Practice Guidelines for Perioperative Blood Management

An Updated Report by the American Society of Anesthesiologists

Task Force on Perioperative Blood Management*

PRACTICE guidelines are systematically developed recommendations that assist the practitioner and patient in making decisions about health care. These recommendations may be adopted, modified, or rejected according to clinical needs and constraints, and are not intended to replace local institutional policies. In addition, practice guidelines developed by the American Society of Anesthesiologists (ASA) are not intended as standards or absolute requirements, and their use cannot guarantee any specific outcome. Practice guidelines are subject to revision as warranted by the evolution of medical knowledge, technology, and practice. They provide basic recommendations that are supported by a synthesis and analysis of the current literature, expert and practitioner opinion, open forum commentary, and clinical feasibility data.

This document updates the “Practice Guidelines for Perioperative Blood Transfusion and Adjunct Therapies: An Updated Report by the American Society of Anesthesiologists Task Force on Perioperative Blood Transfusion and Adjunct Therapies,” adopted by the ASA in 2005 and published in 2006.†

Methodology

Definition of Perioperative Blood Management

Perioperative blood management refers to perioperative blood transfusion and adjunct therapies. Perioperative blood transfusion addresses the preoperative, intraoperative, and postoperative administration of blood and blood components (e.g., allogeneic or autologous blood, red blood cells, platelets, cryoprecipitate, and plasma products, fresh-frozen plasma [FFP], PF24, or Thawed Plasma).‡ Adjunct therapies refer to drugs and techniques to reduce or prevent blood loss and the need for transfusion of allogeneic blood.

Purpose of the Guidelines

The purposes of these updated Guidelines are to improve the perioperative management of blood transfusion and

- What other guidelines are available on this topic?
  o Other guidelines on the topic for the management of blood transfusion have been published by the ASA, American College of Cardiology/American Heart Association,2 Society of Thoracic Surgeons, Society of Cardiovascular Anesthesiologists,3 and the American Association of Blood Banks,4 The field of Blood Conservation has advanced considerably since the publication of the ASA Guidelines for Transfusion and Adjunct Therapies in Anesthesiology in 2006.
  o Why was this guideline developed?
    o In October 2012, the Committee on Standards and Practice Parameters elected to search for new evidence to determine if recommendations in the existing practice guideline continue to be supported by current evidence. The resultant guideline, presented in this issue, includes an update of the scientific literature and findings from surveys of expert consultants and randomly selected ASA members.
  o How does this statement differ from existing guidelines?
    o New evidence presented includes greater emphasis of the preoperative assessment of the patient, assessment of the risk for transfusion, and the use of adjunct medications to prevent and/or treat bleeding
    o The updated ASA practice guidelines differ from those published by other organizations in that:
      o They include greater use of pharmacologic therapies to minimize blood transfusions, such as erythropoietin for the anemic patient, prothrombin complex concentrates for urgent reversal of warfarin, and intraoperative antifibrinolytic therapy during selected cardiac and noncardiac procedures having a high risk for bleeding.
      o They advocate the use of transfusion algorithms, especially those based on thromboelastographic testing, blood ordering schedules, and restrictive transfusion strategies.
  o Why does this statement differ from existing guidelines?
    o These ASA guidelines differ from the existing guidelines because they provide new evidence obtained from recent scientific literature along with findings from new surveys of expert consultants and randomly selected ASA members.

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† American Society of Anesthesiologists: Practice guidelines for perioperative blood transfusion and adjunct therapies: An updated report by the American Society of Anesthesiologists Task Force on Perioperative Blood Transfusion and Adjunct Therapies. ANESTHESIOLOGY 2006; 105:00–00

‡ FFP refers to plasma frozen within 8h after phlebotomy. PF24 refers to plasma frozen within 24h after phlebotomy, and Thawed Plasma refers to FFP stored up to 5 days at 1°C–6°C after thawing. In the United States, it is common practice to use these terms interchangeably. Throughout this document, the term FFP will refer to the use of any of these plasma products.
adjuvant therapies and to reduce the risk of adverse outcomes associated with transfusions, bleeding, or anemia.

**Focus**

These Guidelines focus on the perioperative management of patients undergoing surgery or other invasive procedures in which significant blood loss occurs or is expected. This includes but is not limited to (1) patients undergoing cardiopulmonary bypass or cardiac surgery, urgent or emergent procedures, obstetric procedures, organ transplantation, and noncardiac surgery; (2) patients with pre-existing blood disorders or acquired coagulation deficiency; (3) critically ill patients undergoing surgical or other interventional procedures; and (4) patients who elect not to undergo perioperative transfusion. Excluded from the focus of these Guidelines are neonates, infants, children weighing less than 35 kg, and patients who are not undergoing procedures.

The Task Force recognizes that the physiology of bleeding may be influenced by the vasodilatory effects of anesthetics; therefore, for some clinical presentations or surgical situations, the recommendations in these Guidelines may not apply. Practitioners will need to use their judgment of the clinical situation in applying the more generalized recommendations contained in these Guidelines.

**Application**

These Guidelines apply to both inpatient and outpatient surgical settings, and to interventional procedures performed in operating rooms as well as in other locations (e.g., interventional radiology, critical care units) where blood transfusion or other adjuvant therapy is indicated. They are directly applicable to care administered by anesthesiologists and individuals who deliver care under the medical direction or supervision of an anesthesiologist. They are also intended to serve as a resource for other physicians and patient care personnel who are involved in the perioperative care of these patients.

**Task Force Members and Consultants**

In 2012, the ASA Committee on Standards and Practice Parameters requested that the updated Guidelines published in 2006 be re-evaluated. This current revision consists of a literature evaluation and an evaluation of new survey findings of expert consultants and ASA members. A summary of recommendations is found in appendix 1.

This revision was developed by an ASA appointed Task Force of 10 members, consisting of anesthesiologists in both private and academic practices from various geographic areas of the United States, a pathologist specializing in transfusion medicine, and two consulting methodologists from the ASA Committee on Standards and Practice Parameters.

The Task Force developed the Guidelines by means of a seven-step process. First, they reached consensus on the criteria for evidence of effective blood transfusion and adjuvant therapies. Second, original published research studies from peer-reviewed journals relevant to the perioperative management of patients undergoing blood transfusions were reviewed. Third, a panel of expert consultants was asked to (1) participate in opinion surveys on the effectiveness of various perioperative management strategies and (2) review and comment on a draft of the Guidelines developed by the Task Force. Fourth, survey opinions about the Guideline recommendations were solicited from a random sample of active members of the ASA. Fifth, the Task Force held open forums at two major national meetings to solicit input on its draft recommendations. National organizations representing specialties whose members typically care for patients undergoing perioperative transfusion were invited to participate in the open forums. Sixth, the consultants were surveyed to assess their opinions on the feasibility of implementing the Guidelines. Seventh, all available information was used to build consensus within the Task Force to finalize the Guidelines.

**Availability and Strength of Evidence**

Preparation of these updated Guidelines followed a rigorous methodological process. Evidence was obtained from two principal sources such as scientific evidence and opinion-based evidence (appendix 2).

**Scientific Evidence**

Scientific evidence used in the development of these updated Guidelines is based on cumulative findings from literature published in peer-reviewed journals. Literature citations are obtained from PubMed and other healthcare databases, direct internet searches, Task Force members, liaisons with other organizations and from manual searches of references located in reviewed articles.

Findings from the aggregated literature are reported in the text of the Guidelines by evidence category, level, and direction. Evidence categories refer specifically to the strength and quality of the research design of the studies. Category A evidence represents results obtained from randomized-controlled trials (RCTs), and Category B evidence represents observational results obtained from nonrandomized study designs or RCTs without pertinent comparison groups. When available, Category A evidence is given precedence over Category B evidence in the reporting of results. These evidence categories are further divided into evidence levels. Evidence levels refer specifically to the strength and quality of the summarized study findings (i.e., statistical findings, type of data, and the number of studies reporting/replicating the findings) within the two evidence categories. For this document, only the highest level of evidence is included in the summary report for each intervention, including a directional designation of benefit, harm, or equivocality for each outcome.
Preoperative evaluation of a patient to identify risk factors for requiring a blood transfusion or adjuvant therapy includes (1) reviewing previous medical records, (2) conducting a patient or family interview, (3) reviewing existing laboratory test results, and (4) ordering additional laboratory tests when indicated.

**Literature Findings:** Although it is well accepted clinical practice to review medical records and conduct a patient interview, comparative studies are insufficient to evaluate the impact of these practices. Observational studies and case reports indicate that certain congenital or acquired conditions (e.g., sickle-cell anemia, clotting factor deficiency, hemophilia, and liver disease) may be associated with blood transfusion complications (Category B3/B4-H evidence)\(^6,2^1\). In addition, observational studies relevant to each topic was considered in the development of these updated Guidelines. However, only the findings obtained from formal surveys are reported.

Opinion surveys were developed for this update by the Task Force to address each clinical intervention identified in the document. Identical surveys were distributed to expert consultants and a random sample of ASA members.

**Category A: Expert Opinion.** Survey responses from Task Force-appointed expert consultants are reported in summary form in the text, with a complete listing of consultant survey responses reported in appendix 2.

**Category B: Membership Opinion.** Survey responses from active ASA members are reported in summary form in the text, with a complete listing of ASA member survey responses reported in appendix 2.

Survey responses from expert and membership sources are recorded using a 5-point scale and summarized based on median values.#

- **Strongly Agree:** Median score of 5 (At least 50% of the responses are 5)
- **Agree:** Median score of 4 (At least 50% of the responses are 4 or 4 and 5)
- **Equivocal:** Median score of 3 (At least 50% of the responses are 3, or no other response category or combination of similar categories contain at least 50% of the responses)
- **Disagree:** Median score of 2 (At least 50% of responses are 2 or 1 and 2)
- **Strongly Disagree:** Median score of 1 (At least 50% of responses are 1)

**Category C: Informal Opinion.** Open-forum testimony obtained during development of these Guidelines, Internet-based comments, letters, and editorials indicate the lack of sufficient scientific evidence in the literature may occur when the evidence is either unavailable (i.e., no pertinent studies found) or inadequate. Inadequate literature cannot be used to assess relationships among clinical interventions and outcomes, as such literature does not permit a clear interpretation of findings due to methodological concerns (e.g., confounding in study design or implementation) or does not meet the criteria for content as defined in the “Focus” of the Guidelines.

**Guidelines**

**Patient Evaluation**

Preoperative evaluation of a patient to identify risk factors for requiring a blood transfusion or adjuvant therapy includes (1) reviewing previous medical records, (2) conducting a patient or family interview, (3) reviewing existing laboratory test results, and (4) ordering additional laboratory tests when indicated.

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indicate that findings from pertinent preoperative laboratory
tests (e.g., hemoglobin, hematocrit, coagulation tests) may be
predictive of perioperative blood loss, the risk of transfusion, or
other adverse events (e.g., acute kidney injury) associated with
transfusion (Category B2-B evidence).25-45

Survey Findings: The consultants and ASA members both
strongly agree to (1) a review of previous medical records and
interview the patient or family to identify previous blood
transfusion, history of drug-induced coagulopathy, presence
of congenital coagulopathy, history of thrombotic events, and
risk factors for organ ischemia and (2) a review of available
laboratory test results including hemoglobin, hematocrit, and
coaulation profile and the ordering of additional laboratory
tests depending on a patient’s medical condition (e.g.,
coagulopathy, anemia). The ASA members agree and the consul-
tants strongly agree regarding (1) informing patients of the
potential risks versus benefits of blood transfusion and elicit
their preferences and (2) conducting a physical examination
of the patient (e.g., ecchymoses, petechiae, pallor).

