Techniques to Maximize Blood Management

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September 9, 2006

Disclosures

- Bayer – Honoraria
- Novo Nordisk – Research support

Peri-operative Blood Transfusion & Blood Conservation in Cardiac Surgery

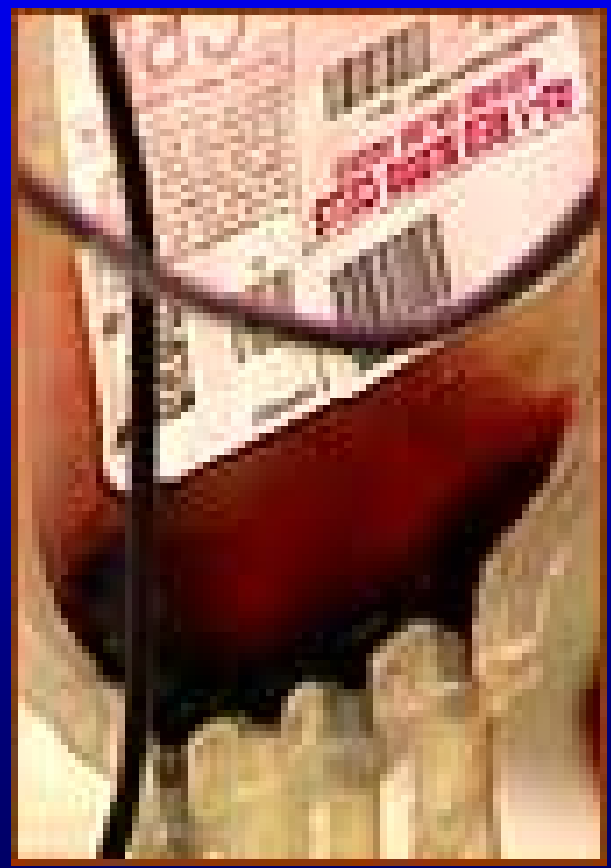
- The Society of Thoracic Surgeons and The Society of Cardiovascular Anesthesiologists Practice Guideline Series
  - STS (Ferraris V, Ferraris S, Saha S, Haan C, Royston D, Bridges C, Higgins R, Despotis G)
  - SCA (Spiess B, Shore-Lesserson L, Stafford-Smith M, Mazer C, Bennett-Guerrero E, Hill S, Body S)
    - *In press*

Evidence Supporting Techniques

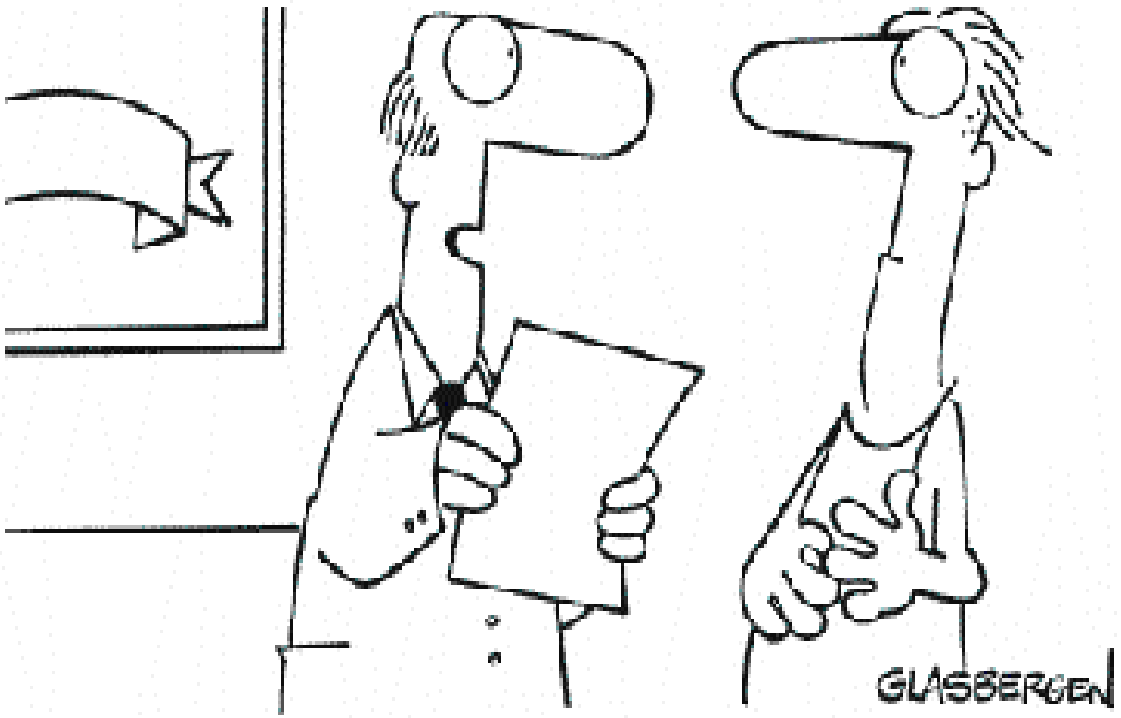
- **Based on AHA/ACC classification scheme**
- **Class I –** Evidence or general agreement that technique is useful or effective
- **Class II –** Conflicting evidence exists about the usefulness of the technique
  - **Class IIa –** Weight of evidence favors technique
  - **Class IIb –** Usefulness is less established, but expert consensus favors acceptance of technique
- **Class III –** Evidence exists that technique is not useful and/or possibly harmful

