective because it couldn't be initiated until the patient was fully prepped and draped. Air-free warming can be started before induction of general anesthesia.

Forty patients were randomized into two groups to receive different warming technologies: Bair Hugger® lower body blankets (Group A) and HotDog® Patient Warming System (Group B).

A statistically significant increase in body temperature was observed in the HotDog Patient Warming group, whereas the Bair Hugger warming group experienced a decrease in body temperature throughout the procedure.

The authors' concluded that the ability to warm prior to the induction of anesthesia (thereby reducing redistribution hypothermia) and the larger warming surface area with HotDog were responsible for greater warming effectiveness.



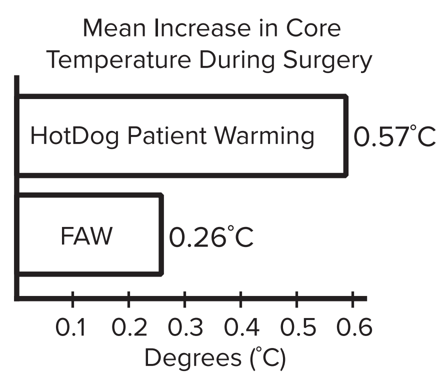

## Usefulness of HotDog Patient Warming System in Patient's Temperature Management During Surgery Under General Anesthesia[7]

Okura, M. Hokkaido *Surgical Nursing Society Collection.* May 19, 2018. | *No Company Support*

**SUMMARY:** This study compared the capabilities of patient warming between two different devices that use different mechanisms of warming: forced-air warming and air-free warming. The authors were motivated by patient safety. "Patient safety in healthcare includes the use of devices and technology that minimize potential adverse events to patients."

One hundred twenty patients undergoing total hip or total knee arthroplasty received patient warming via a forced warming device or an air-free HotDog®.

Both groups achieved similar results in maintaining the core temperature of patients undergoing total knee or hip arthroplasty. Operating room staff observed that HotDog was less noisy. The authors preferred the air-free system for safety reasons, noting that "Quality improvement efforts aimed to enhance patient safety should include the implementation of healthcare equipment with the least known or suspected risk."




## Resistive-Polymer Versus Forced-Air Warming: Comparable Efficacy in Orthopedic Patients[8]

Brandt, S.; Kimberger, O.; et al. Anesth Analg 2010; 110:834-8. | *Company Support*

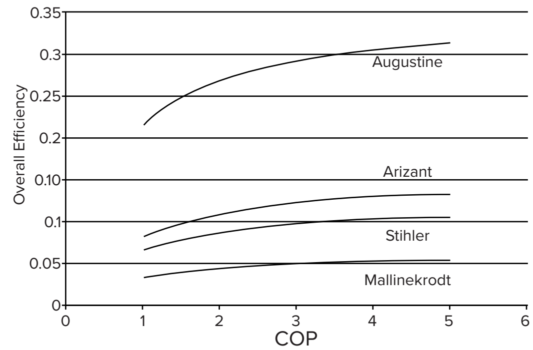
**SUMMARY:** 80 orthopedic surgery patients were randomized to forced-air warming (FAW) or resistive polymer warming (HotDog) upper body blankets during surgery. The warming rates were comparable for the two groups. No differences in mean skin and core temperatures. The waste heat from FAW also caused the environment of anesthesia's workspace to be 1.8°C warmer in that group. "Resistive polymer warming performed as efficiently as FAW in patients undergoing orthopedic surgery."

## Energy Efficiency Comparison of Forced-air Versus Resistance Heating Devices for Perioperative Hypothermia Management[9]

Bayazit, Yilmaz; Sparrow, Ephraim M. Energy. 2010 vol. 35, no. 3, pp. 1211-15. *| Company Support*

**SUMMARY:** Surface area being equal, efficiency of heat transfer is the most important predictor of warming effectiveness. This study found that there is a wide range of energy efficiencies among the various patient warming products that were investigated. Two technology-types were investigated: warming by convection using forced-air systems and warming by direct contact conduction using resistive warming systems.

The experimental data revealed that the specific characteristics of individual devices played a larger role with regard to energy efficiency than did the category. In particular, the most efficient device warmed by direct contact (HotDog, 35.4%), the second most efficient was a convective warming device (Bair Hugger, 15.4%), the third a direct-contact device (Stihler, 12.4%), and the last warmed by convection (Warm Touch, 6.3%). As a result, HotDog was shown to be 2.3x more efficient than Bair Hugger, 2.9x more efficient than Stihler, and 5.6x more efficient than Warm Touch.




## Implementation of Resistive Warmers for Total Joint Arthroplasty Procedures.[10]

Brown, Jenny. *AORN Journal.* April 2021. 113;4:400-404. *| No Company Support*

**SUMMARY:** In this AORN Quality Improvement Showcase, the author outlines her hospital's selection of air-free patient warming for total joint arthroplasty procedures. Orthopedic surgeons at Methodist North Hospital prohibited the use of forced-air warming (FAW) due to concerns about airflow disruption and increased risk for SSI. At first, the staff resorted to only passive warming intraoperatively until they eventually implemented air-free resistive warming (HotDog). The implementation was deemed a Quality Improvement success. Average intraoperative temperature increased 0.3˚C, and, more importantly, peri-prosthetic joint infections reduced from 3 to 1 over the two seven-month periods.


## Forced-Air Warming and Resistive Heating Devices. Updated Perspectives on Safety and Surgical Site Infections.[11]

Ackermann, Wiebke et al. *Frontiers in Surgery.* 2018;5:64. *| No Company Support*

**SUMMARY:** The authors conducted a literature review and found 73 relevant references that met their search criteria. Based on their review, they concluded that forced-air warming (FAW) can disrupt laminar flow systems and transport floor contaminants directly to the sterile surgical field, but the direct link to SSI is unclear. They also concluded that both FAW and Resistive Warming (RH) are equally effective in maintaining core body temperatures and reducing hypothermia. They advise clinicians to "weigh the risks and benefits when deciding to use either one of these devices."

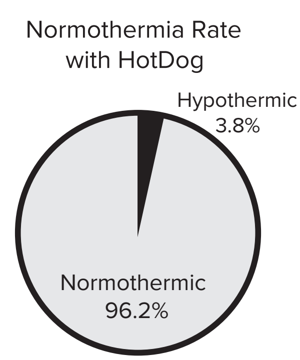
## Normothermia rate produced by the HotDog Patient Warming System in a multi-center, multi-specialty review of data[12]

Augustine Surgical Inc. Internal Company Data. Data on file.

**SUMMARY:** Augustine Surgical has collected temperature data from 400 + patients at a variety of inpatient and outpatient facilities including university hospitals, large community hospitals, and outpatient clinics.

The procedure types are non-cardiac, multi-specialty with heavy emphasis on orthopedic procedures. Only procedures warming above and below with HotDog underbody mattresses and warming blankets were included in the analysis. Patient temperatures were recorded in compliance with the SCIP/Medicare guidelines (within 30 minutes prior to or 15 minutes after anesthesia end-time).

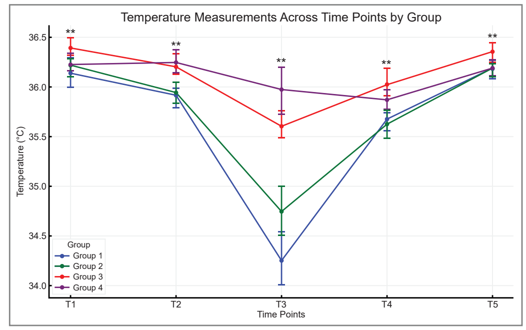
The results showed that HotDog produced a 96.2% normothermia rate.



