General Anesthesia

Red blood cell transfusion practices amongst Canadian anesthesiologists: a survey

[Les pratiques transfusionnelles chez les anesthésiologistes canadiens : une enquête]

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Purpose: To assess red blood cell transfusion practices among Canadian anesthesiologists.

Methods: A survey depicting three realistic clinical scenarios of elective surgical procedures with different risks of bleeding was administered to all Canadian practicing members (n = 2,100) of the Canadian Anesthesiologists' Society. Respondents were requested to choose hemoglobin thresholds for which they would transfuse red blood cells under various conditions within each scenario.

Results: We obtained a response rate of 47% (719/1,512). Transfusion thresholds differed significantly between baseline scenarios. A threshold above 70 $g{\cdot}L^{-1}$ was chosen by 48% of respondents in the general surgery scenario compared to 56% in the orthopedic surgery scenario and 79% in the vascular surgery scenario ($P < 0.001$). A history of coronary artery disease was associated with a transfusion threshold ≥ 100 $g{\cdot}L^{-1}$ in a significant proportion of respondents ranging from 20% in the orthopedic surgery scenario to 31% in the general surgery scenario and to 49% in the vascular surgery scenario ($P < 0.001$). Conversely, changing the patient's age from 60 to 20 yr resulted in the adoption of a transfusion threshold ≤ 60 $g{\cdot}L^{-1}$ by > 30% of respondents in two scenarios ($P < 0.001$). The year of respondent graduation was strongly associated with these findings.

Conclusion: There was significant variation in transfusion practices among Canadian anesthesiologists. The type of surgical procedure, patient's age and a history of coronary artery disease influenced reported transfusion threshold. Practice variation in specific subgroups would support the need for further research to identify optimal transfusion thresholds.

Objectif *: Évaluer les pratiques transfusionnelles de culots globulaires chez les anesthésiologistes canadiens.*

Méthode *: Une enquête illustrant trois scénarios cliniques réalistes d'interventions chirurgicales réglées comportant différents risques de saignement a été présentée aux membres canadiens en exercice (n = 2 100) de la Société canadienne des anesthésiologistes. Les répondants devaient choisir les seuils d'hémoglobine pour lesquels ils transfuseraient des culots globulaires selon diverses conditions à l'intérieur de chaque scénario.*

Résultats *: Le taux de réponse a été de 47 % (719/1 512). Les seuils de transfusion différaient significativement entre les scénarios de base. Un seuil de plus de 70 $g{\cdot}L^{-1}$ a été choisi par 48 % des répondants dans le scénario de chirurgie générale comparé à 56 % en chirurgie orthopédique et 79 % en chirurgie vasculaire ($P < 0{,}001$). Une histoire de cardiopathie ischémique a été associée à un seuil de transfusion ≥ 100 $g{\cdot}L^{-1}$ chez un nombre significatif de répondants, allant de 20 % pour le scénario de chirurgie orthopédique jusqu'à 31 % pour la chirurgie générale et à 49 % pour la cardiochirurgie ($P < 0{,}001$). À l'inverse, la modification de l'âge du patient, de 60 à 20 ans, a amené l'adoption d'un seuil de transfusion ≤ 60 $g{\cdot}L^{-1}$ par > 30 % des répondants pour deux scénarios ($P < 0{,}001$). Le nombre d'années de pratique a fortement influencé ces résultats.*

Conclusion *: Il y a une variabilité significative de pratiques transfusionnelles chez les anesthésiologistes canadiens. Le type de chirurgie, l'âge du patient et une histoire de cardiopathie ischémique influencent le seuil de transfusion choisi. La diversité de la pratique de sous-groupes spécifiques renforce la nécessité de rechercher à l'avenir des seuils de transfusion optimaux.*

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DESPITE technologies to minimize allogeneic blood exposure, the use of red blood cell (RBC) transfusions is frequently required in the perioperative setting.[1] Indeed, anesthesiologists are among the foremost users of RBCs. Despite the heavy use of RBC in perioperative care, there is limited evidence evaluating RBC transfusion practice in this setting and Canadian guidelines are dated. At this time, the one large trial was conducted in critically ill patients.[2] In this study, a RBC transfusion threshold of 70 $g \cdot dL^{-1}$ of hemoglobin was shown to be as safe as a threshold ≥ 100 $g \cdot L^{-1}$ in terms of effects on morbidity and mortality. Guidelines published since the reporting of the Transfusion Requirements In Critical Care (TRICC) trial have either chosen to extrapolate evidence from the critical care study[3,4] or opt for recommendations that suggest the avoidance of extreme transfusion thresholds.[5]

