Innovative Strategies in Patient Blood Management for Cardiac Surgery

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The Korean Society of Patient Blood Management

Disclosures

Baxter – Medical Consultant

hc1 – Medical Advisory Board

Pharmacosmos – Medical Advisor

Cardiac surgery accounts for 15-20% of all perioperative blood transfusions. Patient Blood Management (PBM) reduces unnecessary transfusions through evidence-based strategies.

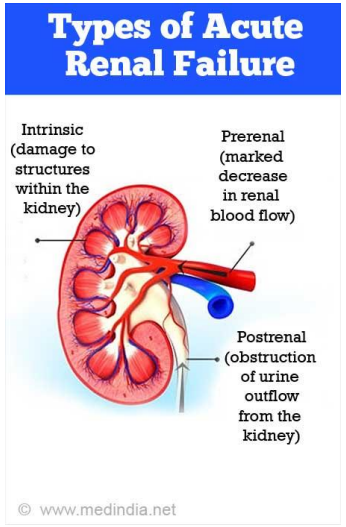
A multidisciplinary approach optimizes outcomes across all perioperative phases.

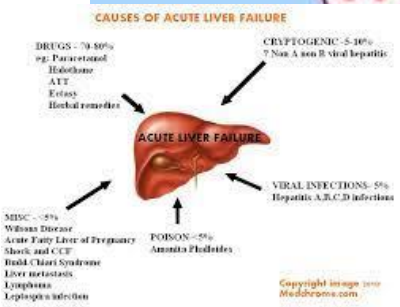
QUESTIONS TO BE ANSWERED

- What is Patient Blood Management?
- Why is PBM important?
- Who's role is it to manage PBM in surgery?
- What is "Blood Failure"?
- What therapeutic options do we have available to prevent or treat "blood failure" in the pre, intra and post-operative setting?
- What constitutes a robust PBM department?
- What obstacles still remain?

The Concept of Blood Failure

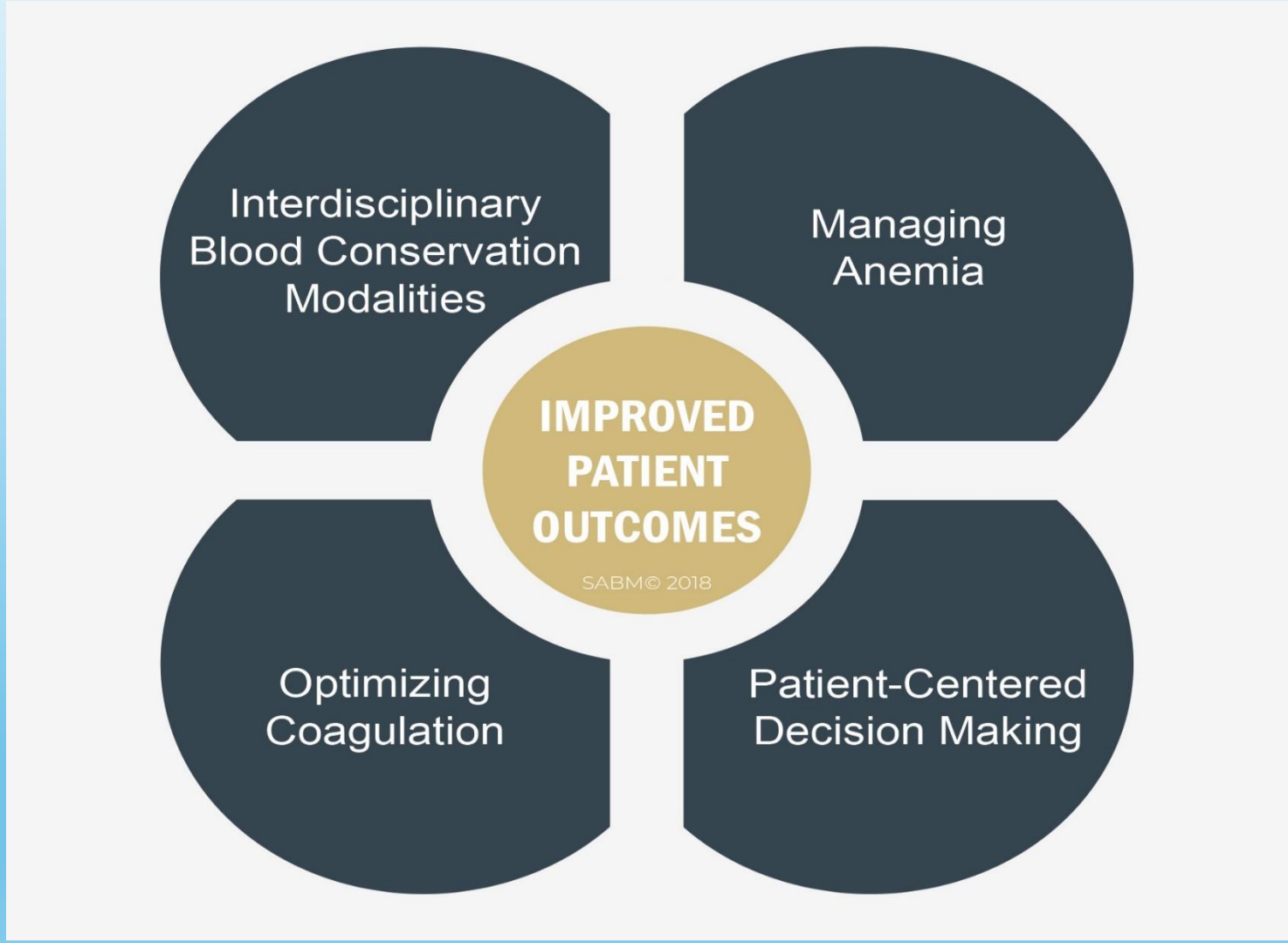
BLOOD AS AN ORGAN SYSTEM



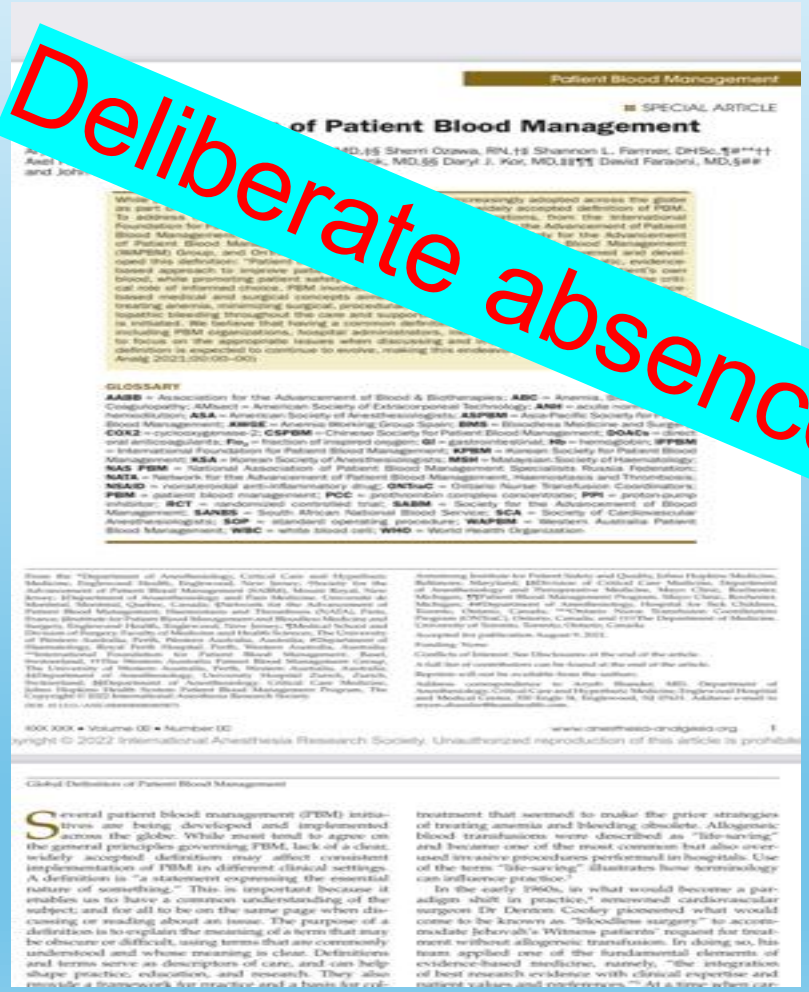


Blood is absent (anemia)
Blood is defective (hypo or hyper coagulable, O2 carrying capacity)
Blood is lost (Bleeding, Destruction)

SABM/STS FOUR PILLARS OF PBM



PBM - “GLOBAL DEFINITION”


Patient Blood Management

SPECIAL ARTICLE

of Patient Blood Management

Deliberate absence of the word “Transfusion”

- “Patient Blood Management is a patient-centered, systemic, evidence-based approach to improve patient outcomes by managing and preserving a patient’s own blood, while promoting patient safety and empowerment”

lander et al Anesthesia and Analgesia 2022

INCREASED ASSOCIATION OF ADVERSE OUTCOMES IN PATIENTS WITH ANEMIA AND/OR TRANSFUSION

Tibi PR et al.
The Annals Of Thoracic Surgery
Patient Blood Management Guidelines
Volume 112, Issue 3, P981-1004, September 01, 2021

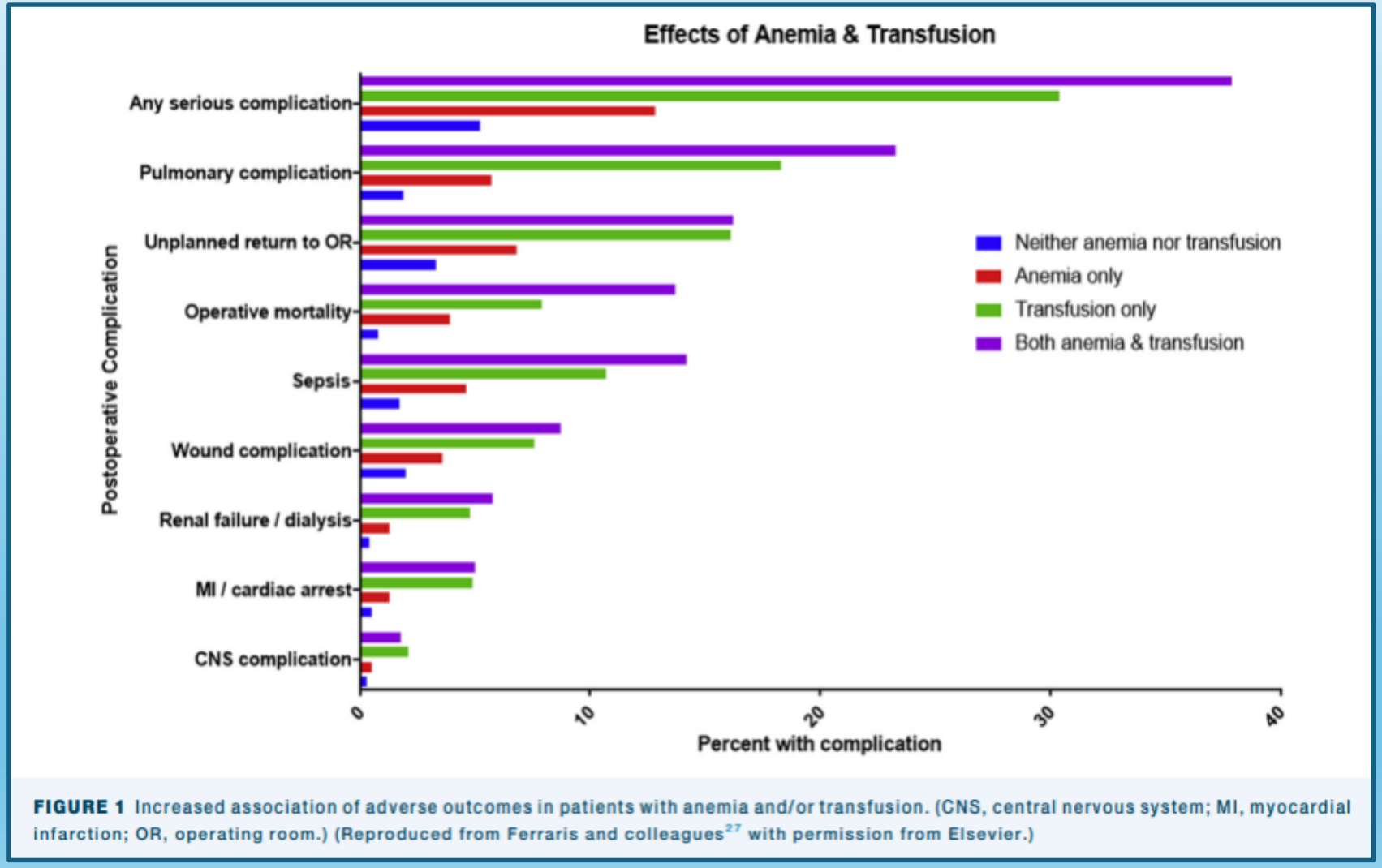
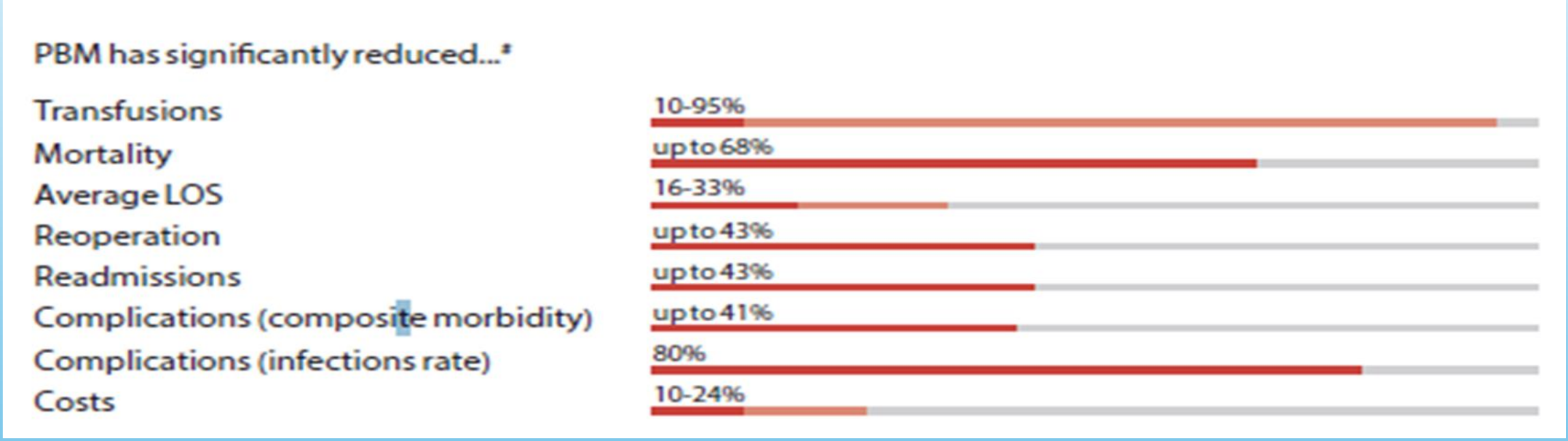


FIGURE 1 Increased association of adverse outcomes in patients with anemia and/or transfusion. (CNS, central nervous system; MI, myocardial infarction; OR, operating room.) (Reproduced from Ferraris and colleagues[27] with permission from Elsevier.)

