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Risk and Safety Perceptions Contribute to Transfusion Decisions in Coronary Artery Bypass Grafting

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Abstract: Variability persists in intraoperative red blood cell (RBC) transfusion rates, despite evidence supporting associated adverse sequelae. We evaluated whether beliefs concerning transfusion risk and safety are independently associated with the inclination to transfuse. We surveyed intraoperative transfusion decision-makers from 33 cardiac surgery programs in Michigan. The primary outcome was a provider's reported inclination to transfuse (via a six-point Likert Scale) averaged across 10 clinical vignettes based on Class IIA or IIB blood management guideline recommendations. Survey questions assessed hematocrit threshold for transfusion ("hematocrit trigger"), demographic and practice characteristics, years and case-volume of practice, knowledge of transfusion guidelines, and provider attitude regarding perceived risk and safety of blood transfusions. Linear regression models were used to estimate the effect of these variables on transfusion inclination. Mixed effect models were used to quantify the variation attributed to provider specialties and hematocrit triggers. The mean inclination to transfuse was 3.2 (might NOT transfuse) on the survey Likert scale (SD: .86) across vignettes among 202/413 (48.9%) returned surveys. Hematocrit triggers ranged from 15% to 30% (average: 20.4%; SE: .18%). The inclination to transfuse in situations with weak-to-moderate evidence for supporting transfusion was associated with a provider's hematocrit trigger ($p < .01$) and specialty. Providers believing in the safety of transfusions were significantly more likely to transfuse. Provider specialty and belief in transfusion safety were significantly associated with a provider's hematocrit trigger and likelihood for transfusion. Our findings suggest that blood management interventions should target these previously unaccounted for blood transfusion determinants.
Keywords: CABG, blood transfusion, transfusion, RBC, intraoperative. *J Extra Corpor Technol. 2021;53:270–8*

Intraoperative red blood cell (RBC) transfusions are common (1) and as few as one to two units of RBCs are associated with increased morbidity and mortality following coronary artery bypass grafting (CABG) (2,3). Despite

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published clinical guidelines for transfusion (e.g., a restrictive RBC transfusion hemoglobin threshold of 8 g/dL for patients undergoing cardiac surgery), considerable variability persists in RBC transfusion practices, with reported intraoperative hospital-level transfusion rates in cardiac surgery ranging from less than 10% to greater than 90% (4–7).

Variation in RBC transfusions within the setting of cardiac surgery is thought to be explained by a combination of patient, provider, and organizational-level factors (7–12). Prior work has examined the role of some of the following with regard to the risk of RBC transfusion 1): patient comorbidities, 2) blood conservation practices (e.g., reducing circuit prime volume at the onset of cardiopulmonary bypass, retrograde autologous priming), and 3) institutionally based, multi-disciplinary blood management teams (13–16). While traditionally unaccounted for in published series, variation in intraoperative transfusion rates across hospitals may be attributed to provider-level factors such as the culture of the team (e.g., who makes the transfusion decision, institutional norms), a provider's transfusion trigger, and his/her beliefs and attitudes toward the safety and risk of RBC transfusions (7,15). Unfortunately, such provider-level measures are not contained within traditional registries and thus their association with a hospital's transfusion rate remains thus far understudied.

A statewide survey of intraoperative provider transfusion decision-makers was conducted to examine predictors of the likelihood to transfuse intraoperatively, including provider demographics, practice characteristics, provider hematocrit trigger, beliefs, and attitudes concerning risk and safety of transfusion, beliefs and attitudes concerning blood management, and familiarity with professional society blood management guidelines. Hematocrit trigger is defined as the minimum hematocrit level at which a decision-maker would decide to transfuse. Secondarily, potential predictors of a provider's hematocrit trigger were also explored, including 1) the provider's beliefs and attitudes concerning risk and safety of transfusion, 2) a provider's specialty, and 3) other potential predictors (provider demographics, age). We hypothesized that provider characteristics are significantly associated with hematocrit trigger and likelihood to transfuse.

MATERIALS AND METHODS

The study was approved by the University of Michigan's Institutional Review Board (HUM00093011).