A recent survey of the American Society of Anesthesiologists (ASA) noted the adoption of lower transfusion thresholds among its membership compared to a survey conducted 20 years ago.[6,7] A second survey from Israel also suggested the adoption of lower transfusion thresholds.[8] Given recent publications and the limited information on the views of anesthesiologists, we undertook a scenario-based survey of members of the Canadian Anesthesiologists' Society (CAS) to better understand physician attitudes toward transfusion practices.

Methods

Study population

We surveyed all Canadian members of the CAS listed in the 2002 mailing list. Members of the CAS are mainly physicians certified as specialists in anesthesia. From a listing comprising specialists and family physicians who have an interest in anesthesiology, we included only anesthesiologists with certification from the Royal College of Physicians and Surgeons of Canada and/or the "Collège des Médecins du Québec", working in Canada. We excluded anesthesiologists not treating adult patients, not practicing general anesthesia, not practicing in Canada, non-certified or retired. For privacy reasons, this exclusion process could not be done from the original CAS mailing list, but from information obtained from respondents and by cross matching the list with the Canadian Medical Directory. The Canadian Medical Directory included a list of physicians gathered from the Canadian Medical Association and from provincial medical associations. It was used as a means to identify physicians who met the exclusion criteria in the group of non-respondents. The study was approved by the Research Ethic Board of The Ottawa Hospital, Ottawa, Ontario.

Survey development and administration

The survey consisted of two parts: 1) three scenario-based questions designed to elucidate thresholds for RBC transfusion within realistic clinical contexts while varying physiologic parameters; 2) specific questions regarding the use of different blood conservation strategies and sources of information on transfusion practices. The scenario-based questions were developed by a panel of experts including anesthesiologists, epidemiologists and critical care physicians with previous experience in performing surveys in transfusion.[9] Through extensive consultations, three scenarios were chosen to represent a reasonable spectrum of elective surgical cases frequently encountered by anesthesiologists (Table 1). A hypothetical patient undergoing a right hemicolectomy, a second undergoing revision of a total hip replacement and a third undergoing an abdominal aortic aneurysm repair were described in order to represent a progressive increase in the risk of bleeding related to the type of surgery. Scenarios were constructed to contain potential risk factors for transfusion of RBCs previously identified by literature search and expert opinion. Thus, scenarios were based on a non-smoking 60-yr-old male patient, with a normal preoperative assessment, no comorbid illness or health concern who had an uncomplicated perioperative course. Respondents were asked to indicate the lowest hemoglobin concentration at which they would elect to transfuse using five discrete hemoglobin concentrations: ≤ 60 $g \cdot L^{-1}$, 70 $g \cdot L^{-1}$, 80 $g \cdot L^{-1}$, 90 $g \cdot L^{-1}$ or ≥ 100 $g \cdot L^{-1}$. These values were based upon response patterns from previous surveys suggesting preferences for end digit "0" values.[9,10] Within each scenario, this threshold for transfusion was reassessed after having systematically altered one patient characteristic or physiologic variable without modifying the remainder. Two of these variables were modified in all three scenarios: gender and coronary artery disease. Other modified variables were presence of preoperative chronic anemia, availability of autologous blood, increased perioperative bleeding, preoperative assessment instead of in the operating room and postoperative assessment for RBC requirements. These variables were modified in one or two scenarios only. Each scenario was validated for realism, content and clarity by piloting the survey to anesthesiologists ($n = 5$) and residents ($n = 10$). A French language version of the survey was also validated in the same way.

In the second part of the survey, the use of erythropoietin was assessed using a scenario-based question.

