


### Update on Blood Component Therapy in Anesthesia



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### Recent Developments in Blood Transfusion

- RBC Therapy
  - Age of RBCs vs Complications
  - RBC-centered Perioperative Algorithms
- Non-RBC Component Therapy
  - Component Therapy Algorithms
  - Massive Transfusion
    - FFP:RBC ratios
    - Rebirth for Whole Blood?

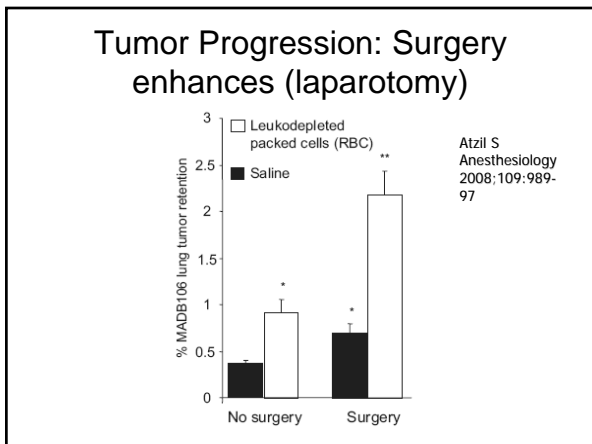
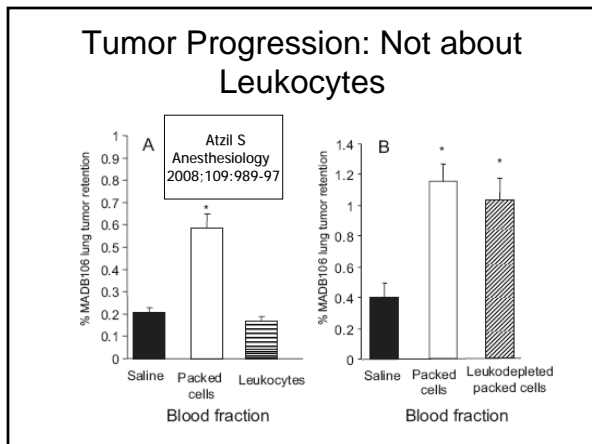
### Educational Objectives

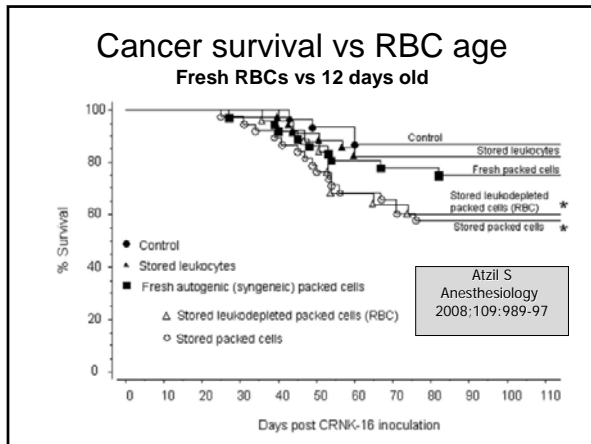
- Understand controversy about RBC storage age and Cx
- Explain patient-centered perioperative transfusion avoidance algorithms in elective surgery
- Understand differences between component Rx in Trauma vs Elective Surgery
- Explain pros/cons of Whole Blood in massive transfusion

### Cancer Progression and Transfusion

Atzil S, Anesthesiology 2008;109:989-97

- Rat cancer model
- Transfuse rats with various ages of RBCs, leukocyte-reduced RBCs, and leukocytes
- Inject a marked tumor that targets lung, sacrifice rats, and assess tumor cell retention as a function of component transfused
- Assess survival as a function of component transfused





THE NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

### Duration of Red-Cell Storage and Complications after Cardiac Surgery

Colleen Gorman Koch, M.D., Liang Li, Ph.D., Daniel I. Sessler, M.D., Priscilla Figueroa, M.D., Gerald A. Hoeltge, M.D., Tomislav Mihaljevic, M.D., and Eugene H. Blackstone, M.D.