## Effects of Optimal Temperature Control in Body Contouring Surgery: A Nonrandomized Controlled Clinical Trial.[13]

Hoyos AE, et al. Aesthetic Surgery Journal. 2024 Oct 15;44(11). | *Company Support*

**SUMMARY:** 197 adult patients undergoing body contouring surgery were divided into 4 groups with different warming interventions. Results shown in the graph: air-free, active patient warming during body contouring procedures significantly diminishes the risk of hypothermia and enhances overall clinical outcomes. Patients in the HotDog group had lowest Area Under the Curve (time and severity of hypothermia). Group comparisons showed a relationship between hypothermia and increased nausea, vomiting, shivering, pain, and additional analgesia requirements. According to the authors, "Our results demonstrate that [Blanketrol and HotDog] had a significant impact on clinical outcomes for patients undergoing body contouring procedures."




## The optimal warming strategy to reduce perioperative hypothermia: A prospective randomized non-blinded clinical trial.[14]

Desai R, et al. PLoS One. 2025 Jun 12;20(6):e0325954. | *No Company Support*

**SUMMARY:** Summary: The researchers compared the effectiveness of HotDog conductive warming ("CW") with Bair Hugger FAW by measuring patients' time with a hypothermic core temperature (<36˚C). They created a metric called Area Under the Curve (AUC). AUC is T˚(C below 36) * min.

182 surgical patients were randomized into 4 groups:

| Group | Prewarming Method | Intraop Warming Method |
|---|---|---|
| 1 | Conductive Warming (CW) | CW |
| 2 | Forced-air Warming (FAW) | FAW |
| 3 | No Prewarming (NPW) | CW |
| 4 | NPW | FAW |

The results showed significantly less hypothermia with CW than with FAW. The scientists verified that those warmed with Bair Hugger (without prewarming) spent the longest time below 36°C. Conversely, when HotDog was used (also without prewarming), patients were below 36°C less than half the time as compared to Bair Hugger. CW/CW Group performed the best with 76% less ypothermia than FAW. The authors concluded: "CW [HotDog] is more effective than FAW[Bair Hugger] at reducing intraoperative hypothermia when FAW is used without prewarming."

*Normothermia Score displays AUC relative to the historical standard of care— intraoperative FAW—with a median AUC of 19.9. Normothermia Score = 1- (AUC/19.9)

Desai R, Gosschalk J, van Helmond N, Mitrev L, Zhang C, McEniry B, Hunter K, Wallace E, Mele M, Ocbo J, Trivedi K, Hsu G, Krishnan S, Dibato J, Patel K. The optimal warming strategy to reduce perioperative hypothermia: A prospective randomized non-blinded clinical trial. PLoS One. 2025 Jun 12;20(6):e0325954.

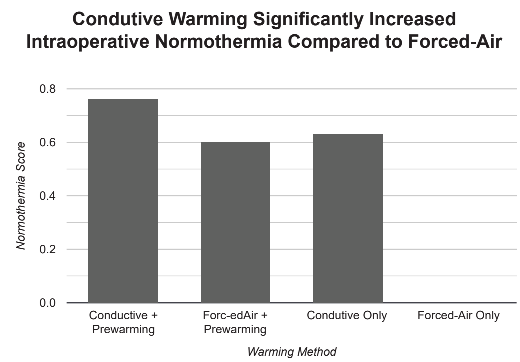



Chart shows normalized inverse metric of raw median hypothermia (AUC <36°C) values. CW/CW 4.7. NAPW/CW 7.4. FAW/FAW 8.0. NAPW/FAW 19.9. Normothermia Score = AUC (˚C*min) relative to the historical standard of care. The historical current standard of care is intraoperative FAW with a median AUC of 19.9. A Normothermia Score of 1 would mean that core temperature never dips below 36˚C.

## Examination of Effective Body Temperature Management Methods in Total Hip Arthroplasty: Comparison of Forced Air Warming and Conductive Air-Free Warming.[15]

Nakamaru, Y. The Japanese Journal of Operating Room Nursing. 2021. 17(1). | *No Company Support*

**SUMMARY:** The hospital discontinued warming during THA surgery due to concerns about contamination from FAW, so an air-free alternative was evaluated. Twenty patients were warmed with FAW (Group A) and 17 patients were warmed with the conductive system [HotDog] (Group B). All patients underwent THA under general anesthesia combined with epidural anesthesia.

The average maximum decrease in body temperature after induction of anesthesia was significantly less in Group B (-0.04˚C) compared to Group A (-0.33˚C). In group B, the body temperature at the time of leaving the room increased significantly by 0.31 ° C on average compared to the start of measurement.V

According to the authors, "The conductive warming device can be used without worrying about the possibility of contamination of the surgical field. Therefore, group B was able to continue warming during the epidural anesthesia insertion operation, and the preoperative heating time was extended. The heating efficiency was good, leading to suppression of redistribution hypothermia and intraoperative body temperature drop. From these facts, it is considered that more effective body temperature control was possible compared with the conventional method."

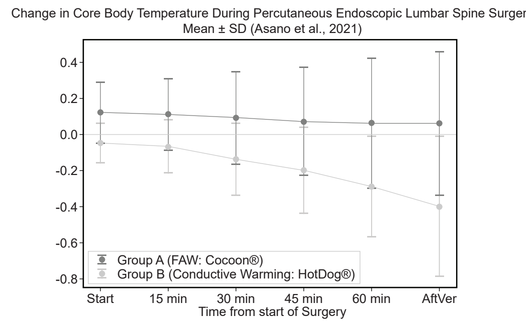
## Verifying The Effectiveness of a Patient Warming Device in Preventing Body Temperature Drop in Percutaneous Endoscopic Lumbar Spine Surgery[16]

Asano, Y. The Japanese Journal of Operating Room Nursing. 2021. 17(1) | *Company Support*

**SUMMARY:** Percutaneous endoscopic spinal surgery uses a large amount of perfused water to secure the field of view of the surgical field. Heat of vaporization from these fluids contributes to a decrease in core body temperature.

Twenty-Eight patients undergoing percutaneous endoscopic lumbar spinal surgery on a Jackson Table in prone position were divided into two groups of: Group A (FAW: Cocoon® warm air) and Group B (air-free, conductive warming: HotDog).

The decrease in body temperature in Group B was significantly less ($p<0.05$) at all times compared to Group A. According to the authors, "It was shown that the warm air generated from the warm air heating device warms the patient, but may have increased the heat of vaporization due to the convection generated by the air supply. On the other hand, since the conductive patient warming device warms the patient by conduction without supplying air, the heat loss due to the heat of vaporization could be minimized, which led to the prevention of the decrease in body temperature."

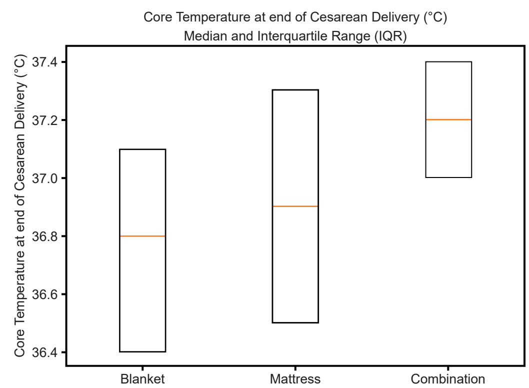



## A Nonrandomized Comparative Study of the Warming Effects of Conductive-Polymer Heating Devices in Patients Undergoing Cesarean Delivery with Spinal Anesthesia.[17]

Hagiwara, H; Hara, K; et al. AORN J. 2025 Jun;121(6):449-461. | *No Company Support*

**SUMMARY:** This nonrandomized study of 70 patients undergoing cesarean delivery with spinal anesthesia compared the effectiveness of a conductive-polymer heating device (CPHD) in maintaining temperatures and enhancing thermal comfort. Patients were divided into 3 groups each receiving a different CPHD treatment: 1) HotDog Blanket, 2) HotDog Mattress, 3) Combination HotDog Blanket and Mattress. All devices were set at 38˚C.