PBM - CLINICAL OUTCOMES



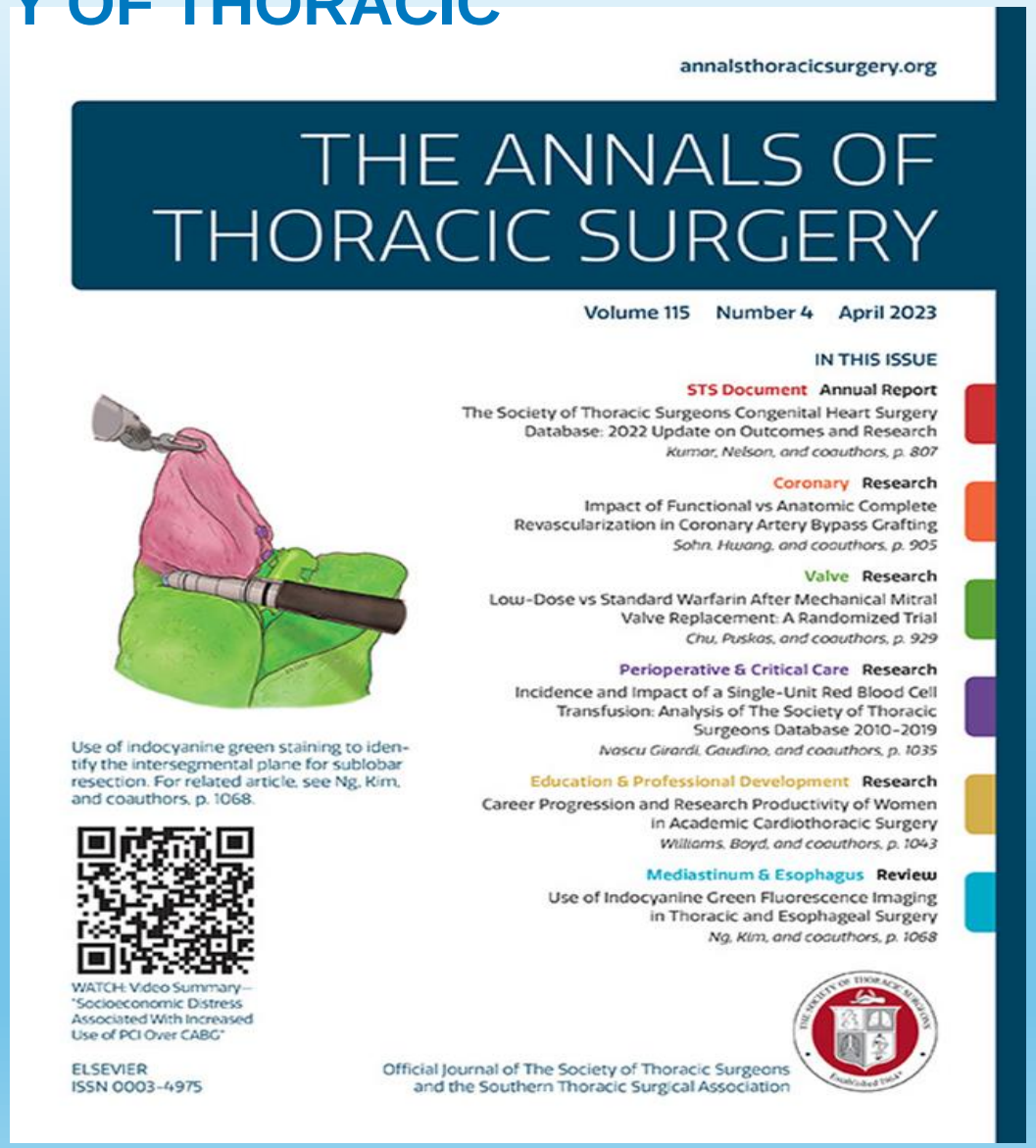
LaPar 2013, Kotze 2012, Moskowitz 2010, Reddy 2009, Brevig 2009, Ferraris 2007, Wong 2007, Ghiglione 2007, Freedman 2007, Martinez 2007, DeAnda 2006, Freedman 2005, pierson 2004, Kourtzis 2004, Morgan 2004, Slappendel 2003, Van der Linden 2001, Helm 1998

INCIDENCE AND IMPACT OF A SINGLE-UNIT RED BLOOD CELL TRANSFUSION: ANALYSIS OF THE SOCIETY OF THORACIC SURGEONS DATABASE 2010–2019

- Girardi *et al. Ann Thorac Surg* 2023;115:1035–42
  - 10 years
  - Isolated CABG and AVR
  - 2,151,430 encounters
  - 847,442 received transfusions
    - 1,303,988 received 0 units
    - 206,555 received 1 unit
  - Propensity matching of 206,555 pairs for comparison

TABLE 4 Outcomes of Propensity-Matched Cohort

Variable	No RBCs (n ¼ 206,555)	1 Unit of RBCs (n ¼ 206,555)	P Value
Operative mortality	2058 (1.0)	2990 (1.4)	<.001
Stroke	2492 (1.2)	3458 (1.7)	<.001
Sternal wound infection	1070 (0.5)	1343 (0.7)	<.001
Prolonged ventilation	6990 (3.4)	13,305 (6.4)	<.001
New hemodialysis	1816 (0.9)	3703 (1.8)	<.001
Reoperation for bleeding	1064 (0.5)	2685 (1.3)	<.001



AVR, aortic valve replacement CABG, coronary artery bypass grafting; RBCs, red blood cells.

Cardiac surgery is the "poster child" for PBM

Blood Loss Risk

Cardiac procedures inherently cause significant bleeding. High-dose anticoagulation complicate management.

Bypass Complications

Cardiopulmonary bypass (CPB) creates complex interactions. These affect coagulation and increase transfusion needs.

Transfusion Consequences

Adverse effects include infections, allergic reactions, and immunosuppression. Blood products also create economic burden.

PBM IN SURGERY- WHO'S ROLE IS IT?

- Primary Care? Only pre-op
- Admitting Physician? Only pre-op
- Anesthesiologist? Only intra-op
- Intensivist/Hospitalist? Only post-op

SURGEON

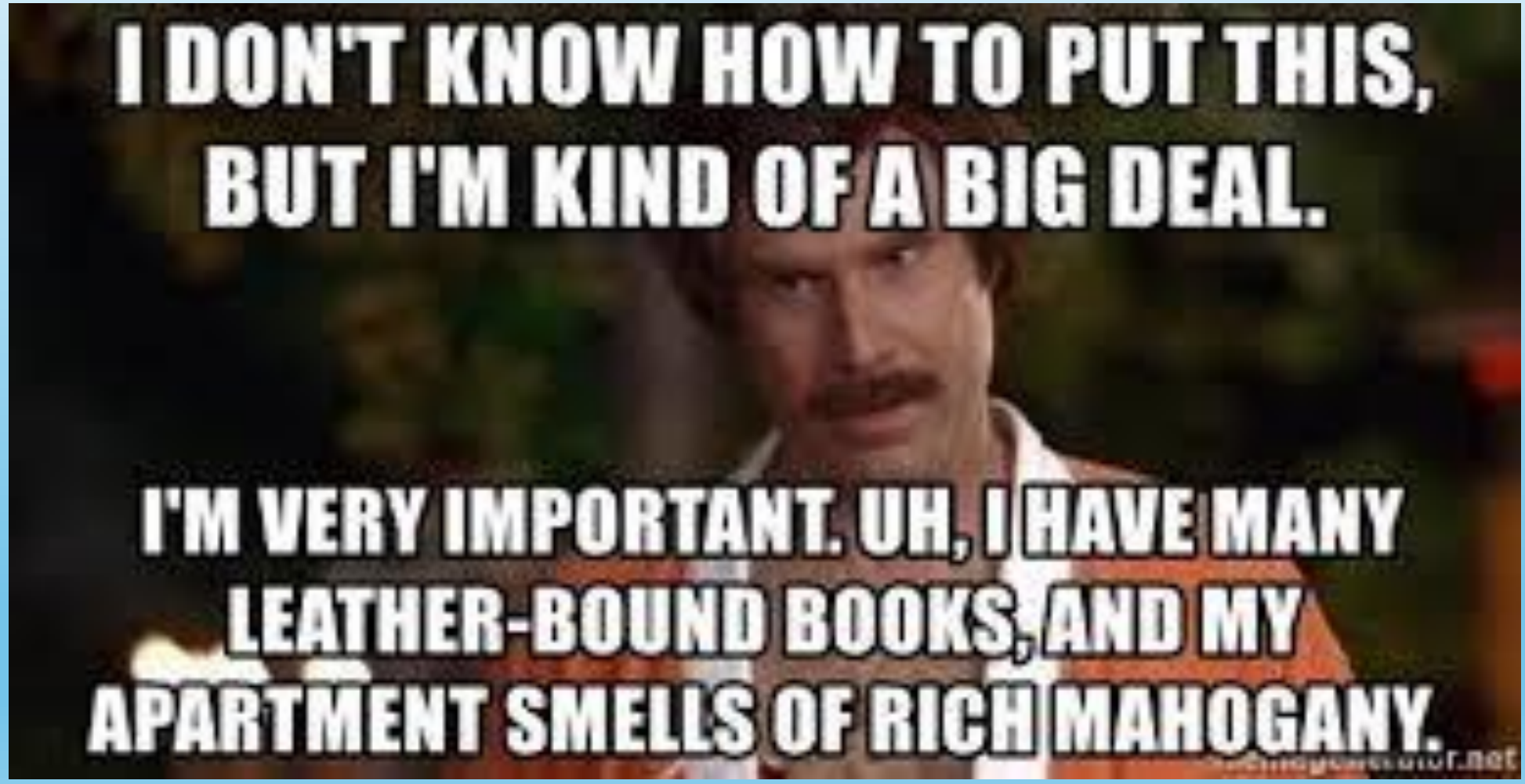
Pre-op

Intra-op

Post-op

PBM spans the full spectrum of care and is to be practiced long before admission, surgery or any need for transfusion other than immediate and overwhelming blood loss. The surgeon is in the best position to do so.

Many Cardiac Surgeons



0003-4975/$36.00

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https://doi.org/10.1016/j.athoracsur.2021.03.033

PATIENT BLOOD MANAGEMENT GUIDELINES

STS/SCA/AmSECT/SABM Update to the Clinical Practice Guidelines on Patient Blood Management

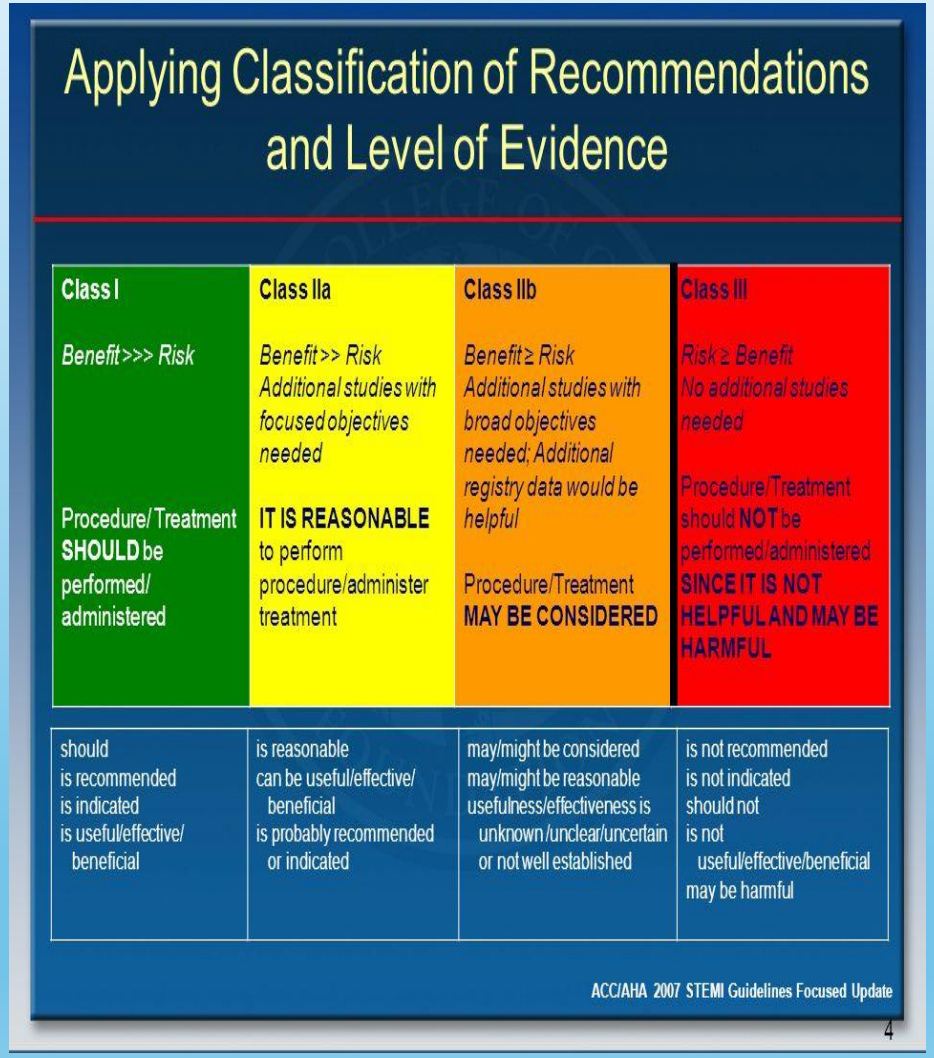
Pierre Tibi, MD, R. Scott McClure, MD, FRCSC, Jiapeng Huang, MD, Robert A. Baker, PhD, CCP, David Fitzgerald, DHA, CCP, C. David Mazer, MD, Marc Stone, MD, Danny Chu, MD, Alfred H. Stammers, MSA, CCP Emeritus, Tim Dickinson, CCP, Linda Shore-Lesserson, MD, Victor Ferraris, MD, Scott Firestone, MS, Kalie Kissoon, and Susan Moffatt-Bruce, MD, FRCSC