Recommendations for Patient Evaluation

- Review previous medical records and interview the patient
  or family to identify:
  - Previous blood transfusion
  - History of drug-induced coagulopathy (e.g., warfarin,
clopidogrel, aspirin and other anticoagulants, as well
as vitamins or herbal supplements that may affect
coagulation [appendix 3])
  - Presence of congenital coagulopathy
  - History of thrombotic events (e.g., deep vein throm-
bois, pulmonary embolism)
  - Risk factors for organ ischemia (e.g., cardiorespiratory
disease) which may influence the ultimate transfusion
trigger for red blood cells (e.g., hemoglobin level)
- Inform patients of the potential risks versus benefits of
blood transfusion and elicit their preferences.
- Review available laboratory test results including hemo-
globin, hematocrit, and coagulation profiles.
- Order additional laboratory tests depending on a patient’s
medical condition (e.g., coagulopathy, anemia).
- Conduct a physical examination of the patient (e.g.,
ecchymosis, petechiae, pallor).
- If possible, perform the preoperative evaluation well
enough in advance (e.g., several days to weeks) to allow
for proper patient preparation.

Preadmission Patient Preparation

Preadmission patient preparation includes (1) treatment of
anemia, (2) discontinuation of anticoagulants and antiplate-
let agents, and (3) preadmission autologous blood collection.

Treatment of Anemia. The World Health Organization
identifies anemia as hemoglobin thresholds of 11.0 g/dl
**Neonates, infants, and children weighing less than 35 kg are
excluded from the focus of these ASA Guidelines.

for children 0.50–4.99 yr,** 11.5 g/dl for children 5.0–
11.99 yr, 12.0 g/dl for children 12.0–14.99 yr, and nonpreg-
nant women ≥15.0 yr, 11.0 g/dl for pregnant women and
13.0 g/dl for men ≥15.0 yr. 86,47 Preadmission treatment of
anemia includes the administration of erythropoietin and/or
iron to improve preoperative hemoglobin levels.

Literature Findings: Meta-analyses of placebo-controlled
RCTs indicate that erythropoietin with or without iron is
effective in reducing the number of patients requiring allo-
geneic transfusions as well as reducing the volume of allo-
geneic blood transfused (Category A1-B evidence).48-62 The
literature is insufficient to evaluate the efficacy of erythropoi-
etin with iron compared with erythropoietin without iron.
RCTs report equivocal findings when preadmission oral iron
is compared with either placebo or no iron regarding preop-
ervative hemoglobin levels or perioperative allogeneic blood
transfused (Category A2-E evidence).63-65

Survey Findings: Both the consultants and ASA members
agree that erythropoietin with or without iron may be admin-
istered when possible to reduce the need for allogeneic blood
in select patient populations (e.g., renal insufficiency, anemia
of chronic disease, refusal of transfusion); and both the consultants
and ASA members strongly agree regarding the administration
of iron to patients with iron deficiency anemia if time permits.

Discontinuation of Anticoagulants and Antiplatelet Agents.

Literature Findings: One nonrandomized comparative
observational study is equivocal regarding the effect of discon-
tinuing warfarin and replacing it with low-molecular-weight
heparin on blood transfusion requirements when compared
with patients not on warfarin (Category B1-E evidence).66
Observational studies report blood loss volumes ranging from
265 to 756 ml, and blood transfusion requirements ranging
from a mean of 0.08 to 0.5 units when clopidogrel is discontin-
ued preoperatively (Category B3 evidence).67-69 The literature
is insufficient to evaluate the effects of discontinuing aspirin before
surgery; although two RCTs comparing the administration of
aspirin with placebo before surgery report equivocal findings
(\(P > 0.01\)) for perioperative blood loss, transfusion require-
ments, or postoperative adverse events (e.g., myocardial infar-
cation, major bleeding, or death) (Category A2-E evidence).70,71

Survey Findings: Both the consultants and ASA members
strongly agree regarding (1) discontinuing anticoagulation
therapy (e.g., warfarin, anti-Xa drugs, antithrombin agents)
for elective surgery, in consultation with an appropriate spe-
cialist; (2) if clinically possible, discontinuing nonaspirin
antiplatelet agents (e.g., thienopyridines such as clopidogrel,
ticagrelor, or prasugrel) for a sufficient time in advance of
surgery, except for patients with a history of percutaneous
coronary interventions; and (3) that the risk of thrombosis
versus the risk of increased bleeding should be considered
when altering anticoagulation status.

Preadmission Autologous Blood Donation.

Literature Findings: RCTs indicate that the preadmis-
sion donation of autologous blood reduces the number of

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patients requiring allogeneic transfusions and the volume of allogeneic blood transfused per patient (Category A2-B evidence). The Task Force notes that certain adverse outcomes (e.g., transfusion reaction due to clerical errors, bacterial contamination) may still occur with the use of autologous blood. The Task Force recognizes that erythropoietin administration is perceived as being expensive and requires time (in weeks) to induce a significant increase in hemoglobin concentration. The Task Force cautions that clopidogrel and aspirin should not be stopped before surgery in patients with coronary stents placed for the advance of surgery, except for patients with a history of percutaneous coronary interventions.

The risk of thrombosis versus the risk of increased bleeding should be considered when altering anticoagulation status. Antifibrinolytics for prophylaxis of excessive blood loss refers to preoperative administration. Preprocedure patient preparation includes the following strategies: decreasing the risk of perioperative myocardial infarction. See American Society of Anesthesiologists Committee on Standards and Practice Parameters: Practice alert for the perioperative management of patients with coronary artery stents: A report by the American Society of Anesthesiologists Committee on Standards and Practice Parameters. Anesthesiology 2009; 110:22–3. Additional information may be found in American College of Cardiology/American Heart Association: 2014 ACC/AHA guideline on perioperative cardiovascular evaluation and management of patients undergoing noncardiac surgery.2

Liberal Transfusion Strategy.

Estimates for a restrictive transfusion strategy for blood transfusions when comparing a rotational thromboelastometry (ROTEM)-guided algorithm with no algorithm for bleeding burn patients (Category A1-B evidence). In the above studies report protocols or algorithms that contain a large variety of interventional components and the impact of any single component on outcome is not reported.
criteria for transfusion less than 8 g/dl and hematocrit values less than 25% are typically reported as restrictive.

**Literature Findings:** Meta-analysis of RCTs comparing restrictive with liberal transfusion criteria report fewer red blood cell transfusions when restrictive transfusion strategies are employed (Category A1-B evidence).85–89 RCT findings for mortality, cardiac, neurologic or pulmonary complications, and length of hospital stay were equivocal (Category A2-E evidence).85–93

**Survey Findings:** The ASA members agree and the consultants strongly agree that a restrictive red blood cell transfusion strategy may be used to reduce transfusion requirements.

**Avoidance of Transfusion.** A protocol to avoid transfusion or to reduce the volume of blood lost may be preferred in certain selected cases.

**Literature Findings:** Studies with observational findings report low blood loss volumes for certain cardiac or other major procedures when these protocols are implemented (Category B3-B evidence).94–99

**Survey Findings:** Both the consultants and ASA members strongly agree that a protocol for avoidance of transfusion may be used as a strategy to reduce blood loss for patients in whom transfusion is refused or is not possible.

**Massive Transfusion Protocols.** Massive transfusion protocols are implemented in cases of life-threatening hemorrhage after trauma and/or during a procedure, and are intended to minimize the adverse effects of hypovolemia and dilutional coagulopathy. These protocols require the availability of large amounts of allogeneic blood and blood products. They often prescribe the transfusion FFP and platelets in a higher (e.g., 1:1) ratio with the transfusion of red blood cells.

**Literature Findings:** An observational study indicates that the ratio of FFP to red blood cells (RBCs) is higher after the implementation of a massive transfusion protocol (Category B3-E evidence).100

**Survey Findings:** The consultants and ASA members both strongly agree regarding use of a massive transfusion protocol when available as a strategy to optimize the delivery of blood products to massively bleeding patients.

**Maximal Surgical Blood Order Schedule.**

**Literature Findings:** Observational studies indicate that implementing a maximal surgical blood order schedule or surgical blood order equation may improve the efficiency of blood ordering practices (Category B2-B evidence).101–106 An RCT comparing a surgical blood order equation (SBOE) with a maximal surgical blood order schedule showed an improved match-to-transfusion ratio for SBOE (Category A3 evidence).111

**Survey Findings:** The consultants and ASA members both agree regarding the use of a maximal surgical blood order schedule, when available and in accordance with institutional policy, as a strategy to improve the efficiency of blood ordering practices.

**Reversal of Anticoagulants.**

Reversal of anticoagulants includes the topics of (1) preprocedure administration of prothrombin complex concentrates (PCCs), (2) administration of FFP, and (3) preprocedure administration of vitamin K.

**Literature Findings:** Observational studies and case reports indicate that four-factor PCCs administered preoperatively are followed by a reduction in International Normalized Ratio (INR) values (Category B3/4-B evidence), with thromboembolic events reported in 0.003% of patients following infusions (Category B3 evidence).112–114 The literature is insufficient to evaluate the impact of the use of FFP with reversal of anticoagulants. One retrospective study comparing vitamin K administered immediately before surgery with no vitamin K administered reports equivocal findings for transfusion requirements (Category B3-E evidence).111

**Survey Findings:** Both the consultants and ASA members strongly agree that for urgent reversal of warfarin, administer PCCs in consultation with the appropriate specialist, or administer FFP. The ASA members agree and the consultants strongly agree regarding administration of vitamin K for nonurgent reversal of warfarin, except when rapid restoration of anticoagulation after surgery is required.

**Antifibrinolytics for Prophylaxis of Excessive Blood Loss.**

**Literature Findings:**

- **ε-Aminocaproic Acid.** Meta-analysis of placebo-controlled RCTs indicate that the use of ε-aminocaproic acid administered before and/or during a procedure is effective in reducing total perioperative blood loss and the number of patients transfused in major cardiac, orthopedic, or liver surgery (Category A1-B evidence); equivocal findings are reported for the volume of blood transfused (Category A1-E evidence).116–125 An RCT comparing ε-aminocaproic acid with placebo reports less blood loss and lower RBC transfusion requirements when ε-aminocaproic acid is administered for prophylaxis of excessive bleeding after total knee replacement surgery and before tourniquet deflation (Category A3-B evidence).126

- **Tranexamic Acid.** Meta-analysis of placebo-controlled RCTs indicate that tranexamic acid for prophylaxis of excessive bleeding administered before and/or during a procedure is effective in reducing perioperative blood loss, the number of patients transfused, and the volume of blood products transfused (CategoryA1-B evidence).127–150 Randomized trials comparing tranexamic acid with placebo or no tranexamic acid controls report no differences for stroke, myocardial infarction, renal failure, reoperation for bleeding, or mortality (Category A2-B evidence).151–157

Meta-analysis of placebo-controlled RCTs indicate that tranexamic acid for prophylaxis of excessive bleeding initiated after a knee and hip arthroplasty and before tourniquet deflation compared with placebo also reported lower blood loss volumes (Category A1-B evidence).126,158–163 One RCT did not show efficacy when tranexamic acid was administered after cardiac surgery and continued for 12 h (Category A3-E evidence).164
Survey Findings: The consultants and ASA members both agree regarding use of prophylactic antifibrinolytic therapy to reduce bleeding and the risk of transfusion for patients at risk of excessive bleeding. The consultants and ASA members both agree regarding use of antifibrinolytic therapy to reduce allogeneic blood transfusion in patients undergoing cardiopulmonary bypass. They also both agree regarding the consideration of using antifibrinolytic therapy in other clinical circumstances at high risk for excessive bleeding.