SURVEY DEVELOPMENT AND VALIDATION

A two-part survey, targeting intraoperative transfusion decision-makers at all 33 non-federal cardiac surgery programs in Michigan, was designed in collaboration with the Michigan Society of Thoracic and Cardiovascular Surgeons Quality Collaborative (MSTCVS-QC) and the Northern New England Cardiovascular Disease Study Group (NNECDSG). An inter-professional expert panel consisting of anesthesiologists, surgeons, perfusionists, and Certified Registered Nurse Anesthetists (CRNAs) from the MSTCVS-QC and NNECDSG assisted in survey development and refining the specific clinical vignettes. After implementing changes based on feedback from survey experts and pilot testing at three hospitals, the edited survey was distributed to intraoperative providers across MSTCVS-QC hospitals.

The first section of the survey (Supplemental Appendix: Survey) was composed of 10 clinical vignettes designed to elicit a provider's inclination to transfuse in situations with moderate or weak guideline evidence (Class IIA/IIB) supporting transfusions (14). After each clinical vignette statement, the provider was asked to "indicate the likelihood of recommending a transfusion of RBCs" with responses collected on a six-point Likert Scale (ranging from "definitely would not transfuse" to "definitely would transfuse.") The survey was not designed to assess which patient-level risk factors increased a provider's inclination to transfuse. The second section of the survey included items assessing the following domains: ideal and actual levels of provider involvement in transfusion decision-making, beliefs and attitudes concerning risk and safety of transfusion, beliefs and attitudes concerning blood management, and familiarity with professional society blood management guidelines and other information sources regarding transfusion medicine. These items used a 5-point scale (ranging from "strongly disagree" to "strongly agree,") with the exception of 1) 3-point scale for items regarding levels of provider involvement in transfusion decision-making (ranging from "not involved in transfusion decision-making" to "can decide to independently transfuse"), 2) 5-point scale for assessing familiarity with blood management guidelines (ranging from "not at all familiar" to "extremely familiar"), 3) 5-point scale for assessing confidence in guidelines (ranging from "not at all confident" to "extremely confident," and 4) 5-point scale for assessing the effect of information sources on clinical practice (ranging from "no effect" to "major effect.") The final section of the survey included items concerning respondent demographics and practice characteristics.

STUDY COHORT AND SURVEY DISTRIBUTION

An e-mail invitation was distributed to intraoperative team members involved in transfusion decision-making (cardiac surgeons, anesthesiologists, perfusionists, CRNAs) at all 33 MSTCVS-QC hospitals. Surveys were distributed

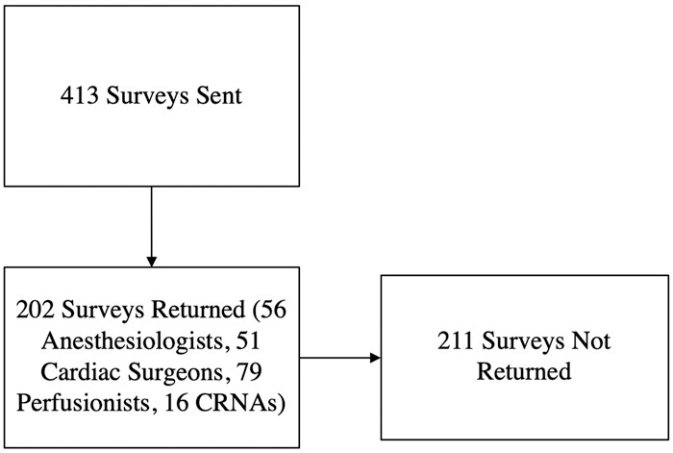

Figure 1. Survey responses. This figure displays survey responses across cardiac surgery intraoperative transfusion decision-makers. CRNA, certified registered nurse anesthetist.

using Qualtrics (Provo, UT) with subsequent e-mail invitations sent to non-responders and incomplete responders. The survey was closed 127 days after the initial distribution.

The breakdown of survey responses is presented in Figure 1. This manuscript adheres to the applicable SQUIRE 2.0 guidelines (17).

STATISTICAL ANALYSIS

The primary outcome was the inclination to transfuse, as defined by composite score (mean) across the 10 clinical vignettes. If a respondent did not respond to one or more vignettes, then the composite score was taken as the mean of the other responses. If the respondent did not respond to any vignettes, they were excluded from analyses focusing on the primary outcome of the likelihood to transfuse. Potential predictors for likelihood or inclination to transfuse included the respondent's hematocrit trigger and specialty, as well as responses to survey questions in the following domains: provider demographics and practice characteristics, beliefs, and attitudes concerning risk and safety of transfusion, beliefs, and attitudes concerning blood management, and familiarity with professional society blood management guidelines.

