Principles of Perioperative Autologous Cell Processing

AmSECT International Conference

Reno, Nevada: April 27, 2010

Preparation / Review for IBBM PBMT Exam

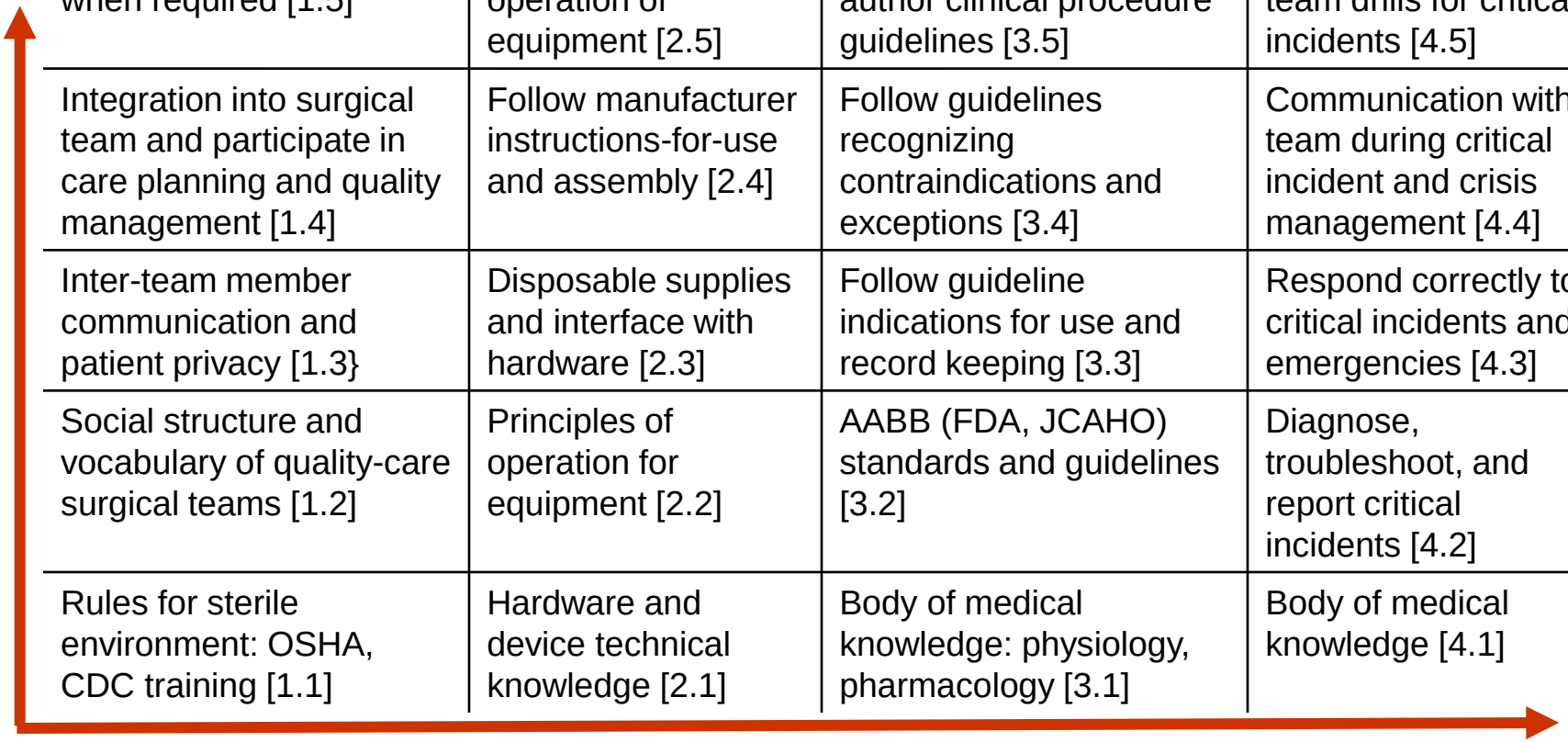
No disclosures or conflicts to report

Perioperative Blood Management Technologist [PBMT]

Job Domain Analysis

Theoretical Hierarchical Construct for K/S/A for Competency Exam

Environmental Factors	Equipment / Disposables	Patient Care Procedures	Critical Incidents
Assertiveness, lead team when required [1.5]	Application and operation of equipment [2.5]	Suggest changes to and author clinical procedure guidelines [3.5]	Design and practice team drills for critical incidents [4.5]
Integration into surgical team and participate in care planning and quality management [1.4]	Follow manufacturer instructions-for-use and assembly [2.4]	Follow guidelines recognizing contraindications and exceptions [3.4]	Communication with team during critical incident and crisis management [4.4]
Inter-team member communication and patient privacy [1.3}	Disposable supplies and interface with hardware [2.3]	Follow guideline indications for use and record keeping [3.3]	Respond correctly to critical incidents and emergencies [4.3]
Social structure and vocabulary of quality-care surgical teams [1.2]	Principles of operation for equipment [2.2]	AABB (FDA, JCAHO) standards and guidelines [3.2]	Diagnose, troubleshoot, and report critical incidents [4.2]
Rules for sterile environment: OSHA, CDC training [1.1]	Hardware and device technical knowledge [2.1]	Body of medical knowledge: physiology, pharmacology [3.1]	Body of medical knowledge [4.1]



Increasing complexity, proficiency and difficulty

Riley, April, 2008

April 2010: Examination Plan

Section	Label	Items	Percent	Col	Percent
1.1	Sterile environment	4	0.04		
1.2	Social structure	1	0.01		
1.3	Communication	0	0.00		
1.4	Team integration	0	0.00		
1.5	Leadership	0	0.00	5	0.05
2.1	Device knowledge	2	0.02		
2.2	Equipment operation	9	0.08		
2.3	Disposable supplies	8	0.07		
2.4	Manufacturer's IFUs	5	0.05		
2.5	Equipment applications	5	0.05	29	0.26
3.1	Physiology, pharmacology	23	0.21		
3.2	Standards and guidelines	4	0.04		
3.3	Indications for use	11	0.10		
3.4	Contraindications and exceptions	6	0.05		
3.5	Author CPGs	1	0.01	45	0.41
4.1	Medical knowledge	8	0.07		
4.2	Diagnose and troubleshoot	11	0.10		
4.3	Critical incident response	11	0.10		
4.4	Team crisis management	1	0.01		
4.5	Design safety drills	0	0.00	31	0.28
Total		110	1.00	110	1.00

Perioperative Blood Management Technologist [PBMT]

Job Domain Analysis

Theoretical Hierarchical Construct for K/S/A for Competency Exam

K/S/A	Label	Count	Percent
K	Knowledge	45	0.41
S	Skills	31	0.28
A	Application	34	0.31
	Total	110	1.00

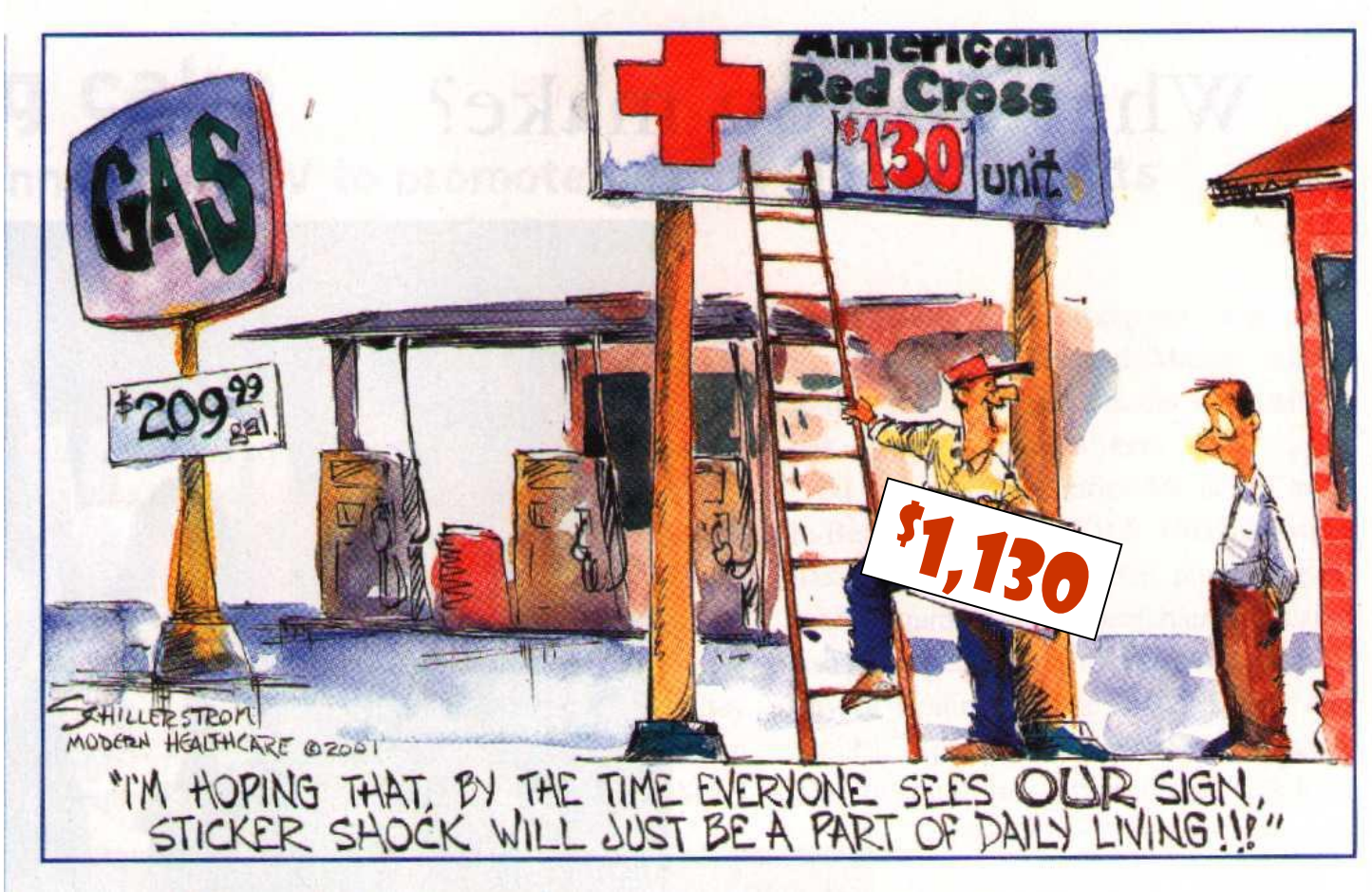
Environmenta Factors			
Assertiveness, lead te when required [1.5]			
Integration into surgica team and participate ir care planning and qua management [1.4]			
Inter-team member communication and patient privacy [1.3}	and interface with hardware [2.3]	indications for use and record keeping [3.3]	critical incidents and emergencies [4.3]
Social structure and vocabulary of quality-care surgical teams [1.2]	Principles of operation for equipment [2.2]	AABB (FDA, JCAHO) standards and guidelines [3.2]	Diagnose, troubleshoot, and report critical incidents [4.2]
Rules for sterile environment: OSHA, CDC training [1.1]	Hardware and device technical knowledge [2.1]	Body of medical knowledge: physiology, pharmacology [3.1]	Body of medical knowledge [4.1]

