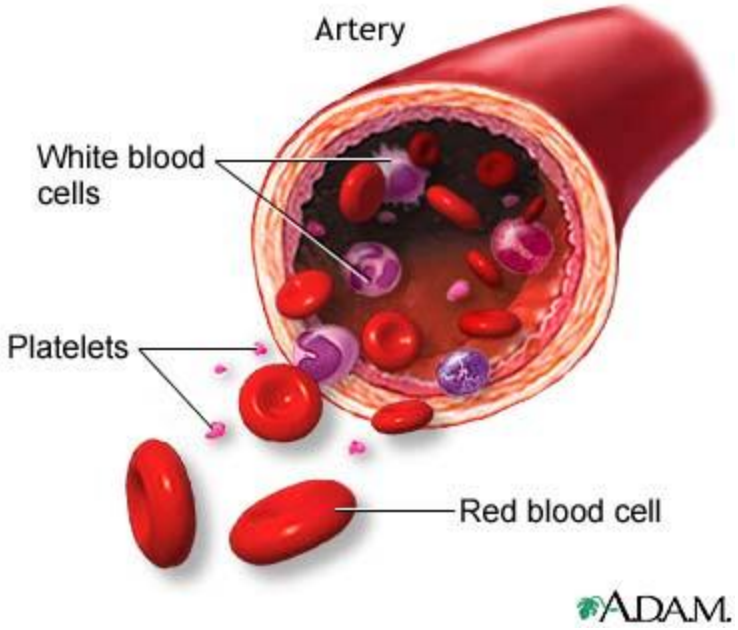
A Multidisciplinary Multimodality Approach to Blood Conservation



Keith Samolyk CCP, LCP

AmSECT IBBM RENO 2010

ETHICS OF BLOOD MANAGEMENT

-First Do No Harm "**Primum Non Nocere"**

-Transfuse only when absolutely necessary

-Transfuse Only what's Required / Sparingly

-The Freshest Components Possible

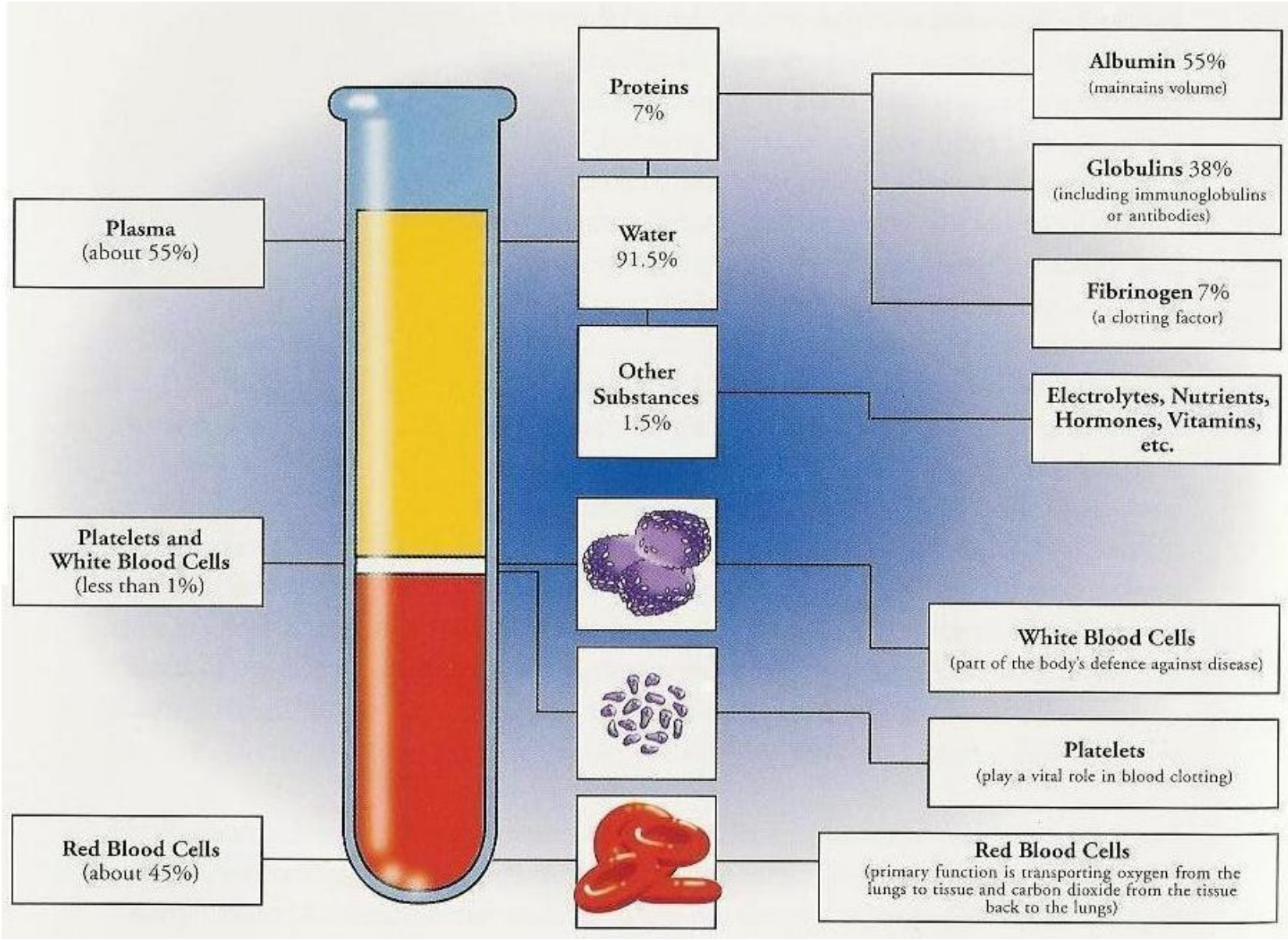
- Minimal Blood Draws for Sampling

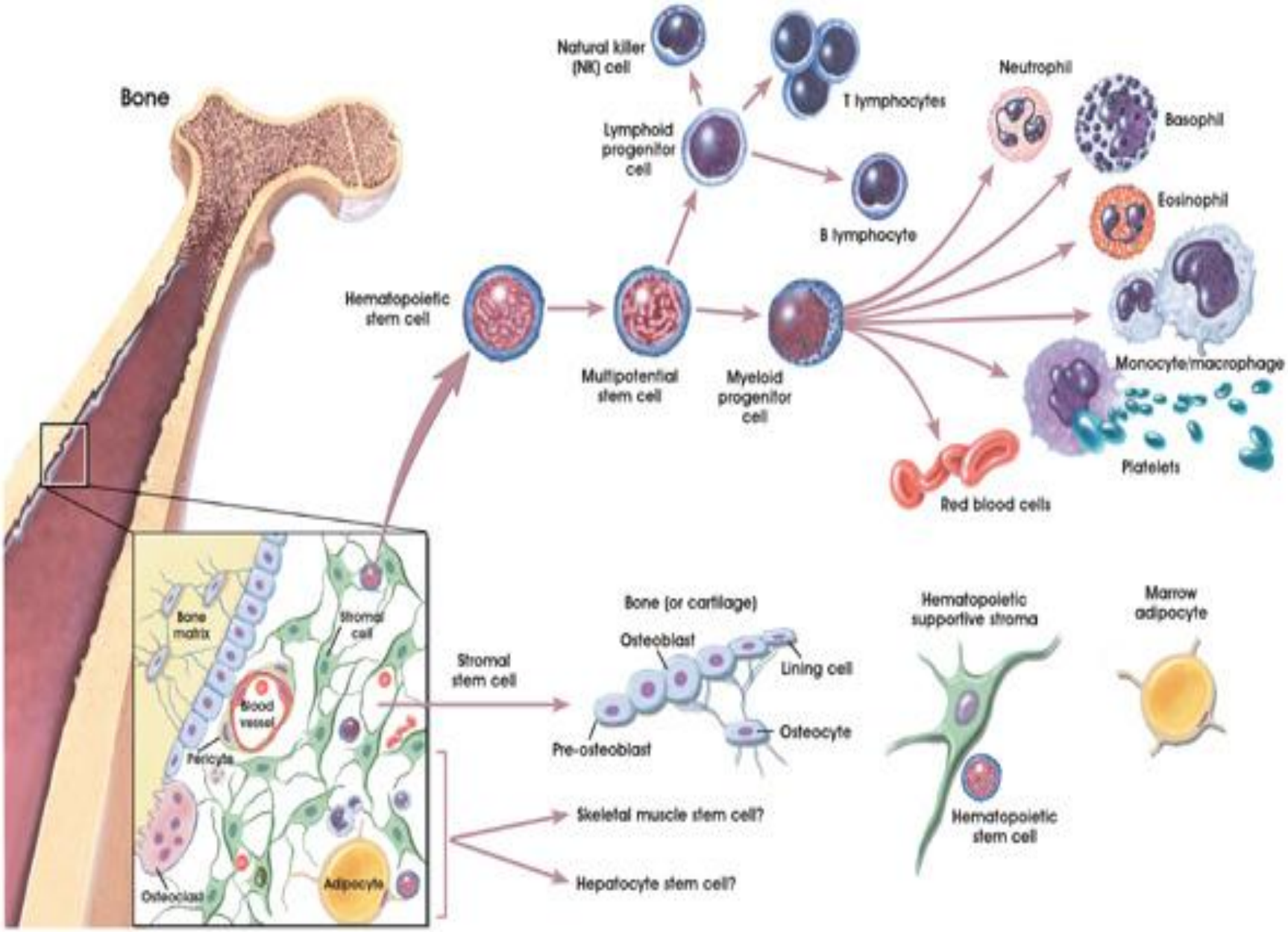
-Avoid Waste/ Recover as much Autologous as poss

-Use POC Labs to Justify Transfusions

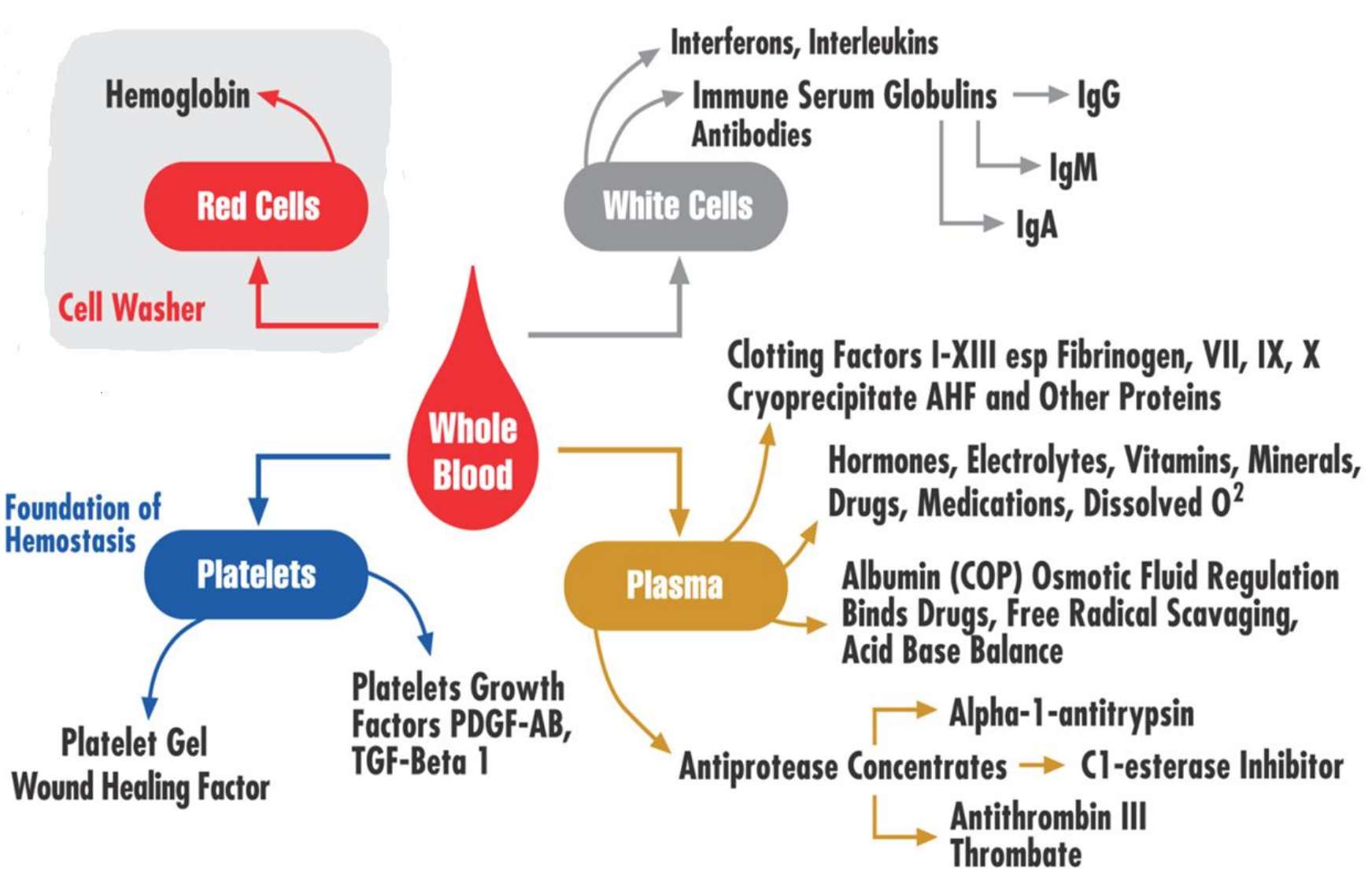
-Use Evidence Based Medicine in Decisions

To Start What is Blood?





