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Consensus Statement | Surgery

Intraoperative Blood Management Strategies for Patients Undergoing Noncardiac Surgery

The Ottawa Intraoperative Transfusion Consensus

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Abstract

IMPORTANCE There is marked variability in red blood cell (RBC) transfusion during the intraoperative period. The development and implementation of existing clinical practice guidelines have been ineffective in reducing this variability.

OBJECTIVE To develop an internationally endorsed consensus statement about intraoperative transfusion in major noncardiac surgery.

EVIDENCE REVIEW A Delphi consensus survey technique with an anonymous 3-round iterative rating and feedback process was used. An expert panel of surgeons, anesthesiologists, and transfusion medicine specialists was recruited internationally. Statements were informed by extensive preparatory work, including a systematic reviews of intraoperative RBC guidelines and clinical trials, an interview study with patients to explore their perspectives about intraoperative transfusion, and interviews with physicians to understand the various behaviors that influence intraoperative transfusion decision-making. Thirty-eight statements were developed addressing (1) decision-making (interprofessional communication, clinical factors, procedural considerations, and audits), (2) restrictive transfusion strategies, (3) patient-centred considerations, and (4) research considerations (equipoise, outcomes, and protocol suspension). Panelists were asked to score statements on a 7-point Likert scale. Consensus was established with at least 75% agreement.

FINDINGS The 34-member expert panel (14 of 33 women [42%]) included 16 anesthesiologists, 11 surgeons, and 7 transfusion specialists; panelists had a median of 16 years' experience (range, 2-50 years), mainly in Canada (52% [17 of 33]), the US (27% [9 of 33]), and Europe (15% [5 of 33]). The panel recommended routine preoperative and intraoperative discussion between surgeons and anesthesiologists about intraoperative RBC transfusion as well as postoperative review of intraoperative transfusion events. Point-of-care hemoglobin testing devices were recommended for transfusion guidance, alongside an algorithmic transfusion protocol with a restrictive hemoglobin trigger; however, more research is needed to evaluate the use of restrictive triggers in the operating room. Expert consensus recommended a detailed preoperative consent discussion with patients of the risks and benefits of both anemia and RBC transfusion and routine disclosure of intraoperative transfusion. Postoperative morbidity and mortality were recommended as the most relevant outcomes associated with intraoperative RBC transfusion, and transfusion triggers of 70 and 90 g/L were considered acceptable hemoglobin triggers to evaluate restrictive and liberal transfusion strategies, respectively, in clinical trials.

CONCLUSIONS AND RELEVANCE This consensus statement offers internationally endorsed expert guidance across several key domains on intraoperative RBC transfusion practice for noncardiac

(continued)

Key Points

Question How can intraoperative red blood cell (RBC) transfusion variability in noncardiac surgery be reduced?

Findings In this Delphi consensus survey study, a 33-member expert panel of surgeons, anesthesiologists, and transfusion medicine specialists recommended a wide variety of strategies that can be used in the preoperative, intraoperative, and postoperative periods to minimize intraoperative RBC transfusion variability among patients undergoing major noncardiac surgery.

Meaning This internationally endorsed consensus document can be used to develop local institutional transfusion protocols with the goal of minimizing unwarranted intraoperative RBC transfusion variability between physicians.

+ Supplemental content

Author affiliations and article information are listed at the end of this article.

Abstract (continued)

surgical procedures for which patients are at medium or high risk of bleeding. Future work should emphasize knowledge translation strategies to integrate these recommendations into routine clinical practice and transfusion research activities.

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Introduction

Red blood cell (RBC) transfusions are frequently given during major surgical procedures,[1] with between 40% and 70% of all RBC transfusions occurring in the surgical setting.[2-6] Although RBC transfusions are potentially life-saving, they can also cause harm,[7] are costly,[8] are in limited supply, and are donated altruistically. As such, their appropriate use is an important priority for all stakeholders, including physicians, donors, government funding agencies, and patients.

Intraoperative transfusion decision-making is a complex and dynamic process that relies heavily on clinician judgment, aided by physiological parameters. Although perioperative blood management programs have made strong gains in implementing strategies targeting the preoperative and postoperative periods to reduce unwarranted RBC transfusion, the intraoperative context remains a source of high variability in terms of transfusion practice and blood conservation strategies.[9] Although some variation is anticipated based on patient and surgical factors, significant variation that cannot be explained by patient-level variables most likely represents clinician preferences or institutional practice patterns, which may indicate potentially harmful variation in clinical care.[10-12] Estimates in the literature of unwarranted RBC transfusion given during surgery range from 20% to 50%,[13-21] highlighting the magnitude of the problem.