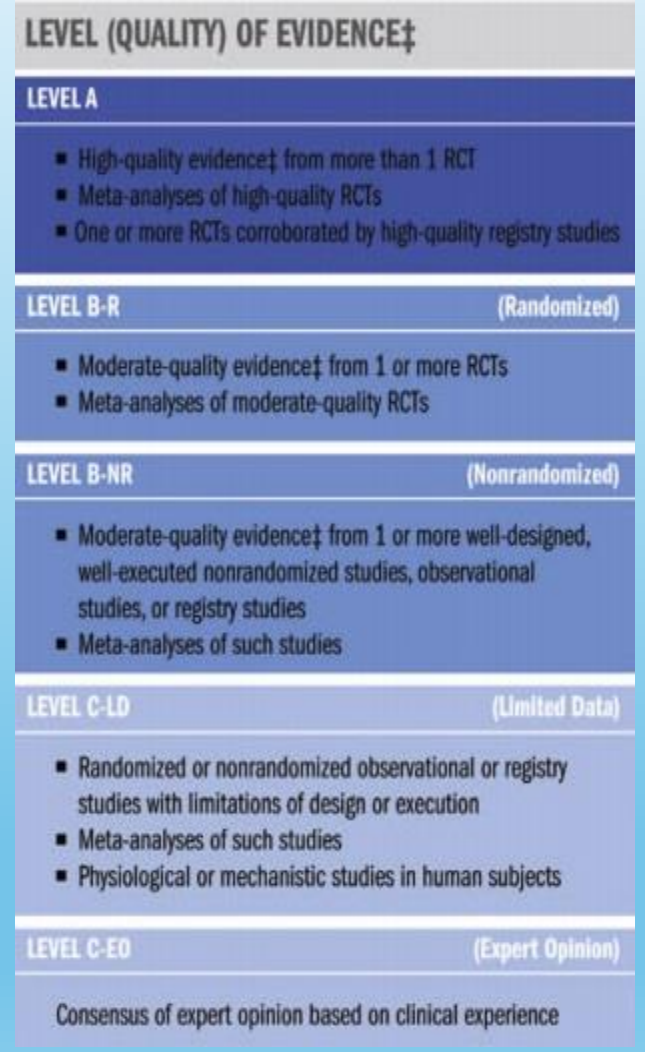
Department of Cardiovascular Surgery, Yavapai Regional Medical Center, Prescott, Arizona; Division of Cardiac Surgery, Libin Cardiovascular Institute, Foothills Medical Center, University of Calgary, Calgary, Alberta, Canada; Department of Anesthesiology & Perioperative Medicine, University of Louisville, Louisville, Kentucky; Cardiac Surgery Research and Perfusion, Flinders University and Flinders Medical Centre, Adelaide, South Australia, Australia; Division of Cardiovascular Perfusion, Medical University of South Carolina, Charleston, South Carolina; Department of Anesthesia, St. Michael's Hospital, University of Toronto, Toronto, Ontario, Canada; Department of Anesthesia, Mount Sinai Medical Center, New York, New York; Department of Cardiothoracic Surgery, University of Pittsburgh School of Medicine, Pittsburgh, Pennsylvania; Specialty Care, Nashville, Tennessee; Department of Cardiovascular Surgery, Mayo Clinic, Rochester, Minnesota; Department of Anesthesiology, Zucker School of Medicine at Hofstra/Northwell Northshore University Hospital, Manhasset, New York; Division of Cardiovascular and Thoracic Surgery, University of Kentucky, Lexington, Kentucky; The Society of Thoracic Surgeons, Chicago, Illinois; and Division of Thoracic Surgery, Department of Surgery, University of Ottawa, Ottawa, Ontario, Canada

CLASS 1 RECOMMENDATION

What is a Class 1 recommendation?

Class I ***recommendations are strong*** and indicate that the treatment, procedure, or intervention ***is useful and effective*** and ***should be*** performed or administered for most patients under most circumstances.

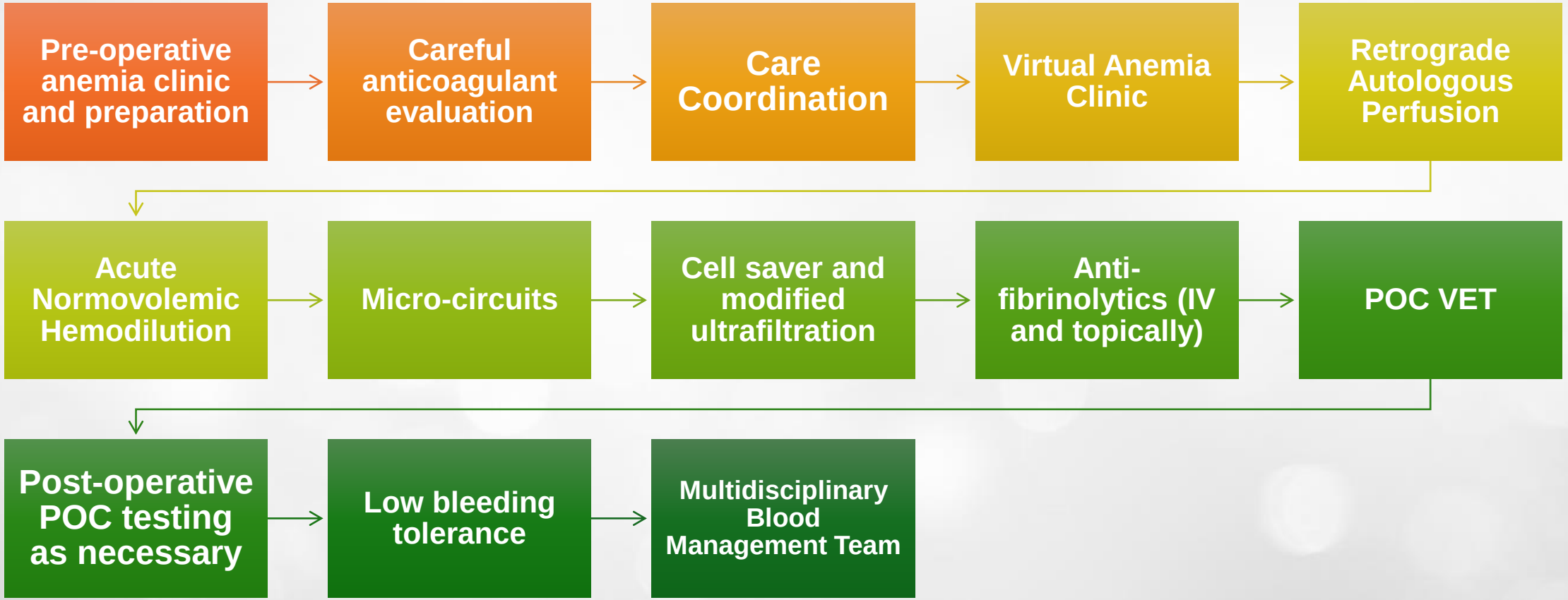




10 CLASS 1 STS RECOMMENDATIONS

- ***A comprehensive multimodality blood conservation program led by a multidisciplinary team of health care providers should be part of any patient blood management program to limit utilization of blood resources and decrease the risk of bleeding. Class I, Level B-R***
- Preoperative identification of high-risk patients should be performed, and all available preoperative and perioperative measures of blood conservation should be undertaken in this group as they account for the majority of blood products transfused. Class I, Level A
- Routine use of red cell salvage using centrifugation is helpful for blood conservation in cardiac operations using CPB. Class I, Level A
- In order to reduce bleeding in patients requiring elective cardiac surgery, ticagrelor should be withdrawn preoperatively for a minimum of 3 days, clopidogrel for 5 days, and prasugrel for 7 days. Class I, Level B-NR
- **Use of synthetic antifibrinolytic agents such as epsilon-aminocaproic acid (EACA) or tranexamic acid reduces blood loss and blood transfusion during cardiac procedures and are indicated for blood conservation**. Class I, Level A
- Antithrombin III concentrates are indicated to reduce plasma transfusion in patients with antithrombin-mediated heparin resistance immediately before cardiopulmonary bypass. Class I, Level A
- Retrograde autologous priming of the CPB circuit should be used wherever possible. Class I, Level B-R
- Reduced priming volume in the CPB circuit reduces hemodilution and is indicated for blood conservation, Class I, Level B-NR
- In patients undergoing cardiac surgery, a restrictive perioperative allogeneic red blood cell (RBC) transfusion strategy is recommended in preference to a liberal transfusion strategy for perioperative blood conservation, as it reduces both transfusion rate and units of allogeneic RBCs without increased risk for mortality or morbidity. Class I, Level A
- **Goal-directed transfusion algorithms, which incorporate point-of-care testing, such as with viscoelastic devices, are recommended to reduce periprocedural bleeding and transfusion in cardiac surgical patients.** Class I, Level B-R

Patient Blood Management is a "Total Care Package"



	Optimize hemopoiesis	Minimize blood loss & bleeding	Harness & optimize tolerance of anemia
Preoperative	• Screen for anemia • Identify underlying disorder(s) causing anemia • Manage underlying disorder(s) • Refer for further evaluation if necessary • Treat iron deficiency, anemia of chronic disease, iron-restricted erythropoiesis • Note: anaemia is a contraindication for elective surgery	• Identify and manage bleeding risk (past/family history, current medications, etc) • Minimize iatrogenic blood loss • Procedure planning and rehearsal	• Assess/optimize patient's physiological reserve and risk factors • Compare estimated blood loss with patient-specific tolerable blood loss • Formulate patient-specific management plan using appropriate blood conservation modalities to minimize blood loss, optimize red cell mass and manage anemia • Restrictive, evidence-based transfusion strategies
Intra-operative	• Timing surgery with hematological optimization	• *Meticulous hemostasis and surgical techniques* • *Blood-sparing surgical techniques* • *Anesthetic blood conserving strategies* • *Autologous blood options* • *Pharmacological/haemostatic agents*	• Optimize cardiac output • Optimize ventilation and oxygenation • Restrictive, evidence-based transfusion strategies
Postoperative	• Treat anemia /iron deficiency • Stimulate erythropoietin • Be aware of drug interactions that can cause/increase anemia	• Vigilant monitoring and management of post-operative bleeding • Avoid secondary hemorrhage • Rapid warming - maintain normothermia (unless hypothermia specifically indicated) • Autologous blood salvage • Minimizing iatrogenic blood loss • Hemostasis/anticoagulation management • Prophylaxis of upper GI hemorrhage • Avoid/treat infections promptly • Be aware of adverse effects of medications	• Optimise tolerance of anaemia • Treat anaemia • Maximize oxygen delivery • Minimize oxygen consumption • Avoid/treat infections promptly • Restrictive, evidence-based transfusion strategies

Modified from Hofmann et al.,
The Oncologist 2011;16(suppl 3):3–1

PATIENT BLOOD MANAGEMENT GUIDELINES

STS/SCA/AmSECT/SABM Update to the Clinical Practice Guidelines on Patient Blood Management

Pierre Tibi, MD, R. Scott McClure, MD, FRCSC, Jiapeng Huang, MD, Robert A. Baker, PhD, CCP, David Fitzgerald, DHA, CCP, C. David Mazer, MD, Marc Stone, MD, Danny Chu, MD, Alfred H. Stammers, MSA, CCP Emeritus, Tim Dickinson, CCP, Linda Shore-Lesserson, MD, Victor Ferraris, MD, Scott Firestone, MS, Kalie Kissoon, and Susan Moffatt-Bruce, MD, FRCSC

EXECUTIVE SUMMARY

REPORT

“PREOPERATIVE TREATMENT OF ANEMIA-PHARMACOLOGIC AGENTS

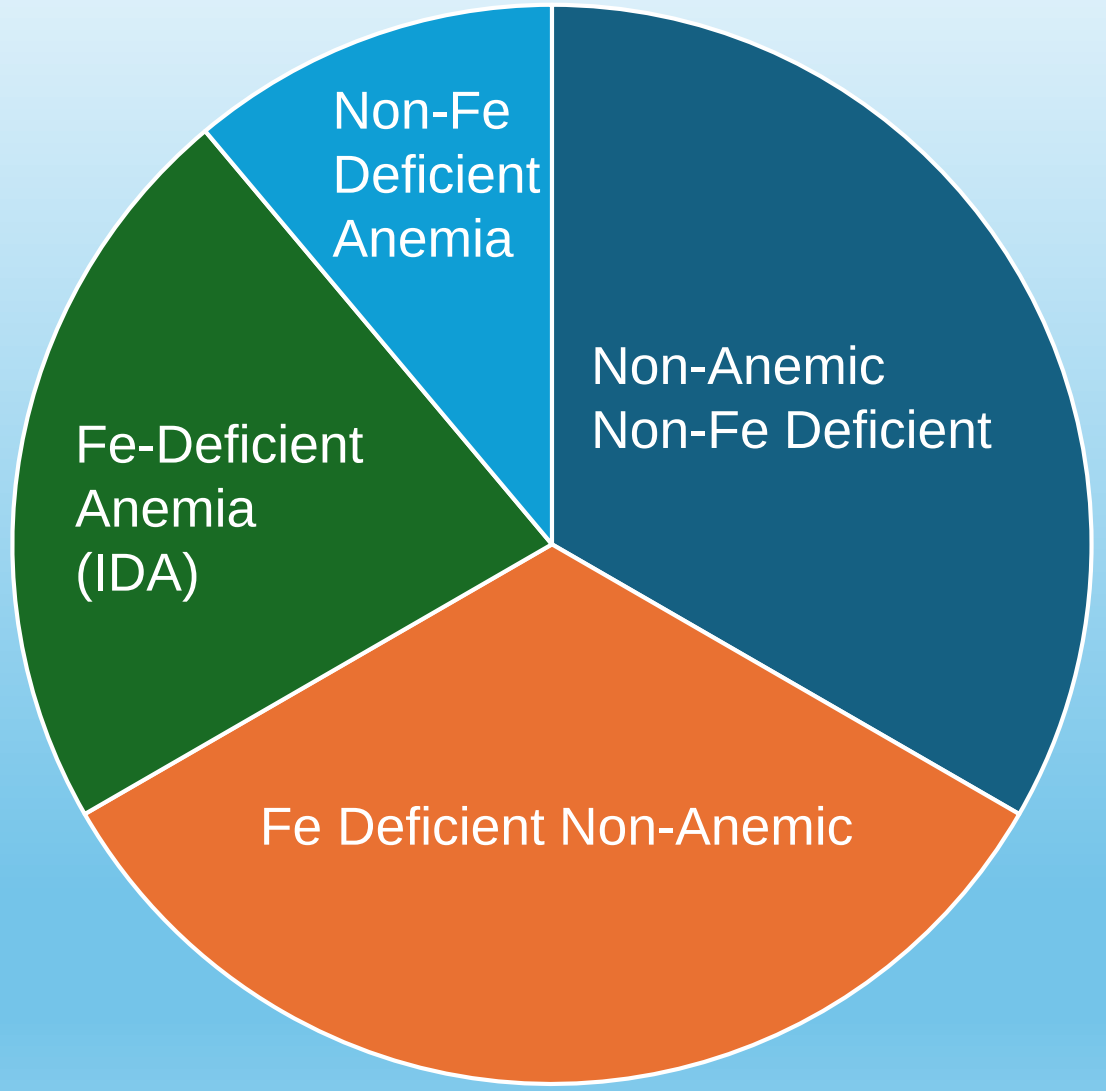
In patients who have (i) preoperative anemia, (ii) refuse blood transfusion, (iii) or are deemed high-risk for postoperative anemia, it is reasonable to administer preoperative erythropoietin stimulating agents (ESA) and iron supplementation several days prior to cardiac operations to increase red cell mass (Class IIA, Level B-R)”

