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An Assessment of Clinician and Patient Baseline Knowledge and Preferences Regarding Red Blood Cell Transfusions in Cardiac and Non-Cardiac Surgery

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ABSTRACT

Purpose: To delineate the current knowledge of, and preference for perioperative red blood cell transfusion by clinician and patients.

Methods: In this single center study, clinicians and patients were asked to complete a 21-item survey, and a 19-item survey, respectively.

Results: On a 7-point category scale, clinicians felt more knowledgeable about when red blood cells should be transfused (5.5 vs 2.1; p<0.0001), clinicians, in preparation for open heart surgery, were more interested in hearing about the risks and benefits of a blood transfusion (4.6 vs 2.6; p<0.0001), and more clinicians felt it was important for them to be involved in deciding whether they should receive a blood transfusion (5.7 vs 5.0; p=0.015). The majority of clinicians chose hemoglobin triggers of either <7.5 mg/dL for non-cardiac surgery or 7.5-8.9 mg/dL for cardiac surgery, while patients either felt they did not have enough information or did not know.

Conclusion: Our results highlight important differences between clinicians and patients in the basic knowledge about, and preferences for perioperative red blood transfusion, and imply a clinician-driven decision model to transfuse RBCs, and supports future efforts to develop decision aids to facilitate patient involvement in the shared decision-making about perioperative transfusion.

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Introduction

The human and economic costs of unnecessary blood transfusions are staggering. Autologous red blood cells (drawn and provided to same patient) are associated with acute hemolytic transfusion reactions, allergic reactions, and coagulopathy. These events prompt additional blood transfusions that contribute to metabolic derangements, septic contamination, and transfusion-associated circulatory overload. Beyond the human costs of unnecessary transfusions are the direct costs of unjustified transfusion and indirect costs of managing avoidable, adverse associated events [1-3]. Best practice alerts (BPA), designed to leverage evidence-based guidelines into management of transfusions [4-6]. have had modest impact on clinician behavior [7]. As many as 30% of clinicians with access to BPAs override the recommendation [8]. This fact warrants attention given the intended role of evidence-based practice guidelines to reduce practice based variation and improve patient outcomes.

In 2011, the Agency for Healthcare Quality and Research estimated that 8% of hospitalized patients receive a red blood

cell transfusion—the most common clinical interventions in adults aged 45 years and older [9]. This significantly impacts the stability of our healthcare system and creates additional, unnecessary costs associated with unnecessarily transfused blood [10]. (10) [10] (10) ((ABIM) 2014) [10 10 10 10 10 10 10] Due to findings that blood transfusion-associated hospitalization rates have increased rapidly between 1997 and 2011 for all adults aged 18 and older, this fact is especially concerning; the direct and indirect cost of storing, testing, and administering a single unit of blood to these patients is estimated at $500-$1,200 [11]. Moreover, it remains likely that blood continues to be administered unnecessarily which suggests these costs will continue to place an additional burden on the economic well-being of the health care system [10]. Current efforts to curb these costs, and to mitigate the risk to patients by limiting unnecessary transfusions, have been largely unsuccessful.

The American Society of Anesthesiologists among others have argued that the decision to transfuse should be considered equally by both physician and patient, given their equivocation about thresholds for transfusion [12]. In other words, in the absence of clear evidence for transfusion, patient's preferences should be considered [13]. Here the concept of shared decision making (SDM) offers useful insight into best practices, particularly when current transfusion guidelines are applied haphazardly and clinical outcomes for non-trauma patients receiving transfusion are equivalent [14]. SDM refers to a clinical communication strategy where patients and their physician review pros and cons of treatment, deliberate the evidence and the patient's preference, and determine a course of treatment in partnership [15].

The use of decision aids to facilitate patient involvement in the SDM of their care between clinicians and patients have gained increasing popularity [16-18]. Decision aids as educational tools have been shown to increase patient's understanding of basic medical knowledge—improving patients' comprehension of the risks and benefits of medical interventions [17]. Considered a key component for patient-centered care, SDM is a process through which patients can make the most appropriate medical decision using the best and most current evidence available [19, 20]. In a recent cross-sectional survey of US-based practitioners across multiple clinical care disciplines, investigators demonstrated a relatively positive attitude toward using SDM [21]. Patients, physicians, and healthcare purchasers see potential value in SDM aids as a way to incorporate patients' wishes into preference-sensitive decisions prior to surgery [22]. And Decision support interventions or decision aids as they are commonly termed, are useful in clinical scenarios where there is clinical or surgical equipoise and patient preference is an accepted approach for ensuring effective treatment. Decision aids come in many forms from electronic media to one-page grids that display frequently asked questions with treatment options and their associated risks and benefits [23].