First, demographic and practice characteristics were analyzed by specialty using chi-square tests for categorical variables and non-parametric tests of the trend form continuous variables. Independent *t* tests were used to analyze differences in the likelihood of transfusing across the clinical vignettes between providers of different specialties.

Second, survey questions were examined via bivariate linear regression models for potential inclusion as predictors of inclination to transfuse. When appropriate, responses were converted from a 5-point Likert scale to a 3-point categorical form: "strongly agree" or "agree," "neutral," and "strongly disagree" or "disagree." The missingness of response for survey items was tested for significance. When missingness was not observed to be significantly associated with the outcome, missing observations were excluded from subsequent regression analyses.

Third, multi-variable linear regression models were used to associate predictors of transfusion with the mean likelihood of transfusion across clinical vignettes. Pre-specified predictors included specialty, demographics, years and volume of practice, hematocrit trigger, knowledge of transfusion guidelines, and attitudes and beliefs concerning risk and safety of transfusion.

To assess the degree of variation in a provider's response that may be explained by provider specialty and hematocrit trigger, the following nested mixed effect models with provider and vignettes as random effects were fit: 1) empty model, 2) adjusting for specialty, 3) adjusting for hematocrit trigger and specialty. The response of transfusion likelihood to each vignette was analyzed as the outcome.

As a secondary outcome, we also explored predictors of hematocrit trigger using linear regression, specifically focusing on responses to questions related to transfusion risk and safety. We investigated possible interactions between provider beliefs and age as well as provider beliefs and specialty when predicting hematocrit trigger.

All analyses were performed using SAS 9.4 (Cary, NC) and STATA 14.0 (College Station, TX).

RESULTS

Surveys were sent to 413 providers in the state of Michigan and 202 surveys (48.9) were completed. Of these, 182 (90.1%) respondents completed all 10 clinical vignettes and 192 (95.1%) completed at least 8. Three (1.5%) respondents did not complete any vignettes. One-hundred and forty respondents (69.3%) reported having a hematocrit trigger. The demographic and professional characteristics of the sample are reported by specialty

Table 1. Respondent demographics and professional characteristics by specialty.

	Anesthesiologists ($n = 56$)	Cardiac Surgeons ($n = 51$)	Perfusionists ($n = 79$)	CRNAs ($n = 16$)	p-Value*
Male (% yes)	66.07%	78.43%	64.56%	25.00%	<.01
No response	19.64%	19.61%	12.66%	25.00%	–
White (% yes)	69.64%	64.71%	81.01%	68.75%	.34
No response	19.64%	17.65%	12.66%	25.00%	–
Provider age (years, % yes)	–	–	–	–	<.0001
30–35	16.07%	0%	11.39%	25.00%	–
36–40	21.43%	3.92%	11.39%	25.00%	–
41–45	17.86%	5.88%	2.53%	31.25%	–
46–50	5.36%	17.65%	15.19%	0%	–
51–55	8.93%	17.65%	16.46%	6.25%	–
≥56	16.07%	45.10%	27.85%	0%	–
Missing	14.29%	9.80%	15.19%	12.50%	–
Years post-training					<.01
≤5	28.57%	3.92%	11.39%	31.25%	–
6–10	26.79%	1.96%	7.59%	31.25%	–
11–15	5.36%	23.53%	12.66%	12.50%	–
>16	25.00%	62.75%	59.49%	12.50%	–
No response	14.29%	7.84%	9%	12.50%	–
Number of CABG* procedures in 12 months					.04
1–50	42.86%	23.53%	27.85%	50.00%	–
51–100	35.71%	25.49%	27.85%	25.00%	–
101–150	7.14%	27.45%	20.25%	12.50%	–
151+	0%	15.69%	15.19%	0%	–
No response	14.29%	7.84%	8.86%	12.50%	–
Hematocrit trigger (Mean)	21.69	20.49	19.67	21.04	<.01†
No response (%)	35.71%	21.57%	18.99%	25.00%	–

CABG, coronary artery bypass grafting; CRNA, Certified Registered Nurse Anesthetist.
*p-Value of chi-square test, unless otherwise noted.
†p-Value of ANOVA.

(Table 1). Respondents were predominantly male and Caucasian, with the majority reporting performing greater than 50 CABG procedures annually. Proportion of missing data for vignettes and key survey items is shown in Supplemental Appendix Table 1.