The 4 Major Components of Blood



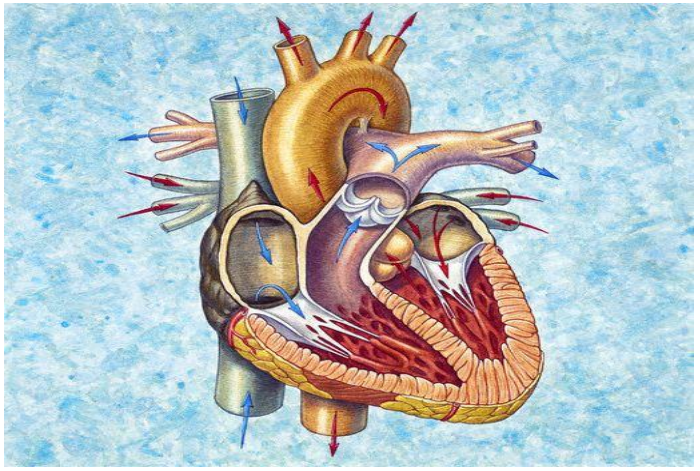
A Multidisciplinary Approach with Door to Door Hemovigilance Or it Doesn't Work at All !

- Primary Doctor
- Cardiologist
- Admission Care Team
- Anesthesia
- Surgeon
- Perfusion (Its not your fault) GWH
- ICU Care Team, Nurses
- Administrators

The Primary Doctors Office

- Baseline lab work (preferably 6 wks early)
- Micro-sampling (Peds Tubes)
- Iron therapy
- Epo therapy
- Help patient to select best Hospital
- Help patient to select best Cardiologist
- Help guide patient to select best Surgeon

The Cardiologist



- Minimal Labs with Micro Sampling at all times
- Meticulous attention to blood loss during Cath
- Minimize the use of Heparin and ACT's < 999
- The Use of Anti-Platelet drugs like Plavix < is best
- Identify the best hospital to have Surgery done at
- Identify the best Surgeon to do the Case (specialist)
- No more than 2 easy Stents w/o Stent Jail please or send me to Surgery as grafts last longer!

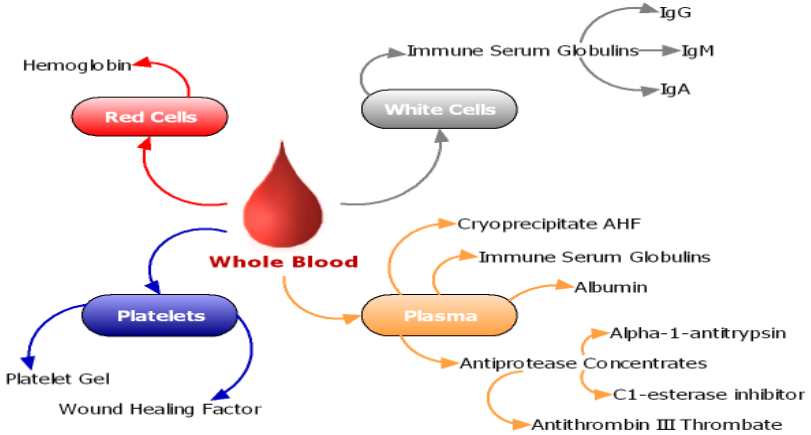
The Admission Care Team

- Preferably the day of surgery
- Micro Sampling for Labs
- That first I.V. Line (Let the games begin)
- For every 1 liter of Crystalloid given

Only 200- 250mls will stay Intravascular within 30 minutes, the remaining 750mls will cross extravascularly causing Organ Edema and Dysfunction dropping the Visc and COP.

Pre Game Plan (The Big 3)

- When ever possible the members of the Cardiac surgical team should communicate
- (The Surgeon, Anesthesia, and Perfusion) should meet prior to surgery and discuss the best course of action for optimizing the case and avoiding Allogeneic Blood Products.
- **The Team Approach to Blood Management !**

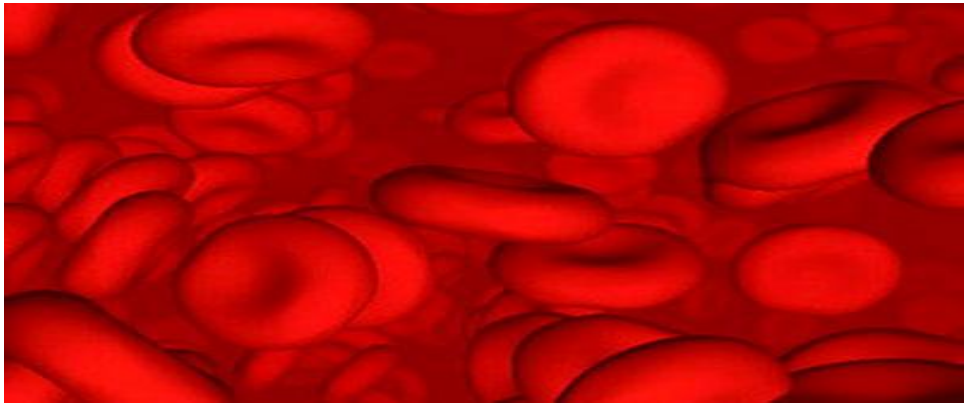


Anesthesia

*8 gm – 10 gm Hgb

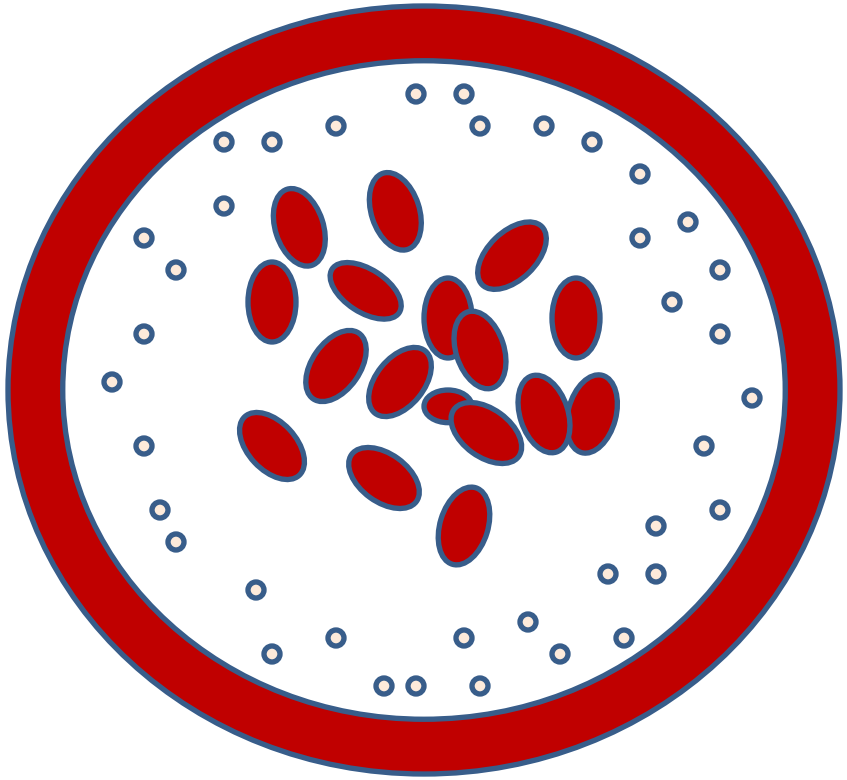
DUKE / Chappell / Henry Ford

No Benefit and No Harm



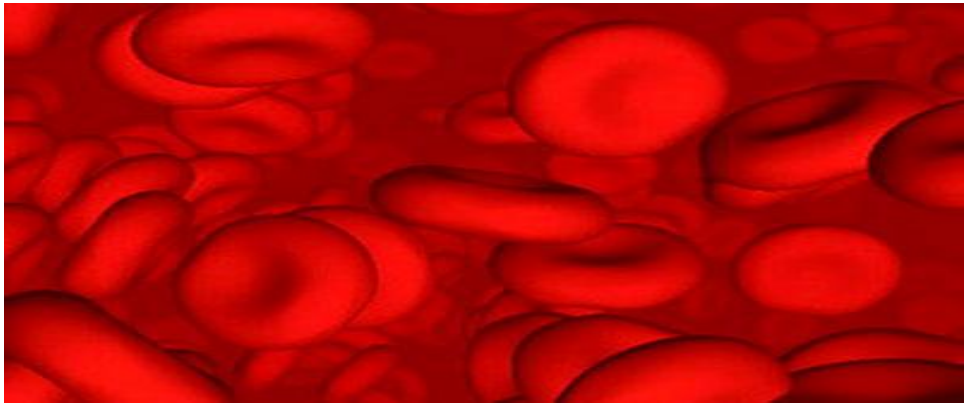
- Meticulous placement of Lines to function correctly and not loose any blood or make any extra holes.
- Limit the amount of Crystalloid given during the case and opt for Colloids like Albumin instead for Volume.
- Vascular Tone (SVR) use Pressors as tolerated by cardiac index to achieve a normal SVR of between 800-1200.
- ANH Acute Normovolemic Hemodilution, usually 1-2 units or more can be removed safely and still keep a good Hct while on Pump. This should be the first vol seen post CPB.
- Targeted Pharmacotherapy (Amicar, ~~Aprotinin~~, DDAVP, rFVIIa Novo 7, Vitamin K and other recombinant factors)

Red Cell Mass Contributes to Hemostasis By Pushing the Platelets out to the Endothelium



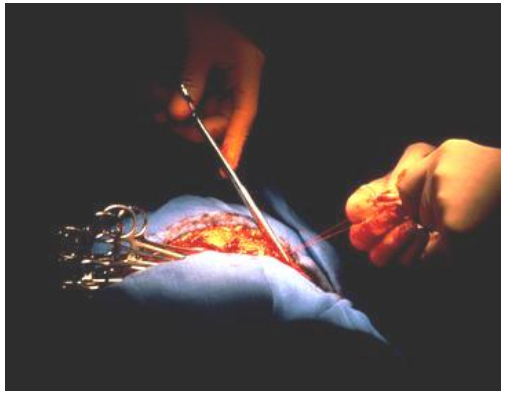
HCT OF AT LEAST 24%

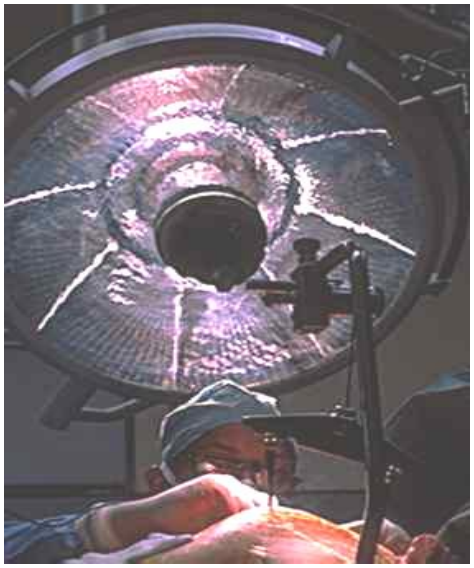
Anesthesia Continued



- Hypotension is NOT Hypovolemia! (Chappell Fluid Article)
- Push the SVR not the Starling Curve! normal 800-1200.
- Hemodilution is the Enemy! It leads to Organ Edema and Organ Dysfunction that leads to Morbidity and Mortality!
- HD creates to a Dilutional Anemia and a Dilutional Coagulopathy that leads to Blood Products leads to M&M!
- Give min Volume and keep Patient tight as Index tolerates

