

# Transfusion considerations for adult surgical patients

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These slides are part of a transfusion toolkit offering an overview of obstetric hemorrhage, and considerations for cardiac and pediatric surgery. For more information, please visit the <u>MPOG Transfusion Toolkit</u>.

#### Acknowledgements

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#### **Previous Versions**

Version 2: July 2022

Version 1: July 2018





# 01

Review incidence, risk, and costs associated with transfusion and review of blood components 02

Review preoperative transfusion considerations 03

Review intraoperative transfusion considerations 04

Review postoperative transfusion considerations



### **Toolkit Overview**

- This presentation is part of a perioperative transfusion toolkit offering an overview of transfusion practices and considerations for cardiac, pediatric and obstetric surgical populations as well as general recommendations for patient blood management.
- For other patient blood management recommendations please reference additional toolkit components:
  - <u>Transfusion Management for the Obstetric Hemorrhage</u>
  - Transfusion Management for the Cardiac Surgical Patient (Coming soon!)
  - Transfusion Management for the Pediatric Surgical Patient (Coming soon!)
  - <u>MPOG Perioperative Blood Management Toolkit webpage</u>



# **Objective #1: Background**





# Why are blood products administered?

- Treatment of anemia
- Address clotting deficiencies
- Ultimately, to improve tissue oxygenation







References: Lotterman S, Sharma S: Blood Transfusion. StatPearls Publishing, 2023

#### **Blood Product Administration is Common**

- Every 2 seconds, someone in the U.S. requires a blood product
- Nearly 16 million blood components are transfused each year in the US
- Nearly 5,000 units of platelets and 6,500 units of plasma are required daily in the US
- Approximately 29,000 units of red blood cells are needed every day in the US  $\,$
- Approximately 15 million units RBCs, platelets, and plasma were transfused in 2021, averaging 42,000 blood products transfused daily

- 1. American Red Cross: Importance of Blood Supply 2024 at https://www.redcrossblood.org/donate-blood/how-to-donate/how-blood-donations-help/blood-needs-blood-supply.html
- 2. Cho BC, Serini J, Zorrilla-Vaca A, Scott MJ, Gehrie EA, Frank SM, Grant MC: Impact of Preoperative Erythropoietin on Allogeneic Blood Transfusions in Surgical Patients: Results From a Systematic Review and Meta-analysis. Anesth Analg 2019; 128:981–92



#### **MPOG Transfusion Data - 2024**



Transfusion Rates by Site January - December 2024

Total MPOG Cases with Transfusion: 38,758\*





Breakdown of Units Transfused per Case January - December 2024





#### **Transfusions may case harm**

Table 1. Approximate Per-Unit Risk for Red Blood Cell (RBC) Transfusion in the US <sup>a</sup>	
Adverse event	Approximate risk per RBC transfusion
Febrile reaction	1:161 <sup>3</sup>
Allergic reaction	1:345 <sup>3</sup>
Transfusion-associated circulatory overload	1:125 <sup>3</sup>
Transfusion-related acute lung injury	1:1250 <sup>3</sup>
Anaphylactic reactions	1:5000 <sup>3</sup>
Hepatitis B virus	1:11000004
Hepatitis C virus	1:12000004
HIV	1:16000004

#### Reference:

1. Carson JL, Stanworth SJ, Guyatt G, Valentine S, Dennis J, Bakhtary S, Cohn CS, Dubon A, Grossman BJ, Gupta GK, Hess AS, Jacobson JL, Kaplan LJ, Lin Y, Metcalf RA, Murphy CH, Pavenski K, Prochaska MT, Raval JS, Salazar E, Saifee NH, Tobian AAR, So-Osman C, Waters J, Wood EM, Zantek ND, Pagano MB: Red Blood Cell Transfusion: 2023 AABB International Guidelines. JAMA 2023 doi:10.1001/jama.2023.12914



#### **Causes of transfusion related deaths (per FDA)**



Transfusion reaction	Deaths (2022)
Transfusion associated circulatory overload (TACO)	15
Transfusion related acute lung injury (TRALI)	7
Blood contamination	5
Hemolytic transfusion reaction (HTR)	5
Anaphylaxis	4
Transfusion reaction (undetermined type)	3
Hemolytic transfusion reaction (HTR) non-ABO	2

#### All US transfusion related fatalities and donation related deaths are reported to the FDA

#### References

1. Center for Biologics Evaluation, Research: Transfusion/Donation Fatalities 2023 at <a href="https://www.fda.gov/vaccines-blood-biologics/report-problem-center-biologics-evaluation-research/transfusiondonation-fatalities">https://www.fda.gov/vaccines-blood-biologics/report-problem-center-biologics-evaluation-research/transfusiondonation-fatalities</a>



# Blood acquisition is the largest expense for a hospital's blood bank $^{1\mathcharceleft}$

- Approximate average acquisition cost for an RBC unit in 2021 was approximately \$225 (\$210 - \$240) per hospital's blood bank
- While labor associated with transfusion is difficult to quantify, a transfusion procedure in 2021 was billed for approximately \$2,000
- The approximate median negotiated out-of-pocket price for one PRBC unit in 2021 was \$1,388 (\$1,087 -\$1,911)
- The approximate median negotiated rate for health insurance companies in 2021 was \$ 1,589 (\$1,198 -\$3,093)



Image source: Blood Management Program Yields

- 1. Ja cobs JW, Diaz M, Arevalo Salazar DE, Tang A, Stephens LD, Booth GS, Lehmann CU, Adkins BD: United States blood pricing: A cross-sectional analysis of charges and reimbursement at 200 US hospitals. Am J Hematol 2023; 98:E179–82
- 2. Donated blood products median amount paid by hospitals U.S. 2021 at https://www.statista.com/statistics/1204177/donated-blood-products-median-amont-paid-by-hospitals-us/



### **Summary of Blood Components**





### Homologous vs Autologous Transfusions

#### Autologous

Patient donates their own blood for future use. Collected blood is stored and transfused back to the patient if needed during or after procedure<sup>1</sup>

#### **Homologous (allogeneic)**

Transfusion of blood or blood components obtained from a compatible donor to a patient<sup>1</sup> Can be further divided into directed and non-directed transfusions

