BLOOD CONSERVATION & MANAGEMENT

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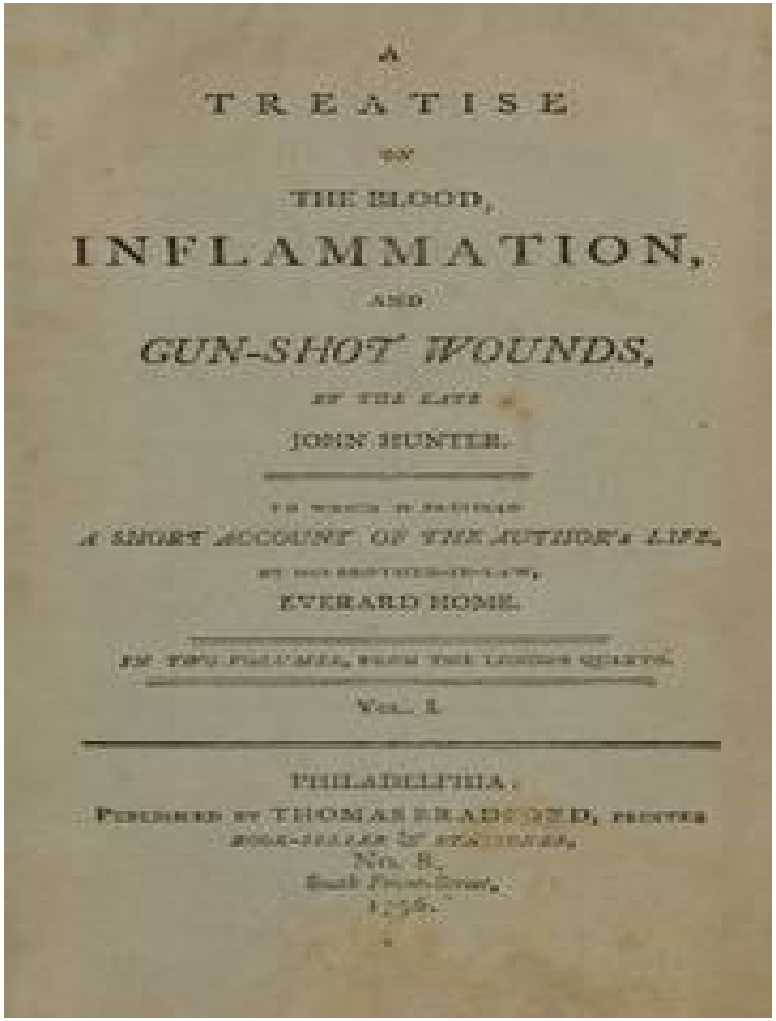
OBJECTIVES

1. List various parameters blood conservation is indicated.
2. Identify blood conservation methods.
3. Explain which blood conservation method may be appropriate.
4. Know when blood conservation is not warranted.

History of BLOOD CONSERVATION


A
TREATISE
ON
THE BLOOD,
INFLAMMATION,
AND
GUN-SHOT WOUNDS,
BY THE LATE
JOHN HUNTER.
A SHORT ACCOUNT OF THE AUTHOR'S LIFE,
EVERARD HOME.
Vol. I.
PHILADELPHIA:
No. 8,

Ambroise Paŕe (1510-1590)

- Used a solution of egg yolk, rose oil & turpentine to dress battle wounds.
- Barber & Surgeon.
- Stressed the knowledge of anatomy.
- Challenged Authority

John Hunter (1728-1793)

- Considered the father of experimental surgery
- First documented ligation of arterial vessels in cases of aneurysm.

History of BLOOD CONSERVATION

- Hunter attended the Vienna School of Medicine.
- After becoming an orthopedic surgeon, he developed an allergy to carbolic acid used at that time for asepsis.
- This lead to his “dry surgery” techniques.

(Jackson & Pollo, 2004)

Blood Facts

- Every 2 seconds, someone in the United States needs blood.
- Less than 38% of the population is eligible to give blood & only 3% do.
- Approximately 36,000 units of blood are needed everyday.
  - Average transfusion = 3 units

Transfusions

- In the United States, there are approximately ***21 million*** units of blood products transfused each year.

Daily -

- 36,000 units of PRBCs
- 7000 units of platelets & 10,000 units of plasma transfused.

Centers for Disease Control. (2017) & American Red Cross

Importance of Blood Conservation

Becoming increasing more prominent with:

Blood Transfusion safety

Blood Storage

RBCs – 42 days

Platelets – 5 days

Blood Shortages

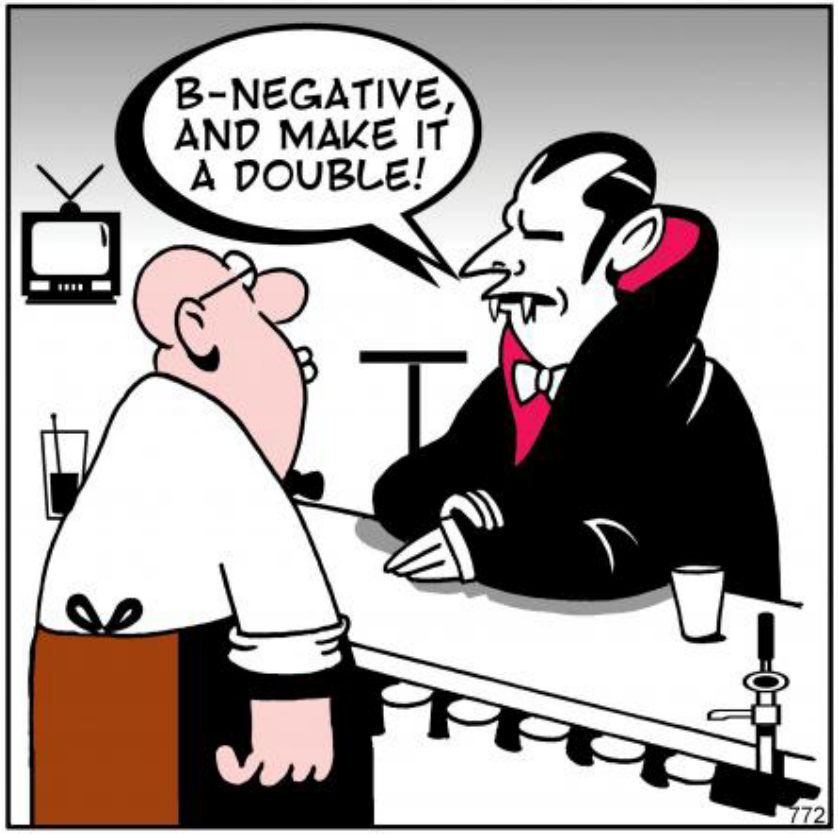
BLOOD CONSERVATION

- Gained popularity due to religious faiths refusing blood transfusions.
- Concern with the transmission of bloodborne diseases.
- There are many techniques that we as CRNAs can help to employ.
- Surgical techniques are vital.
- Recent evidence comes from Cardiothoracic surgery.

Blood Conservation

- Initiatives to utilize blood conservation techniques & minimize blood transfusions have worked.
- According to the American Red Cross, which holds 40% of the market,
  - Transfusions are down almost 1/3 over the last 5 years.
  - A drop to approximately 11 million units from 15 million units of RBCs

IMPORTANCE OF A BLOOD CONSERVATION PROGRAM



- PATIENT SAFETY
- DECREASED RISKS ASSOCIATED WITH TRANSFUSIONS
- LACK OF SUPPLY
- GREATER DEMAND
- COSTS

Quick Review of some Basics

IMPORTANCE OF BLOOD CELLS

1. Transport of 02 and C02.
2. Coagulation
3. Defense against disease/immunity
4. Acid - Base balance

Normal Hemoglobin (Hgb)

Hemoglobin values - (g/dL)

	Male	Female
Newborns	14.7–18.6	12.7–18.3
6 months–2 years	10.3–12.4	10.4–12.4
2–6 years	10.5–12.7	10.7–12.7
6–12 years	11.0–13.3	10.9–13.3
12–18 years	11.5–14.8	11.2–13.6
18 years	10.9–15.7	10.7–13.5

Estimated Blood Volume & Loss

$$MABL = EBV\ x \frac{(Initial\ Hct - Lowest\ Acceptable\ Hct)}{Initial\ Hct}$$

MABL - MAXIMUM ALLOWABLE BLOOD LOSS

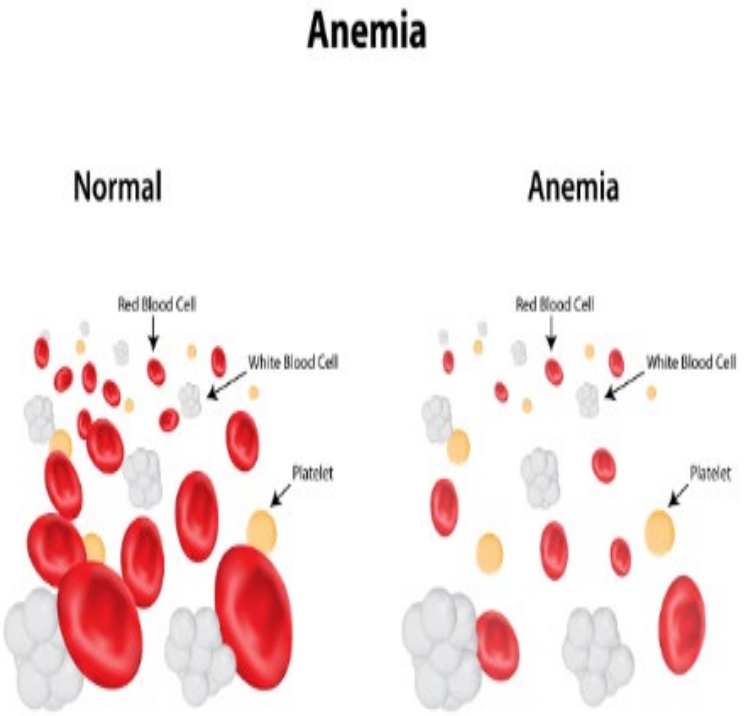
EBV - ESTIMATED BLOOD VOLUME

Average Estimated Blood Volume

Obese	60 ml/kg	Preemie	95 -105 ml/kg
Female	65 ml/kg	Term	85 ml/kg
Male	70 ml/kg	<1 year	80 ml/kg
Muscular	75 ml/kg	1-6 years	70-75 ml/kg

