3M Bair Hugger™

Temperature Management Solutions

Comparative heat transfer evaluations

3M™ Bair Hugger™ Temperature Management Solutions

A comprehensive solution for virtually every patient, every procedure, every time.

From noninvasive temperature monitoring and patient-pleasing warming gowns to an extensive array of unique warming blankets, the 3M™ Bair Hugger™ temperature management solutions offer a complete temperature management portfolio.

3M™ Bair Hugger™ warming gown

Getting your patients safely through surgery and on their way home takes clinical expertise, along with a dose of warm, caring encouragement that can help relieve the anxiety of the surgical process.[1] The gown adds a new dimension to patient warming, providing clinical and comfort warming options in a single patient gown.

3M™ Bair Hugger™ Warming Blankets

Warming patients who are undergoing surgery is important, but it should not be complicated. The Warming Blankets have demonstrated, flexible temperature management solutions designed to make your job easier by helping you deliver optimal care while maintaining normothermia.

3M™ Bair Hugger™ Temperature Monitoring System

Technology limitations and clinical needs force hospitals to stock and use multiple temperature monitoring methods. The Temperature Monitoring System eliminates the variation in temperature readings due to device accuracy or technique and provides an accurate, noninvasive temperature measuring method that can be used throughout the perioperative environment and in any type of anesthesia.

With the right partner, you can confidently maintain normothermia

The 3M™ Bair Hugger™ temperature management solutions are ideal for all of your patient warming needs – leveraging clinically researched technologies that are trusted and proven.

A full line including a temperature monitoring solution, blankets, and gowns.

9 of the top 10 hospitals in the United States use Bair Hugger temperature management.[2,3]

170+ studies supporting clinical benefits, efficacy and safety

3M℠ Health Care Academy

The impact of perioperative hypothermia on patients and facilities

Core temperature is a critical vital sign. If you're not monitoring continuously and managing consistently, you could be putting patients at risk. A core temperature below 36.0°C can cause unintended perioperative hypothermia, which can:

This can have a large impact on facility costs:

The average hospital length of stay is 2.6 days longer for a hypothermic patient[4]

$7K When a patient becomes hypothermic, it can cost up to $7,000[9]

Why heat transfer matters?

The human body must maintain core temperature at approximately 37°C.[10] Under typical conditions, the body's thermoregulatory system maintains this temperature by managing the transfer of heat across the skin's surface. Anesthesia interferes with thermoregulation in several ways, but overall, it produces redistribution temperature drop, which can contribute to unintended hypothermia.

Unintended hypothermia is associated with several serious adverse consequences including coagulopathy and increased transfusion requirement, surgical site infection, delayed drug metabolism, prolonged recovery, shivering, and thermal discomfort.[11,12] However, unintended hypothermia can be prevented or minimized by transferring heat into the body before, during and after surgery.

Guidelines support the use of a convective forced-air warming system as one of the most effective ways to transfer heat into the body.[13] Although there are several convective warming systems on the market, not all of them have equivalent performance or safety profiles. We will explain the characteristics that make convective forced-air warming systems effective and review the differences between systems from three manufacturers.

Core temperature

Core body temperature is the temperature of the region where a patient's vital internal organs are located.

Patient warming systems are designed to transfer heat to help maintain normal core body temperature, referred to as normothermia, as well as provide thermal comfort.

The value for normal core body temperature is typically 37.0°C.[14,15]

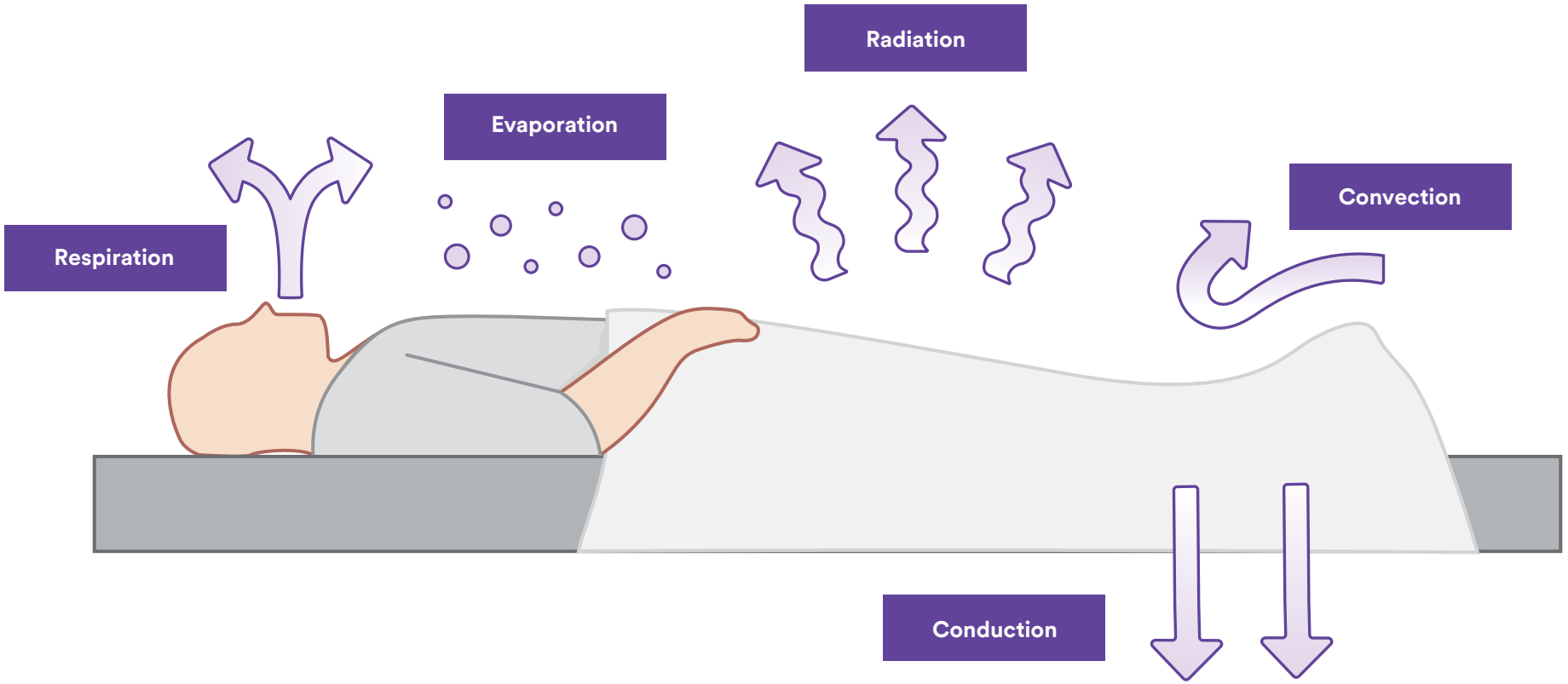
The normal core body temperature range is