- Non-directed transfusion: Donation from a living donor with no known relation to recipient<sup>2</sup>
- Directed transfusion: Donated blood from ABO and Rh-compatible family member<sup>2</sup>





Image source: <u>Autologous Blood Transfusion</u>

#### Image source: Young Blood: When Conservation is Critical

- 1. Sam AM, Gupta D, Radhakrishnan A, Sethuraman M, Dash PK, Pitchai S, Kesava pisharady K: Autologous versus allogeneic blood transfusion: A comparative study of the peri-operative outcomes in a tertiary care hospital in South India amidst the COVID-19 pandemic. Transfus Apher Sci 2023; 62:103753
- 2. Autologous and Directed Donations at https://www.redcrossblood.org/donate-blood/how-to-donate/types-of-blood-donations/autologous-and-directed-donations.html



# Packed Red Blood Cells (PRBCs)

- Red blood cells constitute 45% of the volume of blood
- Consists of erythrocytes concentrated from whole blood donation or by apheresis (a process where specific blood components are separated from the whole blood by machine)
- Typically contain citrate anticoagulant and one of several types of preservative solutions
  - Depending on the preservative, the hematocrit of RBCs is 55-65%
  - + Each unit contains 50-80 g of hemoglobin and  ${\sim}250~{\rm mg}$  iron
- In a non-bleeding, non-hemolyzing adult, hemoglobin should equilibrate within 15 minutes after transfusion of RBCs
- One unit should increase hemoglobin by ~1 g/dL (or hematocrit by 3%)



- 1. American Red Cross: Compendium of Transfusion Practices 2021 at https://www.redcross.org/content/dam/redcrossblood/hospital-page-documents/334401\_compendium\_v04jan2021\_bookmarkedworking\_rwv01.pdf
- 2. American Red Cross: Importance of Blood Supply 2024 at https://www.redcrossblood.org/donate-blood/how-to-donate/how-blood-donations-help/blood-needs-blood-supply.html



### Plasma

- Plasma for transfusion is obtained by centrifuging whole blood or through apheresis
- Post-collection processing or storage methods can result in variation in levels of coagulation factors, fibrinolytic proteins, immunoglobulins, albumin, and other proteins
- Plasma is generally anticoagulated with citrate
- Whole blood-derived units contain approximately 200 250 mL and apheresis-derived units containing 400 – 600 mL plasma
- Plasma administration is indicated for bleeding or prophylaxis of bleeding due to deficiency of multiple coagulation factors OR urgent reversal of warfarin when prothrombin complex concentrate (PCC) is not available



#### References:

1. American Red Cross: Importance of Blood Supply 2024 at https://www.redcrossblood.org/donate-blood/how-to-donate/how-blood-donations-help/blood-needs-blood-supply.html



# Cryoprecipitate

- Cryoprecipitate is an acellular blood component
- It is prepared by thawing one unit of fresh frozen plasma (FFP) at a temperature of 1-6 °C and recovering the cold insoluble precipitate  $^{1-2}$
- Cryoprecipitate contains concentrated levels of fibrinogen, Factor VIII, von Willebrand factor (vWF), Factor XIII, and fibronectin<sup>1-2</sup>
- Each unit of cryoprecipitate contains and average of 215 IU of Factor VIII and 700 mg of Fibrinogen with an average volume range of 20-25mL. Red Cross pools contain 5 units)<sup>1,3</sup>
- Although compatibility testing is unnecessary, administration of cryoprecipitate that is ABO compatible with recipients red cells is common practice  $^1$
- When thawed, cryoprecipitate must be administered within 6 hours, as levels of Factor VIII activity can be significantly decreased<sup>2</sup>

#### References:

- 1. Cryoprecipitate at https://www.redcrossblood.org/biomedical-services/blood-products-and-services/cryoprecipitate.html
- 2. Nascimento B, Levy JH, Tien H, Da Luz LT: Cryoprecipitate transfusion in bleeding patients. CJEM 2020; 22:S4-11
- 3. American Red Cross: Compendium of Transfusion Practices 2021 at https://www.redcross.org/content/dam/redcrossblood/hospital-page-documents/334401\_compendium\_v04jan2021\_bookmarkedworking\_rwv01.pdf



Image source: Callum, Jeannie L., and Bartolomeu Nascimento. 2016. "Cryopre Transfusion." In Trauma Induced Coagulopathy, 339–46. Cham: Springer Interna Publishing.

### **Platelets**

- Platelets are the smallest cells of blood
- ~93% platelet transfusions are apheresis platelets (collected from a single donor – Single Donor Platelets)
- Contain  $\geq 3.0 \ge 10^{11}$  platelets (billion = 10<sup>9</sup>) per unit in 100-500 mL of plasma or plasma mixed with an additive solution)<sup>1-2</sup>
- Random Donor Platelets are typically comprised of 4-6 units pooled together. A single unit of platelets, contains ~55 x 10<sup>9</sup> platelets in 40 mL 70 mL of plasma<sup>1,3</sup>
- In a stable, afebrile, non-bleeding adult, transfusion of one unit should raise recipient's platelet count by approximately 30,000 (per microliter of blood)<sup>3</sup>



Image source: Canadian Blood Services

- 1. American Red Cross: Compendium of Transfusion Practices 2021 at <a href="https://www.redcross.org/content/dam/redcrossblood/hospital-page-documents/334401\_compendium\_v04jan2021\_bookmarkedworking\_rwv01.pdf">https://www.redcross.org/content/dam/redcrossblood/hospital-page-documents/334401\_compendium\_v04jan2021\_bookmarkedworking\_rwv01.pdf</a>
- 2. American Red Cross: Importance of Blood Supply 2024 at https://www.redcrossblood.org/donate-blood/how-to-donate/how-blood-donations-help/blood-needs-blood-supply.html
- 3. Hess AS, Ramamoorthy J, Hess JR: Perioperative Platelet Transfusions. Anesthesiology 2021; 134:471–9