Blood Management Techniques

- Preoperative
- Intraoperative
- Postoperative



Tolerating Anemia



"The bad news is, you only have one red blood cell. The good news is, he's a workaholic."

Tolerating Anemia

- When does oxygen delivery-dependent consumption start?
  - Critical DO2 occurs at Hb 3-4g/dl in mammals
  - Good evidence that tissue oxygenation is supported in healthy patients down to 7 g/dl
  - Experimental literature demonstrates no serious complications down to 5 g/dl
  - Much lower levels reported in JWs, no complications
  - CPB is a special case
- **Recommendation**: NIH guidelines and consensus expert opinion (STS/SCA) agree that 7 g/dl is reasonable (6 g/dl on CPB) (Class IIa)

Preoperative Techniques

CIRCULAR OF INFORMATION
FOR THE USE OF HUMAN BLOOD AND BLOOD COMPONENTS

This circular was prepared jointly by the American Association of Blood Banks, America's Blood Centers and the American Red Cross. It has the approval of the Center for Biologics Evaluation and Research, Food and Drug Administration, and is consistent with the use of uniform blood labeling.

aa BB
AMERICAN ASSOCIATION OF BLOOD BANKS

America's Blood Centers

American Red Cross

Federal law prohibits dispensing the blood and blood components described in this circular without a prescription.

Identification of the High-risk Patient (Class I)

- Characteristics
  - Advanced age
  - Low preoperative red cell volume (anemia or small body size)
  - Preoperative anti-platelet and anti-thrombotic drugs
  - Redo or complex procedures, long CPB time
  - Emergency
  - Non-cardiac patient comorbidities
- Employ **all available strategies possible** since these patients account for 80% of all transfused blood