Patients who were warmed with a combination CPHD blanket and mattress had significantly higher core temperatures ($P < .01$) than those warmed only by a CPHD blanket or mattress. Patients who were warmed with a CPHD blanket and those warmed with a CPHD blanket and a CPHD mattress reported significantly higher thermal comfort scores.



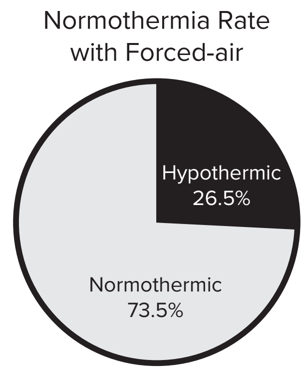
# Forced-Air Warming Effectiveness

A review of published literature was conducted to determine the effectiveness of forced-air warming (FAW) systems. Data was extracted from a review conducted by the National Institute for Health and Care Excellence (NICE) for its Addendum to Clinical Guidelines CG64, Inadvertent Perioperative Hypothermia. Data was also taken from two recent articles published in the British Journal of Anaesthesia and the British Journal of Arthroplasty.

NICE conducted a single systematic search to answer the question, "Are warming devices/mechanisms effective in preventing inadvertent perioperative hypothermia in adults in different phases of perioperative care?" After screening and further review, it was determined that 26 articles were included in the review for various types of warming technologies.

The cumulative results showed that forced-air warming resulted in a normothermia only 73.5% of the time, meaning that 26.5% of patients remained hypothermic at the end of surgery.

| Journal | Lead Author | Hypothermic at End | N/n |
|---|---|---|---|
| J. Cardiac Surg | Calcaterra[18] | 25% | 5/25 |
| A & A | Egan[19] | 12% | 4/34 |
| Anesthesiology | Janicki[20] | 21.4% | 6/28 |
| Anaesth & Inten Care | Kadam[21] | 15.3% | 2/13 |
| Anaesthesia | Leung[22] | 50% | 15/30 |
| Asian Biomedicine | Suraseranivongse[23] | 27.2% | 6/22* |
| Anesth & Inten Care | Torrie[24] | 32.2% | 10/31 |
| J. Canadian d'anaesthesie | Trentman[25] | 56% | 14/25 |
| Brit J Anaesthesia | Min[26] | 18.7% | 23/123 |
| BJ Arthroplasty | Leijtens[27] | 26.9% | 181/672 |
| **Cumulative** | | **26.5%** | **266/1003** |



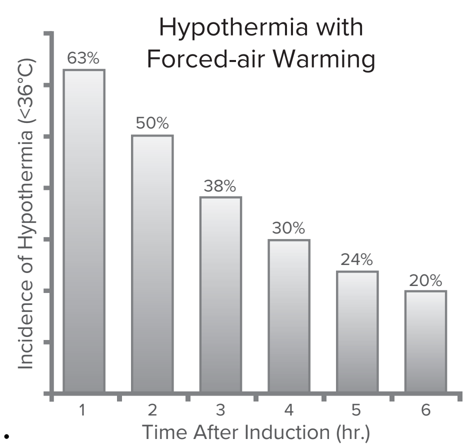

## Intraoperative Core Temperature Patterns, Transfusion Requirement, and Hospital Duration in Patients Warmed with Forced Air[28]

Sun,Z.; Sessler, D. Anesthesiology. 2015; 122:276-285.

**SUMMARY:** Researchers evaluated core temperatures in 58,814 adults having surgery lasting >60 min who were warmed with forced-air warming at the Cleveland Clinic.

Hypothermia rates were far more than anticipated. The incidence of hypothermia 2 hrs after induction was nearly 50%. The authors' concluded that "Intraoperative hypothermia was common, and often prolonged."

In an accompanying Editorial[29] called Time for a New Standard of Care, Harriet Hopf, MD, wrote, "The study by Sun et al. starts a new conversation on perioperative temperature management. Future studies should evaluate the effectiveness of interventions to reduce the degree and duration of intraoperative hypothermia..."




## Effect of Preoperative Warming on Intraoperative Hypothermia: a Randomized-controlled Trial[30]

Lau, Aaron. *Canadian Journal of Anaesthesia.* June 2018. 65.

*| No Company Support*

**SUMMARY:** In this study funded by 3M, patients were randomized into two groups to evaluate the effects of pre-warming on intraoperative temperatures. The pre-warmed patients showed lower rates of hypothermia, but the most interesting takeaway was this: "The odds of hypothermia increased by 4.9% for every minute of delay encountered by pre-warmed participants between the end of the pre-warming period to initiation of intraoperative forced-air warming [OR, 1.05; 95% CI, 1.02 to 1.08]." Delays between the end of pre-warming and initiating intraoperative warming can exceed 30 minutes, completely negating the benefits of pre-warming.

With HotDog, warming can start immediately upon entering the O.R. The operating table is prewarmed, which enhances patient satisfaction and prevents heat loss. A warming blanket can also be initiated earlier because it's not blowing air (no airborne contamination).

# Benefits of Intra-Operative Normothermia

Without active warming, surgical patients become hypothermic under anesthesia. Even mild hypothermia is associated with higher rates of infection, blood loss, morbid cardiac events, mortality, and longer hospital stays. Here is a sampling of some of the more prominent studies:

| Complication | N | °C hypothermia | Normothermic | Hypothermic | p value | Author |
|---|---|---|---|---|---|---|
| Surgical wound infection | 200 | 1.9 | 6% | 19% | <0.01 | Kurz et al[31] |
| Surgical wound infection | 45,304 | 0.9 | 7.5% | 12.9% | <0.0001 | Scott et al[32] |
| Duration of hospitalization | 200 | 1.9 | 12.1 +/- 4.4d | 14.7+/-6.5d | <0.01 | Kurz et al[31] |
| Allogenic transfusion requirement | 60 | 1.6 | 10 +/- 55 mL | 80 +/- 154 mL | <0.05 | Schmied et al[33] |
| Intraoperative blood loss | 60 | 1.6 | 1.7 +/- 0.3 L | 2.2 +/- 0.5 L | <0.001 | Schmied et al[33] |
| Intraoperative blood loss | 150 | 0.4 | 488 mL | 618 mL | 0.002 | Winkler et al[34] |
| Intraoperative blood loss | 60 | 1.8 | 1.5 +/- 0.5 L | 2.7 +/- 1.0 L | 0.01 | Hofer et al[35] |
| Allogenic transfusion requirement | 60 | 1.8 | 0.4 +/- 0.4 L | 1.1 +/- 0.9 L | 0.013 | Hofer et al[35] |
| Morbid cardiac events | 300 | 1.3 | 1% | 6% | <0.05 | Frank et al[36] |
| Postop ventricular tachycardia | 300 | 1.3 | 2% | 8% | <0.05 | Frank et al[36] |
| Ischemic cardiac events | 45,304 | 0.9 | 1.4% | 3.1% | <0.0001 | Scott et al[32] |
| Myocardial damage | 60 | 1.0 | 8 +/- 5 ng/mL | 22 +/- 9 ng/mL | <0.01 | Nesher et al[37] |
| AAA mortality | 262 | 2.0 | 1.5% | 12.1% | <0.01 | Bush et al[38] |
| Mortality | 45,304 | 0.9 | 1.4% | 4.8% | <0.0001 | Scott et al[32] |
| Liver transplant CMV infections | 100 | 1.6 | 4% | 17% | 0.06 | Paterson et al[39] |
| Duration of post anesthetic recovery | 150 | 1.9 | 53 +/- 36 min | 94 +/- 65 min | <0.001 | Lenhardt et al[40] |

# Cost of Hypothermia-Caused Complications

## Maintaining Intraoperative Normothermia: A Meta-Analysis of Outcomes with Costs[41]

Mahoney, C; Odom, J. AANA Journal. 1999; 67(2):155-164. *| No Company Support*

**SUMMARY:** Intraoperative hypothermia averaging only 1.5˚C less than normal resulted in adverse outcomes that negatively affected the quality and length of patients' lives. The cumulative adverse outcomes added between $2,500 and $7,000 per surgical patient to hospitalization costs across a variety of surgical procedures.