Acute Normovolemic Hemodilution (ANH).

Literature Findings: Meta-analyses of RCTs indicate that ANH is effective in reducing the volume of allogeneic blood transfused and the number of patients transfused with allogeneic blood for major cardiac, orthopedic, thoracic, or liver surgery (Category A1-B evidence). Additional meta-analyses of RCTs indicate that ANH combined with intraoperative red cell blood recovery compared with intraoperative red cell blood recovery alone is effective in reducing the volume of allogeneic blood transfused (Category A1-B evidence) and is equivocal regarding the number of patients transfused with allogeneic blood (Category A1-E evidence).

Survey Findings: Both the consultants and ASA members agree regarding use of ANH to reduce allogeneic blood transfusion in patients at high risk for excessive bleeding (e.g., major cardiac, orthopedic, thoracic, or liver surgery), if possible.


- Multimodal protocols or algorithms may be employed as strategies to reduce the usage of blood products. However, no single algorithm or protocol can be recommended at this time.
- A restrictive red blood cell transfusion strategy may be safely used to reduce transfusion administration.***
  - The determination of whether hemoglobin concentrations between 6 and 10 g/dl justify or require red blood cell transfusion should be based on potential or actual ongoing bleeding (rate and magnitude), intravascular volume status, signs of organ ischemia, and adequacy of cardiopulmonary reserve.
  - Red blood cells should be administered unit-by-unit, when possible, with interval reevaluation.
- A protocol for avoidance of transfusion may be used as a strategy to reduce blood loss for patients in whom transfusion is refused or is not possible.

Antifibrinolytics for Prophylaxis of Excessive Blood Loss.

- Use antifibrinolytic therapy for prophylaxis of the use of allogeneic blood transfusion in patients undergoing cardiopulmonary bypass.
  - Consider using antifibrinolytic therapy for prophylaxis in certain orthopedic procedures such as knee replacement surgery.
  - Consider using antifibrinolytic therapy for prophylaxis in liver surgery and other clinical circumstances at high risk for excessive bleeding.

Acute Normovolemic Hemodilution (ANH).

- Consider ANH to reduce allogeneic blood transfusion in patients at high risk for excessive bleeding (e.g., major cardiac, orthopedic, thoracic, or liver surgery), if possible.

Intraoperative and Postoperative Management of Blood Loss

Intraoperative and postoperative interventions include (1) allogeneic red blood cell transfusion, (2) reinfusion of recovered red blood cells, (3) intraoperative and postoperative patient monitoring, and (4) treatment of excessive bleeding.

Allogeneic Red Blood Cell Transfusion. Transfusion of allogeneic blood includes the topics of (1) the age of stored blood and (2) leukocyte reduction.

Age of Stored Blood.

- A massive (i.e., hemorrhagic) transfusion protocol may be used when available as a strategy to optimize the delivery of blood products to massively bleeding patients.
- Use a maximal surgical blood order schedule, when available and in accordance with your institutional policy, as a strategy to improve the efficiency of blood ordering practices.

Reversal of Anticoagulants.

- For urgent reversal of warfarin, administer PCCs in consultation with the appropriate specialist, or administer FFP.
- Administer vitamin K for selected patients for nonurgent reversal of warfarin, except when rapid restoration of anticoagulation after surgery is required.
Leukocyte Reduction.

**Literature Findings:** RCTs are equivocal regarding postoperative infections and infectious complications when leukocyte RBC depletion is compared with nonleukocyte depletion (*Category A2-B evidence*).\(^{199–205}\)

**Survey Findings:** The ASA members agree and the consultants strongly agree that leukocyte-reduced blood may be used for transfusion for the purpose of reducing complications associated with allogeneic blood transfusion.

Reinfusion of Recovered Red Blood Cells.

**Intraoperative Red Blood Cell Recovery.**

**Literature Findings:** Meta-analyses of RCTs indicate that intraoperative red blood cell recovery compared with conventional transfusion (i.e., nonblood cell recovery) is effective in reducing the volume of allogeneic blood transfused (*Category A1-B evidence*).\(^{206–217}\)

**Postoperative Red Blood Cell Recovery.**

**Literature Findings:** RCTs indicate that postoperative blood recovery and reinfusion with recovered red blood cells reduces the frequency of allogeneic blood transfusions (*Category A2-B evidence*) in patients undergoing major orthopedic surgery.\(^{218–220}\)

**Survey Findings:** The consultants and ASA members both strongly agree regarding the reinfusion of recovered red blood cells as a blood-sparing intervention in the intraoperative and/or postoperative period.

Intraoperative and Postoperative Patient Monitoring.

Intraoperative and postoperative monitoring consists of monitoring for: (1) blood loss, (2) perfusion of vital organs, (3) anemia, (4) coagulopathy, and (5) adverse effects of transfusion.

**Monitoring for Blood Loss.**

Blood loss monitoring consists of visual assessment of the surgical field, including the extent of blood present, presence of microvascular bleeding, surgical sponges, clot size and shape, and volume in suction canister.

**Literature Findings:** The literature is insufficient to evaluate the impact of periodically assessing the surgical field for the extent of blood present, the presence of excessive microvascular bleeding (i.e., coagulopathy) or observing surgical sponges, clot size and shape, or the volume of blood in the suction canister to measure blood loss.\(^{88}\)

**Survey Findings:** Both the consultants and ASA members strongly agree regarding: (1) periodically conducting a visual assessment of the surgical field jointly with the surgeon to assess the presence of surgical or excessive microvascular (i.e., coagulopathy) bleeding and (2) use of standard methods for quantitative measurement of blood loss including checking suction canisters, surgical sponges, and surgical drains.

**Monitoring for Perfusion of Vital Organs.**

Monitoring for perfusion of vital organs includes standard ASA monitoring. Additional monitoring may include echocardiography, renal monitoring (urine output), cerebral monitoring (i.e., cerebral oximetry and near infrared spectroscopy [NIRS]), analysis of arterial blood gases, and mixed venous oxygen saturation.

**Literature Findings:** The literature is insufficient to evaluate the efficacy of the above monitoring techniques on clinical outcomes associated with blood transfusion.

**Survey Findings:** Both the consultants and ASA members strongly agree regarding: (1) monitoring for perfusion of vital organs using standard ASA monitors (i.e., blood pressure, heart rate, oxygen saturation, electrocardiography) in addition to observing clinical symptoms and physical examination features and (2) that additional monitoring may include echocardiography, renal monitoring (urine output), cerebral monitoring (i.e., cerebral oximetry and NIRS), analysis of arterial blood gases, and mixed venous oxygen saturation.

**Monitoring for Anemia.**

Monitoring for anemia includes hemoglobin/hematocrit monitoring.

**Literature Findings:** The literature is insufficient to evaluate the efficacy of perioperative monitoring for anemia.

**Survey Findings:** The consultants and ASA members both strongly agree that if anemia is suspected, monitor hemoglobin/hematocrit values based on estimated blood loss and clinical signs.

**Monitoring for Coagulopathy.**

Monitoring for coagulopathy includes standard coagulation tests (e.g., INR, activated partial thromboplastin time [aPTT], fibrinogen concentration), as well as platelet count. Additional monitoring for coagulopathy may include tests of platelet function, and viscoelastic assays (e.g., TEG, ROTEM).

**Literature Findings:** An observational study examining point-of-care measurement of aPTT and prothrombin time by a portable laser photometer reports shorter times for obtaining test results with point-of-care monitoring (*Category B2-B evidence*).\(^{221}\) Significant correlations were reported between photometer and traditional laboratory test findings. An observational study examining platelet count during cardiopulmonary bypass to predict excessive blood loss reports a sensitivity value of 83% and a specificity value of 58% (*Category B2 evidence*).\(^{222}\) An RCT reported equivocal findings for blood loss and transfusion requirements when TEG is compared with standard laboratory coagulation tests (*Category A3-E evidence*).\(^{223}\) An RCT reported equivocal findings with ROTEM versus no fibrinolysis monitoring for RBC, FFP, and platelet transfusion requirements (*Category A3-E evidence*).\(^{224}\) Note that TEG
and ROTEM-guided algorithms are shown to be effective in reducing blood transfusion requirements (see multimodal protocols or algorithms above). For ROTEM, a sensitivity finding for blood loss was reported to be 13%, specificity values ranged from 52% to 80%, and a positive predictive value of 45% (Category B2 evidence).225,226 Nonrandomized correlational studies reported significant correlations (P < 0.01) with standard coagulation tests for fibrinogen level and platelet count, whereas correlations between ROTEM and prothrombin time (PT) and aPTT measures were not statistically significant (Category B2 evidence).227–232

Survey Findings: Both the consultants and ASA members agree that if coagulopathy is suspected, obtain viscoelastic assays (e.g., TEG and ROTEM), when available, as well as platelet count. They both strongly agree that if viscoelastic assays are not available, obtain standard coagulation tests (e.g., INR, aPTT, fibrinogen concentration), as well as platelet count for monitoring.

Monitoring for Adverse Effects of Transfusions.
Monitoring for adverse effects of transfusions includes periodic checking for signs of ABO incompatibility such as hyperthermia, hemoglobinuria, or microvascular bleeding; signs of transfusion-related acute lung injury or transfusion-associated circulatory overload such as hypoxemia, respiratory distress and increased peak airway pressure; signs of bacterial contamination such as hyperthermia and hypotension; signs of allergic reaction such as urticaria; and signs of citrate toxicity such as hypocalemia (appendix 4).

Literature Findings: Nonrandomized comparative studies report higher risk of infection after RBC transfusion (Category B1-H evidence),233–236 and case reports indicate that adverse outcomes including transfusion-related acute lung injury and delayed hemolytic transfusion reaction may occur after transfusion (Category B4-H evidence).237–239 The literature is insufficient to recommend specific monitoring practices to identify these adverse transfusion effects.

Survey Findings: Both the consultants and ASA members strongly agree that (1) during and after transfusion, periodically check for hyperthermia, hemoglobinuria, microvascular bleeding, hypoxemia, respiratory distress, increased peak airway pressure, urticaria, hypotension, and signs of hypocalcemia and (2) before instituting therapy for transfusion reactions, stop the blood transfusion and order appropriate diagnostic testing.

Treatment of Excessive Bleeding.
Intraoperative and postoperative treatment of excessive bleeding includes (1) transfusion of platelets, (2) transfusion of FFP, (3) transfusion of cryoprecipitate, and (4) pharmacologic treatment of excessive bleeding.

Transfusion of Platelets.
Literature Findings: Recent literature is insufficient to evaluate the impact of platelet transfusion on resolution of coagulopathy.

Survey Findings: The consultants and ASA members both agree regarding obtaining a platelet count before transfusion of platelets, if possible; however, the ASA members agree and the consultants are equivocal regarding obtaining a test of platelet function, if available, in patients with suspected or drug-induced (e.g., clopidogrel) platelet dysfunction.