Since cardiac surgical patients are one of the highest consumers of perioperative red blood cell transfusions, and in light of emerging evidence that a more conservative approach to perioperative transfusion does not increase postoperative morbidity or mortality, the Societies of Thoracic Surgeons (STS) and of Cardiovascular Anesthesiologists (SCA) partnered in 2007 to urge a more restrictive approach to perioperative red blood cell transfusions in cardiac surgical patients [4-6, 24]. Guidelines were updated in 2011; however, despite these modified recommendations, clinical adoption and implementation has remained limited [25, 26]. Given a high incidence of transfusions to cardiac and other surgical patients during their perioperative period and their resultant predisposition to unfavorable outcomes there was sufficient need to examine how shared decision making around transfusion. Therefore, in order to examine this question a multidisciplinary team was convened to design, test, and implement an educational tool to promote SDM around timing of transfusion of allogeneic red blood cells both during and after cardiac surgery.

Methods

By directly involving the cardiac surgical patient in his or her care through preoperative education and informed SDM, this project seeks to address unjustified red blood cell transfusions in cardiac surgical patients via a novel, innovative approach. To accomplish this, two surveys, one for patients and another for clinicians, were created. The intention of these surveys was to delineate basic understanding of and preferences for perioperative blood transfusions. Prior to survey distribution, research methods were reviewed and approved by the Medical Center's Institutional Review Board (IRB ID STUDY00005927). All participants' participation was strictly voluntary. Informed consent was obtained from all who agreed to participate; no incentives were offered.

Survey Development and Content

The final *clinician* survey contained 21 questions: 11 were grouped into categorical questions and queried their basic understanding of and preferences for perioperative blood transfusions, while the remaining 10 asked for basic demographic information. The final *patient* survey contained 19 questions: 10 questions pertained to participants' basic understanding of and preferences for perioperative blood transfusions while 9 questions asked for basic demographic information.

Clinician Survey

The clinician survey was emailed to clinicians affiliated with the Departments of Cardiac Surgery, Anesthesiology, and Internal Medicine at a large academic health center in the Upper Midwest. Clinicians within these departments included cardiac surgeons, anesthesiologists, internists, physician assistants (PAs), certified registered nurse anesthetists (CRNAs), advanced nurse practitioners, registered nurses (RNs) and perfusionists. Clinician participants were emailed a unique, electronic link that provided access to the individual survey questions; this method eliminated the risk of duplicate responses. Two weeks after the initial email was sent to potential clinician-participants, two reminder emails were sent to non-responders, each two weeks apart.

While completing the survey, clinician participants were not allowed to review or change their responses after advancing each electronic section. Once completed, results were compiled and organized with the Research Electronic Data Capture (REDCap) tool [27].

Patient Survey

All cardiac and non-cardiac patients presenting to the Preoperative Assessment Center (PAC) for a total of one week were invited to complete a survey at the time of their preoperative visit. For added convenience, paper surveys were chosen as the primary survey medium. Patient responses were manually entered into an excel spreadsheet.

Statistical Analysis

Responses from the 7-category Likert scales for each survey type (clinician, patient) were aggregated and expressed as means ± SD, absolute numbers and percentages. Mann-Whitney was used to compare nonparametric data. $P \leq 0.05$ was considered statistically significant. JMP Pro 14 (SAS Institute, Cary, NC) was used for statistical analysis.

Results

Clinician Demographic Survey Results

Of the 313 surveys emailed to clinicians, a total of 99 surveys (32%) were returned (Table 1). The majority of respondents were between the ages of 25-34 years and identified as White. Forty-seven percent were female, 52% percent were physicians, 20% were certified registered nurse anesthetists (CRNAs); the remainder were physician assistants (PAs), advanced nurse practitioners (APNs), registered nurses (RNs), or "other". The majority (81%) of respondents had annual incomes greater than $200,000 and had a graduate level of education, and 71% were either married or in a domestic partnership. Sixty-one percent saw a primary care clinician every 1-2 years, whereas 37% rarely saw a primary care clinician. Seventeen percent of respondents saw a specialty care clinician every 1-2 years, while 81% rarely saw a specialty care clinician.