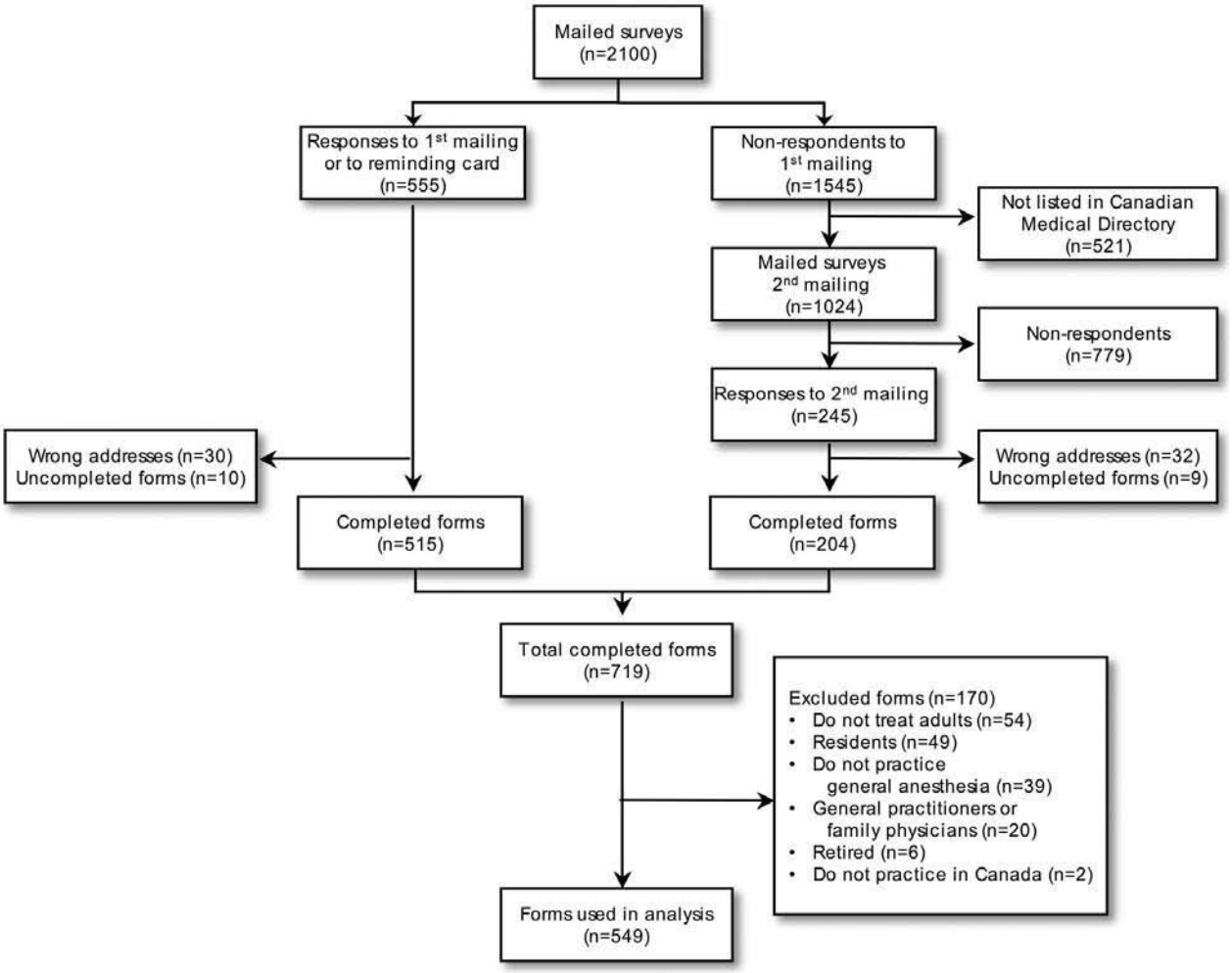

FIGURE 1 Flow diagram describing responses to two mailings of 2,100 self-administered surveys.

The reported use of different blood conservation strategies was also ascertained by response to a five-point Likert scale anchored with "never" and "always". The importance of different sources of medical information that may influence practice was evaluated using a five-point Likert scale anchored at "not important" and "extremely important". Demographic data of respondents were recorded such as age, gender, province of work, year of graduation, presence of an accredited anesthesia residency program in their hospital, number of beds in their hospital and anesthesia training.

The first mailing was sent in August 2002 followed four to six weeks later by a reminder card. A second mailing was sent six to eight weeks after the reminder card to 1,024 members whose form was not returned. For this second mailing, non-respondents not listed in the 2002 Canadian Medical Directory were considered ineligible and were excluded. All anesthesiologists received a survey in English language except those from the provinces of Quebec and New Brunswick who received both English and French versions of the survey.

