Hypothermia and operative mortality during on-pump coronary artery bypass grafting

Kevin L. Greason, MD,[a] Sunghee Kim,[b] Rakesh M. Suri, MD,[a] Amelia S. Wallace, BSPH,[b] and Brian R. Englum, MD[b]

Objective: Controversy surrounds the effect of hypothermia on operative mortality during cardiac surgery. The present study accessed a large clinical database of coronary artery bypass graft operations to address the issue.

Methods: A retrospective review of the Society of Thoracic Surgeons Adult Cardiac Surgery Database identified patients treated with isolated, nonemergency, on-pump coronary artery bypass grafting from July 2011 to December 2012. The patients were divided into 3 groups according to their lowest core temperature during the procedure: moderate hypothermia (≤34°C), mild hypothermia (>34°C but ≤36°C), and normothermia (>36°C). The primary endpoint of the study was operative mortality, defined according to the Database criteria.

Results: During the study period, 142,541 patients were available for analysis; 94,777 (66.5%) received moderate hypothermia, 42,750 (30.3%) mild hypothermia, and 5014 (3.5%) normothermia. Operative mortality occurred in 1394 patients (1.5%) in the moderate hypothermia, 534 (1.3%) in the mild hypothermia, and 105 (2.1%) in the normothermia group. Multivariate analysis identified hypothermia (both mild [odds ratio, 0.66; 95% confidence interval, 0.54-0.81; $P < .0001$] and moderate [odds ratio, 0.73; 95% confidence interval, 0.60-0.89; $P = .0015$]) was protective against operative mortality compared with normothermia. No incremental benefit was noted between the different hypothermia grades ($P = .0827$).

Conclusions: Most patients receive hypothermia during on-pump coronary artery bypass grafting. Hypothermia is protective against operative mortality compared with normothermia in such patients. Moderate hypothermia does not provide additional survival benefit. (J Thorac Cardiovasc Surg 2014;148:2712-8)

See related commentary on pages 2718-9.

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Controversy exists about the risks and benefits of hypothermia during cardiac surgery.[1,2] Ho and Tan[3] reviewed the effect of hypothermia on cardiac operative mortality in a 2009 meta-analysis and identified 37 reports totaling 6444 patients. The general conclusion was that normothermia during cardiopulmonary bypass in adult cardiac surgery was as safe as that of hypothermia. Importantly, in that meta-analysis, more than one half of the studies contained <100 patients and therefore lacked an adequate sample size to address the issue. The Society of Thoracic Surgeons (STS) Adult Cardiac Surgery Database (STS-ACSD) began collecting lowest core temperature data during the procedure in July 2011. The addition of this field to the database has offered an opportunity to study the effect of hypothermia on operative mortality during cardiac surgery in a large patient population.

METHODS

The Duke University Health System institutional review board declared this research exempt from review owing to the de-identified nature of the STS-ACSD. Funding limitations allowed analysis of only on-pump coronary artery bypass grafting (CABG). The STS-ACSD was reviewed for all patients treated with isolated CABG from July 1, 2011 to December 31, 2012. Of the 216,321 patients identified, 73,780 patients (34.1%) were excluded to develop a more homogenous cohort of stable, nonemergency patients for evaluation (Figure 1). No exclusion criteria were used at the hospital level; however, some hospitals were excluded from the analysis on the basis of the applied patient exclusion criteria.

The patients were divided into 3 groups according to the lowest core temperature during the procedure (STS-ACSD, version 2.73, sequence no. 2780): moderate hypothermia (≤34°C), mild hypothermia (>34°C and ≤36°C), or normothermia (>36°C). The distinction between mild and moderate hypothermia was determined by institutional practice. The patient characteristics studied were the standard STS risk model covariates (ie, risk calculator variables) and additional non–risk model covariates (Table 1), which also included the hospital CABG volume.[4]

The primary endpoint of the present study was operative mortality, which was defined as operative death (sequence no. 6390), discharge death (no. 6370), or death at 30 days after surgery (no. 6380). The secondary individual endpoints were permanent stoke (no. 6030) and reoperation for bleeding or tamponade (no. 5760). A combined infection endpoint was also used and consisted of the individual endpoints of deep sternal

From the Division of Cardiovascular Surgery,[a] Mayo Clinic, Rochester, Minn; and Duke Clinical Research Institute,[b] Durham, NC.

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Address for reprints: Kevin L. Greason, MD, Division of Cardiovascular Surgery, Mayo Clinic, 200 First St SW, Rochester, MN 55905 (E-mail: greason.kevin@mayo.edu).

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Abbreviations and Acronyms

CABG = coronary artery bypass grafting
CI = confidence interval
OR = odds ratio
STS = Society of Thoracic Surgeons
STS-ACSD = Society of Thoracic Surgeons Adult Cardiac Surgery Database

infection (no. 5860), mediastinitis (no. 5870), pneumonia (no. 6150), and sepsis (no. 6010).