Increasing complexity, proficiency and difficulty

Riley, April, 2008

Intraoperative Autologous Transfusion
Principles of Cell Washing for the PBMT

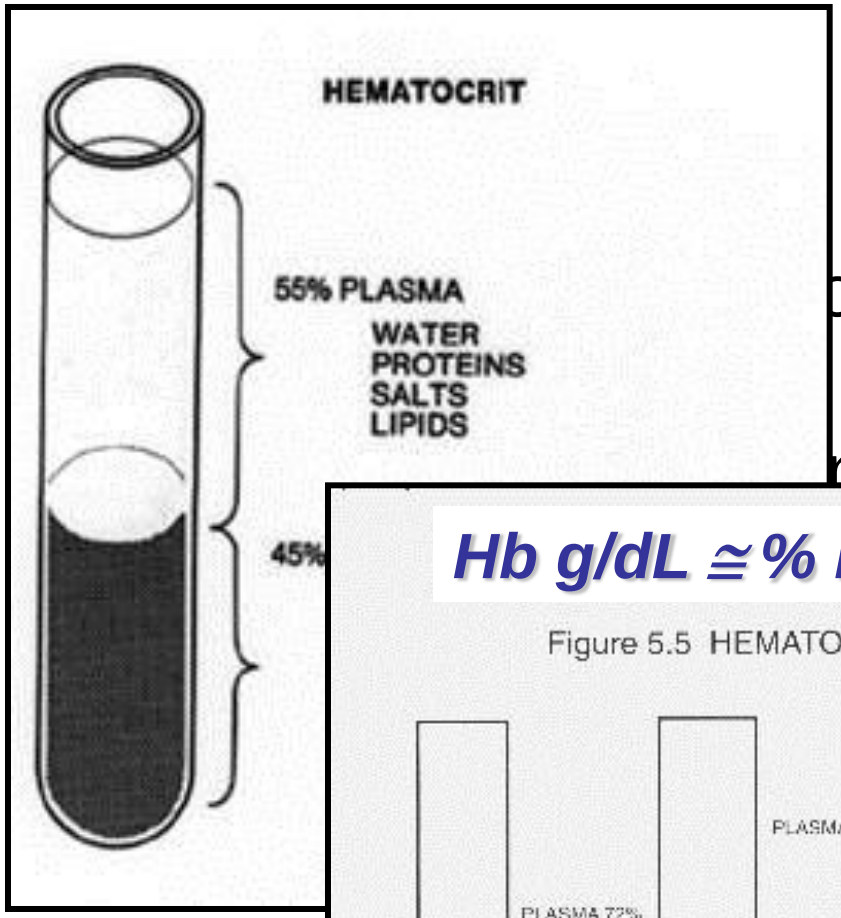
Objectives / Review Areas



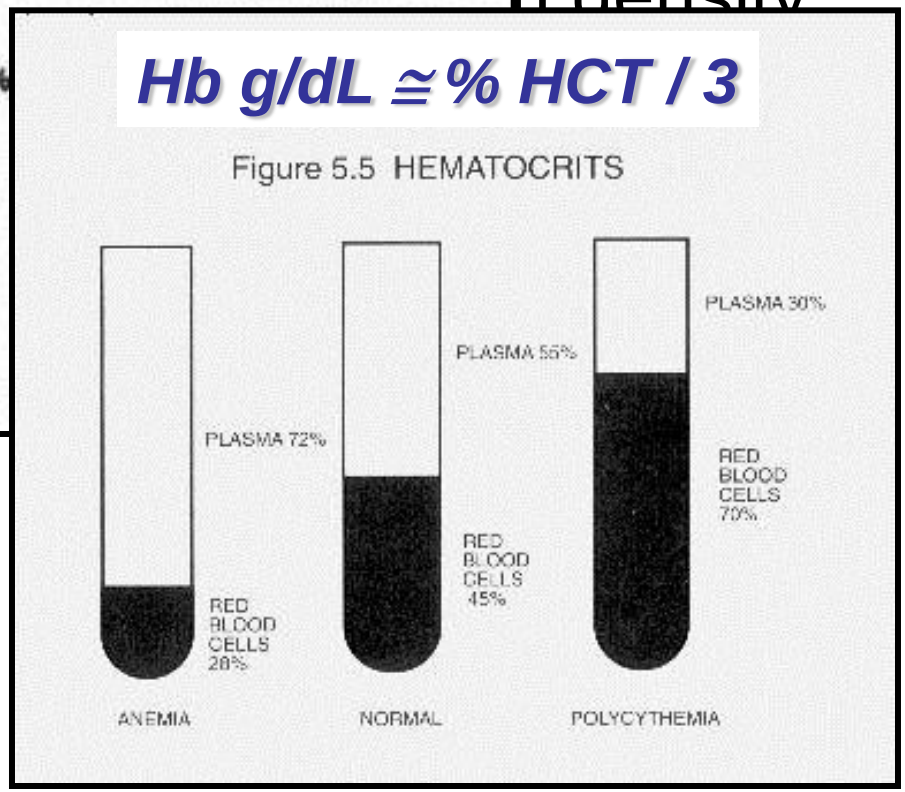
- RBCs
- WBCs
- Platelets
- Buffy Coat
- Plasma
- Hematocrit
- Hemoglobin
- Hemolysis
- Hemoglobinuria
- Blood typing / Rh

onents

n density



Hb g/dL ≅ % HCT / 3

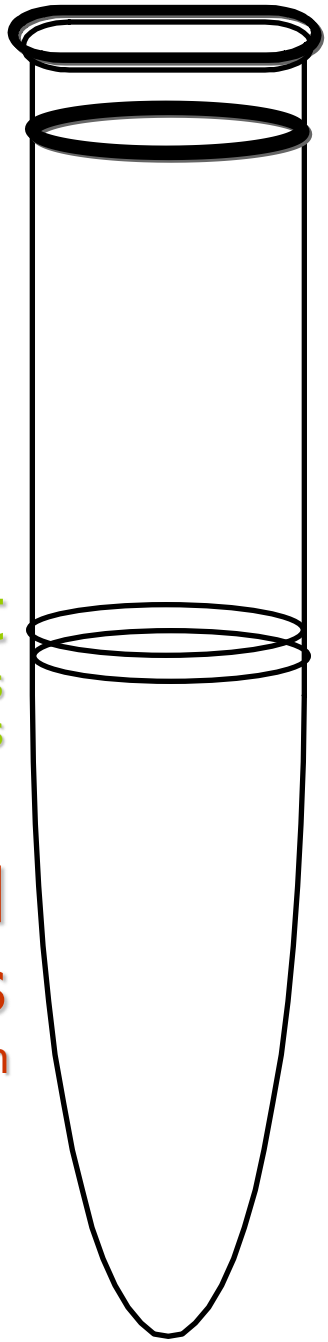


Effects of Hemodilution

- Reduces blood viscosity
- Reduced hematocrit decreases total vascular resistance
- Marked dropped in perfusion pressure followed by compensatory increase in cardiac output
- Patients with arterial occlusive disease may be susceptible to ischemia
- Surgical bleeding results in less RBC loss
- Transfusion triggers are important
- What is ANH (acute normovolemic hemodilution)?

Blood separation technology

Whole blood



Plasma

Proteins / Lipids
Antibodies
Electrolytes
Water

→ plasma components, clotting factors

'Buffy' coat

Platelets
White blood cells

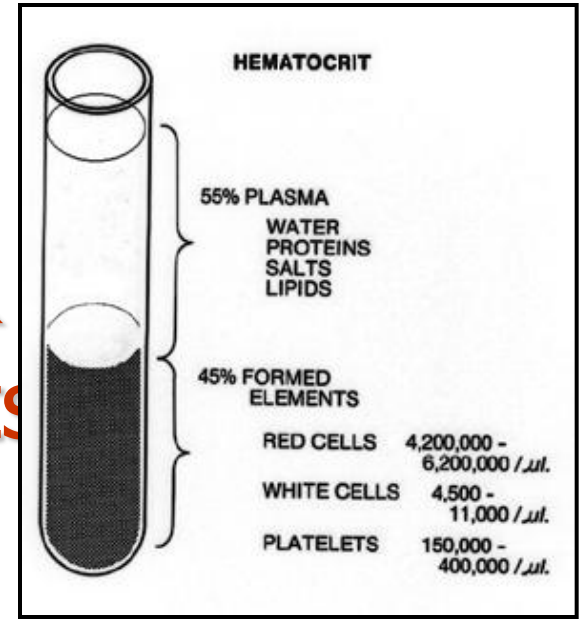
→ platelets & WBCs

Red blood cells

Hemoglobin

→ Packed RBCs & platelets

PRP v. PPP



Platelet rich plasma (PRP) sequestration, platelet gel / glue, AGF^{tm}, Stem cell harvesting

Whole blood

Plasma

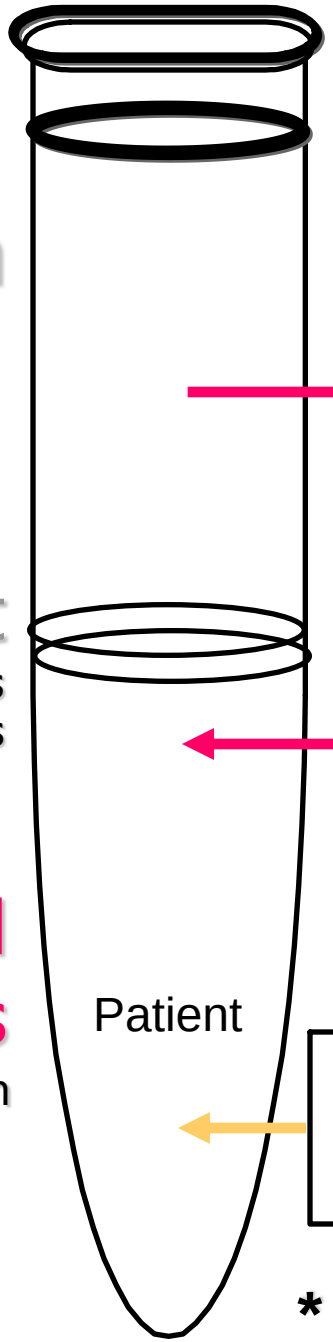
Proteins / Lipids
Antibodies
Electrolytes
Water

'Buffy' coat

Platelets
White blood cells

Red blood cells

Hemoglobin



collect whole blood

separate* plasma, RBCs and 'buffy' coat

Keep the cells?

YES

Return RBCs

NO

Decant concentrated 'buffy' coat rich with PLTs

Keep the plasma?

YES

Return PP plasma

PLT rich concentrate delivered to surgeon

* Via centrifuge

Common BCST Terminology

- adsorption column
- aggregated growth factor
- antibodies
- apheresis
- autoimmune disease
- autotransfusion
- bovine
- ‘buffy’ coat
- cell processing
- centrifugation
- colony stimulating factors
- cryoglobulin
- erythrocyte (RBC)
- fibrinogen
- filtration
- granulocytes (WBC)
- hemoconcentration
- hemofiltration
- leukocyte (WBC)
- lymphocyte (WBC)
- leukodepletion
- photopheresis
- platelet derived growth factor
- platelet gel or glue
- platelet poor / rich plasma
- platelet-pheresis
- rheumatoid arthritis
- thrombin
- thrombocyte (platelet)
- transforming growth factor

Clotting Factors in plasma

Clotting Factors

Normal Lab Values

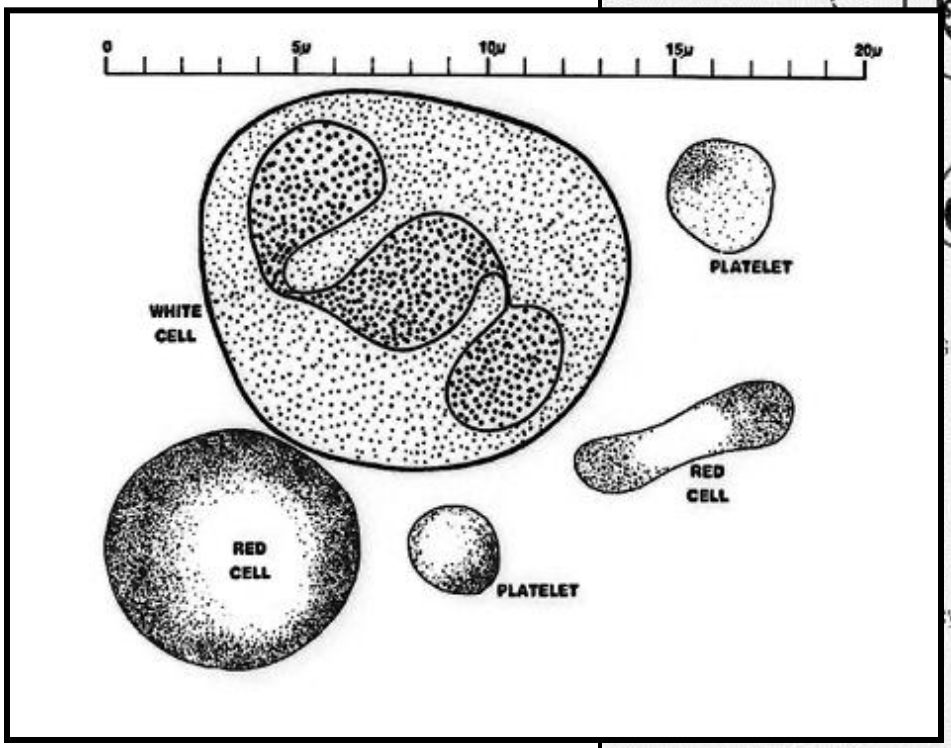
Factor I	Fibrinogen	0.15-0.35 gm/100 ml
Factor II	Prothrombin	60-140% of control
Factor III	Thromboplastin	
Factor IV	Calcium	
Factor V	Proaccelerin	
Factor VI	None	
Factor VII	Proconvertin	
Factor VIII	Antihemophilic	
Factor IX	Plasma Thromboplasti	
Factor X	Stuart Factor	
Factor XI	Plasma Thromboplasti	
Factor XII	Hageman Factor	
Factor XIII	Fibrin Stabilizing Fact	