The Surgeon

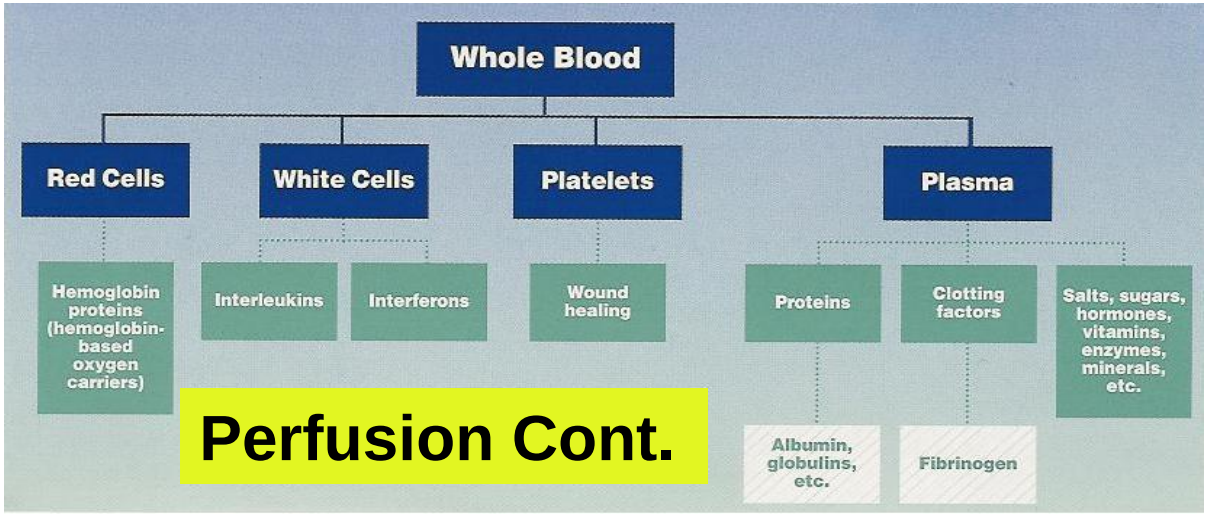




- Communicate clearly during the case and work diligently
- Have patience with the Perfusionists while they are RAP'ing
- Refrain from cooling as much, as it hurts the Platelets
- Meticulous surgical technique should be employed throughout the surgical procedure when bleeding
  - When ever there is obvious surgical bleeding the surgeon should stop to tie down or cauterize the area to reduce the waste of blood. (And also fix the venous air) Micro-bubbles !
- Remember that transfusion of any Allogeneic blood or blood products is an "Organ Transplant", and not just another medication that is without side-effects. Treat everyone like a JW !

The Perfusionist

- **Condense your Circuit Prime down safely to 1000 - 1400mls !**
- **Calculate the Post-Dilutional Hct, Protein, COP values**
- **RAP/VAP (Auto Prime) both sides of your Circuit with the help of Anesthesia and the Surgeon. This is not only proven very effective in many studies, and its $$$ economical as it costs nothing.**
- **Add Albumin / Osmitrol to Increase the COP / Diuresis of the patient.**
- **Limit the Cell Washer to the Pre and Post Heparinization periods!**
- **Use the pump's Coronary Sucker during the Heparinization period to preserve franc Autologous Whole Blood lost outside the heart inside the pericardium and return it to back to the patient's circulation.**
- **A waste sucker should be kept in the field for undesirable shed blood and irrigant solutions (or a cell washer for this as well).**



- **On-site coagulation monitoring like the thromboelastography TEG, Sonoclot and Heparin concentration determination like the Hepcon are essential tools in determining the Hemostasis.**
- **Targeted pharmacotherapy (antifibrinolytics and desmopressin acetate) are an integral part to prevent transfusions of donor allogeneic blood and blood products.**
- **Hemoconcentration should be considered for use to reverse excess fluid administration, eliminate undesirable byproducts including antiplatelet medications and concentrate the patient's red cell mass and plasma proteins during the case.**
- **Once safely off bypass Salvage the CPB circuit with Ultrafiltration so you don't waste any of the patient's OWN viable and vital blood fractions and components.**

"The Big Bang of Hemofiltration: The Beginning of a new era…"

- Selective, rapid removal of plasma water & dissolved solutes, (<50K Daltons) including drugs. i.e. Integrilin, ReoPro, Aggrestat, Plavix
- Conservation cellular blood components & proteins.
  - Hct
  - platelets & clotting factors
-
  - C3a, C4a, C5a
  - IL-1, IL-2, IL-6, IL-8,
  - TNFα, TNFβ
  - MDF, bradykinins
- Improves organ fx
  - myocardial fx
  - cerebral oxygenation
  - pulmonary compliance
- Reduces post-op blood loss & transfusions
- ***Removes platelet-activating factor***

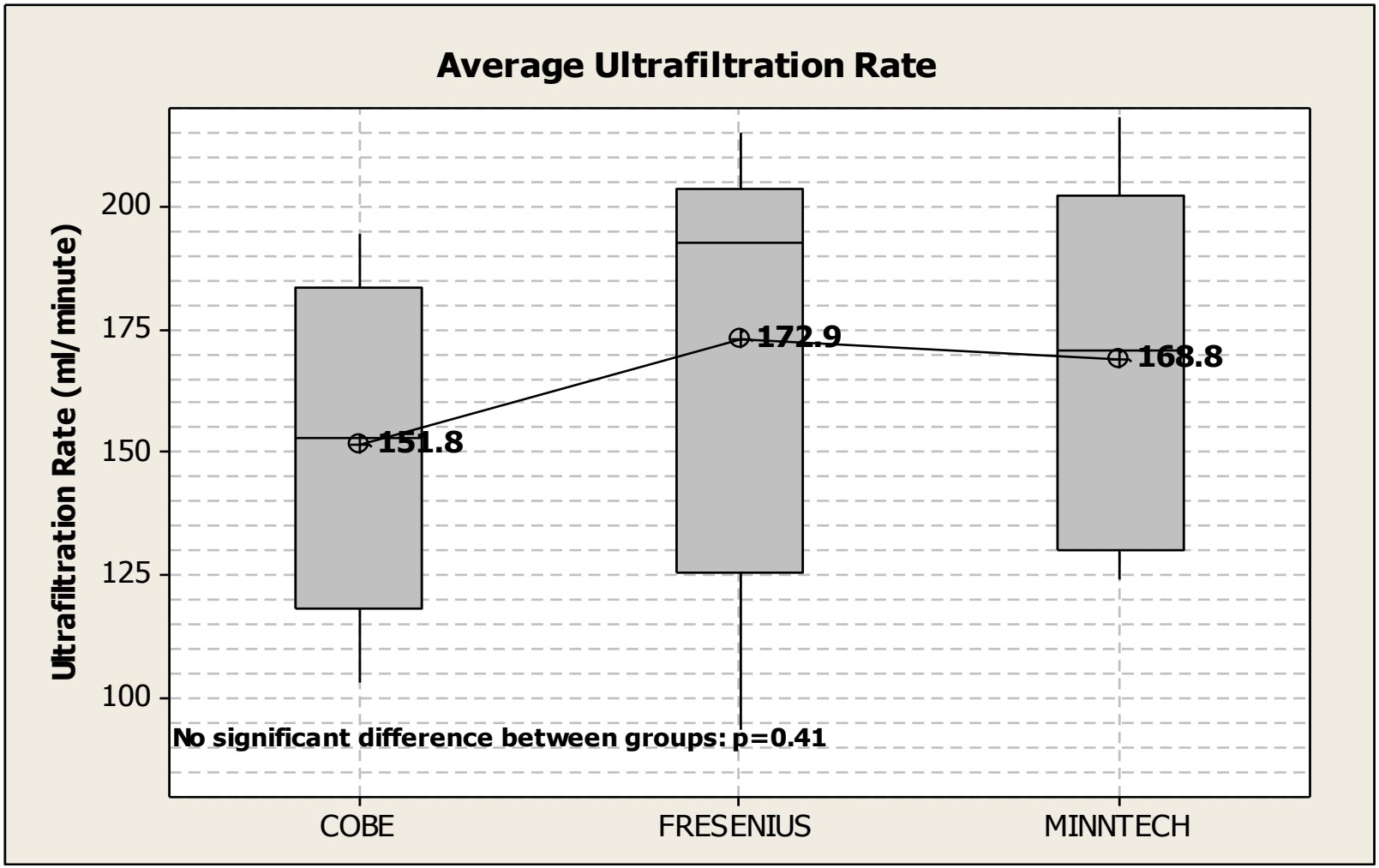
Critical Care Medicine. 23(1):99-107, January 1995

tics for the
d retention.

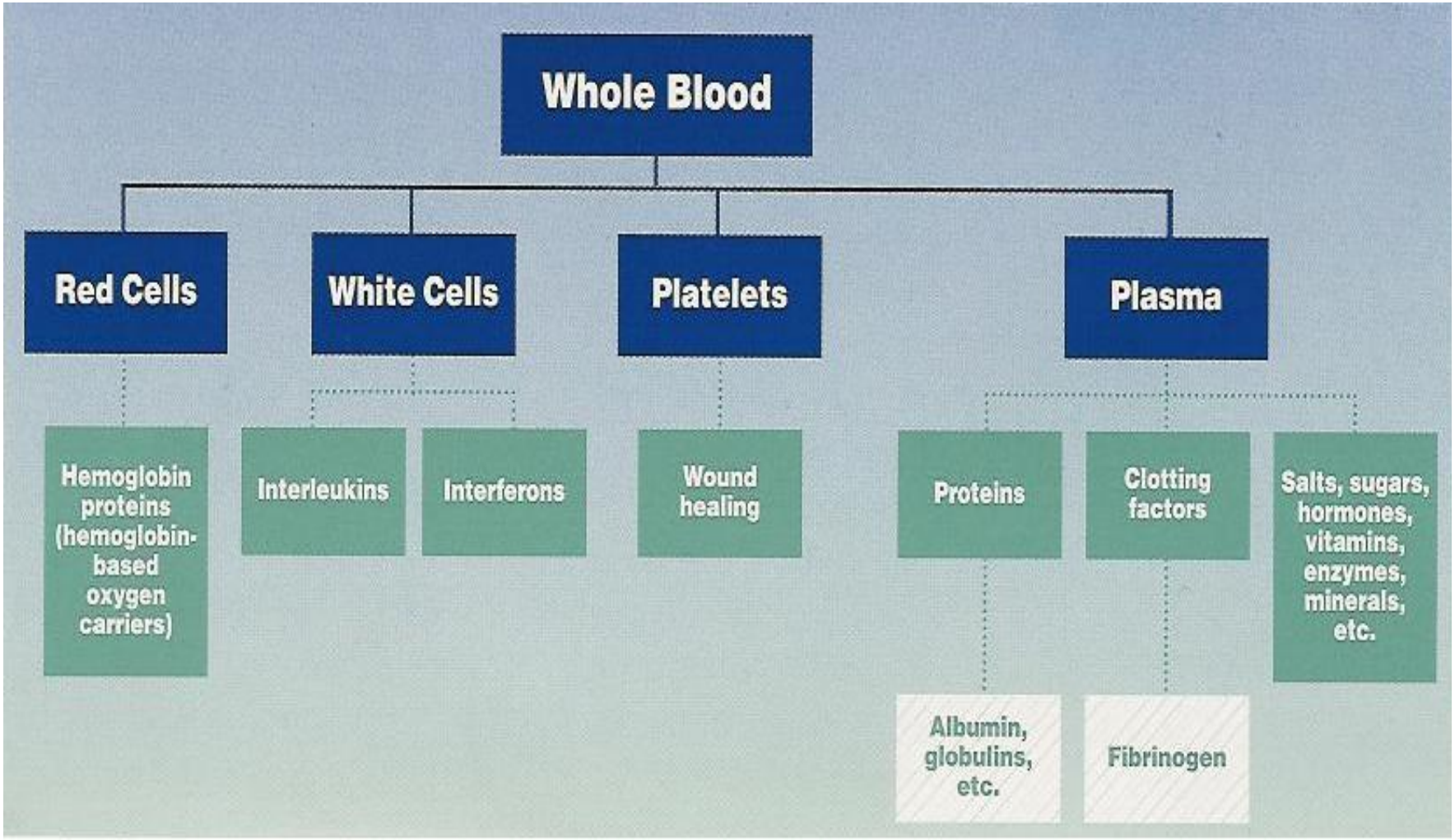
"…platelets having the aggregation activity still exist in residual blood in the CPB circuit."

