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# BLOOD CONSERVATION DEFINITION

- Blood Conservation refers to strategies aimed at appropriate alternatives to blood transfusion and the appropriate use of blood products.
- The World Health Organization (WHO) defines appropriate transfusion as: 'to treat a condition leading to significant morbidity and mortality that cannot be prevented or managed effectively by other means'.

Continuous....

# GUIDING PRINCIPLES

1. There are inherent risks associated with blood transfusion
2. Blood conservation methods provide alternatives to transfusion
3. Blood conservation provides the patient with an opportunity to make an informed choice about care and management
4. Patient education, planning and timely interventions may reduce recovery time
5. The banked blood supply is limited

# Transfusion Types

- Allogeneic transfusions involve the infusion of blood from a donor
- Autologous transfusions involve the re-infusion of the patient's own erythrocytes
- Autologous transfusions have emerged as a viable alternative to allogeneic transfusions
  - decrease immunomodulation
  - prevent transmission of viral diseases
  - decrease transfusion reactions associated with the more traditional technique
  - religious beliefs

# Topic to discuss

1. When to transfuse ?
2. The Crossmatch:Transfusion ratio
3. Blood ordering schedule
4. Blood conservation techniques

: a  $\frac{EBV}{H_i} (H_i - H_f)$

## 1. Monitor blood loss –

- Visual assessment of the surgical field
- Blood loss >25% of total blood volume
- MABL

$$\text{MABL} = \frac{\text{EBV} (H_i - H_f)}{H_i}$$

H<sub>i</sub> = Initial Hct

H<sub>f</sub> = Lowest acceptable Hct

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## 2. Monitor for inadequate perfusion & oxygenation of vital organs

- Sr. lactate > 2meq/lit
- O<sub>2</sub> extraction 50%
- U/O < 0.5ml /kg/ hr.
- BP, HR, O<sub>2</sub> saturation, ABG

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### 3. ASA guidelines (2006) transfusion indicators

- Transfusion rarely indicated when Hb > 10 gm/dl and almost always indicated when Hb < 6 gm/dl
- Patients with Hb b/w 6-10 gm/dl should be based on patient risk for complications of inappropriate oxygenation, rate and magnitude of ongoing bleeding and patient intravascular volume status

*Practice Guidelines for Perioperative Blood Transfusion and Adjuvant Therapies. Anesthesiology*  
2006; 105:198-208



# The Crossmatch:Transfusion ratio

- (C:T ratio) is too high
  - Lots of blood is being crossmatched and never transfused
- Why is a high C:T ratio bad
  - I. Securing blood that is never transfused is taxing on the blood bank
    - Non-transfused blood has to be placed back in the general inventory which is costly and time consuming
    - Takes time and effort away from the blood banks ability to secure blood for other cases

## C/T Ratio Goal is <1.5

- Ideal C/T Ratio = 1.0

When the number of red cell units crossmatched or setup for the patient is equal to the number of red cell units transfused

- **Our goal should be of <1.5**

# Maximum Blood Order Schedules

- The MBOS defines the number of units required to meet the needs of 80% to 90% of patients undergoing a specific procedure and assists in ordering blood.
- The hospital transfusion laboratory, however, must give special consideration to patients with a positive antibody screen.
- The available shelf life of a unit of red cells decreases each time the red cell unit is held for crossmatched
- When more blood is crossmatched than is required, it is unavailable for other patients increasing the chance that the blood will expire before it is used.

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- **Preoperative autologous donation**
- **Preoperative erythropoetin**
- **Anti fibrinolytic**
- **Acute normovolemic hemodilution**
- **Intraoperative blood salvage**
- **Postoperative blood salvage**
- **Topical hemostatic agents**
- **Recombinant Factor VIIA**
- **Hemoglobin-Based Oxygen Carrying Solutions**

# 1. Predeposit phlebotomy or donation

- It is a process in which one or more units are collected before an elective procedure for reinfusion during or after the procedure.
- Donations are often scheduled weekly or four days intervals with last phlebotomy 72 hours before operation.
- The Hb level recommended is 11g% and haematocrit >34%.
- Before each phlebotomy oral iron supplements are administered.
- It has been indicated that preoperative autologous donation appears to increase the risk of postoperative anaemia