Beyond the objective clinical parameters associated with intraoperative transfusion practice, a variety of cognitive, affective, social, and environmental factors also have an effect on transfusion, which may underlie part of the observed interclinician variability.[22] The lack of evidence guiding intraoperative transfusion decision-making and the influence of various behavioral factors highlight the need for comprehensive consensus guidelines to inform transfusion decision-making and minimize unwarranted variation in transfusion practice in noncardiac surgery. The objective of this work was therefore to identify areas of professional consensus among international content experts regarding parameters relevant to transfusion decision-making during major noncardiac surgery.

Methods

Study Design

We used a Delphi method to reach consensus among clinicians on intraoperative RBC transfusion management and acceptable transfusion protocols. This study focused on noncardiac surgical contexts due to significant differences in transfusion practice in cardiac surgery and limited availability of clinical practice guidelines outside of cardiac surgery. The Delphi process gathers expert opinion through iterative anonymous surveys to generate consensus.[23-25] Delphi consensus studies are increasingly used to develop clinical practice guidelines and define core outcome sets for clinical trials.[26-28] Ethical and institutional approval were provided by The Ottawa Hospital Research Ethics Board. Panelists provided verbal consent to participate in study activities. The study protocol was prospectively registered with Open Science Framework.[29] Study methods were developed and reported based on the Conducting and Reporting Delphi Studies (CREDES) guidelines (eTable 1 in Supplement 1).[23]

Panel Identification, Sampling, and Recruitment

The research team, consisting of a general surgeon (G.M.), an anesthesiologist (D.I.M.), a hematologist (A.T.), a methodologist with experience conducting Delphi surveys (D.A.F.), and a graduate student and resident physician (T.L.), assembled an expert panel of physicians involved in intraoperative transfusion decision-making. Internationally recognized experts in transfusion practice and patient blood management programs were selected based on their publications and on the research team's personal knowledge of clinical perioperative transfusion experts. Anesthesiologists and surgeons were primarily represented on the panel, with panelists, including authors of relevant publications and members of stakeholder agencies, recruited through purposive sampling.[30,31] This sampling involved the deliberate selection of panelists by the research team investigators based on their recognized expertise in the field. Snowball sampling techniques were then used, whereby the initial group of experts was asked to nominate additional individuals from their professional networks with differing viewpoints from their own, thus ensuring a range of participant perspectives.[25,32] The panel was diverse in terms of gender (14 of 33 women [42%]), geographic regions (17 of 33 from Canada [52%], 9 of 33 from the US [27%], 5 of 33 from Europe [15%], and 2 of 33 from Australia [6%]), and practice characteristics (representing a variety of surgical and anesthesia specialties).

Although fewer participants may be sufficient when the background and expertise of the panel is homogeneous, more participants are needed if various reference groups are required.[25] As such, we aimed to assemble a representative panel of 34 experts across perioperative medicine, blood management, and transfusion medicine. This panel size was considered sufficient to encompass the diverse range of perspectives, experiences, and knowledge necessary for a comprehensive exploration of the subject matter, enabling a well-rounded consensus-building process. This decision was in alignment with established guidelines for Delphi panel sizes while accommodating the practical constraints imposed by the study's available resources.[25]

Background Work and Statement Generation

Our multidisciplinary research team (T.L., D.I.M., A.T., D.A.F., and G.M.) developed initial statements for the study. This process was informed by an extensive body of preparatory work including systematic reviews and in-depth interviews with patients and physicians on intraoperative transfusion (**Figure**).[9,33-35] This work included systematic reviews identifying clinical practice guidelines[9] and summarizing randomized clinical trials of perioperative RBC transfusion strategies.[33] We conducted semistructured interviews with patients to gain a deeper understanding of their perspectives and experiences concerning intraoperative RBC transfusion.[34] These interviews offered valuable insights into patient preferences and concerns, particularly in areas such as preoperative blood consent processes. Consequently, statements addressing preoperative blood consent processes were incorporated into the survey statements, reflecting the specific concerns and preferences expressed by patients. Similarly, interviews with physicians were integral to exploring the factors influencing their behavior associated with intraoperative RBC transfusion.[35] By delving into the perspectives and potential mediators of physician behavior, we were able to identify areas within an intraoperative transfusion protocol that could benefit from intervention and improvement. These data, along with the results of our systematic reviews, were used to develop survey statements and obtain consensus on feasible interventions for an intraoperative RBC transfusion protocol.