Naik, 1991, Hospital for the Sick, Great Ormond St. UK.
Luciani, 2001, MUF reduces morbidity after adult cardiac operations. A prospective, randomized clinical trial.
Tanemoto, 2004, Platelet activity of residual blood remained in the cardiopulmonary bypass circuit after cardiac surgery

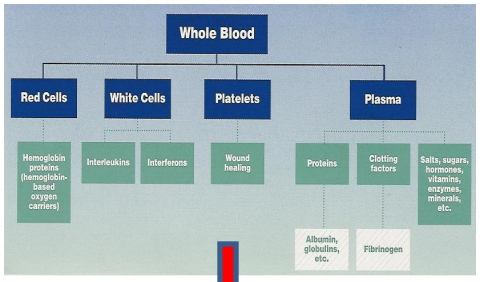
Average Ultrafiltration Rate of the 3 H/C's



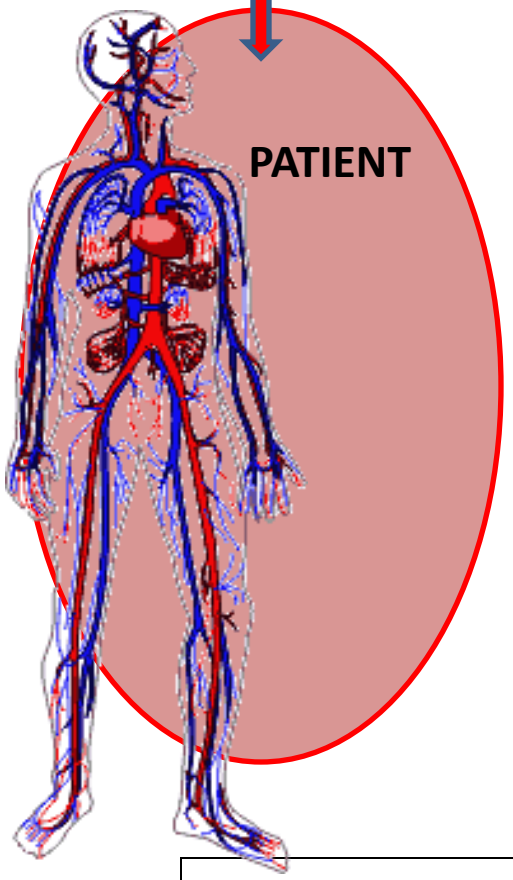
The Big Picture about Whole Blood

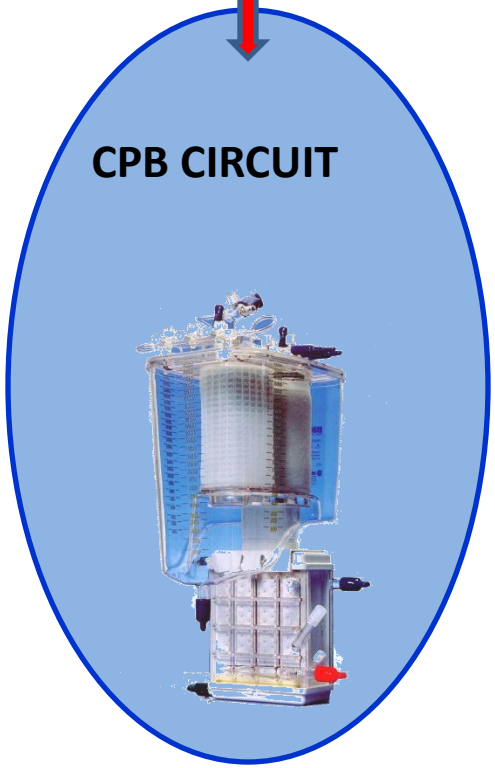


Choices/ Alternatives Publication Vol 4 Issue 2, Center for Bloodless Medicine and Surgery, University of Miami / Jackson Med Ctr.



Priming Volume Generally Crystalloid Fluid

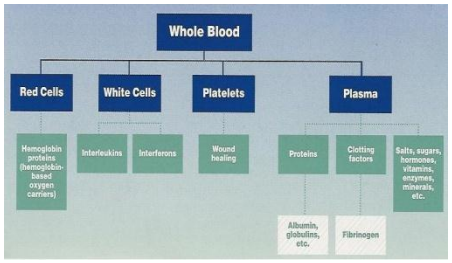


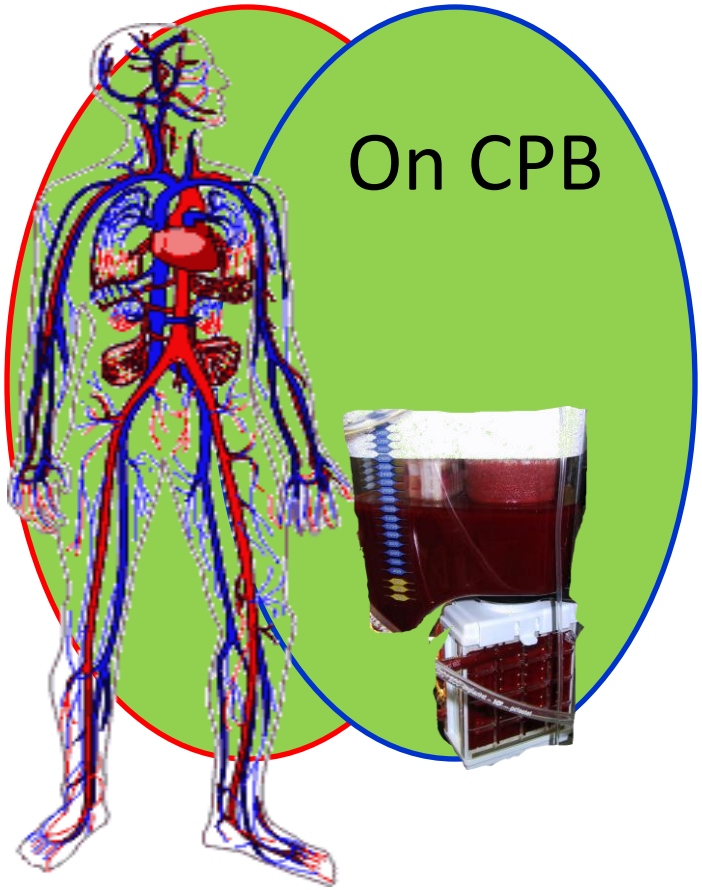


2 <u>Separate</u> Circuits

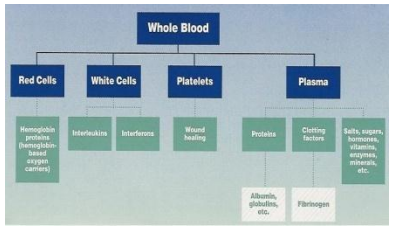
with

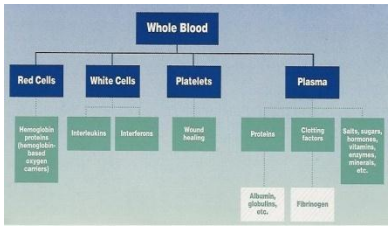
2 <u>Different</u> Volume Types





Now Only 1 (ONE) Circuit
with the
Same Volume Type





PATIENT
Once
Disconnected
from CPB

CPB CIRCUIT
Once
Disconnected
from the
PATIENT
Primed with
Whole Blood

2 Separate Circuits Now
with
Exactly the Same Blood (No Difference!)

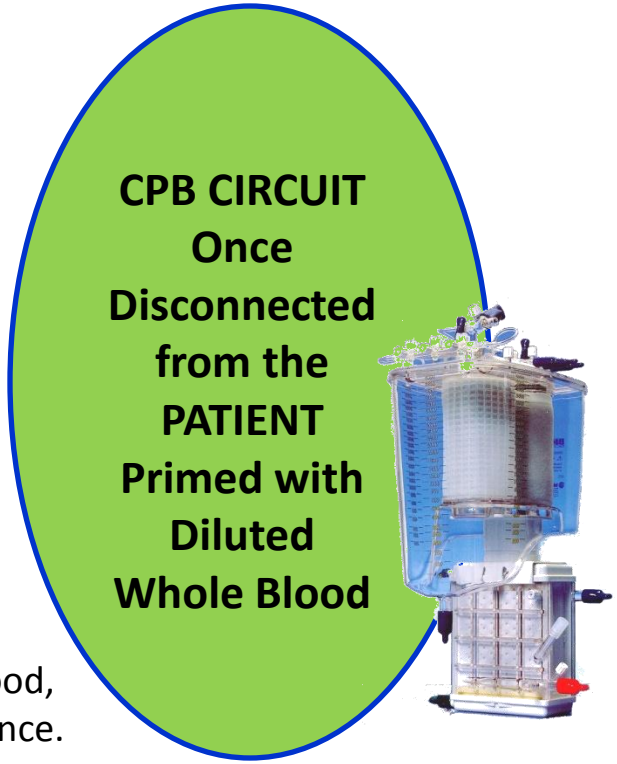
Processing Residual CPB Circuit Whole Blood

How You Process this Blood Changes Outcomes

Fluid overload is an independent predictor of mortality

Three re-infusion methods

- **Direct**
- **Cell-Wash**
- **Ultrafiltration**



Fluid Shifts in Microcirculation, COP, Lymphatic's and Organ Edema are the “New Frontier" for Improving Patient Outcomes by Teams in Cardiac Surgery, along with Hemostasis when dealing with diluted blood, Plasma Volume Contraction and pushing Renal Function for fluid balance. Fluid overload is an independent predictor of Mortality in Cardiac Surgical patients as well as an indirect Trigger for Transfusions, which carries it’s own Evidence for Morbidity and Mortality.

Processing Residual Circuit Whole Blood

Three re-infusion methods

- Direct *Ann Thorac Surg*. 1993;56(4):938-43.
- Cell-Wash *JECT*. 1996;28(3):134-9.
- Ultrafiltration *Perfusion*. 2005;20(6):343-9.

Final Infusion Volume Contents

Technique Volume cc	% HCT	Plt Cnt 10^9/L	[Fib] mg/dL	% Clot Factors
Direct 700-1800+	17-25	50-140	80-135	15-40
Cell-wash 225-450	40-58	5-25	10-30	2-10
Ultrafiltration 450-1000	45-55	125-325	225-385	85-259

Note: 90 percent confidence limits for pre-protamine infusion volumes and blood component values
(*Proc Amer Soc Extra Corpor Technol.* 2006)

Hemobag®
www.mybloodfirst.com/
J Extra Corpor Technol. 2004;36(2):162-5.

Ideal End Product Given Back to the Patient !

- High HCT
- High Albumin
- High Total Protein
- High Platelets
- Normal Electrolytes
- Very High Fibrinogen
- 8-10 Minute Procedure
- Keeps the CPB Circuit **Safety primed for Security**
- All Autologous Cells are returned to the patient!

Improved Coagulation

- (Example of typical results in when ECC is returned with UF)

	PRE-OP	INTRA-OP	POST- INFUSION
HCT	35%	25%	33%
PT	9.9 sec.	⬆	11.2 sec
PTT	27 sec	⬆	34 sec
INR	1.0	⬆	1.1
ACT	155 sec	594 sec	142 sec
PLT. COUNT 276,000		⬇ ⬇	241,000 (Functional)

Typically the Total 24 hour Chest Tube Drainage is **100**- **300 ml**s of Serous Fluid

Patients are discharged with No Blood Products and No Complications.

Is This a Good Idea?

THIS TECHNIQUE WILL DISCARD THE PLASMA BLOOD CONSTITUENTS

ATS Waste Calculator (JECT 2007)

On-Line Autotransfusion Waste Calculator

Jeffrey B. Riley, MHPE, CCT;* Keith A. Samolyk, BS, CCP, LCP†

*Circulation Technology Division, School of Allied Medical Professions, The Ohio State University, Columbus, Ohio; and †Global Blood Resources LLC, Somers, Connecticut

Presented as a poster at the 45th International Conference of the American Society of Extra-Corporeal Technology, Atlanta, Georgia, April 26, 2007.