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- The efficacy of PAD is dependent on the degree to which the pt's erythropoiesis increases the production of RBCs
- “ Weekly PAD ” is accompanied by an expansion in RBC volume of 11% (with no oral Fe supplementation) to 19% (with oral Fe supplementation), which is not sufficient to prevent increasing anemia & an ↑ed likelihood of allogeneic blood transfusion in pts undergoing PAD

- Studies of “aggressive” autologous blood phlebotomy (twice wkly x 3 wks, beginning 25 - 35 days before surgery) have demonstrated that endogenous erythropoietin levels increase, along with enhanced erythropoiesis representing RBC volume expansion of 19% to 26% .
- Exogenous (pharmacologic) erythropoietin therapy to further stimulate erythropoiesis (up to 50% RBC volume expansion) during autologous phlebotomy has been approved in some countries.
- Erythropoietin dose 300U/ kg everyday 10 days pre operative.

# Intra operative Blood conservation Method



# Method of blood conservation

## 1. Position

- In horizontal position, the influence of gravity on vascular system is minimal.
- Intravascular pressures from head to foot vary little from mean pressure at level of heart.
- No perfusion gradient either the head or the lower extremities.
- If the patient in the dorsal decubitus position effects of gravity on blood flow become quite .Pressures change by 2 mm Hg for each 2.5cm varies in vertical height above or below the reference point at the heart
- lower extremities are below the level of the heart blood pools in distensible dependent vessels causing a reduction in circulating volume, cardiac output and systemic perfusion.
- The position is used to advantage in various surgical procedures viz. neurosurgery, gynaecological surgery, etc.

## 2. Regional blockade

- Spinal anaesthetics act by sympathetic efferent blockade.
- The resultant cardiovascular haemodynamics of hypotension and bradycardia can be taken to advantage of reducing the blood loss.
- Venous pooling and resultant preload reduction decrease the cardiac output.
- Arterial dilatation decreases the total peripheral resistance.
- Clinically significant bradycardia occurs with an incidence of 10-15%.
- Blockade of sympathetic cardiothoracic accelerator fibres from T1-T4 may elicit vagally mediated reflex slowing the heart rate.

Continuation...

- In epidural anaesthesia, the haemodynamic changes decrease in
  - Stroke volume,  
Cardiac output,  
Total peripheral resistance and arterial pressure.

- Continuation...
- A combined spinal, epidural anaesthetic technique with postoperative pain
  - Extensive surgery in the lower abdomen and decreases blood loss and conserves blood.
- Combined regional and GA
  - Reduce blood loss in major surgical procedures.
  - Regional anaesthesia techniques reduce the blood loss in patients undergoing hip surgery is well documented

### 3. Deliberate hypotension

- Used along with GA as a means of reducing blood loss.
- Various drugs have been used to induce hypotension, viz. SNP, NTG, trimetaphan, etc.
- Supplemental drugs like esmolol, diltiazem and captopril along with inhalational agents like halothane and isoflurane.
- In a comparative study using SNP for hip arthroplasty the blood loss was 1.3L as compared to 2.6 and 2.1L with nitrous oxide halothane without hypotension
- Judicial use of haemodynamic monitoring is a useful tool to reduce blood loss and thereby minimize transfusion and conserve blood

# Pharmacological Agents to Reduce the Blood Loss

## 1. Antifibrinolytic Drugs

- When exaggerated fibrinolysis is suspected of contributing to the intraoperative bleeding. Eg. Cardiopulmonary (CP) bypass, hepatic transplantations, and prostate surgery.
- These drugs are quite useful in surgeries, artero venous malformations, meningiomas and other surgical procedures where major blood loss is expected.
- Antifibrinolytic mouth washes have been recommended in the context of dental procedures in patients with haemophilia.