### RBC Age and Outcome

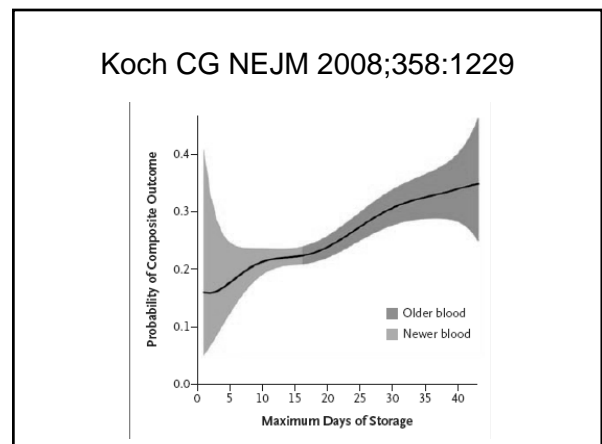
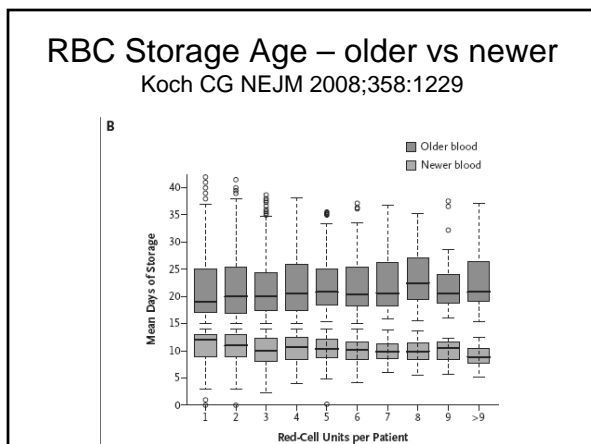
Koch CG NEJM 2008;358:1229

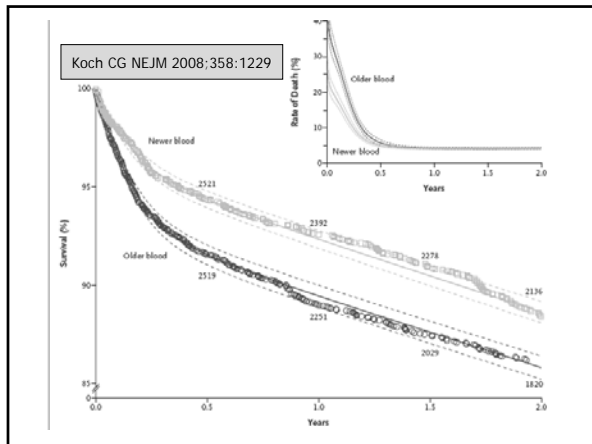
- Retrospective, CABGs and Valves, 1998-2006
- Comparison: <14 days vs >14 days
  - <14 D: 2872 Pts, 8802 U RBCs
  - >14 D: 3130 Pts, 10782 U RBCs
- Outcomes adjusted for comorbidity, multivariable anal. and propensity scores used on all baseline variables, Kaplan-Meier M&M curves generated

### Outcomes Assessed

Koch CG NEJM 2008;358:1229

- Primary outcomes assessed: Death, MI, asystole, V.tach/fib., tamponade, dissection, renal failure, sepsis, resp. insuffic., prolonged vent., PE, pneumonia, CVA, coma, wound infec., MOF, limb ischemia





### Authors' comments

Koch CG NEJM 2008;358:1229

- Previous studies show ND: but could not get separation between “age” groups – continuous variable with regression anal.
- Possible mechanisms: Reduced RBC function/viability/deformability, decreased 2,3 DPG, decreased NO, accum of proinflammatory substances
- No formal recommendation to decrease storage age: decrease transfusion (editorial also)

### RBC Age: Blood Banker's Response

Dzik W, Transf Med 2008;18:260-5

- RBC shelf life is based on radiolabelled RBC survival post-tsfm: based on RBC **presence** rather than function
  - (So findings could make sense in that context)
- No correction for multiple testing – if used standard correction for 20 comparisons (conservative?), only prolonged vent. support remains significant

### RBC Age: Blood Banker's Response

Dzik W, Transf Med 2008;18:260-5

Were the groups comparable? Older blood group had

- Lower LVEF (58 v 63%), greater incidence MR (67% v 64%) and PVD (58 v 54%), higher percentage of leukoreduced blood (suggests more recent surgery, possibly higher risk group)
- [Are these enough to make a difference? Debatable]

### RBC Age: Blood Banker's Response

Dzik W, Transf Med 2008;18:260-5

And also

- Koch's K-M curve was not adjusted for the propensity/ multivariate analysis: exaggerates difference
- Says the cutoff @ 14 days is arbitrary, favors a three-group comparison or a <10 D to >30 D comparison to assess extremes


### RBC Age: Blood Banker's Response

Dzik W, Transf Med 2008;18:260-5

But check this out:

- Younger storage group: 53% Type O
- Older storage group: 31% Type O
- Cites study that CAD is more extensive in Type A Pts (Ketch TR, Thromb Res 2008)
- Notes that storage age of Type O is predictably less than other types *because of greater availability!*