Statistical analysis

Hemoglobin thresholds for transfusion were compared between and within the three scenarios using a Chi-square test. As a second step, we performed a logistic regression analysis to identify physicians characteristics associated with the adoption of a threshold of 70 $g \cdot L^{-1}$ in at least two of the three scenarios. Adjusted odds ratios (OR) and 95% confidence intervals (CI) were calculated for all demographic variables of respon-

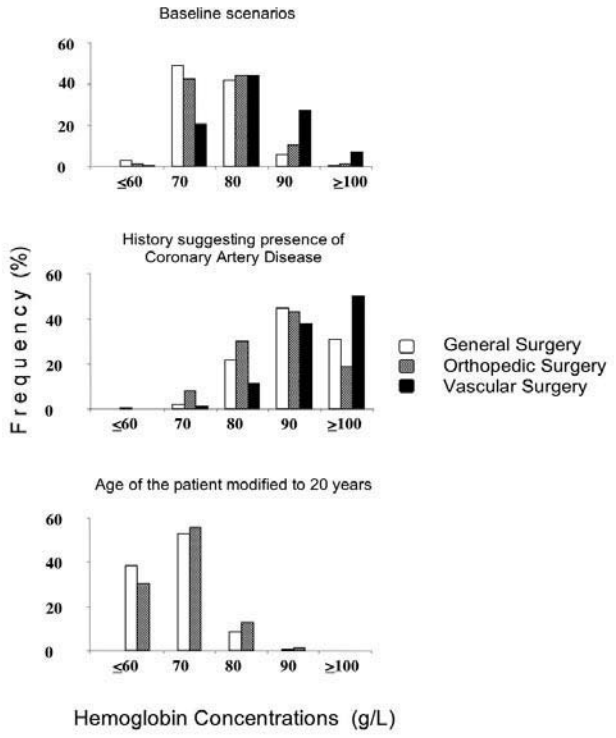

FIGURE 2 Percentage of respondents for every respective hemoglobin concentration they would elect to transfuse the patient within each scenario. Top: baseline hemoglobin thresholds from the original question of the scenario. Centre: hemoglobin thresholds with history suggesting coronary artery disease in each scenario. Bottom: hemoglobin thresholds with age of the patient modified to 20 yr in two scenarios.

TABLE I Clinical scenarios of elective surgical cases used for the survey. For each scenario, respondents were asked to chose at what hemoglobin concentration they would elect to transfuse the patient between the following stratified levels: ≤ 60 $g \cdot L^{-1}$, 70 $g \cdot L^{-1}$, 80 $g \cdot L^{-1}$, 90 $g \cdot L^{-1}$ or ≥ 100 $g \cdot L^{-1}$.

1. GENERAL SURGERY SCENARIO - You are in the operating room providing anesthetic care for a 60-year-old man undergoing a right hemicolectomy for colon cancer under general anesthesia. In your preoperative assessment, there was no prior history of coronary artery disease. He can walk briskly for approximately 1 mile without any difficulty. He does not smoke. He has no comorbid illnesses. He did not report any other health concerns. He is currently hemo dynamically stable in the operating room.

2. ORTHOPEDIC SURGERY SCENARIO - You are in the operating room providing anesthetic care for a 60-year-old man who is undergoing an elective revision of a right total hip replacement under general anesthesia. In your preoperative assessment, there was no prior history of coronary artery disease. Eight months prior to his problems, he was active and could exercise without any difficulty. He does not smoke. He has no comorbid illnesses. He did not report any other health concerns. He is currently hemodynamically stable in the operating room.

3. VASCULAR SURGERY SCENARIO - You are providing anesthetic care to a 60-year-old man who is undergoing an elective abdominal aortic aneurysm repair for a 5x6 cm. asymptomatic infrarenal aneurysm under general anesthesia. The surgeon has not yet cross-clamped the aorta. The aneurysm was not amenable to repair by endovascular stenting. In your preoperative assessment, there was no prior history of coronary artery disease. He can walk briskly for approximately one mile without any difficulty. He does not smoke. He has no comorbid illnesses. He did not report any other health concerns. He is currently hemodynamically stable in the operating room.

dents. Using the same procedure, we identified the characteristics of respondents who adopted the more extreme thresholds of a hemoglobin concentration ≤ 60 $g \cdot L^{-1}$ when the patient's age was modified to 20 yr, and a hemoglobin concentration ≥ 100 $g \cdot L^{-1}$ when presence of coronary artery disease was suggested. In an attempt to quantify response biases, we compared anesthesiologists who responded after the first mailing to individuals who responded after the second mailing. We reported absolute *P* values and 95% CI. A *P* value < 0.05 was considered significant.