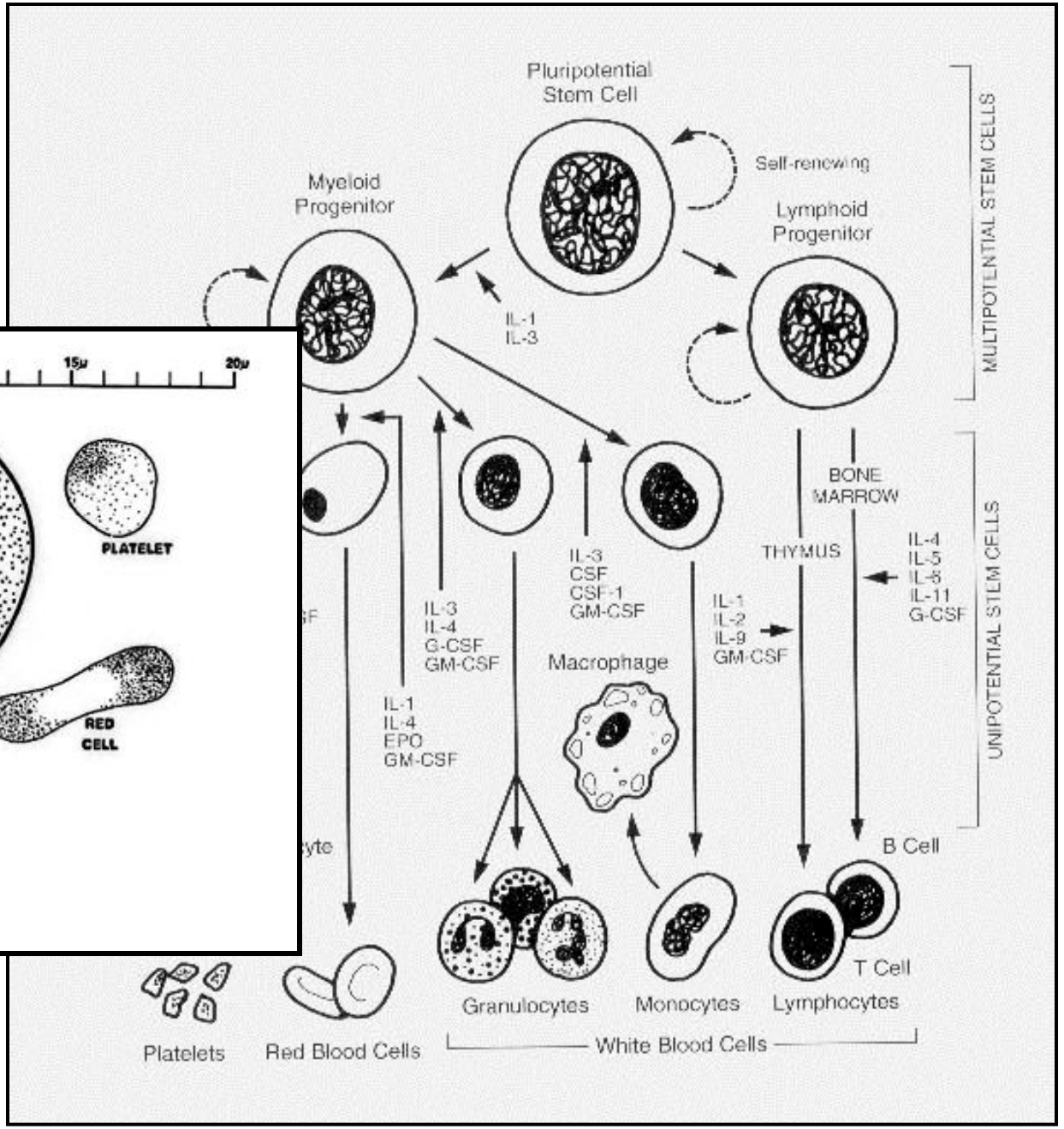
I	Fibrinogen
II	Prothrombin
III	Platelet factor 3 (thromboplastin)
IV	Calcium
V	Labile factor (proaccelerin)
VI	Not assigned
VII	Stable factor (proconvertin)
VIII	Antihemophilic factor A (AHF)
IX	Antihemophilic factor B (Christmas factor)
X	Stuart-Prower Factor
XI	Antihemophilic factor C (PTA)
XII	Hageman factor
XIII	Fibrin-stabilizing factor (FSF)

** Factors V and VIII are not true serine proteases, but are commonly referred to as such.*

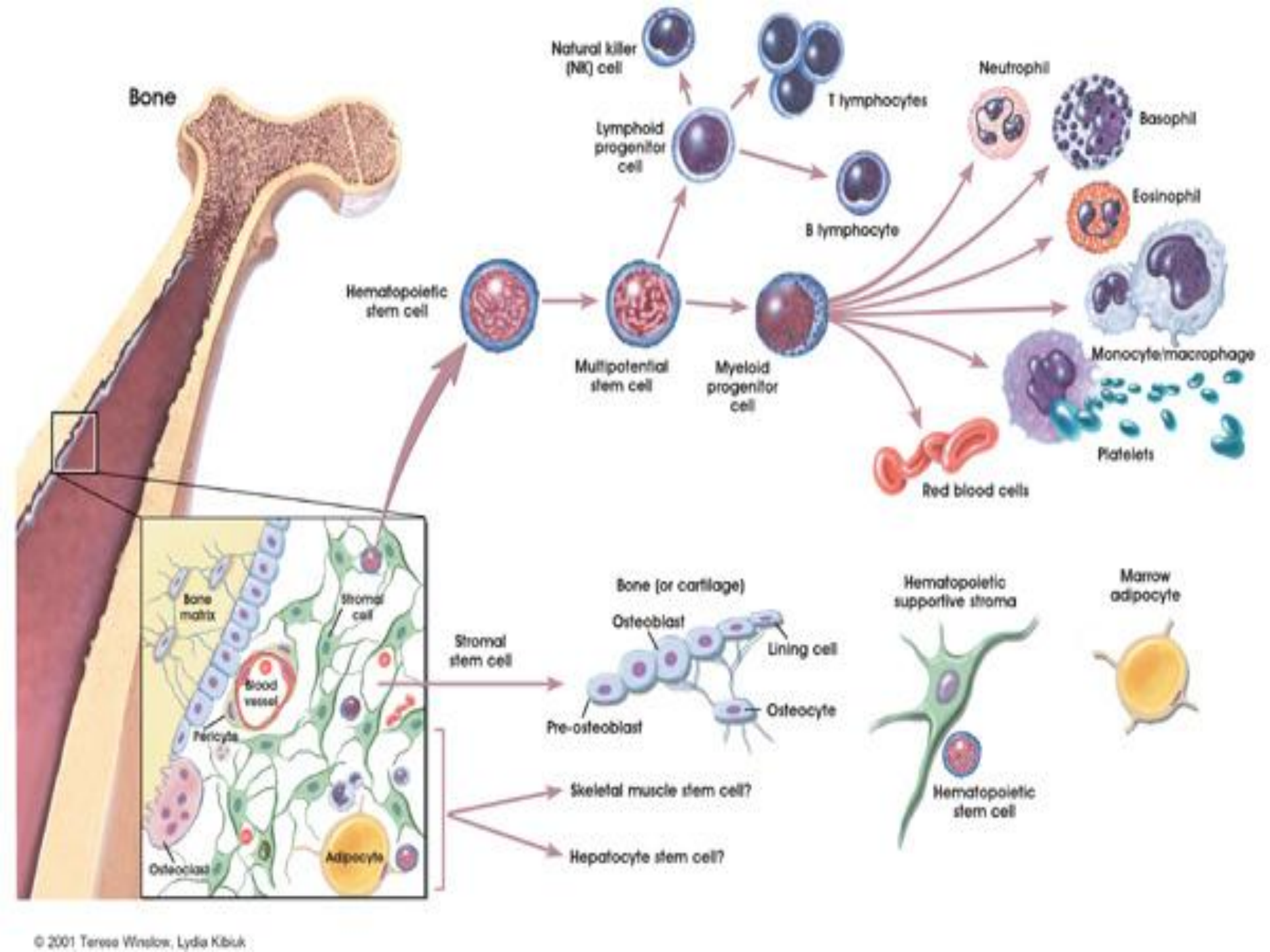
Dailey pp 61;
Brodie pp 41

Stem Cells





Dailey pp 4;
Austin pp 11



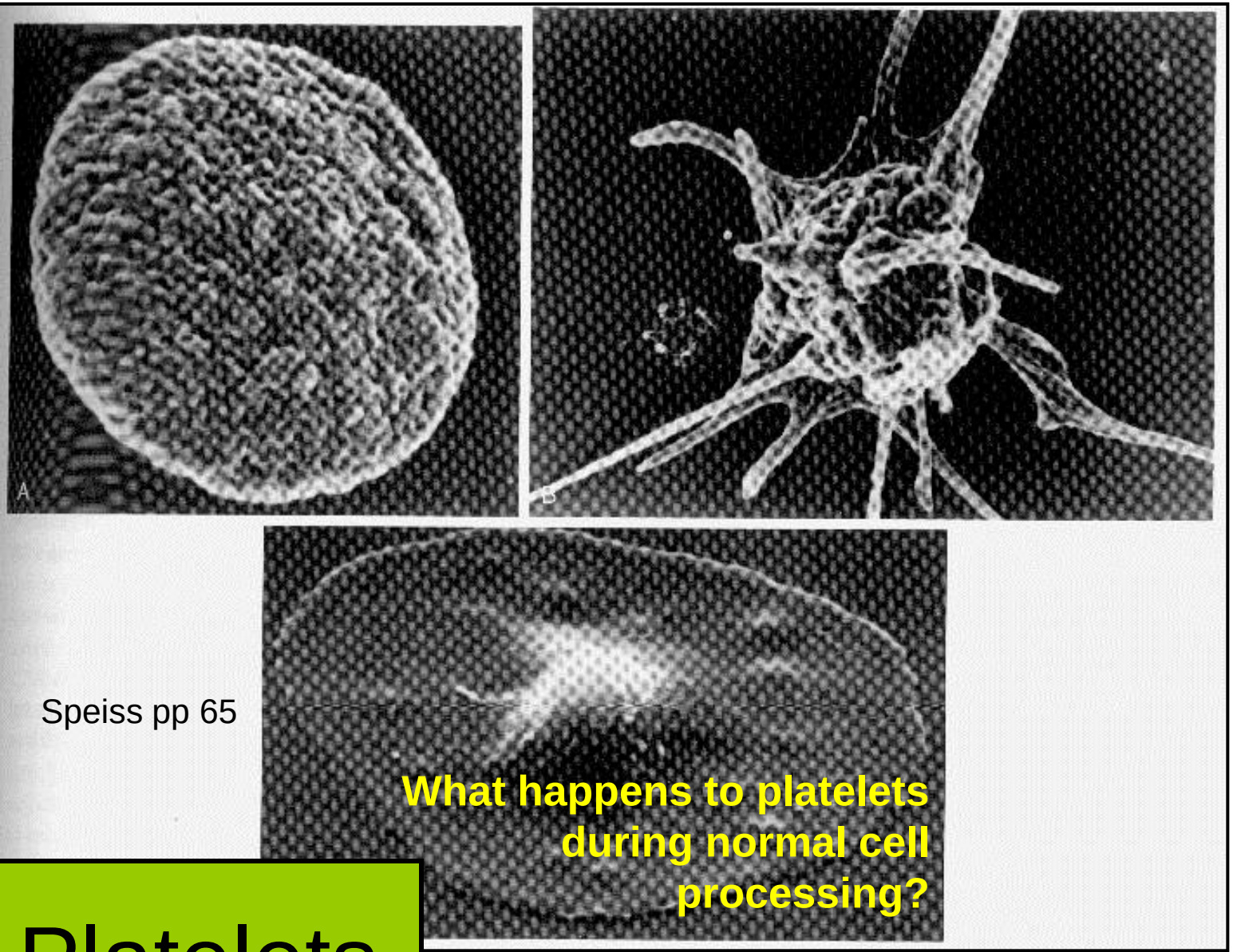
Potential Uses for Stem Cells

Figure 11: Potential Uses for Stem Cells

- Growing nerve cells to repair spinal injuries and restore function to paralyzed limbs.
- Growing heart muscle cells to replace useless scar tissue after a heart attack.
- Making brain cells that would secrete dopamine for the treatment and control of Parkinson's disease.
- Growing cells that make insulin, creating a lifelong treatment for diabetes.
- Growing bone marrow to replace blood-forming organs damaged by disease or radiation.
- Making blood cells genetically altered to resist specific disease, such as HIV, to replace diseased blood cells.