Abstract: Cell concentrating and washing techniques are widely accepted and believed to be beneficial to cardiac surgery patients. During cell processing, platelets, proteins, and clotting factors are wasted as the plasma is washed away by saline. Beneficial and costly plasma constituents are sacrificed for the sake of removing potentially harmful drugs, debris, and naturally activated cells and chemical mediators. An interactive Microsoft Excel spreadsheet was designed to input patient and autotransfusion system (ATS) reservoir blood values, processed centrifugal bowl data, and hospital allogeneic blood product concentration and cost information. The spreadsheet calculates the number of wasted platelets, grams of protein, and milligrams of fibrinogen. The calculator further estimates the number of units and cost of allogeneic blood products needed to replace the wasted blood components. The simulation allows for variable levels of platelet activation and protein removal during centrifugal cell processing. Specific case scenarios may be simulated with the calculator. If a known volume of residual extracorporeal circuit blood with a known hematocrit, platelet count, and protein concentration is diverted to the ATS reservoir to be processed and washed after bypass, the number of units of fresh frozen plasma, platelet packs, and albumin concentrate needed to replace the wasted proteins and platelets may be calculated. When typical end-bypass patient and blood bank product values are input, the cost to replace the wasted blood components in 1550 mL of residual circuit blood with allogeneic blood products is about US $2097. There are risks and costs associated with replacing the platelets, proteins, and clotting factors wasted during cell washing compared with other techniques such as whole blood ultrafiltration. **Keywords:** cell processor, autotransfusion, cell washing, hemofiltration, ultrafiltration, Internet, ethics, blood salvaging, blood management. *JECT 2007;40:68–73*

ATS Waste Cost Estimator for Residual CPB Circuit Volume

Patient's ECC Values

Hematocrit %	25	1
Platelet count K/mm³	140	2
Protein gm/dL	4	3
Fibrinogen mg/dL	120	4

ATS Blood Reservoir

Reservoir volume cc	2,000	5
Irrigant cc	0	6
Heparinized saline cc	0	7
Patient's shed blood cc	2000	8

RBC Mass

RBC Mass to process cc	500	9
Plasma mass cc	1,500	10

ATS Bowl

Bowl volume cc	225	11
Bowl hematocrit %	55	12
Processed bowls #	4.0	13
Anesthesia pRBC cc	909	14

ATS Waste Components

Platelet activation %	25	15
Wasted platelets M	210.0	16
Protein removal %	90	17
Wasted fibrinogen mg	2,160	18
Wasted protein gm	70	19

Allogeneic Platelet Packs

Platelet volume cc	75	20
Platelet K/mm³	300	21
Platelet M	22.50	22
Cost $	200	23

Allogeneic FFP

FFP volume cc	125	24
Fibrinogen mg/dL	275	25
Fibrinogen mg	343.75	26
Cost $	175	27

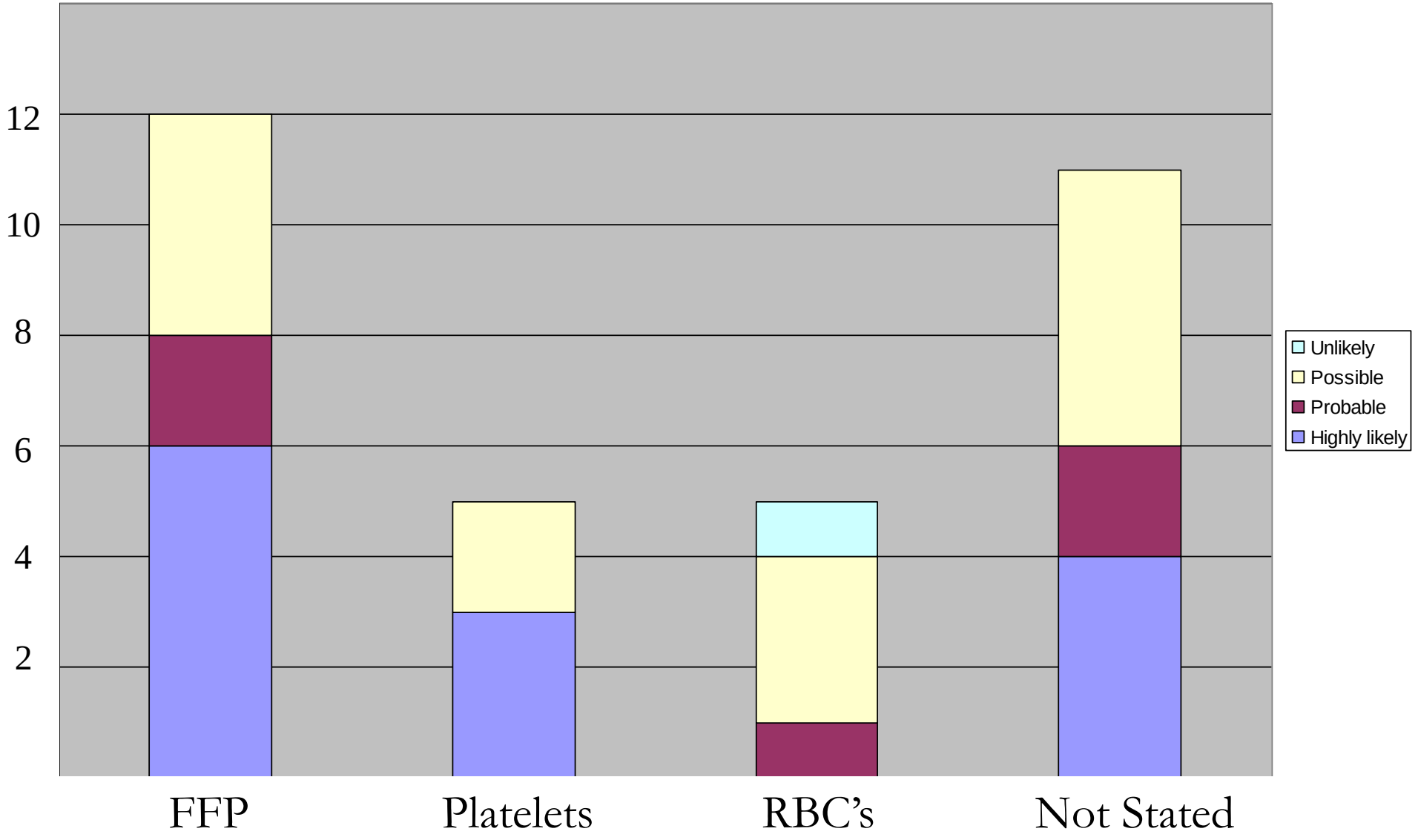
Protein Substitute

Protein volume cc	50	28
Protein conc %	25	29
Protein gm	12.5	30
Cost $	225	31

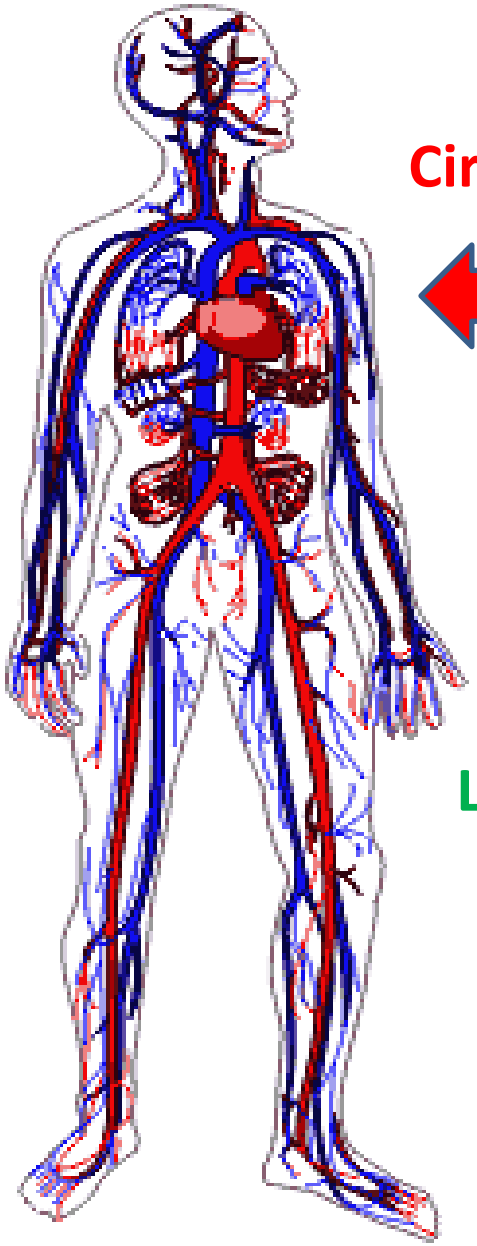
ATS Waste Replacement Cost

Platelets packs	9.3	32
Platelets $	$1,867	33
FFP units	6.3	34
Fibrinogen $	$1,100	35
Protein vials	5.6	36
Protein $	$1,257	37
Total replacement $	$4,223	38

