Summary of Published Research Supporting Air-free HotDog® Patient Warming

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Effects of Waste Heat on Deep Joint Infections

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

McGovern P.D., et al: *J. Bone and Joint Surgery Br*, Vol. 93-B, Issue 11, pp 1537-44. Nov. 2011.

SUMMARY:

"[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)."
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

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

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.

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.

Effects of Waste Heat on the Surgical Field

Forced-air patient warming blankets disrupt unidirectional airflow

Legg, A.J. et al: Bone and Joint Journal, March 2013 vol. 95-B no. 3 407-410

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 Bair 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.

Effect of forced-air warming on the performance of theatre laminar flow ventilation

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

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) °C; $p < 0.001$). "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: Effects on Orthopedic Operating Room Ventilation Performance.

Belani, K; et al. Accepted for publication in *Anesthesia & Analgesia*. 2012. (Available Online)

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 effect.

Effects of Waste Heat on the Surgical Field (cont.)

Do forced-air patient-warming devices disrupt unidirectional downward airflow?

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

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."

Contaminated Forced-air Warming Blowers

Forced Air Warming Blowers: An Evaluation of Filtration Adequacy and Airborne Contamination Emissions in the Operating Room.

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

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 ft^3 of air (80 million particles per hour).

Forced Air Warming Design: An Evaluation of Intake Filtration, Internal Microbial Build-Up, and Airborne-Contamination Emissions.

Reed M, McGovern P, Gauthier R et al: Accepted for publication in *JAANA*. 2012.

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.

Efficacy: HotDog Conductive Fabric vs. Forced-air

Resistive polymer versus forced-air warming: Comparable heat transfer and core rewarming rates in volunteers.

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

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.

Resistive-Polymer Versus Forced-Air Warming: Comparable Efficacy in Orthopedic Patients.

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

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."

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The forced-air warming (FAW) device used in all of the studies was Bair Hugger® brand, a trademark of Arizant/3M.

Level of company support for studies (by lead author): Company supplied measurement equipment, researchers received no financial support (McGovern, Dasari, Reed); company supported (Albrecht, Kimberger, Brandt); minimal company support (Belani); no company support (Legg).

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