**HYPOTHERMIA COST**
**$2,500–$7,000**
**Per Patient**

## Clinical Guidelines CG65, Inadvertent Perioperative Hypothermia[42]

National Institute for Health and Care Excellence. September 2016. Available Online. *| No Company Support*

**SUMMARY:** The mean net monetary benefit per hypothermia case averted is approx. $3,000. Hypothermia defined as (<36˚C).

**HYPOTHERMIA COST**
**$3,000~**
**Per Patient**

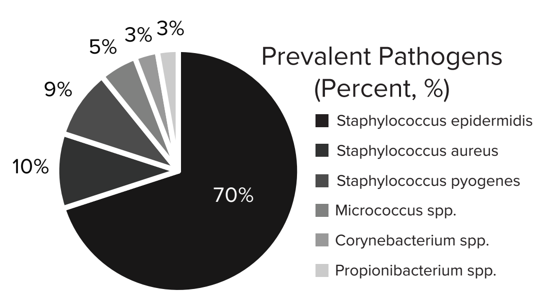
***Safety Comparison***

# Forced-Air Warming Blowers Contaminated

## Forced Air Contamination Risk in the OR[43]

Lange, Victor R. *American Journal of Infection Control*. June 2019. 47:6;S25-26. *| No Company Support*

**SUMMARY:** Surface and air samples were collected from 35 FAW devices used in varying procedures in OR's at participating hospitals. Of the 320 samples, 24.4% had higher-than-maximum-acceptable colony forming unit (CFU) pathogen levels and 42.5% had higher-than-minimum-acceptable CFU pathogen levels. The study also identified a correlation with airborne samples that had high-pathogen contamination, resulting "in a possible increased patient infection risk." The authors concluded that FAW device-component contamination may be a heightened risk in the OR and that "a reduction in surface and airborne CFUs may positively reduce SSI and HAI risk."



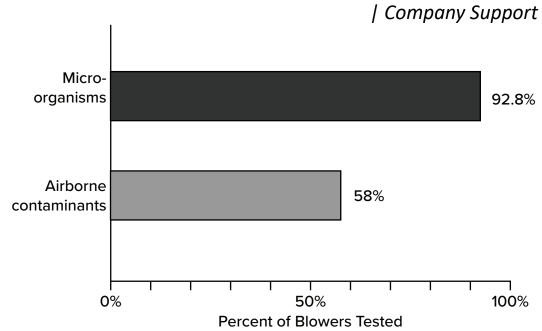
# Forced-Air Warming Blowers Contaminated (cont.)

## Forced-air Warming Blowers: An Evaluation of Filtration Adequacy and Airborne-contamination Emissions in the Operating Room[44]

Albrecht, M.; Leaper, D.; et al: American Journal of Infection Control, 2011; 39:321-8.

*| Company Support*

**SUMMARY:** 52 forced-air blowers sampled in their operating room environments. Micro-organisms were cultured from the internal air-flow paths of 92.3% of the blowers. 58% of the blowers tested were found to be internally generating and emitting significant levels of airborne contaminants >0.3 µm in size (germ size), up to 35,272 particles per ft³ of air (80 million particles per hour).

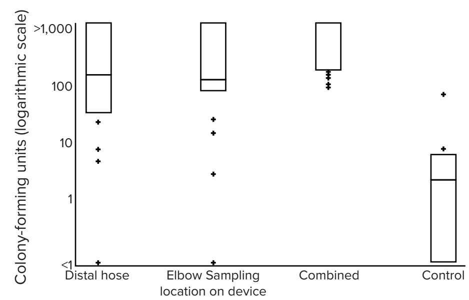



## Forced-air Warming Design: Evaluation of Intake Filtration, Internal Microbial Buildup, and Airborne-contamination Emissions[45]

Reed, R.; McGovern, P.; Guathier R.; et al: JAANA. 2013;81(4).

*| Company Support*

**SUMMARY:** 23 forced-air blowers were sampled in their operating room environments. Micro-organisms were cultured from the internal air-flow paths of 100% of the blowers. 100% of the blowers were emitting internally generated particles >0.3 µm in size, up to 112,000 particles per ft³ of air (300 million particles per hour). Emitted particle count was 40 times greater than the intake particle count for that blower, and virtually all of the emitted particles were internally generated.

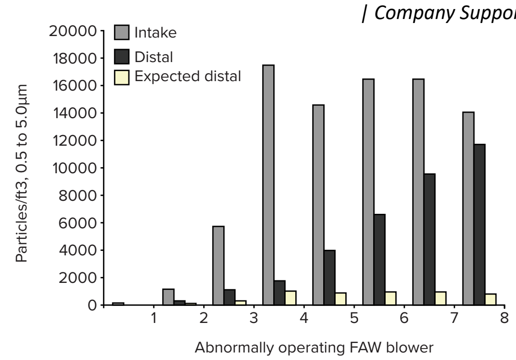



## Forced-air Warming: A Source of Airborne Contamination in the Operating Room?[46]

Leaper, D.; Albrecht, M.; Gauthier, R.; Orthopedic Reviews 2009; 1:e28.

*| Company Support*

**SUMMARY:** 25 Bair Hugger blowers sampled in their operating room environment. Pathogenic bacteria were cultured from the internal airflow paths of 94% of the blowers. 32% of the blowers tested were emitting internally generated airborne contamination in the size range of bacteria. 24% of the blowers tested were emitting "significant levels of internally generated airborne contamination." "...findings in this study and those of others suggest that bacteria colonize the internal air path surfaces of the majority of FAW blowers. The findings also suggest that a significant percentage of FAW blowers are emitting particulates, which were shown to originate inside the blowers." "Clinicians should be aware that FAW blowers emit more than just hot air..."




## Skin Contamination Following Use of a Forced-air Warming Device[47]

Hamilton KR. Poster Presentation. American Association of Nurse Anesthetists Annual Meeting, 2016.

*| No Company Support*

**SUMMARY:** In this 30 patient study, 47% of forced-air warming blanket interiors were contaminated (culture positive) by organisms originating in the Bair Hugger blowers. 10% of the patients experienced skin that was contaminated (culture positive) by organisms originating in the Bair Hugger blowers.

## Persistent Acinetobacter Baumannii? Look Inside Your Medical Equipment[48]

Bernards AT et al. Infection Control and Hospital Epidemiology. 2004;25:1002-1004.

*| No Company Support*

**SUMMARY:** The authors reported two multidrug-resistant Acinetobacter baumannii outbreaks in their hospital that were genetically linked to organisms growing in several pieces of medical equipment including Bair Hugger forced-air blowers. The first outbreak was controlled by disinfecting the internal airflow path of the Bair Hugger blowers.