Transfusion of FFP.
Literature Findings: RCTs report inconsistent findings regarding blood loss and RBC transfusion requirements when FFP transfusion is compared with non-FFP transfusion, (Category A2-E evidence).240,241

Survey Findings: The consultants and ASA members both agree that, in patients with excessive bleeding, obtain coagulation tests (i.e., PT or INR and aPTT) before transfusion of FFP, if possible.

Transfusion of Cryoprecipitate.
Literature Findings: The literature is insufficient to evaluate the intraoperative or postoperative transfusion of cryoprecipitate to manage actual or potential coagulopathy.

Survey Findings: The ASA members agree and the consultants strongly agree that, in patients with excessive bleeding, assess fibrinogen levels before the administration of cryoprecipitate, if possible.

Pharmacologic Treatment of Excessive Bleeding.
Pharmacologic treatments for excessive bleeding include: (1) desmopressin, (2) antifibrinolytics (i.e., ε-aminocaproic acid, tranexamic acid), (3) topical hemostatics (i.e., fibrin glue, thrombin gel), (4) PCCs, (5) coagulation factor concentrates (recombinant factor VIIa), and (6) treatments for hypofibrinogenemia (cryoprecipitate, fibrinogen concentrate).

Desmopressin:
Literature Findings: Meta-analysis of placebo-controlled RCTs indicate that desmopressin is effective in reducing the volume of postoperative blood loss (Category A1-B evidence).242–248

Survey Findings: Both the consultants and ASA members agree that, in patients with excessive bleeding and platelet dysfunction, consider the use of desmopressin.

Antifibrinolytics:
Literature Findings: An RCT is equivocal regarding blood loss and RBC transfusion requirements when ε-aminocaproic acid is compared with placebo to treat postoperative blood loss in patients with chest drainage of 100 ml/h or more (Category A3-E evidence).249 The literature is insufficient to evaluate the postoperative administration of tranexamic acid for treatment of excessive blood loss.

Survey Findings: The consultants and ASA members both agree that, in patients with excessive bleeding, consider the use of antifibrinolytics (i.e., ε-aminocaproic acid, tranexamic acid), if not already being used.
Topical Hemostatics:

Literature Findings: Meta-analysis of RCTs indicates that fibrin glue is effective in reducing the volume of perioperative blood loss and the number of patients transfused when compared with no fibrin glue (Category A1-B evidence). RCTs indicate that thrombin gel is effective in reducing perioperative blood loss and time to hemostasis (Category A2-B evidence).

Survey Findings: The consultants and ASA members both agree that, in patients with excessive bleeding, consider topical hemostatics such as fibrin glue or thrombin gel.

Prothrombin Complex Concentrates:

Literature Findings: Observational studies and case reports indicate that intraoperative administration of four-factor PCCs are followed by a reduction in blood loss and normalization of INR values (Category B3/4-B evidence).

Survey Findings: Both the consultants and ASA members agree that, when traditional options for treating excessive bleeding due to coagulopathy have been exhausted, consider administering recombinant activated factor VII.

Coagulation Factor Concentrates:

Literature Findings: Meta-analysis of placebo-controlled RCTs of recombinant activated factor VII reports equivocal findings regarding the volume of blood loss, the volume of blood transfused, and the number of patients transfused (Category A1-E evidence).

Survey Findings: Both the consultants and ASA members agree that, when traditional options for treating excessive bleeding due to coagulopathy have been exhausted, consider administering recombinant activated factor VII.

Treatments for Hypofibrinogenemia:

Literature Findings: The literature is insufficient to evaluate the intraoperative or postoperative transfusion of cryoprecipitate to manage hypofibrinogenemia. RCTs comparing fibrinogen concentrate with placebo report a lower volume of RBC transfusion and a reduced frequency of patients transfused when fibrinogen concentrate is administered intraoperatively (Category A2-B evidence).

Survey Findings: The consultants and ASA members both agree that, in patients with excessive bleeding, consider the use of fibrinogen concentrate.

Recommendations for Intraoperative and Postoperative Management of Blood Loss

Allogeneic Red Blood Cell Transfusion.

• Administer blood without consideration of duration of storage.

Reinforcement of Recovered Red Blood Cells.

• Reinfuse recovered red blood cells as a blood-sparing intervention in the intraoperative period, when appropriate.

Intraoperative and Postoperative Patient Monitoring.

• Periodically conduct a visual assessment of the surgical field jointly with the surgeon to assess the presence of excessive microvascular (i.e., coagulopathy) or surgical bleeding.
• Use standard methods for quantitative measurement of blood loss, including checking suction canisters, surgical sponges, and surgical drains.
• Monitor for perfusion of vital organs using standard ASA monitors (i.e., blood pressure, heart rate, oxygen saturation, electrocardiography) in addition to observing clinical symptoms and physical exam features.

• Additional monitoring may include echocardiography, renal monitoring (urine output), cerebral monitoring (i.e., cerebral oximetry and NIRS), analysis of arterial blood gasses, and mixed venous oxygen saturation.

• If anemia is suspected, monitor hemoglobin/hematocrit values based on estimated blood loss and clinical signs.
• If coagulopathy is suspected, obtain standard coagulation tests (e.g., INR, aPTT, fibrinogen concentration) or viscoelastic assays (e.g., TEG and ROTEM), if available, as well as platelet count.
• During and after transfusion, periodically check for signs of a transfusion reaction including hyperthermia, hemoglobinuria, microvascular bleeding, hypoxemia, respiratory distress, increased peak airway pressure, urticaria, hypotension, and signs of hypocalcemia.

• If signs of a transfusion reaction are apparent, immediately stop the transfusion, give supportive therapy, and initiate supportive care.
• Notify the blood bank of the transfusion reaction case.

Treatment of Excessive Bleeding.

• In patients with excessive bleeding, the following recommendations are made based upon the evidence for each of these interventions when studied singly or when compared with placebo. The impact of combinations of these interventions is not addressed in these Guidelines.

º Obtain a platelet count before transfusion of platelets, if possible (see table 1 for suggested transfusion criteria for platelets).*** In addition, obtain a test of platelet function, if available, in patients with suspected or drug-induced (e.g., clopidogrel) platelet dysfunction.
º Obtain coagulation tests (i.e., PT or INR and aPTT) before transfusion of FFP, if possible (see table 1 for suggested transfusion criteria for FFP).****
º Leukocyte-reduced blood may be used for transfusion for the purpose of reducing complications associated with allogeneic blood transfusion.
• Assess fibrinogen levels before the administration of cryoprecipitate, if possible (see table 1 for suggested transfusion criteria for cryoprecipitate).
• Desmopressin may be used in patients with excessive bleeding and platelet dysfunction.
• Consider topical hemostatics such as fibrin glue or thrombin gel.
• Consider the use of antifibrinolytics (i.e., ε-aminocaproic acid, tranexamic acid) if fibrinolysis is documented or suspected and if these agents are not already being used.
• PCCs may be used in patients with excessive bleeding and increased INR.
• Consider recombinant activated factor VII when traditional options for treating excessive bleeding due to coagulopathy have been exhausted.††††
• Fibrinogen concentrate may be used.

Appendix 1. Summary of Recommendations

I. Patient Evaluation

- Review previous medical records and interview the patient or family to identify:
  - Previous blood transfusion.
  - History of drug-induced coagulopathy (e.g., warfarin, clopidogrel, aspirin and other anticoagulants, as well as vitamins or herbal supplements that may affect coagulation [appendix 3]).
  - The presence of congenital coagulopathy.
  - History of thrombotic events (e.g., deep vein thrombosis, pulmonary embolism).
  - Risk factors for organ ischemia (e.g., cardiopulmonary disease) which may influence the ultimate transfusion trigger for red blood cells (e.g., hemoglobin level).
- Inform patients of the potential risks versus benefits of blood transfusion and elicit their preferences.
- Review available laboratory test results including hemoglobin, hematocrit, and coagulation profiles.
- Order additional laboratory tests depending on a patient’s medical condition (e.g., coagulopathy, anemia).

II. Preadmission Patient Preparation

- Erythropoietin with or without iron may be administered when possible to reduce the need for allogeneic blood in selected patient populations (e.g., renal insufficiency, anemia of chronic disease, refusal of transfusion).‡‡‡‡
- Administer iron to patients with iron deficiency anemia if time permits.
- In consultation with an appropriate specialist, discontinue anticoagulation therapy (e.g., warfarin, anti-Xa drugs, antithrombin agents) for elective surgery.
- Transition to a shorter acting drug (e.g., heparin, low-molecular-weight heparin) may be appropriate in selected patients.
- If clinically possible, discontinue nonaspirin antiplatelet agents (e.g., thienopyridines such as clopidogrel, ticagrelor, or prasugrel) for a sufficient time in advance of surgery, except for patients with a history of percutaneous coronary interventions.‡‡‡‡
- Aspirin may be continued on a case-by-case basis.
- The risk of thrombosis versus the risk of increased bleeding should be considered when altering anticoagulation status.
- Assure that blood and blood components are available for patients when significant blood loss or transfusion is expected.
- When autologous blood is preferred, the patient may be offered the opportunity to donate blood before admission only if there is adequate time for erythropoietic reconstitution.||

III. Preprocedure Preparation

Blood Management Protocols

- Multimodal protocols or algorithms may be employed as strategies to reduce the usage of blood products. However, no single algorithm or protocol can be recommended at this time.
- A restrictive red blood cell transfusion strategy may be safely used to reduce transfusion administration.***
- The determination of whether hemoglobin concentrations between 6 and 10 g/dl justify or require red blood cell transfusion should be based on potential or actual ongoing bleeding (rate and magnitude), intravascular volume status, signs of organ ischemia, and adequacy of cardiopulmonary reserve.
- Red blood cells should be administered unit-by-unit, when possible, with interval reevaluation.
• A protocol for avoidance of transfusion may be used as a strategy to reduce blood loss for patients in whom transfusion is refused or is not possible.

• A massive (i.e., hemorrhagic) transfusion protocol may be used when available as a strategy to optimize the delivery of blood products to massively bleeding patients.

• Use a maximal surgical blood order schedule, when available and in accordance with your institutional policy, as a strategy to improve the efficiency of blood ordering practices.

Reversal of Anticoagulants

• For urgent reversal of warfarin, administer PCCs in consultation with the appropriate specialist, or administer FFP.

• Administer vitamin K for selected patients for nonurgent reversal of warfarin, except when rapid restoration of anticoagulation after surgery is required.

Antifibrinolytics for Prophylaxis of Excessive Blood Loss

• Use antifibrinolytic therapy for prophylaxis of the use of allogeneic blood transfusion in patients undergoing cardiopulmonary bypass.

• Consider using antifibrinolytic therapy for prophylaxis in certain orthopedic surgery.

• Consider using antifibrinolytic therapy for prophylaxis in liver surgery and other clinical circumstances at high-risk for excessive bleeding.†††

Acute Normovolemic Hemodilution (ANH)

• Consider ANH to reduce allogeneic blood transfusion in patients at high-risk for excessive bleeding (e.g., major cardiac, orthopedic, thoracic, or liver surgery), if possible.‡‡‡

IV. Intraoperative and Postoperative Management of Blood Loss

Allogeneic Red Blood Cell Transfusion

• Administer blood without consideration of duration of storage.