36.4°C to 37.2°C[14,15]

However, the value varies throughout the body and over time.

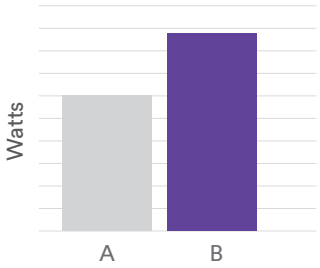
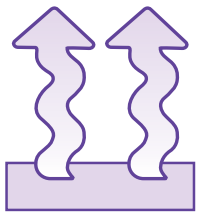
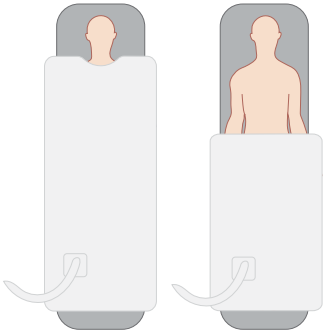
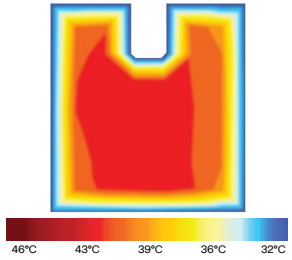
Mechanisms of heat transfer

Body temperature is controlled by thermoregulation and maintains the normal core temperature range which is typically 36.4°C to 37.2°C.[14,15] The body controls heat exchange with the surrounding environment to achieve steady state core temperature.



Calculating the variables

The law of physics that governs both natural and forced convection is Isaac Newton's law of cooling: $Q = h \cdot A \cdot \Delta T$

Q	h	A	ΔT
			
Q: total heat rate (W) The thermal energy being transferred	**h: heat transfer coefficient (W/m² °C)** The ability of the air to carry away the thermal energy; this varies over the surface of the body, so typically an average value is used	**A: skin surface area (m²)** The total area being warmed	**ΔT: temperature difference** ΔT: $T_{air} - T_{skin}$ (°C) The temperature difference between the convecting air and the skin surface temperature

While the area (A) is typically very similar across forced air warming systems, the heat rate (Q), heat transfer coefficient (h) and temperature difference (ΔT) can vary greatly and can have an impact on performance. These values were tested to determine what differences exist among various systems in comparison to the 3M™ Bair Hugger™ Warming System.

The impact of forced convection

The convective heat transfer coefficient discussed on the previous page is a measure of the strength of convective heat transfer. This is measured by a test fixture designed after the one described by Bräuer et al.[16-18] This test fixture provides an "overall heat transfer coefficient", which combines the impact of both the convective and radiative heat transfer into a single measure. This value varies slightly over the area where the forced air warming (FAW) is applied and may also vary depending on ΔT. Measured values from the test fixture are area- and time-averaged to allow for estimation of the overall thermal energy that would be transferred for a given surface area and ΔT.

The convective heat transfer coefficient is determined by many factors, including the physical properties of the working gas or fluid, the speed at which it is moving, and the way it is directed over the surface that is being heated or cooled.