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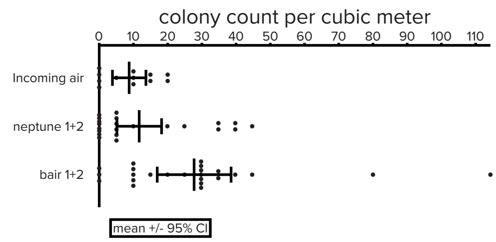
# Forced-Air Warming Blowers Contaminated (cont.)

## Potential Sources of Operating Room Air Contamination: A Preliminary Study[49]

Ward, Justin et al. *Journal of Hospital Infection*. 2021 July;113:59-64.

*| No Company Support*

**SUMMARY:** A Stanford University research team collected 200 air samples on Agar plates in 12 randomly selected ORs. The Bair Hugger blowers emitted four times as many colony-forming units as room air. "We can say with certainty," Dr. Ward, the lead author, concluded, "that the Bair Hugger is contributing airborne microbes into the air." In fact, pathogens were identified by DNA sequencing that were unique to Bair Hugger and that could not be cultured from OR inlet air.




*Safety Comparison*

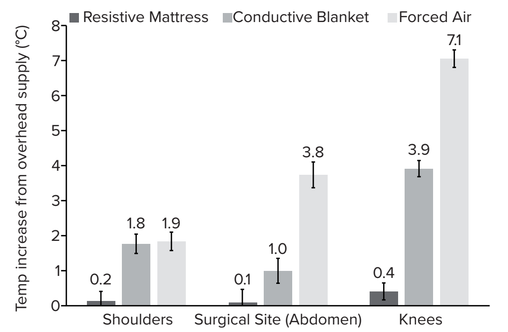
# Waste Heat Contamination

## Effect of Forced-air Warming on the Performance of Operating Theatre Laminar Flow Ventilation[50]

Dasari, K.B.; et al. Anaesthesia. Vol. 67; 2012: 244-249.

*| Company Support*

**SUMMARY:** Floor-to-ceiling temperatures were analyzed in a laminar flow operating room with different patient warming devices. With forced-air warming, mean (SD) temperatures were significantly elevated over the surgical site vs those measured with the conductive blanket (+2.73 (0.7)0C; p < 0.001). "We conclude that forced-air warming generates convection current activity in the vicinity of the surgical site. The clinical concern is that these currents may disrupt ventilation airflows intended to clear airborne contaminants from the surgical site."

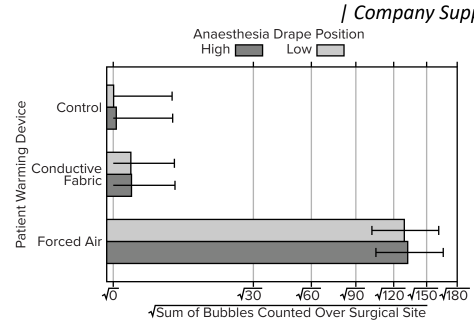



## Patient Warming Excess Heat: The Effects on Orthopedic Operating Room Ventilation Performance[51]

Belani, K.G.; Albrecht, M.; McGovern, P.D.; Reed, M.; Nachtsheim, C. Anesthesia & Analgesia. 2013;117(2):406-11.

*| Company Support*

**SUMMARY:** Researchers assessed the effects of waste heat from upper body patient warming devices by releasing neutral buoyancy bubbles into the non-sterile region under the head side of the anesthesia drape and assessing if the bubbles were mobilized to the surgical site. "The direct mass-flow exhaust from forced-air warming generated hot-air convection currents that mobilized 'bubbles' over the anesthesia drape and into the surgical site." Conductive fabric warming had no such affect.

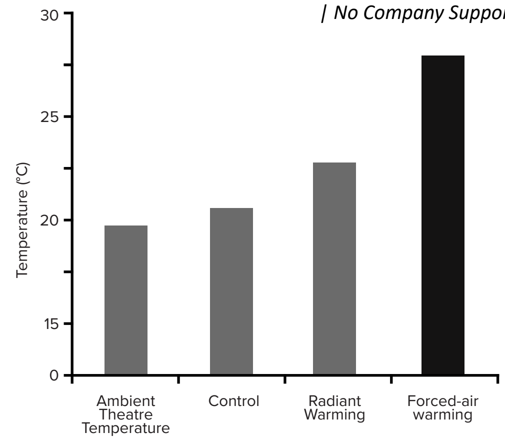



## Do forced-air patient-warming devices disrupt unidirectional downward airflow?[52]

Legg, A.J.; Cannon, T; Hammer, A.J. Journal of Bone and Joint Surgery Br. 2012;94-B:244-256.

*| No Company Support*

**SUMMARY:** The researchers studied the temperature and number of particles over the surgical site comparing forced-air warming, radiant warming (HotDog), and no warming during lower-limb arthroplasty. "Forced-air warming resulted in a significant mean increase in the temperature (1.1°C vs 0.4°C, p<0.0001) and number of particles (1038.2 vs 224.8, p=0.0087) over the surgical site when compared with [HotDog] warming, which raises concern as bacteria are known to require particles for transport."



# Waste Heat Contamination (cont.)

## Forced-air patient warming blankets disrupt unidirectional airflow[53]

Legg, A.J.; Hamer, A.J.; et al: Bone and Joint Journal, March 2013 vol. 95-B no. 3 407-410. | *No Company Support*

**SUMMARY:** Knee Replacement: The waste heat from forced-air warming (FAW) torso blankets radiated through the surgical drape to form tornado-like vortexes of rapidly spinning air near the surgical site. The vortexes sucked contaminated air from the operating room floor and deposited it over the surgical wound.

2,000 times more contaminant particles were found in the air over the wound with Bair Hugger warming than with air-free HotDog conductive warming. With HotDog, only 1,000 particles per cubic meter of air were present. With Bar Hugger warming, the particle count was 2,174,000 per cubic meter, an increase of 217,300%.

Conclusion: Waste heat from FAW significantly disrupts unidirectional airflow, drawing contaminant particles to the surgical site. Therefore, a warming device that disperses heat away from the patient should not be used.

Particle Entrainment Concentration

| Warming scenario | Concentration (particles/m³) |
|---|---|
| Control | 2000 |
| Radiant warming | 1000 |
| Forced-air warming | 2 174 000 |

## Active warming systems to maintain perioperative normothermia in hip replacement surgery: a therapeutic aid or a vector of infection?[54]

Moretti, B.; Larocca, A.M.; Napoli, C.; et al. J Hosp Infect 2009;73:58e63. | *No Company Support*

**SUMMARY:** This study assessed the risk of contamination of the surgical site correlated to the use of the Bair Hugger blanket during hip replacement surgery. The level of bacterial contamination of the air in the operating theatre was quantified with and without the use of the Bair Hugger, during the course of 30 total hip implant procedures, by measuring the colony forming units (cfu) at three different points around the operative site. In the 20 procedures in which the Bair Hugger was used, the mean bacterial load values were significantly increased in the three points compared with the at-rest conditions (A1 = 41.7 ± 28.1 cfu/m³ vs. 17.8 ± 14.5 cfu/m³, P<0.001; A2 = 42.2 ± 28.6 cfu/m³ vs. 19.4 ± 17.5 cfu/m³, P=0.001; A3 = 42.3 ± 28.2 cfu/m³ vs. 19.2 ± 17.7 cfu/m³, P<0.001). No wound infections occurred in the 20 patients.

## Effect of Heated-Air Blanket on the Dispersion of Squames in an Operating Room[55]

He, X.; Elghobashi, S. Int J Numer Meth Biomed Engng. 2018;34:e2960. | *No Company Support*

**SUMMARY:** High fidelity, large eddy simulation (LES) was used to study the interaction of the operating room ultra-clean ventilation air flow and the flow created by Bair Hugger® forced air warming and its impact on the dispersion of squames particles.