## a) Epsilon Amino Capronic Acid (EACA),

- Lysine analogue and tranexemic acid bind to both plasminogen and plasmin molecule to produce a structural change.
- This prevents the conversion of plasminogen to plasmin and prevents plasma to degrade fibrinogen to fibrin.
- Prevents clot lysis and splitting fibrin to degradation products, which are anticoagulants
- We recommend the consideration of tranexamic acid (20–25 mg kg<sup>-1</sup>).

Eur J Anaesthesiol 2013

## B) Aprotinin

- It inhibits various serine proteases including plasmin and kallikrein.
- The later participated in the process of contact activation to factor XII.
- Therefore it prevents degradation of fibrinogen to fibrin.
- Additional beneficial effects on platelets may be by preservation of the GPIIb/IIIa receptor which is necessary for initial platelet adhesion to vascular defects.
- 1-2 million KIU bolus followed by .25-.5 million KIU/hr reduce blood loss In spine surgery



# Autologous Transfusion

- Autotransfusion was frequently reported in obstetrics and gynaecological surgery (ectopic pregnancy) and by 1931 there were 282 reports in literature of blood salvage and autotransfusion.

## Mechanism

- Blood for autologous transfusion is collected from donor/patient for subsequent reinfusion into the same patients.
- Such transfusions carry no risk of alloimmunisation hepatitis, malaria, cytomegalo virus or HIV.
- Although beneficial to most patients they are particularly valuable to patients with rare blood types who have antibodies to common antigens.
- They preserve bank blood stores and often decrease overall health care costs

# Contraindications to Participation in Autologous Blood Donation Programs

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1. Evidence of infection and risk of bacteremia
2. Scheduled surgery to correct aortic stenosis
3. Unstable angina
4. Active seizure disorder
5. Myocardial infarction or cerebrovascular accident within 6 months of donation
6. Patients with significant cardiac or pulmonary disease who have not yet been cleared for surgery by their treating physician
7. High-grade left main coronary artery disease
8. Cyanotic heart disease
9. Uncontrolled hypertension

# Advantages and Disadvantages of Autologous Blood Donation

## Advantages

Prevents transfusion-transmitted disease

Prevents red cell alloimmunization

Supplements the blood supply

Provides compatible blood for patients

Prevents some adverse transfusion reactions

Provides reassurance to patients concerned about blood risks

## Disadvantages

Does not affect risk of bacterial contamination

Does not affect risk of ABO incompatibility error

Is more costly than allogeneic blood

Results in wastage of blood not transfused with alloantibodies

Increased incidence of adverse reactions to autologous donation

Subjects patient to perioperative anemia and increased likelihood of transfusion

# Acute Normovolemic Haemodilution (ANH)

- Removal of whole blood from a patient immediately before surgery
- Simultaneous replacement with an acellular fluid such as crystalloid or colloid to maintain normovolaemia.
- **3 mL crystalloid for each 1 mL of blood withdrawn**
- Blood is collected into standard blood bags containing anticoagulant and is reinfused after major blood loss has ceased or sooner if indicated.

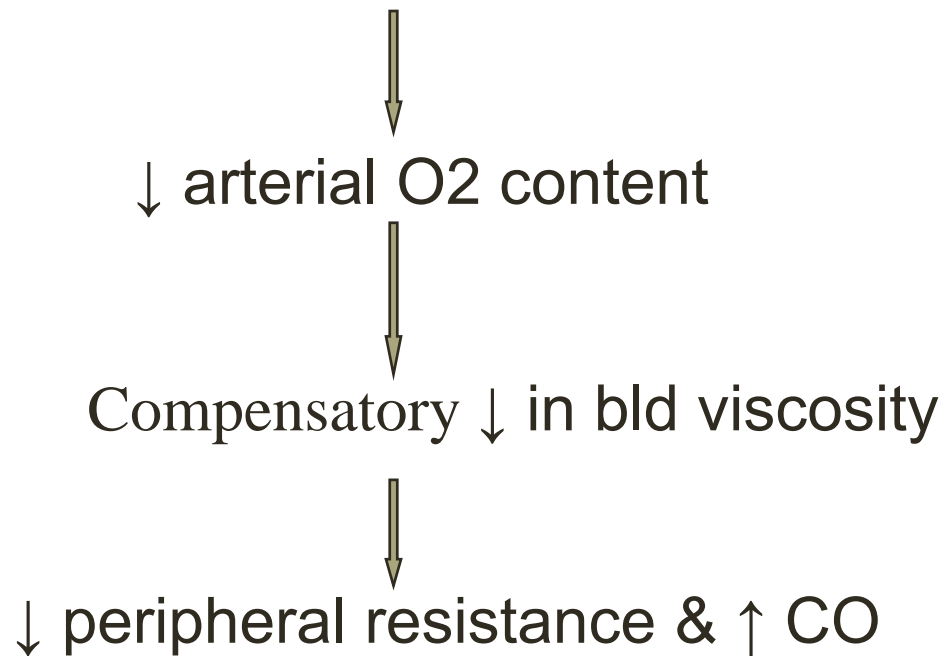
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1. Conservation of red cell mass