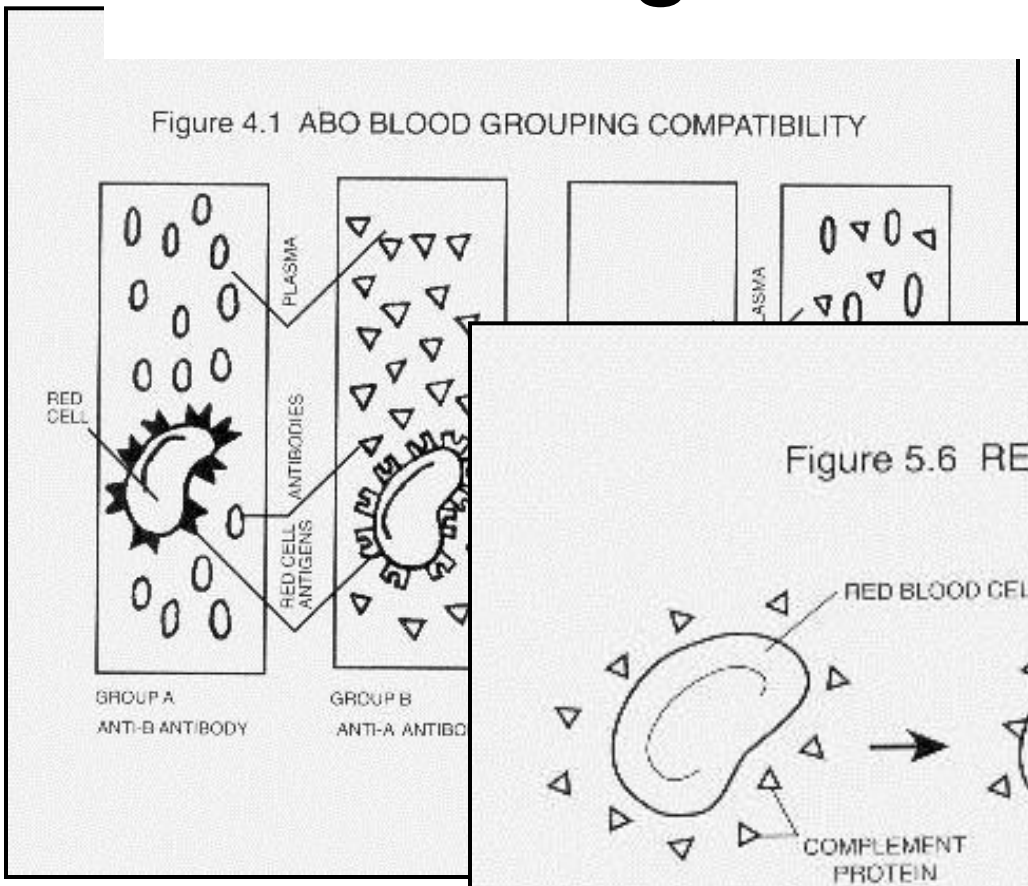
Source: James Thomson, assistant professor of anatomy at the University of Wisconsin Medical School, and John Gearhart, a professor of GYN/OB and physiology at Johns Hopkins University School of Medicine

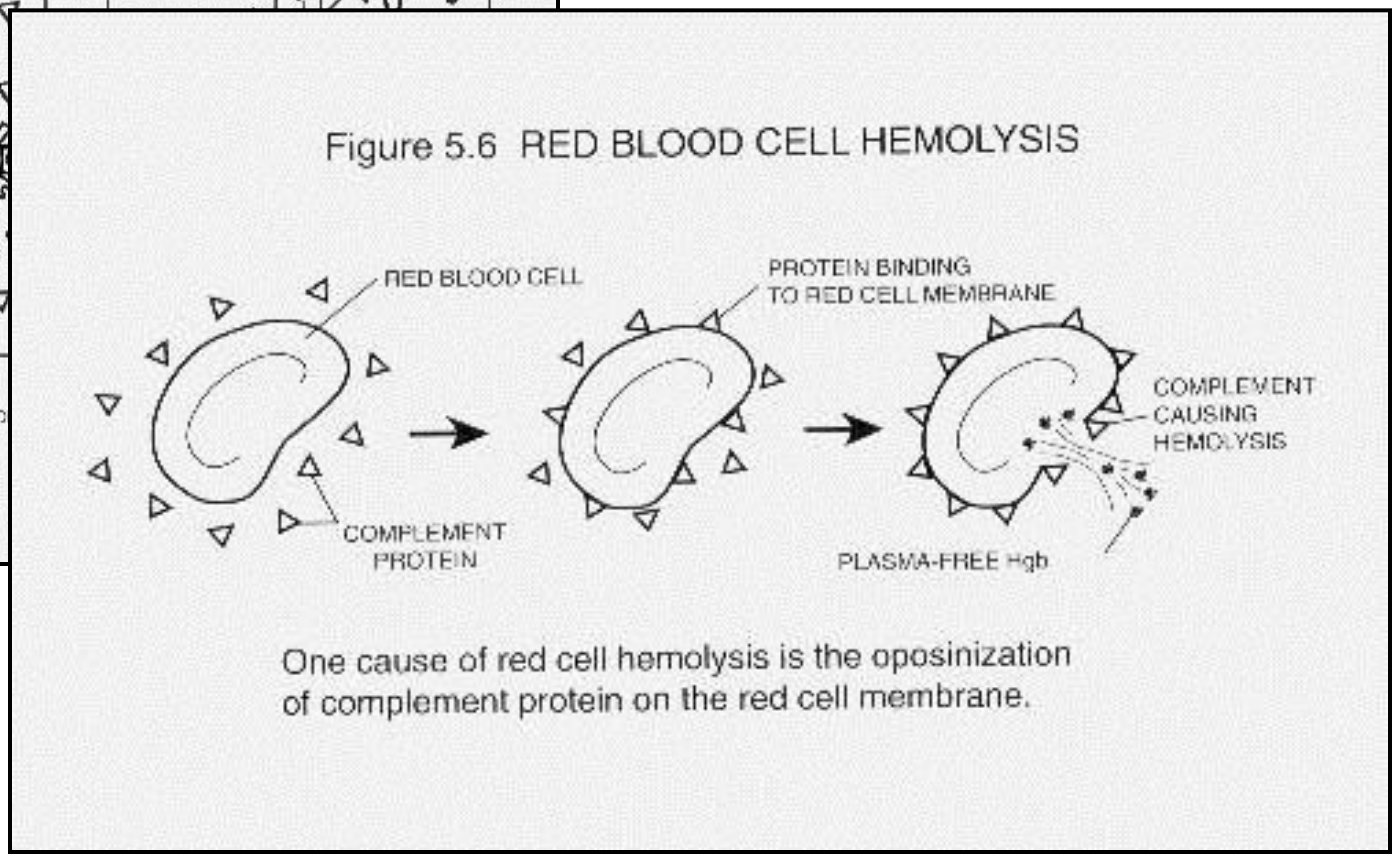
http://www.nih.gov/news/stemcell/primer.htm


A
B
Speiss pp 65
What happens to platelets during normal cell processing?

Platelets

RBC antigens and antibodies

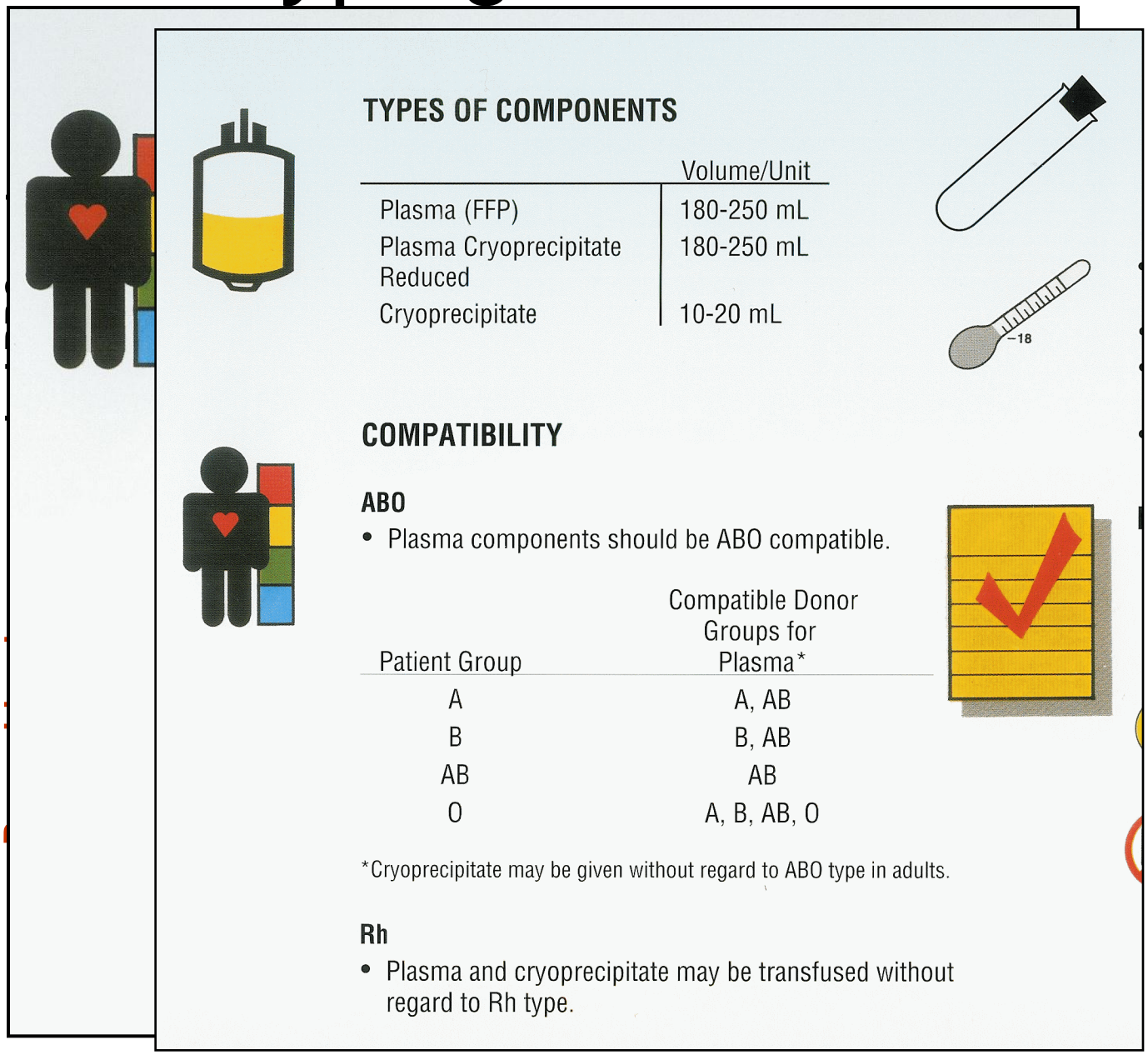




Dailey, pp 26, 38

Blood Typing: RBCs

- Group A has anti-B antibodies
- Group B has anti-A antibodies
- Group AB has both antigens and no antibodies
- Group O has no antigens and both antibodies



TYPES OF COMPONENTS

	Volume/Unit
Plasma (FFP)	180-250 mL
Plasma Cryoprecipitate Reduced	180-250 mL
Cryoprecipitate	10-20 mL

COMPATIBILITY

ABO

- Plasma components should be ABO compatible.