Statements for inclusion within the Delphi consensus were selected and refined by our research team. Statements were framed with reference to noncardiac surgical procedures with more than a 5% chance of requiring an RBC transfusion. Participants were asked to rate statements on a 7-point Likert scale based on their agreement regarding the perceived importance or relevance of the item, where higher scores indicated greater agreement. A 7-point scale was used, as this approach has been demonstrated in the literature to maximize the reliability, validity, ease of use, and discriminating power of responses when compared with other numbers of response categories.[36]

Categories of statements included (1) intraoperative decision-making (interprofessional communication, clinical factors, hemoglobin measurement, procedural considerations, and audits), (2) restrictive transfusion strategies, (3) patient-centered considerations, and (4) research considerations (equipoise, outcomes, protocol suspension, and minimal clinically important differences).

A closed-ended, structured (modified) first Delphi round was chosen to save time and effort for both the study team and panelists.[37,38] This approach decreased the time between the first and second rounds, which would normally be needed to collate first-round responses and develop the statements for the second round. Furthermore, this decision aimed to enhance the ease of survey completion and reduce survey response time, which, in turn, helped lower the panelist dropout rate, an important consideration for ensuring the validity of the study results. This approach also ensured that important statements identified by researchers through previous background work were included that otherwise might have been omitted by using an open first round.

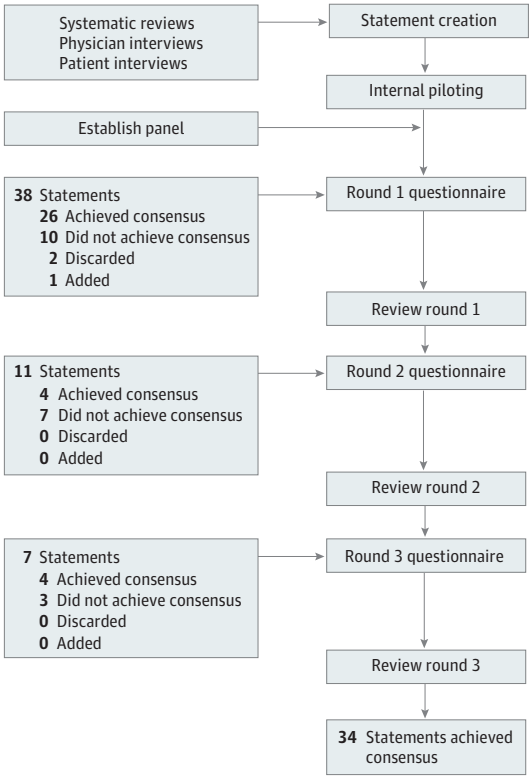
Delphi Survey

The Delphi method comprised 3 online survey rounds, hosted on Canadian servers to mitigate privacy concerns (eAppendix in Supplement 1). All surveys were sent out in 2022. Based on prior research on physician views of intraoperative transfusion, a modified closed-ended first round was used to save time for the study team and panelists.[37,38] As the panelists were all experts in transfusion and perioperative medicine, no extra background information was given before the survey.

Round 1

Panelists received an email invitation with a link to the survey and were given 2 weeks to respond. Reminder emails were sent, and nonresponders received individualized emails. Following each

Figure. Process Used to Achieve Consensus for Statements



statement, panelists could provide comments or suggest new statements. The research team reviewed comments and identified new or edited statements.

Survey responses were deidentified and analyzed by categorizing responses into either disagreement (1-3 on the Likert scale), neutral (4 on the Likert scale), or agreement (5-7 on the Likert scale). Consensus was defined as 75% or greater agreement or disagreement. Statements achieving consensus agreement were included, while those that achieved consensus disagreement were removed. Statements that achieved consensus agreement or disagreement in round 1 were not included in subsequent rounds.

Participants were also asked to rate lists of clinical factors to consider when to initiate an intraoperative RBC transfusion, the clinical outcomes associated with intraoperative RBC transfusion, and the reasons to justify suspending an intraoperative transfusion protocol as part of a clinical trial. These factors were rated for importance on a 7-point Likert scale, where higher scores indicated greater agreement.