Thrombosis Research (2008) 123, 200-209



THROMBOSIS RESEARCH

www.elsevier.com/locate/thromres

REGULAR ARTICLE

**ABO blood types: Influence on infarct size, procedural characteristics and prognosis**

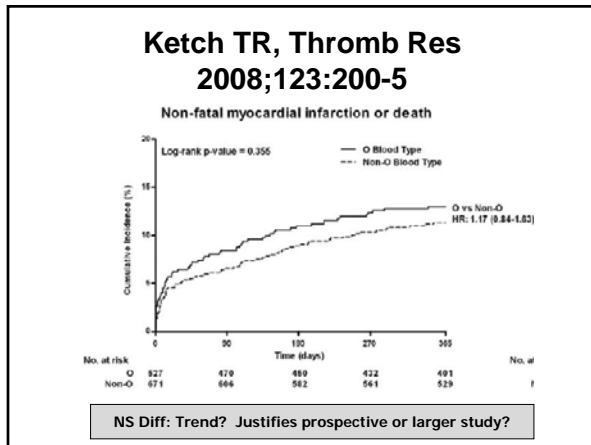
Terry R. Ketch, Samuel J. Turner, Matthew T. Sacrinty, Kevin C. Lingle, Robert J. Applegate, Michael A. Kutcher, David C. Sane\*

Cardiology Section, Wake Forest University School of Medicine, Medical Center Boulevard, Winston-Salem, NC 27157-1045, United States

Received 29 December 2007; received in revised form 29 January 2008; accepted 5 February 2008  
Available online 18 April 2008

**Ketch TR, Thromb Res 2008;123:200**

- 1198 Pts for percutaneous intervention for acute MI vs blood type: Retrospective
- Type O: Older, more hypercholesterolemia & higher incidence of previous PCIs
- Non-O: Larger infarcts, more visible thrombus pre-intervention, reduced pre-procedure flow in distribution of occluded Cor. Art.
- Type O lyses vWF better than non-O, hence possibly better spontaneous clot dissolution



What if Koch's findings are valid?

- Do you preferentially provide younger blood for cardiac surgical Pts?
  - Ethically: No can do
- Do you reduce maximum storage age for all RBCs?
  - MAJOR issue – Insufficient data to make this call as yet

**Recent Developments in Blood Transfusion**

- RBC Therapy
  - Age of RBCs vs Complications
  - RBC-centered Perioperative Algorithms
- Non-RBC Component Therapy
  - Component Therapy Algorithms
  - Massive Transfusion
    - FFP:RBC ratios
    - Rebirth for Whole Blood?

Let's take it as a given that

Transfusion avoidance is good when feasible

Many centers still overtransfuse RBCs and other components

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## Major Transfusion Predictor with surgery

# Preoperative Hct

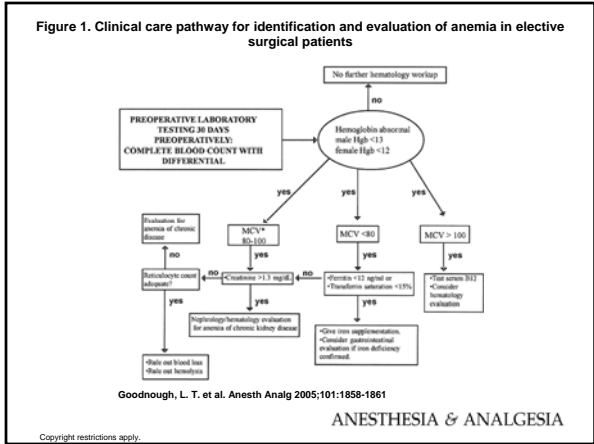
### Anemia in Elective Surgical Patient

Goodnough LT, Anesth Analg 2005;101:1858-61

- Expert panel evaluating best practices
- *Recommendation 1:* Elective surgical Pts should have Hgb level tested a minimum of 30 days before scheduled surgery
- *Recommendation 2:* Unexplained anemia should be considered secondary to some other process, and elective surgery should be deferred until an appropriate diagnosis is made

### Clinical Scenario

- Mrs Jones, 70 y/o woman with hypertension is scheduled for bilat. total knee arthroplasties. Pre-op CBC shows Hgb 10.1 (microcytic, hypochromic). Expected intra-op and post-op blood loss is 1500-2000 mL.
- What do you do?
  - What if Mrs. Jones doubles her chance of deep wound infection by having RBCs?



### Situation-specific triggers

- Most healthy people: Hgb 7/Hct 20ish
- Most sick people: Hgb 8/Hct 24ish
- Coronary artery disease: Hgb 9/Hct 28

### It's Not as Simple as a Transfusion Trigger

Consider "Patient Performance" markers:

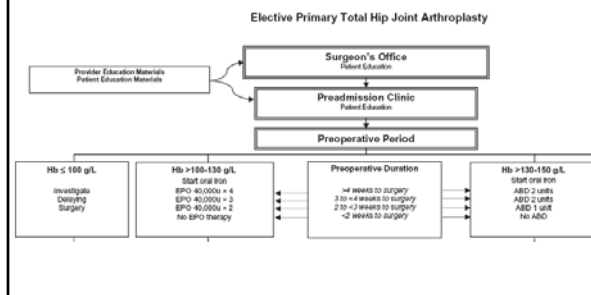
- Myocardial ischemia: ECG, TEE
- Increased susceptibility: LVH, CVD, hyperthermia/hypermotabolic states
- Evidence of global O<sub>2</sub> delivery failure: SvO<sub>2</sub>/PvO<sub>2</sub>, lactic acidosis
- Correct up for hypovolemia or high risk of sudden blood loss

### Conclusions (RBCs)

- Anemia is bad
- Transfusion is bad
- You can't win!