Patient Group	Compatible Donor Groups for Plasma*
A	A, AB
B	B, AB
AB	AB
O	A, B, AB, O

*Cryoprecipitate may be given without regard to ABO type in adults.

Rh

- Plasma and cryoprecipitate may be transfused without regard to Rh type.

Dailey, pp 26

Risks Allogeneic Transfusion

TABLE 1. Risks of transfusi

Risk
1. Hepatitis B
2. Hepatitis C
3. HIV
4. HTLV
5. TTV
6. West Nile virus
7. Cytomegalovirus conversion
8. Epstein-Barr virus
9. TRALI
10. ABO-Rh mismatch Occurrence Mortality
11. Delayed hemolytic reaction
12. Alloimmunization (PLTs and WBCs)
13. Alloimmunization (RBCs)
14. Allergic reactions
15. Febrile reaction
16. GVHD
17. Volume overload
18. Depressed erythropoiesis

* Some of the reported risks of transf
either as risk per number of units tra

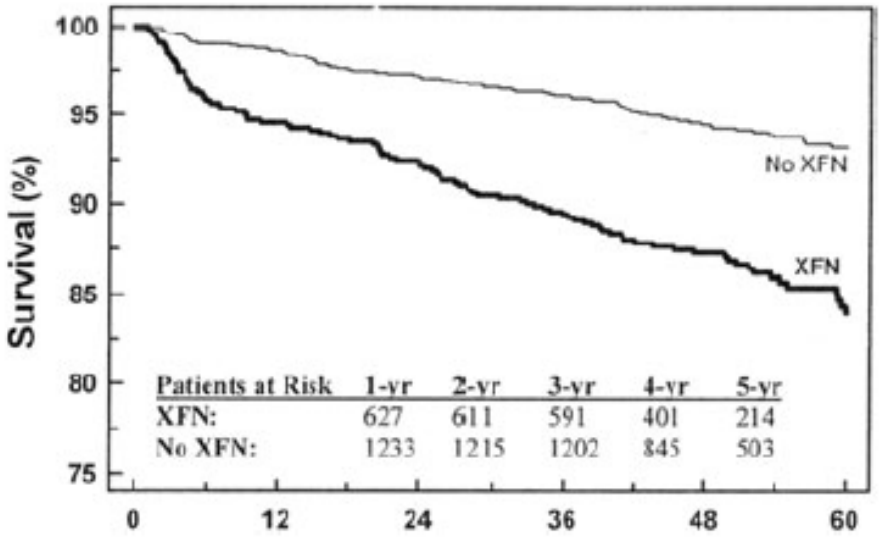
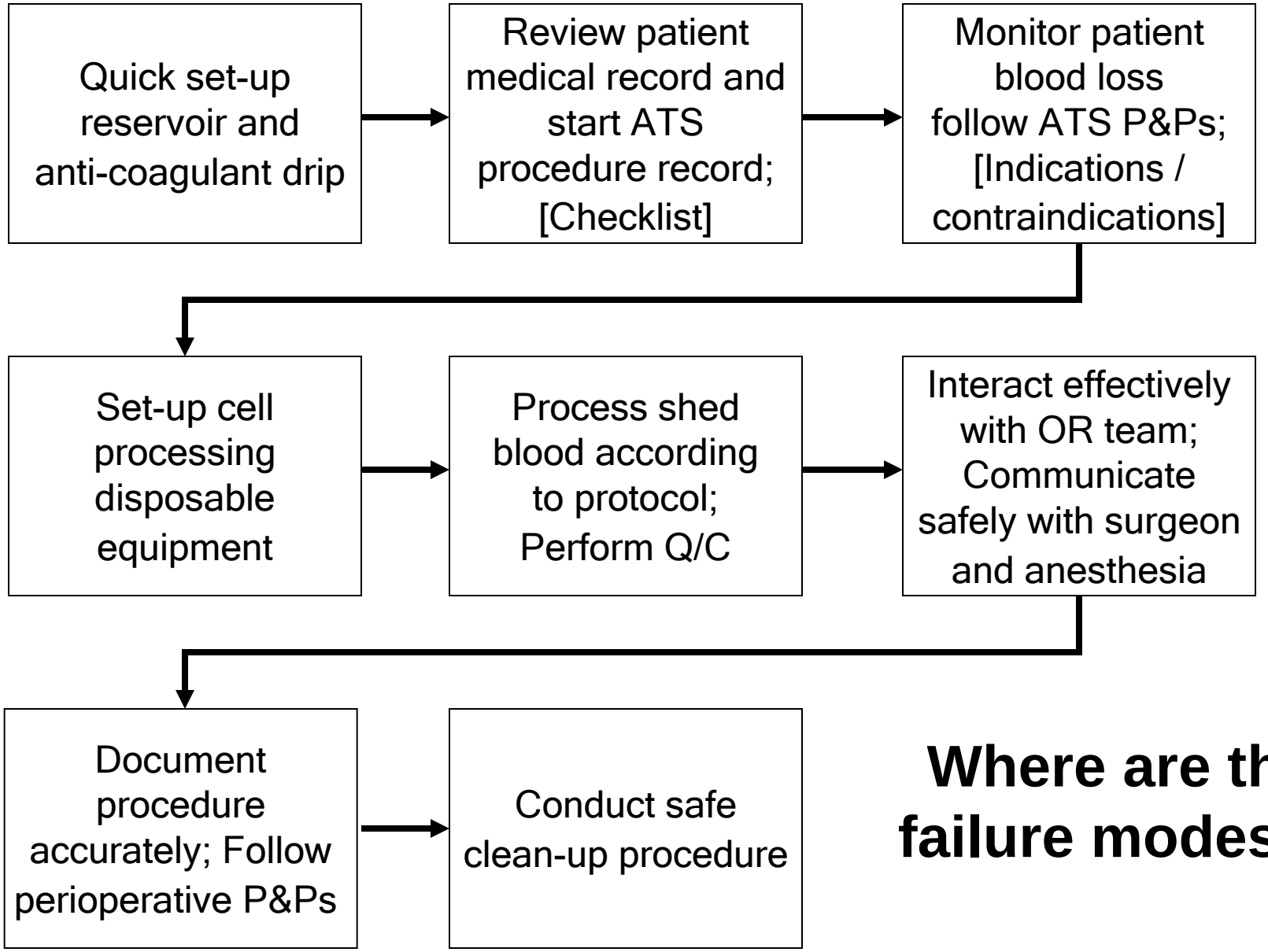


Fig. 1. The Kaplan-Meier mortality curves for those patients transfused perioperatively and for those not transfused. Those patients not transfused had approximately 2.5-fold better survival than those that received one or more units of RBCs during their CABG hospital stay. These data were after propensity analysis weighting confounding events and risks. Reprinted with permission from Engoren et al.[38]

Spiess BD. Risks of transfusion: Outcome focus. *Transfusion*. 2004;44:4S-14S
Waters JW. Indications and contraindication of cell salvage. *Transfusion*. 2004;44:S40-4.

Simulation flow for basic PBMT defined competencies



Where are the failure modes?

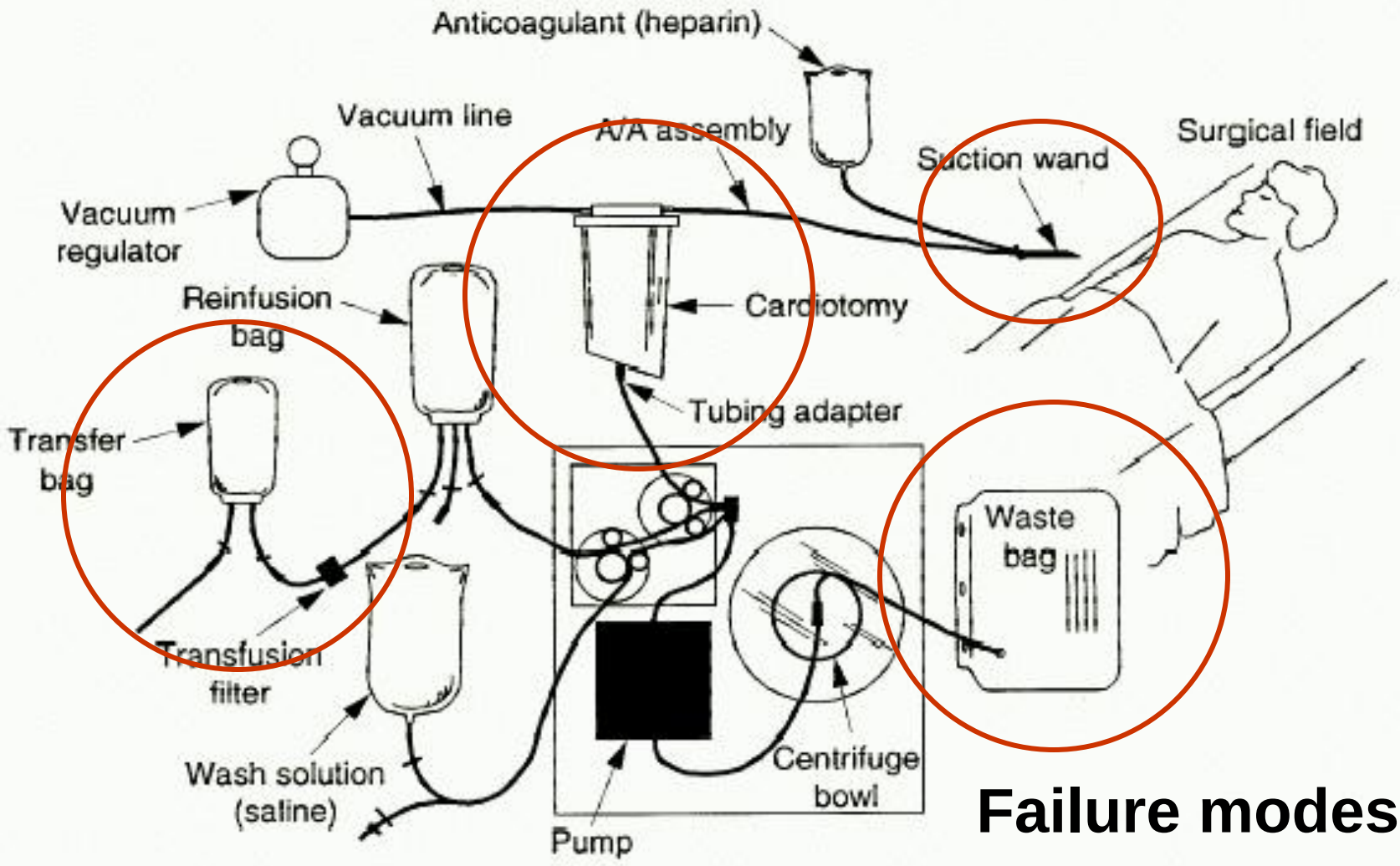
Blood Management Techniques During Phases of Operative Period

Perioperative Blood Management

Pre-Op	Anesthetic	Operative	Post-Op
☐ Hematologic analysis	☐ Pharmacology	☐ Meticulous hemostasis	☐ ATS: Cell processing
☐ Plan for hemorrhage	☐ BCST, Cellular therapies	☐ ATS: Cell processing	☐ Cell washing
☐ Pharmacology	☐ Plasma sequestration	☐ Tissue glue	☐ Transfusion
☐ Pre-donation	☐ RBC sequestration	☐ Platelet gel	☐ Total leukocyte depletion
☐ Pheresis	☐ Hypotension	☐ Ultrafiltration	☐ Ultrafiltration
☐ Exchange transfusion	☐ Transfusion	☐ Surface treatments	☐ Hematologic monitoring
☐ Genetic therapy	☐ Non-blood vol expansion	☐ Transfusion	
☐ Transfusion	☐ Artificial blood	☐ Rapid infusion	
	☐ Hematologic monitoring	☐ Artificial blood	
		☐ Hematologic monitoring	

ASA. Practice guidelines for perioperative blood transfusion and adjuvant therapies. *Anesthesiology*. 2006;105:198.