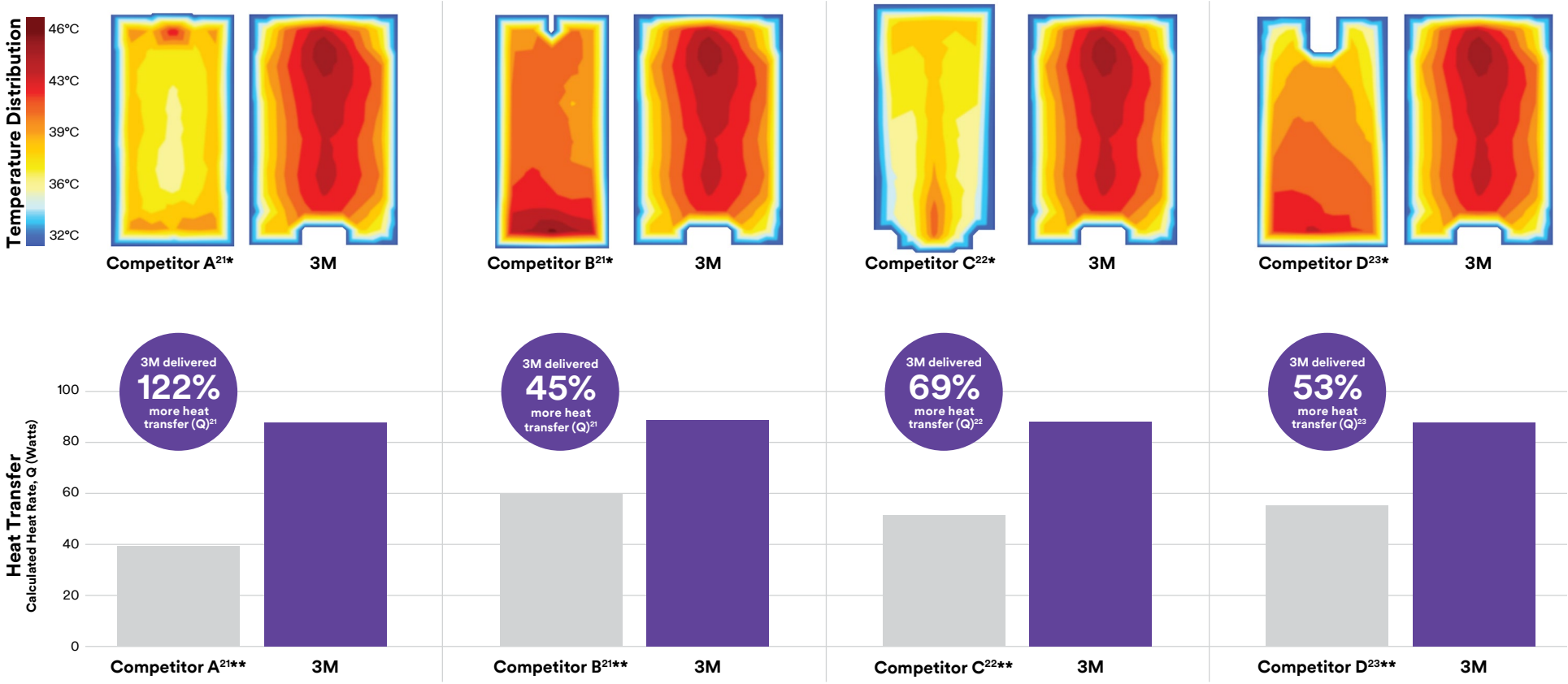
Temperature difference

The temperature difference, ΔT, refers to the difference between (i) the average air temperature coming out of the FAW blanket, measured by the methodology described in IEC 80601-2-35,[19] and (ii) the patient's average skin temperature.

The skin temperature of the patient is a dynamic value that changes as they move through a perioperative workflow. Clinical measurements of actively warmed patients' average skin temperature have been shown to be between 33°C and 35°C.[20] Therefore, an average value of 34°C was used for the calculations detailed in this document.

The values used herein are intended to represent prototypical conditions to allow for a direct comparison, but it should be remembered that in practice, the heat being transferred to a patient will vary with time throughout the perioperative journey.

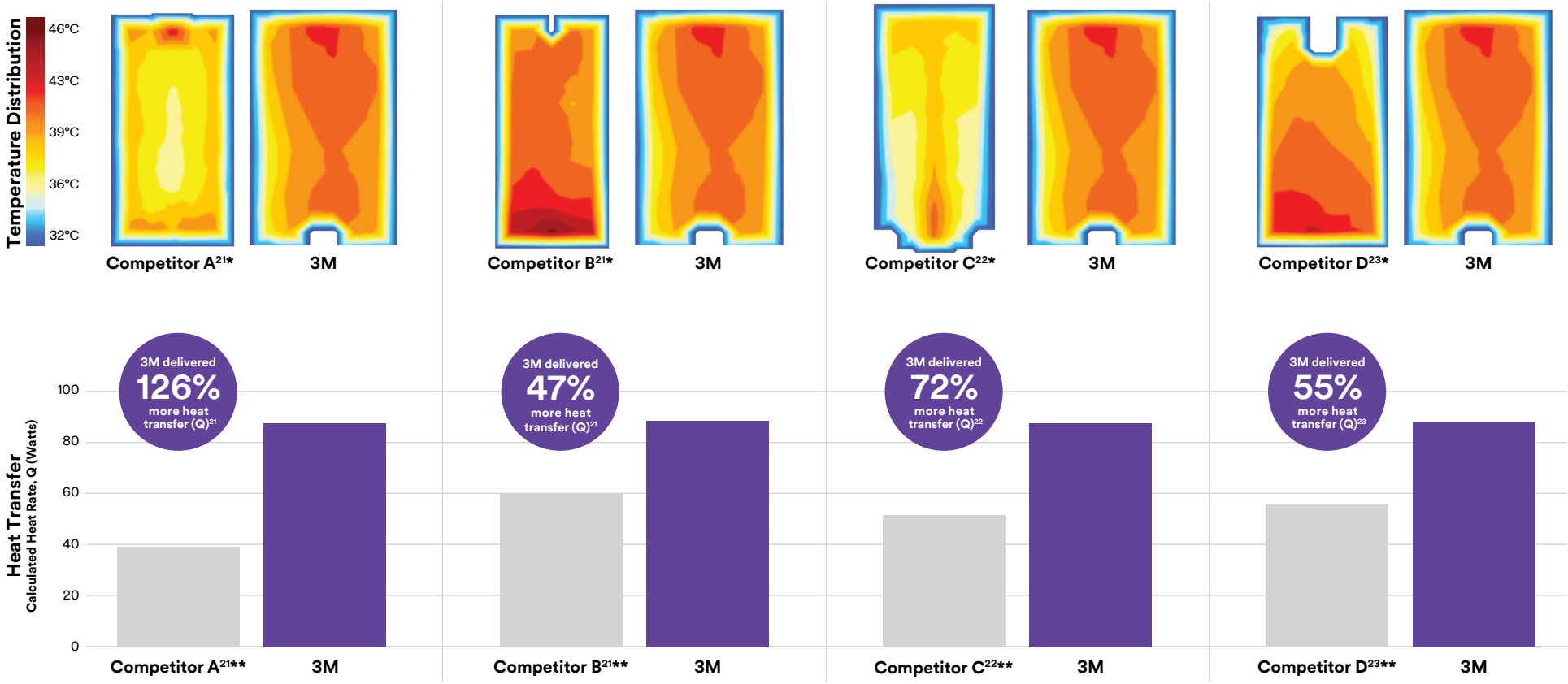
3M™ Bair Hugger™ warming unit Model 675 (120V/60hz) with Model 30000 full body warming blanket