Results

The response rate was 47% (719/1,517). Among the 2,100 surveys mailed between August 2002 and March 2003, 583 potential respondents were considered not eligible because of inaccurate addresses or because they were not listed in the Canadian Medical Directory. Seven hundred nineteen completed questionnaires were returned (Figure 1). From these, 549 were retained for analysis after removal of 170 questionnaires filled by respondents meeting exclusion criteria (Figure 2). Seventy-six percent of the responders were males, averaging 46 yr of age and working in a hospital with an accredited anesthesia residency program (61%). Among analyzed surveys returned within the study period, 369 surveys were after the first mailing. Missing data were < 1% for all questions except for the number of beds, where 32 respondents omitted to answer.

Thresholds for transfusion within scenarios

Responses to baseline hemoglobin threshold for transfusion were different between the three scenarios (*P*

TABLE II Percentage of respondents for specific demographic characteristics who adopted a hemoglobin threshold of 70 $g \cdot L^{-1}$, a hemoglobin threshold ≤ 60 $g \cdot L^{-1}$ in scenarios with age modified to 20 yr, and ≥ 100 $g \cdot L^{-1}$ in scenarios with history suggesting CAD

Characteristics	*Respondents*		*Hemoglobin thresholds (%)*		
	*n**	*(%)*	*70 g·L⁻¹†*	*60 g·L⁻¹‡ (age < 20)*	*100 g·L⁻¹§ (CAD)*
Gender					
Male	417	76.2	41.3	28.8	31.7
Female	130	23.8	42.3	31.5	23.1
Year of graduation					
Prior to 1981	123	22.4	21.1	13.8	44.7
1981 – 1985	95	17.3	44.2	27.4	26.3
1986 – 1990	117	21.3	41.9	26.5	29.1
1991 – 1995	94	17.1	50.0	39.4	27.7
1996 – 2002	111	20.2	52.3	41.4	20.7
Anesthesia residency program					
No	214	60.9	36.5	27.1	36.0
Yes	334	39.1	44.6	31.1	25.8
Acute care beds in hospital					
0-199	77	14.0	36.4	22.1	39.0
200-499	260	47.4	36.2	26.9	31.5
500+	180	32.8	49.4	35.0	23.9
Region					
West	173	31.5	45.1	30.1	33.0
Ontario	219	39.9	35.2	28.3	26.0
Quebec	91	16.6	42.9	35.2	37.4
East	66	12.0	50.0	24.2	22.7
Response period					
First Mail out	369	67.2	40.7	28.7	33.1
Second Mail out	180	32.8	42.8	31.1	22.8
Overall	549	100.0	41.4	29.5	29.7

CAD = coronary artery disease. *Missing data can explain unequal summations; †Physicians who adopted a threshold of 70 $g \cdot L^{-1}$ in at least two of three baseline scenarios; ‡Physicians who adopted a threshold of ≤ 60 $g \cdot L^{-1}$ in both scenarios with age modified to 20 yr; §Physicians who adopted a threshold of ≥ 100 $g \cdot L^{-1}$ in at least two of three scenarios with history suggesting coronary artery disease.

< 0.001). A threshold above 70 $g \cdot L^{-1}$ was chosen by 48% of respondents in the general surgery scenario compared to 56% in the orthopedic surgery scenario and 79% in the vascular surgery scenario ($P < 0.001$), (Figure 2). Using the original responses from the three scenarios in multivariable analysis, more recently graduated physicians were more likely to choose a threshold of 70 $g \cdot L^{-1}$ in at least two of the three scenarios (Tables II and III).