Safe IAT Circuit



Failure modes?

Hemoconcentration

- Hemoconcentrators
  - Dialysis
  - Ultrafiltration
- Centrifuge
  - Single bowl
  - Continuous processing
- Filtration
  - Micro-aggregate filtration
  - Leukocyte-depleting filters

Anticoagulation for ATS

- ACD, CPD
  - 15 ml/100 ml shed blood
  - 1:7 ratio
  - [Ca^{+2}]
  - Thrombocytes
- Heparin solution
  - (30,000 IU/L)
  - 1:7 ratio
  - Antithrombin

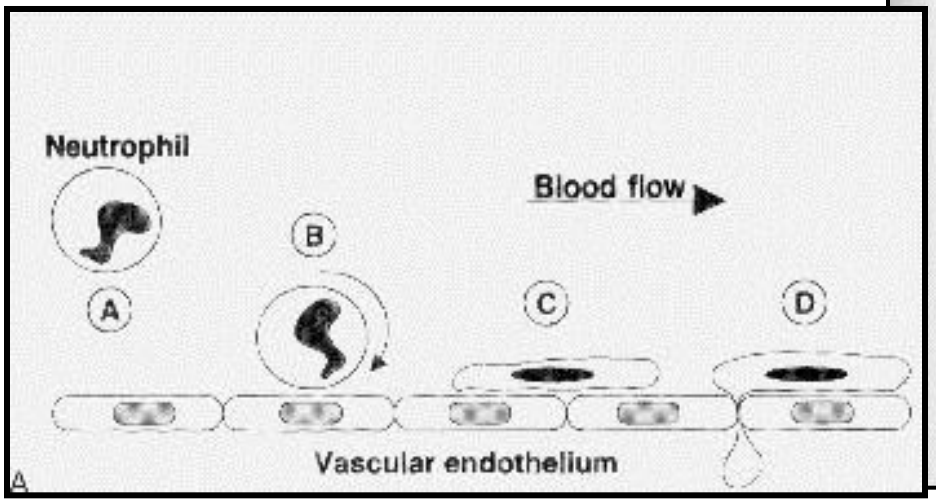
Organizations

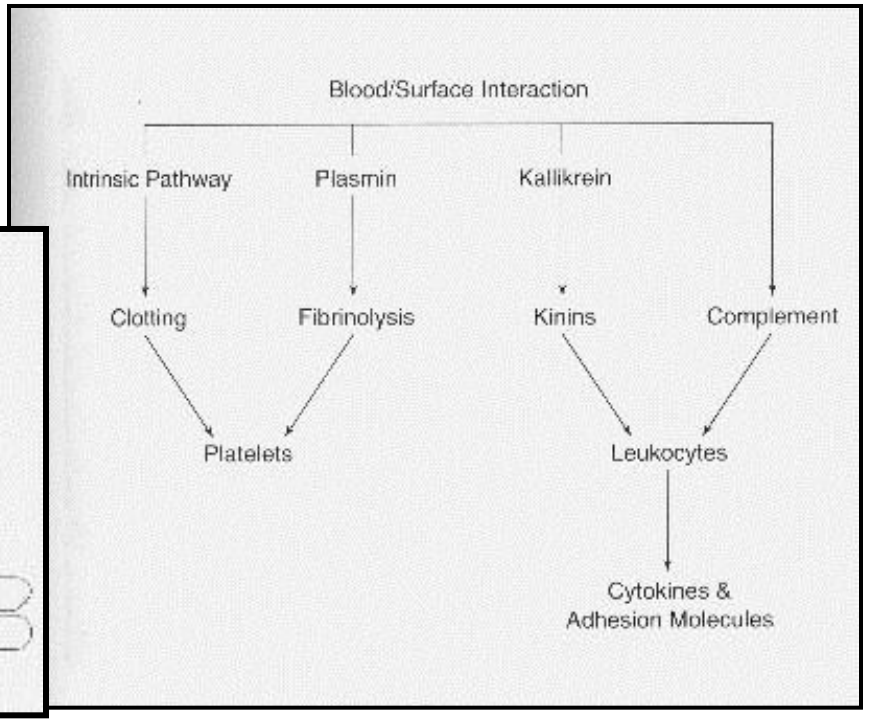
- FDA
- OSHA
- CDC
- JC
- CAP
- CMS
- AABB
- ASA
- AmSECT

- Hand hygiene
- Body fluid precautions
- Blood labeling
- Storage time
- Body fluid exposure
- Sharps
- Contaminated waste
- PPE
- Guidelines for PABCT
- GLP
- POCT

Collection System / Vacuum

- Filtered vs. non-filtered
- Safe vacuum levels / Suction tips
- Blood-gas interface
  - SIRS
- Activated WBCs





Tonicity

- Osmolarity
  - Ions (osmotic force)
  - Proteins (oncotic force)
- Hypotonic
  - Cells placed in a hypotonic solution swell
- Isotonic
- Hypertonic
  - Cells placed in a hypertonic solution shrink
- Hemolysis

Wash solutions

- Saline
- PlasmaLyte-A
- NormoSol-R
- Lactated Ringers – contains calcium ions
- D_5W – do not use as a wash solution
- Anticoagulant compatibility
- IV compatibility
- Type of shed blood (procedure-specific)

Blood and plasma volume

- Body weight: pounds to kg
- Estimated blood volume: % kg
- Estimated plasma volume: $(1.0 – f_{Hct})$
- Red cell mass (L)
  - Patient
  - ATS reservoir
- ANH volumes
- PRP (plasma pheresis fraction)

Pharmacology

- Anticoagulation
  - Anti-platelet drugs
- Antibiotics
  - Plasma-bound
- IV wash solutions – FDA indications
- Electrolytes / supplement
- Procoagulants
  - Topical hemostatic agents
- Allogeneic blood products

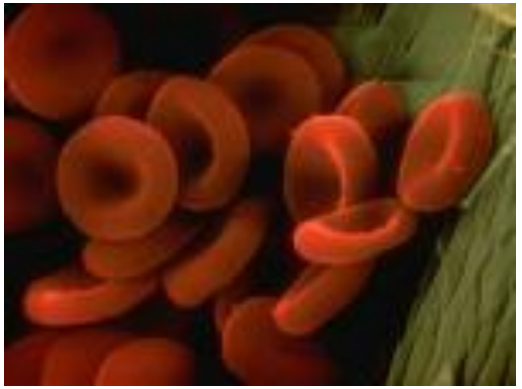
Theory and practice of Latham Bowl ATS

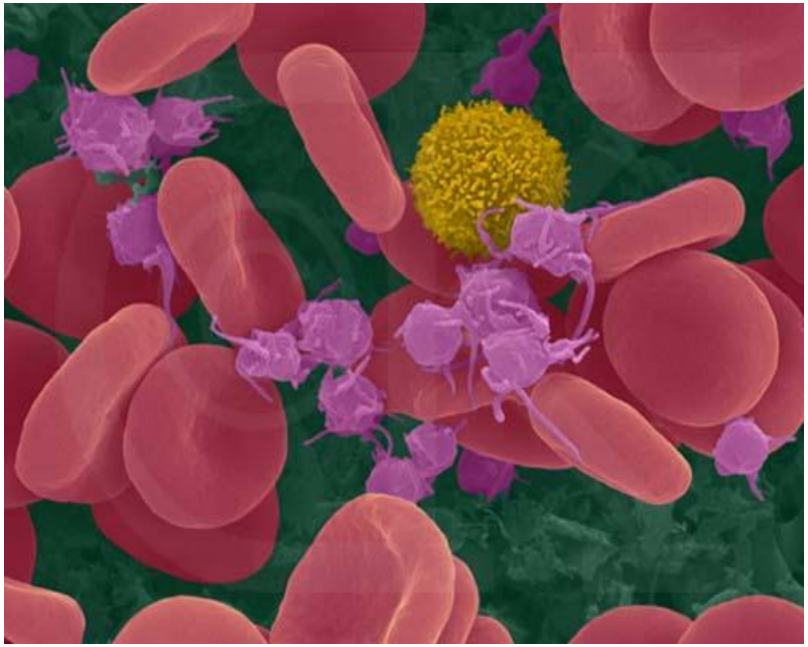
Reeder G. Autotransfusion theory or operation: a review of the physics and hematology. *Transfusion.* 2004;44:35S-39S

Reeder G. Autotransfusion theory or operation: a review of the physics and hematology. *Transfusion.* 2004;44:35S-39S

TABLE 1. Density range for the constituents of blood

Blood component	Component density range
Plasma	1.025-1.029
Thrombocytes	1.060-1.067
WBCs	1.065-1.090
RBCs	1.085-1.097





Megakaryocytes are similar in density to the lower density RBCs, so some platelets are found in the top of the RBC pack

Centrifugation

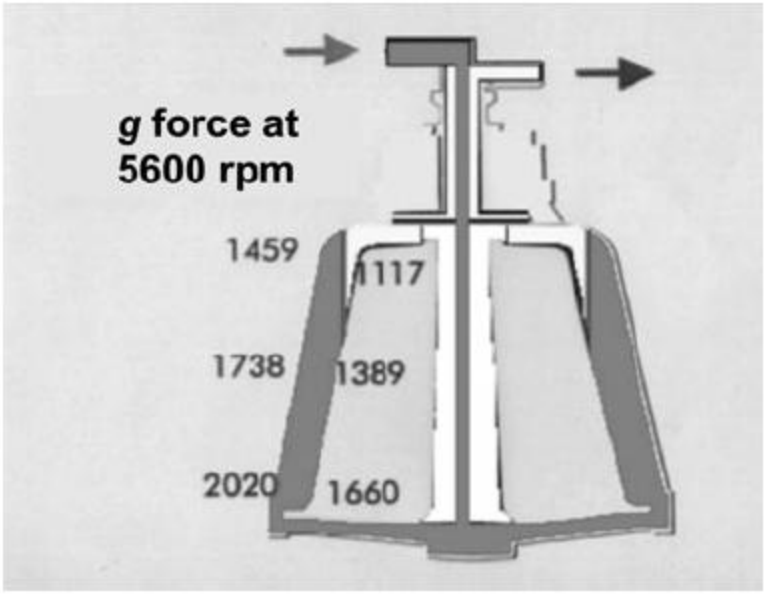
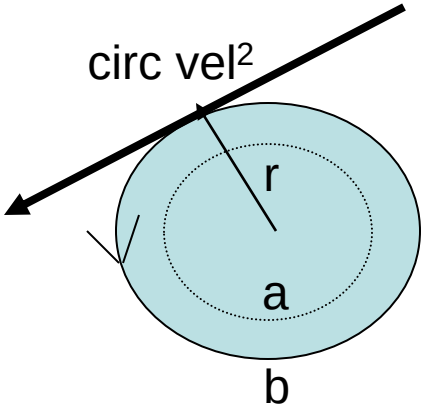


Fig. 2. Bowl *g* forces at 5600 rpm.

$$F = m\left[\frac{v^2}{r}\right],$$

Newton



Contaminants vary, always consider the source of the shed blood

TABLE 2. Contaminants found in shed wound or pump blood[1,2]

Fibrin(ogen) split products and D-dimers
Activated fibrinolytic products—plasmin
Activated complement—C3a and C5a
Proteolytic enzymes
Marker enzymes, including creatine phosphokinase-myocardial fraction (CPKMB) from mediastinal drainage
Stroma, cell fragments, and internal cellular contents
Activated WBCs
Free Hb
Bacteria and endotoxins
Fats
Anticoagulants

