Optimal Use of Blood Component

Wichai Prayoonwiwat
Blood Donor

- Normal healthy adults 18-25 years
- Pregnant & lactating women are not accepted
- Volumes of blood taken
  - <1/10 of total blood volume
    - <420 mL
- Blood 500 mL ~ Iron 250 mg
Blood Donor

- Male Hb > 13.5 g/dL
- Female Hb > 12.5 g/dL
- Donors are not bled more than twice a year without replacement
- FeSO$_4$ 0.4 g daily for 30 days
- BP > 200/110 mmHg is not bled.
Hazards of Blood Donation

- Fainting
- venous spasm
- Hyperventilation, tetany
- Bruising
- Infection
## Clinically important blood group systems

<table>
<thead>
<tr>
<th>Systems</th>
<th>Frequency of antibodies</th>
<th>Cause of haemolytic transfusion reaction</th>
<th>Cause of haemolytic disease of newborn</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABO</td>
<td>Very common</td>
<td>Yes (common)</td>
<td>Yes (usually mild)</td>
</tr>
<tr>
<td>Rh</td>
<td>Common</td>
<td>Yes (common)</td>
<td>Yes</td>
</tr>
<tr>
<td>Kell</td>
<td>Occasional</td>
<td>Yes (occasional)</td>
<td>Yes</td>
</tr>
<tr>
<td>Duffy</td>
<td>Occasional</td>
<td>Yes (occasional)</td>
<td>Yes</td>
</tr>
<tr>
<td>Kidd</td>
<td>Occasional</td>
<td>Yes (occasional)</td>
<td>Yes (occasional)</td>
</tr>
<tr>
<td>Lutheran</td>
<td>Rare</td>
<td>Yes (rare)</td>
<td>Yes (occasional)</td>
</tr>
<tr>
<td>Lewis</td>
<td>Occasional</td>
<td>Yes (rare)</td>
<td>No</td>
</tr>
<tr>
<td>P</td>
<td>Occasional</td>
<td>Yes (rare)</td>
<td>No</td>
</tr>
<tr>
<td>MN</td>
<td>Rare</td>
<td>Yes (rare)</td>
<td>Yes (rare)</td>
</tr>
<tr>
<td>Li</td>
<td>Rare</td>
<td>Unlikely</td>
<td>Yes (rare)</td>
</tr>
</tbody>
</table>
Modern Transfusion Practice
• Blood is separated into various components
• Individual component ....need of the patient
• Superior to whole blood
  - concentration
  - increasing efficacy
  - minimizing volume
• Donated blood to maximal and optimal use
Optimal Use

- Indication
- Efficacy
- Complication
Blood Components

Whole blood

Cellular components
Red cells
Platelets
White cells

Fresh plasma

Fresh frozen plasma

Cryoprecipitate
Factor VIII concentrate

Cryosupernatant
Albumin
Immunoglobulins
Other concentrates
Fresh Whole Blood
  \[
  1,800 \text{ cpm 7 min}
  \]
  Packed Red Cell
  \[
  \text{Store at 4 } ^\circ\text{C}
  \]
  Plasma + Platelets
  \[
  3,000 \text{ cpm 10 min}
  \]
  Plasma Platelet Concentrate
  \[
  \text{Store at -20 } ^\circ\text{C 24 h}
  \]
  Fresh Frozen Plasma with Cryoprecipitate
  \[
  \text{Store at 22 } ^\circ\text{C}
  \]
  FFP Cryoprecipitate
  \[
  \text{Store at -20 } ^\circ\text{C for 1 y}
  \]
Blood Components

- Red blood cells
- Platelets
- Plasma and derivation
- Granulocytes
Red Blood Cells

- Homologous packed RBC
- Leukocyte-poor RBC
- Washed RBC
- Frozen RBC
- Neocytes
- Directed donor RBC
- Autologous RBC
Platelets

- Random donor
- Single-donor
- Leukocyte-poor
- HLA-matched
Plasma and derivatives

- Fresh frozen plasma
- Cryoprecipitate-poor plasma
- Cryoprecipitate
Granulocytes

- Stimulated leukapheresis
Measures to Protect the Recipient

- Viral hepatits: HBV, HCV, Non-A Non-B
- HIV
- CMV
- Syphilis 4°C 4 days
- Malaria 4°C 3 weeks
The Storage of Blood

- Heparin 24 Hours
- ACD 21 Days
- CPD 21 Days
- Adenine 17 mg to 1 unit of blood 1-2 weeks longer
Some of the Changes Occurring in Blood Stored in ACD Solution at 4°C