• Leukocyte-reduced blood may be used for transfusion for the purpose of reducing complications associated with allogeneic blood transfusion.

Reinfusion of Recovered Red Blood Cells

• Reinfuse recovered red blood cells as a blood-sparing intervention in the intraoperative period, when appropriate.

Intraoperative and Postoperative Patient Monitoring

• Periodically conduct a visual assessment of the surgical field jointly with the surgeon to assess the presence of excessive microvascular (i.e., coagulopathy) or surgical bleeding.

• Use standard methods for quantitative measurement of blood loss, including checking suction canisters, surgical sponges, and surgical drains.

• Monitor for perfusion of vital organs using standard ASA monitors (i.e., blood pressure, heart rate, oxygen saturation, electrocardiography) in addition to observing clinical symptoms and physical exam features.||||

○ Additional monitoring may include echocardiography, renal monitoring (urine output), cerebral monitoring (i.e., cerebral oximetry and NIRS), analysis of arterial blood gases, and mixed venous oxygen saturation.

○ If anemia is suspected, monitor hemoglobin/hematocrit values based on estimated blood loss and clinical signs.

○ If coagulopathy is suspected, obtain standard coagulation tests (e.g., INR, aPTT, fibrinogen concentration) or viscoelastic assays (e.g., thromboelastography [TEG] and ROTEM), if available, as well as platelet count.

○ During and after transfusion, periodically check for signs of a transfusion reaction including hyperthermia, hemoglobinuria, microvascular bleeding, hypoxemia, respiratory distress, increased peak airway pressure, urticaria, hypotension and signs of hypocalcemia.

○ If signs of a transfusion reaction are apparent, immediately stop the transfusion, give supportive therapy, and initiate supportive care.

○ Notify the blood bank of the transfusion reaction case.

Treatment of Excessive Bleeding

• In patients with excessive bleeding, the following recommendations are made based upon the evidence for each of these interventions when studied singly or when compared with placebo. The impact of combinations of these interventions is not addressed in these Guidelines.

• Obtain a platelet count before transfusion of platelets, if possible (see table 1 for suggested transfusion criteria for platelets).### In addition, obtain a test of platelet function, if available, in patients with suspected or drug-induced (e.g., clopidogrel) platelet dysfunction.

• Obtain coagulation tests (i.e., PT or INR and aPTT) before transfusion of FFP, if possible (see table 1 for suggested transfusion criteria for FFP).****

• Assess fibrinogen levels before the administration of cryoprecipitate, if possible (see table 1 for suggested transfusion criteria for cryoprecipitate).

• Desmopressin may be used in patients with excessive bleeding and platelet dysfunction.

• Consider topical hemostatics such as fibrin glue or thrombin gel.

• Consider the use of antifibrinolytics (i.e., ε-aminocaproic acid, tranexamic acid) if fibrinolysis is documented or suspected and if these agents are not already being used.
• PCCs may be used in patients with excessive bleeding and increased INR.
• Consider recombinant activated factor VII when traditional options for treating excessive bleeding due to coagulopathy have been exhausted. ††††
• Fibrinogen concentrate may be used.

Appendix 2. Methods and Analyses

State of the Literature
For these updated Guidelines, a review of studies used in the development of the previous update was combined with studies published subsequent to approval of the update in 2005.† The scientific assessment of these Guidelines was based on evidence linkages or statements regarding potential relationships between clinical interventions and outcomes. The interventions listed below were examined to assess their relationship to a variety of outcomes related to the perioperative blood transfusion and adjuvant therapies.

Patient Evaluation
• Reviewing medical records (checking for acquired or congenital conditions, previous lab tests)
• Conducting a patient interview
• Conducting/ordering new laboratory tests when indicated
  - Hemoglobin or hematocrit (to identify preoperative anemia)
  - Coagulation profile (PT, aPTT, ACT, TEG)
  - Type and cross versus type and screen
  - Maximum surgical blood ordering schedule for elective procedures

Preadmission Patient Preparation
• Prevention or reduction of perioperative anemia
  - Erythropoietin
  - Iron
• Discontinuation of anticoagulants
  - Warfarin
• Discontinuation of antithrombotic agents
  - Clopidogrel or other thienopyridines
  - Aspirin
• Preadmission autologous blood donation (PAD)
  - PAD versus allogeneic blood or blood products
  - PAD versus preprocedure ANH
  - PAD versus intraoperative or postoperative blood recovery

Preprocedure Preparation
• Blood management protocol
  - Multimodality protocol or algorithm
  - Restrictive versus liberal transfusion protocol
  - Nontransfusion protocol (i.e., bloodless surgery)
• Massive transfusion protocol
• Maximum surgical blood ordering schedule for elective procedures
• Reversal of anticoagulants
  - Vitamin K
  - PCCs
• Antifibrinolytics for prophylaxis of excessive blood loss
  - ε-Aminocaproic acid
  - Tranexamic acid
• ANH
  - ANH versus no ANH
  - ANH combined with intraoperative blood recovery versus either ANH or intraoperative blood recovery

Intraoperative and Postoperative Interventions
• Allogeneic red blood cell transfusion
  - Age of stored RBCs
  - Leukocyte reduction
• Autologous red blood cell transfusion
  - Intraoperative blood recovery
• Cell salvage
• Whole blood
  - Postoperative blood recovery
    - Cell salvage
    - Whole blood
• Intraoperative and postoperative patient monitoring:
  - Monitoring blood loss:
    - Visual assessment of the surgical field
    - Extent of blood present
    - Presence of microvascular bleeding
    - Surgical sponges
    - Clot size and shape
    - Volume in suction canister
  - Monitoring for inadequate perfusion and oxygenation of vital organs
    - Cardiac monitoring (blood pressure, heart rate, oxygen saturation)
    - Renal monitoring (urine output)
    - Cerebral monitoring
      - Cerebral oximetry
      - NIRS
    - Arterial blood gas measurement
    - Mixed venous oxygen saturation
  - Monitoring for non-RBC transfusion—coagulopathy
    - Platelet function monitoring
    - Viscoelastic hemostatic assays
• TEG
• ROTEM
  o Monitoring (periodic checking) for adverse effects of transfusions
  o Transfusion-related acute lung injury
  o Hemolytic (ABO incompatibility) transfusion reactions
  o Citrate toxicity (hypocalcemia)
  o Transfusion-associated circulatory overload
  o Bacterial contamination
  o Immunomodulation (e.g., graft versus host disease infection)

• Treatment of excessive bleeding
  o Transfusion treatments:
    • Platelet transfusion
    • FFP transfusion
    • Cryoprecipitate
  o Pharmacologic treatments:
    • Desmopressin
    • Antifibrinolytics
    • e-Aminocaproic acid
    • Tranexamic acid
    • Topical hemostatics
    • Fibrin glue
    • Thrombin gel
    • PCC
    • PCC, versus FFP
    • Bepulin
    • Profilin
    • Kcentra (Beriplex, Confidex)
    • Coagulation factor concentrates
    • Recombinant Factor VIIa
    • Treatments for hypofibrinogenemia:
      • Cryoprecipitate
      • Fibrinogen concentrate (Riastap)

For the literature review, potentially relevant clinical studies were identified via electronic and manual searches of the literature. The updated searches covered an 11-yr period from 2004 to 2014. Over 1800 new citations that addressed topics related to the evidence linkages were identified. These articles were reviewed and those meeting the appropriate criteria as outlined in the “Focus” section above were combined with pre-2005 articles used in the previous update, resulting in a total of 520 articles that contained direct linkage-related evidence. A complete bibliography used to develop these Guidelines, organized by section, is available as Supplemental Digital Content 2, http://links.lww.com/ALN/B101.

Initially, each pertinent study finding was classified and summarized to determine meta-analysis potential. Literature pertaining to 11 evidence linkages contained enough studies with well-defined experimental designs and statistical information sufficient for meta-analyses. These linkages were (1) erythropoietin versus placebo, (2) e-aminocaproic acid versus placebo; (3) tranexamic acid versus placebo administered before or during surgery; (4) ANH versus no ANH; (5) ANH with intraoperative red blood cell recovery versus red blood cell recovery alone, (6) restrictive versus liberal transfusion strategy, (7) intraoperative red blood cell recovery versus conventional transfusion, (8) desmopressin versus placebo, (9) tranexamic acid versus placebo administered after surgery, (10) fibrin glue versus no fibrin glue, and (11) recombinant activated factor VII versus placebo (table 2).

General variance-based effect-size estimates or combined probability tests were obtained for continuous outcome measures, and Mantel–Haenszel odds ratios were obtained for dichotomous outcome measures. Two combined probability tests were employed as follows: (1) the Fisher combined test, producing chi-square values based on logarithmic transformations of the reported P values from the independent studies, and (2) the Stouffer combined test, providing weighted representation of the studies by weighting each of the standard normal deviates by the size of the sample. An odds ratio procedure based on the Mantel–Haenszel method for combining study results using 2 × 2 tables was used with outcome frequency information. An acceptable significance level was set at P < 0.01 (one-tailed). Tests for heterogeneity of the independent studies were conducted to assure consistency among the study results. DerSimonian-Laird random-effects odds ratios were obtained when significant heterogeneity was found (P < 0.01). To control for potential publishing bias, a “fail-safe n” value was calculated. No search for unpublished studies was conducted, and no reliability tests for locating research results were done. To be accepted as significant findings, Mantel–Haenszel odds ratios must agree with combined test results whenever both types of data are assessed. In the absence of Mantel–Haenszel odds ratios, findings from both the Fisher and weighted Stouffer combined tests must agree with each other to be acceptable as significant.

For the previous update, interobserver agreement among Task Force members and two methodologists was established by inter-rater reliability testing. Agreement levels using a kappa (κ) statistic for two-rater agreement pairs were as follows: (1) type of study design, κ = 0.83–0.94; (2) type of analysis, κ = 0.87–0.94; (3) evidence linkage assignment, κ = 0.89–0.96; and (4) literature inclusion for database, κ = 0.44–0.78. Three-rater chance-corrected agreement values were: (1) study design, Sav = 0.89, Var (Sav) = 0.004; (2) type of analysis, Sav = 0.88, Var (Sav) = 0.004; (3) linkage assignment, Sav = 0.92 Var (Sav) = 0.002; (4) literature database inclusion, Sav = 0.58 Var (Sav) = 0.054. These values represent moderate to high levels of agreement.

Consensus-based Evidence

For the previous update, consensus was obtained from multiple sources, including: (1) survey opinion from consultants who were selected based on their knowledge or...
expertise in perioperative blood transfusion and adjuvant therapies, (2) survey opinions from a randomly selected sample of active members of the ASA, (3) testimony from attendees of two publicly held open forums at two national anesthesia meetings, § (4) Internet commentary, and (5) Task Force opinion and interpretation. The survey rate of return was 31% (n = 21 of 67) for consultants, and 29% (n = 87 of 300) for membership respondents. Survey results are reported in tables 3 and 4, and summarized in the text of the Guidelines.