*Images reflect the temperature of the portion of the blanket that transfers heat when inflated (tested per IEC 60601-2-35:2020), without showing additional brand identifying features. Competitive (full/lower/upper) body blanket used in conjunction with a full sized blower (120V/60hz) on its highest temperature and fan speed settings.

**Temperature measurements were taken in accordance with IEC 60601-2-35:2020, heat transfer coefficients were measured using the method of Brauer et al.[16-18] and skin temperatures for the calculation of 'Q' were assumed to be 34°C.[20] Heat rates are estimates based upon a typical use case, actual heat rate may vary depending on the patient circumstances and clinical practice.

3M™ Bair Hugger™ warming unit Model 775 (120V/60hz) with Model 30000 full body warming blanket



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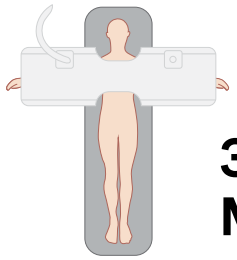
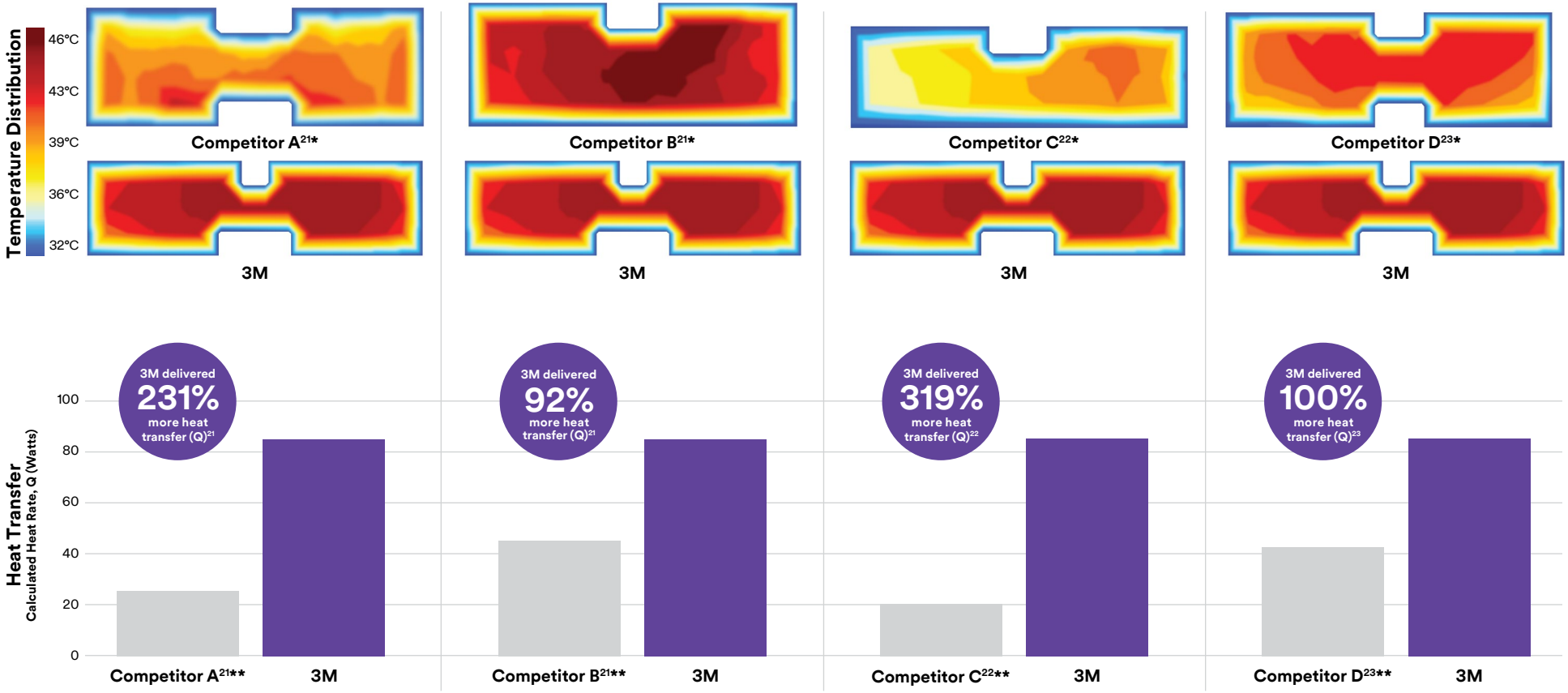