### **Patient Blood Management – an introduction**

- Patient Blood Management (PBM) is a framework and comprehensive approach focused on identifying and addressing the root causes of blood anomalies, rather than relying solely on short-term solutions like transfusions
- In the early 1960s, cardiovascular surgeon Denton Cooley was an early adopter of these principles to accommodate Jehovah's Witness patients who requested treatment without allogeneic transfusion.
- Dr. Cooley and his team adopted a 3-step approach which later evolved into the three pillars of Patient Blood Management:
  - Optimizing the patient's red cell mass preoperatively
  - Utilizing surgical, anesthetic, and pharmacological techniques to minimize blood loss
  - Tolerating postoperative anemia

<sup>1.</sup> Shander A, Javidroozi M, Naqvi S, Aregbeyen O, Caylan M, Demir S, Juhl A: An update on mortality and morbidity in patients with very low postoperative hemoglobin levels who decline blood transfusion (CME). Transfusion 2014; 54:2688–95; quiz 2687



### **Patient Blood Management (PBM) Principles**



#### **Potential Benefits**<sup>2</sup>

- Fewer transfusions
- Avoidance of potential complications
- Decreased hospitalization
- Fewer readmissions
- Reduction in the many associated costs

Image source: International Society of Blood Transfusion

#### More information on PBM Programs can be found <u>here</u>

- 1. Goodnough LT, Shander A: Patient blood management. Anesthesiology 2012; 116:1367–76
- 2. American Red Cross: Compendium of Transfusion Practices 2021 at https://www.redcross.org/content/dam/redcrossblood/hospital-page-documents/334401\_compendium\_v04jan2021\_bookmarkedworking\_rwv01.pdf



### **Summary of transfusion overview**

- Blood products are administered to enhance tissue oxygenation
- Acquiring blood is the most significant expense for a hospital's blood bank
- Commonly transfused blood components include red blood cells, plasma, cryoprecipitate, and plasma
- Transfusions carry risks, such as allergic reaction, transfusion-associated circulatory overload, anaphylactic reactions, and Hepatitis B & C, along with other complications that could lead to death
- Patient blood management is a comprehensive approach focused on identifying and addressing the underlying causes of blood abnormalities rather than short-term solutions like transfusions
- The potential benefits of patient blood management include fewer transfusions, avoidance of potential complications, decreased hospitalization, fewer readmissions, and lower costs associated with transfusions



### **Objective #2: Preoperative Considerations**





#### **Review Preoperative Plan for Blood Management**

- Perform several days to weeks in advance, if possible.
  - Review Previous Medical Records & conduct a Patient/Family Interview
    - ✓ Previous blood transfusion?
    - ✓ History of drug-induced coagulopathy?
    - ✓ Presence of congenital coagulopathy?
    - $\checkmark$  Risk factors for organ ischemia?
    - ✓ History of thrombotic events?
- Review existing lab results (hemoglobin, hematocrit, coagulation profiles)
- Order additional lab tests based on patient's condition (anemia, coagulopathy)
- Conduct physical exam (ecchymosis, petechiae, pallor)

Prior to surgery, inform patient of potential risks vs. benefit of blood transfusion and identify patient preferences.

<sup>1.</sup> ASA Task Force on Perioperative Blood Management. (2015). Practice guidelines for perioperative blood management: an updated report by the American Society of Anesthesiologists Task Force on Perioperative Blood Management\*. Anesthesiology. 122(2):241-75.



# Identifying and treating anemia preoperatively

- Preop anemia is a strong predictor of postoperative complications  $^{1}\,$
- Preop assessment and treatment of anemia helps reduce RBC transfusion requirements in the perioperative phase.<sup>2</sup>
- Most common anemia is iron-deficiency anemia: ferritin < 30 ng/mL or transferrin saturation <20%<sup>1</sup>
- Commonly used definitions of anemia
  - Mild: hemoglobin between 10 g/dL 12 g/dL<sup>2-3</sup>
  - + Moderate: hemoglobin between 8 g/dL to 10 g/dL<sup>2-3</sup>
  - + Severe: hemoglobin 6.5 g/dL to 7.9 g/dL<sup>2-3</sup>
  - + Life threatening: hemoglobin less than 6.5 g/dL  $^{2\text{-}3}$



Image source: Shaik, Z. A. (2019, May 21). Anemia.; Getcured Apothecary Private Limited. <u>https://getcured.xyz/anemia/</u>

- 1. Oehme F, Hempel S, Knote R, Addai D, Distler M, Muessle B, Bork U, Weitz J, Welsch T, Kahlert C: Perioperative Blood Management of Preoperative Anemia Determines Long-Term Outcome in Patients with Pancreatic Surgery. J Gastrointest Surg 2021; 25:2572–81
- 2. American Red Cross: Compendium of Transfusion Practices 2021 at <a href="https://www.redcross.org/content/dam/redcrossblood/hospital-page-documents/334401\_compendium\_v04jan2021\_bookmarkedworking\_rwv01.pdf">https://www.redcross.org/content/dam/redcrossblood/hospital-page-documents/334401\_compendium\_v04jan2021\_bookmarkedworking\_rwv01.pdf</a>
- 3. Badireddy M, Baradhi KM: Chronic anemia, StatPearls. Treasure Island (FL), StatPearls Publishing, 2024
- 4. National Institute of Health: Common terminology criteria for adverse events V3.0 (ctcae). Handydex, 2017 at https://ctep.cancer.gov/protocoldevelopment/electronic\_applications/docs/ctcae\_v5\_quick\_reference\_8.5x11.pdf



#### **Examples of Laboratory Tests to Assess Anemia and Coagulation Status Preoperatively**

- Complete Blood Count (CBC)
- Reticulocyte Count
- Vitamin B12
- Folate
- Iron studies
- Erythropoietin
- PT (prothrombin time) / aPTT ( activated partial thromboplastin time / INR (international normalized ratio)

- 1. Smith D: Anemia in the Presurgical Patient Recognition Diagnosis and Management at <a href="https://www.sabm.org/anemia-in-the-presurgical-patient-recognition-diagnosis-and-management">https://www.sabm.org/anemia-in-the-presurgical-patient-recognition-diagnosis-and-management</a>
- 2. Graetz TJ: Perioperative blood management: Strategies to minimize transfusions, UpToDate. Edited by O'Connor MF, Nussmeier NA. Waltham, MA, UpToDate, 2023