For the previous update, the consultants were asked to indicate which, if any, of the evidence linkages would change their clinical practices if the Guidelines were instituted. The rate of return was 24% (n = 16 of 67). The percent of responding consultants expecting no change associated with each linkage were as follows: preoperative evaluation—75%; discontinuation of anticoagulation and delay of surgery—94%; drugs to manage perioperative anemia—75%; drugs to promote coagulation and minimize blood loss—80%; preoperative autologous blood collection—88%; monitoring for inadequate perfusion and oxygenation—94%; monitoring for transfusion indications—88%; transfusion of allogeneic red blood cells—94%, transfusion of autologous blood—100%; transfusion of platelets—88%; transfusion of frozen plasma—88%; transfusion of cryoprecipitate—94%; treatment of excessive bleeding—88%; and monitoring and laboratory testing for transfusion reactions—88%. Eighty-eight percent of the respondents indicated that the Guidelines would have no effect on the amount of time spent on a typical case. Two respondents (12%) indicated that there would be an increase in the amount of time they would spend on an atypical case with the implementation of these Guidelines. The amount of increased time anticipated by these respondents was 5 and 10 min.

**Appendix 3. Vitamin and Herbal Supplements that May Affect Blood Loss**

**Herbal Supplements that Decrease Platelet Aggregation**

- Bilberry
- Bromelain
- Dong Quoi
- Feverfew
- Fish oil
- Flax seed oil
- Garlic
- Ginger
- Ginko biloba
- Grape seed extract
- Saw palmetto

**Herbs that Inhibit Clotting**

- Chamomile
- Dandelion root

**Vitamins that Affect Coagulation**

- Vitamin K
- Vitamin E

**Appendix 4. Adverse Effects Associated with Transfusion**

**Acute intravascular hemolytic transfusion reactions** occur when red cells break down in the intravascular space due to either a complement-mediated immune mechanism (usually secondary to ABO incompatibility) or to physical damage to the red cells (osmotic or temperature related). Both mechanisms result in hemoglobinemia and hemoglobinuria. However, the severe, often fatal complications such as shock and disseminated intravascular coagulation are usually only seen in ABO incompatibility. The frequency of fatalities due to ABO incompatibilities, once the major cause of transfusion-associated fatalities, has markedly decreased over the last decade as strict processes for identifying the patient and the blood units being transfused have been put in place. In the operating room, acute intravascular hemolytic transfusion reactions secondary to ABO incompatibility are manifested by intractable bleeding in the operating field, hypotension and shock, fever, and hemoglobinuria. Treatment consists of stopping the blood transfusion, supportive measures to maintain blood pressure, and aggressive transfusion of platelets, FFP, and cryoprecipitate to counteract the consumptive coagulopathy while maintaining oxygen carrying capacity through transfusion of type O red blood cells.

**Transfusion-associated acute lung injury** is now the leading cause of transfusion-associated fatalities. It is caused by donor antibodies in plasma-containing blood components (usually FFP or platelets, and occasionally red blood cells) interacting with antigens on the patient’s granulocytes (human leukocyte antigen or granulocyte specific) resulting in granulocytes aggregation and complement activation in the lung capillaries. The symptoms (fever, hypoxemia, acute respiratory distress, increased peak airway pressure) occur within 6 h after the transfusion. Except for the presence of fever, these symptoms are undistinguishable from those of transfusion-associated circulatory overload. Treatment consists of stopping the transfusion and instituting critical care supportive measures.

**Bacterial contamination of blood components** is most often associated with platelet transfusion as platelets are stored at 20°–24°C which facilitates the growth of bacteria. There has been a significant decrease in fatalities associated with bacterial contamination since 2001, as processes to detect bacterial contamination in platelets have been put into place. Bacterial contamination is manifested by hyperthermia and...
hypotension. Treatment consists of stopping the transfusion, starting antibiotics, and supportive measures.

Allergic reactions are caused by immunoglobulin E antibodies in the patient against proteins in the plasma of the blood component transfused. As very small amounts of allergenic protein is needed to cause a reaction, any blood components can be associated with such a reaction except for washed blood. Symptoms usually are restricted to urticaria and other erythematous skin manifestations and subside spontaneously or with diphenhydramine administration. Occasionally, allergic reactions are more severe and result in anaphylaxis.

Citrate is the anticoagulant used to collect blood components and it is present in significant amounts in all blood components. It readily binds calcium and magnesium. When large numbers of blood components are transfused over a short period of time, the metabolism of citrate is overwhelmed and the patient develops citrate toxicity (hypocalcemia and hypomagnesemia) which may result in adverse cardiac manifestations.
Table 1. Suggested Criteria for Perioperative Transfusion of Non-RBC Blood Products*

<table>
<thead>
<tr>
<th>Blood Product</th>
<th>Criteria</th>
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| **Platelets** | - Platelet transfusion may be indicated despite an apparently adequate platelet count or in the absence of a platelet count if there is known or suspected platelet dysfunction (e.g., the presence of potent antiplatelet agents, cardio-pulmonary bypass, congenital platelet dysfunction and bleeding)†
- In surgical or obstetric patients, platelet transfusion is rarely indicated if the platelet count is known to be greater than 100 × 10^9 /l and is usually indicated when the count is less than 50 × 10^9 /l in the presence of excessive bleeding |
| **Plasma products (e.g., FFP, PF24, or Thawed Plasma)‡** | - FFP is indicated:
  - For correction of excessive microvascular bleeding (i.e., coagulopathy) in the presence of an INR greater than 2.0, in the absence of heparin
  - For correction of excessive microvascular bleeding secondary to coagulation factor deficiency in patients transfused with more than one blood volume (approximately 70ml/kg) and when PT or INR and aPTT cannot be obtained in a timely fashion
  - For urgent reversal of warfarin therapy when PCCs are not available
  - For correction of known coagulation factor deficiencies for which specific concentrates are unavailable
- FFP is not indicated:
  - If PT or INR and aPTT are normal
  - Solely for augmentation of plasma volume or albumin concentration
| **Cryoprecipitate** | - Cryoprecipitate is indicated:
  - When a test of fibrinogen activity indicates a fibrinolysis
  - When the fibrinogen concentration is less than 80–100mg/dl in the presence of excessive bleeding||
  - As an adjunct in massively transfused patients when fibrinogen concentrations cannot be measured in a timely fashion
  - For patients with congenital fibrinogen deficiencies
  - Whenever possible, decisions regarding patients with congenital fibrinogen deficiencies should be made in consultation with the patient's hematologist
- Transfusion of cryoprecipitate is rarely indicated if fibrinogen concentration is greater than 150mg/dl in nonpregnant patients.
- Treat bleeding patients with von Willebrand disease types 1 and 2A with desmopressin and subsequently with specific VWF/FVIII concentrate, if available. Cryoprecipitate should be administered if there is no response to or availability of desmopressin or VWF/FVIII concentrate
- Treat bleeding patients with von Willebrand disease types 2B, 2M, 2N, and 3 with specific VWF/FVIII concentrate, if available. If VWF/FVIII concentrate is not available, cryoprecipitate is indicated |

* This table displays some transfusion criteria that may suggest when to transfuse with the above blood products. The decision to apply some or all of the criteria shown in this table is dependent upon the clinical context and judgment of the practitioner. The table is not intended as a mandatory or exhaustive list. Scientific evidence is insufficient to evaluate the perioperative benefit of applying the above suggested criteria. † The proper dose of platelets should be based on recommendations of the local institutional transfusion committee. ‡ FFP refers to plasma frozen within 8h after phlebotomy, PF24 refers to plasma frozen within 24h after phlebotomy, and Thawed Plasma refers to FFP stored up to 5 days at 1°–6°C after thawing. In the United States, it is a common practice to use these terms interchangeably. In this table, the term FFP refers to the use of any of these plasma products. § Many institutions in the United States no longer have fresh whole blood available from the blood bank. || Cryoprecipitate may be indicated at a higher fibrinogen concentration in actively bleeding obstetric patients.

aPTT = activated partial thromboplastin time; INR = International Normalized Ratio; PCC = prothrombin complex concentrates; PT = prothrombin time; RBC = red blood cell.
## Table 2. Meta-analysis Summary

<table>
<thead>
<tr>
<th>Linkages</th>
<th>N</th>
<th>Fisher Chi-Square</th>
<th>P Value</th>
<th>Weighted Stouffer Zc</th>
<th>P Value</th>
<th>Effect Size</th>
<th>Mantel-Haenszel OR</th>
<th>CI Significance</th>
<th>Effect Size</th>
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<td><strong>Preadmission patient preparation</strong></td>
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<tr>
<td>Prevent or reduction of perioperative anemia</td>
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<tr>
<td>Erythropoietin vs. placebo</td>
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<td>—</td>
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<td>—</td>
<td>0.38</td>
<td>0.27-0.53</td>
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<tr>
<td>Patients transfused</td>
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<td>—</td>
<td>—</td>
<td>—</td>
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<td>—</td>
<td>0.45</td>
<td>0.26-0.78</td>
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<td>Pts. transfused (without iron)</td>
<td>8</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>0.34</td>
<td>0.23-0.52</td>
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<tr>
<td>Patients transfused (with iron)</td>
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<td>—</td>
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<tr>
<td><strong>Antifibrinolics for Prophylaxis of Excessive Bleeding</strong></td>
<td></td>
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<tr>
<td>e-Aminocaproic acid vs. placebo (administered before or during surgery)</td>
<td>7</td>
<td>58.34</td>
<td>0.001</td>
<td>-5.35</td>
<td>0.001</td>
<td>-0.28</td>
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<td>0.490</td>
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<td>9</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>0.58</td>
<td>0.33-0.96</td>
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<tr>
<td>Tranexamic acid vs. placebo (administered before or during surgery)</td>
<td>10</td>
<td>68.83</td>
<td>0.001</td>
<td>-4.41</td>
<td>0.001</td>
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<td>0.340</td>
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<td>Intraoperative blood loss</td>
<td>12</td>
<td>172.51</td>
<td>0.001</td>
<td>-10.20</td>
<td>0.001</td>
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<td>0.001</td>
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<td>Total blood loss</td>
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<td>-6.22</td>
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<td>-0.30</td>
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<tr>
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<td>—</td>
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<td>0.29</td>
<td>0.13-0.86</td>
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<tr>
<td>Tranexamic acid vs. placebo (administered after surgery)</td>
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<td>91.77</td>
<td>0.001</td>
<td>-10.84</td>
<td>0.001</td>
<td>-0.59</td>
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<td>0.043</td>
<td>0.001</td>
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<tr>
<td>Patients transfused</td>
<td>6</td>
<td>—</td>
<td>—</td>
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<td>—</td>
<td>—</td>
<td>0.33</td>
<td>0.49-2.38</td>
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<tr>
<td><strong>Acute Normovolemic Hemodilution (ANH)</strong></td>
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<tr>
<td>ANH vs. no ANH</td>
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<td>0.001</td>
<td>-2.79</td>
<td>0.003</td>
<td>-0.21</td>
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<tr>
<td>Patients transfused with allogeneic blood</td>
<td>11</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>0.59</td>
<td>0.38-0.90</td>
<td>—</td>
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<tr>
<td>ANH + intraoperative blood recovery vs. intraoperative blood recovery</td>
<td>7</td>
<td>64.52</td>
<td>0.001</td>
<td>-5.05</td>
<td>0.001</td>
<td>-0.21</td>
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<td>0.011</td>
<td>0.017</td>
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<td>Volume transfused with allogeneic blood</td>
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<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>0.71</td>
<td>0.48-1.05</td>
<td>—</td>
</tr>
<tr>
<td>Patients transfused with allogeneic blood</td>
<td>13</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>0.29</td>
<td>0.10-1.22</td>
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<tr>
<td><strong>Intraoperative and postoperative interventions</strong></td>
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<tr>
<td>Restrictive vs. liberal transfusion protocol</td>
<td>5</td>
<td>49.88</td>
<td>0.001</td>
<td>-3.31</td>
<td>0.001</td>
<td>-0.13</td>
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<td>Intraoperative blood recovery vs. conventional transfusion</td>
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<td>66.07</td>
<td>0.001</td>
<td>-4.16</td>
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<td>-0.26</td>
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<td>0.036</td>
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<tr>
<td>Volume transfused with allogeneic blood</td>
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<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>0.29</td>
<td>0.10-1.22</td>
<td>—</td>
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<tr>
<td>Patients transfused with allogeneic blood†</td>
<td>6</td>
<td>51.72</td>
<td>0.001</td>
<td>-2.34</td>
<td>0.010</td>
<td>-0.11</td>
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<tr>
<td>Postoperative blood loss</td>
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<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>0.92</td>
<td>0.51-1.66</td>
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(Continued)
### Table 2. Continued