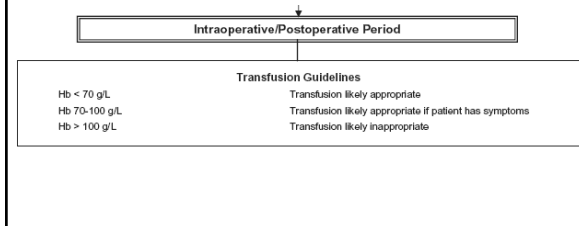
### Total Hip Periop RBC Algorithm

Wong CJ, Transfusion 2007;47:832-41



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Wong CJ, Transfusion 2007;47:832-41

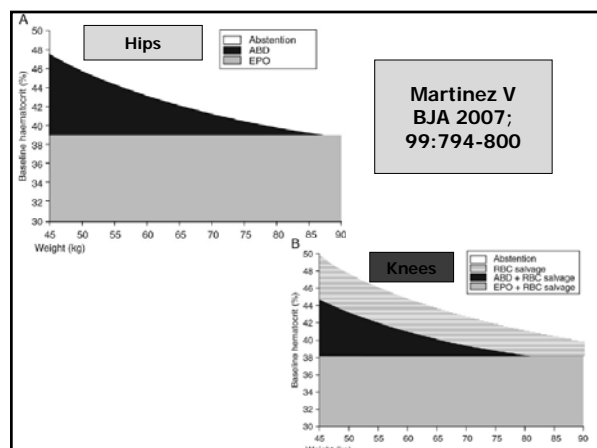


### Total Hip Periop RBC Algorithm

Wong CJ, Transfusion 2007;47:832-41

Canadian 14-Hospital consortium used protocol

- Allogeneic transfusion with protocol: 16.5% of Pts, without protocol 26.1%
- Adjusted odds ratio for transfusion outside protocol: 1.8 (1.0-3.1, P=0.037)



### After Total Joint Protocol Implementation

Martinez V, BJA 2007;99:794-800

	Initial evaluation	After implementation	P-value
All arthroplasties (n)	302	173	
Transfused patients	167 (55%)	42 (24%)*	0.0001
Autologous transfused patients	97 (32%)	20 (12%)*	0.0001
Allogeneic transfused patients	62 (21%)	22 (13%)	0.07

### Other Major Orthopedics

Slappendel R, Acta Orthop Scand 2003;74:569-75

- Periop algorithm involving expected blood loss estimation, hypothermia avoidance, Hgb assessment, selective use of pre-op Fe and Epo, selective use of autotransfusion (autologous predonation, cell salvage, hemodilution), and selective use of prophylactic aprotinin
- Reduced RBC use 80% and wound infections 40% (but retrospective)

### Other Major Orthopedics

- Calculation/use of ABL with target Hct 27-30 reduces transfused Pts 66% to 24%
  - Helm AT, J Bone Joint Surg 2003;85-B:484-9
- 1-page flow chart for intra- and post-op RBC decisions (Hgb, CAD, tachycardia, estimated volume status) decreased transfused Pts from 35% to 20%
  - Muller U, BMJ 2004;328:934-8

### Can't we do a better job for Mrs. Jones?

Anesthesiologists need to lead this effort in U.S.

Start with major elective orthopedics

### Recent Developments in Blood Transfusion

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  - Massive Transfusion
    - FFP:RBC ratios
    - Rebirth for Whole Blood?

### Blood Component Therapy Algorithms:

Application is post-CPB

Conspicuously absent:

Prospective Component Therapy Algorithm Trials in liver transplant, other major noncardiac surgery, and trauma/massive transfusion

### Blood Component Therapy

- Enormous variation despite well-published indications
- Basically locally driven:
  - Thought leaders
  - Longstanding local norms
  - [Bullies?]

### Post-CPB Component Therapy Algorithms

**Six prospective trials since 1994**

- Typically 50-100 patients each
- Comparisons involving centralized laboratory testing, POC traditional lab tests (PT, PTT, plt ct), POC TEG
- Typical findings: **Algorithm reduces FFP (5/6), Platelets (6/6)**
- Fewer RBCs in 3/6 and had less chest tube drainage in 2/6

### Original Despotis Algorithm

Original Algorithm: Despotis GJ, Transfusion 1994;34:290-6  
**[All POC tests]**

Some use of DDAVP in middle and right columns

### Modified Despotis Algorithm

Despotis GJ, Clin Chem. 1997;43:1684-96  
 Original Algorithm: Despotis GJ, Transfusion 1994;34:290-6

Adds at the top:

#### Treatment Algorithm for Microvascular Bleeding (MVB)

### Despotis Algorithm

Despotis GJ, Transfusion 1994;34:290-6

- Compared POC to central laboratory tests
- POC results < 10 min
- POC Group: Fewer RBCs and non-RBC components intra-op and post-op
- Total donor exposures 10±9 vs 27±34 (P=0.007)