We observed a mean inclination to transfuse of 3.2 (SD: .86) across vignettes (with three corresponding to "Might NOT transfuse"). The most common response to the clinical vignettes was "Might NOT transfuse" (32.8%, 636 responses summed across all vignettes), Supplemental Appendix Table 2. Within clinical vignette variability, as measured by the standard error, ranged from .06 to .10, Supplemental Appendix Table 1. A mean hematocrit trigger of 20.4% (SE: .18) was observed, with a minimum hematocrit trigger of 15% and a maximum of 30%.

The inclination to transfuse across the clinical vignettes increased by .23 (SE: .03) points on a 6-point Likert scale ($p < .001$) for every one-unit increase in a provider's

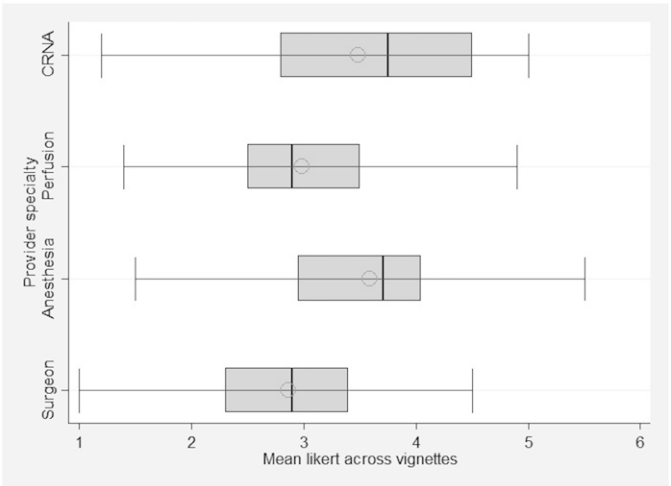

Figure 2. Variation in provider inclinations to transfuse by specialty using average Likert scores from clinical vignettes in the survey. The upper and lower borders of the box represent the upper and lower quartiles. The middle horizontal line represents the median, the circle represents the mean. The upper and lower whiskers represent maximum and minimum values. Likert scale categories are as follows: 1 = "Definitely would NOT transfuse," 2 = "Would NOT transfuse," 3 = "Might NOT transfuse," 4 = "Might transfuse," 5 = "Would transfuse," 6 = "Definitely WOULD transfuse." CRNA, certified registered nurse anesthetist.

hematocrit trigger. Inclination to transfuse was not significantly associated with missingness of hematocrit trigger. Differences in unadjusted inclination to transfuse across providers (Figure 2) were observed, with anesthesiologists more likely to transfuse than perfusionists (mean difference = .81, $p < .001$) and surgeons (mean difference = .81, $p < .001$). Perfusionists and surgeons were less likely to transfuse than CRNAs (mean difference = .58, $p = .04$; and mean difference = .58, $p = .048$). There was no significant difference in the inclination to transfuse between surgeons and perfusionists (difference = .005, $p = .98$). After accounting for a respondent's transfusion trigger, the magnitude and significance of the difference diminished for anesthesiologists versus perfusionists (difference = .37, $p = .04$) and anesthesiologists versus surgeons (difference = .56, $p = .003$). Anesthesiologists and CRNAs no longer significantly differed in their likelihood to transfuse (difference = .47, $p = .07$). Overall, provider specialty and transfusion trigger accounted for 35.1% of the total variation in provider likelihood to transfuse, with 12.5% due to specialty alone and transfusion trigger explaining the additional 22.7% of the total variation.

In the final adjusted model predicting inclination to transfuse, anesthesiologists were significantly (beta coefficient: .43, $p = .02$) more likely to transfuse than surgeons, Table 2. Older respondents were less likely to transfuse relative to respondents aged 30–35 years (p-values $< .01$ for 41–45, 46–50, 51–55, and ≥56-year-olds). Every 1-unit increase in a provider's hematocrit trigger was significantly associated with a higher likelihood to transfuse (beta coefficient: .19, $p < .01$). Providers who agree or strongly agree that RBC transfusions are safe had a higher likelihood to transfuse across the clinical vignettes, relative to those who disagreed (Strongly Agree/Agree — beta coefficient: .32, $p = .03$). The absence of a transfusion trigger was not significantly associated with the likelihood to transfuse, relative to those reporting a transfusion trigger. Additional findings regarding provider-level predictors of transfusion are noted in Supplemental Appendix Table 3. In a sensitivity analysis of beliefs and specialty, CRNAs were mostly likely to be concerned about the potential risks of anemia and were the most likely to believe that RBC transfusions were safe, Table 3.