<table>
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<tr>
<th>Linkages</th>
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<th>P Value</th>
<th>Weighted Stouffer Zc</th>
<th>P Value</th>
<th>Effect Size</th>
<th>Mantel-Haenszel OR</th>
<th>CI</th>
<th>Significance</th>
<th>Effect Size</th>
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<td><strong>Topical hemostatics</strong></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fibrin glue vs. no fibrin glue</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Postop/total blood loss</td>
<td>11</td>
<td>145.03</td>
<td>0.001</td>
<td>-4.34</td>
<td>0.001</td>
<td>-0.29</td>
<td>—</td>
<td>—</td>
<td>0.001</td>
<td>0.001</td>
</tr>
<tr>
<td>Patients transfused</td>
<td>7</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>0.58</td>
<td>0.34–0.97</td>
<td>—</td>
<td>0.012</td>
</tr>
<tr>
<td>Factor VII vs. no Factor VII*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blood volume transfused</td>
<td>5</td>
<td>44.55</td>
<td>0.001</td>
<td>-0.01</td>
<td>0.496</td>
<td>-0.21</td>
<td>—</td>
<td>—</td>
<td>0.075</td>
<td>0.001</td>
</tr>
</tbody>
</table>
| Patients transfused† | 6   | —                 | —       | —                    | —       | —           | 0.16              | 0.03–2.85 | —            | 0.001       *

* Double-blind studies only. † DerSimonian-Laird random effects odds ratio.
CI = 99% confidence interval; OR = odds ratio; pts = patients.

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### Table 3. Consultant Survey Responses*

<table>
<thead>
<tr>
<th>Percent Responding to Each Item</th>
<th>N</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Uncertain</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>I. Patient Evaluation:</strong></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>1. Review previous medical records and interview the patient or family to identify previous blood transfusion, history of drug-induced coagulopathy, presence of congenital coagulopathy, history of thrombotic events, and risk factors for organ ischemia</td>
<td>74</td>
<td>68.9†</td>
<td>24.3</td>
<td>2.7</td>
<td>4.1</td>
<td>0.0</td>
</tr>
<tr>
<td>2. Inform patients of the potential risks vs. benefits of blood transfusion and elicit their preferences</td>
<td>74</td>
<td>75.7†</td>
<td>12.2</td>
<td>8.1</td>
<td>4.1</td>
<td>0.0</td>
</tr>
<tr>
<td>3. Review available laboratory test results including hemoglobin, hematocrit, and coagulation profiles and order additional laboratory tests depending on a patient's medical condition (e.g., coagulopathy, anemia)</td>
<td>74</td>
<td>91.9†</td>
<td>6.8</td>
<td>1.4</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>4. Conduct a physical examination of the patient (e.g., ecchymoses, petechiae, pallor)</td>
<td>74</td>
<td>58.1†</td>
<td>29.7</td>
<td>10.8</td>
<td>1.4</td>
<td>0.0</td>
</tr>
</tbody>
</table>

(Continued)
II. Preadmission Patient Preparation:

5. Erythropoietin with or without iron may be administered when possible to reduce the need for allogeneic blood in select patient populations (e.g., renal insufficiency, anemia of chronic disease, refusal of transmission)

6. Administer iron to patients with iron deficiency anemia if time permits

7. In consultation with an appropriate specialist, discontinue anticoagulation therapy (e.g., warafin, anti-Xa drugs, antithrombin agents) for elective surgery

8. If clinically possible, discontinue nonaspirin antiplatelet agents (e.g., thienopyridines such as clopidogrel, ticagrelor, or prasugrel) for a sufficient time in advance of surgery, except for patients with a history of percutaneous coronary interventions

9. The risk of thrombosis vs. the risk of increased bleeding should be considered when altering anticoagulation status

10. Assure that blood and blood components are available for patients when significant blood loss or transfusion is expected

11. When autologous blood is preferred, the patient should be offered the opportunity to donate blood before admission only if there is adequate time for erythropoietic reconstitution

III. Preprocedure Preparation:

Blood Management Protocols

12. Employ multimodal protocols or algorithms as strategies to reduce the usage of blood products

13. A restrictive red blood cell transfusion strategy may be used to reduce transfusion requirements

14. A protocol for avoidance of transfusion (i.e., bloodless surgery) may be used as a strategy to reduce blood loss for patients in whom transfusion is refused or is not possible

15. Use massive transfusion protocol when available as a strategy to optimize the delivery of blood products to massively bleeding patients

16. Use a maximal surgical blood order schedule, when available and in accordance with your institutional policy, as a strategy to improve the efficiency of blood ordering practices

Reversal of Anticoagulants

17. For urgent reversal of warafin, administer PCCs in consultation with the appropriate specialist, or administer FFP

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Table 3. Continued

<table>
<thead>
<tr>
<th>N</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Uncertain</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
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<td>72</td>
<td>43.2</td>
<td>30.6†</td>
<td>19.4</td>
<td>5.6</td>
<td>1.4</td>
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<td>71</td>
<td>63.4†</td>
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<td>2.8</td>
<td>2.8</td>
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<tr>
<td>71</td>
<td>74.6†</td>
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<td>71</td>
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<td>72</td>
<td>94.4†</td>
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<td>1.4</td>
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<tr>
<td>71</td>
<td>23.9</td>
<td>31.0†</td>
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<td>11.3</td>
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<td>72</td>
<td>66.7†</td>
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<td>4.2</td>
<td>1.4</td>
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<td>71</td>
<td>59.2†</td>
<td>35.2</td>
<td>2.8</td>
<td>1.4</td>
<td>1.4</td>
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<td>69.4†</td>
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<td>30.6†</td>
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<td>53.5†</td>
<td>35.2</td>
<td>4.2</td>
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(Continued)
Table 3. Continued

<table>
<thead>
<tr>
<th>Practice Parameters</th>
<th>Percent Responding to Each Item</th>
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<tbody>
<tr>
<td>18. Administer vitamin K for nonurgent reversal of warafin, except when rapid</td>
<td></td>
</tr>
<tr>
<td>restoration of anticoagulation after surgery is required</td>
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</tr>
<tr>
<td>Antifibrinolytics for prophylaxis of excessive bleeding</td>
<td></td>
</tr>
<tr>
<td>19. In patients at risk for excessive bleeding, use prophylactic antifibrinolytic</td>
<td>71</td>
</tr>
<tr>
<td>therapy to reduce the bleeding and risk of transfusion</td>
<td></td>
</tr>
<tr>
<td>20. Use antifibrinolytic therapy to reduce allogeneic blood transfusion in patients</td>
<td>71</td>
</tr>
<tr>
<td>undergoing cardiopulmonary bypass</td>
<td></td>
</tr>
<tr>
<td>21. Consider using antifibrinolytic therapy in other clinical circumstances at</td>
<td>69</td>
</tr>
<tr>
<td>high risk for excessive bleeding</td>
<td></td>
</tr>
<tr>
<td>Acute Normovolemic Hemodilution</td>
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</tr>
<tr>
<td>22. Use ANH to reduce allogeneic blood transfusion in patients at high risk for</td>
<td>72</td>
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<tr>
<td>excessive bleeding (e.g., major cardiac, orthopedic, thoracic, or liver surgery),</td>
<td></td>
</tr>
<tr>
<td>if possible</td>
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<tr>
<td>IV. Intraoperative and Postoperative Management of Blood Loss and Transfusions:</td>
<td></td>
</tr>
<tr>
<td>Allogeneic Red Blood Cell Transfusion</td>
<td></td>
</tr>
<tr>
<td>23. Administer blood without consideration of duration of storage</td>
<td>72</td>
</tr>
<tr>
<td>24. Leukocyte-reduced blood may be used for transfusion for the purpose of</td>
<td>72</td>
</tr>
<tr>
<td>reducing complications associated with allogeneic blood transfusion</td>
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<tr>
<td>Reinfusion of Recovered Red blood cells</td>
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<tr>
<td>25. Reinfuse recovered red Blood Cells as a blood-sparing intervention in the</td>
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</tr>
<tr>
<td>intraoperative and/or postoperative period</td>
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<tr>
<td>Intraoperative and Postoperative Patient Monitoring</td>
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<tr>
<td>26. Periodically conduct a visual assessment of the surgical field jointly with</td>
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<td>the surgeon to assess the presence of excessive microvascular (i.e., coagulopathy)</td>
<td></td>
</tr>
<tr>
<td>or surgical bleeding</td>
<td></td>
</tr>
<tr>
<td>27. Use standard methods for quantitative measurement of blood loss including</td>
<td>72</td>
</tr>
<tr>
<td>checking suction canisters, surgical sponges, and surgical drains</td>
<td></td>
</tr>
<tr>
<td>28. Monitor for perfusion of vital organs using standard ASA monitors (i.e.,</td>
<td>71</td>
</tr>
<tr>
<td>blood pressure, heart rate, oxygen saturation, electrocardiography) in addition to</td>
<td></td>
</tr>
<tr>
<td>observing clinical symptoms and physical examination features</td>
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<td>29. Additional monitoring may include echocardiography, renal monitoring (urine</td>
<td>72</td>
</tr>
<tr>
<td>output), cerebral monitoring (i.e., cerebral oximetry and NIRS), analysis of arterial</td>
<td></td>
</tr>
<tr>
<td>blood gases, and mixed venous oxygen saturation</td>
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(Continued)
### Practice Guidelines

30. If anemia is suspected, monitor hemoglobin/hematocrit values based on estimated blood loss and clinical signs.

31. If coagulopathy is suspected, obtain viscoelastic assays (e.g., thromboelastography and ROTEM, when available), as well as platelet count.

32. If coagulopathy is suspected, in addition to the above, obtain standard coagulation tests (e.g., INR, aPTT, fibrinogen concentration), as well as platelet count.

33. During and after transfusion, periodically check for hyperthermia, hemoglobinuria, microvascular bleeding, hypoxemia, respiratory distress, increased peak airway pressure, urticaria, hypotension, and signs of hypocalcemia.

34. Before instituting therapy for transfusion reactions, stop the blood transfusion and order appropriate diagnostic testing.

35. In patients with excessive bleeding:
   - (a) obtain a platelet count before transfusion of platelets if possible
   - (b) in addition, obtain a test of platelet function, if available, in patients with suspected or drug-induced (e.g., clopidogrel) platelet dysfunction.

36. In patients with excessive bleeding, obtain coagulation tests (i.e., PT or INR and aPTT) before transfusion of FFP, if possible.