### Examples of Preoperative Treatment of Anemia in Elective Cases

- Vitamin  $B_{12}$  deficiency:  $B_{12}$  intramuscular injection<sup>1</sup>
- Folate deficiency: folate replacement<sup>1</sup>
- Iron-deficiency anemia <sup>1</sup>
  - Iron PO x4 weeks prior to surgery, recheck levels and continue until day of surgery if responding
  - Consider IV iron if no response or intolerance to oral iron
  - <u>Note</u>: Oral iron takes  $\geq$  15 days to take effect, has poor GI tolerance, and low adherence rates.
- Limiting lab draws or using pediatric sized specimen tubes and POC instruments when  ${\rm possible}^2$
- Epoetin Alpha daily until Hgb > 7 g/dL (4.43 mmol/L)<sup>2</sup>





<sup>1.</sup> Crowe EP, DeSimone RA: Transfusion support and alternatives for Jehovah's Witness patients. Curr Opin Hematol 2019; 26:473–9

<sup>2.</sup> Posluszny JA Jr, Napolitano LM: How do we treat life-threatening anemia in a Jehovah's Witness patient? Transfusion 2014; 54:3026–34 Image source: https://dravinashtank.in/gastro\_health/anaemia-causes-diagnosis-treatment-and-prevention/

#### **Identifying bleeding risk and potential therapies**

- Surgeries with high bleeding risk
  - Examples include major vascular, cardiac, liver transplant, major abdominal or pelvic surgery
- Factor Deficiency
  - + Hemophilia A &  $B^1\,$  consider factor VIII, factor IX, or factor XI replacement therapy
  - von Willebrand  $Disease^{1\,-}\,consider$  factor VII and TXA administration
- + Factor XI deficiency  $^1$  Consider FFP and Factor XI availability / administration
- DDVAP (1-deamino-8-d-arginine vasopressin) may be appropriate to reduce excessive bleeding and the need for transfusions in certain patients with specific platelet dysfunctions that are known to respond to this medication<sup>2</sup>

- 1. Abou-Ismail MY, Connell NT: How to manage bleeding disorders in aging patients needing surgery. Hematology Am Soc Hematol Educ Program 2021; 2021:529–35
- 2. Tibi P, McClure RS, Huang J, Baker RA, Fitzgerald D, Mazer CD, Stone M, Chu D, Stammers AH, Dickinson T, Shore-Lesserson L, Ferraris V, Firestone S, Kissoon K, Moffatt-Bruce S: STS/SCA/AmSECT/SABM Update to the Clinical Practice Guidelines on Patient Blood Management. Ann Thorac Surg 2021; 112:981–1004



### Erythropoietin

#### Impact of Preoperative Erythropoietin on Allogeneic Blood Transfusions in Surgical Patients: Results From a Systematic Review and Meta-analysis

Brian C. Cho, MD,\* Jessica Serini, MD,† Andres Zorrilla-Vaca, BS,‡ Michael J. Scott, MBChB,§ Eric A. Gehrie, MD, III Steve M. Frank, MD,\* and Michael C. Grant, MD\*

- In their systematic review and meta-analysis of randomized controlled trials, Cho et al. concluded that:
  - Preoperative erythropoietin administration is linked to a reduction in allogeneic blood transfusions during both the intraoperative and postoperative phases of care, and it also contributes to a shorter overall hospital stay
  - Preoperative erythropoietin administration does not significantly raise the risk of thromboembolic complications

<sup>1.</sup> Cho BC, Serini J, Zorrilla-Vaca A, Scott MJ, Gehrie EA, Frank SM, Grant MC: Impact of Preoperative Erythropoietin on Allogeneic Blood Transfusions in Surgical Patients: Results From a Systematic Review and Meta-analysis. Anesth Analg 2019; 128:981–92



### **Anesthetic plan for blood management**

- Type & screen if blood loss anticipated
- Determine blood products required in OR, if any
- Consider delaying elective surgery if there is an opportunity improve anemia
- Provide information to patients regarding likelihood and risk of transfusion, share possible alternatives to transfusion, and obtain informed consent<sup>1</sup>



### **Patients who refuse transfusion**

- Patients with certain religious beliefs may wish to abstain from receiving blood products or may specify when blood components can be used.
- Though studies show that refusing blood when hemoglobin is critically low can significantly increase morbidity and mortality,<sup>1</sup> specific surgical techniques and minimally invasive surgery can improve outcomes.<sup>2</sup>
- Some patients will accept intraoperative cell salvage if the circuit is continuous<sup>2</sup>
- However, each patient should be assessed individually before administration of any transfusion

- 1. Guinn NR, Cooter ML, Villal pando C, Weiskopf RB: Severe anemia associated with increased risk of death and myocardial ischemia in patients declining blood transfusion. Transfusion 2018; 58:2290–6
- 2. Crowe EP, DeSimone RA: Transfusion support and alternatives for Jehovah's Witness patients. Curr Opin Hematol 2019; 26:473–9



#### **Summary of Preoperative Considerations**

- Examine the patient's preoperative medical record and conduct an interview with the patient/family interview before the procedure
- Review existing labs including hemoglobin and hematocrit, as well as coagulation profiles
- Order additional labs based on patient's condition to identify and treat any anemia or identify any coagulopathies
- Consider postponing elective surgery if there is a chance to improve the patient's anemic condition
- Discuss the potential risks and benefits of blood transfusion with the patient and understand their preferences prior to surgery
- Identify bleeding risks and consider appropriate treatment therapies
- Evaluate whether the patient might benefit from erythropoietin
- Recognize that some patients, due to their religious beliefs, may prefer to avoid blood products or may ha e specific conditions under which blood components can be used
- Assess each patient individually before administering of any transfusion



### **Objective #3: Intraoperative considerations**

Review preoperative considerations before surgery
Transfuse based upon evidence-based hemoglobin/hematocrit triggers as well as patient physiologic status
Apply blood conservation techniques such as acute normovolemic hemodilution, hemostatic agents, and cell salvage if appropriate and available



