Variation in Red Blood Cell Transfusion Practices During Cardiac Operations Among Centers in Maryland: Results From a State Quality-Improvement Collaborative

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Background. **Variation in red blood cell (RBC) transfusion practices exists at cardiac surgery centers across the nation. We tested the hypothesis that significant variation in RBC transfusion practices between centers in our state's cardiac surgery quality collaborative remains even after risk adjustment.**

Methods. **Using a multiinstitutional statewide database created by the Maryland Cardiac Surgery Quality Initiative (MCSQI), we included patient-level data from 8,141 patients undergoing isolated coronary artery bypass (CAB) or aortic valve replacement at 1 of 10 centers. Risk-adjusted multivariable logistic regression models were constructed to predict the need for any intraoperative RBC transfusion, as well as for any postoperative RBC transfusion, with anonymized center number included as a factor variable.**

Results. **Unadjusted intraoperative RBC transfusion probabilities at the 10 centers ranged from 13% to 60%; postoperative RBC transfusion probabilities ranged from 16% to 41%. After risk adjustment with demographic, comorbidity, and operative data, significant intercenter variability was documented (intraoperative probability range, 4% –59%; postoperative probability range, 13%–39%). When stratifying patients by preoperative hematocrit quartiles, significant variability in intraoperative transfusion probability was seen among all quartiles (lowest quartile: mean hematocrit value, 30.5% ± 4.1%, probability range, 17%–89%; highest quartile: mean hematocrit value, 44.8% ± 2.5%; probability range, 1%–35%).**

Conclusions. **Significant variation in intercenter RBC transfusion practices exists for both intraoperative and postoperative transfusions, even after risk adjustment, among our state's centers. Variability in intraoperative RBC transfusion persisted across quartiles of preoperative hematocrit values.**

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Red blood cell (RBC) transfusion practices have garnered much attention in the modern cardiac surgical literature. Transfusion has been associated with increased risks of postoperative infection and morbidity, prolonged hospital lengths of stay, and early and late mortality [1, 2]. Moreover, restrictive approaches to transfusion have been associated with at least equivalent morbidity and mortality compared with liberal strategies in the cardiac surgery population [3–5].

Despite the accumulation of literature supporting the restriction of blood transfusion to varying degrees in patients undergoing cardiac operations, wide variation among these practices persists [6–8]. In the United States, perioperative transfusion rates have been documented to vary widely in cardiac surgery centers, with rates of RBC transfusion ranging from 7.8% to 92.8% [9]. Moreover, details regarding center-level data have not been thoroughly explored, nor has the distinction between intraoperative and postoperative transfusions. As standardization of medical practice draws increasing

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Abbreviations and Acronyms

AVR	= aortic valve replacement
BMI	= body mass index
CAB	= coronary artery bypass
CI	= confidence interval
COPD	= chronic obstructive pulmonary disease
CVD	= cerebrovascular disease
LVEF	= left ventricular ejection fraction
GFR	= glomerular filtration rate
MI	= myocardial infarction
PAD	= peripheral arterial disease
RBC	= red blood cell

attention from both providers and policy makers, we felt an examination of our statewide RBC transfusion practices would be an essential first step in improving patient care.

The purpose of this study was to explore variability in transfusion rates and associated risk factors in 10 centers performing cardiac operations in Maryland. These centers recently formed a nonprofit collaborative, the Maryland Cardiac Surgery Quality Initiative (MCSQI), to share data and standardize best practices in the name of improving patient care. We conducted a retrospective cohort study of patients undergoing cardiac operations at any 1 of the 10 MCSQI hospitals between 2011 and 2014 to test the hypothesis that significant intercenter variation in blood transfusion practices exists even after performing risk adjustment for patient and operative characteristics. We also sought to explore the interaction between preoperative hematocrit values and center variations, hypothesizing that patients with relatively lower preoperative hematocrit values would more likely require intraoperative RBC transfusions (ie, transfusion would be common for these patients at any center).

Patients and Methods

MCSQI Collaborative and Patient Population

The MCSQI was founded in 2013 as a nonprofit consortium of 10 cardiac surgery programs from across the state of Maryland. In addition to holding regular meetings and conference calls to discuss best practices, the MCSQI functions to collect data from member hospitals for analysis after project approval by the MCSQI's research committee.

After obtaining appropriate approval from the MCSQI board as well as our institutional review board, we included the records of patients undergoing isolated coronary artery bypass (CAB) and isolated aortic valve replacement (AVR) on cardiopulmonary bypass at each of the 10 MCSQI hospitals from 2011 to 2014. Patients who had any other concomitant procedure were excluded. Patient and hospital identifiers were removed before analysis.

Primary Outcomes and Variable Definitions

The primary outcomes were the occurrence of transfusion of 1 or more units of packed red blood cells (RBCs) either intraoperatively or postoperatively. Each outcome was considered independently. The intraoperative period was defined as the time between the patient entering the operating room and the time the patient leaves the operating room, whereas the postoperative period encompassed the period from postoperative intensive care unit (ICU) admission to hospital discharge. Variable definitions were collected according to The Society of Thoracic Surgeons data abstraction guide, versions 2.73 and 2.81 [10].

Statistical Analysis

Demographic, clinical, and operative characteristics were analyzed in patients who did and those who did not receive any RBC transfusion intraoperatively and between patients who did and those who did not receive any RBC transfusion postoperatively. Continuous variables were compared using *t* tests or rank-sum tests, or both, according to distribution, whereas χ^2 tests were used to compare categorical variables. A p value of less than 0.05 was the threshold for significance for all tests performed. Statistical analysis was performed using STATA, version 12.0 (StataCorp LP, College Station, TX).

For each primary outcome—intraoperative or postoperative RBC transfusion—2 multivariable logistic regression models with progressive degrees of adjustment were developed to assess the probability of RBC transfusion in each surgical center. These models were derived across all 8,141 patients. Model I assessed the unadjusted probability of receiving RBC transfusions by center. Model II further adjusted for demographic characteristics, including age and sex; clinical characteristics, including body mass index, diabetes, cerebrovascular disease (CVD), lung disease, immunocompromised status, myocardial infarction (MI) within 21 days of operation, glomerular filtration rate (GFR), left ventricular ejection fraction (LVEF), use of anticoagulants preoperatively, use of nonaspirin antiplatelet agents preoperatively, use of thrombolytic agents preoperatively, and preoperative hematocrit value; operative variables, including bypass time, cross-clamp time, previous cardiac operations, urgent or emergent operative status, and coronary artery bypass grafting (compared with AVR). These 2 models were executed for each primary outcome of intraoperative and postoperative RBC transfusion, as well as in aggregate (ie, any RBC transfusion during the hospital stay).

To define intercenter variation, the anonymized center identifier (1–10) was included as a factor variable in our multivariable models and was forced into the 4 models. Centers were reranked in descending order of patients contained within the database, with center 1 defined as the center contributing the greatest number of patients to the MCSQI database and center No. 10 as the center with the fewest patients. Centers were then included in a multivariable analysis. The 2 logistic regression models