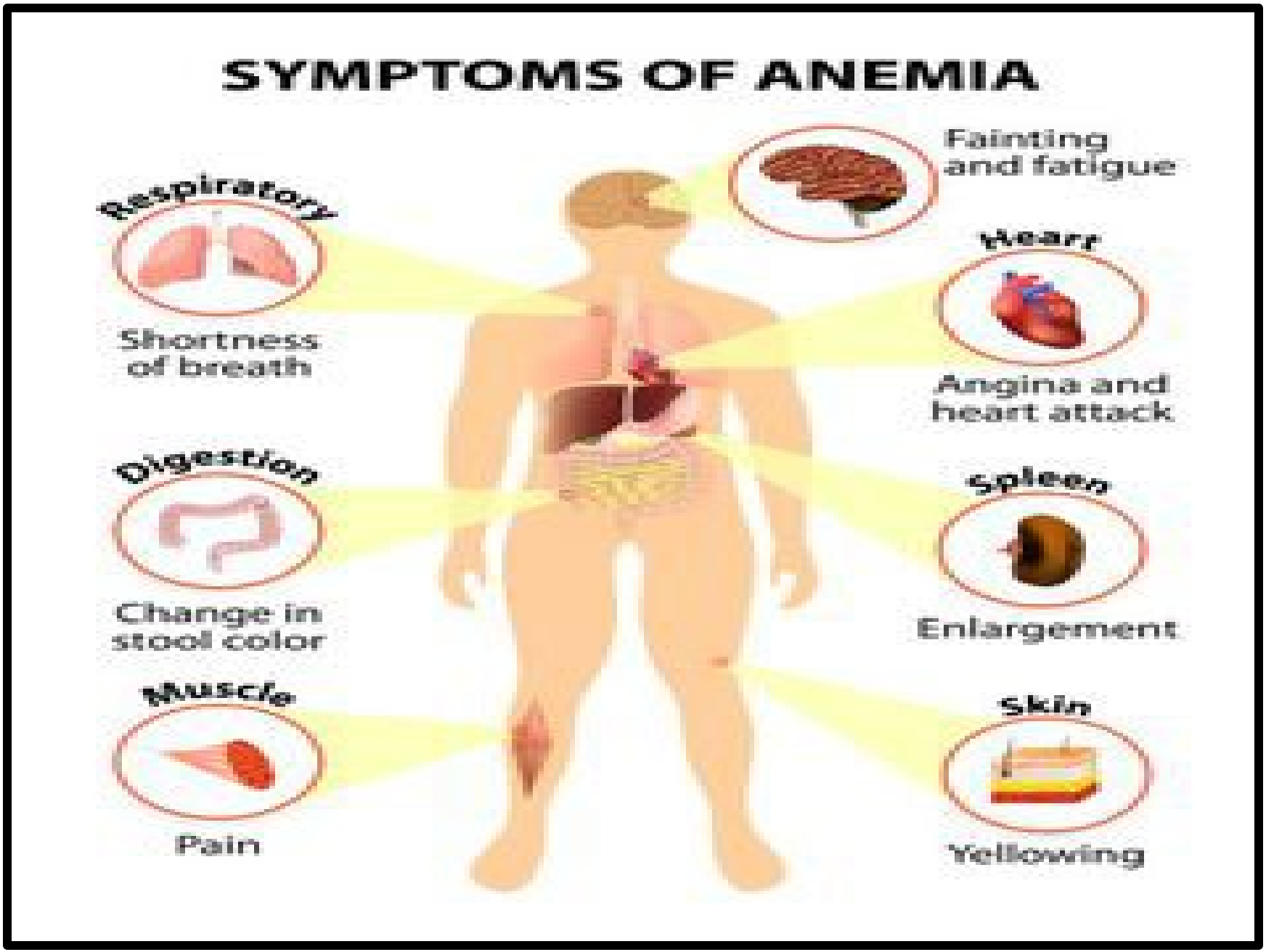
ANEMIA

- **AFFECTS MORE THAN *3 MILLION* AMERICANS.**
- **ALMOST 10% OF PEOPLE OVER THE AGE OF 65 ARE ANEMIC.**
- **ANEMIA IN PREGNANCY IS COMMON DUE TO THE INCREASE IN BLOOD VOLUME BY 20-30%.**

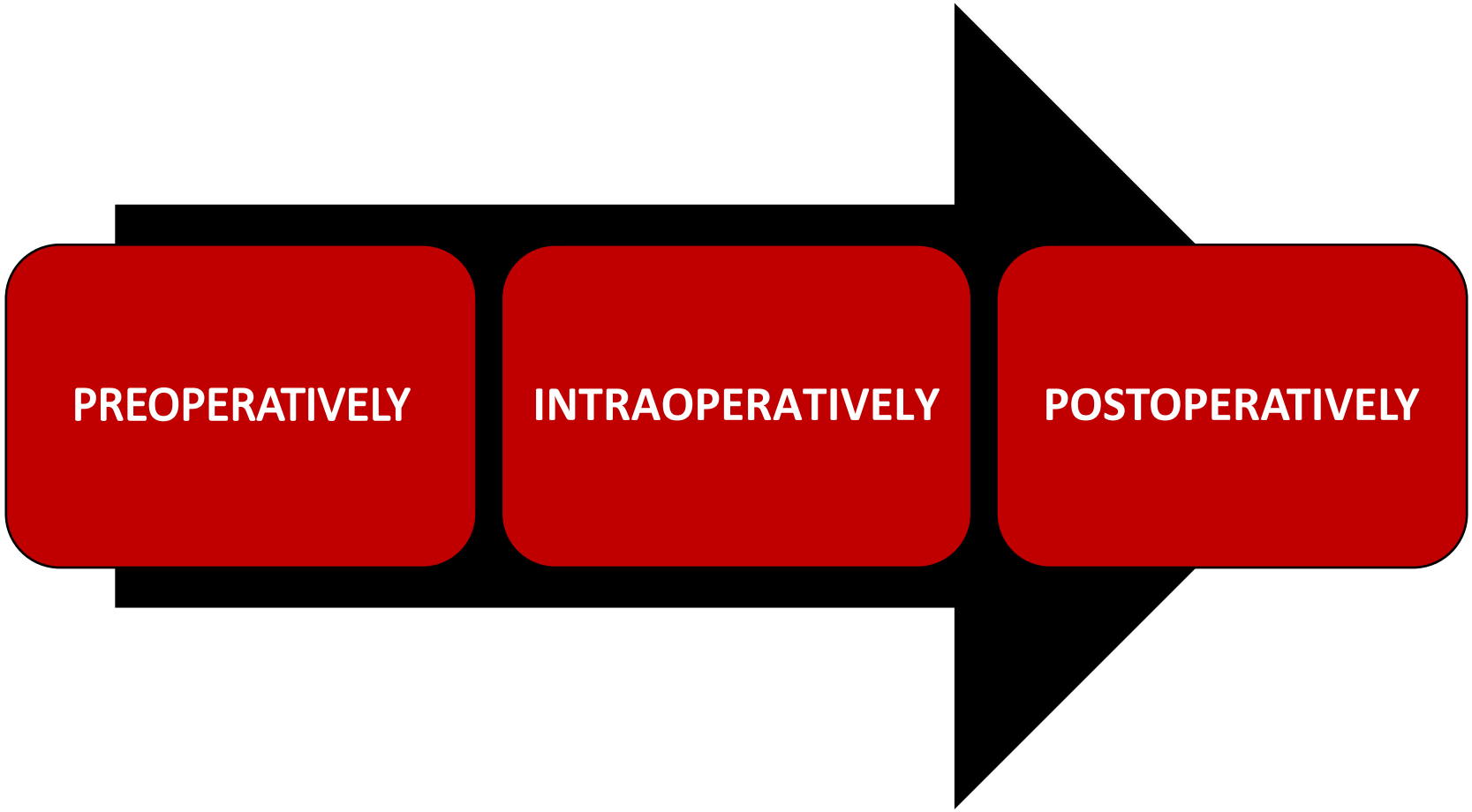


Types of Anemia

1. Iron deficiency Anemia
2. Vitamin B12 deficiency Anemia
3. Thalassemia (Folic Acid deficiency Anemia)


SYMPTOMS OF ANEMIA
Fainting and fatigue
Respiratory
Shortness of breath
Heart
Angina and heart attack
Digestion
Change in stool color
Spleen
Enlargement
Muscle
Pain
Skin
Yellowing

Where do we start?