- Reduction of RBC losses when whole blood is shed perioperatively at lower hematocrit levels after ANH is completed

## 2. Improved Oxygenation

Withdrawal of whole blood & replacement with crystalloid or colloid solution



### 3. Preservation of Hemostasis

- Blood collected by ANH is stored at room temperature
- Returned to the patient within 8 hours of collection
- Little deterioration of platelets or coagulation factors
- Esp. helpful in protecting plasma & platelets from the acquired coagulopathy of extracorporeal circulation in cardiac surgery (k.a “blood pooling”)

- The guidelines for ANH

1. Potential surgical blood loss is likely to exceed 20% of blood volume in patients who have preoperative haemoglobin level of more than 10g dl
  2. Who do not have severe myocardial disease.
  3. The aim is to reduce red cell volume loss during perioperative period as haematocrit is already lowered.
- Retrospective study in 800 patients who underwent total joint arthroplasty reduced the need for allogenic transfusion



Acute normovolaemic haemodilution has several advantages over predeposit donation.

- I. First the units do not require testing,
- II. costs are lower,
- III. The clerical errors are minimal and risk of bacterial contamination is eliminated.
- IV. It does not require extra time to be spent by the patient, nor does it prolong the duration of surgery or anaesthesia.

ANH has shown to be a cost effective alternative to preoperative donation by patients undergoing retropubic prostatectomy

# Criteria for Selection of Patients for Acute Normovolemic Hemodilution

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1. Likelihood of transfusion exceeds 10% (i.e., blood requested for crossmatch according to a maximum surgical blood order schedule)
2. Preoperative hemoglobin level of at least 12 g/dL
3. Absence of clinically significant coronary, pulmonary, renal, or liver disease
4. Absence of severe hypertension
5. Absence of infection and risk of bacteremia

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- Strict vigilance of pt's hemodynamic & perfusion status during the procedure required.
- Blood must be collected in an aseptic manner, ordinarily into standard blood collection bags with citrate anticoagulant
- Label must contain pt's full name, medical record number, date & time of collection, & the statement "For Autologous Use Only."
- Room temp. storage not > 8 hrs
- If more time elapses b/w collection & transfusion, the blood should be stored in a monitored refrigerator

# Intraoperative Cell Salvage

- Technically more complex and expensive procedure.

## Prerequisite

- It requires strict aseptic conditions.
- The blood from operating field is collected, filtered, washed and subsequently reinfused.
  - The RBC yield is to the tune of 75%.
  - Microaggregate filters (40  $\mu\text{m}$ ) used, because recovered blood may contain tissue debris, small blood clots, or bone fragments

