The Society of Thoracic Surgeons, The Society of Cardiovascular Anesthesiologists, and The American Society of ExtraCorporeal Technology: Clinical Practice Guidelines for Cardiopulmonary Bypass—Temperature Management During Cardiopulmonary Bypass

Richard Engelman, MD, Robert A. Baker, PhD, CCP, Donald S. Likosky, PhD, Alina Grigore, MD, Timothy A. Dickinson, MS, Linda Shore-Lesserson, MD, and John W. Hammon, MD

Department of Surgery, Baystate Medical Center and Tufts University School of Medicine, Springfield, Massachusetts; Cardiac Surgery Research and Perfusion, Flinders University and Flinders Medical Centre, Adelaide, South Australia, Australia; Department of Cardiac Surgery, University of Michigan, Ann Arbor, Michigan; Department of Anesthesiology, University of Nevada, Las Vegas, Nevada; Clinical Performance Improvement, SpecialtyCare, Nashville, Tennessee; Department of Anesthesiology, Hofstra Northshore-Long Island Jewish School of Medicine, New Hyde Park, New York; and Department of Cardiothoracic Surgery, Wake Forest University School of Medicine, Winston-Salem, North Carolina

Abstract

In order to improve our understanding of the evidence-based literature supporting temperature management during adult cardiopulmonary bypass, The Society of Thoracic Surgeons, the Society of Cardiovascular Anesthesiology and the American Society of ExtraCorporeal Technology tasked the authors to conduct a review of the peer-reviewed literature, including: 1) optimal site for temperature monitoring, 2) avoidance of hyperthermia, 3) peak cooling temperature gradient and cooling rate, and 4) peak warming temperature gradient and rewarming rate. Authors adopted the American College of Cardiology/American Heart Association method for development clinical practice guidelines, and arrived at the following recommendations:

For related article, see page 385

Class I Recommendations

a) **The oxygenator arterial outlet blood temperature is recommended to be utilized as a surrogate for cerebral temperature measurement during CPB. (Class I, Level C)**
b) **To monitor cerebral perfusate temperature during warming, it should be assumed that the oxygenator arterial outlet blood temperature under-estimates cerebral perfusate temperature. (Class I, Level C)**
c) **Surgical teams should limit arterial outlet blood temperature to <37°C to avoid cerebral hyperthermia. (Class 1, Level C)**
d) **Temperature gradients between the arterial outlet and venous inflow on the oxygenator during CPB cooling should not exceed 10°C to avoid generation of gaseous emboli. (Class 1, Level C)**
e) **Temperature gradients between the arterial outlet and venous inflow on the oxygenator during CPB rewarming should not exceed 10°C to avoid outgassing when blood is returned to the patient. (Class 1, Level C)**

Class IIa Recommendations

a) **Pulmonary artery or nasopharyngeal temperature recording is reasonable for weaning and immediate post-bypass temperature measurement. (Class IIa, Level C)**
b) **Rewarming when arterial blood outlet temperature ≥30°C:**
   i. **To achieve the desired temperature for separation from bypass, it is reasonable to maintain a temperature gradient between arterial outlet temperature and the venous inflow of ≤4°C. (Class IIa, Level B)**

This article is copublished in *The Annals of Thoracic Surgery, Journal of Cardiothoracic and Vascular Anesthesia,* and the *Journal of ExtraCorporeal Technology*.

The Society of Thoracic Surgeons requests that this document be cited as follows: Engelman R, Baker RA, Likosky DS, Grigore A, Dickinson TA, Shore-Lesserson L, Hammon JW. The STS/SCA/AmSECT: clinical practice guidelines for cardiopulmonary bypass—temperature management during cardiopulmonary bypass. Ann Thorac Surg 2015;100:748–57.

Address correspondence to Dr Engelman, Department of Surgery, Baystate Medical Center, 759 Chestnut St, Springfield, MA 01199; e-mail: richard.engelman@baystatehealth.org.

0003-4975/$36.00
http://dx.doi.org/10.1016/j.athoracsur.2015.03.126

ii. **To achieve the desired temperature for separation from bypass, it is reasonable to maintain a rewarming rate ≤0.5°C/min. (Class IIa, Level B)**

c) **Rewarming when arterial blood outlet temperature <30°C: To achieve the desired temperature for separation from bypass, it is reasonable to maintain a maximal gradient of 10°C between arterial outlet temperature and venous inflow. (Class IIa, Level C)**

No Recommendation

No recommendation for a guideline is provided concerning optimal temperature for weaning from CPB due to insufficient published evidence.