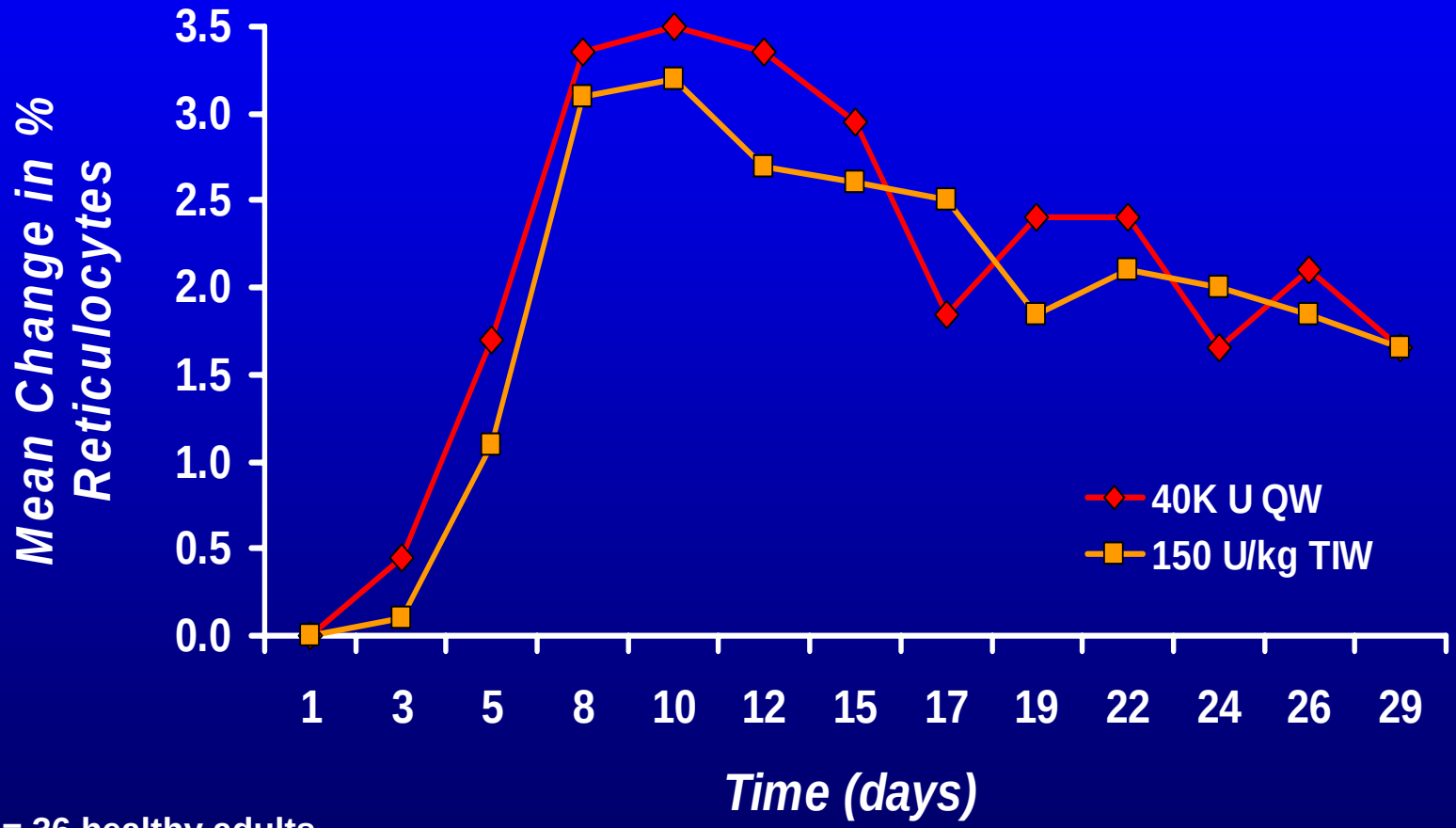
Preoperative Autologous Donation (Class IIa)

- Historically employed in non-cardiac settings
- Efficacy and safety questionable
- Cardiac surgery
  - Concerns regarding preoperative stability
  - Good evidence for safety and efficacy
  - Class IIa technique when combined with EPO (off-label) and iron
  - Up to two units can be beneficial in selected elective patients
  - Cost effectiveness?

Erythropoetin (EPO)

- Class I recommendation when coupled with PAD
  - "Off-label" indication, use with caution in cardiac disease
  - Need about a week
  - Especially effective in pediatrics
  - Cost?
- Class IIa for anemia (Hb<13) with iron supplementation several days preoperatively
- Class IIb in those with risk factors for postoperative anemia or decreased endogenous EPO production at least a few days preoperatively

Preoperative - rHuEPO



N = 36 healthy adults

Cheung W, et al. Eur J Clin Pharmacol 2001;57:411-418.