3M™ Bair Hugger™ warming unit Model 675 (120V/60hz) with Model 62200 multi-position upper body warming blanket



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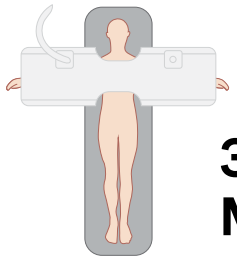
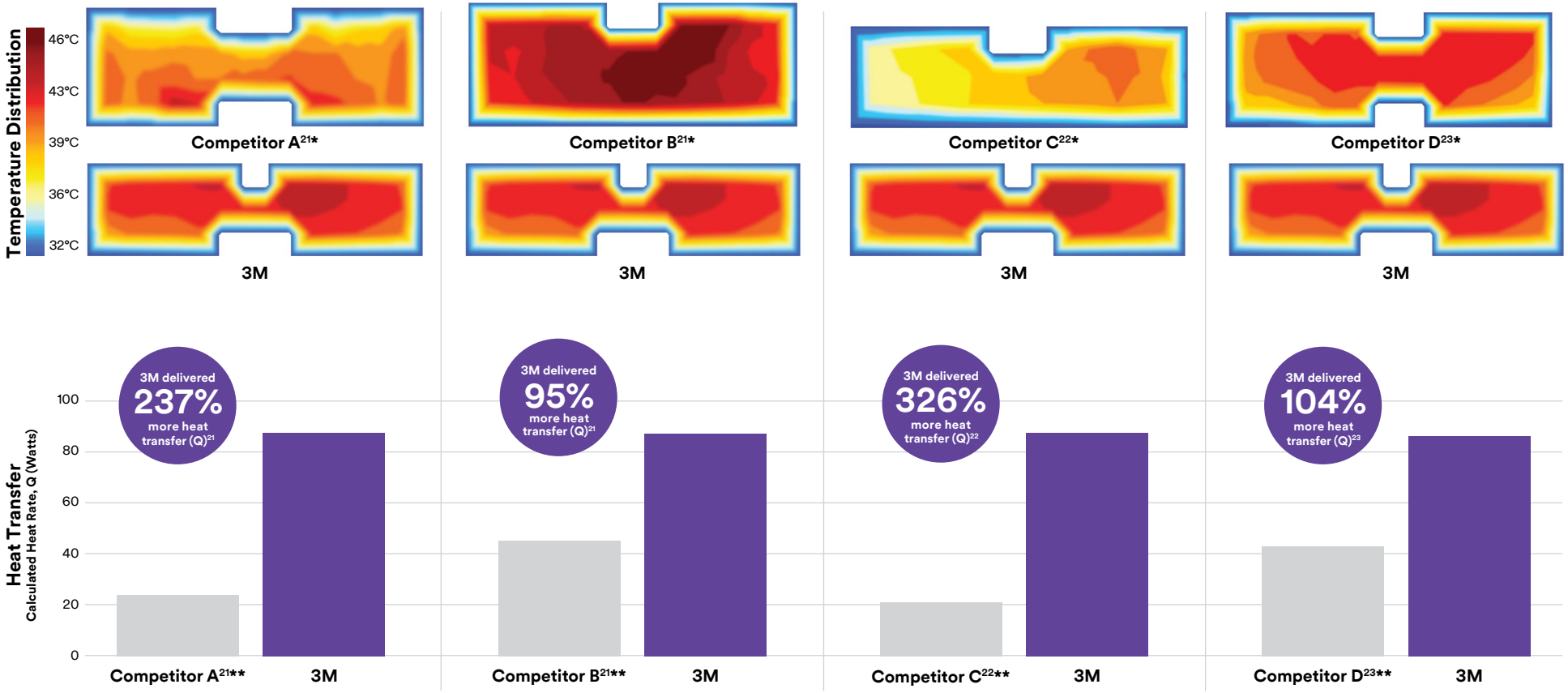


3M™ Bair Hugger™ warming unit Model 775 (120V/60hz) with Model 62200 multi-position upper body warming blanket