Round 2

Statements without consensus from round 1 were revised and presented to the panelists, along with the results and comments from the previous round. Panelists had 2 weeks to respond. Invitees who had not responded to the previous round were excluded. Survey results were anonymized and analyzed in the same manner as round 1 using the same consensus threshold. Clinical outcomes that had reached consensus as important in the previous round were presented to participants, who were then asked to rank the 5 outcomes they considered the most important to be associated with intraoperative RBC transfusion.

Round 3

Statements with consensus agreement or disagreement from round 2 were excluded. Statements without consensus were revised and presented with the results and comments from the previous round. Participants were also asked about follow-up periods and noninferiority margins for important clinical outcomes, as well as preferred study designs.

Results

Panelists

Of the 51 physicians invited, 34 (16 anesthesiologists, 11 surgeons, and 7 hematologists or transfusion medicine specialists) participated, with 1 surgeon later excluded for nonresponse (eTable 2 in Supplement 1). A total of 42% of participants (14 of 33) identified as women, and multiple surgical subspecialties, including hepatopancreaticobiliary, surgical oncology, trauma, orthopedic, gynecology, urology, vascular, and thoracic surgery, were represented. Panelists had a median of 16 years (range, 2-50 years) of experience in academic hospital settings. Most panelists practiced in Canada (52% [17 of 33]), with the remainder in the US (27% [9 of 33]), Europe (15% [5 of 33]), or Australia (6% [2 of 33]).

Delphi Rounds

Response rates were high across all 3 rounds, with 97% in round 1 (33 of 34) and 100% in rounds 2 and 3 (33 of 33). Of the 38 statements scored in round 1, 26 achieved consensus agreement, 2 were discarded due to consensus disagreement, and 1 statement was added based on feedback. Round 2 included 11 statements, of which 4 reached consensus. Round 3 included the 7 remaining statements, with 4 achieving consensus and 3 not reaching consensus (**Table**). Overall, 34 statements achieved consensus and were included in the final recommendations (**Box**).

Table. Results of Delphi Survey[a]

Statement	Consensus (>75%) reached, %		
	Round 1	Round 2	Round 3
The patient's baseline hemoglobin should be formally reviewed prior to every case.	88		
The potential for intraoperative transfusion should be discussed as part of the preoperative checklist prior to every case.	97		
The decision to initiate an intraoperative blood transfusion should be shared between the anesthesiologist and surgeon, except in cases of uncontrolled massive hemorrhage.		82	
The anesthesiologist and surgeon should pause and discuss the indication for transfusion prior to every intraoperative transfusion event, situation permitting.			76
In the operating room, a single unit of blood should be transfused at a time in most cases.	79		
The ordering clinician should be prompted to provide an indication when ordering an intraoperative transfusion using an electronic medical record system, except in cases of massive transfusion.			76
The indication for intraoperative transfusion should be approved by the institutional blood bank and/or a transfusion medicine specialist prior to release, situation permitting.	Discarded		
The decision to administer an intraoperative transfusion should be made by the attending physician, except in cases of extreme urgency (eg, massive hemorrhage).			53
A review of the appropriateness of intraoperative transfusion events should be formally included in the postoperative debrief.	79		
Hospitals should establish audits of institutional intraoperative transfusion practice.	91		
Groups of anesthesiologists and/or surgeons should review the appropriateness of their intraoperative transfusion events regularly.	91		
Point-of-care devices to measure hemoglobin (eg, HemoCue, iSTAT, noninvasive pulse co-oximeters, blood gas analyzers) are accurate enough to guide intraoperative transfusion.	88		
Point-of-care hemoglobin devices should be routinely used to measure hemoglobin to guide intraoperative transfusion.	78		
Point-of-care hemoglobin measurements should be confirmed with a central laboratory measurement (ie, CBC) prior to intraoperative transfusion, except in cases of extreme urgency (eg, massive hemorrhage).			39
A margin of error of 4 g/L (0.4 g/dL) (the allowable performance limit defined by the Institute for Quality Management in Healthcare) is acceptable for point-of-care hemoglobin testing devices in the operating room.		78	
Hemoglobin should routinely be measured at set time points in the operating room.	Discarded		
Hemoglobin should only be measured in the operating room if determined to be clinically indicated.	76		
Hemoglobin should be routinely measured before every intraoperative transfusion if the situation permits.	85		
When the situation permits, hemoglobin should be routinely measured within 1 h after an intraoperative transfusion episode (which could include >1 unit).			67
Hemoglobin should be measured between successive intraoperative transfusions in cases where multiple units are being transfused, situation permitting.	76		
In general, intraoperative transfusions should be guided by a predetermined algorithmic transfusion protocol.	79		
A hemoglobin threshold or trigger should generally be used to guide intraoperative transfusion as part of a broader transfusion strategy.		82	
Restrictive transfusion strategies should be adopted for intraoperative transfusions, which would include a restrictive hemoglobin transfusion threshold or trigger.		82	
Patients should always be informed that they received a blood transfusion during their surgery.	97		
Patient preferences should be incorporated into intraoperative transfusion decision-making.	88		
Transfusion decisions made in the operating room should take into account the patient's previously stated perioperative goals of care regarding blood products.	91		
Preoperative consent to intraoperative blood transfusion should include a presentation of the risks and benefits.	97		
Preoperative consent discussions should emphasize the spectrum of risk associated with transfusion.	94		
Preoperative consent discussions should emphasize the spectrum of risks associated with anemia.	91		