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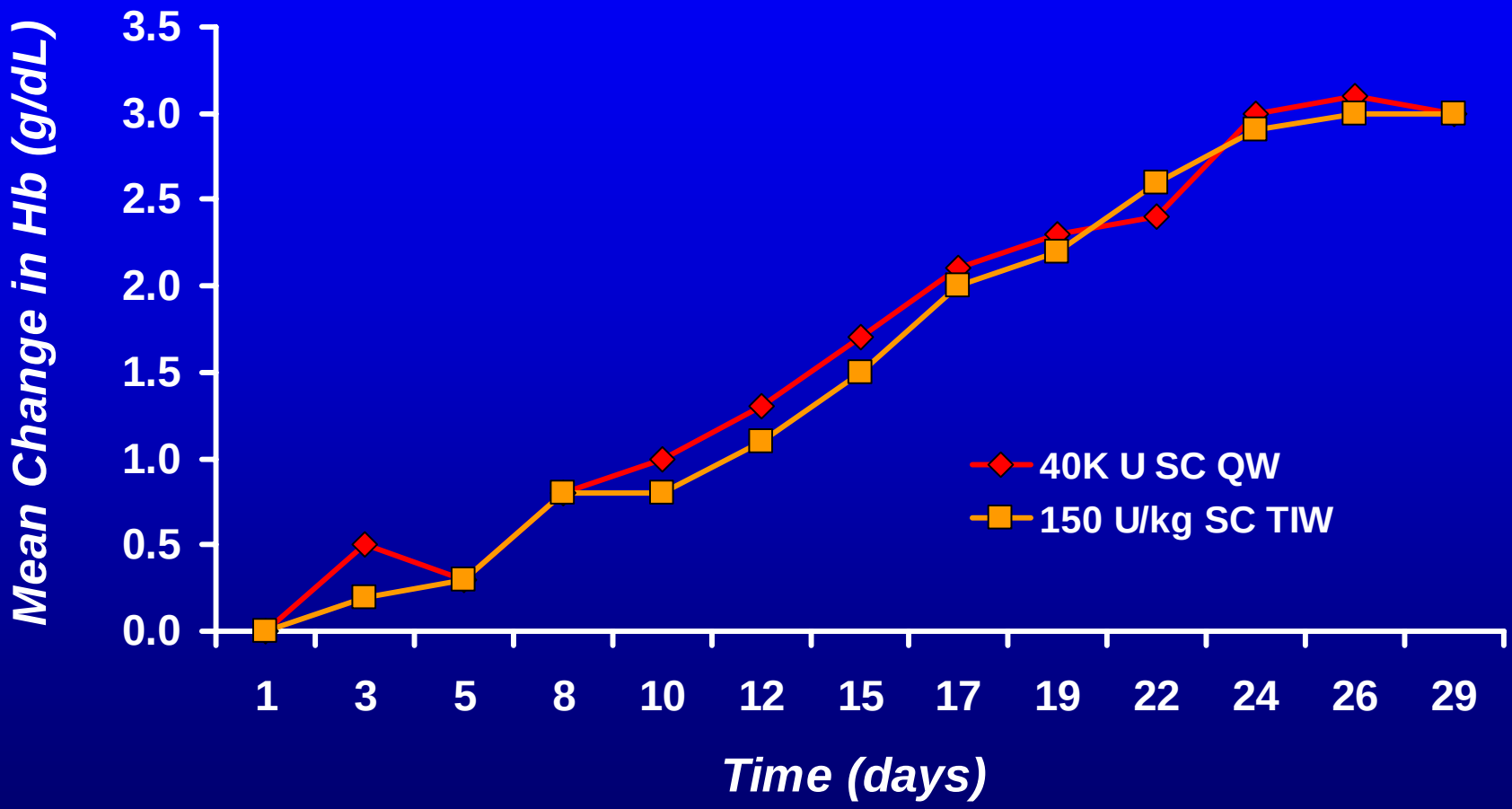