Table 1: Clinician and Patient Demographic Information

	Clinicians	Patients
Age Categories in Years, n (%)		
18-24	0 (0%)	5 (5.9%)
25-34	34 (40.0%)	9 (10.6%)
35-44	20 (23.5)	8 (9.4%)
45-54	11 (12.9%)	13 (15.3%)
55-64	15 (17.6%)	16 (18.8%)
65-80	5 (5.8%)	34 (40.0%)
81-100	0 (0%)	0 (0%)
Gender (Female), n (%)	39 (47.0%)	49 (57.8%)
Ethnicity, n (%)	0 (0%)	3 (3.6%)
Hispanic/Latino	0 (0%)	0 (0%)
American Indian	7 (8.2%)	2 (2.4%)
Asian	0 (0%)	0 (0%)
Native Hawaiian or Pacific Islander		
Black African American	1 (1.2%)	4 (4.8%)
White	68 (80.0%)	71 (85.5%)
Other	2 (4.5%)	0 (0%)
Prefer not to answer	5 (5.9%)	3 (3.6%)
Marital Status, n (%)		
Single	18 (21.4%)	12 (15.0%)
Married or in domestic partnership	60 (71.4%)	56 (70.0%)
Divorced/Separated	4 (4.8%)	4 (5.0%)
Widowed	1 (1.2%)	6 (7.5%)
Prefer not to answer	1 (1.2%)	1 (1.3%)
Annual Personal Income, n (%)		
Less than $25,000	1 (1.2%)	15 (19.7%)
$25,000-$39,999	0 (0%)	6 (7.9%)
$35,000-$49,999	1 (1.2%)	7 (9.2%)
$50,000-$74,999	12 (14.4%)	16 (21.1%)
$75,000-$99,999	1 (1.2%)	7 (9.2%)
$100,000-$149,999	12 (14.4%)	2 (2.6%)
$150,000-$199,999	15 (18.1%)	3 (3.9%)
Greater than $200,000	26 (31.3%)	7 (9.2%)
Prefer not to answer	15 (18.1%)	13 (17.1%)
Level of Education, n (%)		
Less than High School	0 (0%)	3 (3.7%)
High School Equivalency	0 (0%)	16 (19.8%)
Some College	0 (0%)	23 (28.4%)
Bachelor Degree	2 (2.3%)	17 (21.0%)
Associate Degree	1 (1.2%)	0 (0%)

Some Graduate Degree	13 (15.5%)	3 (3.7%)
Graduate Degree	68 (81.1%)	19 (23.5%)
Primary Care Visitation		
1-2/Year	51 (60.7%)	45 (56.3%)
Every Few Monthly	2 (2.3%)	13 (16.3%)
Rarely	31 (36.9%)	18 (22.5%)
Specialty Care Visitation		
1-2/Year	14 (16.6%)	25 (30.5%)
Every Few Monthly	2 (2.3%)	19 (23.2%)
Rarely	68 (80.9%)	32 (39.0%)

Patient Demographic Survey Results

Of the 121 surveys distributed to patients, 93 (77%) were completed (Table 1). Forty percent of respondents were between the ages of 65-80 years, 80% identified as White, and 58% were female. Just under 20% of patient responders had an annual income between $50,000-$74,999 (19.7%), had "Some College" level of education (28.4%), and 70.0% were Married or in a Domestic Partnership. Fifty-six percent of patient respondents saw a primary care provider every 1-2 years, 23% rarely saw a primary care provider. Thirty percent of patient respondents saw a specialty care provider every 1-2 years, 39% rarely saw a specialty care provider.