### Shore-Lesserson TEG Algorithm

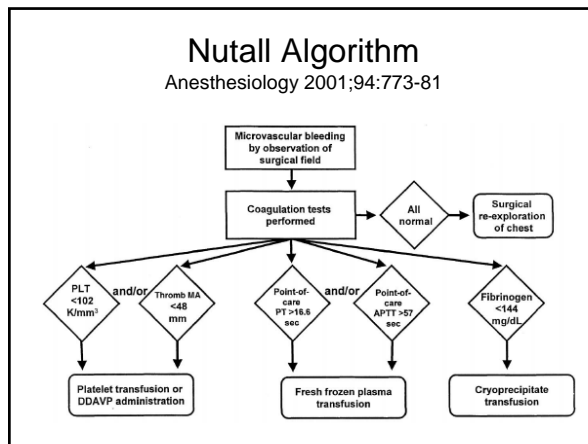
Anesth Analg 1999;88:312-9

### Shore-Lesserson Algorithm

Anesth Analg 1999;88:312-9

- 105 CPB Pts, Moderate to high risk for MVB after CPB
- TEG vs “standard therapy”

	TEG	Control
<b>RBCs</b>	22/53	31/52
<b>FFP</b>	4/53*	16/52
<b>Platelets</b>	7/53*	15/52



### Nuttall Algorithm Results

Nuttall GA, Anesthesiology 2001;94:773-81

- 92 post-CPB Pts with MVB (11% of pop<sup>n</sup>)
- Algorithm: Fewer plts and FFP units in OR, fewer plts and RBCs for entire hospitalization, lower chest tube drainage, lower re-exploration rate

- ### Transfusion Algorithms for Component Therapy
- It's not so much which you use as that you use one – there needs to be some science/discipline to choice and administration of FFP, Plts, Cryo
    - TEG alone is fine – even better with Plt Ct?
    - POC PT + Plt Ct is fine also
  - POC beats central laboratory because of speed
  - Even with POC, designated tech.-equivalent oversight is key (QA checks, consistent operators, etc.)
  - Least efficacious study started in ICU and used central lab-based tests (too late, too slow)
    - Capraro L, Acta Anaesth Scand 2001;2001;45:200-6

### Post-CPB Algorithms

Note that there was a role for DDAVP in Despotis and Nuttall studies (and another):

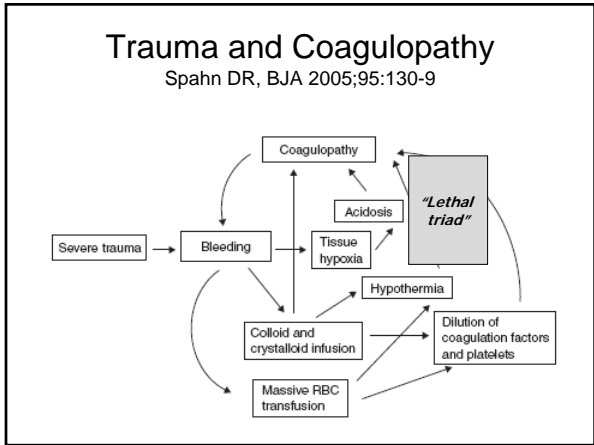
Try first for Plt Ct > 100K if reduced TEG MA (or other test showing decreased platelet function)

- ### Transfusion Algorithm Implementation
- In the words of an ex-American president, “It’s hard work.”
  - Buy-in is challenging: **Surgeons**, anesthesiologists, clinical lab., blood bank, hospital administration, sometimes perfusionists or anesthesia technicians
  - It requires a local “champion” willing to invest chunks of time and clear hurdles one by one over an extended period

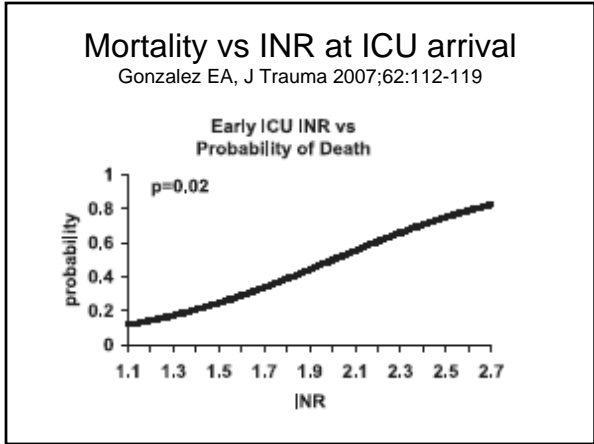
### Transfusion Algorithms

If they work in cardiac surgery (and they do):  
It seems reasonable to infer applicability to noncardiac surgery cases with large blood loss (except maybe trauma: stay tuned)