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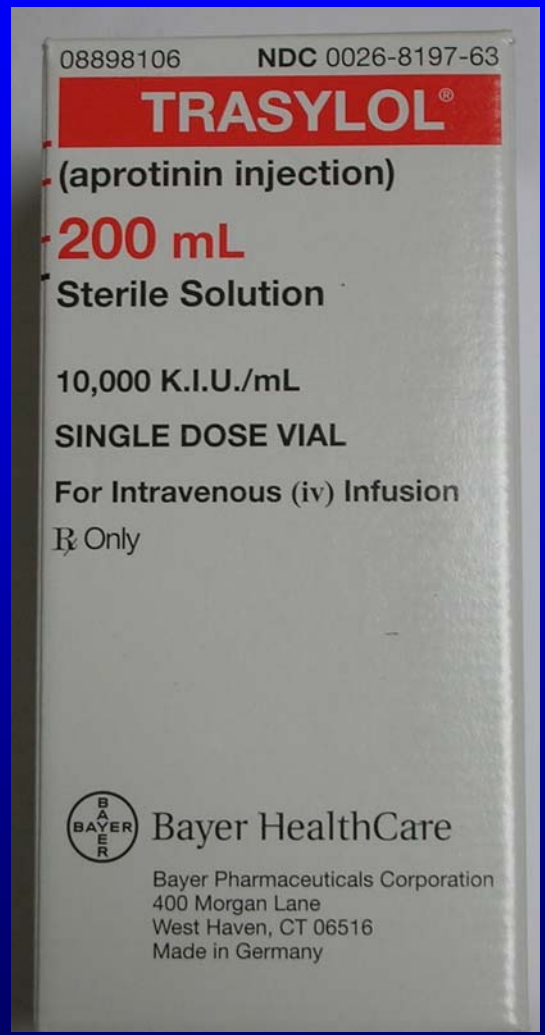
Other Preoperative Techniques

- Avoidance of phlebotomy (IIa)
- Avoid coagulopathy (warfarin, ASA, clopidogrel, ticlopidine, gpIIb/IIIa)
- Preoperative laboratory screening
- Cath lab access site closure device (IIb), especially within 48 hours of operation
  - 1-9% complication rate, 5% require transfusion

Intraoperative Techniques

Aprotinin

- Bovine lung serine protease inhibitor
  - Class I for high-dose regimen
  - Class IIa for reducing return to OR
  - Class IIb for low dose regimen, but may be associated with increased morbidity
  - Safety profile is excellent
- Reduces transfusion in orthopedics, thoracic, hepatic resection and transplant



Lysine Analogues

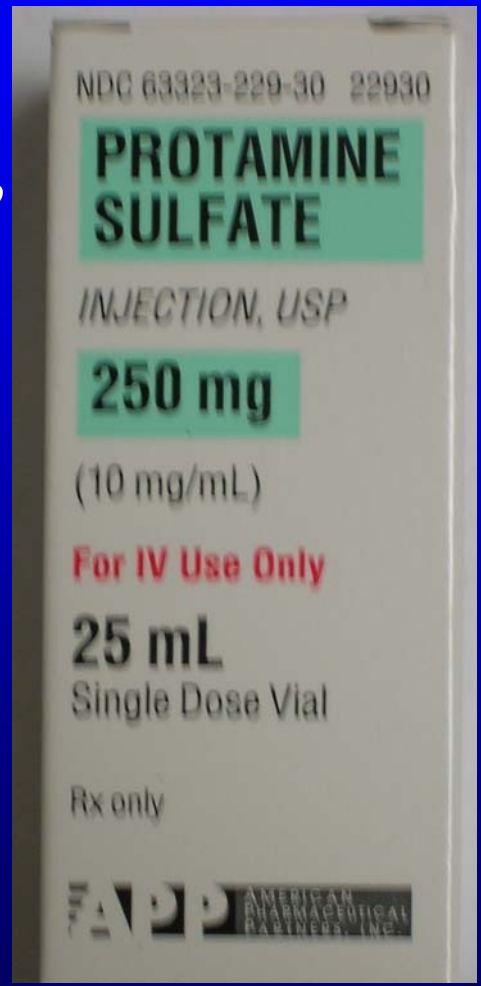
- Epsilon aminocaproic acid (EACA) (US only)
- Tranexamic acid (TXA)
- Class IIb
- “Off-label”
- Do not reduce the rate of operative re-exploration (Class III)

DDAVP

- Desmopressin acetate
- Class IIb for specific patients with demonstrable and specific platelet dysfunction such as acquired or inherited vWF deficiency
- Releases endogenous FVIII and vWF
- Not effective for routine prophylaxis (Class III)