(continued)

Table. Results of Delphi Survey[a] (continued)

Statement	Consensus (>75%) reached, %		
	Round 1	Round 2	Round 3
The patient's perception of the spectrum of risk associated with transfusion and anemia should be explicitly considered when making intraoperative transfusion decisions on their behalf.	79		
A stronger evidence base is needed to guide intraoperative transfusion decision-making.	91		
Expanding the evidence base around intraoperative transfusion is an important research priority.	94		
There is uncertainty surrounding the benefits of restrictive transfusion protocols in the operating room.	76		
There is uncertainty surrounding the risks of restrictive transfusion protocols in the operating room.	79		
A restrictive transfusion protocol including a restrictive hemoglobin transfusion trigger would be feasible to implement in the operating room.	76		
I would be willing to participate in a 2-arm interventional trial evaluating restrictive and liberal transfusion protocols.	87		
I would be willing to participate in a 3-arm randomized trial evaluating restrictive and liberal transfusion strategies that includes a usual care arm.			76
70 g/L (7 g/dL) Is an acceptable restrictive hemoglobin trigger to use in the operating room for patients without major cardiac comorbidities.	79		
90 g/L (9 g/dL) Is an acceptable liberal hemoglobin trigger to use in the operating room as part of a clinical trial.			79

Abbreviation: CBC, complete blood cell count.

[a] Applies to surgical procedures at medium or high risk of red blood cell transfusion (>5%).

Transfusion Decision-Making

Interprofessional Communication

The panel recommends reviewing the patient's preoperative baseline hemoglobin level before each case to anticipate the need for RBC transfusion, as well as discussing the possibility of intraoperative RBC transfusion during the preoperative checklist between the surgeon and anesthesiologist. The panel recommends that the decision to transfuse should typically involve both the surgeon and anesthesiologist except in cases of extreme urgency, such as massive uncontrolled hemorrhage. In addition, if possible, every intraoperative transfusion should be discussed by the surgeon and anesthesiologist before initiation. The panel recommends a routine review of the appropriateness of any intraoperative transfusion event during the postoperative debrief between the anesthesiologist and surgeon.

Clinical Factors

The panel recommends that the following clinical and patient-related factors are important to consider when deciding whether to administer an intraoperative RBC transfusion: ongoing surgical bleeding and potential for additional bleeding, estimated blood loss, hemodynamic stability, signs of end-organ ischemia, and underlying patient medical comorbidity.

Hemoglobin Measurement

The panel recommends using point-of-care testing devices to measure the hemoglobin concentration in the operating room and agrees that they are accurate enough to guide intraoperative transfusion, with an acceptable margin of error of 4 g/L (the allowable performance limit defined by the Institute for Quality Management in Healthcare).[39] The panel recommends measuring intraoperative hemoglobin concentration only if clinically indicated. The panel recommends that hemoglobin concentration be measured only if clinically indicated, prior to every intraoperative RBC transfusion event, and between successive transfusions in cases where multiple units are being transfused.

Procedural Considerations and Audits

The panel recommends transfusing a single unit of RBCs at a time in most cases and using a predetermined algorithmic transfusion protocol with a hemoglobin trigger to guide intraoperative RBC transfusions. They also recommend that an indication for transfusion be provided in the

electronic medical record system when ordering an intraoperative transfusion except in cases of extreme urgency, such as massive hemorrhage. Last, the panel recommends both institutional and internal audits by groups of surgeons and anesthesiologists to review the appropriateness of intraoperative transfusion events.