(Ann Thorac Surg 2015;100:748–57)

Numerous strategies are currently invoked by perfusion teams to manage the requirements of cooling, temperature maintenance, and rewarming patients during cardiac surgical procedures. To date there have been very few evidence-based recommendations for the conduct of temperature management during perfusion. Although Bartels and coauthors [1] (2002) found no supporting evidence for an evidence-based guideline for managing the temperature gradient during cardiopulmonary bypass (CPB), Shann and coauthors [2] (2006) recommended that "limiting arterial line temperature to 37°C might be useful for avoiding cerebral hyperthermia," including checking "coupled temperature" ports for all oxygenators for accuracy and calibration (Class IIa, Level B).

Owing to differences in interpreting the literature and the paucity of published guidelines in this clinical area, there is extensive variability in the conduct of managing perfusate temperature during CPB. A recent survey of perfusionists found that (1) in more than 90% of centers, mildly hypothermic perfusion of 32° to 34 C is routinely used and 63% achieve that temperature without active cooling; (2) during CPB, the most common sites for measuring temperature are nasopharyngeal (NP, 84%), venous return (75%), arterial line (72%), bladder (41%), and rectum (28%); (3) 19% of centers reported routinely calibrating their in-line temperature probes, and (4) 44% of centers exceed the 37°C peak temperature limit for the arterial line temperature during rewarming [3]. Although temperature management strategies are frequently reported in the literature, the rationale for these practices is often underreported or absent.

To improve our understanding of the evidence-based literature supporting temperature management, we conducted a review of the peer-reviewed literature, including: (1) optimal site for temperature monitoring, (2) avoidance of hyperthermia, (3) peak cooling temperature gradient and cooling rate, and (4) peak warming temperature gradient and rewarming rate.

Material and Methods

Literature Search

We used a systematic search of MeSH terms to identify peer-reviewed articles related to temperature management in the setting of adult CPB (Appendix). Candidate articles were published in PubMed between January 1, 2000, and March 31, 2014. Our search revealed 768 abstracts, all of which were reviewed in duplicate by independent reviewers, with 153 abstracts selected for full paper review. To be included, each paper had to report data on each of the following: (1) optimal site for temperature monitoring, (2) avoidance of hyperthermia, (3) peak cooling temperature gradient and cooling rate, and (4) peak warming temperature gradient and rewarming rate.

According to American College of Cardiology/American Heart Association (ACC/AHA) rules (Table 1), any reviewer could select an abstract for inclusion in a paper review, but at least 2 reviewers had to agree to exclude a paper [4]. At the paper review stage, at least 2 reviewers had to agree to exclude a paper. These rules were incorporated into Guideliner reviewing software (www.guideliner.org/default.aspx, accessed May 20, 2014). Thirteen articles considered relevant to the topic by the authors were included to provide method, context, or additional supporting evidence for the recommendations.

Results

Synthesizing the Evidence

Two reviewers rejected 615 abstracts based on a lack of relevance, leaving 153 abstracts for full paper review (Fig 1). Two panel members reviewed each paper, and 82 of these papers were found not to contribute to the topic by both reviewers, a further 32 had conflicting reviews and were individually resolved, and the final 39 were considered for inclusion in the guideline. Of the additional 13 articles relevant to the development of the guideline 8 predated 2000.

Optimal Site for Temperature Measurement

A number of sites for routine core and cerebral temperature management have been reported, including NP, tympanic membrane, bladder, esophagus, rectum, pulmonary artery, jugular bulb (JB), arterial inflow, and venous return [3]. A single, easily monitored, optimal core temperature site has not been reported, although the intravascular and intracorporeal location of a pulmonary artery catheter probably renders this site the best access for core temperature recording. However, pulmonary artery catheters are used infrequently in many centers, necessitating a different core temperature measurement site. The measurement of the JB temperature is recognized as being the best indicator of cerebral temperature [5, 6], but it is not a routinely used as a monitor and its accuracy depends on the optimal positioning of this invasive temperature probe [6].