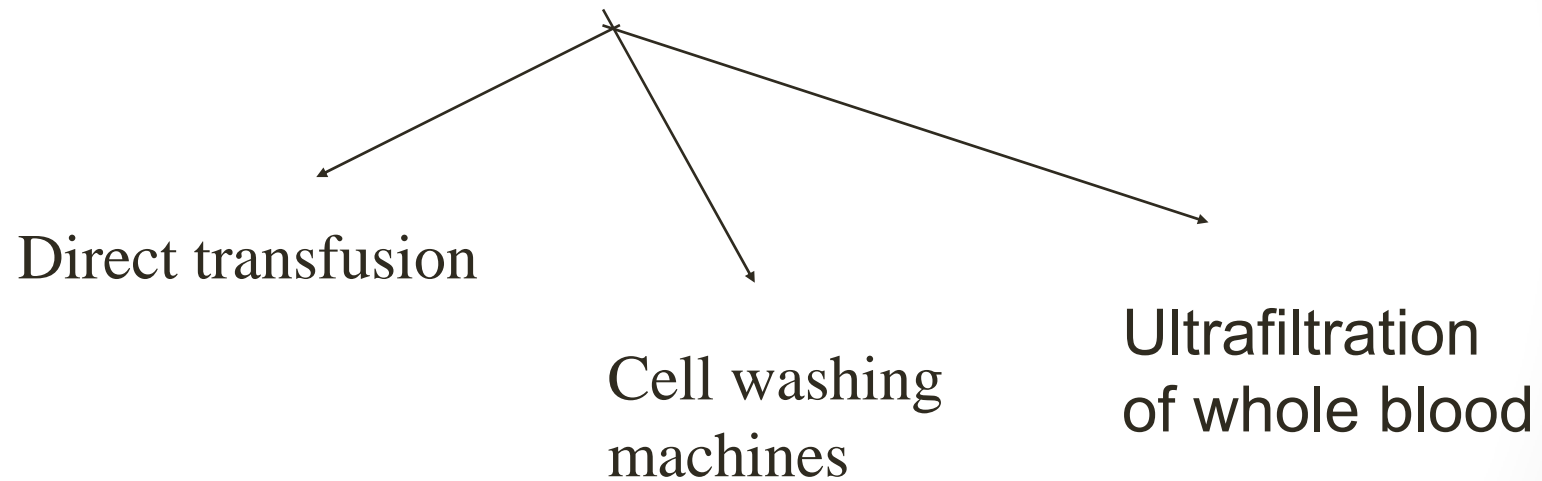
➤ Adverse effects are

- Haemolysis,
- Air embolism,
- Shortened red cell survival,
- Platelet and fibrinogen loss,
- Changes in 2-3 DPG.
- Dilutional coagulopathy in assoc. with large volume loss as all clotting factors & most platelets are removed by the washing process
- A DIC-like coagulopathy.

➤ Contraindicated

- Sepsis and malignancy,
- Contaminated by amniotic or ascitic fluid, or
- Gross contamination of the operating field.
- Not cost effective

## Types of Intraoperative blood salvage



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- Varying degrees of coagulation / fibrinolysis & hemolysis of shed blood → infusion of large volumes of unwashed blood is assoc. with DIC
- Esp seen when :
  - a) Blood collected at low flow rates / during slow bleeding from pts who are not systemically anticoagulated
  - b) High suction pressure & during aspiration & the turbulence or mechanical compression as in roller pumps & plastic tubing
- Precautions :
  - a) Cautious use in pts with renal impairment ( free Hb nephrotoxic)
  - b) Limit to the quantity of unwashed blood used
  - b) Vacuum level should not be > 150 mm Hg