RPM Determine G Forces

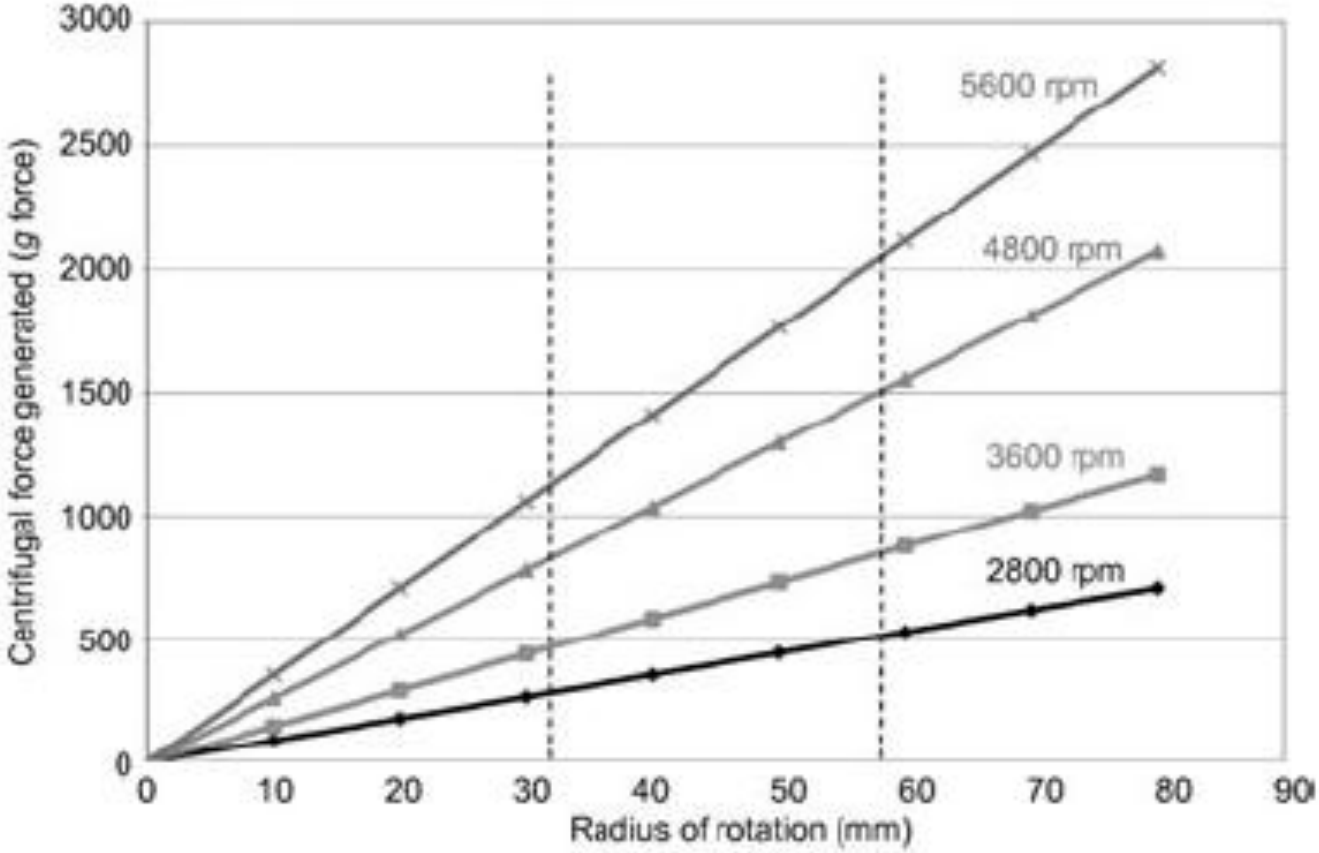


Fig. 1. Relationship between rpm and developed *g* forces in centrifugal cell processing bowls.

Operational Settings

TABLE 5. Operational settings (mL/min)

	Mode								
	"Wakeup"			"Standard"			"Maximum"		
Machine type	Fill	Wash	Empty	Fill	Wash	Empty	Fill	Wash	Empty
AT-1000	300	300	300	500	500	500	1000	1000	1000
Sequestra	300	300	300	500	500	500	1000	1000	1000
BRAT-2	400	800	600	500	500	500	1300	1300	1300
Compact A	400	450	500	500	500	500	1000	1000	1000
Cell Saver 4	500	600	500	500	500	500	1000	1000	1000
Cell Saver 5	200-600	200-600	500	500	500	500	1000	1000	1000

Higher rotation rates apply higher G forces, different cell processing algorithms employ different RPMs to optimize RBC / buffy coat separation

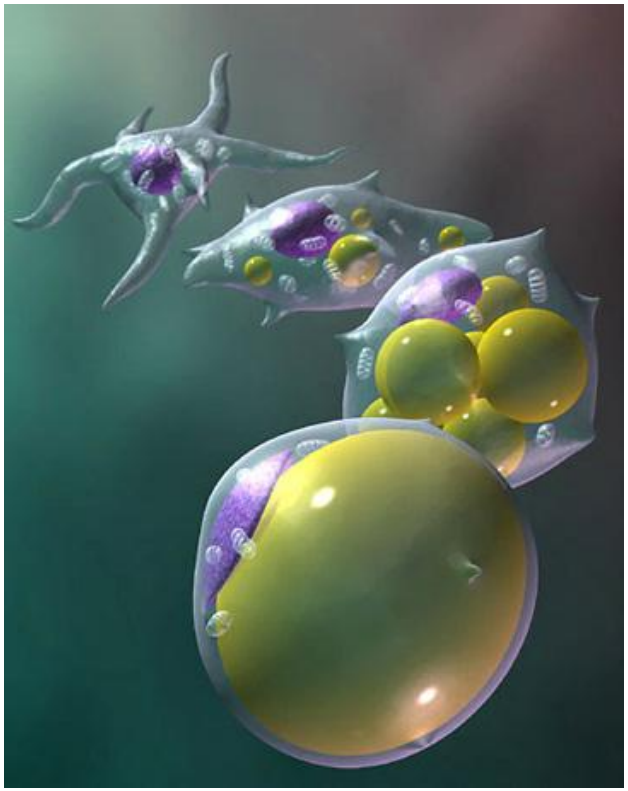
Before Wash

TABLE 3. Coagulation factors in shed blood

Coagulation factor	Venous blood	Shed blood
Factor VIII (%)	156.7	17
Factor V (%)	113.5	0
Antithrombin III (%)	97.3	46
Fibrinogen (mg/dL)	246	0
Plasminogen (%)	84.3	54.0
Protein C (%)	89.7	68.7
Protein S (%)	88.7	73.7

TABLE 4. Biochemical debris in shed blood

Biochemical agent	Venous blood	Shed blood
D-dimer (µg/mL)	0.7	1024
Fibrin(ogen) degradation products (µg/mL)	4.0	5120
Tissue plasminogen activator (ng/mL)	16	38.5
Complement C3a (ng/mL)	428	14784



Fat and debris removal are issues

http://www.gcarlson.com/cellular_platelets.htm

Quality Indicators of Cell

TABLE 6. P

System	Hct
A	47.5
B	41.3
C	45.2
D	52.2
E	33.2
F	45.6

* All data are perc

AAE
5.3,
reco
ana
auto

PERGAMON

Transfusion and Apheresis Science 27 (2002) 153–157

TRANSFUSION AND APHERESIS SCIENCE

www.elsevier.com/locate/transci

Intraoperative blood salvage in cancer surgery: safe and effective?

Ernil Hansen *, Volker Bechmann, Juergen Altmeppen

Department of Anesthesiologie, University of Regensburg, D-93042 Regensburg, Germany

Abstract

To support blood supply in the growing field of cancer surgery and to avoid transfusion induced immunomodulation caused by the allogeneic barrier and by blood storage leasions we use intraoperative blood salvage with blood irradiation. This method is safe as it provides efficient elimination of contaminating cancer cells, and as it does not compromise the quality of RBC. According to our experience with more than 700 procedures the combination of blood salvage with blood irradiation also is very effective in saving blood resources. With this autologous, fresh, washed RBC a blood product of excellent quality is available for optimal hemotherapy in cancer patients.

Keywords: cell salvaging, contraindications, neoplasm, in vitro, blood salvage, intraoperative technique, autotransfusion

rofes-

1995.

Fill

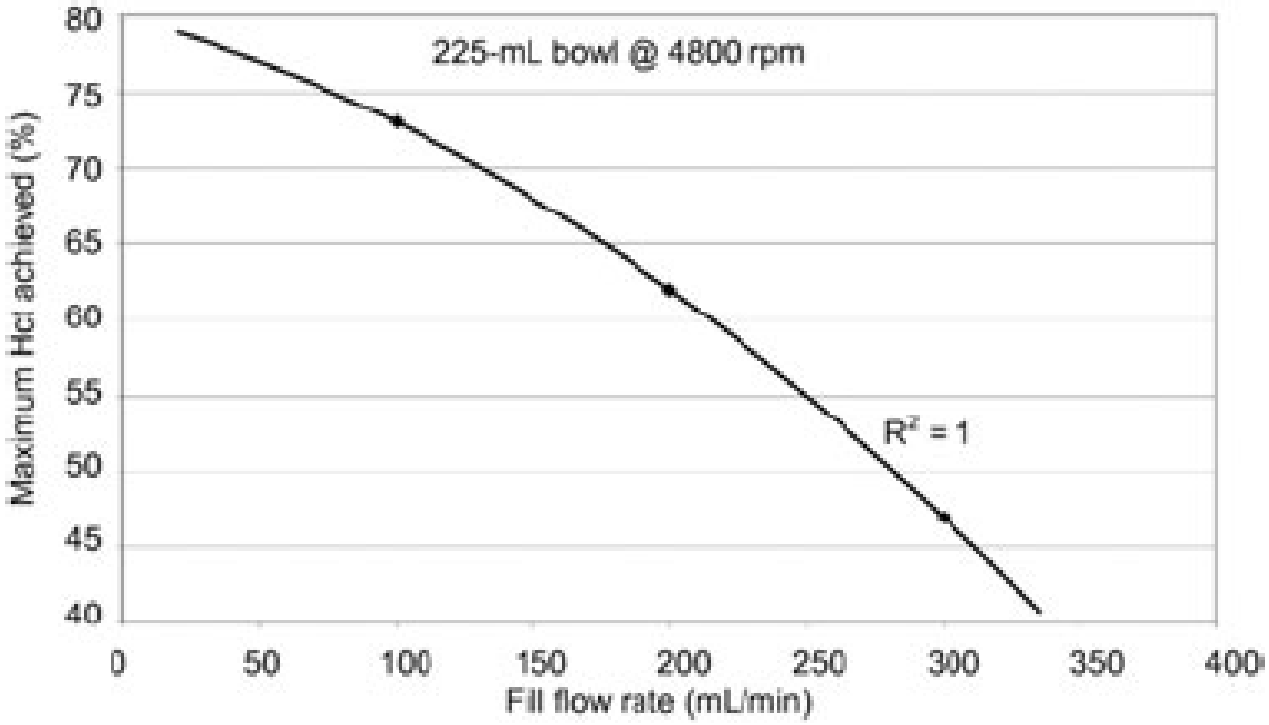


Fig. 4. Relationship between fill speed and achieved Hct.