Providers who agreed or strongly agreed that RBC transfusions are safe were more likely to transfuse than respondents who disagreed (p-value = .03, Table 2). A significant interaction ($p < .01$) between provider belief and specialty (outcome: transfusion trigger) was observed for the survey statement, "The risk associated with anemia is more worrisome than the risk of transfusion." No interaction between any provider belief and provider age was observed. Additional findings regarding respondent beliefs and inclination to transfuse across clinical vignettes are displayed in Supplemental Appendix Table 4. A provider's beliefs concerning potential complications of transfusions were not significantly associated with his/her hematocrit trigger. Complications of transfusion included long-term risk of death (p-value = .30), acute circulatory overload (p-value = .08), risk of infections (p-value = .40), risk of pulmonary dysfunction (p-value = .10), risk of kidney injury (p-value = .13), and risk of transfusion reaction (p-value = .10), Supplemental Appendix Table 5. The absence of a transfusion trigger was not significantly associated with beliefs regarding the risks and safety transfusion.

DISCUSSION

A statewide survey of intraoperative blood transfusion decision-makers was used to examine the relationship between a provider's perceptions of risks and the safety of blood transfusions and the likelihood for intraoperative transfusions in the setting of cardiac surgery. Findings from this statewide survey reveal that the decision to transfuse in a given clinical setting is influenced by an individual provider's beliefs and attitudes toward the risks and safety of transfusions, which are influenced by factors such as specialty and age. Across the 10 clinical vignettes focusing on Class IIa/IIb recommendations from the Society of Thoracic Surgeons (STS) Blood Conservation Task Force, provider specialty and transfusion trigger accounted for 36% of the total variation in a provider's likelihood to transfuse. Providers differed significantly in their beliefs concerning the risk of anemia, the safety of RBC transfusions, and their perception concerning their colleagues' beliefs regarding anemia and transfusion, with cardiac surgeons being the least and CRNAs the most concerned about the risks of anemia relative to transfusions. Notably, cardiac surgeons and perfusionists had no significant difference in their inclination to transfuse, though both were less likely to transfuse than CRNAs and Anesthesiologists. Prior work has documented the standardization of perfusion practices (e.g., shortening of tubing length, decrease prime volume, alternative priming, retrograde autologous priming) to reduce blood transfusions during cardiac surgery (18). The availability and utilization of these and other blood management approaches may help explain the lower inclination to transfuse among perfusion responders. Overall, these findings suggest that providers' beliefs concerning the risks of anemia and transfusions may be important targets for future blood management interventions.

Despite existing evidence-based blood management guidelines, considerable controversy persists over optimal hematocrit transfusion triggers for cardiac surgery patients. The STS has established a blood conservation guideline task force in partnership with the Society of

Table 2. Multi-variable linear regression model output, association of beliefs with likelihood to transfuse, adjusting for provider specialty and transfusion trigger.