Use POC testing to guide interventions



### **Intraoperative transfusion recommendations**

- In this Delphi consensus survey study, a panel of 33 experts, including surgeons, anesthesiologists, and transfusion medicine specialists, suggested numerous strategies for the preoperative, intraoperative, and postoperative stages to reduce the variability of intraoperative RBC transfusions in patients undergoing significant noncardiac surgery
- Summary of intraoperative recommendations for red blood cell transfusions:
  - Decision to transfuse should be shared between surgeon and anesthesiologist, except in cases of uncontrolled massive hemorrhage
  - Point of care devices such as blood gas analyzer, non-invasive pulse oximeters, iSTAT, and HemoCue should be accurate measures to guide intraoperative transfusion
  - A hemoglobin threshold or trigger is typically recommended to guide intraoperative transfusion within a comprehensive transfusion strategy
  - Hemoglobin of 7 g/dL is an acceptable restrictive threshold for patients without major cardiac comorbidities

#### \*Administer one unit at a time. Early replacement of blood products is advised

<sup>1.</sup> Lenet T, McIsaac DI, Hallet JH, Jerath A, Lalu MM, Nicholls SG, Presseau J, Tinmouth A, Verret M, Wherrett CG, Fergusson DA, Martel G, Ottawa Consensus on Intraoperative Patient Blood Management: Intraoperative Blood Management Strategies for Patients Undergoing Noncardiac Surgery: The Ottawa Intraoperative Transfusion Consensus. JAMA Netw Open 2023; 6:e2349559



### **AABB International RBC Transfusion Recommendations**

- For hemodynamically stable hospitalized adult patients, consider a restrictive transfusion strategy
- Cardiac surgery hemoglobin less than 7.5 g/dL
- Orthopedic surgery hemoglobin less than 7.0 g/dL, or those with preexisting cardiovascular disease, a hemoglobin less than 8.0 g/dL
- Patients with hematologic and oncologic disorders hemoglobin less than 7.0 g/dL



Image reference: "Home - Association for the Advancement of Blood & Biotherapies." n.d. Www.aabb.org. Accessed November 6, 2024. https://www.aabb.org/

#### Reference:

 Carson JL, Stanworth SJ, Guyatt G, Valentine S, Dennis J, Bakhtary S, Cohn CS, Dubon A, Grossman BJ, Gupta GK, Hess AS, Jacobson JL, Kaplan LJ, Lin Y, Metcalf RA, Murphy CH, Pavenski K, Prochaska MT, Raval JS, Salazar E, Saifee NH, Tobian AAR, So-Osman C, Waters J, Wood EM, Zantek ND, Pagano MB: Red Blood Cell Transfusion: 2023 AABB International Guidelines. JAMA 2023 doi:10.1001/jama.2023.12914



# **Systematic Review of Guidelines - 2021**

- Ten guidelines published between 1992 and 2018 provided indications for intraoperative transfusions.
- Six guidelines provided criteria for transfusion based on hemoglobin (range 6.0–10.0 g/dL) or hematocrit (<30%) triggers.
- In the absence of objective transfusion rules, CPGs recommended considering other parameters such as blood loss (n = 7), signs of end organ ischemia (n = 5), and hemodynamics (n = 4).
- Evidence supporting intraoperative recommendations was extrapolated primarily from the nonoperative setting. There was wide variability in the quality of included guidelines based on AGREE II scores.
- Other Recommendations
  - + Frequently repeat measurement of Hgb and Hct levels
  - · Monitor surgical field, drains, sponges, and suction canister to estimate blood loss
  - Monitoring of hemodynamics (BP and HR).



<sup>1.</sup> Baker L, Park L, Gilbert R, Ahn H, Martel A, Lenet T, Davis A, McIsaac DI, Tinmouth A, Fergusson DA, Martel G: Intraoperative Red Blood Cell Transfusion Decision-making: A Systematic Review of Guidelines. Ann Surg 2021; 274:86–96

#### **Recommendations from other societies / groups**

- Michigan Arthroplasty Registry Collaborative Quality Initiative (<u>MARCQI</u>) is a team of orthopedic surgeons and healthcare professionals committed to enhancing the quality of care for patients undergoing hip and knee replacement surgeries in Michigan.<sup>1</sup>
  - Transfusion may benefit patients during acute coronary syndromes if Hgb < 8-10 g/dL</li>
  - There is very rarely an indication to transfuse ANY patient with a Hbg ≥ 10 g/dL
  - Each unit incrementally increases risk
  - Decreasing transfusion may
    - reduce risk of infection and readmission
    - reduce mortality
    - decrease cost



Image reference: MARQI. 2018. "Blood Transfusion Project." Marcqi.org. July 1, 2018. https://marcqi.org/dev/wp-content/uploads/2016/11/Transfusion\_reduction\_10282016.pdf



ererence: MARCQI. 2015. Michigan Arthroplasty Registry Collaborative Quality Initiative. September 30, 2015. <u>https://marcgi.org/</u>

### **Transfusion Trigger Summary**

- Review procedure, comorbidity, and institution transfusion protocols
- Restrictive transfusion protocols should be considered for asymptomatic patients.
- There is rarely an indication to transfuse any patient with a hemoglobin >10g/dL.
- Decision to transfuse should be based on objective assessment of the patient, including hemoglobin or hematocrit.
- In the absence of acute hemorrhage, transfuse one unit at a time.
- Reassess post-transfusion to objectively determine patient status



### **MPOG QI Measure TRAN-01 Measure**

#### <u>TRAN-01</u>: Transfusion management vigilance

- **Description**: Percentage of adult patients receiving a blood transfusion with documented hemoglobin or hematocrit value prior to administration
- Inclusion criteria: adult patients requiring anesthesia who receive transfusion
- Exclusion criteria:
  - Age 18 years
  - ASA 5 & 6 including Organ Procurement
  - Ces arean delivery cases with EBL  $\geq$  1500cc, or HR  $\geq$  110, SBP <85, DBP <45, or SAT <95%
  - Massive transfusion of 4 or more units of blood from 4 hours before Anesthesia start to end
  - Postpartum hemorrhage cases
  - Burn cases
  - Labor epidurals including obstetric non-operative procedures