All patient-specific characteristics modified within each scenario appeared to influence reported transfusion thresholds when compared to the baseline question ($P < 0.05$), with the exception of gender ($P = 0.97$ for the general surgery scenario, $P = 0.81$ for the orthopedic surgery scenario and $P = 0.65$ for the vascular surgery scenario). Among these characteristics, a history of coronary artery disease and the patient's age modified reported transfusion thresholds more importantly compared to other variables. Presence of coronary artery disease resulted in a significant increase in the threshold for transfusion within all scenarios (Figure 2). Indeed, a hemoglobin concentration ≥ 100 $g \cdot L^{-1}$ was chosen as a threshold by 31% of the respondents in the general surgery scenario, 20% in the orthopedic surgery scenario and 49% in the vascular surgery scenario, when a history of coronary artery disease was added as a patient characteristic. When the age of the patient in the general surgery and the orthopedic surgery scenarios was decreased from 60 to 20 yr of age, more than 85% of the respondents opted for a transfusion threshold of 70 $g \cdot L^{-1}$ or less (from baseline percentages of 52% and 44%, $P < 0.001$ for both scenarios). Furthermore, 39% and 31% of respondents chose a hemoglobin value ≤ 60 $g \cdot L^{-1}$ as a transfusion threshold in the general surgery and the orthopedic surgery scenarios respectively. Using logistic regression analysis, year of graduation after 1980 was the only physician characteristic that was independently associ-

TABLE III Adjusted odds ratios (OR) and 95% confidence intervals (95% CI) of respondent characteristics predicting the adoption of a hemoglobin threshold of 70 g·L^{-1}, a hemoglobin threshold ≤ 60 g·L^{-1} in scenarios with age modified to 20 yr, and ≥ 100 g·L^{-1} in scenarios with history suggesting coronary artery disease (CAD)

Characteristics	*Hemoglobin thresholds (%)*								
	*70 g·L^{-1} **			*60 g·L^{-1} † (age < 20)*			*100 g·L^{-1} ‡ (CAD)*		
	OR	*95% CI*	*P*	*OR*	*95% CI*	*P*	*OR*	*95% CI*	*P*
Gender									
Male§	-	-				-			
Female	0.92	(0.61, 1.39)	0.68	0.98	(0.63, 1.53)	0.94	0.71	(0.44, 1.14)	0.15
Year of graduation									
Prior to 1981§	-	-	-	-	-	-			-
1981 – 1985	2.77	(1.52, 5.05)	< 0.001	2.29	(1.15, 4.55)	0.02	0.49	(0.27, 0.88)	0.02
1986 – 1990	2.61	(1.47, 4.63)	0.001	2.18	(1.13, 4.21)	0.02	0.51	(0.29, 0.88)	0.02
1990 – 1995	3.51	(1.93, 6.37)	< 0.001	3.83	(1.98, 7.41)	< 0.001	0.5	(0.28, 0.90)	0.02
1996 – 2002	3.91	(2.19, 6.98)	< 0.001	4.32	(2.27, 8.22)	< 0.001	0.35	(0.19, 0.62)	< 0.001
Anesthesia residency program									
No §	-	-		-	-	-	-		
Yes	1.34	(0.93, 1.93)	0.12	1.22	(0.83, 1.82)	0.31	0.64	(0.43, 0.94)	0.02

*Odds ratios and 95% CI among physicians who adopted a threshold of 70 g·L^{-1} in a least two of three scenarios. Odds ratio > 1 imply a higher proportion of physicians adopting a threshold of 70 g·L^{-1} while OR < 1 imply a lower proportion of physicians adopting a threshold of 70 g·L^{-1}. †Odds ratios and 95% CI among physicians who adopted a threshold of ≤ 60 g·L^{-1} in both scenarios with age modified to 20 yr. Odds ratios > 1 imply a higher proportion of physicians adopting a threshold ≤ 60 g·L^{-1} while OR < 1 imply a lower proportion of physicians adopting a threshold of ≤ 60 g·L^{-1}. ‡Odds ratios and 95% CI among physicians who adopted a threshold ≥ 100 g·L^{-1} in at least two of three scenarios with history suggesting coronary artery disease. Odds ratios > 1 imply a higher proportion of physicians adopting a threshold ≥ 100 g·L^{-1} while OR < 1 imply a lower proportion of physicians adopting a threshold ≥ 100 g·L^{-1}. §Reference groups (OR = 1.00).

ated with the choice of a hemoglobin threshold ≤ 60 in that subgroup (Tables II and III). On the other hand, physicians having graduated prior to 1981 and working in a hospital without an anesthesia residency program were more likely to adopt a threshold ≥ 100 g·L^{-1} to justify the decision to transfuse when a history of coronary artery disease was suggested in the scenario (Tables II and III). Finally, there were no differences noted between responses from the first and the second mailings except for the subgroup with a suggested history of coronary disease where late respondents were less likely to adopt a hemoglobin threshold ≥ 100 g·L^{-1} compared to early respondents (OR = 0.60, 95% CI 0.39 to 0.92, P = 0.02).