Characteristic	Beta Coefficient	Standard Error	95% CI	*p*-Value
Specialty				
Anesthesiologist	.43	.18	.07, .80	.02
Perfusionist	.31	.17	−.03, .64	.07
CRNA	.13	.23	−.34, .60	.58
Surgeon	Ref	Ref	Ref	Ref
Age				
30–35	Ref	Ref	Ref	Ref
36–40	−.44	.23	−.90, .01	.06
41–45	−.78	.27	−1.32, −.24	<.01
46–50	−.79	.30	−1.38, −.20	<.01
51–55	−1.01	.32	−1.64, −.39	<.01
56+	−.98	.33	−1.64, −.35	<.01
Years practicing				
≤5	Ref	Ref	Ref	Ref
6–10	.37	.21	−.04, .79	.08
11–15	.53	.28	−.1, 1.07	.06
≥16	.57	.30	−.02, 1.2	.06
Number of CABGs over last year				
1–50	Ref	Ref	Ref	Ref
51–100	−.02	.14	−.29, .24	.87
101–150	−.08	.15	−.38, .22	.60
151–200	.07	.24	−.40, .55	.75
200+	.26	.25	−.23, .75	.30
Hematocrit trigger	.19	.03	.13, .24	<.01
Degree of concern when considering whether to transfuse a patient regarding risk of Pulmonary dysfunction	−.06	.06	−.16, .05	.32
Others at my institution believe CABG teams need to transfuse 1–2 units of RBC to improve outcomes				
Strongly Agree/Agree	.02	.47	−.89, .94	.96
Neutral	.56	.25	.08, 1.04	.02
Strongly Disagree/Disagree	Ref	Ref	Ref	Ref
Others at my institution believe transfusions of RBCs are an inevitable consequence of CABG surgery				
Strongly Agree/Agree	.45	.25	−.04, .94	.07
Neutral	.42	.31	−.18, 1.02	.17
Strongly Disagree/Disagree	Ref	Ref	Ref	Ref
Risk of anemia is more worrisome than risk of transfusion				
Strongly Agree/Agree	.18	.23	−.28, .64	.44
Neutral	−.08	.20	−.48, .31	.68
Strongly Disagree/Disagree	Ref	Ref	Ref	Ref
RBC transfusions are safe				
Strongly Agree/Agree	.32	.15	.03, .61	.03
Neutral	.28	.14	.01, .55	.04
Strongly Disagree/Disagree	Ref	Ref	Ref	Ref
Others at my institution believe that risk of anemia is more worrisome than risk of transfusion				
Strongly Agree/Agree	.03	.22	−.39, .46	.89
Neutral	.26	.21	−.14, .67	.21
Strongly Disagree/Disagree	Ref	Ref	Ref	Ref
I share similar transfusion strategies with others in my specialty at my institution				
Strongly Agree/Agree	.54	.26	.02, 1.10	.04
Neutral	.57	.32	−.06, 1.21	.08
Strongly Disagree/Disagree	Ref	Ref	Ref	Ref
AABB 2012 Guidelines: How familiar are you with these guidelines?	.04	.06	−.06, .15	.42
Clinical guidelines are an unbiased synthesis of expert opinion				
Strongly Agree/Agree	−.18	.15	−.49, .11	.23
Neutral	−.27	.17	−.60, .06	.10
Strongly Disagree/Disagree	Ref	Ref	Ref	Ref
To what extent does evidence from observation trials influence your clinical practice?	.10	.07	−.24, .04	.16

CABG, coronary artery bypass grafting; CRNA, Certified Registered Nurse Anesthetist; RBC, red blood cell; AABB, American Association of Blood Banks.

Table 3. Differences in respondent beliefs by provider type.

Survey Question	Specialty	Percent of Respondents Answering "Agree" or "Strongly Agree"	Comparison	*p*-Value
Red blood cell transfusions are safe	–	–	Overall	.02
	Surgeon	46.81	Anesthesiologist	.32
	–	–	Perfusionist	.009
	–	–	CRNA	.50
	Anesthesiologist	36.73	Perfusionist	.13
	–	–	CRNA	.17
	Perfusionist	24.00	CRNA	.01
	CRNA	57.14	–	–
I share similar transfusion strategies with others at my institution	–	–	Overall	.01
	Surgeon	80.43	Anesthesiologist	.92
	–	–	Perfusionist	.005
	–	–	CRNA	.28
	Anesthesiologist	79.59	Perfusionist	.004
	–	–	CRNA	.25
	Perfusionist	96.00	CRNA	.60
	CRNA	92.86	–	–
The risk associated with anemia is more worrisome than the risk of transfusion	–	–	Overall	.02
	Surgeon	8.89	Anesthesiologist	.04
	–	–	Perfusionist	.003
	–	–	CRNA	.003
	Anesthesiologist	24.49	Perfusionist	.34
	–	–	CRNA	.18
	Perfusionist	32.43	CRNA	.45
	CRNA	42.86	–	–
Others at my institution believe that the risk of anemia is more worrisome than the risk of transfusion	–	–	Overall	.022
	Surgeon	13.04	Anesthesiologist	.38
	–	–	Perfusionist	.01
	–	–	CRNA	.02
	Anesthesiologist	19.61	Perfusionist	.08
	–	–	CRNA	.07
	Perfusionist	33.78	CRNA	.52
	CRNA	42.86	–	–

CRNA, Certified Registered Nurse Anesthetist.

Cardiovascular Anesthesiologists and the American Society of ExtraCorporeal Technology (19). In its most recent 2011 update, the task force found that transfusions may be reasonable (Class IIa recommendation) to maintain a hematocrit above 18% during cardiopulmonary bypass utilizing moderate hypothermia, except among patients who present with conditions that may impart risk of decreased cerebral oxygen delivery (in whom a higher hematocrit would be acceptable) (14). Nonetheless, few trials or observational series support this hematocrit trigger, resulting in a Level of Evidence "C" recommendation by the Taskforce.