- ✓ Preoperative identification of high-risk patients should be performed, and all available preoperative and perioperative measures of blood conservation should be undertaken in this group as they account for the majority of blood products transfused. **Class I, Level A**

All Cardiac Surgical Patients

Management of Preoperative Iron Deficiency in Cardiac Surgery

Corwin HL, Shander A, Spiess B, Munoz M , Faroni D, Calcaterra D, Welsby I, Ozawa S, Arnofsky, A Goldweit RS, Tibi P, Ann Thor Surg 2022;113:316-323



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Intra-operative	• Timing surgery with hematological optimization	• *Meticulous hemostasis and surgical techniques* • *Blood-sparing surgical techniques* • *Anesthetic blood conserving strategies* • *Autologous blood options* • *Pharmacological/haemostatic agents*	• Optimize cardiac output • Optimize ventilation and oxygenation • Restrictive, evidence-based transfusion strategies
Postoperative	• Treat anemia /iron deficiency • Stimulate erythropoietin • Be aware of drug interactions that can cause/increase anemia	• Vigilant monitoring and management of post-operative bleeding • Avoid secondary hemorrhage • Rapid warming - maintain normothermia (unless hypothermia specifically indicated) • Autologous blood salvage • Minimizing iatrogenic blood loss • Hemostasis/anticoagulation management • Prophylaxis of upper GI hemorrhage • Avoid/treat infections promptly • Be aware of adverse effects of medications	• Optimise tolerance of anaemia • Treat anaemia • Maximize oxygen delivery • Minimize oxygen consumption • Avoid/treat infections promptly • Restrictive, evidence-based transfusion strategies

Modified from Hofmann et al.,
The Oncologist 2011;16(suppl 3):3–1

Intraoperative Management

- Blood loss
- Blood destruction (Trauma from CPB)
- Coagulopathic dysfunction (Platelet Destruction and Factor Loss)
- Dilutional Effects

Intraoperative Management

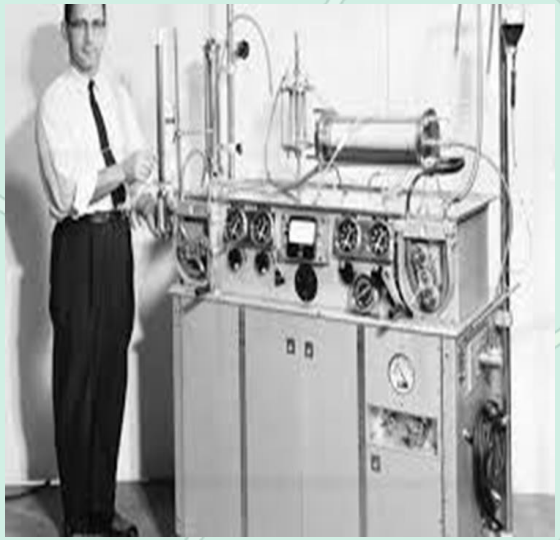
Meticulous technique

Limit Hemodilution

Reduce prime volume in CPB circuits. Minimize crystalloid administration.

Antifibrinolytics

Routine use of tranexamic acid reduces bleeding risk.



Advanced Techniques

Modified ultrafiltration and retrograde autologous priming (RAP) , ANH, VAC, VET POC testing,

.

Cell Salvage

Collect, wash, and return autologous red cells.

Topical Hemostatic Agents

Acute Normovolemic Hemodilution (ANH)

Acute Normovolemic Hemodilution Significantly Reduces RBC Transfusion and Lactic Acidosis Following Cardiac Surgery-A Propensity-Matched Study

Vala Sebt 1, Shahnaz Sharifi 2, Alipasha Meysamie 3, Kianoush Saberi 4

	ANH (*n*=389)	Non-ANH (*n*=389)	*P*
Rate of Perioperative Transfusions (yes/no)			
Blood product transfusion	242 (62.2%)	258 (66.3%)	0.262
RBC transfusion	198 (50.9%)	237 (60.9%)	0.006
FFP transfusion	138 (35.5%)	119 (30.6%)	0.170
Platelet transfusion	144 (37.0%)	127 (32.6%)	0.229
Amount of Perioperative Transfusions (units)			
RBC transfusion	1.0±1.32	1.2±1.39	0.013
FFP transfusion	1.2±1.80	1.1±1.75	0.343
Platelet transfusion	1.6±2.32	1.3±2.08	0.122
Postoperative Outcomes			
Mortality (yes/no)	9 (2.3%)	11 (2.8%)	0.821
Re-intubation (yes/no)	6 (1.5%)	7 (1.8%)	1.000
Re-exploration (yes/no)	19 (4.9%)	20 (5.1%)	1.000
Delayed sternal closure (yes/no)	5 (1.3%)	10 (2.6%)	0.297
Lactic acidosis (yes/no)	35 (9.0%)	75 (19.3%)	<0.001
ICU stay (days)	2±1.1	2±1.3	0.570
Intubation duration (hours)	13±5.1	12±6.5	0.364

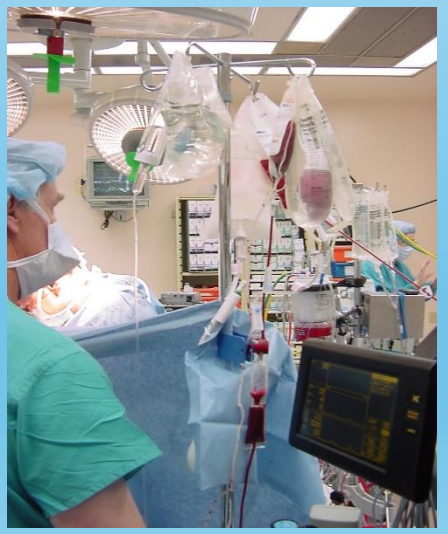
FFP: fresh frozen plasma; ICU: intensive care unit; RBC: red blood cells

Ann Card Anaesth 2025 Apr 1;28(2):136-142. doi: 10.4103/aca.aca_192_24.2025 Apr 16.

The NEW ENGLAND JOURNAL of MEDICINE

A Randomized Trial of Acute Normovolemic Hemodilution in Cardiac Surgery

Fabrizio Monaco, M.D., Chong Lei, M.D., Ph.D., Matteo Aldo Bonizzoni, M.D., Sergey Efremov, M.D., Ph.D., Federica Morselli, M.D., Fabio Guarracino, M.D., Giuseppe Giardina, R.N., M.Sc., +48 , for the ANH Study Group
N Engl J Med 2025;393:450-460DOI: 10.1056/NEJMoa250494



Acute Normovolemic Hemodilution in Adult Cardiac Surgery

Kenichi A. Tanaka, MD, MSc[1]; Kenneth E. Stewart, PhD[1,2]; Kofi B. Vandyck, MD[1] et al

JAMA Surg Published Online: September 3, 2025
doi: 10.1001/jamasurg.2025.3238

Conclusions and Relevance In this study, a volume-dependent association was found between ANH and reduced RBC and non-RBC transfusion rates in patients undergoing cardiac surgery. Despite being safe and cost-effective, ANH remains underused as a blood conservation strategy.

Table 2. Summary of Outcomes for the Propensity Score–Matched Cohorts

Outcome	ANH (n = 2282)	No ANH (n = 2282)	*P* value
Blood component transfusions			
Any blood component, No. (%)	712 (31.2)	830 (36.4)	<.001
RBC, No. (%)	480 (21.0)	547 (24.0)	.02
Platelets, No. (%)	308 (13.5)	352 (15.4)	.06
Plasma, No. (%)	290 (12.7)	310 (13.6)	.38
Cryoprecipitate, No. (%)	248 (10.9)	331 (14.5)	<.001
Any blood component, mean (SD), units	1.40 (3.56)	1.62 (4.02)	.05
RBC, mean (SD), units	0.54 (1.47)	0.62 (2.00)	.16
Platelets, mean (SD), units	0.28 (0.87)	0.41 (1.57)	.001
Plasma, mean (SD), units	0.31 (0.97)	0.31 (0.98)	.93
Cryoprecipitate, mean (SD), pools	0.28 (1.42)	0.29 (0.85)	.69
Secondary end points			
Intensive care unit, mean (SD), h	65.6 (75.5)	64.3 (73.2)	.54
Reoperation for bleeding, No. (%)	50 (2.2)	50 (2.2)	.41

Abbreviations: ANH, acute normovolemic hemodilution; RBC, red blood cells.

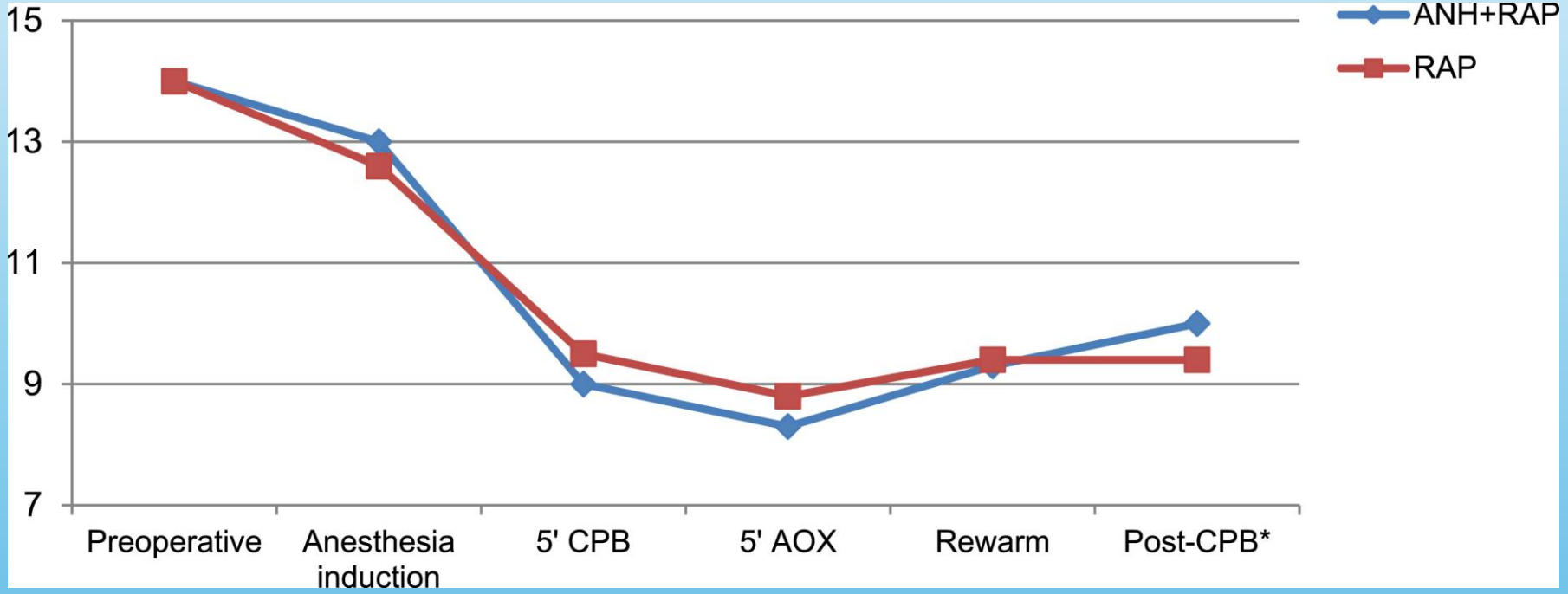
The role of acute normovolemic hemodilution and retrograde autologous priming in reducing intraoperative packed red blood cell transfusion needs in coronary artery bypass surgery: A randomized controlled trial

Boom et al. https://doi.org/10.1177/02676591251372497 Published online August 26, 2025

Single center randomized controlled trial
72 patients

ANH + RAP group reduction in transfusion rate (19.4% vs 47.2%, p = 0.024)

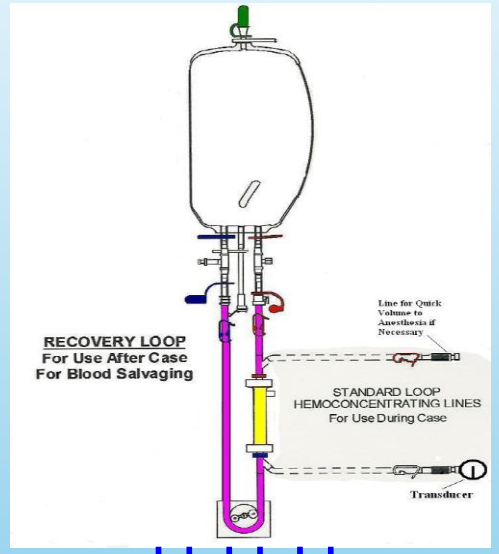
intraoperative allogeneic packed red blood cell units (0.2 ± 0.4 vs 0.5 ± 0.6, p = 0.012)



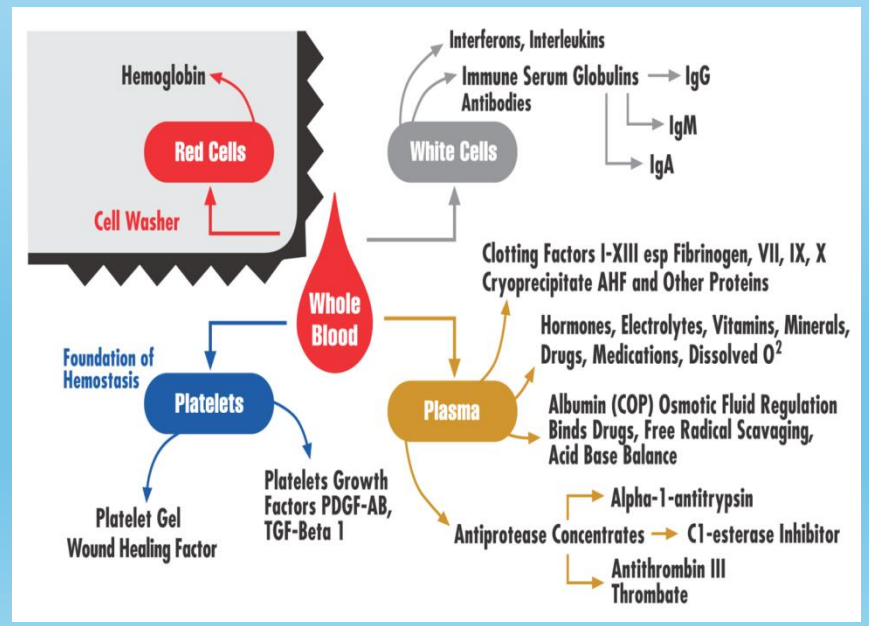
Conclusion:The combined use of ANH and RAP significantly reduces intraoperative allogeneic PRBC needs compared to RAP alone without affecting postoperative outcomes.