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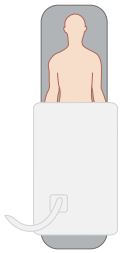
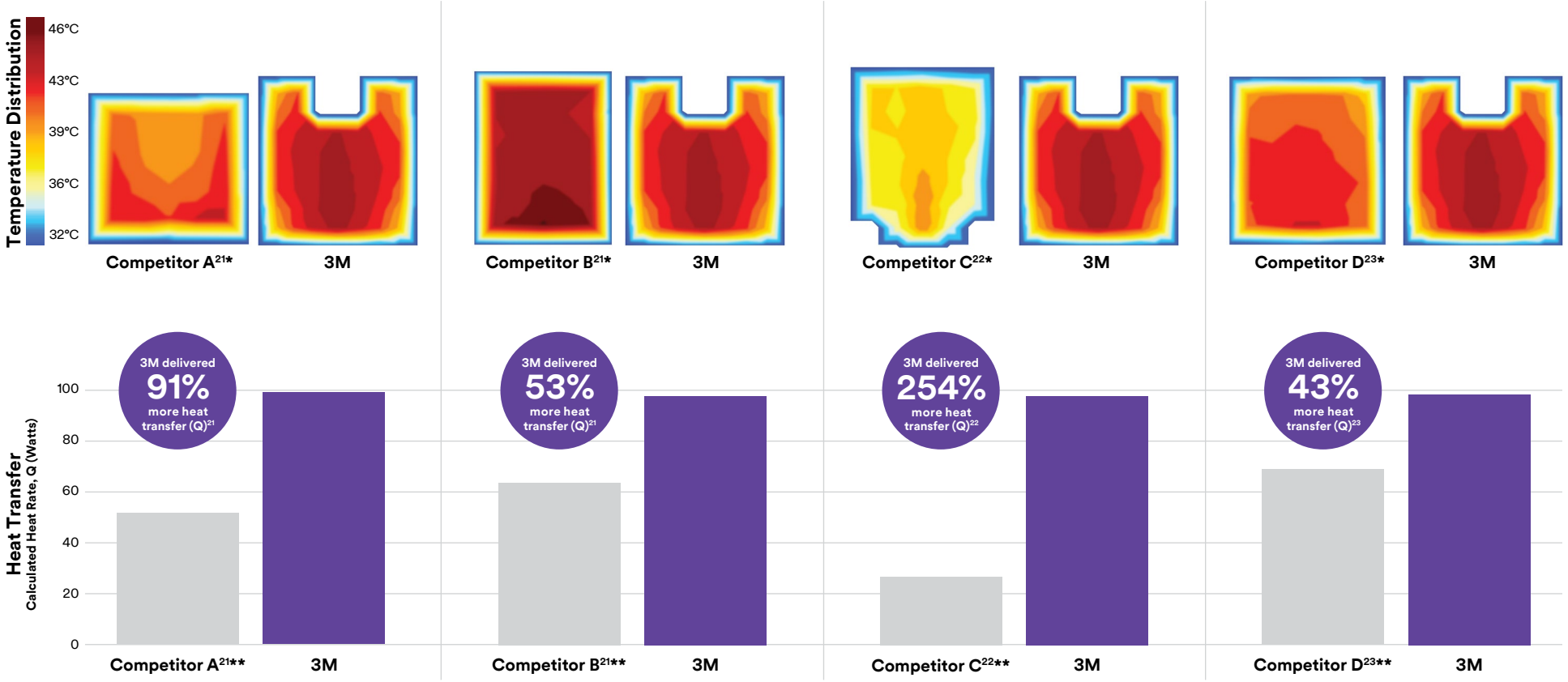


3M™ Bair Hugger™ warming unit Model 675 (120V/60hz) with Model 52500 lower body warming blanket



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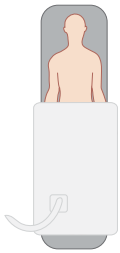
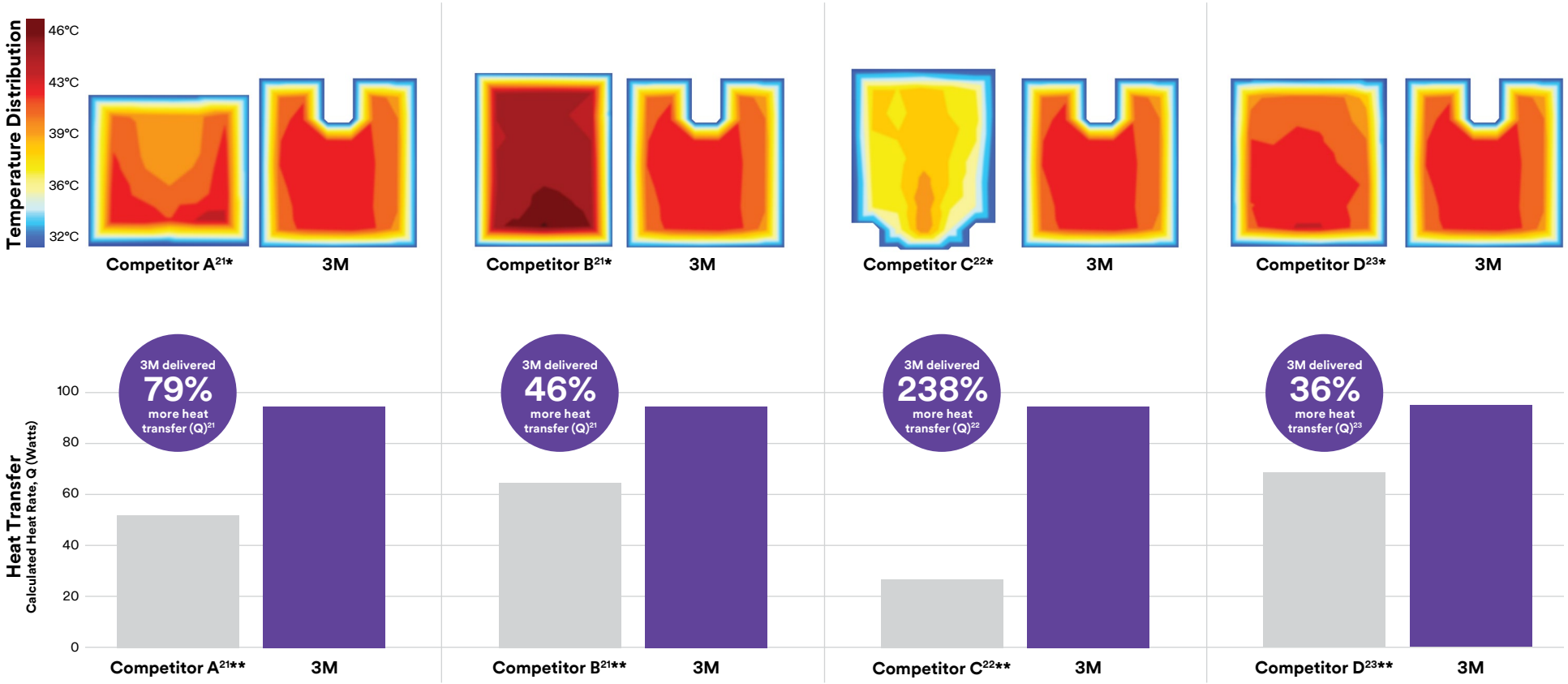