Blood Use

Usage	Percentage (%)
General Surgery	54
General medicine	31
Haematology (blood diseases)	9
Accidents and emergencies	6

Importance of Blood Conservation

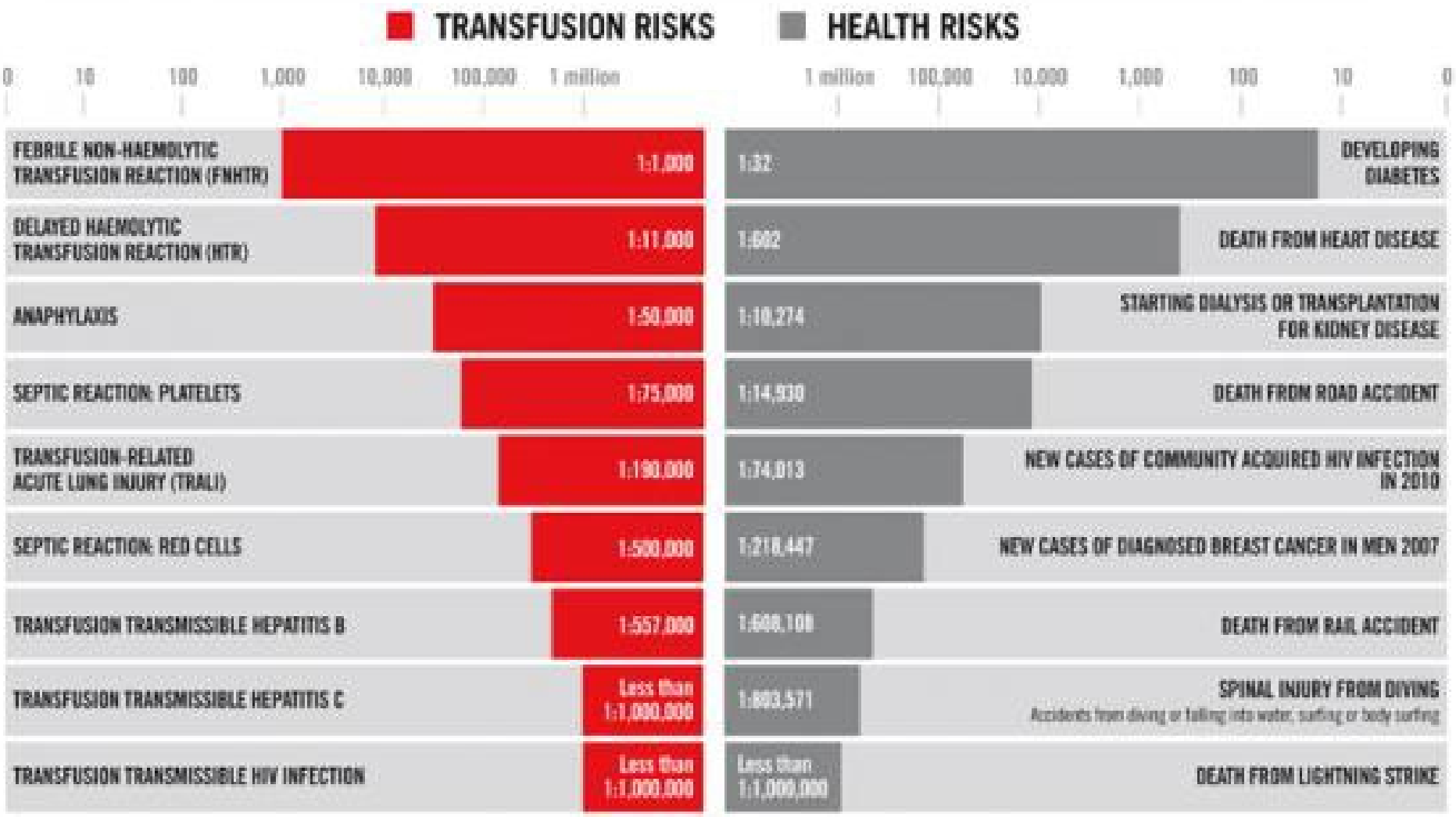
- The morbidity and mortality associated with transfusions are attributed to:

1. Transfusion reactions
2. Altered immune response
3. Circulatory overload,
4. Transfusion-related acute lung injury (TRALI)

- There had been an **over** utilization of components of blood leading to growing gap between supply and demand.

RELATIVE RISK OF TRANSFUSION

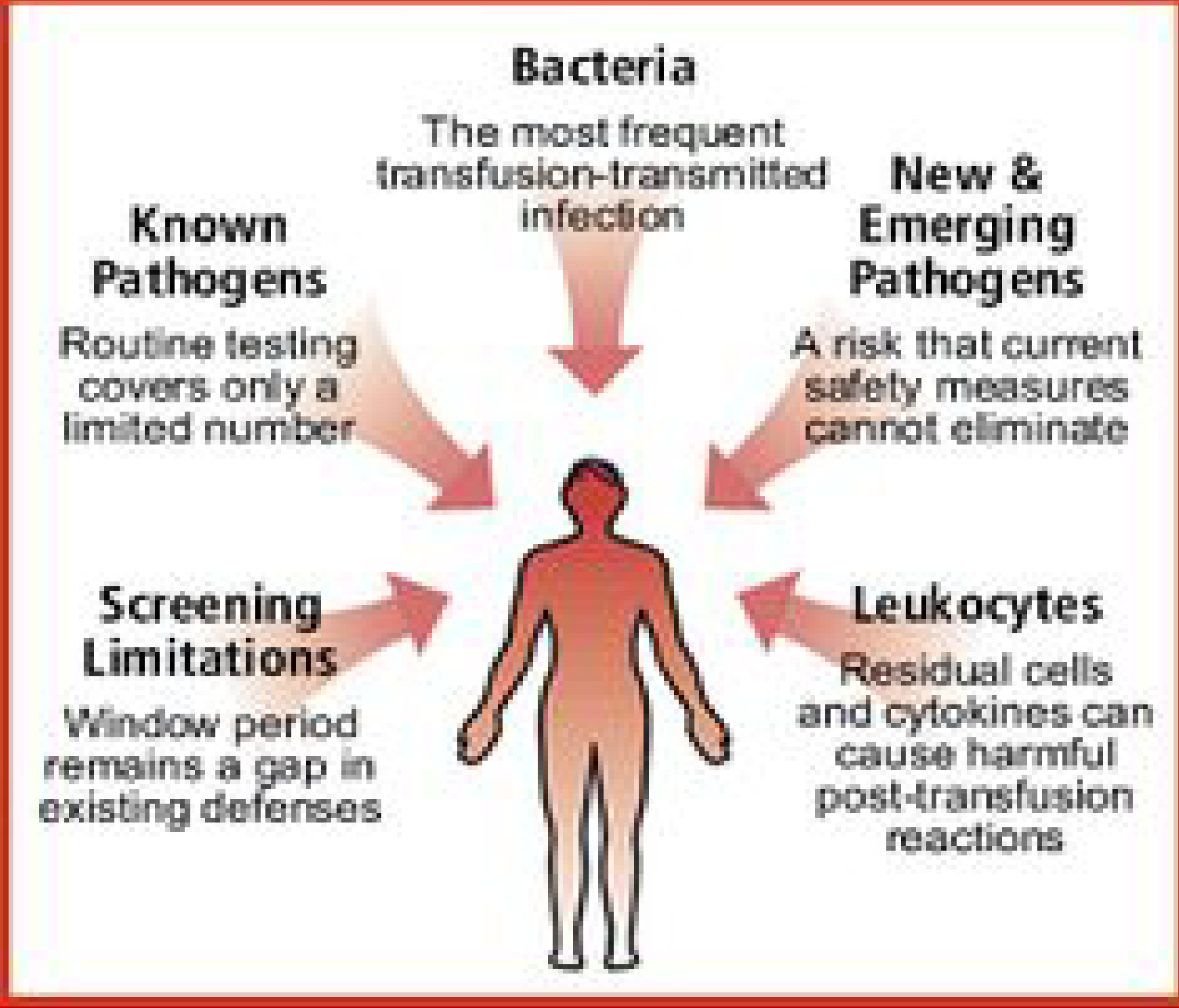
THE RISKS FROM RECEIVING A SINGLE UNIT TRANSFUSION COMPARED WITH OTHER HEALTH RISKS, BASED ON AUSTRALIAN STATISTICS



ansfusion.com.au

Australian Red Cross
BLOOD SERVICE

Current Transfusion-Associated Risks to Patients



BLOOD Transfusion Risks

- Between 2001 and 2006, Transfusion-Related Lung Injury (TRALI) was responsible for greater than **50%** of the deaths in the United States of patients transfused with allogeneic blood.

Centers for Dise**ase** Control. (2013).

Fever/allergic reactions	1:200
Bacterial contamination	1:3,000
Transfusion associated circulatory overload (TACO)	1:5,000
Hemolytic transfusion reactions	1:6,000
Parvovirus B19 [4]	1:10,000
Anaphylaxis	1:50,000
Acute lung injury (TRALI)	1:50,000
Hepatitis B infection	1:180,000
Fatal hemolytic reactions	1:1,000,000
Hepatitis A infection [5]	1:1,000,000
Hepatitis C infection	1:1,600,000
HIV infection	1:1,900,000

Surgical Transfusions

- PRBC transfusions have no correlated risk for incisional SSIs, but may be associated with increased risk for organ space SSI and septic shock after colon resection surgery.
- In one study of more than 2000 critically ill patients, RBC transfusion increased the risk of nosocomial infection by 8%.
- In another study of 125,000 general surgery patients, transfusion of 1–2 PRBCs during surgery significantly increased the odds of postoperative pneumonia, death, and sepsis.

DECISIONS TO TRANSFUSE

Are often based on unsubstantiated hemoglobin (Hgb) or hematocrit “triggers” and are further complicated by:

1) Regulatory constraints
2) Fear of future litigation
3) Public expectations

Vamvakes E. C. (2004)

International Consensus Conference on Transfusion Outcomes

- In 2011, a multidisciplinary panel of 15 experts reviewed 494 published articles to determine the appropriateness of allogeneic red blood cell (RBC) transfusions.
- Using the RAND/UCLA Appropriateness Method – (RUAM).
- Based on the expected impact on outcomes of **stable** nonbleeding patients in 450 typical inpatient medical, surgical, or trauma scenarios.

RUAM

RAND/UCLA Appropriateness Method

- RUAM is a structured process for integrating evidence from the scientific literature with experts' clinical judgment to produce explicit criteria for determining the appropriateness of specific procedures.
- It is used when high-quality and definitive evidence (No randomized controlled trials) are available.
- The RUAM is an important clinical tool that has been used worldwide for more than 2 decades.

Panel Review Process

Within each setting, separate scenarios were defined for 12 different sets of patient characteristics.