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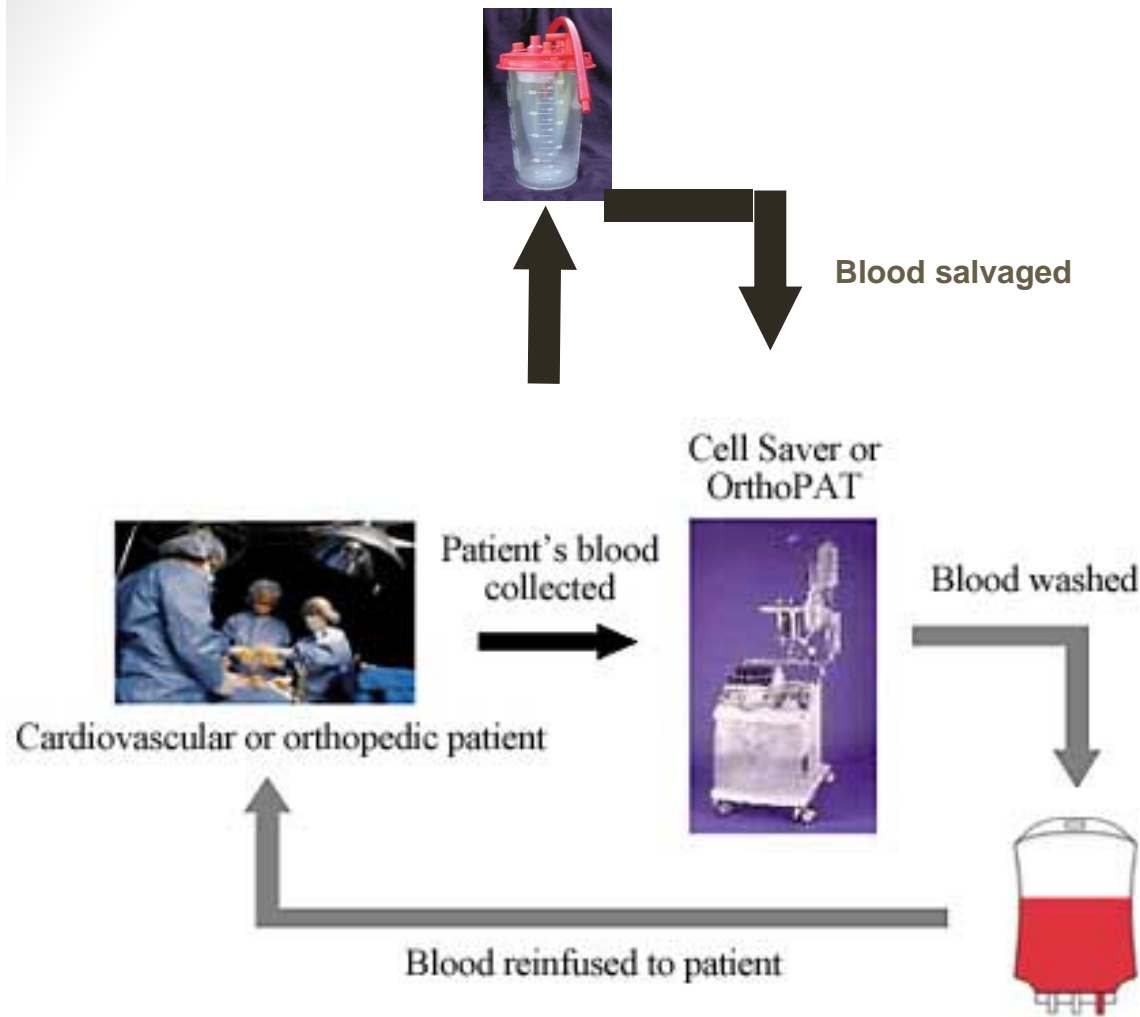
- Cell washing is composed of four steps:
  - harvesting of the pt's blood
  - processing of the shed blood & removal of the serum
  - storage of the red blood cells
  - reinfusion of the high hematocrit RBCs
- Final hematocrits – upto 70%
- Recovered blood must be handled in the transfusion service laboratory like any other autologous unit
- Should be reinfused through a filter



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- Leak-proof
- Transparent for visual blood inspection
- Viable under closed suction system
- Collection, retention, and disposal standards
- Easy connection to cell salvage system



[http://www.haemonetics.com/site/flash/cell\\_saver.html](http://www.haemonetics.com/site/flash/cell_saver.html)

# 8. Ultrafiltration (UF) of whole blood

- Ultrafiltration devices filter pt's anticoagulated whole blood
- Removal of unwanted non-cellular plasma water, low mol. wt solutes, platelet inhibitors, activated cytokines, anaphylatoxins & some particulate matter through hemoconcentration
- Concentrated whole blood (platelets, clotting factors & plasma proteins with a substantial Hb level) available for reinfusion.