Restrictive Transfusion Strategies

The panel agrees that there is uncertainty about both the benefits and the risks of using restrictive transfusion protocols in the operating room to guide RBC transfusion. However, the experts agree that implementing a restrictive transfusion protocol, including the use of a restrictive hemoglobin transfusion trigger, would be feasible in the operating room.

Box. Summary of Recommendations for Intraoperative Red Blood Cell Transfusion

Recommendations

Interprofessional Communication

The patient's baseline hemoglobin should be formally reviewed prior to every case.

The potential for intraoperative transfusion should be discussed as part of the preoperative checklist prior to every case.

The decision to initiate an intraoperative blood transfusion should be shared between the anesthesiologist and surgeon, except in cases of uncontrolled massive hemorrhage.

The anesthesiologist and surgeon should discuss the indication for transfusion prior to intraoperative transfusion, except in cases of extreme urgency (eg, massive hemorrhage).

A review of the appropriateness of intraoperative transfusion events should be formally included in the postoperative debrief.

Hemoglobin Measurement

Point-of-care devices to measure hemoglobin (eg, HemoCue, iSTAT, noninvasive pulse co-oximeters, blood gas analyzers) are accurate enough to guide intraoperative transfusion.

Point-of-care hemoglobin devices should be routinely used to measure hemoglobin to guide intraoperative transfusion.

A margin of error of 4 g/L (0.4 g/dL) (the allowable performance limit defined by the Institute for Quality Management in Healthcare) is acceptable for point-of-care hemoglobin testing devices in the operating room.

Hemoglobin should only be measured in the operating room if determined to be clinically indicated.

Hemoglobin should be routinely measured before every intraoperative transfusion if the situation permits.

Hemoglobin should be measured between successive intraoperative transfusions in cases where multiple units are being transfused, situation permitting.

Procedural Considerations and Audits

In the operating room, a single unit of blood should be transfused at a time in most cases.

The ordering clinician should be prompted to provide an indication when ordering an intraoperative transfusion using an electronic medical record system, except in cases of massive transfusion.

Hospitals should establish audits of institutional intraoperative transfusion practice.

Groups of anesthesiologists and/or surgeons should review the appropriateness of their intraoperative transfusion events regularly.

A hemoglobin threshold or trigger should generally be used to guide intraoperative transfusion as part of a broader transfusion strategy.

In general, intraoperative transfusions should be guided by a predetermined algorithmic transfusion protocol.

Restrictive Transfusion Strategies

There is uncertainty surrounding the benefits of restrictive transfusion protocols in the operating room.

There is uncertainty surrounding the risks of restrictive transfusion protocols in the operating room.

A restrictive transfusion protocol including a restrictive hemoglobin transfusion trigger would be feasible to implement in the operating room.

Restrictive transfusion strategies should be adopted for intraoperative transfusions, which would include a restrictive hemoglobin transfusion threshold or trigger.

70 g/L (7 g/dL) Is an acceptable restrictive hemoglobin trigger to use in the operating room for patients without major cardiac comorbidities.

Patient-Centered Considerations

The patient's perception of the spectrum of risk associated with transfusion and anemia should be explicitly considered when making intraoperative transfusion decisions on their behalf.

Patient preferences should be incorporated into intraoperative transfusion decision-making.

Transfusion decisions made in the operating room should take into account the patient's previously stated perioperative goals of care regarding blood products.

Preoperative consent to intraoperative blood transfusion should include a presentation of the risks and benefits.

Preoperative consent discussions should emphasize the spectrum of risk associated with transfusion.

Preoperative consent discussions should emphasize the spectrum of risks associated with anemia.

Patients should always be informed that they received a blood transfusion during their surgery.

Research Considerations

A stronger evidence base is needed to guide intraoperative transfusion decision-making.

Expanding the evidence base around intraoperative transfusion is an important research priority.

I would be willing to participate in a 2-arm interventional trial evaluating restrictive and liberal transfusion protocols.

I would be willing to participate in a 3-arm randomized trial evaluating restrictive and liberal transfusion strategies that includes a usual care arm.

90 g/L (9 g/dL) Is an acceptable liberal hemoglobin trigger to use in the operating room as part of a clinical trial.

Patient-Centered Considerations

The panel recommends considering patient preferences and perioperative goals of care, including blood product preferences, when making intraoperative transfusion decisions. They suggest discussing the risks and benefits of transfusion and anemia during preoperative consent discussions and taking into account the patient's perception of those risks and benefits. Last, the panel recommends routinely informing patients of any blood product transfusion they receive during surgery.