Baseline Knowledge

There was no statistically significant difference between physician and non-physician clinician responses to the 7-category Likert-style questions pertaining to baseline knowledge and transfusion preferences; therefore, we combined the responses from the two groups into a single Clinician set and then compared the Clinician responses with the patient responses. Of the total responses, three were significantly different (Table 2): clinicians felt more knowledgeable than patients about the hemoglobin level at which red blood cells should be transfused (5.5 vs 2.1; $p<0.0001$), clinicians, in preparation for open heart surgery were more interested in hearing about the risks and benefits of a blood transfusion than patients (4.6 vs 2.6; $p<0.0001$), and more clinicians felt it was important for them to be involved in deciding whether they should receive a blood transfusion when compared with patients (5.7 vs 5.0; $p=0.015$). Asking whether clinicians want their patients to be involved in the overall decision-making process regarding their patient's medical care was not asked of the patients, and, therefore, could not be compared.

Table 2: Seven-category scalar responses by Clinicians and Patients

	Clinicians Mean (SD) Upper/Lower 95%	**Patients Mean (SD) Upper/Lower 95%**	***p* Value**
How knowledgeable are you about the hemoglobin level at which red blood cells should be transfused?	n=73 5.5 (0.83) 1,7	n=92 2.1 (1.67) 1,7	<0.0001
In the past how involved have you been in medical decision-making regarding your personal healthcare plan?	n=93 6.0 (1.36) 1,7	n=92 5.9 (1.50) 1,7	ns
How involved do you want to be in the overall decision-making process about your medical care?	n=91 6.6 (0.94) 1,7	n=92 6.6 (0.70) 3,7	ns
In preparation for open heart surgery, how interested would you be in hearing about the risks and benefits of a blood transfusion?	n=42 4.8 (1.34) 1,7	n=88 2.6 (2.23) 1,7	<0.0001
How important is it for you to be involved in deciding whether you should receive a blood transfusion?	n=83 5.7 (1.52) 1,7	n=88 5.0 (2.14) 1,7	0.015
How important is it for you to be involved in deciding whether your loved one should receive a blood transfusion?	n=85 5.5 (1.55) 1,7	n=87 5.3 (2.06) 1,7	ns
How involved do you want your patients to be in the overall decision-making process about their medical care?	n=85 5.9 (1.20) 3,7	Patients not asked	N/A

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Transfusion-Trigger Preferences

If undergoing non-cardiac surgery, 79% of clinicians would opt for a blood transfusion at a hemoglobin level of <7.5 mg/dL while 72% of patients either did not have enough information or did not know if they would opt for a blood transfusion at that level (Figure 1). If undergoing cardiac surgery, 43% and 39% of clinicians, respectively would opt for a blood transfusion at hemoglobin levels of either <7.5 mg/dL and 7.5-8.9 mg/dL, while a combined 67% of patients either did not have enough information or did not know (Figure 2). The majority of clinicians (78%) would transfuse a loved one undergoing non-cardiac surgery at hemoglobin levels <7.5 mg/dL while 68% of patients either did not have enough information or did not know (Figure 3). Thirty-nine percent and 42% of clinicians, respectively would transfuse a loved one undergoing cardiac surgery at hemoglobin levels of either <7.5 mg/dL and 7.5-8.9 mg/dL while the majority of patients (68%) either did not have enough information or did not know (Figure 4). Finally, 80% of clinicians would transfuse their patients at hemoglobin levels of <7.5 mg/dL, assuming their patients were not actively bleeding, and had no relevant co-morbidities (Figure 5). Patients were not asked this question.

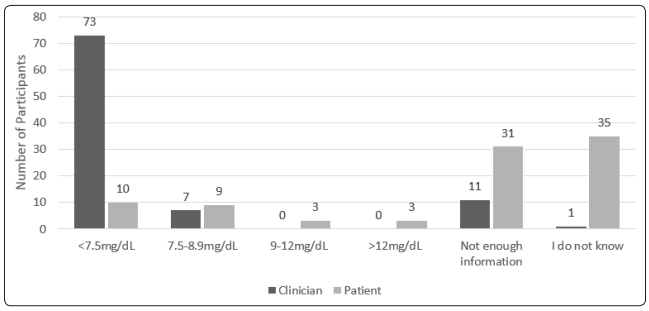

Figure 1: When the clinician and patient were asked; The normal hemoglobin level for women is greater than 12 gm/dL and for men it's greater than 13.5 gm/dL. Assume you are an otherwise healthy patient who feels well and is not actively bleeding: At what hemoglobin level would you want to receive a transfusion of red blood cells?