- ### Recent Developments in Blood Transfusion
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- ### Trauma and bleeding
- Hemorrhage is second leading cause of death
  - In the absence of head trauma, serious coagulopathy was associated with
    - pH < 7.10
    - Temp. < 34 °C
    - ISS score > 25
    - SBP < 70 mmHg
- Cinat M, Arch Surg 1999;134:964-70



- ### Cinat ME, Arch Surg 1999;134:964
- Compared 2 periods of a trauma registry
  - Massive transfusion from trauma
  - Period 2 ('93-'97) had better survival than Period 1 ('88-'92)
  - Later period differences:
    - More aggressive coagulopathy mgmt., more aggressive warming, decreased operative time, increased use of component therapy

### Trauma Registry Data

Cinat M, Arch Surg 1999;134:964-70

#### Survivors

- RBC-platelet ratio 7.7
- RBC/FFP ratio 1.8

#### Nonsurvivors

- RBC-platelet ratio 11.9 \*
- RBC/FFP ratio 2.5 (NS)

**"1" platelet was either a plateletpheresis or a pooled platelet pack (usually 6 units)**  
**•Remember: More than 1 factor changed, historical controls are not ideal, and association doesn't equal causation**

### Recent Combat Hospital Report

Borgman MA, J Trauma 2007;63:805-13

- Single combat hospital in Iraq
- Military Trauma Registry
- Query for massive Tsfns: > 10 u RBCs in 24 hrs
- Retrospective multivariate analysis of outcomes
- Principal query was ratio of plasma to RBCs: 3 categories
  - Low (median 1:8), Medium (1:2.5) and High (1:1.4 – range 1:2-1:0.6)

### Combat Experience – cont

Borgman MA, J Trauma 2007;63:805-13

Lower FFP:RBC ratios associated with

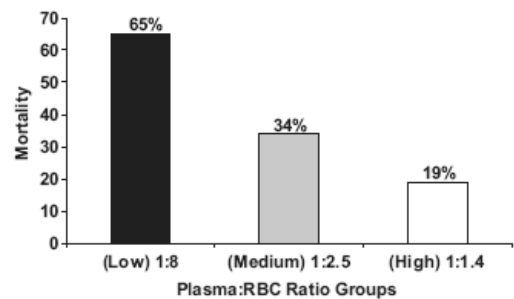
- Lower initial Hgb
- Higher crystalloid and RBC totals
- Less cryoprecipitate
- Thoracic injury

Survival independently associated with

- Higher FFP:RBC ratio
- Lower initial base deficit and Injury Severity Score

### Mortality vs Plasma:RBC ratio

Borgman MA, J Trauma 2007;63:805-13



### Borgman study compelling, but still

- Doesn't explain differences in FFP:RBC ratios
- Forces continuous data into ordinal groupings
- Some FWB was used (counted as RBC *and* plasma, but also has fresh platelets), but low and equal among groups
- Not prospective: critical covariates might be missing
- Lower initial Hgb in low ratio group might suggest higher pre-hospital blood loss, longer injury-to-hospital time, or more pre-hospital crystalloid resuscitation

### US Army Surgeon General

- Endorses 1:1 plasma:RBC ratio in massive transfusion from trauma
  - Will this survive the test of time and rigorous prospective testing?
- Military prospective trials ongoing

### And yet...

#### Prophylactic Administration of FFP and Platelets

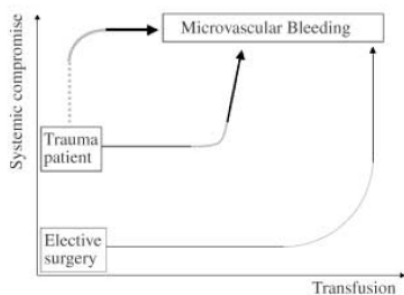
- (i.e., fixed ratios): **Never** proven beneficial in a prospective study
- Some studies show worse outcomes
- **Problem:** all prospective fixed ratio studies came from the era where **both** RBCs and WB were typically given: big difference in decay of plasma coag factors especially

### Trauma and Elective Surgery Massive Bleeding

Apples and Oranges?

### Massive Transfusion Coagulopathy

The 'road to coagulopathy'



Hardy J-F, Vox Sang 2005;89:123-7

### Trauma Pts: Blood Component Administration may be different

- Blunt trauma and CNS trauma lead to consumptive coagulopathy
- Acidosis and hypovolemia before treatment (as compared to euvolemia through most elective surgery)
- Poor outcomes associated with, major vascular injury and decreased use of FFP and platelet transfusion

Hardy J-F, Vox Sang 2005;89:123-7

### But in Elective Surgery with Massive Blood Loss

- Plasma and Platelet deficiencies become clinically significant almost simultaneously at about 1.5 X BV (Murray, A&A 1995;80:336-42)
- Critical hypofibrinogenemia may occur first
  - at 1.42 (1.17-1.69) X BV (Hippala ST, A&A 1995;81;360-5) – definition 1 g/L
  - II, V, VII all at 2.0-2.5 (defined as 20-25%)
  - Platelets at 2.3 (defined as 50K/uL)