Research Considerations

The panel agrees that stronger evidence is needed to guide intraoperative RBC transfusion and that expanding this evidence base is an important research priority. They were willing to participate in a clinical trial comparing restrictive and liberal hemoglobin triggers, as well as a 3-arm trial that included a usual care arm. Hemoglobin triggers of 70 g/L and 90 g/L were chosen as acceptable restrictive and liberal hemoglobin transfusion triggers, respectively. The panel identified reasons to suspend an intraoperative transfusion protocol during a trial, including massive uncontrolled hemorrhage, refractory hemodynamic instability, and evidence of cardiac or cerebral ischemia.

The top 5 research outcomes were identified as overall perioperative morbidity, postoperative mortality, clinically significant cardiac and cerebral ischemia, and postoperative functional capacity or status. Panelists identified 30 days as the ideal time point to measure postoperative morbidity (17 of 33 [52%]), while 30 or 90 days were chosen as the ideal time point to measure postoperative mortality (15 of 33 [46%] for both). Panelists supported a noninferiority clinical trial design (25 of 33 [76%]) and chose absolute noninferiority margins of 0.5% for postoperative mortality and 2% or 3% for overall postoperative morbidity.

Discussion

Due to the considerable variation in intraoperative transfusion, this initiative arose from the need to standardize intraoperative RBC transfusion among patients undergoing noncardiac surgery who were at high risk of transfusion, with the goal of defining expert opinion on optimal care. The panel reached consensus on 34 statements developed from previous studies, covering key elements such as interdisciplinary collaboration, hemoglobin measurements, restrictive transfusion strategies, patient-centered care, and research outcomes for future clinical trials.

Numerous stakeholder organizations have emphasized the ongoing unnecessary use of blood products,[40,41] leading to the development of patient blood management programs that encompass various strategies to minimize inappropriate RBC transfusions.[42] This document builds on previously published landmark patient blood management consensus work advocating for a more restrictive approach to perioperative transfusion, such as the Practice Guidelines for Perioperative Blood Management published by the American Society of Anesthesiologists,[43] and the recommendations from the 2018 Frankfurt Consensus Conference on Patient Blood Management.[44] However, the high variability in uptake of these recommendations and resultant divergent transfusion practices indicate the need for ongoing consensus-building work, particularly focusing on the intraoperative period. This work is particularly relevant in light of the COVID-19 pandemic's blood supply challenges[45,46] and persistent vulnerabilities in the blood supply system of many countries that rely on altruistic donation.

One effective way to mitigate unwarranted variation in health care practices is through the development and implementation of clinical practice guidelines and protocols. However, few guidelines are tailored to the intraoperative environment. A systematic review of guidelines for intraoperative transfusion found limited actionable guidance, with some being based on poor-quality evidence or providing vague recommendations.[9] Although the American Society of Anesthesiologists[43] and Frankfurt Consensus Conference[44] recommendations support using multimodal protocols and patient blood management programs to improve RBC use, they do not

provide specific guidance for developing intraoperative algorithms. Furthermore, a survey of surgeons and anesthesiologists found that many were unaware of these guidelines, and those who were aware of the guidelines reported little influence on their transfusion decisions.[22] The lack of actionable recommendations and inconsistency in implementation highlight the need for knowledge translation efforts and high-quality evidence to guide clinical practice. With the expansion of this knowledge base, it will be possible to reduce potentially harmful clinical practice variation based on best evidence and consensus opinion.

Perioperative blood management requires input from various health care professionals, including those in the operating room. Although clinical practice guidelines outline factors to consider when making intraoperative transfusion decisions, the importance of communication between the surgeon and anesthesiologist is often overlooked. The present document demonstrates a broad commitment to collaboration from transfusion experts and recommends shared decision-making between the anesthesiologist and surgeon. However, concerns about professional autonomy were noted, particularly among Canadian anesthesiologists. Although transfusion without input from the surgeon may be appropriate in some instances (eg, sudden surgical bleeding), increased communication between the surgical and anesthesia teams about factors such as estimated blood loss and remaining surgery time may minimize unwarranted transfusions in equivocal situations.