3M™ Bair Hugger™ warming unit Model 775 (120V/60hz) with Model 52500 lower body warming blanket



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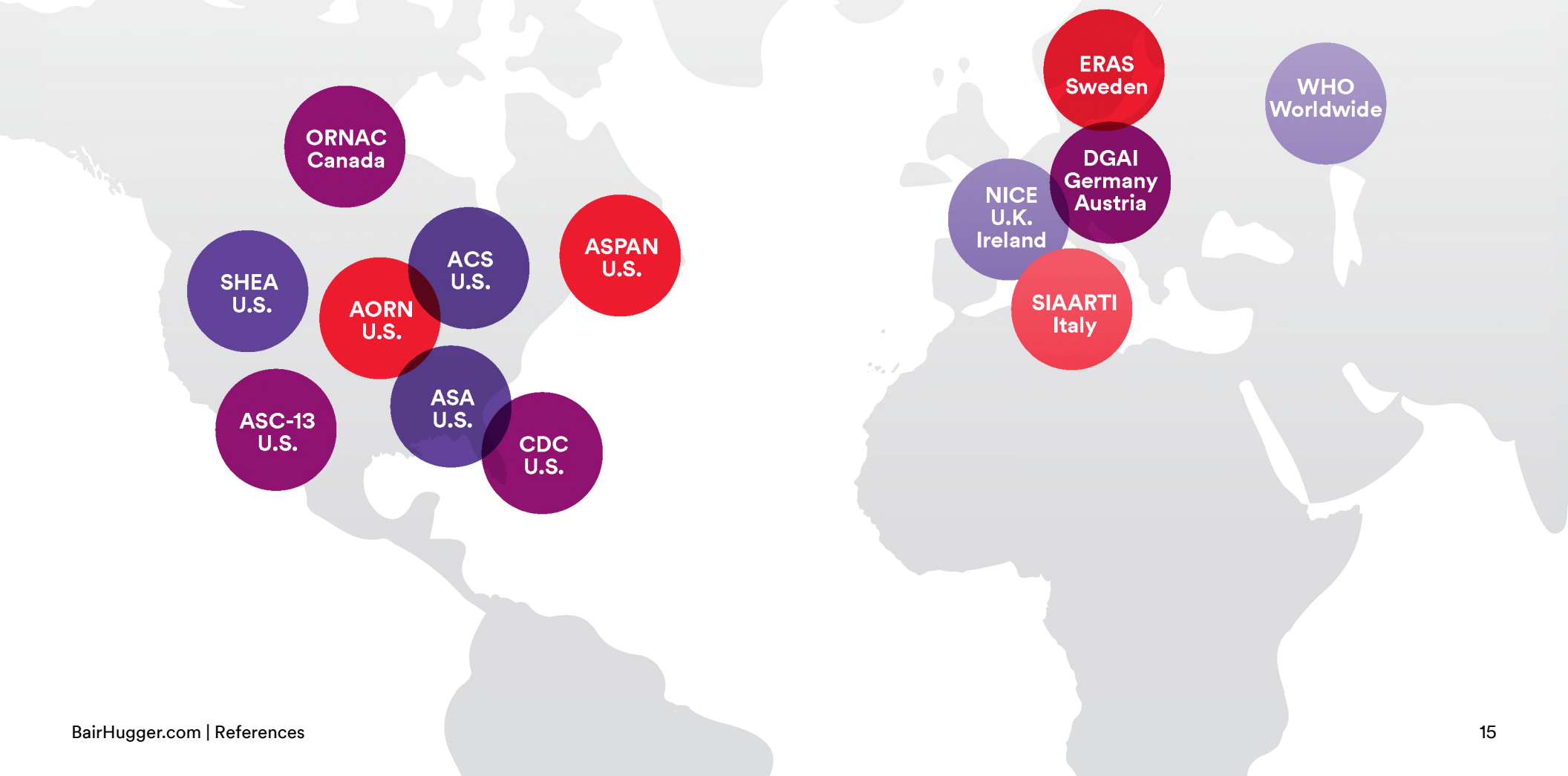
Global support for perioperative temperature management

Several groups around the world support and recommend the core tenets of proactive temperature management.



Throughout the surgical journey, 3M is here to help.