Descriptive statistics for categorical variables are reported as counts and percentages and continuous variables as the mean ± standard deviation and/or median and interquartile range. Categorical variables were compared using the chi-square test and continuous variables using the Kruskal-Wallis test.

Univariate and multivariate associations between the 4 endpoints and the 3 perfusion temperature groups were assessed using logistic regression analysis with the generalized estimating equation. To compare mild or moderate hypothermia with normothermia on each outcome, multivariate models were adjusted for the STS risk model covariates and non–risk model covariates, in addition to the 3 perfusion temperature groups. Missing covariates were imputed using most common category for categorical covariates and group-specific medians for continuous covariates. All continuous covariates were tested for linearity, and nonlinear relationships were accounted for using flexible splines, including linear splines or quadratic polynomial. All statistical tests were 2-sided, with the α level set at 0.05 for statistical significance. All analyses were performed using SAS, version 9.3 (SAS Institute, Cary, NC).

RESULTS

The study group included 142,541 patients treated with on-pump, nonemergency, isolated CABG. During cardiopulmonary bypass, 94,777 patients (66.5%) received moderate hypothermia, 42,750 (30.0%) mild hypothermia, and 5014 (3.5%) normothermia. A histogram of the lowest core temperature of the study group during the procedure is shown in Figure 2. The STS patient risk model covariates are listed as patient characteristics in Table 2. The operative data are reported in Table 3.

Operative mortality occurred in 1394 patients (1.5%) in the moderate hypothermia group, 534 (1.3%) in the mild hypothermia group, and 105 (2.1%) in the normothermia group. Stroke occurred in 1257 patients (1.3%) in the moderate group, 495 (1.2%) in the mild group, and 57 (1.1%) in the normothermia group. Reoperation occurred in 1662 (1.8%) in the moderate group, 716 (1.7%) in the mild group, and 99 (2.0%) in the normothermia group ($P = .025$). Finally, infection occurred in 3189 (3.4%) in the moderate group, 1318 (3.1%) in the mild group, and 161 (3.2%) in the normothermia group.

Univariate analysis identified mild hypothermia to be protective against operative mortality compared with normothermia (odds ratio [OR], 0.60; 95% confidence interval [CI], 0.49-0.72; $P < .0001$) and moderate

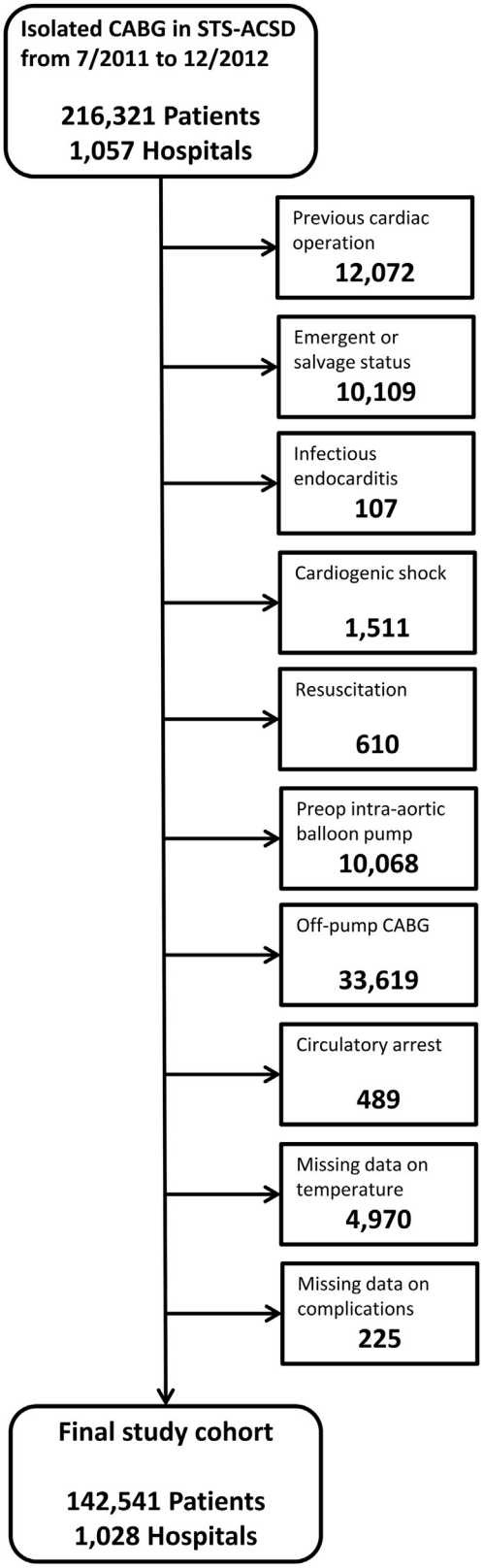

FIGURE 1. Algorithm describing patient exclusion process. *CABG*, Coronary artery bypass grafting; *STS-ACSD*, Society of Thoracic Surgeons Adult Cardiac Surgery Database.

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