"Drastic differences in the trajectories of the squames are observed between the blower-off and blower-on cases." With the blower-off, the majority of the squames are dispersed by the ventilation air flow and never rise to the level of the operating table (OT). In contrast, with the blower-on, a large number of squames are lifted upwards by the rising thermal plumes. "Large number of squames are seen to be above the OT, several are surrounding the surgeons hands, above the side tables, and some are very close to the patient's knee and the surgical site."

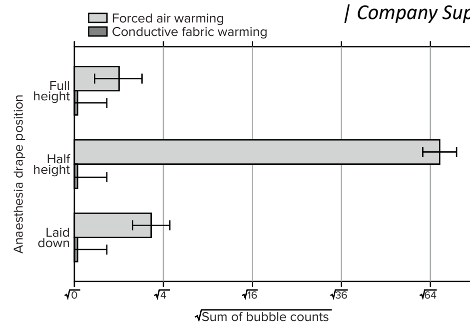
"[T]he hot air from the blower and the resultant thermal plumes are capable of lifting the particles and transporting them to the side tables, above the operating table, and the surgical site."

## Forced-air Warming and Ultra-clean Ventilation Do Not Mix: An investigation of theatre ventilation, patient warming and joint replacement infection in orthopedics[56]

McGovern, P.D.; Reed, M.R.; et al. J. Bone and Joint Surgery Br, 93B:11. 1537-44. Nov 2011. | *Company Support*

**SUMMARY:** 1. Hip Replacement: Forced air warming mobilized under-drape air over the anaesthesia/surgery drape and into the surgical site. In contrast, conductive fabric warming did not have a mobilizing effect. Anaesthesia/surgery drape position had a large effect on under-drape air mobilization for forced air warming.

2. Lumbar Spinal Procedure: Excess heat from forced air warming resulted in the development of hot-air convection currents between the surgeon's body and operating table that transported floor-level air upwards and into the surgical site. Conductive fabric warming did not release sufficient excess heat to establish these convection currents



## Hygiene and room climate in the operating room[57]

Scherrer, M.; et al. Minimally Invasive Thermal Allied Technology. 2003 Nov;12(6):293-9. *| No Company Support*

**SUMMARY:** "The air emitted from [the blankets of forced-air warming systems] disturbs the ultra clean field and preliminary investigations have shown an increase of bacteria in the operating field when the warming system is on." Despite laminar airflow conditions, colony forming units (cfu/m3) were significantly higher across the four measurements when the warming system was 'on' versus 'off.'

## Transmission of Mycobacterium chimaera from Heater-Cooler Units during Cardiac Surgery despite an Ultraclean Air Ventilation System[58]

Sommerstein, R.; Sax, H.; et al. Emerging Infectious Diseases (CDC). 2016;22(6):1008-1013. *| No Company Support*

**SUMMARY:** Heater–cooler units (HCU) are identified as a source of Mycobacterium chimaera causing surgical site infections. The authors investigated transmission of this bacterium from HCUs to the surgical field by using a thermic anemometer and particle counter, videotape of an operating room equipped with an ultraclean laminar airflow ventilation system, and bacterial culture sedimentation plates in a nonventilated room. Smoke from the HCU reached the surgical field in 23 s by merging with ultraclean air. The HCU produced on average 5.2, 139, and 14.8 particles/min in the surgical field at positions Off, On/oriented toward, and On/ oriented away, respectively. Culture plates were positive for M. chimaera <5 m from the HCU in the test room. These experiments confirm airborne transmission of pathogens from a the exhaust vent of a HCU to an open surgical field despite ultraclean air ventilation.

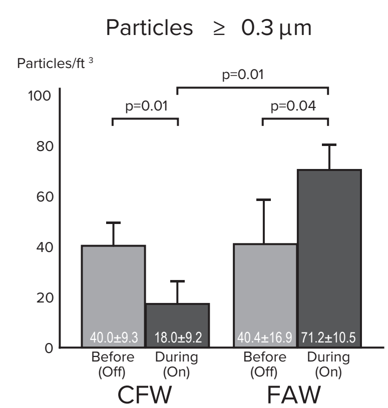
> "Efforts to mitigate infectious risks during surgery should consider contamination from water sources and airflow-generating devices."

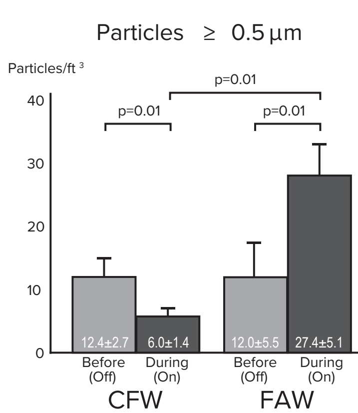
## Do Forced Air Warming Systems Contaminate the Surgical Field? A Comparative Study vs. Electric Patient Warming[59]

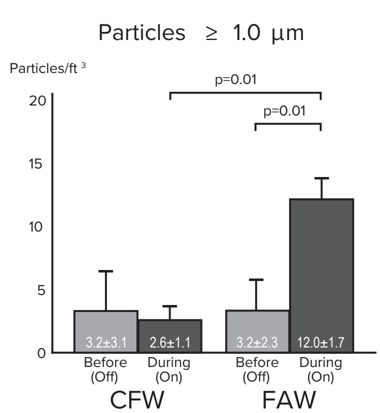
Nishida, T.; Ikejiri, Y. Presented at American Society of Anesthesiologists Annual Meeting 2018. Submitted for Publication. *| No Company Support*

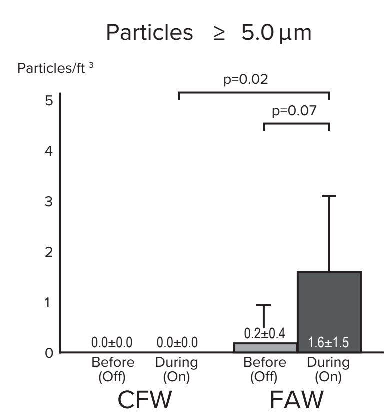
**SUMMARY:** To determine the cleanliness of the surgical field, the authors measured the number of particles above the surgical field while using two different warming methods: forced-air warming (FAW) and a conductive fabric, air-free, electric patient warming system (CFW). In simulated total knee arthroplasty surgery, two groups were formed to compare particles around the surgical site: one utilizing a FAW device (Group M : Mistral-Air, The 37Company) and another utilizing a CFW device (Group H: HotDog, Augustine Temperature Management).

Particle counts in the sterile field were significantly higher in Group M (the FAW group) than in Group H (the CFW group). The authors theorized that the increased contamination was due to the large amount of waste warm air generated by FAW. The authors concluded from the data that it might be desirable to perform intraoperative body temperature management using air-free, conductive fabric electric warming in joint implant procedures and other ultraclean surgeries.



# Waste Heat Contamination (cont.)

## Infection control hazards associated with the use of forced-air warming in operating theatres.[60]

Wood, A.M. Journal of Hospital Infection. 2014 BNov;88(3):132-40. *| No Company Support*

**SUMMARY:** The authors of this review article examined the published experimental and clinical research to identify infection control hazards of using forced air-warming (FAW) in operating theatres to prevent inadvertent hypothermia. The authors conclude that based on the available evidence, FAW does contaminate ultra-clean air ventilation. Furthermore, they concluded that the definitive link to an increased risk of SSI based on current research is incomplete. Because of the risk of infection from increased contamination, however, they "recommend that surgeons should at least consider alternative patient-warming systems in areas where contamination of the operative field may be critical."