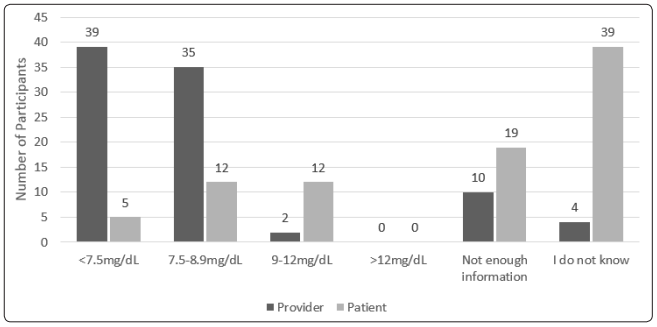

Figure 2: When the clinician and patient were asked; The normal hemoglobin level for women is greater than 12 gm/dL and for men it's greater than 13.5 gm/dL. Imagine you are having open heart surgery and you have the usual amount of blood loss expected for the surgery: At what hemoglobin level would you want to receive a transfusion of red blood cells?

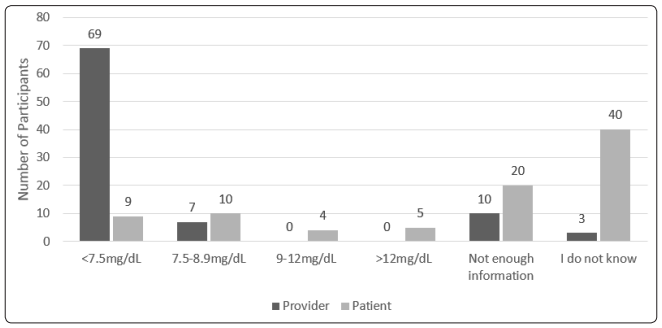

Figure 3: When the clinician and patient were asked; If your loved one is in the hospital, assuming he or she feels well, and is not actively bleeding: At what hemoglobin level should he or she receive a blood transfusion?

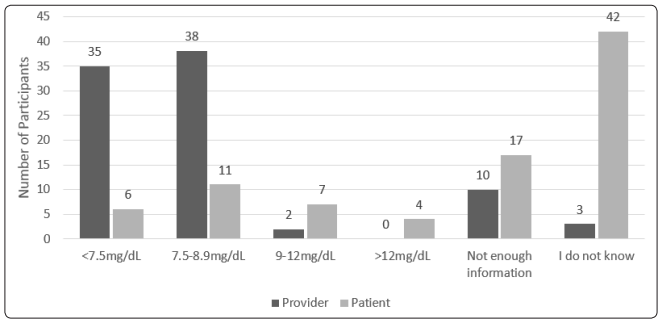

Figure 4: When the clinician and patient were asked; Imagine your loved one is in the hospital for open heart surgery and he or she has the usual amount of blood loss expected for the surgery: At what hemoglobin level would you want him or her to receive a transfusion of red blood cells?

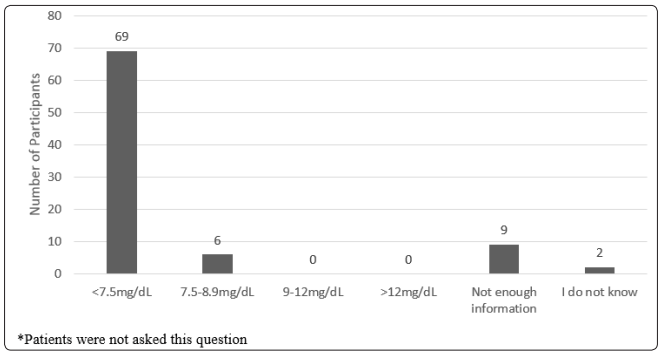

Figure 5: When the clinicians* were asked; Assuming your patient is not actively bleeding, and any co-morbidities are not relevant: At what hemoglobin transfusion threshold would you order/ recommend a blood transfusion for your patient?