1) Age - (≤64 or ≥65 years old)

2) Presence or absence of any major comorbidities:

Heart disease (coronary artery disease, arrhythmia, CHF)

COPD

Chronic renal failure

High blood pressure

Malignancy

Sepsis/overt infection

Diabetes Mellitus (insulin-dependent or independent)

Obesity

3) Severity of anemia: 3 ranges of Hgb concentration:

≤7.9 g/dL 8-9.9 g/dL ≥10 g/dL

Findings

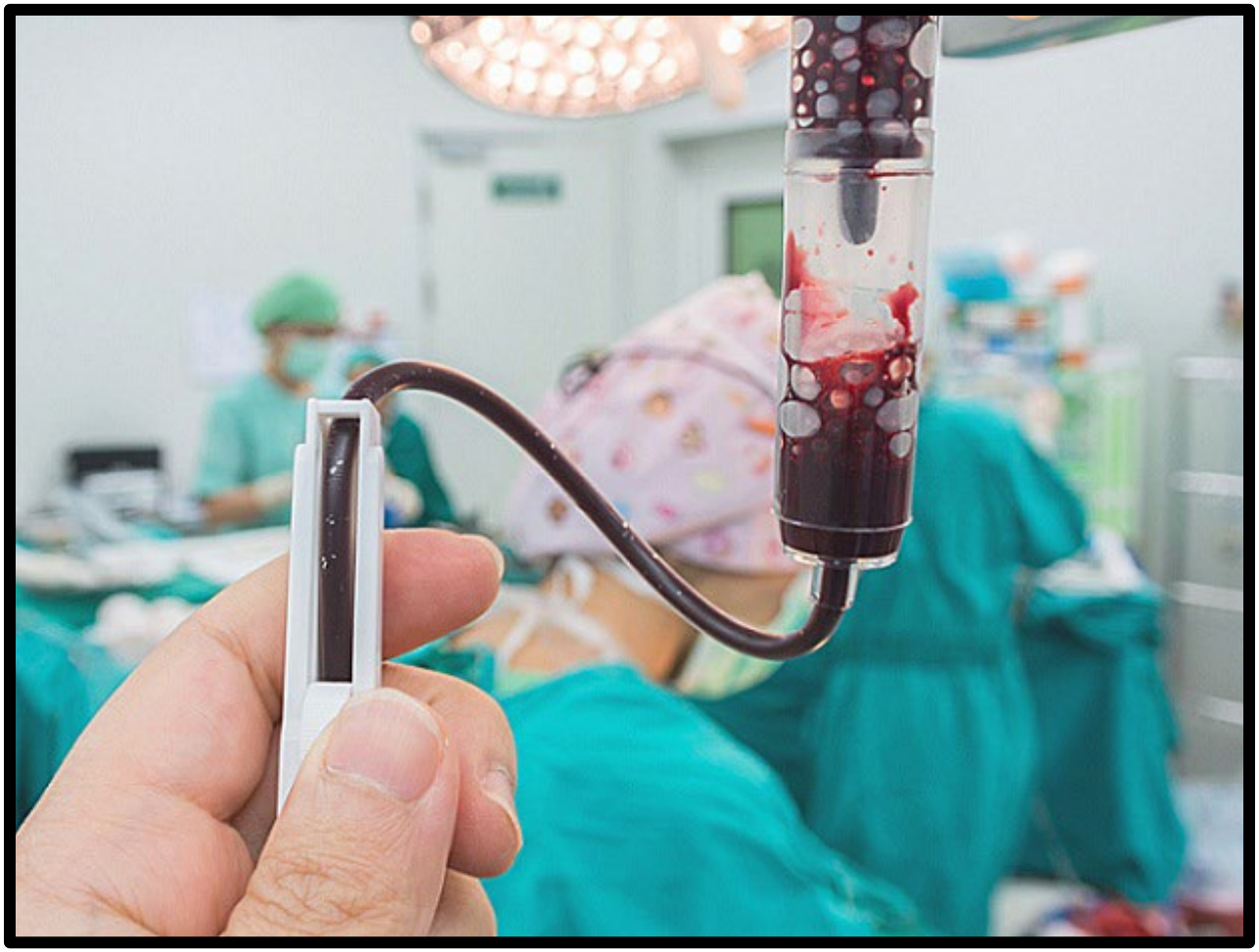
The Systematic Review of these 494 studies, reported that **59%** of blood transfusions were considered **inappropriate** based on patient criteria & outcomes.

Shander et al., (2011)

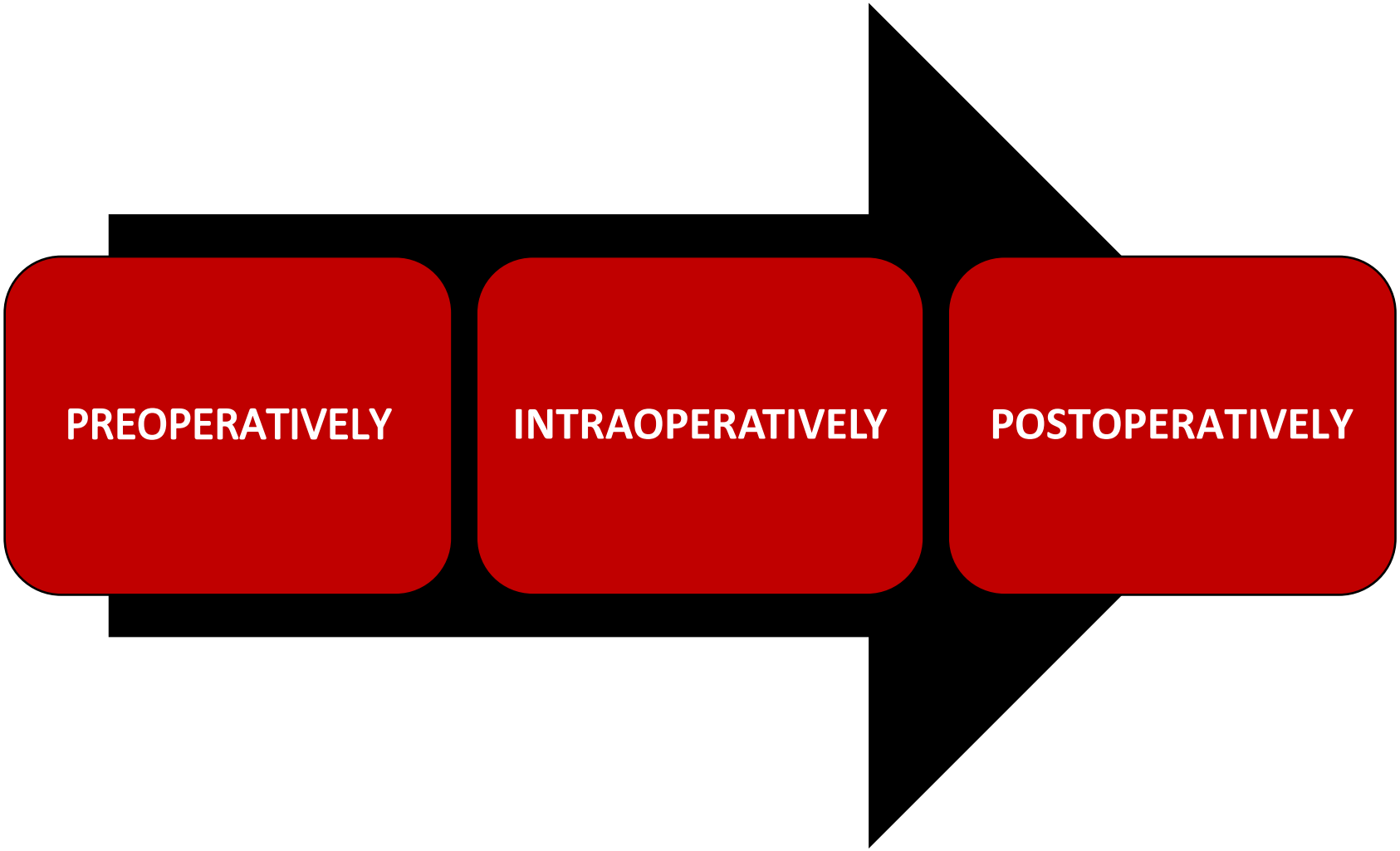
BLOOD TRANSFUSION COSTS

- A blood transfusion costs $4,271
- This accounts for 1% of a hospitals budget.
- Administrative costs for a safe blood supply relate to testing, preserving, transporting and infusing.
- Testing for pathogens and compatibility.

What Can we Do?



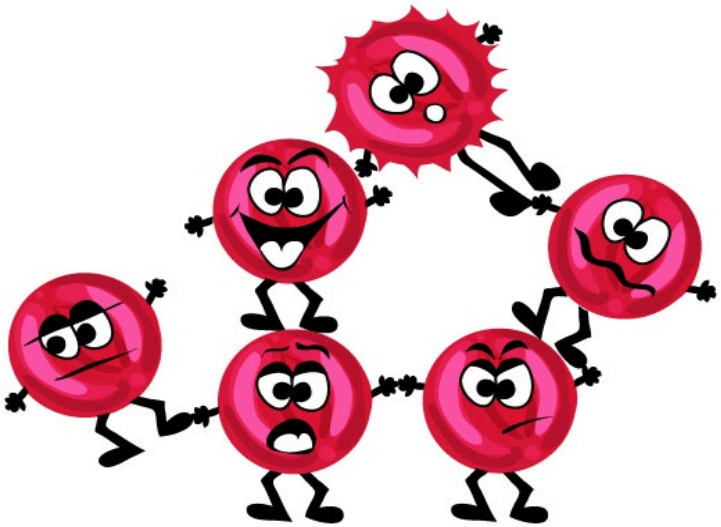
BLOOD CONSERVATION PROCESS



COLLABORATIVE TEAM EFFORT

- PERIOPERTIVE NURSING STAFF
- ANESTHESIA
- SURGEONS
- CIRCULATORS

PREOPERATIVELY



PREOPERATIVELY

- Preoperative evaluation
- Optimization of hemoglobin and bleeding parameters.
- Correct Coagulopathy

PREOPERATIVE RISK FACTORS FOR BLOOD TRANSFUSIONS:

1) Advanced age
2) Preoperative anemia
3) Small body size
4) Preoperative antiplatelet or antithrombotic drugs
5) Re-operative, Emergent or complex surgical procedures
6) Non-cardiac patient comorbidities.