Watch for spilling of RBCs

WASH

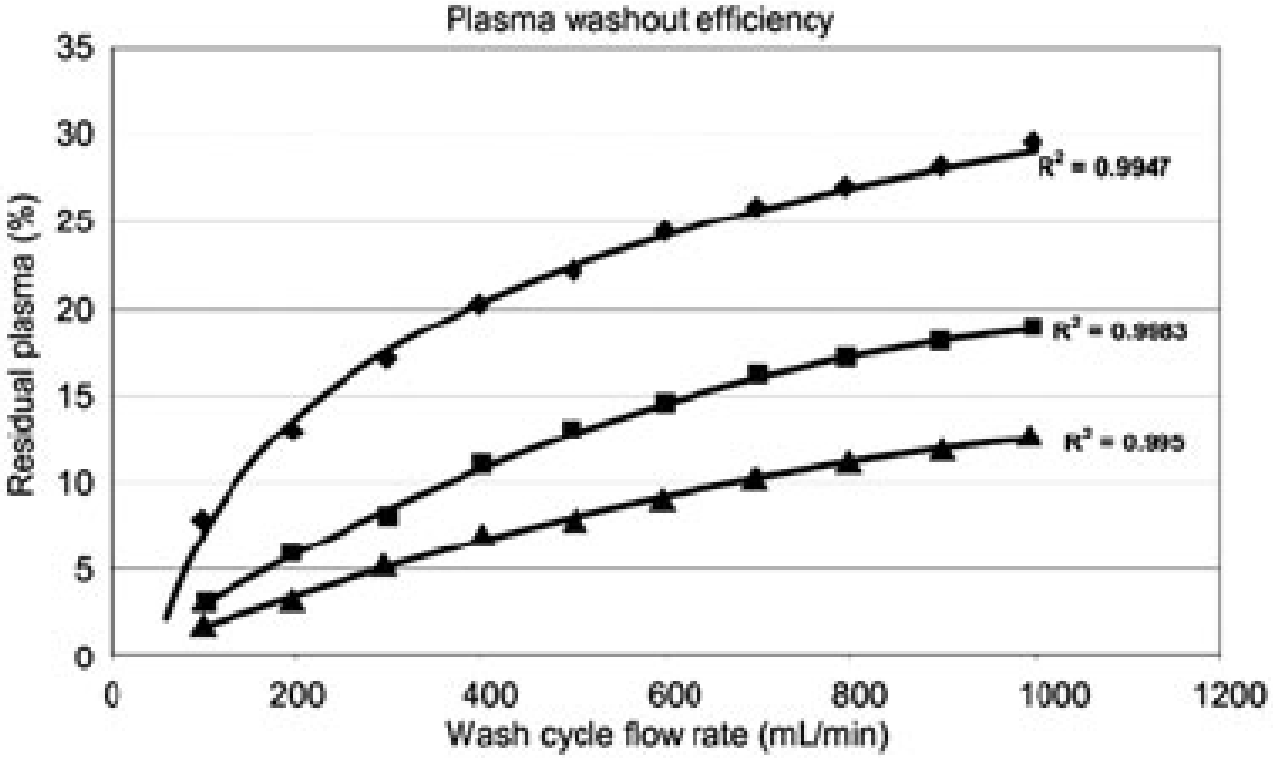


Fig. 5. Effect of flow rate and saline volume on plasma removal. (◆) 750-mL wash; (■) 100-mL wash; (▲) 1500-mL wash.

Examine the exudate

Notes c
Contr

- Procedure-spe
  should contain
  and contraindic
- MDs may veto
  contraindicatio
  order, confirm
- See Waters JH
  Transfusion. 2(
  44S

TABLE 1. General indications for CS

Specialty	Surgical procedure	Comments
Cardiac	Valve replacement	
	Redo bypass grafting	
Orthopedics	Major spine	
	Bilateral knee	

TABLE 2. Proposed contraindications to CS

Pharmacologic agents
- Clotting agents (Avitene, Surgicel, Gelfoam, etc.)
- Irrigating solutions (Betadine, antibiotics meant for topical use)
- Methylmethacrylate

Contaminants
- Urine
- Bone chips
- Fat
- Bowel contents
- Infection
- Amniotic fluid

Malignancy

Hematologic disorders
- Sickle cell disease
- Thalassemia

Miscellaneous
- Carbon monoxide (electrocautery smoke)
- Catecholamines (pheochromocytoma)
- Oxymetazoline (Afrin)

E-B Practice Guidelines

■ SPECIAL ARTICLES

Anesthesiology 2006; 105:198–208

Practice Guidelines for Perioperative Blood Transfusion and Adjuvant Therapies

"When appropriate, intraoperative or postoperative blood recovery and other means to decrease blood loss (*e.g.*, deliberate hypotension) may be beneficial. Acute normovolemic hemodilution, although rarely used, may also be considered."

making decisions about health care. These recommendations may be adopted, modified, or rejected according to clinical needs and constraints.

Practice guidelines are not intended as standards or absolute requirements. The use of practice guidelines cannot guarantee any specific outcome. Practice guidelines are subject to revision as warranted by the evolution of medical knowledge, technology, and practice. They provide basic recommendations that are supported by analysis of the current literature and by a synthesis of expert opinion, open forum commentary, and clinical feasibility data.

and Adjuvant Therapies

Blood transfusion refers to the perioperative administration of blood and blood components (*e.g.*, autologous blood, allogeneic whole blood, red blood cells, fresh frozen plasma [FFP], platelets, and cryoprecipitate). Adjuvant therapies refer to drugs and techniques to reduce or prevent blood loss and the need for transfusion of allogeneic blood.

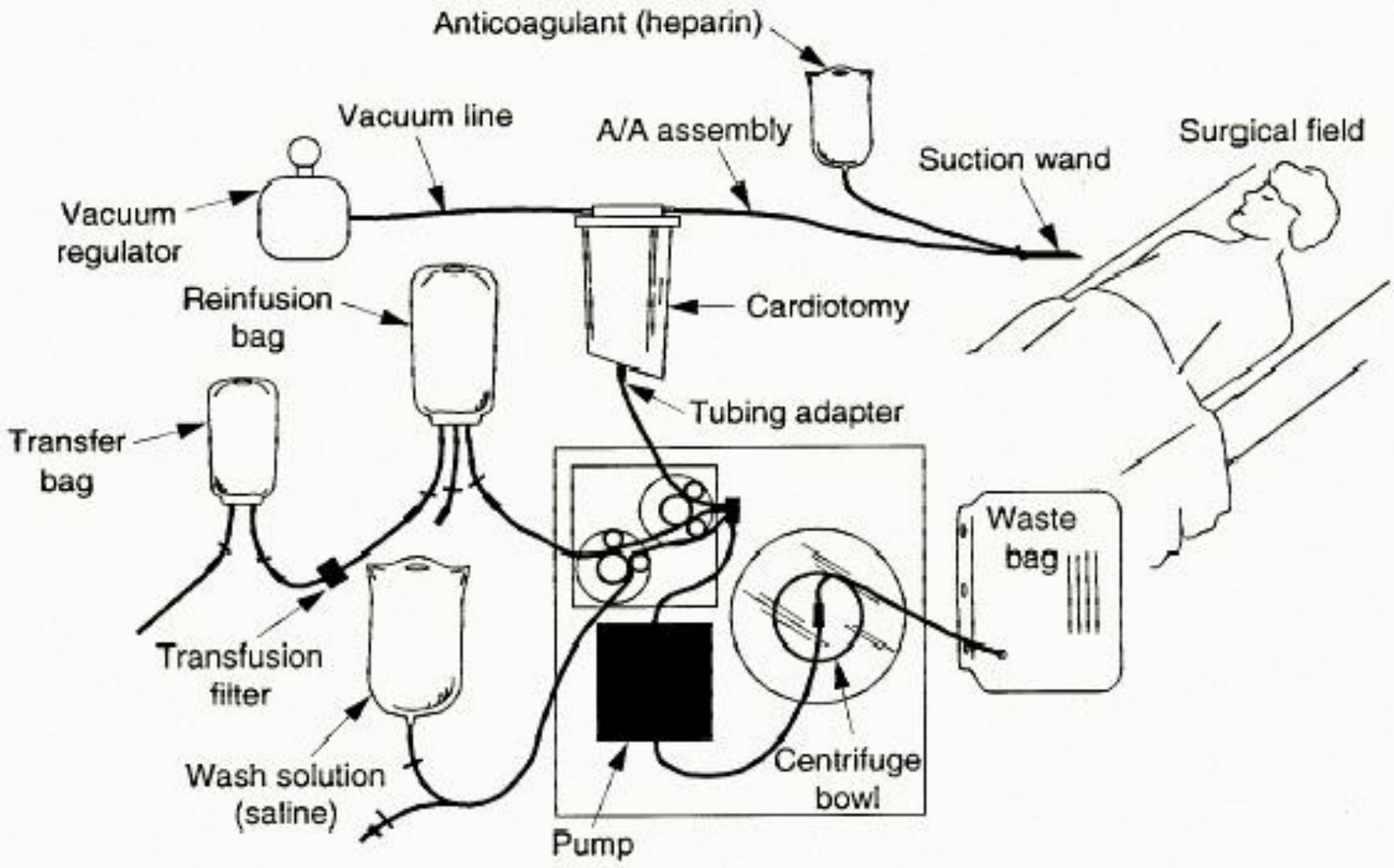
B. Purpose of the Guidelines

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

Quality Monitoring

- Process steps QC
- Final Product Quality Monitoring
  - Hct, [Pr], wash exudate clarity
- Process Improvement
  - Capture opportunities for improvement
  - Capture failure modes
  - Impound non-functioning equipment
- Qualifying FDA-cleared devices for a specific use [AABB]

Safe IAT Circuit



Critical Incidents

1

PERGAMON

Transfusion and Apheresis Science 24 (2001) 255–259

TRANSFUSION AND APHERESIS SCIENCE

2

www.elsevier.com/locate/transci

Current status of bacterial contamination of autologous blood for transfusion

3

Yoriko Sugai *, Katsuhei Sugai, Akihisa Fuse

Department of Anesthesia, Ohmihachiman City Hospital, 395, Demachi, Ohmihachiman City, Shiga 523-0892, Japan

Received 8 December 2000; accepted 28 December 2000

4

Abstract

Autologous transfusion, although not without risk, does decrease the risk of transmitted diseases via homologous transfusion. However, strict quality control is required for autologous transfusion. In Japan, a recent enactment requires that written informed consent be obtained prior to blood transfusion, which therefore requires that clinicians provide sufficient explanation of the risks involved with this procedure. To the best of our knowledge, this is the first study to comprehensively evaluate the manner in which the safety of autologous blood transfusion can be compromised

R

1.

2. affecting quality] [Article in German]. *Anasthesiol Intensivmed Notfallmed Schmerzther.* 2004;39(9):569-575.

3. Hunt A, Stammers AH, Kangas J, Fristoe L, Merrill JH, Vogel J, Galbraith T. Damaged Erythrocytes following Cell Washing with a Hypotonic Solution: A Case Report. JECT. 1993;25:67-70.

Critical Incidents

5. **Medication errors**
    1. **Wrong anticoagulant drug**
    2. **Wrong anticoagulant drug dose**
    3. **Wrong anticoagulant drip solution**
6. **Allergic reactions**
    1. **Anaphylactic reaction (3)**
7. **Equipment failure**
    1. **Cell washing devices**
    2. **Platelet concentration devices**
    3. **Rapid infusion devices**
    4. **Blood warming devices**
8. **Circuit disposable component failure**
    1. **Shed blood reservoir**
    2. **Cell washing bowl or chamber**
9. **Circuit blood line separation**
    1. **Blood spray**
    2. **Blood loss**

Reference

3. Covin R, Ambruso D, England K, et al. Hypotension and acute pulmonary insufficiency following transfusion of autologous red blood cells during surgery: a case report and review of the literature. *Transfus Med.* 2004;14(5):375-383.

Critical Incidents

10. Special patient management requirements

1. **Partial cell washing bowl volume (2, 4)**
2. **Massive red blood cell and platelet loss (5)**
3. **Massive plasma protein and clotting factor loss**
4. **Pediatric patients (6)**
5. **Jehovah Witness (7)**
6. **Cancer patient (8)**
7. **Cesarean patient (9, 10)**
8. **Liver transplant patient**

Reference

4. Serrick C, Scholz M. Partial bowls using the Haemonetics Cell Saver 5: does it produce a quality product? *J Extra Corpor Technol.* 2005;37(2):161-164.
5. Drummond J, Petrovitch C. Intraoperative blood salvage: fluid replacement calculations. *Anesth Analg.* 2005;100(3):645-649.
6. Weldon B. Blood conservation in pediatric anesthesia. *Anesthesiol Clin North America.* 2005; 23(2):347-361.
7. Nieder A, Simon M, Kim S, Manoharan M, Soloway M. Intraoperative cell salvage during radical prostatectomy: a safe technique for Jehovah's Witnesses. *Int Braz J Urol.* 2004;30(5):377-379.
8. Nieder A, Manoharan M, Yang Y, Soloway M. Intraoperative cell salvage during radical cystectomy does not affect long-term survival. *Urology.* 2007;69(5):881-884.
9. Waters J, Lukauskiene E, Anderson M. Intraoperative blood salvage during cesarean delivery in a patient with beta thalassemia intermedia. *Anesth Analg.* 2003;97(6):1808-1809.
10. Fong J, Gurewitsch E, Kang H, Kump L, Mack P. An analysis of transfusion practice and the role of intraoperative red blood cell salvage during cesarean delivery. *Anesth Analg.* 2007;104(3):666-672.

Riley.Jeffrey@Mayo.edu

Questions?