Discussion

Analysis of survey findings from a large, academic tertiary care hospital, highlight significant differences between clinicians and patient's knowledge, views, and perceptions of red blood cell transfusions during the perioperative period. While it may not come as a surprise that clinicians are significantly more knowledgeable about when patients should be transfused (Question 1), it was surprising to learn that patients had a relatively low level of interest in hearing about the risks and benefits of blood transfusion prior to their own surgery (Question 4). This finding is even more compelling as patients acknowledge being aware of how important it is for them to be involved with their own overall medical decision-making (Question 2, 3 and 5) and in the care of their loved ones (Question 6).

A study of anesthesiologist and perfusionist knowledge and attitudes on transfusions suggest that between 25 to 33% do not fully read or are not aware of current transfusion guidelines [14]. Our findings suggest that when asked, clinicians appear comfortable being transfused, or having their loved ones transfused, at a hemoglobin less than 7.5 mg/dL during non-cardiac surgery and at a range between 7.5-8.9 mg/dL during cardiac surgery. While there is little consensus on when to engage patients around transfusion one study from the late 90's suggest it should occur when risk is >1%. The FOCUS trial provides some insight to transfusion in perioperative surgery, showing very little difference in post-operative follow-up at 60 days between a conservative and liberal strategy [28]. Given the continued high rate of unnecessary transfusion rates and practice engaging patients earlier appears both appropriate and necessary [29].

Comparatively, our results indicate the majority of patients either feel as though they do not have enough information or do not know under similar circumstances. This implies that patients are comfortable with a clinician-driven decision model whereby clinicians are the sole decision-makers of when and if to transfuse blood during the perioperative period, and that patients are comfortable with remaining uninformed about this facet of their care. This confirms previous reports that describe clinician overestimation of patient ability to make clinical decisions but an underestimation of patient willingness to have more information for deliberation [30]. More recent evidence shows that patients in cardiology want to be involved in their treatment decisions, but it remains unclear how and in what way they want to be involved [31, 32].

Our findings, however, reveal that, in general, patients do not know enough about when red blood cell transfusions are appropriate to respond in an informed way to the question. We would be remiss if we did not point out the wide variation in confidence intervals for each of the 7-category questions suggesting variability in understanding, possibly underscoring the importance of variation in age and education. Based on these findings, we believe there is an opportunity to design and implement education aids for patients to participate more intentionally in deciding if and when they, or their loved ones, should receive allogeneic red blood cells during the perioperative period.

As of now, clinical decision support (CDS) is being used more often to modify clinician behavior; this method differs from the simple act of publishing best-practice guidelines by using direct education and training campaigns with more intelligent, interactive tools designed to intercept unjustified or inappropriate transfusions at the point of care [33, 34]. This phenomenon was recently illustrated at Stanford University Medical Center where they were able to successfully reduce their red blood cell transfusion rate from 57% to 30% after implementing an interruptive best practice alert (BPA), followed by a hospital-wide education campaign [35]. Similarly, in an interrupted time series analysis of 143,000 hospital admissions over the course of 6 years, Kassakian and colleagues achieved a significant reduction in the incidence of red blood cell transfusion after implementing an evidence-based CDS tool [36].

Support tools are designed to reduce blood transfusions; however, there are many cases when these tools are ignored which ultimately reduces their effectiveness. In a large, well-designed retrospective analysis, Chen and colleagues reviewed common reasons for overriding BPAs in over 10,000 instances and found that more than 34% of instances for overriding the alert was due to 'active bleeding'[7]. However, 11-12% of the decisions for overriding and proceeding with blood transfusions were due to symptomatic anemia, 10-15% were in anticipation of a surgical or procedural intervention, and 2-5% were in anticipation of a hospital discharge—altogether accounting for 23-32% of the rationales for overriding a BPA. Blood transfusion in anticipation of a surgical procedure or hospital discharge is questionable at best and creates three negative consequences: no mortality benefit to the patient, additional costs to the health system, and a potential for patient harm [37, 38]. Moreover, the authors suggest that 'the nonspecific, subjective and non-evidence-based nature of symptom-driven blood transfusion' is an opportunity for further standardization through CDS tools [7]. We interpret this as evidence that variability in transfusion practice remains high even despite well-intentioned tools directed at the clinician and further suggests a need for directly involving patients and their families in the perioperative period in order to further reduce inappropriate transfusions of red blood cells.