Predictive Surgical Patient Characteristics

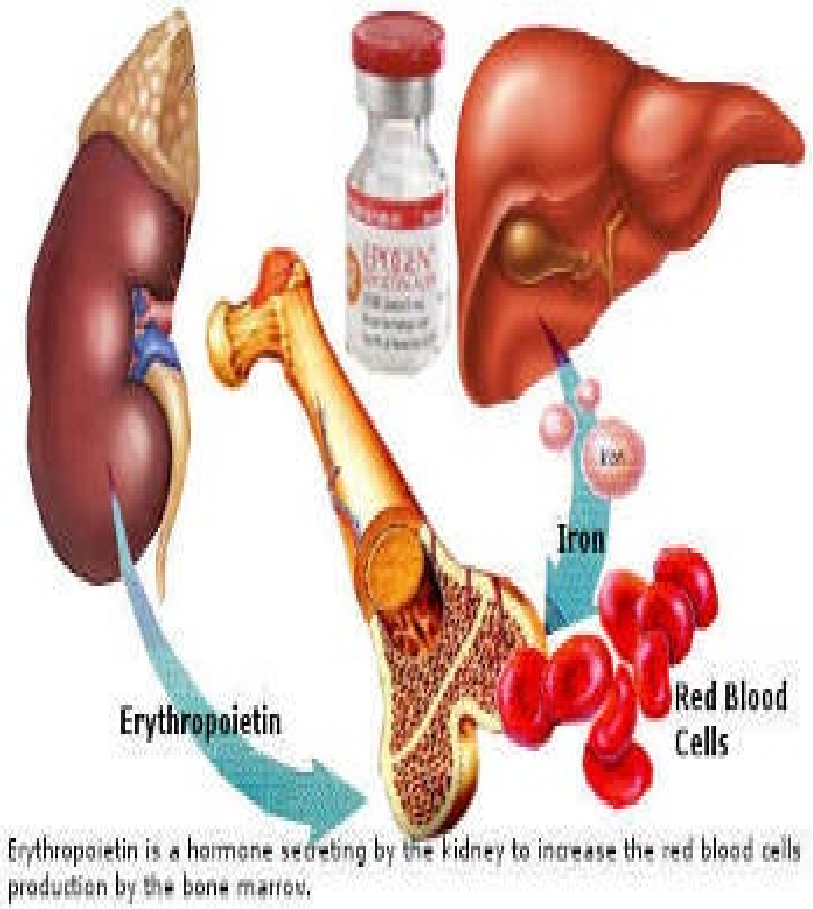
Preoperative Optimization

- Schedule preoperative visit in enough time to assess and manage anemia.
- Hold Anticoagulants; Limit Aspirin use
- Dietary changes
- Addition of supplemental iron/Ferrex.
- Each facility has their own protocols:
- Erythropoietin (Procrit)
- Darbopoetin alfa (Aranesp)
- Pre-donation.

Erythropoietin (EPO)

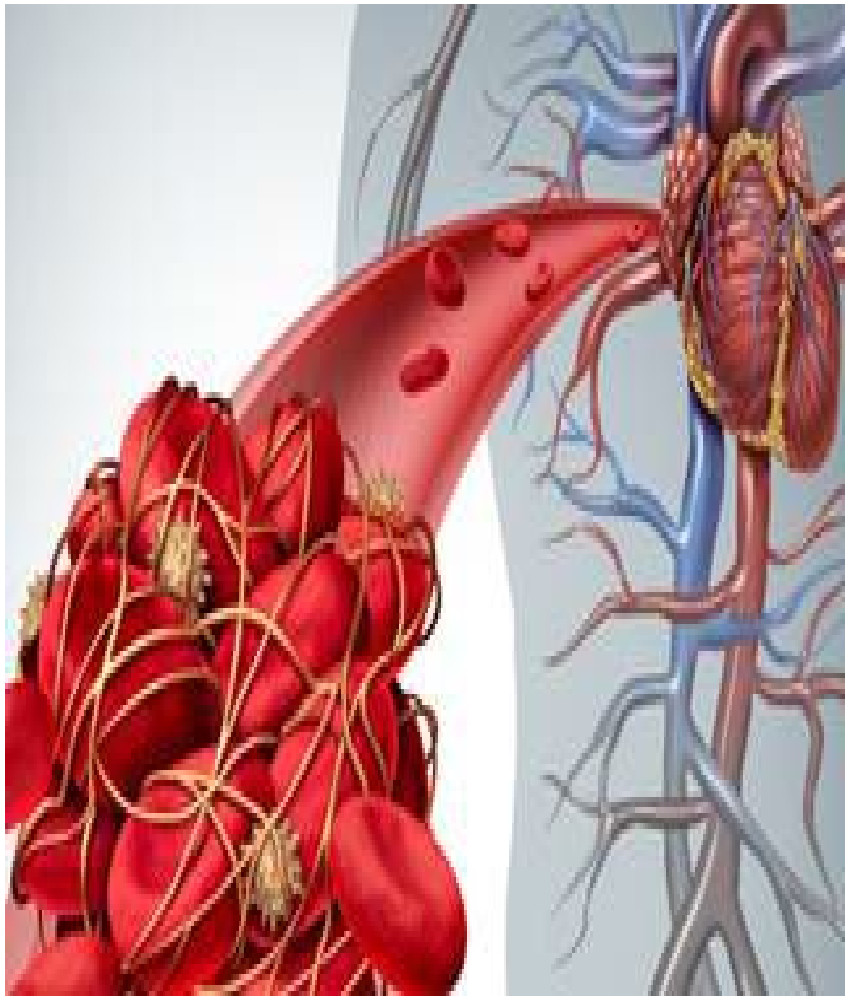
- Endogenous glycoprotein
- Helps you make red blood cells.
- Monitor weekly HgB & BP.
- Increased red cell mass.
- Chronic use is associated with thrombolytic cardiovascular events in renal failure patients
- In a meta-analysis of 32 RCTs, there was a significant decrease in perioperative transfusions & risks & no significant increase in risk of thromboembolic complications -preoperative erythropoietin administration

Cho et al., (2019)



Anticoagulants and Aspirin

- Aspirin use limits vein graft occlusion after coronary bypass grafts (CABG) by 30-40%.
- Previous reports recommended holding for 5 – 7 days.
- Current studies suggest 3 days may be enough to lessen bleeding risk and provide safer outcomes.
- Newer drugs that inhibit the P2Y12 receptor are reversible and show promise in decreasing the risk of bleeding. (Ticagrelor).



PREOPERATIVELY

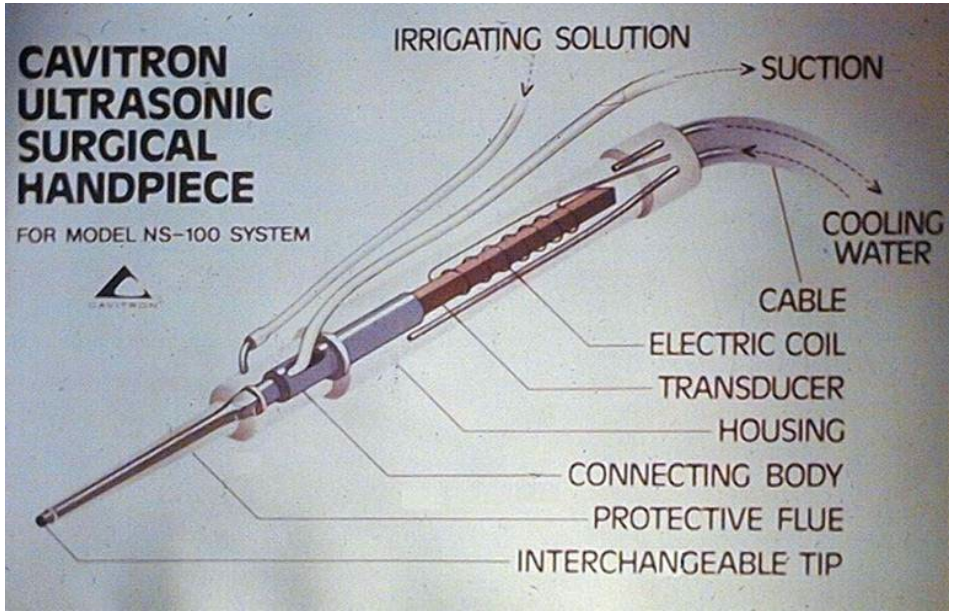
Have a conversation with your Surgeon:

1) Emergency/Life threatening -
   Stop hemorrhage/Damage Control
2) Length of procedure – Definitive repair?
3) Surgical technique
4) Estimated blood loss
5) After initial damage control, ? going to the ICU & → normovolemia, acid-base balance and temperature

INTRAOPERATIVELY

Surgical Methods

- Minimally invasive surgery/Laparoscopy
- Cautery
- Direct Pressure
- Argon Plasma
- Harmonic Scalpel
- Ligasure devices



- Cavitronic Ultrasound Dissector Aspirator (CUSA) – steep learning curve

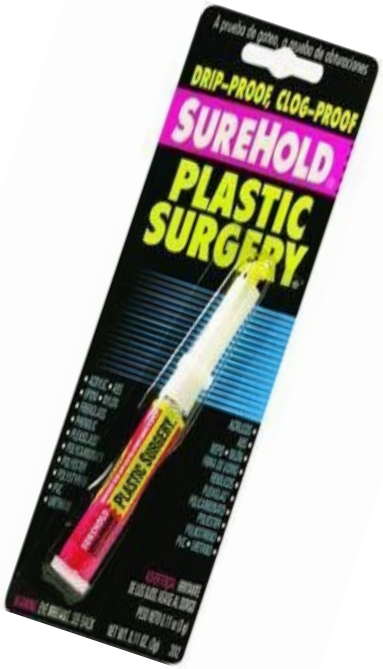
TOPICAL AGENTS

- Fibrin Sealant (Fibrin glue, Tiseel, Flo-Seal)

– Solution of concentrated fibrinogen & Factor XIII

- Forms a coagulum simulating the final stage of the clotting cascade.