37. In patients with excessive bleeding, assess fibrinogen levels before the administration of cryoprecipitate, if possible.

38. In patients with excessive bleeding and platelet dysfunction, consider the use of desmopressin.

39. In patients with excessive bleeding and increasing fibrinogen levels, consider the use of fibrinogen concentrates.

40. In patients with excessive bleeding and increased INR, consider the use of antifibrinolytics (i.e., ε-aminocaproic acid, tranexamic acid), if not already being used.

41. In patients with excessive bleeding and increased INR, consider the use of PCCs.

42. In patients with excessive bleeding and increased INR, consider the use of recombinant activated factor VII.

43. When traditional options for treating excessive bleeding due to coagulopathy have been exhausted, consider administering recombinant activated factor VII.

---

* * = the number of consultants who responded to each item. † Median.
Table 4. ASA Membership Survey Responses*

<table>
<thead>
<tr>
<th>N</th>
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(Continued)
### Table 4. Continued

<table>
<thead>
<tr>
<th>Practice Guidelines</th>
<th>Percent Responding to Each Item</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
</tr>
<tr>
<td>13. A restrictive red blood cell transfusion strategy may be used to reduce transfusion requirements</td>
<td>346</td>
</tr>
<tr>
<td>14. A protocol for avoidance of transfusion (i.e., bloodless surgery) may be used as a strategy to reduce blood loss for patients in whom transfusion is refused or is not possible</td>
<td>344</td>
</tr>
<tr>
<td>15. Use massive transfusion protocol when available as a strategy to optimize the delivery of blood products to massively bleeding patients</td>
<td>345</td>
</tr>
<tr>
<td>16. Use a maximal surgical blood order schedule, when available and in accordance with your institutional policy, as a strategy to improve the efficiency of blood ordering practices</td>
<td>342</td>
</tr>
<tr>
<td><strong>Reversal of Anticoagulants</strong></td>
<td></td>
</tr>
<tr>
<td>17. For urgent reversal of warafin, administer PCCs in consultation with the appropriate specialist, or administer FFP</td>
<td>345</td>
</tr>
<tr>
<td>18. Administer vitamin K for nonurgent reversal of warafin, except when rapid restoration of anticoagulation after surgery is required</td>
<td>344</td>
</tr>
<tr>
<td><strong>Antifibrinolytics for prophylaxis of excessive bleeding</strong></td>
<td></td>
</tr>
<tr>
<td>19. In patients at risk for excessive bleeding, use prophylactic antifibrinolytic therapy to reduce the bleeding and risk of transfusion</td>
<td>326</td>
</tr>
<tr>
<td>20. Use antifibrinolytic therapy to reduce allogeneic blood transfusion in patients undergoing cardiopulmonary bypass</td>
<td>338</td>
</tr>
<tr>
<td>21. Consider using antifibrinolytic therapy in other clinical circumstances at high risk for excessive bleeding</td>
<td>345</td>
</tr>
<tr>
<td><strong>Acute Normovolemic Hemodilution</strong></td>
<td></td>
</tr>
<tr>
<td>22. Use ANH to reduce allogeneic blood transfusion in patients at high risk for excessive bleeding (e.g., major cardiac, orthopedic, thoracic, or liver surgery), if possible</td>
<td>346</td>
</tr>
<tr>
<td><strong>IV Intraoperative and Postoperative Management of Blood Loss and Transfusions: Allogeneic Red Blood Cell Transfusion</strong></td>
<td></td>
</tr>
<tr>
<td>23. Administer blood without consideration of duration of storage</td>
<td>328</td>
</tr>
<tr>
<td>24. Leukocyte-reduced blood may be used for transfusion for the purpose of reducing complications associated with allogeneic blood transfusion</td>
<td>327</td>
</tr>
<tr>
<td><strong>Reinfusion of Recovered Red Blood Cell</strong></td>
<td></td>
</tr>
<tr>
<td>25. Reinfuse recovered red blood cells as a blood-sparing intervention in the intraoperative and/or postoperative period</td>
<td>329</td>
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</tbody>
</table>

*Practice Guidelines*
26. Periodically conduct a visual assessment of the surgical field jointly with the surgeon to assess the presence of excessive microvascular (i.e., coagulopathy) or surgical bleeding

<table>
<thead>
<tr>
<th>N</th>
<th>Strongly Agree</th>
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<tr>
<td>329</td>
<td>69.0†</td>
<td>23.7</td>
<td>6.1</td>
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</tbody>
</table>

27. Use standard methods for quantitative measurement of blood loss including checking suction canisters, surgical sponges, and surgical drains

<table>
<thead>
<tr>
<th>N</th>
<th>Strongly Agree</th>
<th>Agree</th>
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<th>Strongly Disagree</th>
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<tbody>
<tr>
<td>329</td>
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<td>3.3</td>
<td>0.0</td>
<td>0.6</td>
</tr>
</tbody>
</table>

28. Monitor for perfusion of vital organs using standard ASA monitors (i.e., blood pressure, heart rate, oxygen saturation, electro-cardiography) in addition to observing clinical symptoms and physical examination features

<table>
<thead>
<tr>
<th>N</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Uncertain</th>
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<th>Strongly Disagree</th>
</tr>
</thead>
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<tr>
<td>326</td>
<td>86.5†</td>
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<td>0.9</td>
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</tr>
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</table>

29. Additional monitoring may include echocardiography, renal monitoring (urine output), cerebral monitoring (i.e., cerebral oximetry and NIRS), analysis of arterial blood gasses, and mixed venous oxygen saturation

<table>
<thead>
<tr>
<th>N</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Uncertain</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
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</thead>
<tbody>
<tr>
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<td>62.7†</td>
<td>28.7</td>
<td>7.0</td>
<td>1.2</td>
<td>0.3</td>
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</tbody>
</table>

30. If anemia is suspected, monitor hemoglobin/hematocrit values based on estimated blood loss and clinical signs

<table>
<thead>
<tr>
<th>N</th>
<th>Strongly Agree</th>
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<td>30.7</td>
<td>5.2</td>
<td>2.1</td>
<td>1.2</td>
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</table>

31. If coagulopathy is suspected, obtain viscoelastic assays (e.g., thromboelastography and ROTEM) when available, as well as platelet count

<table>
<thead>
<tr>
<th>N</th>
<th>Strongly Agree</th>
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<th>Disagree</th>
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<tr>
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<td>33.7†</td>
<td>17.2</td>
<td>6.1</td>
<td>0.6</td>
</tr>
</tbody>
</table>

32. If viscoelastic assays are not available, obtain standard coagulation tests (e.g., INR, aPTT, fibrinogen concentration), as well as platelet count for monitoring

<table>
<thead>
<tr>
<th>N</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Uncertain</th>
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<th>Strongly Disagree</th>
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<td>5.8</td>
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</tbody>
</table>

33. During and after transfusion, periodically check for hyperthermia, hemoglobinuria, microvascular bleeding, hypoxemia, respiratory distress, increased peak airway pressure, urticaria, hypotension, and signs of hypocalcemia

<table>
<thead>
<tr>
<th>N</th>
<th>Strongly Agree</th>
<th>Agree</th>
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<td>71.3†</td>
<td>25.1</td>
<td>3.3</td>
<td>0.3</td>
<td>0.0</td>
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</table>

34. Before instituting therapy for transfusion reactions, stop the blood transfusion and order appropriate diagnostic testing

### Treatment of Excessive Bleeding

35. In patients with excessive bleeding:

   (a) Obtain a platelet count before transfusion of platelets, if possible

<table>
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<tr>
<th>N</th>
<th>Strongly Agree</th>
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<tr>
<td>331</td>
<td>46.5</td>
<td>25.4†</td>
<td>15.7</td>
<td>9.4</td>
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</table>

   (b) In addition, obtain a test of platelet function, if available, in patients with suspected or drug-induced (e.g., clopidogrel) platelet dysfunction

<table>
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<th>Disagree</th>
<th>Strongly Disagree</th>
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</thead>
<tbody>
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<td>29.2</td>
<td>26.7†</td>
<td>21.0</td>
<td>16.4</td>
<td>6.7</td>
</tr>
</tbody>
</table>

36. In patients with excessive bleeding, obtain coagulation tests (i.e., PT or INR and aPTT) before transfusion of FFP, if possible

<table>
<thead>
<tr>
<th>N</th>
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<th>Uncertain</th>
<th>Disagree</th>
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<tbody>
<tr>
<td>329</td>
<td>42.6</td>
<td>32.2†</td>
<td>14.9</td>
<td>7.6</td>
<td>2.7</td>
</tr>
</tbody>
</table>

37. In patients with excessive bleeding, assess fibrinogen levels before the administration of cryoprecipitate, if possible

<table>
<thead>
<tr>
<th>N</th>
<th>Strongly Agree</th>
<th>Agree</th>
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(Continued)
Table 4.

<table>
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<tr>
<th>Percent Responding to Each Item</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Uncertain</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>38. In patients with excessive bleeding and platelet dysfunction, consider topical hemostatics such as fibrin glue or thrombin gel</td>
<td>328 35.1 40.9†</td>
<td>323 48.6 35.3†</td>
<td>330 39.4 40.0†</td>
<td>327 39.4 40.0†</td>
<td>327 37.0 46.7†</td>
</tr>
<tr>
<td>39. In patients with excessive bleeding, consider the use of antifibrinolytics (i.e., ε-aminocaproic acid, tranexamic acid), if not already being used</td>
<td>323 48.6 35.3†</td>
<td>330 39.4 40.0†</td>
<td>327 39.4 40.0†</td>
<td>327 39.4 40.0†</td>
<td>327 37.0 46.7†</td>
</tr>
<tr>
<td>40. In patients with excessive bleeding and increased INR, consider the use of PCC concentrate</td>
<td>328 35.1 40.9†</td>
<td>323 48.6 35.3†</td>
<td>330 39.4 40.0†</td>
<td>327 39.4 40.0†</td>
<td>327 37.0 46.7†</td>
</tr>
<tr>
<td>41. When traditional options for treating excessive bleeding due to coagulopathy have been exhausted, consider administering recombinant activated factor VII</td>
<td>328 35.1 40.9†</td>
<td>323 48.6 35.3†</td>
<td>330 39.4 40.0†</td>
<td>327 39.4 40.0†</td>
<td>327 37.0 46.7†</td>
</tr>
<tr>
<td>42. In patients with excessive bleeding and platelet dysfunction, consider the use of fibrinogen concentrate</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>43. When traditional options for treating excessive bleeding due to coagulopathy have been exhausted, consider administering recombinant activated factor VII</td>
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<td></td>
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<td></td>
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</tbody>
</table>

* N = the number of ASA members who responded to each item. † Median.

NIRS = near infrared spectroscopy; INR = International Normalized Ratio; aPTT = activated partial thromboplastin time; PT = prothrombin time.

Acknowledgments

Supported by the American Society of Anesthesiologists and developed under the direction of Jeffrey L. Apfelbaum, M.D., Chair, Committee on Standards and Practice Parameters.

Competing Interests

The authors declare no competing interests.

Correspondence

Address correspondence to the American Society of Anesthesiologists: 1061 American Lane, Schaumburg, Illinois 60173. These updated Practice Guidelines, and all ASA Practice Parameters, may be obtained at no cost through the Journal Web site, www.anesthesia.org.

References