3M offers science-based solutions, developed for surgical needs, to help protect patients and staff while helping to deliver optimal outcomes. **Every patient, every time.**

Patient preparation

- Personal protective equipment
- Nasal decolonization
- Preoperative patient warming
- Hair removal

Surgical intervention

- Surgical hand hygiene
- Sterilization assurance
- Vascular access
- Temperature monitoring
- Intraoperative patient warming
- Antimicrobial incise draping
- Surgical skin antisepsis

Patient recovery

- Negative pressure wound therapy with and without instillation
- Postoperative patient warming
- Postoperative incision management
- Closed incision negative pressure therapy

References

1. Wilson I. Kolbaca I. Practical application of comfort theory in perianesthesia setting. Journal of PeriAnesthesia Nursing. 2004;19(3):164-173.
2. 3M data on file. 2018.
3. U.S. News and World Report. 2020-21 Best Hospitals Honor Roll and Medical Specialties Rankings. U.S. News and World Report website. 2020. Accessed April 9, 2021. https://health.usnews.com/health-care/best-hospitals/articles/best-hospitals-honor-roll-and-overview.
4. Kurz A, Sessler DI, Lenhardt R. Perioperative normothermia to reduce the incidence of surgicalwound infection and shorten hospitalization. NEJM. 1996 May 9;334(19):1209-16. Melling AC, AliB, Scott EM, Leaper DJ. Effects of preoperative warming on the incidence of wound infection after clean surgery: a randomised controlled trial. The Lancet. 2001 Sep 15;358(9285):876-80. Scott AV,Stonemetz JL, Wasey JO, Johnson DJ, Rivers RJ, Koch CG, et al. (2015) Compliance with Surgical Care Improvement Project for Body Temperature Management (SCIP Inf-10) Is Associated with Improved Clinical Outcomes. Anesthesiology 123: 116–125.
5. Schmied H, Reiter A, Kurz A, Sessler DI, Kozek S. Mild hypothermia increases blood loss and transfusion requirements during total hip arthroplasty. The Lancet. 1996 Feb 3;347(8997):289-92.
6. Bush H Jr., Hydo J, Fischer E, et al. Hypothermia during elective abdominal aortic aneurysm repair: The high price of avoidable morbidity. J Vasc Surg. 1995;21(3): 392-402.
7. Lenhardt R, Marker E, Goll V, et al. Mild intraoperative hypothermia prolongs postanesthetic recovery. Anesth. 1997;87:1318-23.
8. Sessler, DI. Current Concepts: Mild perioperative hypothermia. NEJM, 1997. Vol. 336, No. 24,pp. 1730-1737.
9. Mahoney CB, Odom J. Maintaining intraoperative normothermia: a meta-analysis of outcomes with costs. AANA J. 1999 Apr;67(2):155-63.
10. Gisolfi CV, Mora MT, Mora F, Teruel FM, Gisolfi L. The hot brain: survival, temperature, and the human body: MIT Press; 2000.
11. Kurz A, Sessler DI, Lenhardt R. Perioperative normothermia to reduce the incidence of surgical-wound infection and shorten hospitalization. Study of Wound Infection and Temperature Group. New England Journal of Medicine. 1996;334(19):1209-1215.
12. Scott AV, Stonemetz JL, Wasey JO, Johnson DJ, Rivers RJ, Koch CG, Frank SM. Compliance with Surgical Care Improvement Project for Body Temperature Management (SCIP Inf-10) Is Associated with Improved Clinical Outcomes. Anesthesiology. 2015;123(1):116-125.
13. Ljungqvist O, Scott M, Fearon KC. Enhanced recovery after surgery: A review. JAMA Surgery. 2017;152(3):292-298.
14. Duffy JF, Dijk D-J, Klerman EB, Czeisler CA. Later endogenouscircadian temperature nadir relative to an earlier wake time in older people. American Journal of Physiology-Regulatory, Integrative and Comparative Physiology. 1998;275(5):R1478-R1487.
15. Mackowiak PA, Wasserman SS, Levine MM. A critical appraisal of98.6 degrees F, the upper limit of the normal body temperature, and other legacies of Carl Reinhold August Wunderlich. Journal of the American Medical Association. 1992;268(12):1578-1580.
16. Bräuer, A., English, M. J., Sander, H., Timmermann, A., Braun, U., & Weyland, W. (2002). Construction and evaluation of a manikin for perioperative heat exchange. Acta Anaesthesiologica Scandinavica,46, 43-50. doi:10.1034/j.1399-6576.2002.460108.x
17. Bräuer, A., English, M. J., Steinmetz, N., Lorenz, N., Perl, T., Braun, U.,& Weyland, W. (2002). Comparison of forced-air warming systems with upper body blankets using a copper manikin of the human body. Acta Anaesthesiologica Scandinavica, 46, 965-972. doi:10.1034/j.1399-6576.2002.460807.x
18. Bräuer, A., English, M. J., Lorenz, N., Steinmetz, N., Perl, T., Braun, U.,& Weyland, W. (2003). Comparison of forced-air warming systems with lower body blankets using a copper manikin of the human body. Acta Anaesthesiologica Scandinavica, 2003, 58-64. doi:10.1034/j.1399-6576.2003.470110.x
19. IEC 60601-2-35 2020 Medical electrical equipment Part 2-35: Particular requirements for the basic safety and essential performance of heating devices using blankets, pads or mattresses and intended for heating in medical use
20. Sessler, D. I. (1997b). Perioperative thermoregulation and heat balance. Ann N Y Acad Sci, 813, 757-777.
21. 3M Data on File. EM-05-312524_2, EM-05-715910_1
22. 3M Data on File. EM-05-277295_4, EM-05-715910_1
23. 3M Data on File. EM-05-312524_2, EM-05-715910_1

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NOTE: Specific indications, contraindications, warnings, precautions and safety information exist for these products and therapies. Please consult a clinician and product instructions for use prior to application. Rx only.