- Thrombin & Gel foam (Surgi foam)
- Collagen (Surgi-net, Avitene)



IV Therapy

- D-DAVP – Desmopressin

- 0.3 mcgs/kg in 200 cc NS over 30 minutes
  - Increase in VWF & Factor VIII
- Enhanced hemostasis in patients with platelet function deficiencies.

- rVIIa (NovoSeven)

  - Vitamin K dependent glycoprotein
- Used for patients with hemophilia
- Expensive $$

Multi-Modal Therapy

Tranexamic Acid – (TXA; Cyklokapron)

- Lysine analogue
- Competitive inhibitor of plasminogen, binding to lysine sites and preventing plasminogen activation to plasmin.
- Inhibits fibrinolysis and clot breakdown.
- Costs less than $50 per treatment.
- Can be given IV, orally or poured into a wound.

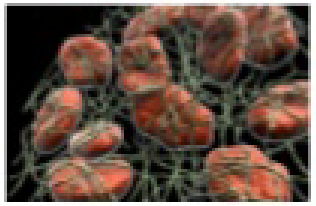
Tranexamic Acid

Plasminogen activator

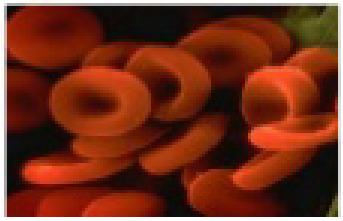
Blockade

Plasminogen

Plasmin



Blockade



Fibrinolysis

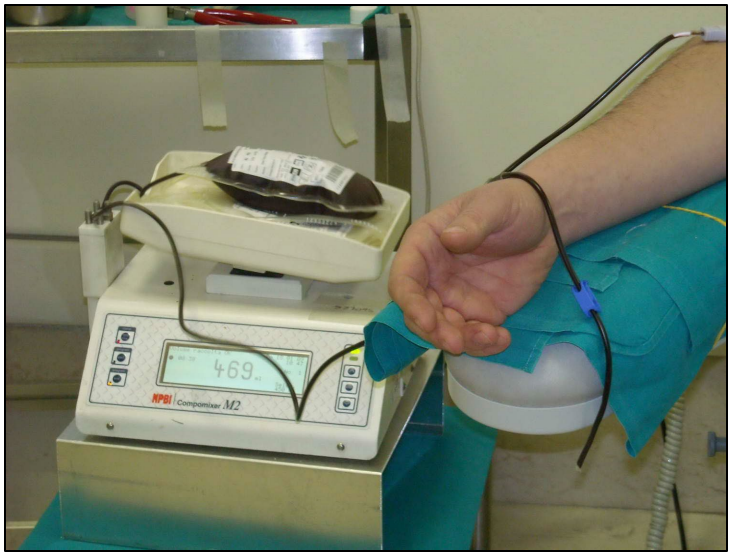
TXA

- Randomized controlled trial of 20,000 patients in 40 countries.
- Trauma patients were given a 1 gram loading dose of TXA, followed by an infusion of another gram over 8 hours.
- Those treated earlier benefited the most – within 1 hour of injury.
- 32% reduction in death due to bleeding.

TXA

- Reduces the rates of re-operation and transfusion in cardiac surgery.
- Can be given for menstrual blood loss.
- Reduces the perioperative blood loss by 25-30% in adults undergoing spinal fusions and > 40% in pediatric patients.
- Multiple Orthopedic studies indicate effectiveness in decreasing blood loss.

Acute Normovolemic Hemodilution



- Removal of blood from the surgical patient immediately prior to or following induction of anesthesia.
- Useful for Hgb <11 or expecting a loss of 2 units of blood during surgery.
- Jehovah's Witnesses agree to ANH if blood is maintained in a closed system.

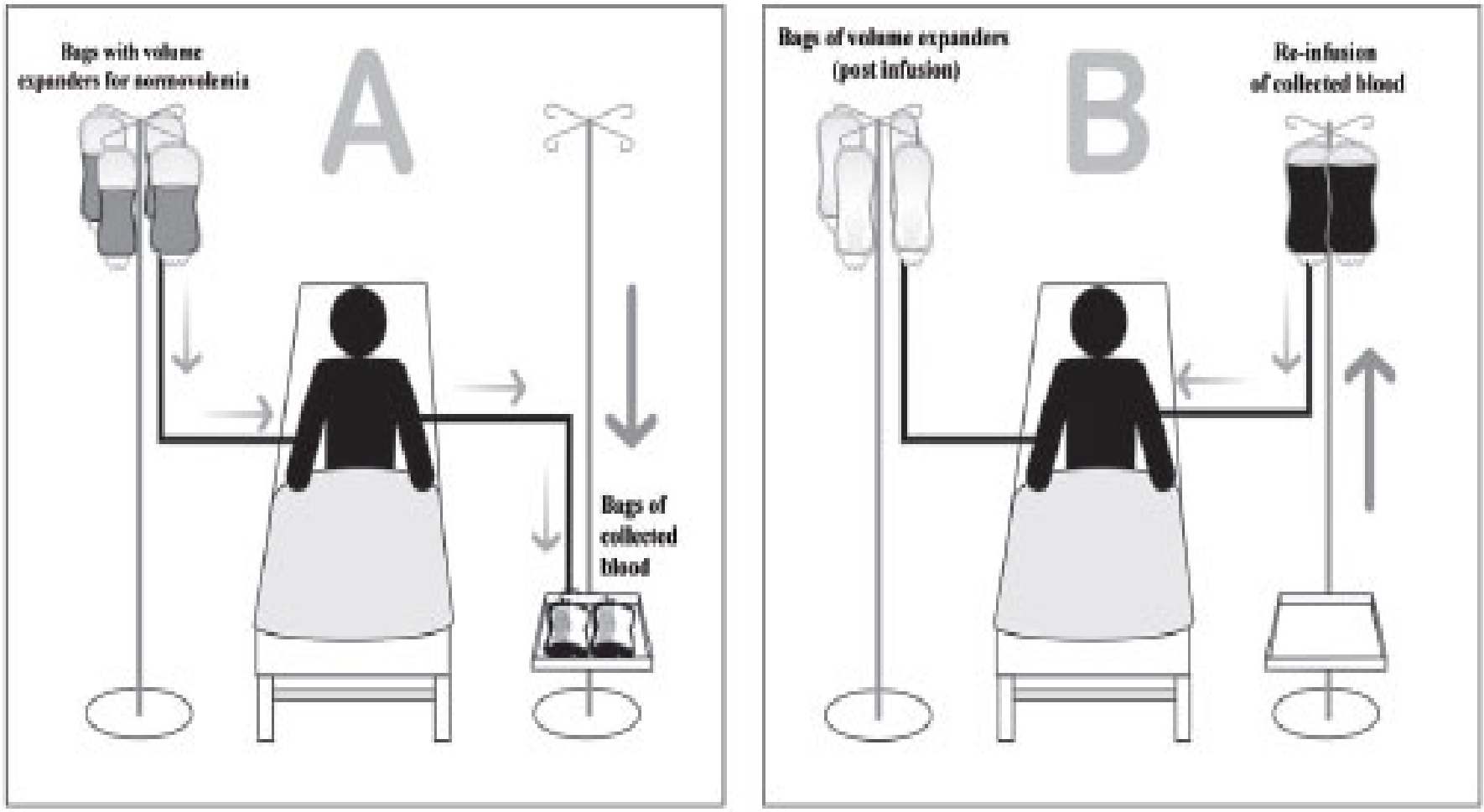


Fig. 3 - Schematic representation of acute normovolemic hemodilution.
(A) Bags of blood being removed immediately before the initiation of surgery, along with the infusion of volume expanders to maintain normovolemia.
(B) Bags of blood being re-infused during and/or immediately after the surgery is completed.

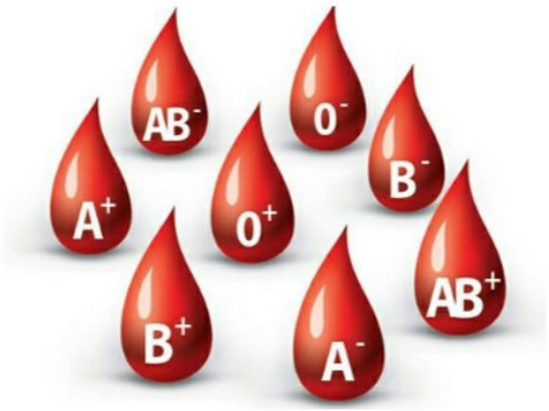
ANH Benefits

- ANH is beneficial for providing fresh blood.
  - Blood is withdrawn from a central or large peripheral IV or the radial artery and collected in a normal blood bag containing CPD.
  - No biochemical alterations to the blood.
  - Platelet function is preserved.
  - Less expensive than transfusing.
- Lost blood volume is replaced by crystalloids or colloids.
  - Crystalloid 3-1 from blood volume removed.
    - Advantage of being easily excreted.
  - Colloid – 1:1 for blood volume removed.
  - Albumin, Hetastarch – no significant differences.
  - Hemodilution leads to decreased blood viscosity → Improved tissue perfusion.

ANH Benefits

ANH is particularly suitable for patients with:

1) Rh negative traits
2) Irregular antibodies
3) Difficult ABO blood typing
4) or with other blood matching problems



ANH Contraindications

- Cardiac Disease

Mechanism to compensate for anemia = Increased Cardiac Output (HR x SV) → MI or cerebral hypoxia.

- Impaired Renal Function

Poor tolerance of volume shifts.