# Practical Considerations for Intraoperative Cell Recovery, Storage, and Reinfusion

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1. If not transfused immediately, units collected from a sterile operating field and processed with a device for intraoperative blood collection that washes with 0.9% saline, shall be stored under one of the following conditions :
  - a. At room temperature for up to 4 hours
  - b. At 1-6°C for up to 24 hours, provided that storage at 1-6°C is begun within 4 hours of ending the collection.
2. Transfusion of blood collected intraoperatively by other means shall begin within 6 hours of initiating the collection.
3. Each unit collected intraoperatively shall be labeled with the patient's first name, last name, and hospital identification number; the date and time of initiation of collection and of expiration; and the statement "For Autologous Use Only."
4. If stored in the blood bank, the unit shall be handled like any other autologous unit.
5. The transfusion of shed blood collected under postoperative or post-traumatic conditions shall begin within 6 hours of initiating the collection.

# Postoperative Blood Salvage

- Collection of blood from surgical drains which is followed by reinfusion.
- The blood recovered is dilute, partially haemolysed and defibrinated, has high concentration of cytokines.
- Use of these techniques varies among institutes.
- Disparity may be due to variability in transfusion practices among different institutes.

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- These agents can be applied directly to wounds that display diffuse microvascular bleeding or can be used to seal vascular grafts
- Imp. to note that these preparations represent additional allogeneic blood donor exposure
- Issues of informed consent for administration of these blood products and criteria for their use need to be addressed
- S/E :
  1. Anaphylactic reaction
  2. Disease transmission

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- **Fibrin Glue :**

- Derived from a source of fibrinogen & F XIII (fibrin-stabilizing factor), in which a solution of fibrinogen is mixed with a solution of thrombin
- Alternatively, the source of fibrinogen & F XIII can be derived from as little as 40 mL of the patient's autologous blood
- A solvent-detergent-treated fibrin glue preparation is now available

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- **Bioglue :**

- Biological glue initially approved for use in the repair of aortic dissection.
- Composed of purified bovine serum, albumin & gluteraldehyde.
- Action is almost instantaneous bcoz gluteraldehyde exposure leads to the tenuous binding of lysine molecules, proteins & tissue surfaces



- **Tisseel VH :**

- A topical protein solution sealer
- Sprayed onto hemorrhagic surfaces.
- Contains fibrinogen, thrombin, CaCl<sub>2</sub> & aprotinin.
- When protein & thrombin solutions are mixed & topically sprayed, a viscous solution that rapidly sets into an elastic coagulum is produced.
- Fibrin sealant safe in regard to viral transmission & highly effective in controlling localized bleeding in cardiac surgeries

- **FloSeal :**

- A gelatin-based hemostatic sealant
- Activates the clotting cascade & simultaneously forms a nondisplacing hemostatic plug
- A FloSeal kit contains a bovine-derived gelatin matrix, a bovine-derived thrombin component & a syringe applicator.
- The gelatinous matrix is biocompatible & reabsorbed in 6 - 8 wks.

# Recombinant Factor VIIA

- For t/t of bleeding in hemophilia patients with inhibitors
- Enhance the thrombin generation on activated platelets & may also likely be of benefit in providing hemostasis in other (nonapproved) situations characterized by profuse bleeding & impaired thrombin generation
- Also used in surgical bleeding situations with dilutional or consumptive coagulopathies & in pts with impaired liver function
- Dosing - 4.8-mg vial administered to an adult pt 50-100 kg (100- $\mu$ g/kg to 50- $\mu$ g/kg )