• **Success criteria**: Documentation of a hemoglobin and/or hematocrit within 90 minutes prior to blood transfusion

\*Review your dashboard for TRAN-01 performance



### **MPOG TRAN-02 Measure**

- <u>TRAN-02</u>: assessment of possible unnecessary transfusion
  - **Description**: Percentage of adult patients with a post transfusion hemoglobin or hematocrit value greater than or equal to 10 g/dL or 30%
  - Inclusion criteria: adult patients requiring anesthesia who receive transfusion
  - Exclusion criteria:
    - Age 18 years
    - ASA 5 & 6 including Organ Procurement
    - \* Cesarean delivery cases with EBL > 1500cc, or HR > 110, SBP <85, DBP <45, or SAT <95%
    - \* Massive blood loss with  $EBL \geq 2000 mL$
    - Massive transfusion of 4 or more units of blood from 4 hours before Anesthesia start to end
    - No intraoperative transfusion cases
    - Postpartum hemorrhage cases
    - Burn cases
    - Labor epidurals including obstetric non-operative procedures
  - Success criteria:
    - Hematocrit value documented as less than or equal to 30% and/or hemoglobin value documented as less than or equal to 10 g/dL  $\mathbf{OR}$
    - No hematocrit or hemoglobin checked within 18 hours of Anesthesia End.

\*Review your dashboard for TRAN-02 performance



### **Blood Conservation Strategies**

- Intraoperative and postoperative autologous blood recovery, including cell salvage
- Fluid management strategies, such as Acute Normovolemic Hemodilution
- Pharmacological measures to reduce blood loss
- Intraoperative temperature management (prevention of hypothermia)



### **Autologous Blood Transfusion**

- Autologous red cells can either be obtained preoperatively or intraoperatively, however, preoperative collection of autologous blood does not guarantee protection from contamination, nor does it protect the patient from receiving the wrong blood<sup>1</sup>
- Preoperative autologous donation is when patient donates one or more units of their blood preoperatively and the blood is held in the blood bank and available for intraoperative or postoperative transfusion<sup>2</sup>
- Preoperative blood donation was promoted in the 1980s as a mechanism to decrease exposure to allogeneic transfusion and its associated risks, particularly viral transmission<sup>3</sup>

- 1. Lakha AS, Chadha R, Von-Kier S, Barbosa A, Maher K, Pirkl M, Stoneham M, Silva MA, Soonawalla Z, Udupa V, Reddy S, Gordon-Weeks A: Autologous blood transfusion reduces the requirement for perioperative allogenic blood transfusion in patients undergoing major hepatopancreatobiliary surgery: a retrospective cohort study. Int J Surg 2023; 109:3078–86
- 2. Henry DA, Carless PA, Moxey AJ, O'Connell D, Forgie MA, Wells PS, Fergusson D: Pre-operative autologous donation for minimising perioperative allogeneic blood transfusion. Cochrane Database Syst Rev 2002; 2010:CD003602
- 3. NAC Statement on Perioperative Autologous and Matched Donations at <a href="https://nacblood.ca/en/resource/nac-statement-perioperative-autologous-and-matched-donations">https://nacblood.ca/en/resource/nac-statement-perioperative-autologous-and-matched-donations</a>



# Cell Salvage (cell saver)

- Cell salvage is a blood conservation technique that reduces the requirement for allogeneic transfusion and maintains postoperative hemoglobin concentration<sup>1</sup>
- Collection of blood for potential cell salvage is typically considered for surgical procedures with moderate to heavy blood loss (EBL > 500mL)<sup>1</sup>
- Potential risks and benefits discussed with the patient preoperatively when cell salvage is used<sup>1</sup>
- Most commonly use in cardiac, trauma, and orthopedic cases



<sup>1.</sup> Klein AA, Bailey CR, Charlton AJ, Evans E, Guckian-Fisher M, McCrossan R, Nimmo AF, Payne S, Shreeve K, Smith J, Torella F: Association of Anaesthetists guidelines: cell salvage for peri-operative blood conservation 2018. Anaesthesia 2018; 73:1141–50



### **Acute Normovolemic Hemodilution (ANH)**

- In the 1970s, ANH was initially employed in cardiac surgery as a blood conservation method to reduce the risk of hepatitis transmission from donor blood products<sup>1</sup>
- ANH acts as reservoir of whole blood, preserves blood, maintains platelet function and thrombin generation, and increases perfusion due to decreased viscosity<sup>1</sup>
- ANH is a method where, under careful monitoring, blood is drawn from the patient in the operating room right after anesthesia is induced, and then crystalloids and/or colloids are used to ensure normovolemia is maintained<sup>2</sup>
- Normovolemic hemodilution and cell salvage can be used for surgeries with high likelihood of substantial blood  $\rm loss^2$



image credit: https://m.blog.naver.com/nopain365/221163864987?view=img\_2

#### References:

1. Henderson RA, Choi S: History and practice of acute normovolemic hemodilution. Curr Anesthesiol Rep 2020; 10:282–8

2. Perini FV, Montano-Pedroso JC, Oliveira LC, Donizetti E, Rodrigues RDR, Rizzo SRCP, Rabello G, Junior DML: Consensus of the Brazilian association of hematology, hemotherapy and cellular therapy on patient blood management: Acute normovolemic hemodilution and intraoperative autotransfusion. Hematol Transfus Cell Ther 2024; 46 Suppl 1:S48–52



#### Medications used in of management of patients with risk of blood loss, undergoing transfusions, or with coagulopathy

- Tranexamic Acid
- Calcium Chloride
- Prothrombin Complex Concentrate
- Fibrinogen Concentrate



# Tranexamic Acid (TXA)

- **TXA** is a synthetic analogue of lysine and an antifibrinolytic agent that reduces bleeding by preventing the breakdown of fibrin clots<sup>1-3</sup>
- High doses of TXA can cause seizures<sup>1</sup>
- Risk of thrombosis is not increased with use of  $TXA^1 \label{eq:tau}$
- Indications may include trauma, cardiac, liver, orthopedic, spine, gynecologic surgery, and postpartum hemorrhage<sup>1-3</sup>
- Typical dosing is 1 gram over 10 minutes,<sup>1</sup> but can vary by indication and organization