Strategies to minimize RBC transfusions

In a separate scenario-based question on erythropoietin use, 39% of the respondents would have prescribed the drug prior to a total hip arthroplasty in a 50-yr-old male with asymptomatic anemia but otherwise healthy. Only 28% of respondents would choose to administer erythropoietin in conjunction with an autologous transfusion program. During the postoperative period, 19% of respondents agreed with the administration of erythropoietin on day five following surgery if the same patient showed mild lethargy and difficulty in ambulating. Additional evidence and lower cost would be the main incentive factors to use erythropoietin in a perioperative setting for 44% of the anesthesiologists surveyed. More than 75% of anesthesiologists stated that they never or rarely use erythropoietin in practice.

Iron therapy (53%), intraoperative blood salvage (36%), autologous RBCs (31%) and antifibrinolytics (23%) were said to be often or always used as blood conservation therapies, while antifibrinolytics and intraoperative blood salvage were said to never be used by 30% and 25% of respondents respectively. Physicians who opted to transfuse at a threshold of 70 g·L^{-1} or lower were more likely to adopt blood conservation techniques such as antifibrinolytics (OR = 1.95, 95% CI 1.12 to 3.39, P = 0.02) and erythropoietin (OR = 6.69, 95% CI 1.54 to 28.91, P = 0.01) in their practice.

Sources of information

Published clinical practice guidelines were the most important source cited by anesthesiologists to guide RBC transfusion followed by review articles, educational conferences, clinical trials and institutional practice guidelines. These sources of information were respectively considered important, very important or extremely important by 91%, 90%, 89%, 85% and 73% of the respondents. The TRICC trial[2] (described previously) was chosen by 68% of the respondents.

Discussion

In this study, we observed that clinical characteristics and type of surgical intervention modified the reported transfusion threshold among Canadian anesthesiologist members of the CAS. In terms of clinical characteristics, a high potential for bleeding during the surgical intervention appeared to increase reported transfusion threshold compared to surgical scenarios with a lower bleeding risk. The most important factor reported to increase the threshold for RBC transfusion during the perioperative period was the presence of coronary artery disease. Conversely, the patient's age was the most important factor to decrease the transfusion threshold and this, to a level as low as 60 $g \cdot L^{-1}$. Except when these two clinical characteristics were present, the survey results suggested that Canadian anesthesiologists have generally adopted the recommendations from the TRICC trial despite significant differences between the perioperative and the intensive care unit populations.

In a recent survey among ASA members,[7] 80 $g \cdot L^{-1}$ was the median minimal hemoglobin concentration tolerated before transfusion by 39% of respondents, a similar percentage to that observed in this study (Figure 2). In the ASA survey, the authors also observed that only 9% of the physicians would have transfused patients undergoing elective surgery to reach a hemoglobin concentration ≥ 100 $g \cdot L^{-1}$. In our study, only 3% of respondents would have transfused RBCs to target a concentration of hemoglobin ≥ 100 $g \cdot L^{-1}$ in the three symptom-free scenarios. This percentage increased to 33% overall when patients were described as having varying degrees of symptoms from ischemic heart disease. Our results suggest that physicians would routinely increase their transfusion threshold in response to coronary artery disease independently of other important characteristics altering transfusion thresholds, such as age and risk of bleeding. In contrast, the ASA survey asked few questions related to different risk factors. Both surveys seem to indicate that RBC transfusion thresholds have decreased compared to the first survey in American anesthesiologists published in 1987.[6] However, CAS members chose a transfusion threshold ≥ 100 $g \cdot L^{-1}$ three times less often than their American counterparts. Some of the observed differences between surveys may have been attributed to the different methodologies especially the use of realistic scenarios in the Canadian study *vs* generic questions in the American study. A survey performed in Israel and published in 2004 showed that obstetric anesthesiologists would choose a mean threshold for transfusion of 73 ± 5.6 $g \cdot L^{-1}$ in a clinical scenario based on a 30-yr-old woman undergoing a c-section with ongoing slow bleeding after adequate resuscitation from an initial profuse bleeding.[8] The transfusion threshold among anesthesiologists in Israel appears comparable to overall responses from the three different elective surgical interventions presented in this survey. In two surveys of critical care physicians using a similar scenario-based approach, our research group observed that many clinical characteristics influenced transfusion thresholds including the age and severity of illness of the hypothetical patient.[9,10] Again, patient characteristics including age and presence of coronary artery disease were noted to influence the choice of a RBC transfusion threshold. In the survey of critical care physicians performed in 2004, recent graduates reported using a threshold of 70 $g \cdot L^{-1}$ as anesthesiologists did in this survey.