- Coagulopathies

Low concentration of coagulation factors

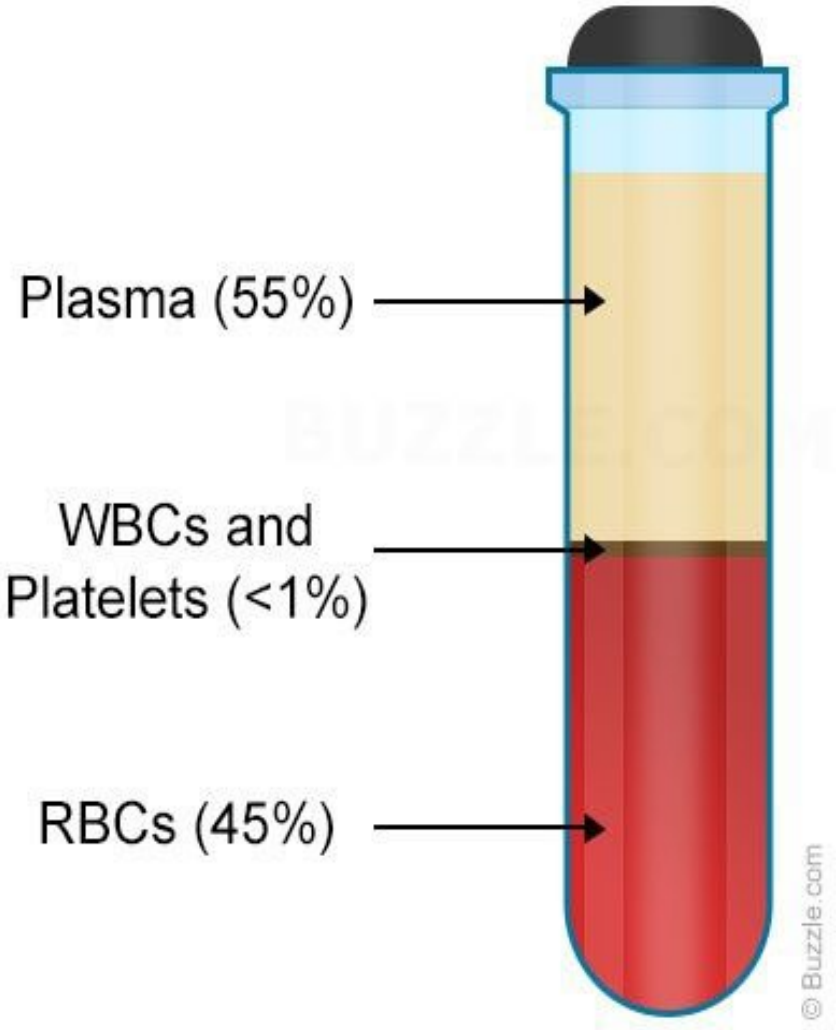
Anemia

*Inadequate vascular access.

* Inappropriate monitoring capabilities.

ANH

- Randomized controlled trial of 130 patients undergoing major hepatic resection versus standard management.
- 2004-2007
- Each patient was randomly assigned to one group or the other.
- The use of ANH decreased the overall transfusion rate by 50%
- ANH group had higher postoperative hemoglobin levels.



Cell Salvage

- Allows for collection of surgical site blood – hemostasis.
- Blood can be collected and reinfused as needed.
- Cleansed via filtration.

Cell Salvage

Contraindications

- Ascites
- Amniotic fluid cavity
- Gross bacterial contamination/Bowel
- Free Tumor tissue

Noninvasive Hemoglobin Monitoring

In a retrospective review of 371 patients

who underwent intraoperative RBC transfusions -

- 94 patients who had noninvasive hemoglobin measurements was compared to with 277 patients who did not.
- The total transfusion volumes and transfusion volume per 1 g of blood loss were determined for each group.
- There was a ***significantly*** lower mean RBC transfusion volume per 1 g of blood loss was observed in the SpHb group.

Imaizumi et al. (2016).

Massive Transfusion Protocols

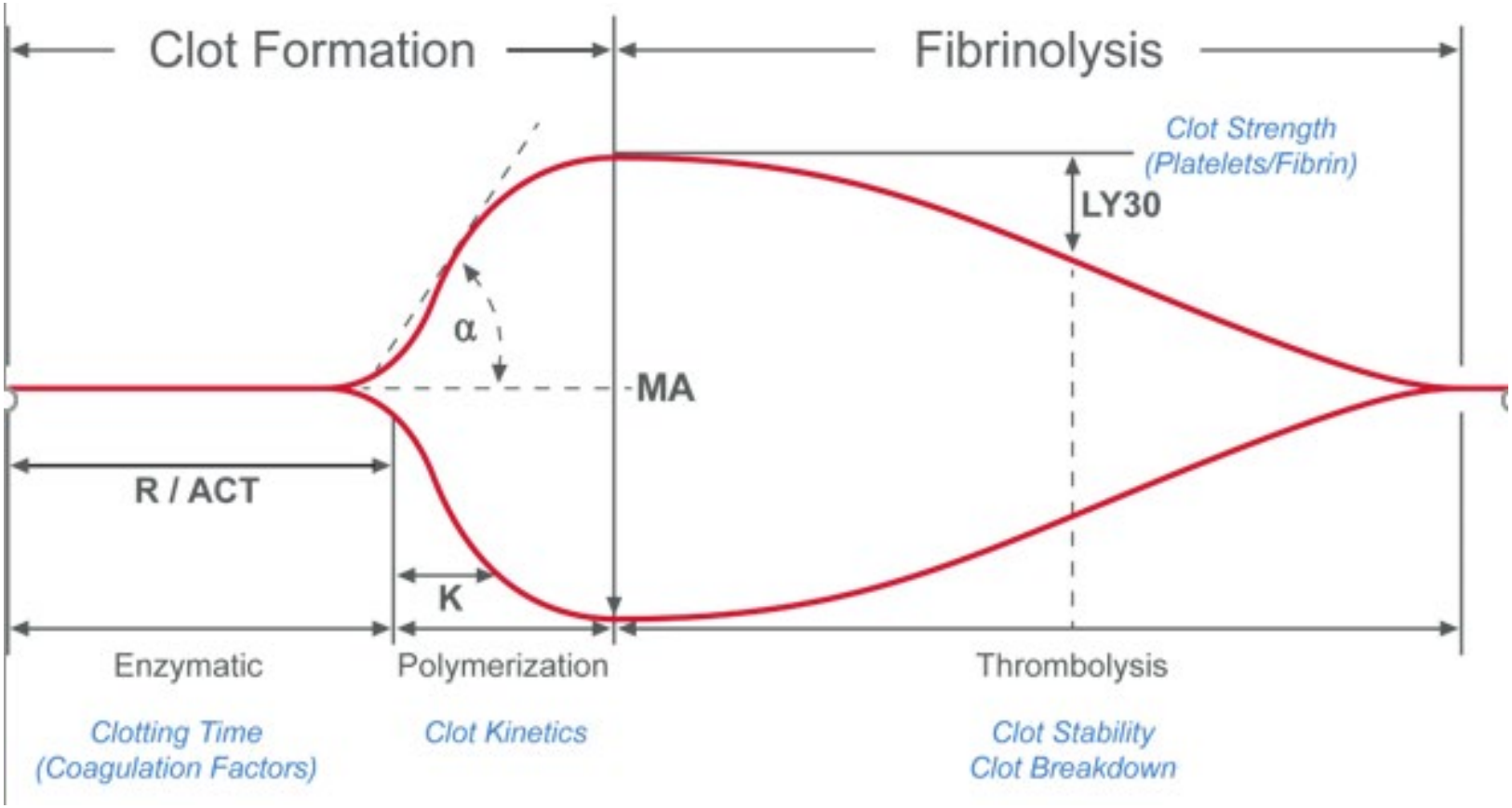
- Up to the implementation of the protocols, it was often a disorderly process – this protocol allows for rapid activation of a collaborative team.
- The transfusion of 10 to 100 units of blood in less than 24 hours.
- Important factors to implement:

1. Temperature is critical!
2. Give fibrinogen or cryoprecipitate early (Factors I, VIII and XIII)
3. FFP – (Factors I, II, V, VIII, X, XI)
4. Ratios such as 1:1:1 RBC: plasma: platelets
5. Minimize colloids and Crystalloids
6. Use of Tranexamic acid
7. Monitor with ROTEM or TEG; PT/INR is not enough.
    - Tensile strength of the clot
    - Reduces the risk of TRALI/TACO