# Hemoglobin-Based Oxygen Carrying Solutions

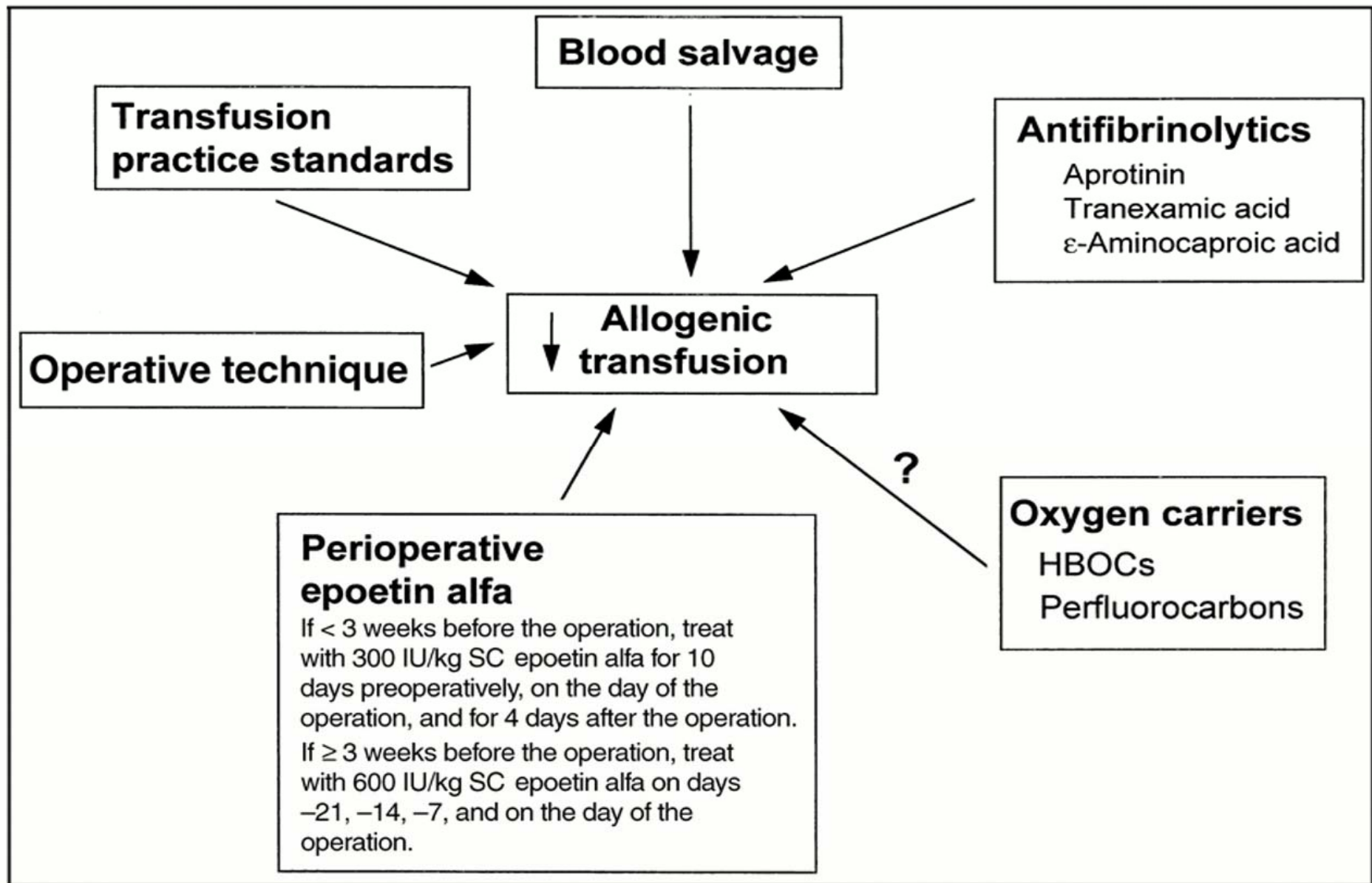
- Polymerized hemoglobin products (polyheme)
- Phase III trial in the US
- The products studied use bovine, outdated human, or recombinant Hb that has been entirely separated from RBC membranes (stroma) & polymerized to ↑ T1/2
- Polymerization ↑ es t1/2 to 18 - 36 hrs but that period is sufficiently short that O<sub>2</sub>-carrying capacity will usually become inadequate before native reticulocytosis can compensate

- S/E :

1. Methemoglobinemia

2. Interference with some calorimetrically based laboratory assays (including creatinine, total bilirubin & LDH)

3. A relatively short half-life



Thank you  
For  
Listening