A.M Wood et al. Journal of Hospital Infection xxx (2014) 1-9

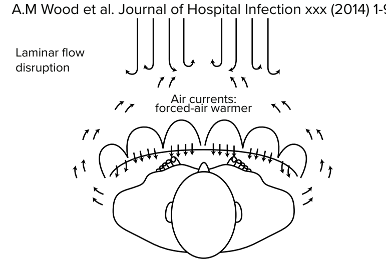
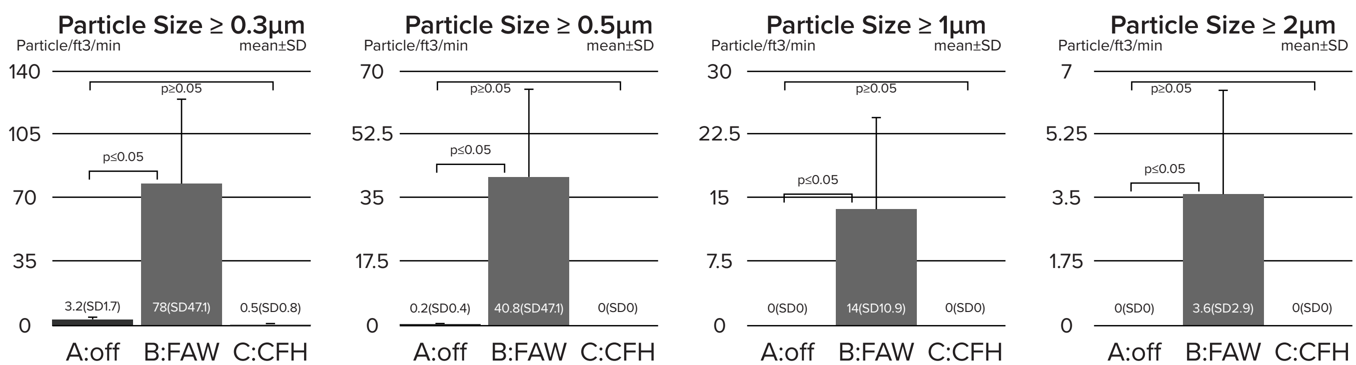



**Figure 3.** Potential effects on laminar flow with forced-air warming.

## Effect of Patient Warming Device on Cleanliness of Surgical Field.[61]

Asano, Yuji. Presented at AORN Global Surgical Conference. A118. 2020. *| No Company Support*

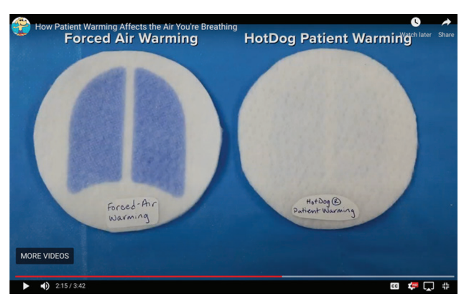
**SUMMARY:** Particle counts were measured in the surgical field during simulated lower limb surgery in three groups with different temperature management methods: control, forced-air warming (FAW), and conductive fabric heating (CFH). Compared with control, the number of particles of ≥ 0.3μm, ≥0.5μm, ≥1μm, and ≥2μm size were significantly higher in the FAW group. Additionally, compared with control the number of particles ≥0.3μm was significantly lower in the CFH group and no different in the other particle sizes. FAW produced significantly more particles in the surgical field of all sizes compared to CFH.




## How Patient Warming Affects the Air You're Breathing[62]

Augustine, Scott. Unpublished Video Research. December 2020. Available Online: hotdogwarming.com/videos

**SUMMARY:** A mannequin equipped with an air suction device to simulate breathing was positioned in the Anesthesia-provider's space near the operating table in a ventilation laboratory. Two groups were compared with different warming systems positioned on the mannequin-patient's upper body: forced-air warming (FAW) and conductive fabric warming (CFW). Blue carpenter chalk was sprayed above the patient's head from a consistent angle in both groups. A filter was positioned inside the breathing circuit of the anesthesia provider to capture inhaled particles. The filter was full of chalk in the FAW group and essentially clear in the CFW group.




This research shows exactly how waste heat from FAW contributes to the airborne transmission of aerosols. Link: https://www.hotdogwarming.com/videos

*Safety Comparison*

# Waste Heat Contamination (cont.)

## How You’re Still Breathing Surgical Smoke[63]

Augustine, Scott. Unpublished Video Research. February 2021. Available Online: hotdogwarming.com/videos

**SUMMARY:** This research video documents the waste heat from a forced-air warming (FAW) upper body blanket as it vents along the surgical drape and is sucked under the surgical light before it counteracts with the downward-flowing laminar ventilation airflow. The mixture of the waste heat with the cool ventilation air causes a large vortex to form over the surgical field that captures unevacuated surgical smoke, bioaersols, and other airborne contaminants above the surgical field and keeps them in the breathing zone of the surgical staff.


This research shows how FAW waste heat forms a large vortex above the surgical field, trapping unevacuated surgical smoke, bioaersols, and other airborne contaminants in the breathing zone of the surgical staff. Link: https://www.hotdogwarming.com/videos

## How to Keep Surgical Smoke Away from Your Lungs[64]

Augustine, Scott. Unpublished Video Research. March 2021. Available Online: hotdogwarming.com/videos

**SUMMARY:** In a ventilation laboratory, a mannequin equipped with an air suction device to simulate breathing was positioned next to the operating table. Two groups were compared to see how the type of warming system—forced-air warming (FAW) versus conductive fabric warming (CFW)—affects the amount of airborne particles inhaled by the surgeon, surgical techs, or nurses standing around the operative field. Blue carpenter chalk was sprayed in the vicinity of the operative site to simulate surgical smoke generation. A filter was positioned inside the breathing circuit of the surgeon-mannequin to capture inhaled particles. The filter was full of chalk in the FAW group and essentially clear in the CFW group. The video shows that the difference was due to the vortex formed by the waste heat from FAW.


This research shows how the vortex caused by FAW waste heat directly results in a significant amount of airborne particles inhaled by the mannequin. Link: https://www.hotdogwarming.com/videos

## Operating Room Temperature and Patient Normothermia.[65]

Wongworawat, M. Orthopaedic Knowledge Update. Musculoskeletal Infection. Ed. 2. Wolters Kluwer, 2025. *| No Company Support*

**SUMMARY:** “Forced air warming (FAW) devices were previously a common type of patient warming device used in orthopaedic surgery. However, as FAW devices expel warm air that is approximately 20°C higher than the temperature of operating room air, the difference in temperature generates convection currents, which have been shown to interfere with the effectiveness of laminar air-flow. One popular alternative to FAW devices is conductive fabric warming devices that are more thermally efficient and release less heat into the surroundings while mitigating the risk of perioperative hypothermia.”

“Although the 2018 [International Consensus Meeting] concluded that there was no definite link between FAW devices and an increased risk of surgical infection, delegates advised that alternative methods of warming should be used.”

*Safety Comparison*

# Waste Heat Linked to Infection

## Transmission of Mycobacterium chimaera from Heater-Cooler Units during Cadiac Surgery despite an Ultraclean Air Ventilation System[66]

Sommerstein, R.; Sax, H.; et al. Emerging Infectious Diseases (CDC). 2016;22(6):1008-1013. *| No Company Support*

**SUMMARY:** The waste heated air from the ventilation fans of Heater–cooler units (HCUs) were recently identified as a source of Mycobacterium chimaera causing surgical site infections in several reports. In this study, the HCU produced on average 5.2, 139, and 14.8 particles/min in the surgical field at positions Off, On/oriented toward, and On/ oriented away, respectively. Culture plates were positive for M. chimaera <5 m from the HCU in the test room. These experiments confirm airborne transmission of M. chimaera aerosols from a contaminated HCU to an open surgical field despite ultraclean air ventilation. “Efforts to mitigate infectious risks during surgery should consider contamination from water sources and airflow-generating devices.”