**Image source:** Relke, Nicole, Nicholas L. J. Chornenki, and Michelle Sholzberg. 2021. "Tranexamic Acid Evidence and Controversies: An Illustrated Review." *Research and Practice in Thrombosis and Haemostasis* 5 (5): e12546

- 1. Roberts I, Murphy MF, Moonesinghe R, Grocott MPW, Kalumbi C, Sayers R, Toh C-H, UK Royal Colleges Tranexamic Acid in Surgery Implementation Group: Wider use of tranexamic acid to reduce surgical bleeding could benefit patients and health systems. BMJ 2024; 385:e079444
- 2. Haider MA, Ward SA, Rajahraman V, Rozell JC, Macaulay W, Schwarzkopf R, Hepinstall M: Blood transfusion in the age of tranexamic acid: Who needs a type and screen before total hip arthroplasty? J Arthroplasty 2025; 40:119–26
- 3. Meza Monge K, Domene SS, Diaz Mendoza DL, Vidal-Gallardo A, Alfaro Llique AM, Rodriguez M, Premchandra P, Anwar Pandya S, Arruarana VS, Aleman Paredes K, Calderon Martinez E: Effectiveness of tranexamic acid in trauma patients: A systematic review. Cureus 2024; 16:e52111

### Fibrinogen Concentrate

- Fibrinogen Concentrate (FC) is used to manage perioperative bleeding due to low levels of fibrinogen (hypofibrinogenemia)<sup>1</sup>
- Fibrinogen replacement therapy can be administered intravenously using FFP, Cryo, fibrinogen concentrate, or topically using liquid adhesives<sup>1</sup>
- The effectiveness of FCs in controlling bleeding is still not substantiated. Small, uncontrolled studies examining the use of FCs have produced inconsistent results<sup>1</sup>
- Positive studies generally focus on an initial dose of 25-50 mg kg^{-1}, typically tailored using viscoelastic testing  $^{1\cdot 2}$
- Fibrinogen administration alone may not result in significant reduction of intraoperative blood loss and typically should be part of a multimodal plan<sup>1</sup>



Image source: https://www.riastap.com/professional/about-riastap/default.aspx

- 1. Fibrinogen Concentrate Godier A, Greinacher A, Faraoni D, Levy JH, Samana CM. 2018. "Use of factor concentrates for the management of perioperative bleeding: guidance from the SSC of the ISTH". Journal of thrombosis and hemostasis. 170-1704.
- 2. Samama CM, Ickx B, Ozier Y, Steib A, Susen S, Godier A: The place of fibrinogen concentrates in the management of perioperative bleeding: A position paper from the Francophone Working Group on Perioperative Haemostasis (GIHP). Anaesth Crit Care Pain Med 2018; 37:355–65



### **Prothrombin Complex Concentrate**

- Prothrombin Complex Concentrate (PCC) is derived from the cryoprecipitate of large plasma pools using ion exchange chromatography  $^1$
- Administered intravenously  $^1$
- Typical indications include<sup>1</sup>:
  - Urgent reversal of acquired coagulation factor deficiency
  - Urgent warfarin reversal
  - Reversal of direct oral anticoagulants
  - Reduction of perioperative bleeding
- In a systematic review and metanalysis of 17 included studies, it was found that PCC alone did not lead to a reduction in mortality, but when PCC was combined with FFP, it was associated with reduced mortality in trauma patients<sup>2</sup>



- 1. Castillo B, Dasgupta A, Klein K, Tint H, Wahed A: Blood components: Transfusion practices, Transfusion Medicine for Pathologists. Elsevier, 2018, pp 125–42
- 2. Brink DP van den, Wirtz MR, Neto AS, Schöchl H, Viersen V, Binnekade J, Juffermans NP: Effectiveness of prothrombin complex concentrate for the treatment of bleeding: A systematic review and meta-analysis. J Thromb Haemost 2020; 18:2457–67

#### **Calcium Chloride or Calcium Gluconate**

- Calcium is administered during blood transfusions to treat hypocalcemia may resulting from the citrate preservatives in  $blood^2$
- Massive blood transfusion, defined as  $\geq 10$  units of PRBCs in 24 hours or  $\geq 4$  units of RBCs in one hour, can result in hypocalcemia due to citrate preservatives added to RBCs, FFP, and platelets to maintain stability of blood during storage<sup>3</sup>
- Liver may not be able to clear citrate quickly enough to prevent hypocalcemia
- Hypocalcemia can result in cardiac arrythmias and neurologic complications such as seizures
- Typical doses are 1-2 grams IV, given slowly, with frequent POC testing





- 1. DiFrancesco NR, Gaffney TP, Lashley JL, Hickerson KA: Hypocalcemia and massive blood transfusions: A pilot study in a level I trauma center. J Trauma Nurs 2019; 26:186–92
- 2. Dorantes RP, Boettcher BT, Woehlck HJ: Calcium chloride requirement and postreperfusion rebound during massive transfusion in liver transplantation. J Cardiothorac Vasc Anesth 2022; 36:2400–5
- 3. Robinson A, Rech MA, DeChristopher PJ, Vaughn A, Rubino J, Bannister E, Moore ME, Chang K: Defining the optimal calcium repletion dosing in patients requiring activation of massive transfusion protocol. Am J Emerg Med 2023; 70:96–100



## **Viscoelastometric Testing**

- Rotational Thromboelastometry (ROTEM)
- Point of care testing device
- Assesses hemostasis by using a whole blood sample to demonstrate how platelets, coagulation factors, RBCs, and other elements work together to:
  - initiate a clot
  - determine clot strength; and
  - investigate if there is any fibrinolysis<sup>1</sup>.
- Can quickly assess the state of hemostasis to help direct care
- Specific ROTEM tests include INTEM (intrinsic pathway), EXTEM (extrinsic pathway), and FIBTEM (fibrinogen contribution to clot firmness)
- <u>MPOG TEG & ROTEM Concepts</u>

#### Coagulation factors, Platelets. Fibrinolytic enzymes, anticoagulants, FDPs, fibrinogen, fibrinolysis inhibitors, tissue factor expression F XIII, colloids F XIII 10 min alpha-angle [mm] Maximum Clot Firmness (MCF) [mm] Clot Firmness Maximum Lysis (ML) [%] Clot Lysis Index 30 or 60 (CLI30; CLI60) [%] A5, A10 = Amplitude 5 / 10 min after CT [mm] Coagulation Time (CT) [s] Clot Formation Time (CFT) [s]

Run Time [min]

Image reference: Görlinger, Klaus & Dirkmann, Daniel & Albrecht, Alexander. (2016). Rotational thromboelastometry (ROTEM®). 10.1007/978-3-319-28308-1\_18.