……????NEJM ARTICLE????

MODIFIED ULTRA-FILTRATION SYSTEMS



- Discarding platelets, clotting factors and important plasma proteins is counter-intuitive
- Maximize the composition of the component volume to achieve the best possible post-CPB coagulation profile for the patient



Mechanical	Thermal	Pharmacologic	Hemostatic Sealants & Adhesive Agents
Digital pressure Packing Clamps Clips Sutures Bone wax Alkaline oxide copolymer (e.g. Ostene)	Hypothermia Harmonic scalpel Electrocautery Vessel sealants (e.g. Ligasure) Argon beam coagulator Radiofrequency (e.g. Aquamantys Laser)	Hypotensive anesthesia Vasoconstrictors Antifibrinolytics (e.g. Aminocaproic acid, TXA) Recombinant Factor VIIa Vitamin K Protamine PCCs Idarucizumab Andexanet alfa	Thrombin – Stand Alone Combination hemostatic agents Fibrin sealants Fibrin patches Synthetic sealants Glues/Adhesives

- Suture line bleeding
- Diffuse soft tissue
- Bone bleeding
- Non-cauterizable sites
- Management of coagulation
- Friable tissue

Surgical Bleeding Challenges

ANTIFIBRINOLYTICS

Use of synthetic antifibrinolytic agents such as epsilon-aminocaproic acid (EACA) or tranexamic acid reduces blood loss and blood transfusion during cardiac procedures and are indicated for blood conservation. Class I, Level A

Tranexamic Acid ATACAS Investigators

31 sites, 7 countries, 2006-2015, n=4631
2x2 factorial design, DB, randomized, CABG
ASA vs placebo; tranexamic acid vs placebo
1°outcome- composite death+thrombotic 30d
TxA 100 mg/kg 1st 1526 patients to 1/2012
TxA50 mg/kg after seizures noted
Groups demographically similar

Myles PS et al: N Engl J Med 2017;376:136-148

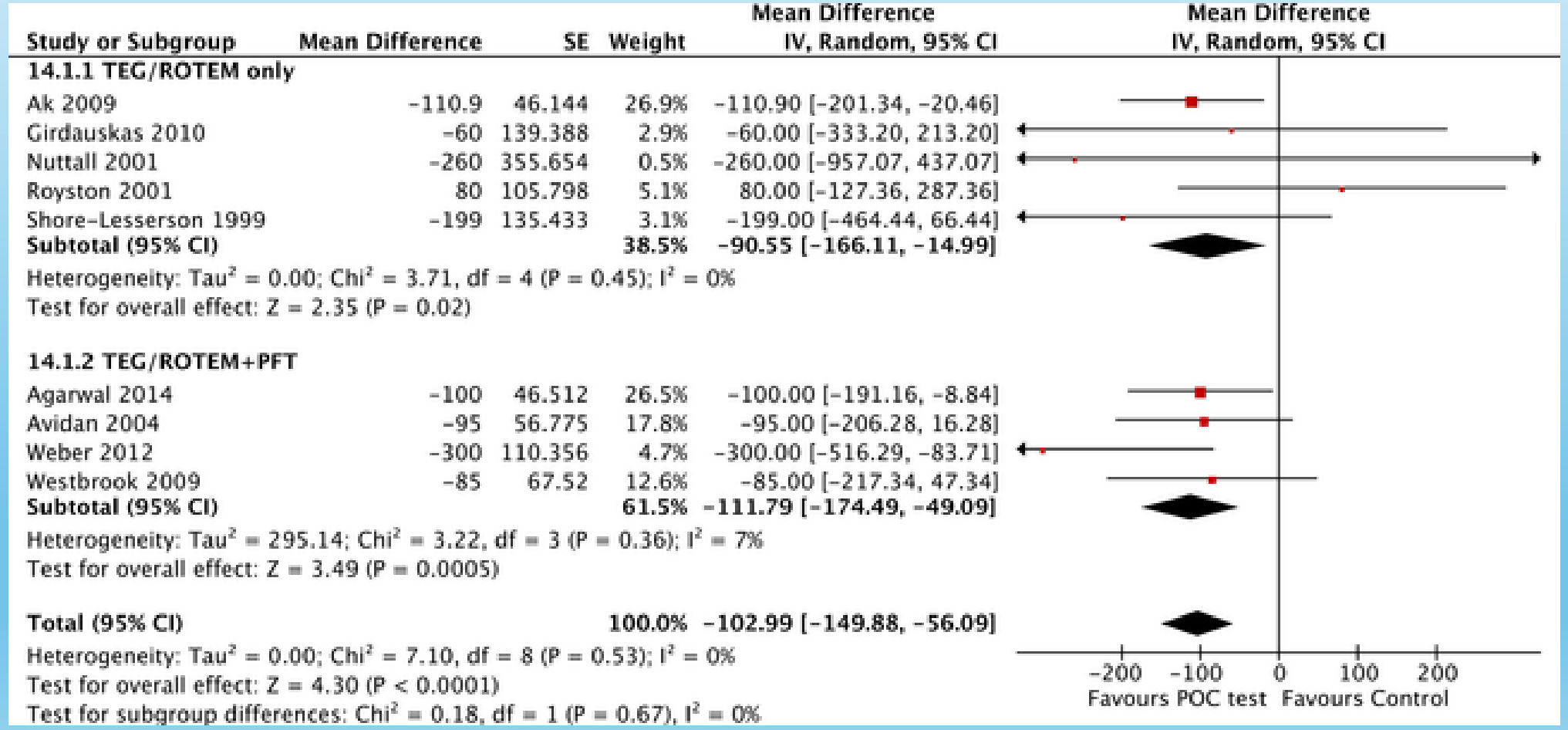
	TxA n=2311	Placebo n=2320	P value
1°Outcome (%)	386(16.7)	420(18.1)	0.22
MI 30d (%)	269(11.6)	300(12.9)	0.19
Reoperation (%)	32(1.4)	65(2.8)	0.001
Tot Products (U)	3(2-6)	4(2-8)	<0.001
Mech Vent hr	8(5-14)	9(6-16)	<0.001
Seizures (%)	15(0.7)	2(0.1)	0.002

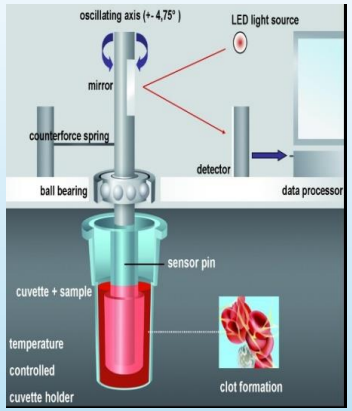
VISCOELASTIC TESTING

Goal directed transfusion algorithms which incorporate point of care testing, such as with viscoelastic devices, are recommended to reduce periprocedural bleeding and transfusion in cardiac surgical patients. Class I, Level B-R

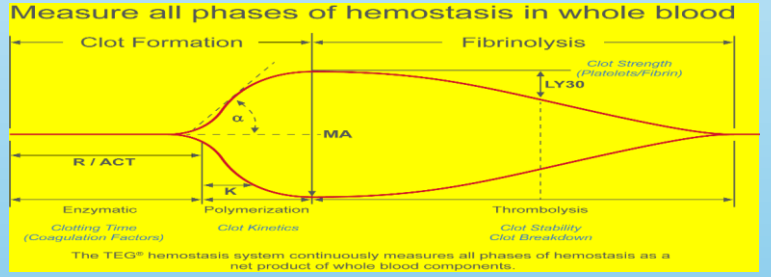
POC Algorithm vs. Control-Bleeding Meta-Analysis

Corridor et al: Anaesthesia 2015;70:715-731

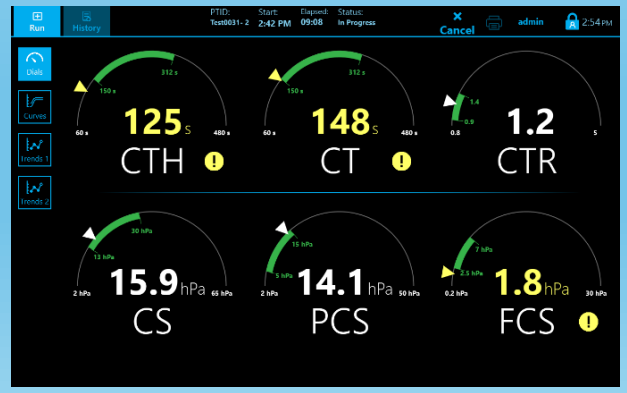




TEG

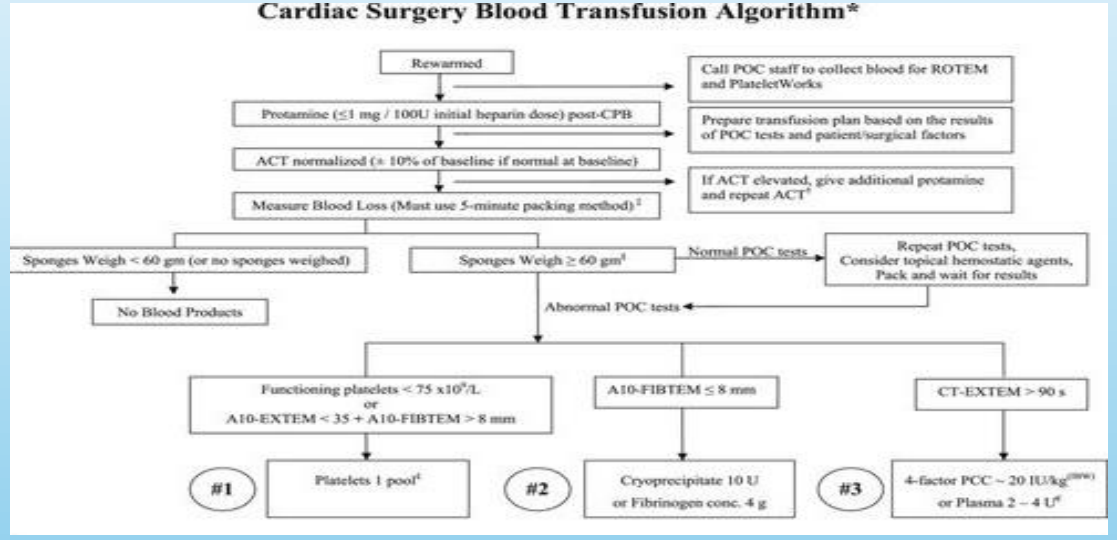


ROTEM

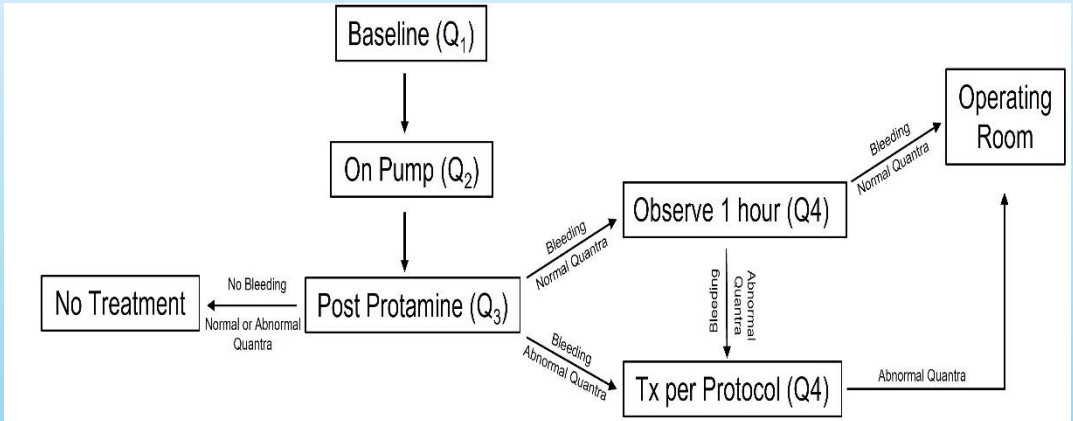


QUANTRA

Viscoelastic Algorithms



TEG Variable	Implication	Therapy
14<R<21mm	↓Clot factors	1 FFP
21<R<28mm	↓↓Clot factors	2 FFP
R>28mm	↓↓↓Clot factors	4 FFP
MA<48mm	↓Plt number/fx	1 Plt pools
MA<40mm	↓↓Plt number/fx	2 Plt pools
LY30>7.5%	Fibrinolysis	Aprotinin



Sampling Protocol:
Baseline: At time of acute normovolemic hemodilution draw from Cordis side port
On Pump Rewarm: At 35-37 degrees prior to cross-clamp release and discontinuation from cardiopulmonary bypass machine
Post Protamine: Same time as post protamine ACT. Usually done after protamine and acute normovolemic hemodilution units transfused
Post Op: See ICU standing orders if chest tube drainage is 150 mls per hour or greater

Algorithm:

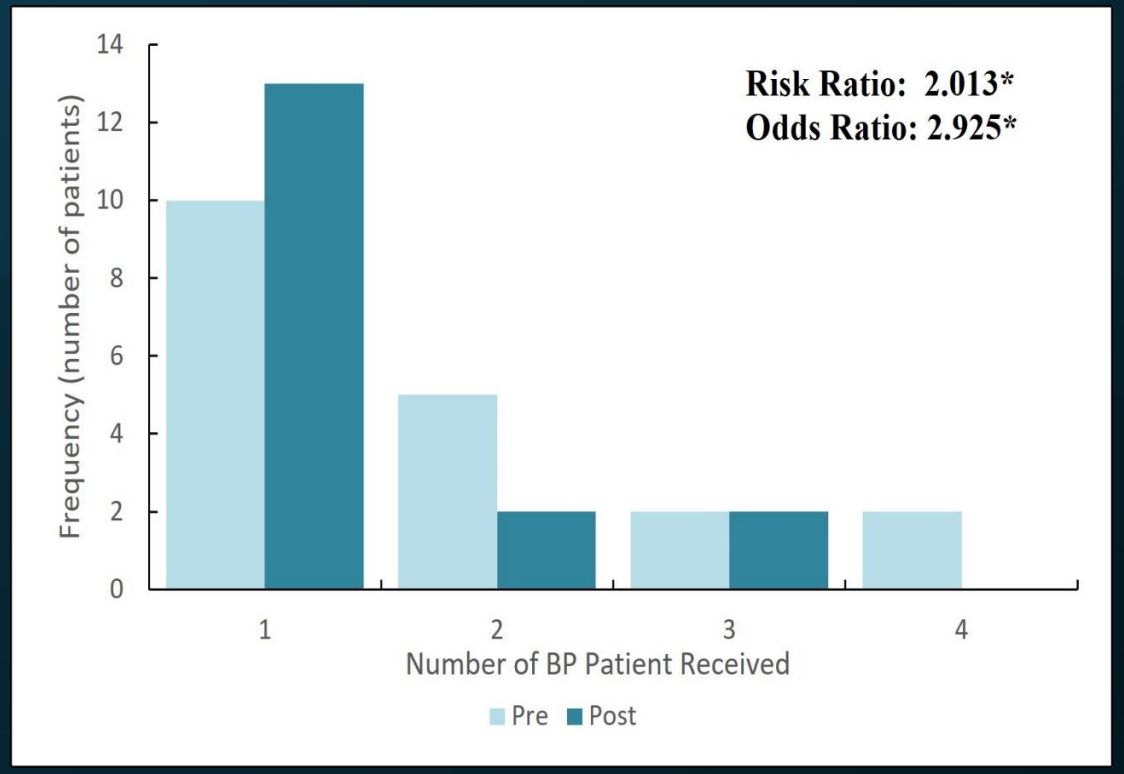
1. If the patient is bleeding and the *Quantra values have changed*, consider in the following order:
   i. If CTR > 1.4: Consider protamine
   ii. If CS is lower than the patient's baseline assess the following:
      1. Fibrinogen: FCS lower than the patient's baseline:
         a. Slow to moderate bleeding: 1-2 5 pack of cryoprecipitate
         b. Moderate to active bleeding: 2-3 5 pack of cryoprecipitate
      2. Platelets: PCS lower than the patient's baseline:
         a. Slow to moderate bleeding: 1-2 units of platelets
         b. Moderate to active bleeding: 2-3 units of platelets
      3. Clotting Factors: If CT/CTH are both elevated and CTR < 1.3:
         a. Slow to moderate bleeding: 1-2 units fresh frozen plasma or Kcentra
         b. Moderate to active bleeding: 2-3 units fresh frozen plasma or Kcentra

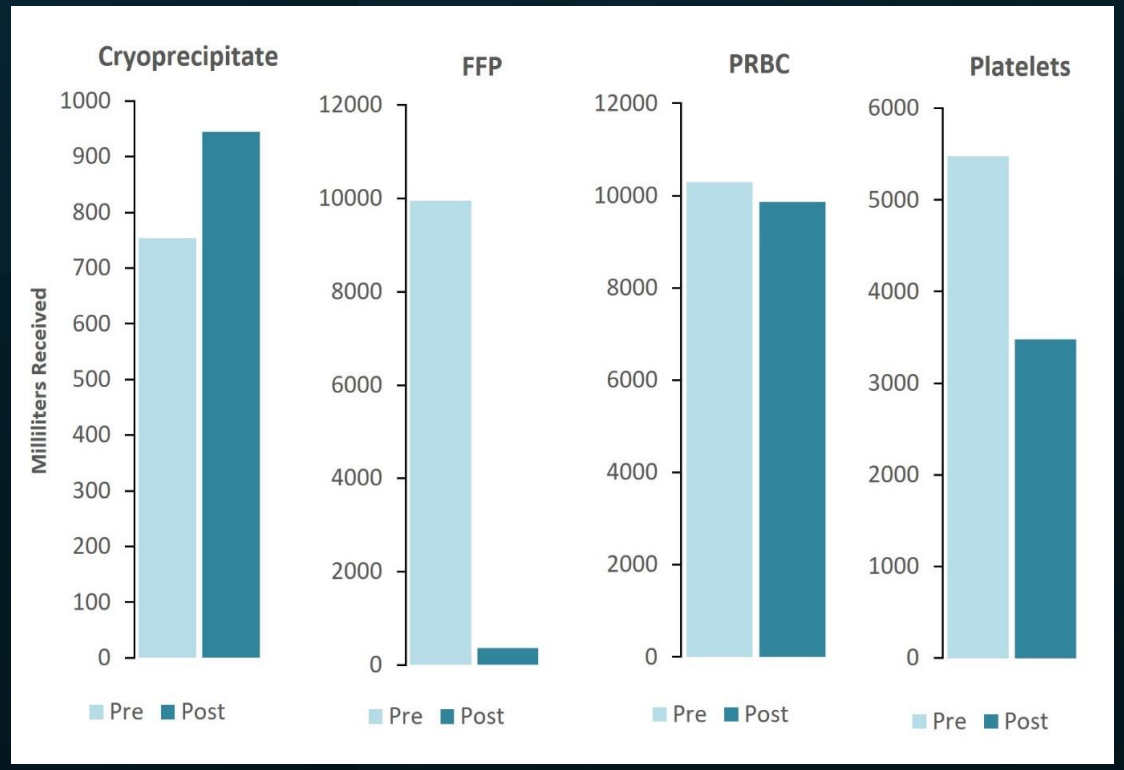
NOTE: *If more than one parameter has changed consider which parameter has changed most significantly and treat with that corresponding blood product. Active bleeding may require more than one type of blood product or treatment. With CT/CTH elevated (high value) and CS/PCS/FCS decreased (low values) the parameter will be reported in yellow.*

2. If the patient is bleeding and the *Quantra values have not changed*, consider the following:
   iii. DDAVP: Will increase platelets ability to adhere. VET, such as Quantra, do not assess platelet adhesion
   iv. Calcium: VET will mask hypocalcemia as the tests utilize calcium to neutralize citrate from the blue top tube
   v. Platelets: If platelet inhibition is suspected or known due to preoperative testing with Verify Now

Standardized Treatment Algorithm for Viscoelastic Testing using the Quantra Analyzer

Pierre R. Tibi MD, Jess Thompson MD, Saina Asl-Attaran MD, Elizabeth Black, Jonathan Mazur
Yavapai Regional Medical Center, Prescott AZ*





Journal of Cardiothoracic Surgery (2023) doi.org/10.1186/s13019-023-02245-x

	Optimize hemopoiesis	Minimize blood loss & bleeding	Harness & optimize tolerance of anemia
Preoperative	• Screen for anemia • Identify underlying disorder(s) causing anemia • Manage underlying disorder(s) • Refer for further evaluation if necessary • Treat iron deficiency, anemia of chronic disease, iron-restricted erythropoiesis • Note: anaemia is a contraindication for elective surgery	• Identify and manage bleeding risk (past/family history, current medications, etc) • Minimize iatrogenic blood loss • Procedure planning and rehearsal	• Assess/optimize patient's physiological reserve and risk factors • Compare estimated blood loss with patient-specific tolerable blood loss • Formulate patient-specific management plan using appropriate blood conservation modalities to minimize blood loss, optimize red cell mass and manage anemia • Restrictive, evidence-based transfusion strategies
Intra-operative	• Timing surgery with hematological optimization	• *Meticulous hemostasis and surgical techniques* • *Blood-sparing surgical techniques* • *Anesthetic blood conserving strategies* • *Autologous blood options* • *Pharmacological/haemostatic agents*	• Optimize cardiac output • Optimize ventilation and oxygenation • Restrictive, evidence-based transfusion strategies
Postoperative	• Treat anemia /iron deficiency • Stimulate erythropoietin • Be aware of drug interactions that can cause/increase anemia	• Vigilant monitoring and management of post-operative bleeding • Avoid secondary hemorrhage • Rapid warming - maintain normothermia (unless hypothermia specifically indicated) • Autologous blood salvage • Minimizing iatrogenic blood loss • Hemostasis/anticoagulation management • Prophylaxis of upper GI hemorrhage • Avoid/treat infections promptly • Be aware of adverse effects of medications	• Optimise tolerance of anaemia • Treat anaemia • Maximize oxygen delivery • Minimize oxygen consumption • Avoid/treat infections promptly • Restrictive, evidence-based transfusion strategies

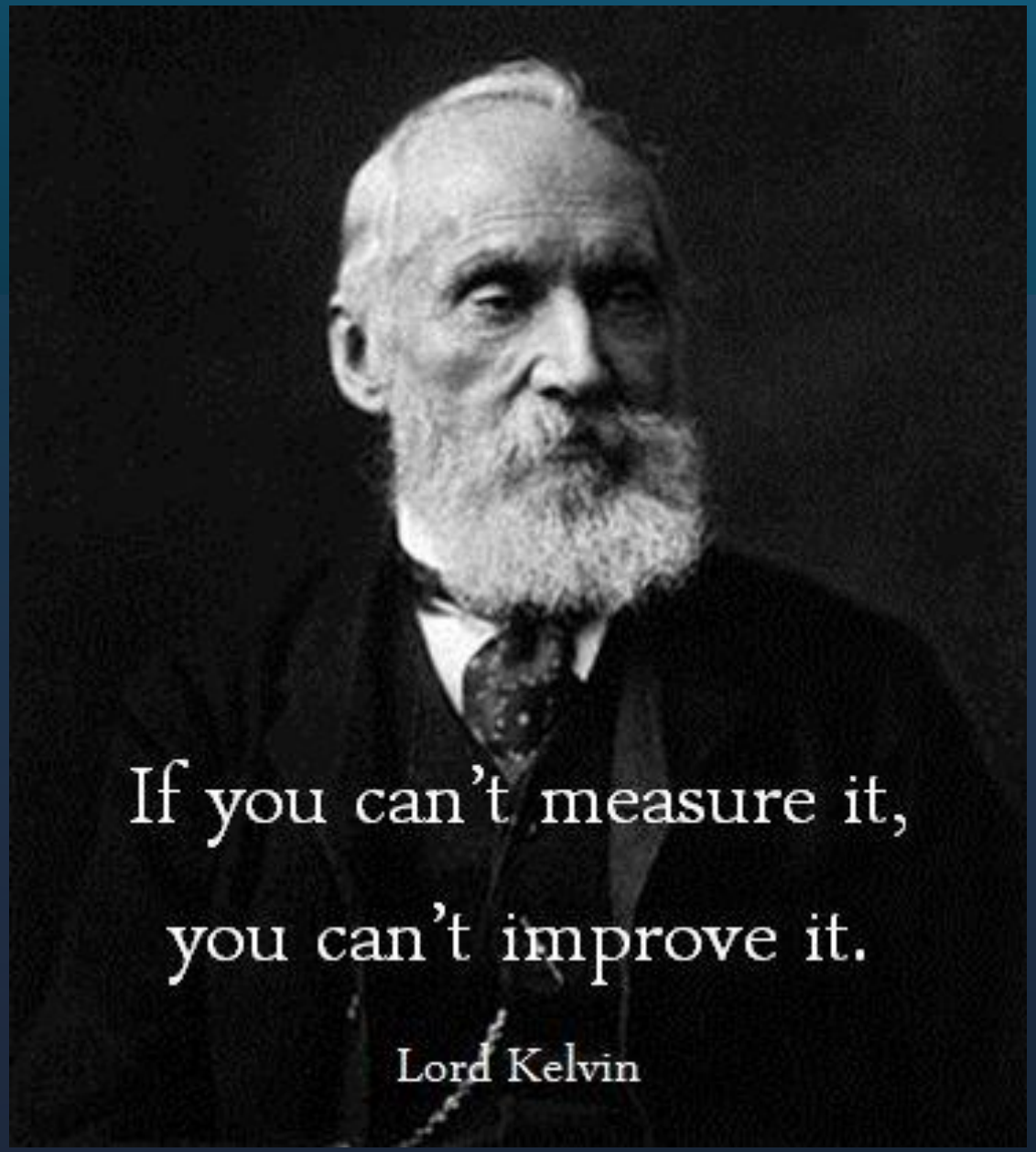
Modified from Hofmann et al.,
The Oncologist 2011;16(suppl 3):3–1

Post-operative Management

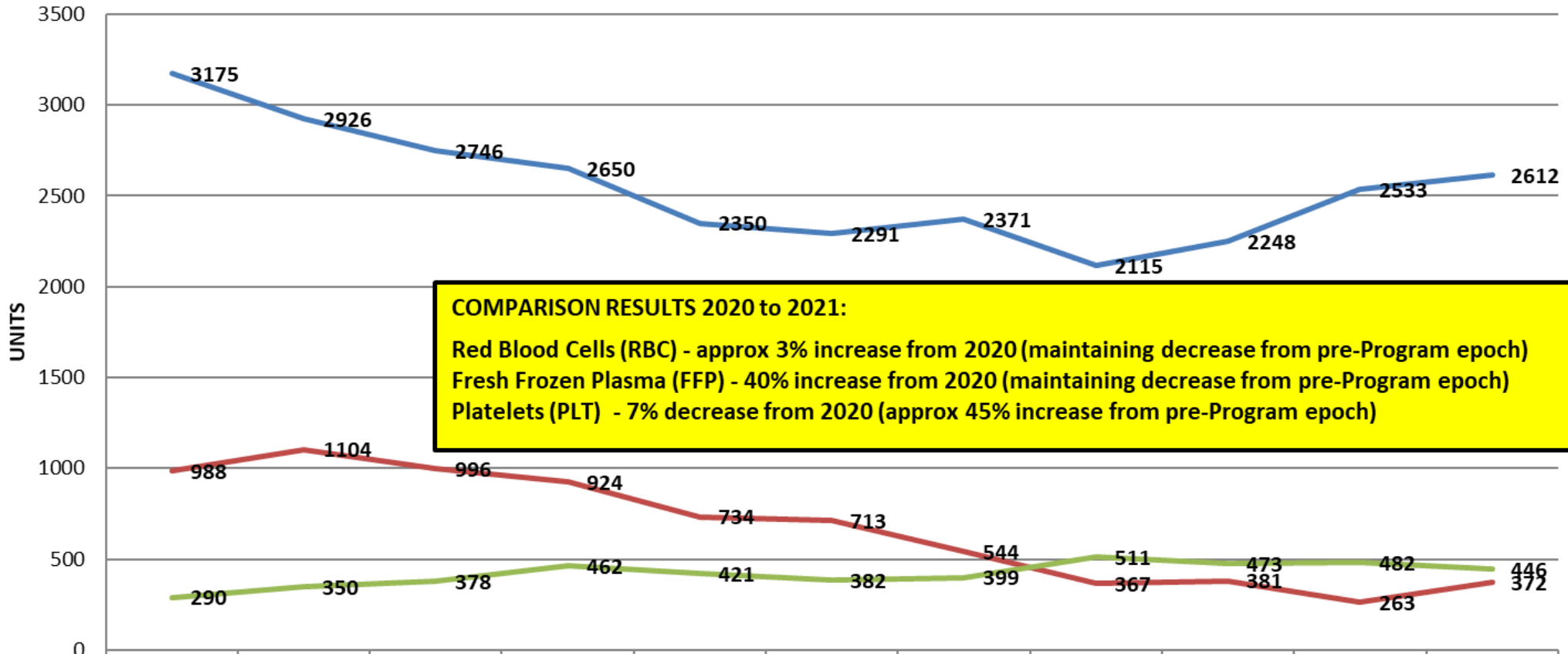
- Blood Loss due to Bleeding
- Blood loss due to Coagulopathy
- Persistent or new anemia
- How much failure is tolerated and what are the ramifications