Recent studies have attempted to determine optimal transfusion thresholds for patients undergoing cardiac surgery. In their multi-center trial TITRe2, Murphy and colleagues reported that although a liberal transfusion threshold was non-superior to a restrictive threshold with respect to a primary composite outcome consisting of serious infections (sepsis, wound infection) or ischemic events, secondary analyses did reveal a significantly increased risk of 90-day mortality among patients in the restrictive threshold arm (20). Concerns have been raised regarding the interpretation of TITRe2 results given the high transfusion rate in both the liberal and restrictive cohorts (94.9% vs. 63.7% transfused, respectively) (21). Transfusion Requirements in Cardiac Surgery (TriCS) investigators, in a multi-center, non-inferiority, randomized control trial among 5,243 adults undergoing cardiac surgery, reported that a restrictive transfusion threshold was non-inferior to a liberal threshold with respect to a primary composite outcome of all-cause mortality, myocardial infarction, stroke, or new-onset renal failure requiring dialysis (22). RBC transfusion rates were significantly lower in the restrictive threshold group (rate ratio of .85, 95% CI: .82–.88). Results from the present survey may reflect the lack of consensus in the literature concerning how to balance the perceived risks of anemia with potential sequelae from RBC transfusions (23).

Existing studies have shown that behavioral interventions (e.g., clinical guidelines, provider education, and feedback) may be effective in lowering blood transfusion rates. In their systematic review, Tinmouth and colleagues

reviewed 19 published studies focusing on single or multi-faceted behavioral interventions and physicians' transfusion practices (24). While the authors found that behavioral interventions were effective in reducing the relative number of units of RBCs transfused and/or in reducing the proportion of patients receiving transfusions, a recent systematic review by the American College of Cardiology/American Heart Association Task Force suggested that some interventions such as audit and feedback and educational outreach visits were more effective than interventions such as reminders and provider incentives in improving guideline adoption (25). Further work is needed to address provider-level transfusions determinants (e.g., beliefs concerning safety and benefit of transfusions), perhaps through behavioral interventions, as a means of reducing potentially avoidable blood transfusions.

The current use of surveys to assess provider-level determinants of practices may serve as the foundation for evaluating other areas of medicine that are similarly supported by Class IIa, Level C recommendations. For example, Marso and colleagues identified variability in the use of bleeding avoidance strategies among patients undergoing percutaneous coronary interventions (26). Specifically, patients with high pre-operative bleeding risk were least likely to receive bleeding avoidance strategies. Much like transfusion decisions in cardiac surgery, bleeding avoidance strategies are implemented by teams consisting of multiple provider types, each drawing on unique training and clinical experience. Further understanding concerning the contribution of provider knowledge, beliefs, and attitudes in the use of bleeding avoidance strategies may be accomplished through surveying frontline clinical care providers.

Several limitations exist in the current study. First, as with any survey, response bias may exist due to incomplete sampling. However, respondents were relatively equally distributed across low and high transfusion rate hospitals and the survey's response rate was similar to other published series (5). Second, while each survey question was pilot tested to assess its validity, the potential exists for some questions to be interpreted by respondents differently than intended. Third, the present study solely focused on intraoperative transfusions, therefore the current findings may not be generalizable to the determinants of transfusion practices in other settings (e.g., post-operative). Fourth, partial responses resulting in missing data for some of the survey items may introduce error; however, no statistically significant associations were observed between missingness, predictors, or the outcome. Fifth, other important determinants of provider transfusion practices were not collected, including data concerning the seniority of a respondent within his/her institution. Sixth, we did not have adequate power to investigate the effect of patient characteristics that may influence provider inclination to transfuse. Seventh, while a provider's awareness of published blood management guidelines was assessed, objective assessments of guideline recommendations were not. Last, although the survey sample spanned providers across all 33 non-federal Michigan institutions, findings may not be generalizable outside of Michigan.

In this statewide survey of intraoperative care providers, a provider's beliefs regarding the safety and benefit of transfusions were significantly associated with a greater likelihood of transfusing RBC transfusions. Provider beliefs and attitudes toward the safety and benefits of transfusions are variable and differ by specialty. These findings may inform targets for future blood management interventions within the setting of cardiac surgery.

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