Products Implicated in TRALI, including likelihood of each case being TRALI

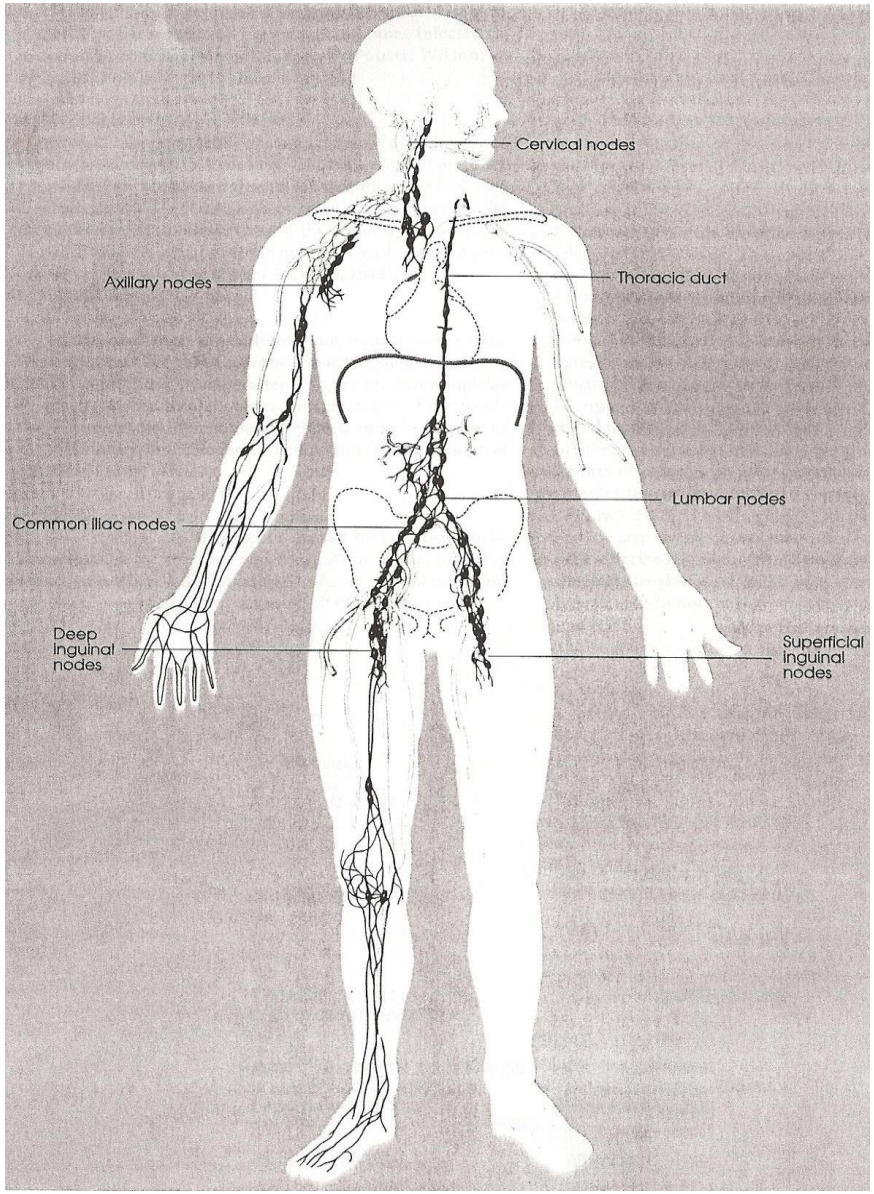


Fluid Volume Management

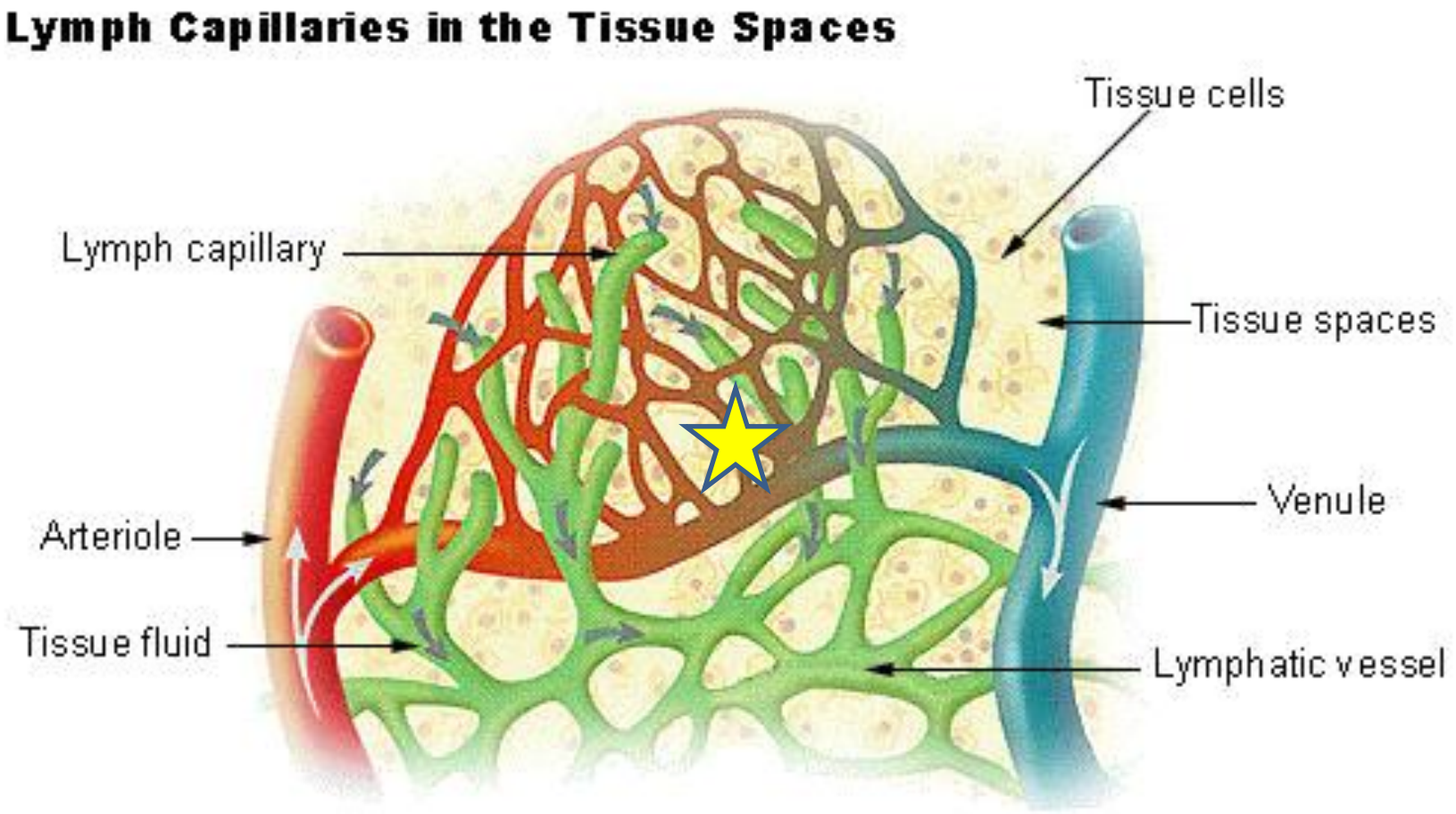


Circulation

Lymphatics



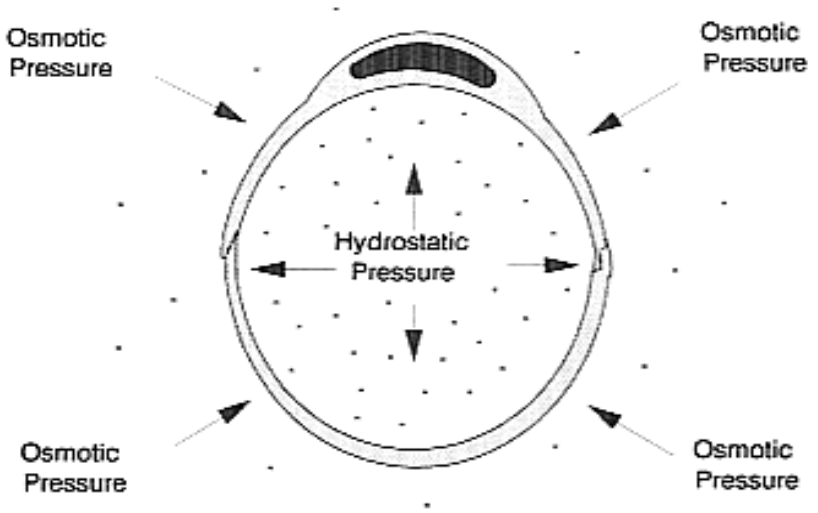
The “Epicenter” of Fluid Balance



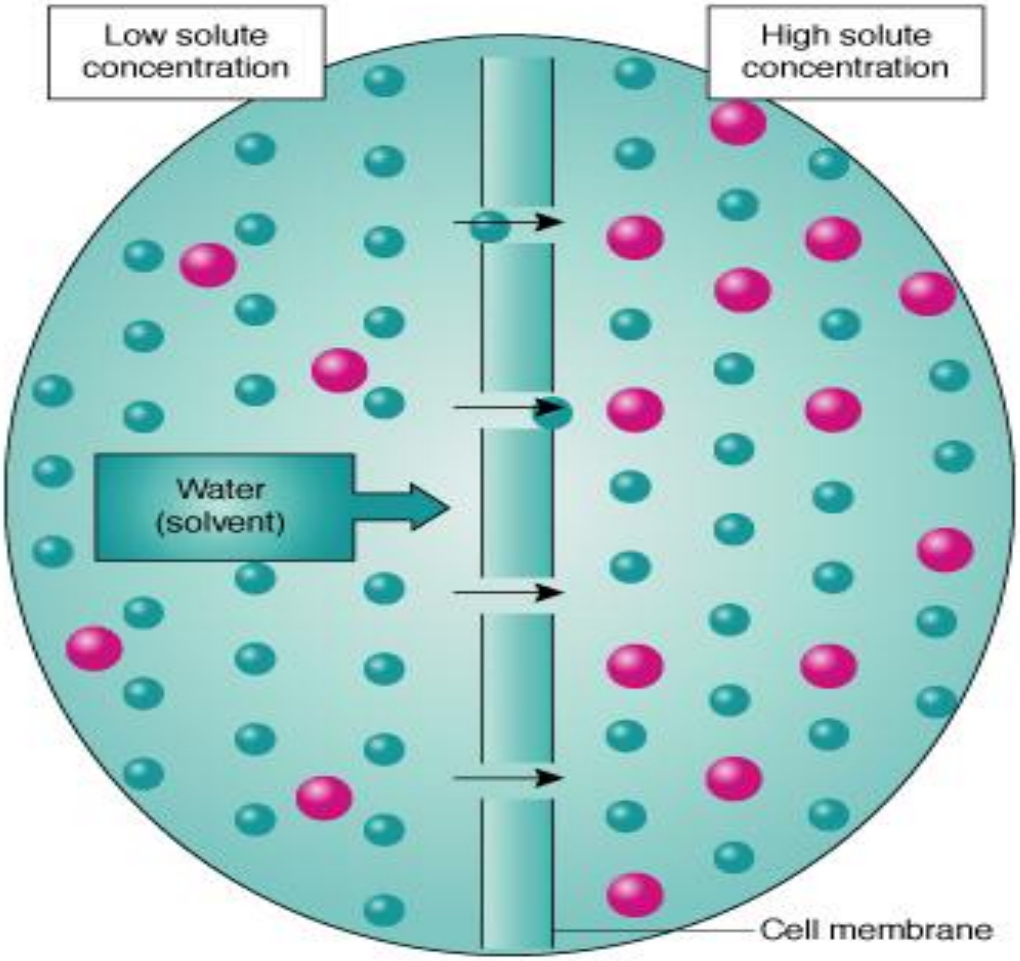
STARLINGS LAW

E. H. STARLING Jodrell Professor of Physiology
University College, London 1899-1923

$$F \propto (P_c - P_{if}) - (\pi_{pl} - \pi_{if})$$



Fluid Movement Between Compartments



FLUID MOVEMENT BETWEEN IVC AND ISC DUE TO HP & COP

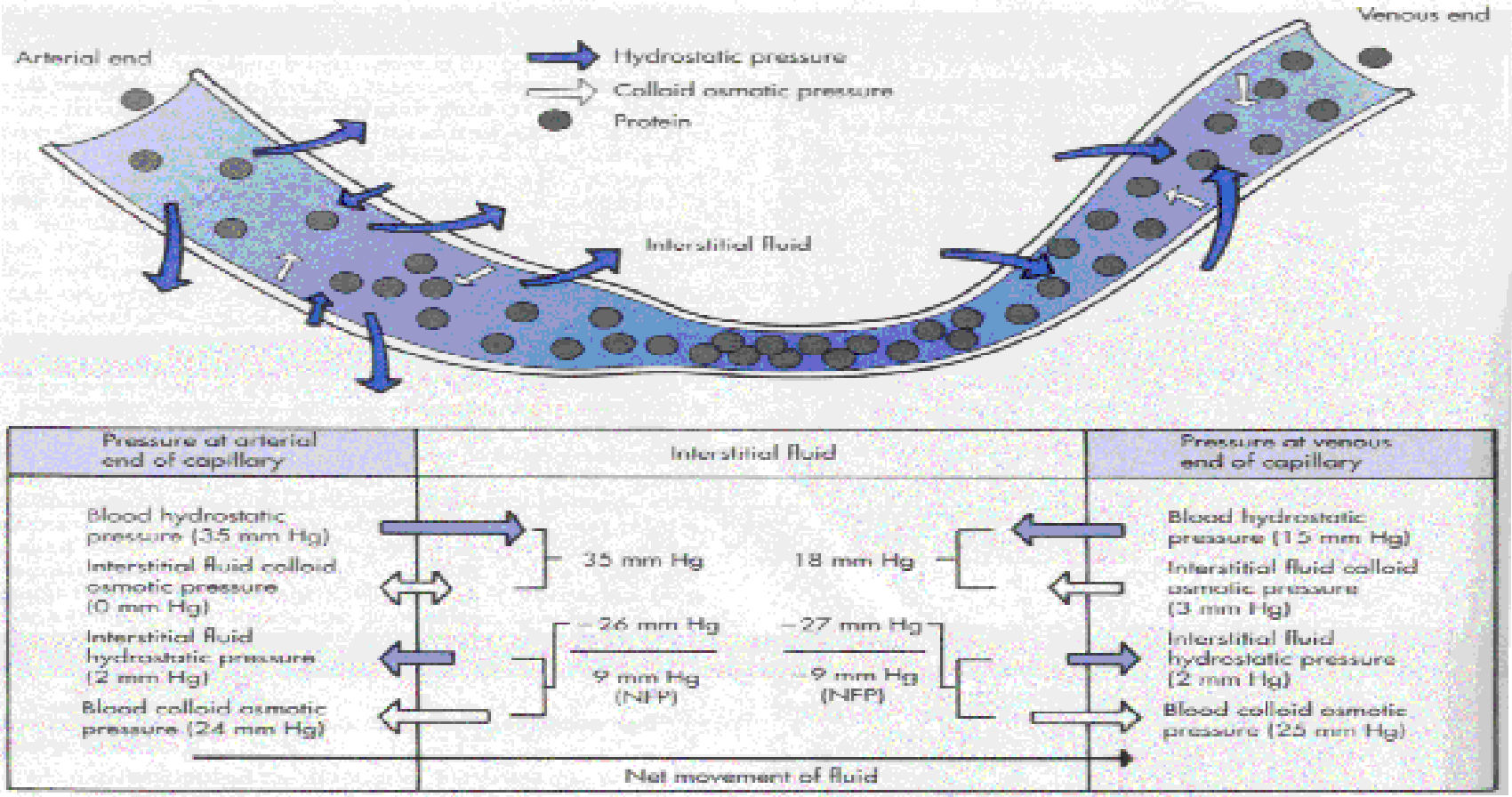
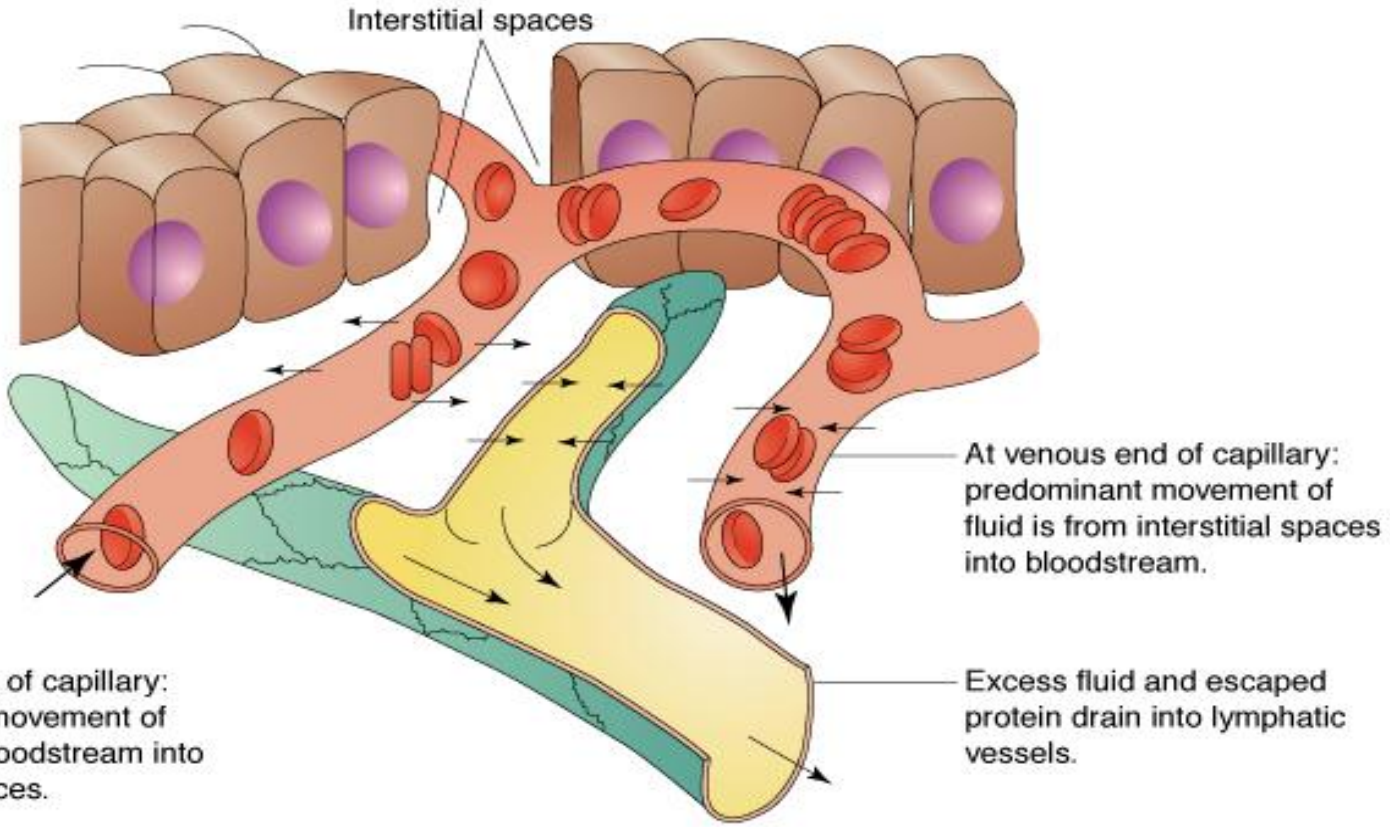


FIG. 4-2 Movement of fluids and electrolytes between plasma and interstitial fluid caused by hydrostatic and colloid osmotic pressure.