Heparin/Protamine Dosing

- Maintain higher heparin concentrations for longer CPB times to limit thrombin formation, preserve platelets and factors (Class IIb)
- Use protamine titration or lower empiric protamine dosing to lower total protamine dose (Class IIb)
- Heparin bonded circuits and low dose heparin regimens are not recommended (Class III)



Cell salvage (Class I)

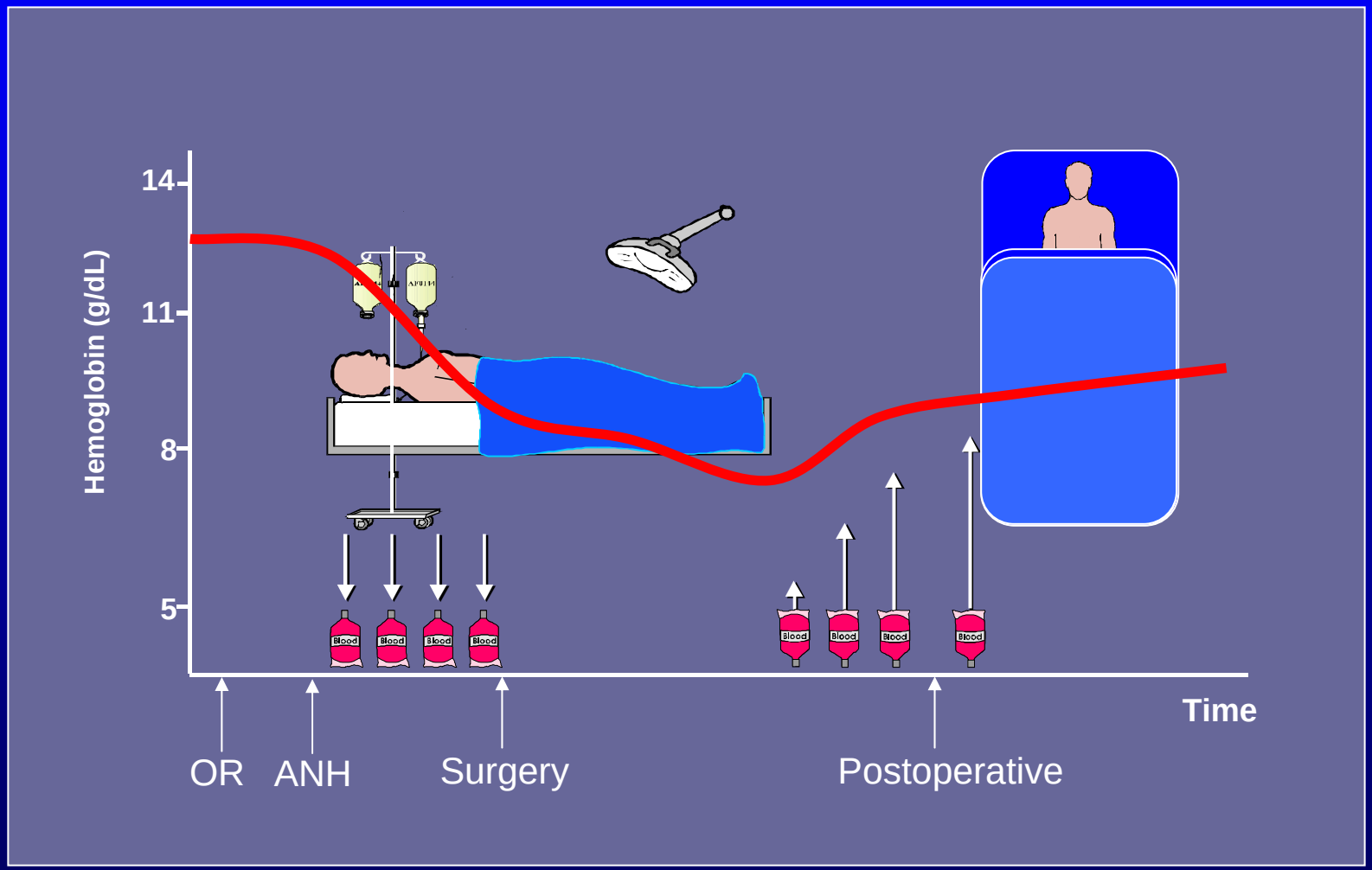
- In the absence of infection, malignancy or topical clotting agents
- Reduction in circulating systemic cytokines
- Loss of coagulation factors when processing CPB circuit volume
- Platelet plasmapheresis not recommended (Class III)