### Is a high Plasma (not necessarily fresh):RBC ratio just a surrogate for Whole Blood?

- 1960s: Vietnam studies (Ron Miller) used a mix of WB and RBCs
- 1980s: WB disappeared largely for blood banking administrative reasons
- Fresh whole blood reappearing in trauma paradigms
- Déjà vu

### Fresh Whole Blood Transfusion: A Controversial Military Practice

David S. Kauvar, MD, John B. Holcomb, MD, Gary C. Norris, MPH, and John R. Hess, MD

The transfusion of fresh whole blood (FWB) for trauma-induced coagulopathy is unusual in civilian practice. However, US military physicians have used FWB in every combat operation since the practice was introduced in World War I and continue to do so during current military operations. We discuss our review of all blood products administered to US military casualties in Operation Iraqi Freedom (OIF) between March and December 2003. FWB transfusions were most frequent when demands for massive transfusions wiped out existing blood supplies. FWB patients had the highest blood product requirements; however, mortality did not differ significantly between FWB and non-FWB patients overall or for massively transfused patients. We review the current military practice of FWB transfusion in combat theaters and conclude that FWB transfusion is convenient, safe, and effective in certain military situations.

J Trauma. 2006;61:181-184

Kauvar DS, J Trauma 2006;61:181-4

**Table 1** Overall Use of Blood Products in US Casualties in Operation Iraqi Freedom

Product	Units	Percent of Total*	Patients	Units/Patient (Range)†
Packed red blood cells	1697	72	281	6.0 (1-35)
Fresh whole blood	242	10	36	6.7 (1-29)
Fresh frozen plasma	360	15	62	5.8 (1-21)
Platelet concentrate	35	1.5	6	5.8 (2-16)
Cryoprecipitate	15	0.6	1	15

\* Total not equal to 100% due to rounding.

† Units per patient receiving that blood product.

### The Use of Fresh Whole Blood in Massive Transfusion

Thomas B. Repine, MD, Jeremy G. Perkins, MD, David S. Kauvar, MD, and Lorne Blackborne, MD

**Background:** Most indications for whole blood transfusion are now well managed exclusively with blood component therapy, yet the use of fresh whole blood for resuscitating combat casualties has persisted in the U.S. military.

**Methods:** Published descriptions of whole blood use in military and civilian settings were compared with use of whole blood at the 31st Combat Support Hospital (31st CSH) stationed in Baghdad in 2004-2005.

**Findings:** Concerns about logistics, safety, and relative efficacy of whole blood versus component therapy have argued against the use of whole blood in most settings. However, military physicians have observed some distinct advantages in fresh warm whole blood over component therapy during the massive resuscitation of acidotic, hypothermic, and coagulopathic trauma patients. In this critical role, fresh whole blood was eventually incorporated as an

adjunct into a novel whole-blood-based massive transfusion protocol.

**Conclusions:** Under extreme and austere circumstances, the risk/benefit ratio of whole blood transfusion favors its use. Fresh whole blood may, at times, be advantageous even when conventional component therapy is available.

**Key Words:** Fresh whole blood, Massive transfusion, Trauma, Combat casualty care, Blood banking, Walking blood bank.

J Trauma. 2006;60:559-569

### FWB: Military and Civilian Use

Repine TB, J Trauma 2006;60:S59-S69

**Table 1** Indications for Whole Blood Use

Massive transfusion	Component-induced coagulopathy
	Volume resuscitation
	Improved O2 characteristics
	Limit donor exposures

### FWB Results

Kauvar DS, J Trauma 2006;61:181-4

- Obviously not randomized
- Front-line (mobile) hospitals typically lacked full component access
- Back line combat support hospitals: Waste 87-94% of RBCs because of logistics
- FWB Pt mortality 19%, non-FWB 12% (NS)
  - Yet blood product requirement 33±15 U for WB Pts, 15±6 in non-FWB

### FWB vs Component Rx

Kauvar DS, J Trauma 2006;61:181-4

	RBCs \$300	Plts \$600	FFP \$80	Sum \$980	FWB
<b>Vol.</b>	335	50	275	660	570
<b>Hct</b>	55	0	0	29	38-45
<b>Plts</b>	0	5X10 <sup>10</sup>	0	88K/μL	150-400K/μL
<b>% Coag</b>	0	Low	80	65	100

### Some Facts about WB vs Component Rx

- Component Rx provides the greatest good for the greatest #, simplifies and extends storage, best serves most elective surgery
- FWB is virtually intact
  - Equal to 10 u Plt Concentrates
    - Mohr R, JTCVS 1988;96:530-4
  - After 1-2 days, Plts are gone
  - But plasma is adequate for hemostasis (not replacement) for ~ 5 D, and except for V and VIII is >70% for over 20 D

## Fresh Whole Blood

Is a comeback possible?