The adoption of a threshold for transfusion ≥ 100 $g \cdot L^{-1}$ in hypothetical patients with ischemic heart disease is consistent with results from a large retrospective study. Wu *et al.* documented a decrease in hospital mortality among older patients who were transfused RBCs following myocardial infarction as compared to patients who were not, when hematocrit values were below 33%.[11] Our survey was conducted soon after the publication of this retrospective study. Results observed could then represent its influence. However, a more recent study by Rao *et al.*, published after the administration of this survey did not detect similar associations.[12] Interestingly, we also noted that a significant proportion of anesthesiologists reported using a transfusion threshold as low as 60 $g \cdot L^{-1}$ before transfusing RBCs to healthy young patients undergoing elective surgery with low bleeding risk. The low risk of subsequent bleeding, the absence of comorbid illness and ongoing concerns about transfusion-transmitted infections may explain this lower threshold reported by anesthesiologists. The patient's gender did not modify transfusion thresholds in this study, a result that was comparable to previous critical care surveys performed by our group.[9,10,13] This would suggest that more women than men reach a transfusion threshold in clinical practice since gender is frequently identified as a risk factor for transfusion in retrospective studies.[14,15]

In this study, differences found in relation with the year of graduation likely reflect guidelines or consensus in effect during these respective periods of training. Indeed, thresholds for RBC transfusions were observed to be in accordance with results from previous surveys performed during these different decades.[6,10,16] On the other hand, differences found in the proportion of respondents who chose a threshold for transfusion ≥ 100 $g \cdot L^{-1}$ in the hypothetical patient

with ischemic heart disease must be considered with discernment since this difference was not seen in any other subgroups (Table III).

In this survey, we also noted that most CAS members considered published clinical practice guidelines as their primary source of information in influencing their RBC transfusion practices, closely followed by review articles. Conversely, blood conservation strategies seemed to be advocated by a significant proportion of respondents despite the actual low-level evidence of a clinical benefit for most of it. Reasons explaining these choices were not integrated into the questionnaire.

The major limitation of this study is the hypothetical nature of this exercise. Results of our previous scenario-based surveys of transfusion practice in the critical care population were reasonably consistent with actual practice patterns.[9,17] However, given this study was conducted by the same investigative team that published much of the literature on restrictive transfusion strategies, there may have been a response bias favouring a lower threshold for RBC transfusion. Moreover, despite an inability to detect consistent modifications in responses from mailing to mailing except in one subgroup, non-responder biases may be present. In this survey, we have chosen to sample a population of certified anesthesiologist members of the CAS, a population that most certainly differs from all health professionals who have an anesthesia practice in Canada. On the other hand, a significant proportion of respondents practiced in academic centres and regional variations in transfusion practices were noted. This survey may therefore better represent the perspective of opinion leaders rather than all practitioners. In addition, this survey was designed to identify individual physician and patient characteristics that affected the hypothetical transfusion thresholds. Because physicians work together within institutional and group practices, we cannot exclude that some individual variables could be affected by a potential clustering effect. The influence of patient and physician variables on response patterns was considered as hypothesis generating and relatively weak. Further information on anesthetic practices might have assisted in better understanding differences in practice patterns at an institutional and regional level.

In this survey, we cannot exclude that the low response rate could have introduced a bias. However, considering the large practice variability already observed, this bias would be more likely in the direction of the actual findings. Thus, we could argue that an increased response rate would have enhanced the actual variability in response patterns rather than minimized it.

In summary, Canadian anesthesiologists appear to have adopted a transfusion threshold comparable to their critical care colleagues.[9] The type of surgical procedure and several patient characteristics such as the patient's age and the presence of coronary artery disease were also noted to modify hypothetical transfusion thresholds. We identified a group of practitioners who adopted a threshold $\leq 60\ g \cdot L^{-1}$ in healthy patients with low bleeding risk. Ongoing practice variation among anesthesiologists would support the need for further research that would identify an optimal transfusion threshold, especially in patients with coronary artery disease. Updated transfusion guidelines may also be warranted.

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