Cell Salvage

Acute Normovolemic Hemodilution (ANH) (Class IIb)

- Blood is protected from activation by CPB, platelet activation and consumption, production of inflammatory cytokines
- Decreases loss of red cell mass
- Usefulness not well established as sole therapy, but in combination
- Only useful in non-anemic patients
- May be detrimental if iatrogenic mishaps occur

Concept of ANH



ANH

Pump Blood Salvage and Autotransfusion (Class IIb)

- Recycling remaining pump blood at end of CPB
- Mediastinal shed blood from cardiotomy suction is reinfused with or without washing
- Particulate matter, fat emboli
- Longer CPB associated with more bleeding
- Limited evidence for either technique

Retrograde Autologous Prime (RAP) (Class IIb)

- Back bleeding of crystalloid prime in arterial and/or venous lines of CPB circuit
- Maintains colloid oncotic pressure and decreases extravascular free fluid
- Decreases transfusion requirements

Conventional/Modified Ultrafiltration (CUF/MUF)

- Removal of excess fluid volume
- Decreases inflammatory mediators
- Especially helpful in pediatric or small BSA patients (Class IIa)
- Not likely beneficial in adults except to reduce transfusions by raising the hemoglobin to avoid a transfusion trigger in volume overloaded patients (Class III)

OPCAB (Class IIa)

- Off-pump coronary artery bypass
- Less transfusions despite roughly equivalent blood loss
- Increased transfusion requirements if emergent conversion to CPB

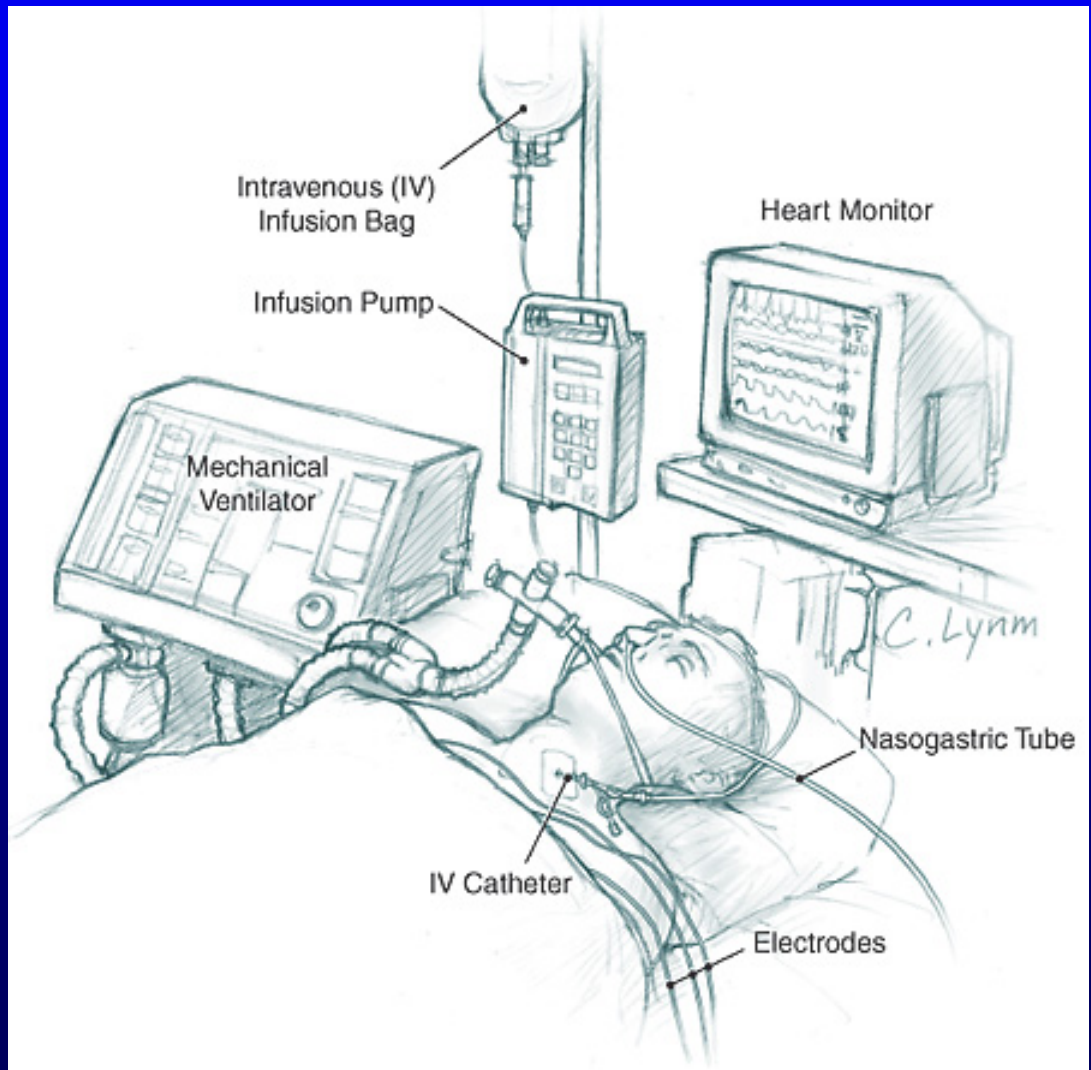
Topical Agents (Class IIb)