A comprehensive multimodality blood conservation program led by a multidisciplinary team of health care providers should be part of any patient blood management program to limit utilization of blood resources and decrease the risk of bleeding. Class I, Level B-R

Something more is needed…


If you can't measure it,
you can't improve it.
Lord Kelvin

DH YRMC BLOOD PRODUCT UTILIZATION COMPARISON
PRE-PBM PROGRAM 4-YEAR AVG (2008-2011) AND POST- PBM PROGRAM YEARLY TOTALS
2012 - 2021

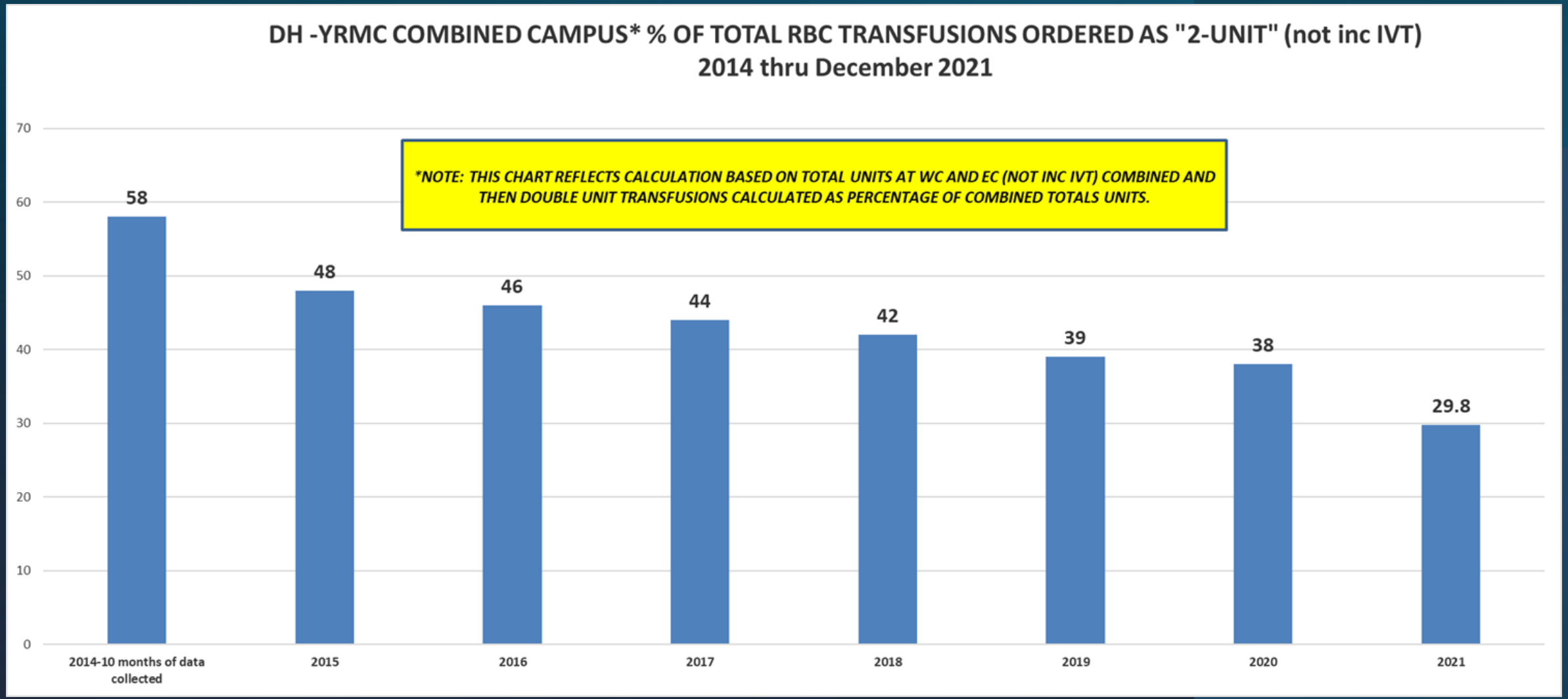


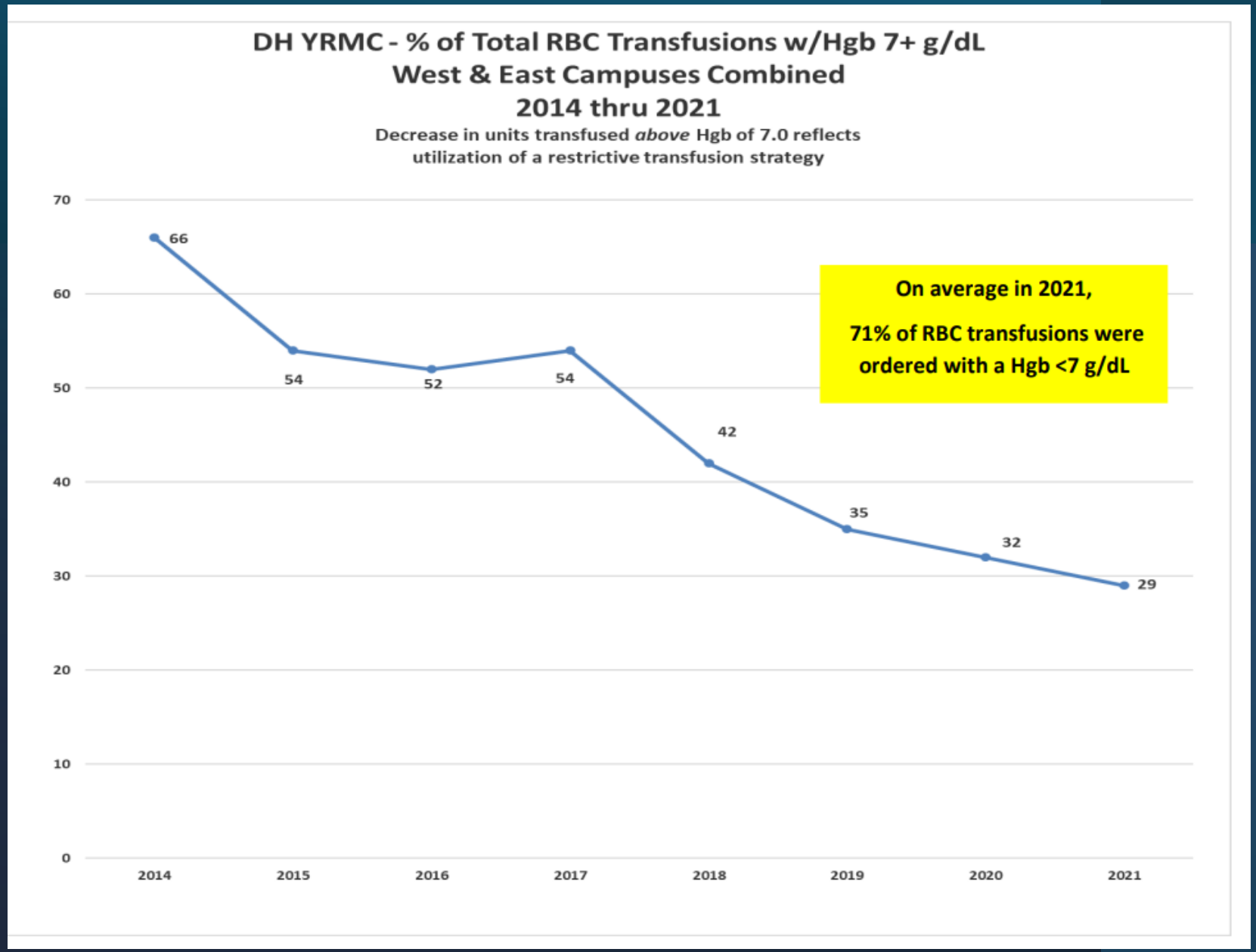
COMPARISON RESULTS 2020 to 2021:

Red Blood Cells (RBC) - approx 3% increase from 2020 (maintaining decrease from pre-Program epoch)
Fresh Frozen Plasma (FFP) - 40% increase from 2020 (maintaining decrease from pre-Program epoch)
Platelets (PLT) - 7% decrease from 2020 (approx 45% increase from pre-Program epoch)

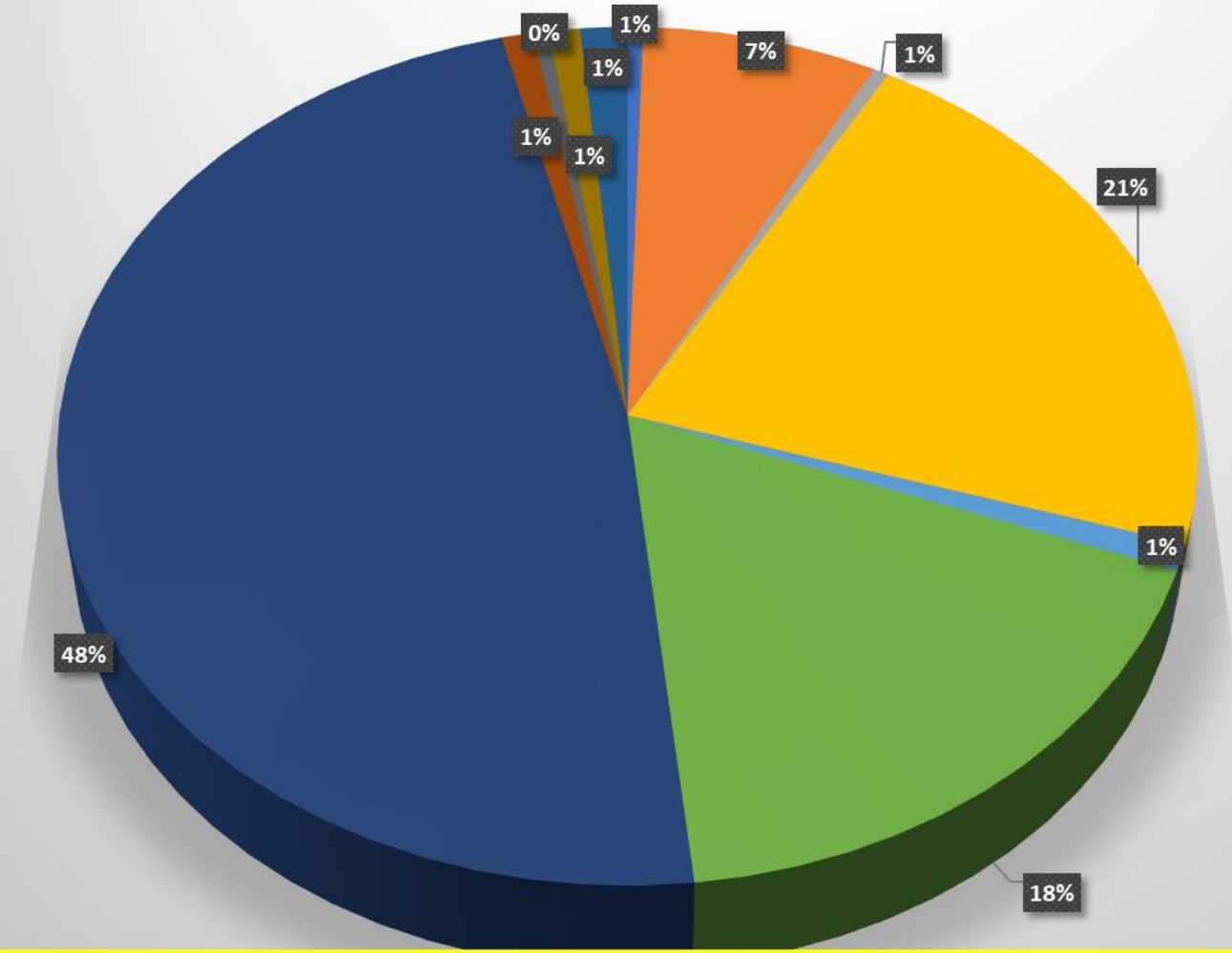
	2008-2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
RBC	3175	2926	2746	2650	2350	2291	2371	2115	2248	2533	2612
FFP	988	1104	996	924	734	713	544	367	381	263	372
PLT	290	350	378	462	421	382	399	511	473	482	446

DH -YRMC COMBINED CAMPUS* % OF TOTAL RBC TRANSFUSIONS ORDERED AS "2-UNIT" (not inc IVT)
2014 thru December 2021




DH YRMC - % of Total RBC Transfusions w/Hgb 7+ g/dL
West & East Campuses Combined
2014 thru 2021
Decrease in units transfused *above* Hgb of 7.0 reflects
utilization of a restrictive transfusion strategy
70
60
50
40
30
20
10
0
66
54
52
54
42
35
32
29
2014
2015
2016
2017
2018
2019
2020
2021
On average in 2021,
71% of RBC transfusions were
ordered with a Hgb <7 g/dL