How Microcirculation Works

Vascular → Interstitial → Lymphatic



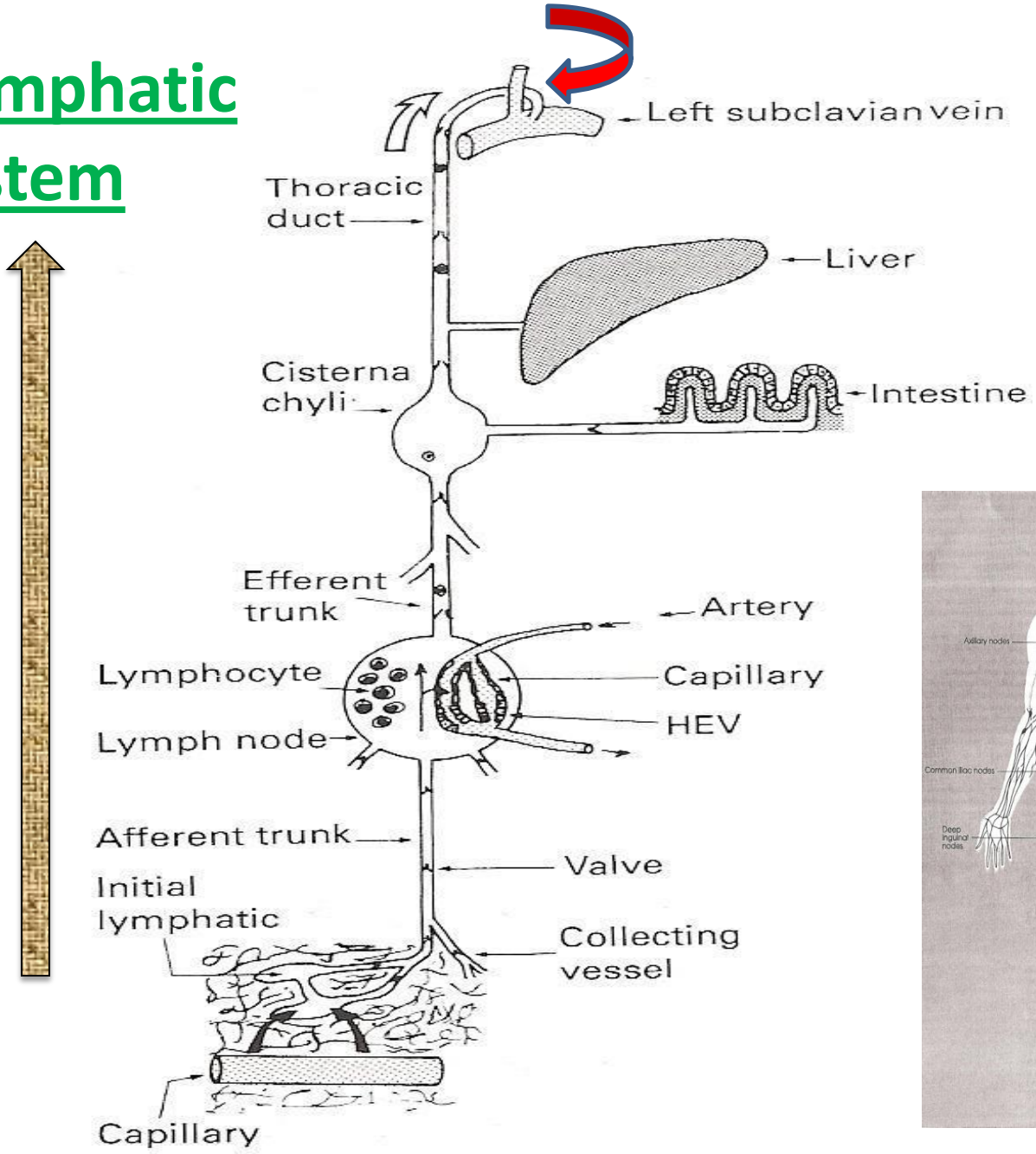
The Lymphatic System

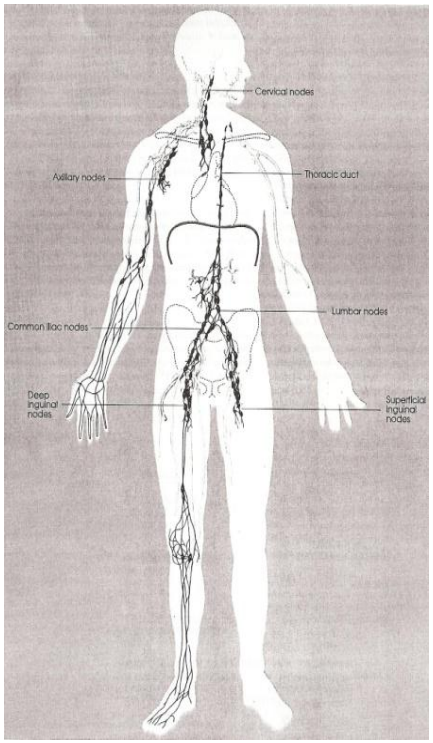
Is a network of conduits that carry a clear fluid called lymph. It also includes the lymphoid tissue that the lymph travels through. Lymphoid tissue is found in many organs, particularly the lymph nodes, and in the lymphoid follicles associated with the digestive system such as the tonsils. The system also includes all the structures dedicated to the circulation and production of lymphocytes, which includes the spleen, thymus, bone marrow and the lymphoid tissue associated with the digestive system.

The dissolved constituents of the blood do not directly come in contact with the cells and tissues in the body, but first enter the interstitial fluid, and then the cells of the body. Lymph is the fluid that is formed when interstitial fluid enters the conduits of the lymphatic system. **The lymph is not pumped through the body like blood, it is moved predominately by the contractions and movements of skeletal muscles**

The lymphatic system has three interrelated functions. It is responsible for the removal of interstitial fluid from tissues. It absorbs and transports fatty acids and fats as chyle to the circulatory system. **The last function of the lymphatic system is the production of immune cells, such as lymphocytes, including antibody & producing monocytes.** Diseases and dysfunction/obstruction of the lymphatic system can cause swelling , **edema** and other symptoms. Problems with the system can impair the body's ability to fight.

The Lymphatic System

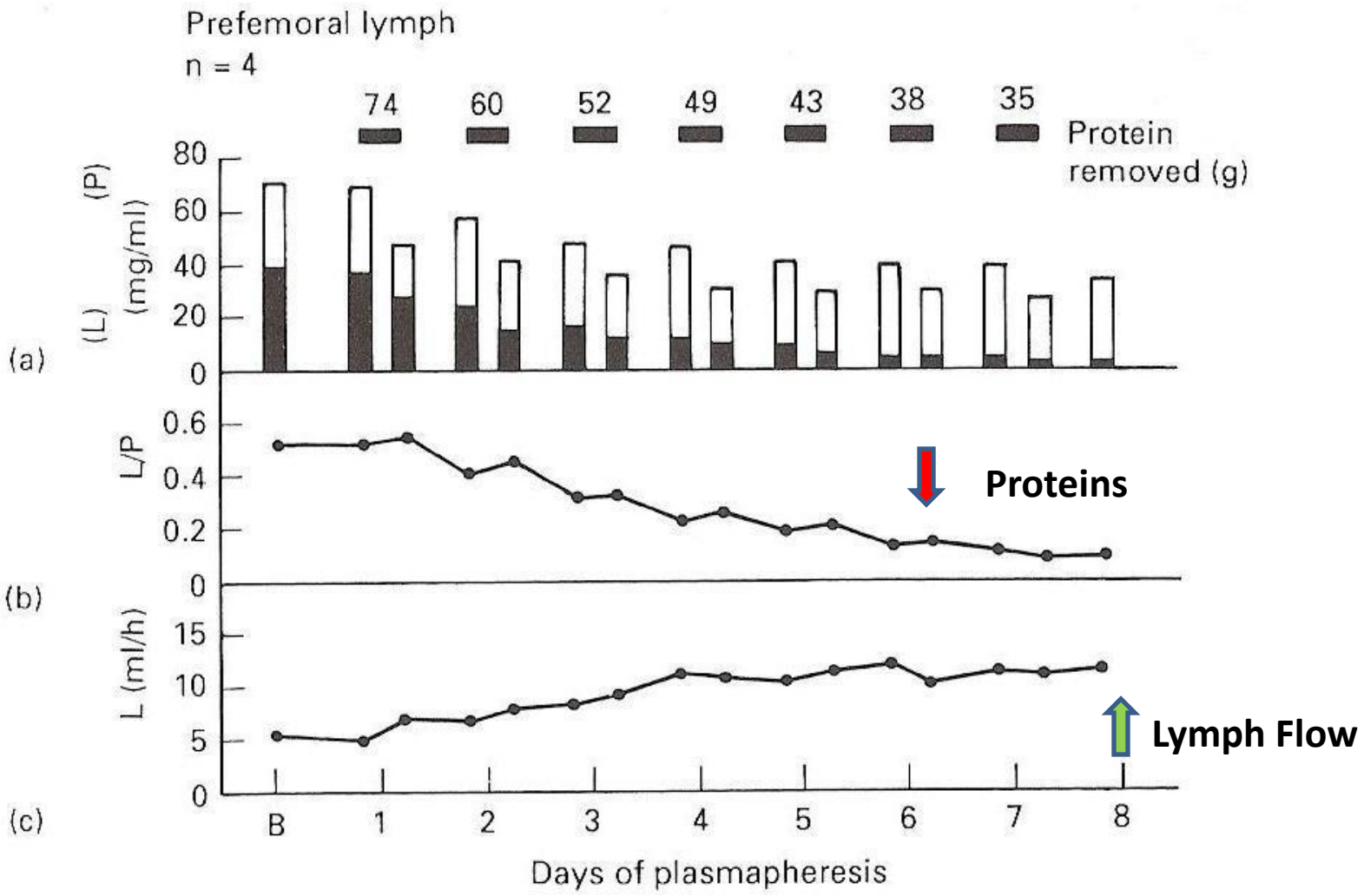




Plasma Protein Effects on Total Colloid Osmotic Pressure (COP)

Albumin	4.5	21.8	**78**
Globulins	2.5	6.0	21
Fibrinogen	0.3	0.2	1
Total	7.3	28.0	100

The Loss of Protein and Lymphatic Flow



Edema: Most common clinical manifestation of an Imbalance of forces at the capillary wall

Excess accumulation of fluid in the interstitial space that has not been readsorbed into capillaries or taken up by the lymphatics

Causes include

- **Obstruction**
- **Permeability** or change in reflection coefficient

  Increased protein permeability results in an imbalance

  – Occurs in trauma, thermal injury, inflammation

  – Life threatening manifestations - endotoxic shock, ARDS

- **Plasma Protein**

  – Reduction in circulating plasma proteins, especially albumin!