*Safety Comparison*

# Waste Heat Linked to Infection (cont.)

## Relationship Between Types of Warming Devices and Surgical Site Infection in Patients Who Underwent Posterior Fusion Surgery Based on National Data.[67]

Kim, SH; Cha, Y; et al. Neurospine. 2023;20(4):1328-1336. | *Company Support*

**SUMMARY:** The effects of warming devices on SSI rates were analyzed using data compiled by the Health Insurance and Review Assessment Service in Korea. The study included 5,406 patients who underwent posterior fusion surgery during a 3-year period. The incidence of SSI was higher in patients who underwent forced-air warming than in those who did not undergo active warming (odds ratio, 1.73; p=.039) especially above 70 years old (odds ratio, 4.11; p=.014). By contrast, the incidence of SSI was not significantly higher in patients who received air-free, conductive warming. In conclusion, SSI rates were higher in patients who underwent warming with FAW than with air-free conductive warming.

Table 1. General characteristics of study subjects according to active warming techniques (Continued)

| Variable | Active warming techniques | | | | p-value |
|---|---|---|---|---|---|
| | Total | No intraoperative warming device | Forced air warming devices | Device using conduction[†] | |
| Surgical site infection | | | | | 0.057 |
| Yes | 88 (1.6) | 21 (1.2) | 56 (2) | 11 (1.3) | |
| No | 5,317 (98.4) | 1,804 (98.8) | 2,708 (98) | 805 (98.7) | |

Values are presented as number (%) unless otherwise indicated.
SD, standard deviation; ASA PS, American Society of Anesthesiologist physical status.
[†]Includes warm water garments, electric blankets, and water heating circulation pumps. [‡]Includes 3rd and 4th generation cephalosporins, quinolones, and glycopeptides.

*Safety Comparison*

# Forced-Air Warming Discontinued: Infection Rates Drop

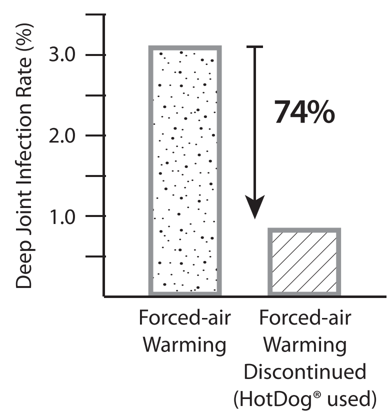
## Forced-air warming and ultra-clean ventilation do not mix[68]

McGovern, P.D.; Reed, M.R.; et al. J. Bone and Joint Surgery Br, 93B:11. 1537-44. Nov 2011. | *Company Support*

**SUMMARY:** Forced air warming waste heat transported non-sterile air to the surgical site in both hip replacement procedures and lumbar spinal procedures. Conductive fabric warming did not release sufficient excess heat to establish the same convection currents. "[Forced-air] Patient warming ventilation disruption was associated with a significant increase in deep joint infections, as demonstrated by an elevated infection odds-ratio (3.8, p=0.028) for the forced air versus conductive fabric patient groups (n=1437 cases, 2.5-year period)."

Discontinuing the use of forced-air warming resulted in a 74% reduction in joint implant infections (p=0.024).

Deep joint infection rates:
9/'08 – 6/'10, Forced-air warming: 3.1% (1066 cases)
7/'10 – 1/'11, FAW discontinued: 0.81% (371 cases); HotDog patient warming used

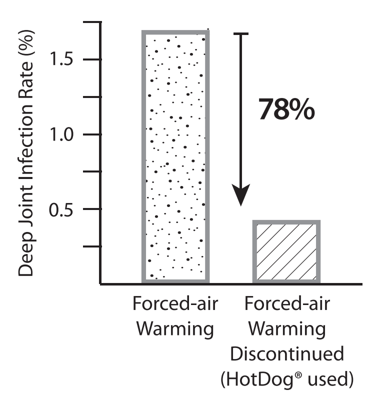



## Forced-air warming discontinued: periprosthetic joint infection rates drop[69]

Augustine S.D.; Orthopedic Reviews 2017; 9:6998. | *Company Support*

**SUMMARY:** Several studies have shown that the waste heat from forced-air warming (FAW) escapes near the floor and warms the contaminated air resident near the floor. The waste heat then forms into convection currents that rise up and contaminate the sterile field above the surgical table. This study retrospectively compared PJI rates during a period of FAW to a period of air-free conductive fabric electric warming (CFW) at three hospitals. Surgical and antibiotic protocols were held constant.

The pooled multicenter data showed a decreased PJI rate of 78% following the discontinuation of FAW and a switch to air-free CFW (n=2034; P=0.002). "The 78% reduction in joint implant infections observed when FAW was discontinued suggests that there is a link between the waste FAW heat and PJIs."



# Other Benefits of HotDog

## Computer Simulation Model of the Economics of a Reusable Fabric Technology Warming Blanket Compared to a Disposable Forced-Air Warming Blanket[70]

Macario, A.; Clancy, T. Affiliation Anesthesia Stanford University School of Medicine and Nursing, University of Minnesota.
Presented at International Anaesthesia Research Society 2009. *| Company Support*

**SUMMARY:** This computer-simulation study evaluated the economics of a reusable warming blanket (HotDog Patient Warming) compared to forced-air disposable blankets analyzing both hard and soft costs (i.e. energy usage, cleaning, disposal costs, etc.). At 1.71 cases/OR/day the cost per system was not significantly different. As the number of surgical cases increases, or the use rate increases, the fixed cost of reusable warming technology is spread among more cases. At the specific hospital studied, for its 9,332 total cases, the predicted per-patient cost for disposable blankets equaled $13.79, +/- .18 and reusable was $9.94, +/- .23 (p<0.001).

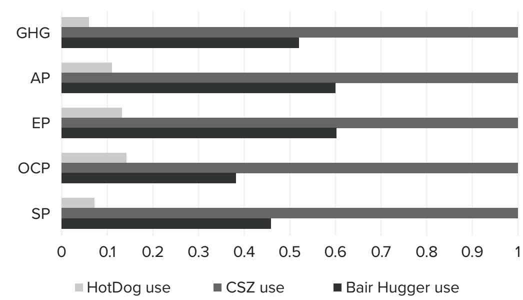
## Life Cycle Pollution Impacts of Reusable Versus Disposable Patient Warming Blankets[71]

Smith-Mannschott, K.; et al. Presented at American Society of Anesthesiologists Annual Meeting 2014. A3194. *| No Company Support*

**SUMMARY:** The authors performed a Life Cycle Assessment (LCA) to determine the environmental impacts of patient warming systems, comparing three systems: the disposable Bair Hugger (Arizant Healthcare) and the Maxi-Therm (Cincinnati Sub-Zero, CSZ), and the reusable HotDog (Augustine Temperature Management) at Yale-New Haven Hospital (YNHH).

LCA is an internationally standardized, science-based approach to quantify multiple environmental and public health impacts of a product or process over its entire life span, from raw materials extraction, transport, use and reuse, and end-of-life disposal. Environmental impacts were assessed using the USEPA's TRACI 2.1 impact assessment method.

The HotDog system was found to yield smaller impacts than the disposable blankets in each of the impact assessment categories. Variational analysis revealed that the HotDog blanket resulted in a more favorable environmental profile over its lifespan and provides a significant decrease in environmental impacts due to patient warming.




Greenhouse Gases (GHG), Acidification Potential (AP), Eutrophication Potential (EP), Photochemical Oxidation Potential (OCP), Smog Potential (SP)

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## Forced-air Warming Effectiveness


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