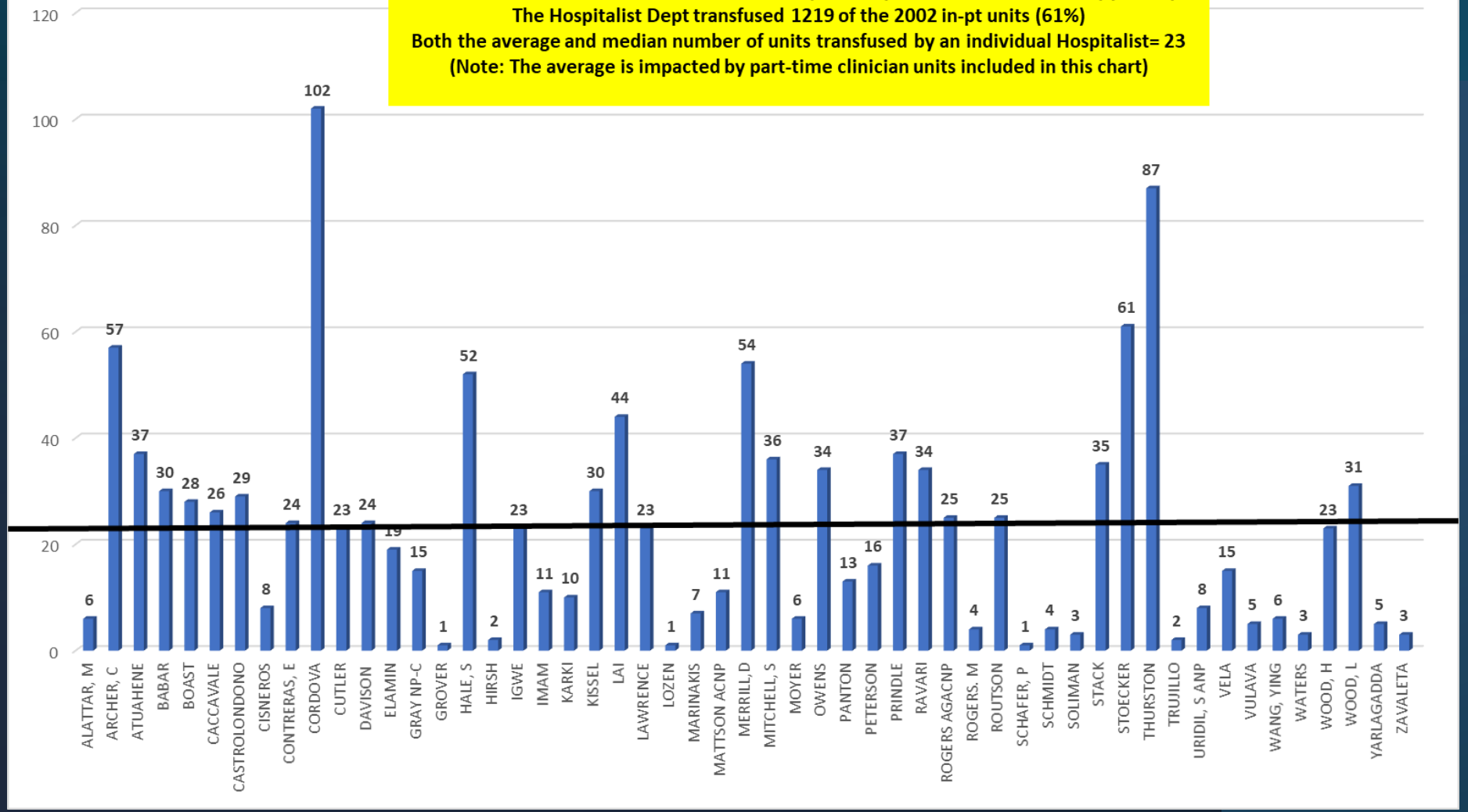
DH-YRMC DECEMBER 2021
RBC Transfusions - % By Department



44 of 205 units (21.5%) were administered in IVT through: Heme/Onc, Hospitalist, Internal Medicine & Nephrology Departments

2021 DH YRMC
RBC Units Transfused By Individual Hospitalist
(List Includes LTs, Current and Past Staff)

2612 Units of RBCs were transfused in 2021 (2002 In-patient and 610 IV Therapy Units)
The Hospitalist Dept transfused 1219 of the 2002 in-pt units (61%)
Both the average and median number of units transfused by an individual Hospitalist= 23
(Note: The average is impacted by part-time clinician units included in this chart)



DH-YRMC WEST AND EAST CAMPUS PLT TRANSFUSIONS – DECEMBER 2021

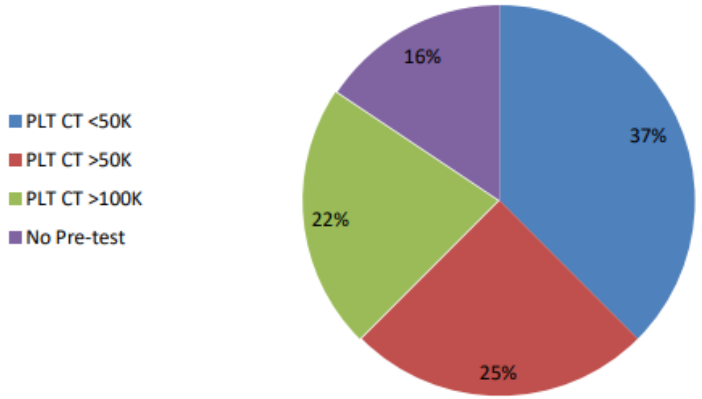
Total 32* Units 13 West/ 8 East

*Per Tx Logs/Tx Review Committee Totals

43 % transfused above threshold of 50k

14 % with No Pre-test

Platelets Destroyed - Total 6 Units 3 West/3 East



MDs Ordering Tx over 50K/No Pre-test:

Cordova	1 @ 203 No TXO
Hamarneh	2 w/no pre-test
Espinosa	1 w/no pre-test
Hale	1 @ 54 ✧
Langerak	2 w/no pre-test
Moualla	1/1 @ 70/82 √ low PLT S/P TAVR
Owens	1 @ 54 √ severe active GI bleed
Petra	2 @ 329 No TXO
Rogers	2 @ 71 ⧫
Stoecker	1/1 @60/80√ dic,needs surg, 60k
Thompson	1/1/2 @ 200/242/229 √ CVICU hold

PLT COUNT	Units Tx	Notes
<50K	12	
50K +	8	54-82
100k+	7	203-242
No Pre-test	5	5 IVT

Platelet Reasons on Tx Orders inc IVT:

11 units (35%)	✧	Platelet Count <30K
4 units (13%)	□	Platelet Count < 50K Invasive procedures
3 units (9%)	⧫	Platelet Count < 50K Bleeding
0 units (0%)	•	Platelet Count <100K ICB/Spinal Bleed
1 units (3%)	⊡	Oncology Patient < 20,000
9 units (27%)	√	Other Explanation (i.e. Platelet Dysfunction)
4 units (13%)		No TXO

DH-YRMC WEST AND EAST CAMPUS FFP TRANSFUSIONS – DECEMBER 2021

Total Units 26 16 West/10 East* **73 % of the transfusions performed were two units or less**

see dosage comments below regarding generally appropriate starting dose

*Per Tx Logs/Tx Review Committee Totals

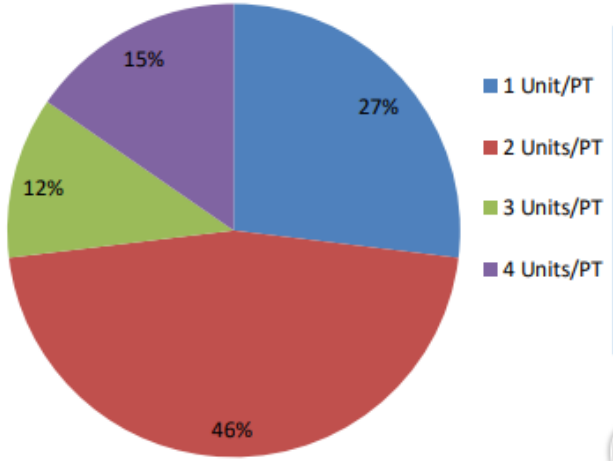
MDs Ordering 1 & 2 Units:

7 Units ordered as 1 Unit / PT:

Babar (2) ♦ √
Campuzano √ also rec'd 2u RBC postOp
Lopez √ GI bleed on Effient
Ravari ♦
Routson √ PT>16, DIC, severe coagulopathy
Wood, H □

12 Units ordered as 2 Units/ PT:

Hale ♦
Prindle □
Thompson √
Tibi √ increased chest tube output
Tung-Tahker √ high INR level
Wood, L □



Reasons per TXO:

8 units	(31%)	□ PT>16 PreOp
4 units	(15%)	♦ PT>16 Bleed
0 units	(0%)	• FCTR Defic & Active Bleed
10 units	(39%)	√ Other (6 w/explanation)
4 units	(15%)	No Transfuse Order (TXO)
0 units	(0%)	∞ At III/Protein C Defic
0 units	(0%)	~ Therapeutic Apheresis/TTP

Please note the following comments from the AABB's "Practical Guide for Transfusion Medicine" re FFP-Indications for Transfusion:

•FFP is indicated to correct deficiencies of coagulation factors for which no specific factor concentrates are available. Whenever possible, alternative therapies, such as vitamin K for warfarin effect, should be tried first. Factor concentrates are preferable to FFP in the case of single-factor deficiencies because such concentrates are all virus inactivated in some way and, thus, carry far less infectious disease risk than does FFP.

•First, FFP is not effective in correcting INRs that are only minimally elevated.

•If correction of a markedly abnormal PT or aPTT is required before surgery, FFP should be transfused immediately before it will be needed because some factors (especially Factor VII) have very short in-vivo half-lives (3-5 hours).

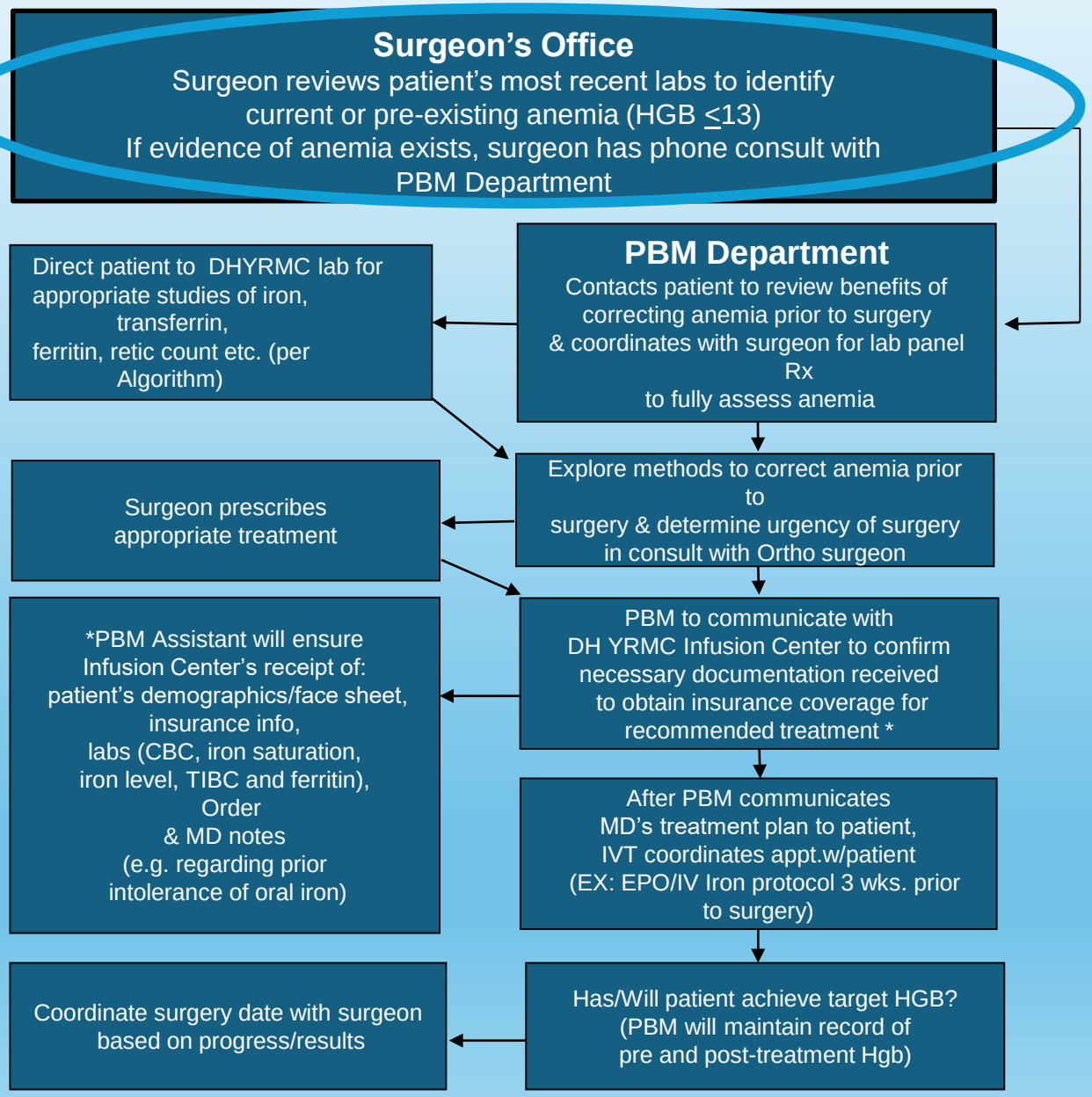
•The dose should be based on the patient's size, with a common rule of thumb to begin by infusing 10mL/kg of recipient body weight and then measuring posttransfusion PT, aPTT or both 15-30 minutes after infusion…because a unit of FFP has a volume of approximately

“VIRTUAL” ANEMIA CLINIC

Evaluation for Readiness Begins with Initial Consult

Preoperative Virtual Anemia Center

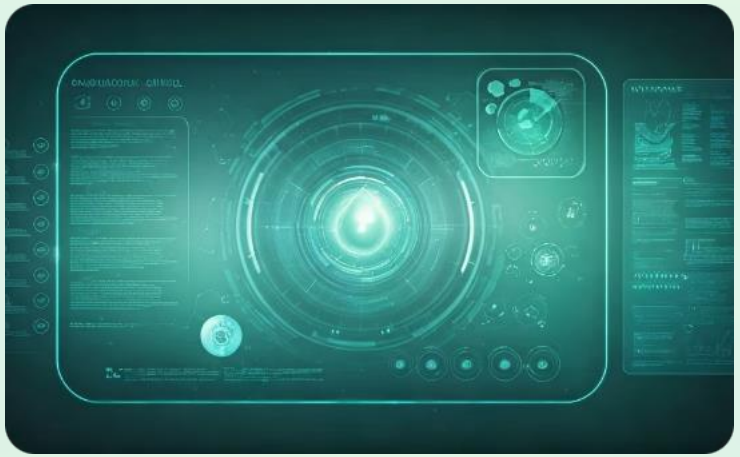
Elective patients scheduled for Orthopedic Surgery



Obstacles Yet to Overcome

- Acceptance (Breaking of old habits)
- Knowledge Deficit
- Suspicion of motive for PBM
- “Fear of Omission” or “Failure of Treatment”
- Economical effects
- Dismissal of import
- Insecurity i.e. “I know what I am doing”

Future Directions in PBM



Advanced Technologies

Novel hemostatic agents and artificial oxygen carriers will transform practice. Nanotechnology enables targeted treatments

Personalized Approaches

Genetic profiling will customize transfusion strategies. AI algorithms predict individual patient needs.

Integrated Pathways

PBM integration with enhanced recovery protocols. Seamless data flow optimizes decision-making.

Thank you!

“I don’t usually transfuse”

…But when I do, it is necessary and evidence-based (stay cautious, my friends)