  – Liver dysfunction, malnutrition, or acute alteration of fluid status

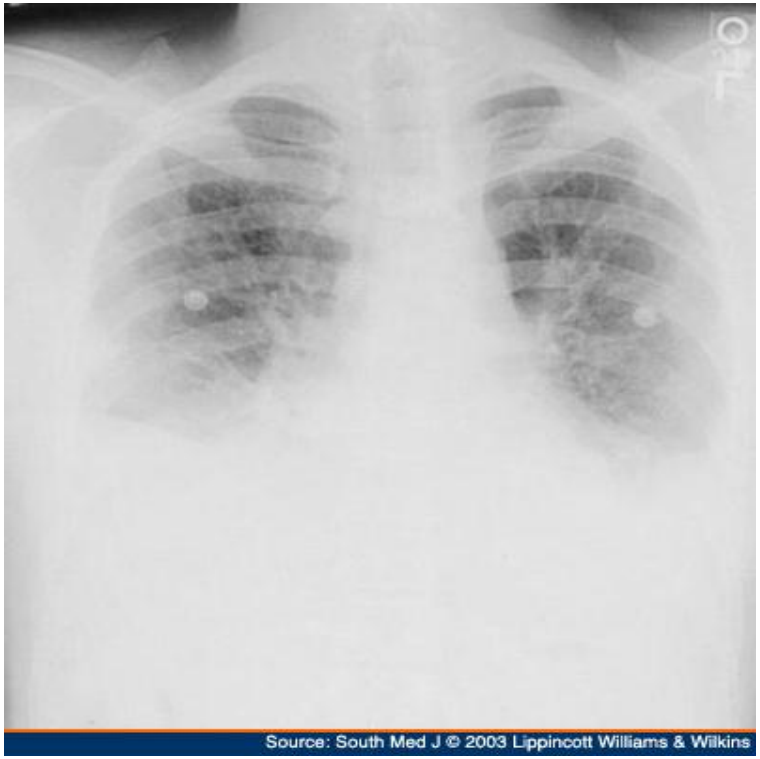
    - **Albumin attenuates extravasation of fluid out of intravascular space to interstitial space**

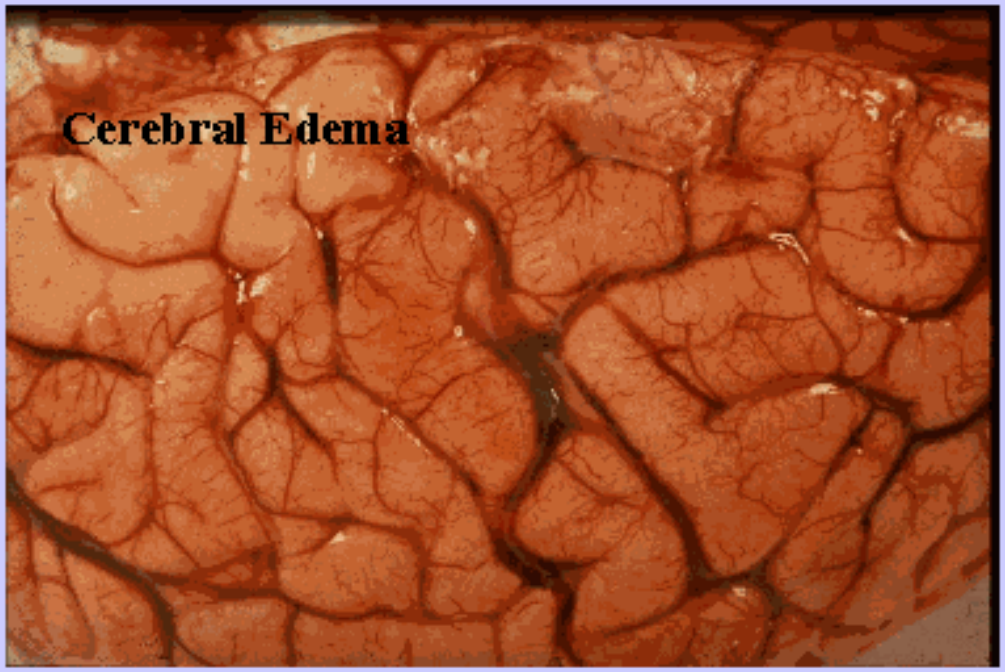
- **Capillary pressure**

Hypoalbuminemia leads to 3rd spacing "Anasarca"

…may cause generalized edema (swelling) via a decrease in oncotic pressure. Levels below 3.5 grams per deciliter are generally considered dangerous.

50 mL of 25% I.V. Albumin draws approximately 175 mL of additional fluid into the circulation within 15 minutes





Perfusionists can reverse the Fluid Shifts that cause 3rd Spacing from Hemodilution & CPB and optimize the Pt's RCM, so that allogeneic blood products to treat a Dilutional Anemia and a Dilutional Coagulopathy can be minimized.

ALBUMIN

Mannitol

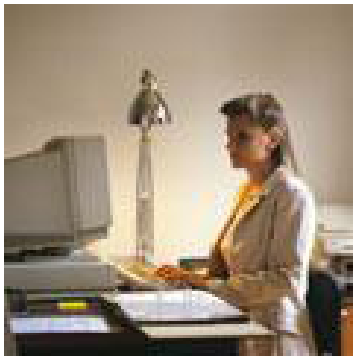
LASIX

HEMOCONCENTRATORS

Perfusion Tools

POST-OP
Nurses & The ICU Care Team

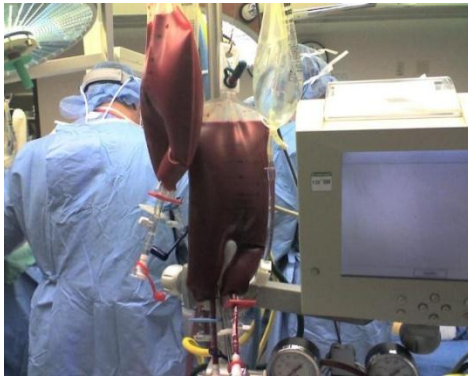
- Maintain Normothermia
- Micro-sampling as little as possible
  - Rely on Oximetry instead of draws
- Careful and judicious use of volume as needed
- Pressors instead of volume
- Colloids instead of crystalloids
- Diuretics if necessary
- Extubate ASAP !
- No “Drive-by Transfusions” from on-call staff !



Hospital Administrators

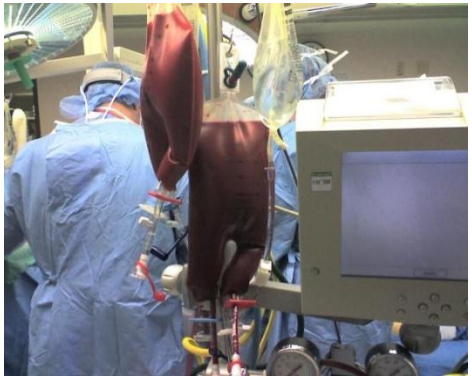
- **Get to know them on a personal basis**
- **Suggest the benefits of a Blood Mgmt Prgm**
- **Get them involved !**
- Look at using Consultants: Infonale', **HemoConcepts, Strategic Blood Mgmt.**
- **Encourage trials of New Equipment / Drugs**
- **Find a Champion for Blood Management !**
- **Show them the facts in $$$ savings for all!**

Other Things You can Do!



- Join AmSECT & get involved with the PBM Taskforce
- Take the PBM T/S exam & be a leader in your Hospital.
- Join the AABB, SABM, NATA or PNBC
  - These are finely tuned international organizations solely focused on better blood management and improved care!
- Surf the web & read current articles and share them with other members of the cardiac team (print, leave around)
- Get on your Hospital's Transfusion Practices committee and make a difference (Go to the monthly meetings).
- Find and support a Champion MD who wants to change the paradigms of Tx's in your hospital's Cardiac team.
- Work as a team that's focused on improvement of care!

More Things You can Do!



- Visit these sites and learn more!
  - NoBlood.org
  - Bloodless Medicine Research (Univ of Pisa)
  - SABM (Society for the Advancement of Blood Mngmt)
  - NATA (Network for Advancement of Tx Alternatives)
  - PNBC (Physicians & Nurses for Blood Conservation)
  - Medical Society for Blood Management
  - Strategic Blood Management
  - Mybloodfirst.com (Excellent site for Perfusionists)
- Get Involved and Change the Paradigm of Blood Use!

The Bottom Line is Always the Truth!

- Life is related to blood and anything you can do to save more of a patient's Own Whole Blood is better than anything else … Period !

- Patients transfused with allogeneic blood products are exposed to a host of new potential complications **The Current Data is Undeniable esp in CT Surgery**
  - No one is exempt from resultant Immunosuppression
  - The least of these is a mild form of TRALI which leads to
    - **longer and delayed time to extubation & discharge from the ICU**
    - **Increased risk of Morbidity and Mortality both Short and Long Term**

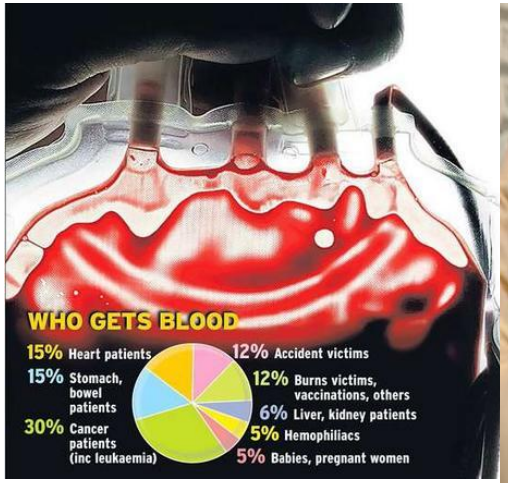
- **Autologous whole blood is Jugular for perfect natural Homeostasis**
  - We should be doing **everything we can to conserve all of this precious substance** with all the cells and fractions still intact and not discard or waste any of it!

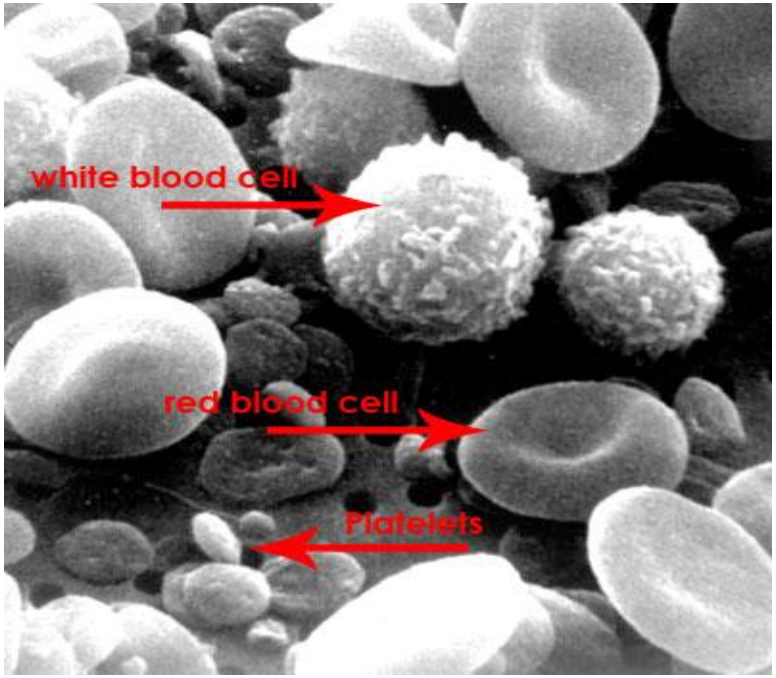
    "Every drop of blood counts"
  - Avoiding unneeded transfusions saves costs and prevents unnecessary side effects
- **It's in the Patient's Best Interest and It's the Right of all Patients!**

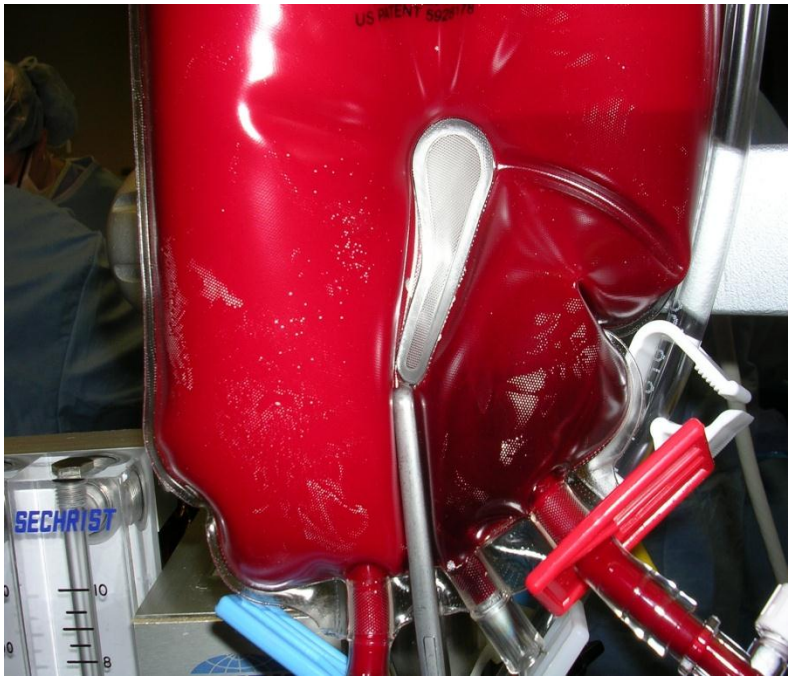
But most Importantly remember!

“If its not yours its an Organ Transplant” with consequences, so try and do your best to avoid it!

Your decisions effect the patient for the rest of their life!







Thank you for your time!

Questions?