- Especially high-risk or aortic procedures
- Fibrin glue
- Use recommended for blood conservation only in high-risk or potentially lethal situations
- Avoid bovine thrombin (Class III)

Other Intraoperative Techniques

- Normothermia
- Surgical hemostasis
- Point-of-care testing with transfusion algorithms in a multimodal approach (Class I)
  - Reduces process variability
  - Cost effective and efficient

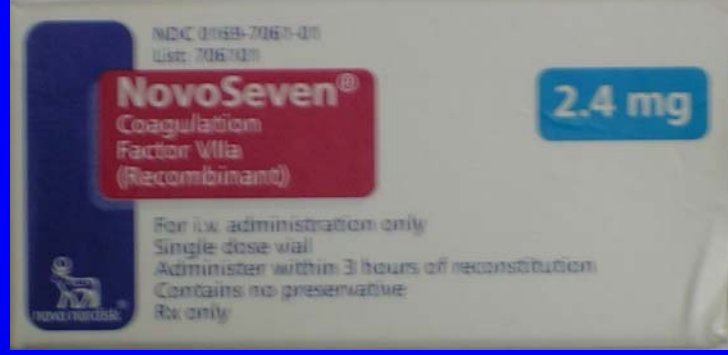
Postoperative



Retransfusion of Washed Mediastinal Shed Blood (Class IIb)

- Washing decreases cytokines, lipids
- Unwashed associated with increased infection, possibly neurologic dysfunction (Class III)

Factor VIIa



- Recombinant human coagulation factor (rhFVIIa)
- Class IIb for intractable bleeding after cardiac surgery (“off-label”)
- Indicated for treatment of bleeding in hemophiliacs with inhibitors to FVIII or FIX
- Used “off-label” as rescue therapy for excessive bleeding in trauma, cardiac, liver transplant with anecdotal dramatic results
- Extremely expensive
- Risk of thrombotic complications still unclear
- Randomized trials underway

Factor XIII

- Recombinant human coagulation factor
- Cross-links fibrin polymers in final step of coagulation pathway
- Acquired FXIII deficiency post-CPB
- Replacement of factor XIII to normal or supranormal levels may result in decreased bleeding
- Extremely expensive
- Phase II trials
- No consensus recommendations

Other Postoperative Techniques

- Normothermia
- PEEP
- Comprehensive, multimodal blood management program (Class I)

Summary

- Tolerate anemia
- Avoid transfusion “triggers”
- Evidence based medicine indicates that the most important intervention is the application of an institution based, multimodal blood conservation program to guide transfusion decisions

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