The consensus document aligns with the movement toward restrictive transfusion strategies recommended by landmark patient blood management documents.[43,44,47,48] It recommends a hemoglobin trigger of 70 g/L for intraoperative RBC transfusion for patients without major cardiac comorbidity. However, the panel acknowledges uncertainty regarding the benefits and harms of these strategies and identifies the need for more research on intraoperative transfusion. The document also establishes consensus on essential trial design elements to guide future research.

Strengths and Limitations

This report has several strengths. Statements were generated after extensive background research, including systematic reviews of clinical practice guidelines,[9] trials of intraoperative hemoglobin transfusion triggers,[33] and behavioral factors associated with intraoperative transfusion practice (T. Lenet, MD, unpublished data, 2023), as well as in-depth qualitative interviews with patients and physicians[34,35] to develop a thorough understanding of stakeholder priorities and opinions. Although patients were not involved in the survey process, statements specifically addressing the integration of patient perspectives into transfusion decision-making and consent processes were included. These perspectives reflect our understanding of the patient experience with intraoperative RBC transfusion that was generated from the aforementioned qualitative interview study. International leaders in intraoperative transfusion practice were recruited, increasing the credibility and applicability of recommendations. The high and sustained response proportion across the 3 survey rounds ensured robustness and minimized nonresponse bias.[38]

This study also has several limitations. First, the panel primarily comprises North American participants (Canada and the US, 26 of 33 [79%]), with limited European and Australian representation. This geographic focus affects the recommendations' relevance to underrepresented regions with varying health care practices, cultural beliefs, and systems that influence intraoperative transfusion decisions. Although our sampling strategy aimed to capture varied views and expertise, the limited international participation suggests the omission of potentially underrepresented groups. We did attempt to engage 5 additional international participants who either did not respond or declined to participate. Although the presented recommendations may not offer a comprehensive global perspective, they reflect the insights and experiences of the transfusion experts on our panel. Future research should strive to assemble a more diverse, international panel for a broader understanding of intraoperative transfusion practices. Second, all panelists were transfusion experts working in academic centers. The selection of physicians with expertise and a track record in transfusion medicine was a deliberate methodological decision made in accordance with the guiding principles of the Delphi method. These physicians are more likely to practice in academic centers and

have influenced current transfusion practice through guideline development and dissemination. Although these recommendations may be less relevant to community centers and may not reflect the opinions of less experienced physicians, they serve as a foundation for transfusion practice, offering clinicians in diverse settings an adaptable, evidence-based resource to enhance patient care. Third, the panel's composition may not be generalizable to all operative contexts, such as neurosurgical procedures. Fourth, although agreement consensus was reached by 75% of panelists, variations in opinions among surgeons, anesthesiologists, and hematologists suggest potential difficulties in implementing these recommendations or a standard transfusion protocol. Although the selection of a 75% agreement threshold to define consensus may be debated, there is no universally agreed-on definition of consensus in Delphi studies. In a systematic review of Delphi methodology, the median threshold for consensus was 75%.[24] This review provided a strong basis for this methodologic choice, as it aligns with the existing literature on consensus definitions in Delphi studies. Fifth, recommendations may not be applicable to all patient populations, such as those with preexisting anemia, frailty, significant medical comorbidity, or advanced age. Although this work aimed to provide generalizable recommendations to guide transfusion practice across a range of populations, the complexity of intraoperative transfusion decisions often necessitates tailoring protocols to the unique characteristics of individual patients. The Delphi method, while a valuable tool for achieving consensus, has its limitations in capturing the depth of clinical decision-making. Sixth, anesthesiologists, who are the primary decision-makers for intraoperative RBC transfusion, were more heavily represented in the panel; however, both surgeons and hematologists were heavily involved in the study design and conduct and are considered essential groups to target for standardizing transfusion practice.

Conclusions

The proposed international consensus statement provides expert guidance on intraoperative RBC transfusion practice for high-risk noncardiac surgical procedures, addressing knowledge gaps and standardizing practice to minimize unwarranted variability and inappropriate transfusions. Consensus was reached on key elements for future clinical trials, but recommendations may not be applicable to all patients or procedures. Future work should focus on integrating these recommendations into clinical practice and transfusion research to improve patient outcomes.

ARTICLE INFORMATION

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Author Contributions: Dr Martel had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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SUPPLEMENT 1.
eTable 1. CREDES Checklist
eAppendix. Delphi Surveys
eTable 2. Expert Panel Participants

SUPPLEMENT 2.
Nonauthor Collaborators

SUPPLEMENT 3.
Data Sharing Statement