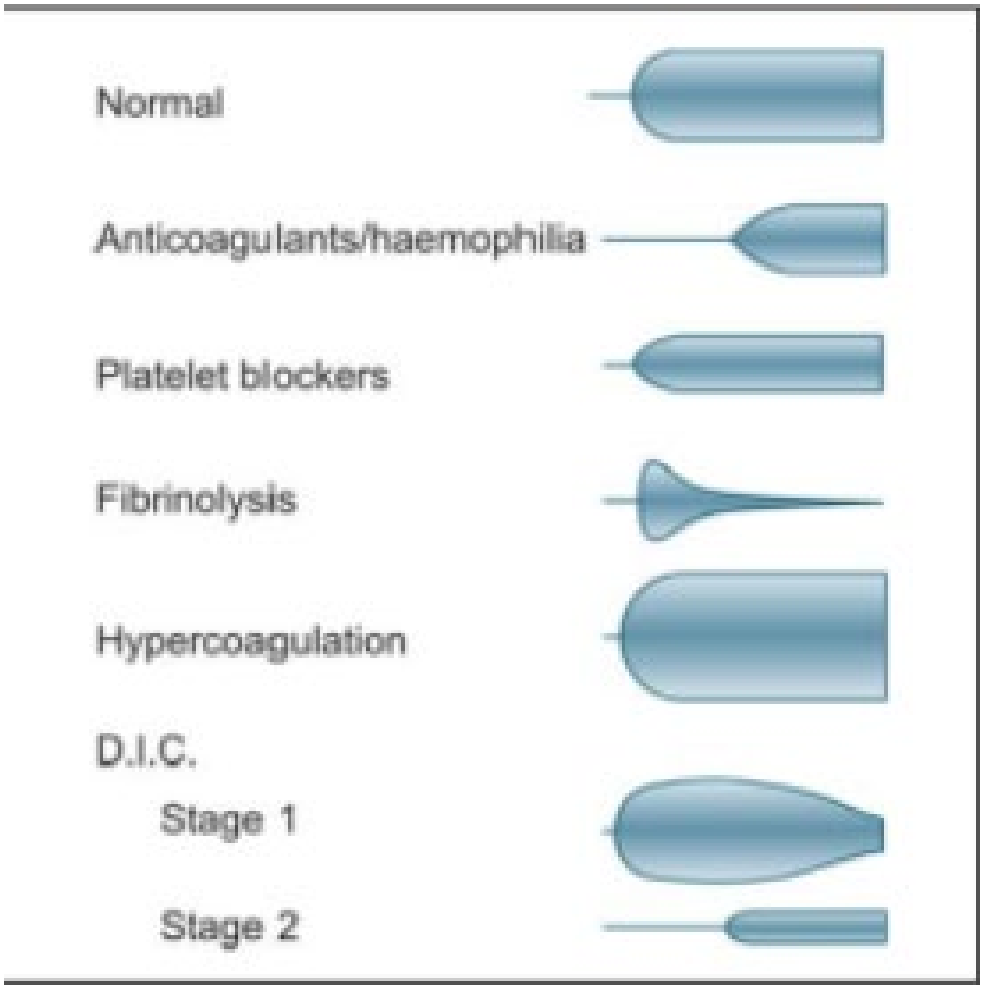
ROTEM® & TEG®

- Normal levels of the body's clotting factors become dilute & the clotting cascade is disrupted during the processes for which massive transfusions are needed.
- Viscoelastic assay technology (VAT) – ROTEM & TEG driven protocols may be superior to traditional coagulation values as they evaluate the whole blood clot formation/process at the point of care.
- Individualized MTP guided by point of care viscoelastic testing → rapid, targeted, & precise administration of the appropriate blood products can decrease patient exposure to the risks of an incorrect transfusion.

ROTEM® & TEG®


Clot Formation
Fibrinolysis
Clot Strength
(Platelets/Fibrin)
LY30
α
MA
R / ACT
K
Enzymatic
Polymerization
Thrombolysis
Clotting Time
(Coagulation Factors)
Clot Kinetics
Clot Stability
Clot Breakdown

Characteristic Waveforms TEG®



ROTEM® & TEG®

TEG Value	Normal*	Description	Measures
TEG-ACT (rapid)	80 - 140 sec	"Activated clotting time" to initial fibrin formation	clotting factors (extrinsic/intrinsic pathways)
R time (conventional)	5.0 - 10.0 min	"Reaction time" to initial fibrin formation	clotting factors (intrinsic pathway)
K time	1.0 - 3.0 min	"Kinetic time" for fibrin cross linkage to reach 20 mm clot strength	fibrinogen, platelet number
α angle	53.0 - 72.0 degrees	Angle from baseline to slop of tracing that represents clot formation	fibrinogen, platelet number
MA	50.0 - 70.0 mm	Maximum amplitude of tracing	platelet number and function
G value	5.3 - 12.4 dynes/cm^2	Calculated value of clot strength	entire coagulation cascade
LY 30	0 - 3%	Clot lysis at 30 minutes following MA	fibrinolysis

α

TEG® Transfusion Strategy

TEG Value	Transfuse
TEG- ACT > 140	FFP
R time > 10 K time >3	FFP Cryoprecipitate
Alpha angle < 53 MA < 30	Cryoprecipitate +/Platelets Platelets
LY30 > 3%	Tranexamic acid

POST OPERATIVELY

Risk factors for excessive post operative bleeding:

1) Advanced age
2) Low RBC volume (preoperative anemia/low body mass)
3) Preoperative anticoagulants or antiplatelet therapy
4) Urgent or emergent operation
5) Prolonged duration of surgical procedure
6) Comorbidities (CHF, Renal dysfunction, COPD)

POST OPERATIVELY

- ✓ Hook drains or chest tubes to a cell saver.
- ✓ Monitor…Monitor…Monitor; but minimize blood draws.
- ✓ **Do not** be afraid to challenge authority
- ✓ Use of multimodality interventions
- ✓ We must think outside the box –

- Identifying a stratification method for classifying those patients at risk.

OUTCOMES

1) Decreased blood loss
2) Elimination of a patient's exposure to allogeneic blood transfusions.
3) Decreased need for transfusions
4) Decreased risks
5) Decreased costs
6) Decreased infections

BRIEF OVERVIEW

PREOPERTIVE	INTRAOPERATIVE	POSTOPERATIVE
Correct pre-existing anemia	Acute Normovolemic hemodilution (ANH)	Cell Salvage
Preoperative autologous blood donation (PABD)	Cell Salvage SpHg monitoring	Reinfusion drains
Supplements/Nutrition	Tranexamic Acid (TXA)	No drains
Hold Aspirin, antiplatelet & anticoagulants if possible	Surgical Interventions	Tranexamic Acid (TXA)

Case Study

73 year old female - 60 Kg

Emergent call case for EGD due to

GI bleed

History: Smoker, chronic alcoholism (a pint of vodka every night)

Initial Hemoglobin 4.1 Hematocrit 14.5

Transfused 1 unit PRBCs immediately prior; MTF protocol initiated, but more blood needs to be delivered from a tertiary facility, as you only have 3 units on hand.

Hemoglobin is now 7.9

Continue Transfusion?

This patient lost 1200ml of blood during this procedure

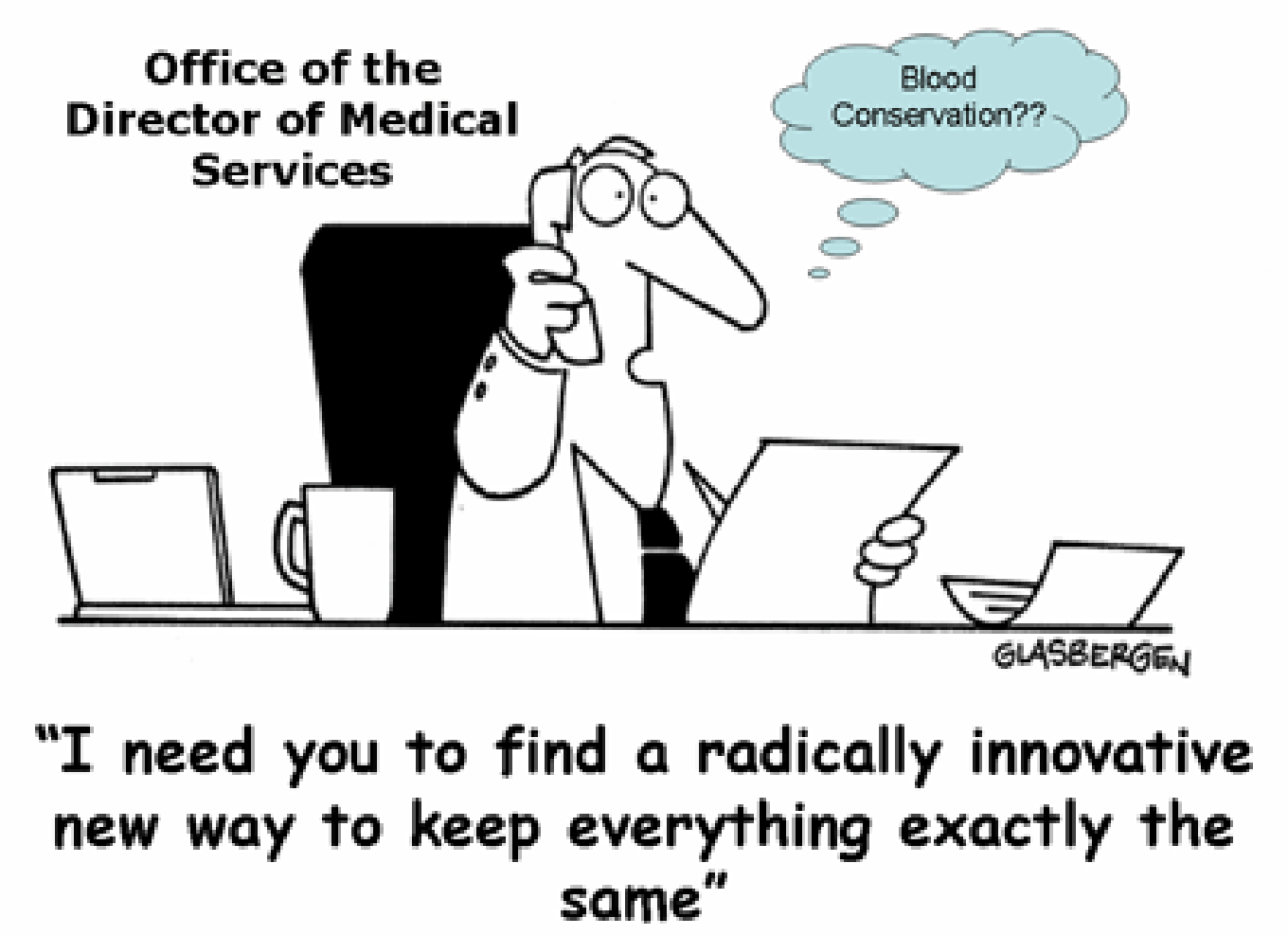
One unit of PRBCs = 300-350ml

Lose 1200ml=1200/350=3.42 gms

If initial Hgb was 7.9-3.42= 4.48gms

Therefore, the Hgb will be around 4.48gms

QUESTIONS ?


Office of the Director of Medical Services
Blood Conservation??
GLASBERGEN
"I need you to find a radically innovative new way to keep everything exactly the same"

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