### Military vs Civilian Realities

<p><b>Military</b></p> <ul style="list-style-type: none"> <li>• Captive audience                             <ul style="list-style-type: none"> <li>– Blood testing: No prob</li> <li>– Blood type instantly available</li> </ul> </li> <li>• Healthy population                             <ul style="list-style-type: none"> <li>– Hcts known and high</li> <li>– Little HIV, Hepatitis</li> </ul> </li> <li>• Non-litigious, accepts risk</li> </ul>	<p><b>Civilian</b></p> <ul style="list-style-type: none"> <li>• Hard to quickly mobilize a WB donor</li> <li>• Hard to know risk profile and state of health</li> <li>• Litigious, risk-averse</li> </ul>
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### Is there hope for FWB in a Civilian Setting?

If there were, maybe it would be in

- Major pediatric elective surgery
- Not likely to gain traction for trauma or adult elective surgery

### What about non-fresh WB?

- Studies from 1970s suggest that a mix of WB/RBCs (perhaps even 1/3) would reduce donor exposure considerably in trauma massive transfusion
- Component requirements acted more like elective surgery using RBCs
- Even emphasis on < 1 week old WB could have a major impact

### Components Administered

Counts RB, Ann Surg 1979;190:91-9

*TABLE 2. Types of 893 Units of Blood Distributed by Blood Center and Administered to 27 Patients*

	Number	
1. Cryo-poor whole blood	170	19
2. Platelet-poor whole blood	326	36
3. Cryo and platelet-poor whole blood	249	28
4. Whole blood	5	1
5. Red blood cells	122	14
6. Unidentified	21	2
<b>Total</b>	<b>893</b>	<b>100</b>

### 27 Massive Transfusion Pts

Counts RB, Ann Surg 1979;190:91-9

- Trauma Center Pts, Harborview Hosp
  - Ruptured aneurysms, mult trauma, massive GI bleeds
- Sequentially tracked coag tests (PT, PTT, platelets)
- Gave mostly WB
- Also investigated WB units over time

Age of blood given

- < 24 hrs: 1%
- 1-5 days: 54%
- 6-10 days: 23%
- 11-21 days: 22%

Mean 33 U/Pt (8-65)

- 69% within first 24 hrs
- Only 9 Pts developed coagulopathy!

### Clotting Decay: Massive Tsfsn

Counts RB, Ann Surg 1979;190:91-9

- Plt ct: Only signif relationship to # of units transfused
- Similar to Miller's Vietnam study
- Using RBCs in elective surgery, need for both FFP and Plts kicks in at 10-15 U

### WB at 2-3 weeks

Counts RB, Ann Surg 1979;190:91-9

TABLE 1. Clotting Factor Levels in Modified Whole Blood (CPD Anticoagulant) Stored at 4°

Clotting Factor	Level After Storage (Days) as a Percentage of the Initial Level	
	14 Days	21 Days
Prothrombin	87	70
VII	57	66
IX	106	97
X	90	85
XI	99	107
XII	133	117
Fibrinogen	98	109

### Why did WB Disappear from Civilian Blood Banks?

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- ### Bottom line – trauma (for now)
- Less controlled situation pre-hospital
  - Earlier onset of coagulopathy if other risk factors are present: hypothermia, brain injury, acidosis, hypotension, high ISS
  - Fixed ratios not proven prospectively, but appropriate in this setting if above risk factors exist
    - Plts approx 1 pool/pheresis per 8 U RBCs
    - FFP: ~1 unit per 1-1.5 U RBCs
    - Usually FFP *before* platelets, but 1:1:1 is used by some

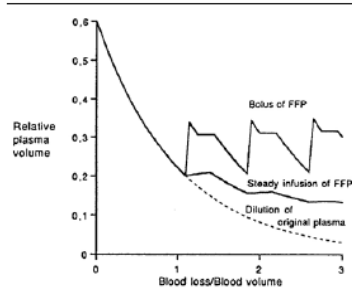
- ### Bottom Line – elective surgery
- Elective Surgery: In the absence pre-existing coagulation disturbance and of loss of control of temp, pH, and BP
- It takes EBL >1 BV to justify FFP or Platelets
    - FFP and Platelet thresholds nearly simultaneous
  - Monitor PT, fibrinogen, and Platelet count periodically or with each 0.5 X BV (plan for delay). Get baseline values if major bleeding likely
  - TEG may help: insufficient data outside CT surgery
  - Some evidence for *hyper*coagulable state at EBL up to 1 BV

### Bottom line – elective surgery 2

- PT ratio of > 1.5 X Control plus coagulopathy: FFP 4 unit bolus
- Platelet count < 50,000: Plateletpheresis or 6-8 unit platelet concentrate
- Fibrinogen 75-100 mg/dL: Try FFP first
  - Fibrinogen < 50: cryoprecipitate 10 units
- rVIIa intervention threshold? Unclear

### FFP Bolus vs Infusion

Hardy J-F, Can J Anesth 2004;51:293



### Suggested Targets

Spahn DR, BJA 2005;95:130-9