- 1. Drotarova M, Zolkova J, Belakova KM, Brunclikova M, Skornova I, Stasko J, Simurda T: Basic principles of rotational thromboelastometry (ROTEM®) and the role of ROTEM-guided fibrinogen replacement therapy in the management of coagulopathies. Diagnostics (Basel) 2023; 13
- 2. Gonzalez E, Moore EE, Moore HB. Management of Trauma Induced Coagulopathy with Thrombelastography. Crit Care Clin. 2017 Jan; 33(1):119-134. doi: 10.1016/j.ccc.2016.09.002. PMID: 27894492; PMCID: PMC5142763 Department of Anesthesiology



# **Summary of Coagulation Support**

- Several therapies available support is to promote clot formation
- Components of primary clot formation can be supplemented by platelet, FFP, and cryoprecipitate transfusion





... Kleinveld DJB, Curry N, Levy JH: Coagulation support during perioperative bleeding management. Intensive Care Med 2023; 49:1110–3

MULTICENTER PERIOPERATIVE

### **Temperature management and transfusion**

- While hypothermia is commonly linked to surgical site infections, it can also result in cardiac abnormalities and coagulopathies<sup>1</sup>
- Pre-warming, active intraoperative warming, increasing OR temperature, and core temperature monitoring can be important components of preventing hypothermia
- MPOG has developed several measures to help sites track temperature management performance
  - <u>TEMP-01: Thermoregulation Vigilance Active Warming</u>
  - <u>TEMP-02</u>: <u>Thermoregulation Monitoring Core Temperature</u>
  - <u>TEMP-03: Perioperative Hypothermia</u>



### Summary

- Administer transfusions on evidence-based hemoglobin and hematocrit thresholds, considering the patient's physiologic status
- Intraoperative transfusion triggers can include low hemoglobin and hematocrit levels and hemodynamic instability
- Blood conservation techniques include acute normovolemic hemodilution, hemostatic agents, and cell salvage
- Frequent POC testing can guide interventions
- Guidelines recommend administering one unit at a time whenever possible
- Medications such as tranexamic acid (TXA), calcium chloride, prothrombin complex concentrate, or fibrinogen concentrate may be administered intraoperatively
- TXA, when administered for the patient, can reduce intraoperative bleeding and need for transfusion
- Viscoeslastometric testing is valuable in assessing coagulopathic bleeding



### **Objective #4: Postoperative Considerations**





## Monitoring of postoperative bleeding

- Warning signs of hemorrhage include <sup>1</sup>
  - Tachycardia
  - Frank bleeding or bruising
  - Swelling and discoloration of extremities
  - Reduction in urine output
  - Restlessness and anxiety
  - Hemodynamic parameter changes such as diminished cardiac output or reduction in  $\ensuremath{\mathrm{CVP}}$
- Check hemoglobin and hematocrit levels if blood administered or concerned for post-operative bleeding

- 1. Johnson AB, Burns B: Hemorrhage. StatPearls Publishing, 2023
- 2. American Red Cross: Compendium of Transfusion Practices 2021 at https://www.redcross.org/content/dam/redcross/blood/hospital-page-documents/334401\_compendium\_v04jan2021\_bookmarkedworking\_rwv01.pdf



### **Elements of handoff to postoperative team**

- Estimated blood loss
- Reason for transfusion, amount and type of blood products received
- Assessment of transfusion reaction
- Most recent lab results, including hemoglobin, hematocrit, platelets, coagulation studies, and calcium level
- Specific recommendations for postoperative assessments, monitoring requirements, and any communication follow-ups

#### Reference:

1. Segall N, Bonifacio AS, Schroeder RA, Barbeito A, Rogers D, Thomlow DK, Emery J, Kellum S, Wright MC, Mark JB, Durham VA Patient Safety Center of Inquiry: Can we make postoperative patient hand overs safer? A systematic review of the literature. Anesth Analg 2012; 115:102–15



### **Anticoagulants resumption considerations**

- Hemostasis and risk of further surgical bleeding
- Characteristics of anticoagulant including duration of action and reversabilty  $^1$
- Most anticoagulants can be restarted within 24-48 hours, including
  - Unfractionated heparin or low molecular weight heparins (within 24 hours)<sup>2</sup>
  - Vitamin K antagonists
  - \* Direct-acting or al anticoagulants with low bleed risks 24 hours  ${\rm postop}^2$
  - \* P2Y12 inhibitors, such as clopidogrel and ticagrelor, 24-48 hours  $postop^2$
- Surgical and medical teams typically manage the resumption of anticoagulants based on each patient's status^3  $\,$

- 1. Briete LD, Towers WF, Bone R, Nair R, Steck M, Cutshall BT, Shah SP: Perioperative Anticoagulation Management. Crit Care Nurs Q 2022; 45:119–31
- 2. Moster M, Bolliger D: Perioperative Guidelines on Antiplatelet and Anticoagulant Agents: 2022 Update. Curr Anesthesiol Rep 2022; 12:286–96
- 3. Jethwa AR, Khariwala SS: When should therapeutic anticoagulation be restarted following major head and neck surgery? Laryngoscope 2018; 128:1025-6



# **Additional Patient Blood Management Resources**



### **Resources for Massive Transfusion**

While this toolkit does not cover massive transfusion protocols, here are some resources for additional information:

American College of Surgeons (ACS)

**Canadian Blood Services** 

International Society of Blood Transfusion

Washington State Department of Health Office



#### **Total Cases with Massive Transfusion: 4,917\***



### Thank you