Decision aids have been routinely used as adjuncts during cardiac surgery to prepare patients for making more informed choices about their perioperative care. These patients had significantly more knowledge about perioperative transfusion and a more realistic risk perception than patients who did not use decision aids during elective cardiac surgery [39]. In addition, patients who had opportunities to actively participate in the decision-making process regarding their care plan via decision aids exhibited greater satisfaction with the overall outcome of their treatment and experience. A recent multicenter randomized trial used shared decision-making aids to assess the impact on cardiac surgical patient care and outcomes in prosthetic valve selection. The findings of this trial suggest no significant decrease in decision conflict, but did result in more knowledgeable, better informed, and less anxious patients when compared with those who were not exposed to decision aids prior to surgery [40]. To date, even despite the few studies aimed at widening our understanding of how decision aids impact patient care, there is a deficiency in published information about whether these decision aids can specifically facilitate shared decision making around hemoglobin triggers for perioperative blood transfusion during cardiac surgery.

Our findings provide additional knowledge of the subject but contain several limitations. First, while a 32% clinician response rate is close to double the expected response rate of online surveys [41]. our results are nevertheless subject to response bias. In an effort to maximize our response rate and minimize our response bias, we made every effort to design a brief, yet highly relevant survey [42]. We were unable to control when, during their visit, patients responded to our survey, and therefore, do not know if some patients received relevant education about perioperative blood transfusions prior to completing the survey. While our survey included broad range of patients and clinicians involved with perioperative surgery, our findings should be interpreted narrowly and do not have broad generalizability. While a mean score of 2.1 out of 7 on patient knowledge about hemoglobin levels and transfusion is not unexpected, it confirms that tools may have vital importance for educating patients on the basics of transfusion. In developing the questions to better delineate preferences for perioperative blood transfusions, we realize that terms such as "otherwise healthy patient who feels well and is not actively bleeding" and "usual amount of blood loss expected for the surgery" may be interpreted differently, and/or may deter responders from committing to a hemoglobin transfusion trigger.

Based on emerging evidence that decision aids can facilitate shared decision-making in even the most complex medical environments,

we believe that developing tools to deliver structured preoperative education about appropriate perioperative hemoglobin transfusion triggers to physicians and non-physician practitioners working in the operating room and in the intensive care setting will reduce unjustified variability in allogeneic red blood cell transfusion rates in both cardiac and non-cardiac surgical patients. Similarly, we feel that patient-centric educational tools developed to engage cardiac surgery patients and their families in a preoperative planning discussion about if and when to transfuse allogeneic red blood cells during the perioperative period would have a similar impact on reducing perioperative variability in unjustified transfusion of red blood cells. Finally, we feel strongly that sharing in the preoperative planning decision of when to transfuse red blood cells during cardiac surgery and immediately (in the ICU) following will reduce the number of unjustified cardiac surgery-related allogeneic red blood cell transfusions in patients undergoing cardiac surgery. Gaining an understanding of how knowledgeable clinicians and patients are about perioperative allogeneic red blood cell transfusions, and their preferences for if and when transfusions should occur was a necessary initial step. The results of our study support further efforts to develop and deliver structured education to both clinicians and patients to convey and reinforce best clinical practice, and to develop and implement a shared decision-aid during the preoperative planning between clinicians and patients to facilitate discussions of when and if to transfuse red blood cells during cardiac surgery.

Practice Implications

In a recent editorial, Drs. Clapp, Fleisher and Lane-Fall suggest that anesthesiology "has lagged behind others in examining issues of decision making and informed consent" [43]. Urman and his colleagues suggest "that creation of decision aids should undergo a rigorous process, featuring patient input, for determining what information should be presented to them" [16]. Herein, we characterize basic clinician and patient knowledge about perioperative blood transfusions, and their preferences for receiving transfusions during and after surgery. In so doing, we have taken the initial step toward developing a decision aid that will facilitate what we hope will be meaningful conversation between clinicians and their patients regarding perioperative blood transfusions. As a result, we hope to reduce unnecessary perioperative blood transfusions, limiting undue risk to patients and reducing cost to our healthcare system.

Declaration of Interest: Tjörvi E. Perry is a consultant for Edwards Lifesciences (Irvine, CA) and is a member of the Medical Advisory Boards for the Improvement of Advanced Hemodynamic Monitoring in Cardiac Surgical Patients. Otherwise the authors report no relevant conflicts of interest.

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