<table>
<thead>
<tr>
<th>DAYS STORED</th>
<th>0</th>
<th>7</th>
<th>14</th>
<th>21</th>
<th>28</th>
</tr>
</thead>
<tbody>
<tr>
<td>%Red cells destroy within 24 h of Tx.</td>
<td>0</td>
<td>5</td>
<td>10</td>
<td>20</td>
<td>33</td>
</tr>
<tr>
<td>Plasma pH</td>
<td>6.9-7</td>
<td>6.8</td>
<td>6.7</td>
<td>6.6</td>
<td></td>
</tr>
<tr>
<td>Plasma K (mM)</td>
<td>3-4</td>
<td>12</td>
<td>24</td>
<td>32</td>
<td>40</td>
</tr>
<tr>
<td>Plasma Na (mM)</td>
<td>150</td>
<td>148</td>
<td>145</td>
<td>142</td>
<td>140</td>
</tr>
<tr>
<td>Plasma Hb (g/dL)</td>
<td>0-0.1</td>
<td>0.25</td>
<td>0.5</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>2-3 DGP</td>
<td>10-20%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Add Adenine = 70%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Storage Defects and Microvascular Perfusion

- Build-up of cytokines, free Hgb, K+, debris (BRMs) $^{1,2}$
- Decreased 2,3- DPG, ADP, NO
- Poor deformability$^{3}$

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2. Fransen, Chest 1999;116
3. Hovav, Transfusion 1999; 39
# Storage of Other Constituents of Blood

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Temperature</th>
<th>24 h</th>
<th>48 h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Platelets</td>
<td>4°C</td>
<td>5%</td>
<td>0%</td>
</tr>
<tr>
<td>Factor VIII</td>
<td></td>
<td>50%</td>
<td></td>
</tr>
<tr>
<td>Factor V</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Platelets: 5% of original plts. are viable after 24 h. 0% after 48 h.

Factor VIII: 50% after 12 h. Not survive or storage.
Indications (RBC)

- Chronic hypoproliferative anemia
- Acute blood loss
- High-risk patients
- Hemolytic anemia
- Sickle cell anemia
- Perioperative transfusion
Un acceptable indication

• Enhance a patient’s general sense of well being
• Promote wound healing
• Expand vascular volume
Perioperative transfusion

- Non cardiac surgery
  .............Hb > 7-8 g/dL
- No risk factors for MI
  ............. > 7-8 g/dL
- Elderly patient Hb
  ............. > 9 g/dL
- Hb < 10 g/dL
Acute blood loss

- Healthy young person generally tolerates 500-1,000 mL of ABL
- ABL 1,000-2,000 mL
  ... volume replacement alone
- ABL > 2,000 mL
  ... required RBC transfusion
- ABL intraoperative > 500 mL
- Burn...volume depletion
High-Risk Patients

- Impairs ability to increase intravascular volume
- Heart rate
- Stroke volume
- Blood flow

- Older patient
- Coronary artery disease
- Vascular disease
Hemolytic anemia

- Symptomatic hemolytic anemia
- ABO & Rh match least degree of in vitro hemolysis
- Blood warmer for cold antibody
RBC Transfusion
When? How much?
• No single Hb threshold
• Clinical status > Hb level
• Hemodynamic instability
• Symptoms and signs of impaired organ function
• Rate of blood loss
• Response to transfusion
• Anemia & platelet dysfunction
RBC

$O_2$ carrying capacity

- Chronic anemia
- Heart failure
- Old aged
- ↑ Hb before surgery

PRC + NSS
Leukocyte Poor Blood

給患者有 febrile reaction

เช่น ผู้ป่วยที่ให้เลือดบ่อย ๆ

pregnancy
Frozen red blood cell
Washed red blood cell
Platelet Concentrate

- Thrombocytopenia < 20x10⁹/L
- Bleeding
Choice of Platelet Product

- Underlying condition
  - acute, reversible, chronic thrombocytopenia
  - local availability of supplies
Pooled random donor platelet
Single-donor platelets

→ Correction of severe thrombocytopenia
→ Platelet dysfunction
→ Massive bleeding
→ Cardiopulmonary bypass
Single-donor platelets
- Decrease exposure to infections agents
Leukocyte-poor platelets (filtered or irradiated)

- Prevent alloimmunization to HLA antigen in inpatients requiring repeated platelet transfusions
HLA-matched platelets
- Treat bleeding associated with thrombocytopenia in patients who are refractory to platelet transfusion due to HLA sensitization
Alternative to Platelet Transfusions

- DDAVP
- Transamnine
- Estrogen
- RBC transfusion
- Erythropoietin
FFP, Cryoprecipitate

- Coagulation factor deficiency
  - Prevention
  - Bleeding
- Replacement therapy
Indication of FFP

- Correct of factor deficiency
- Liver disease
- DIC
- Vitamin K deficiency
- Warfarin overdose
- Massive bleeding
Indication of FFP

- Antithrombin deficiency
- Severe protein-losing
- Severe C1 esterase inhibitor deficiency with life-threatening angioedema
- TTP/HUS
Plasma Exchange Therapy

- Cryoglobulinemia
- Goodpasture syndrome
- Guillain-Barre syndrome
- Homozygous familial hypercholesterolemia
- Pottransfusion purpura
- TTP
Plasmapheresis

- Chronic inflammatory demyelinating polyneuropathy
- Cold agglutinin disease
- Autoimmune thrombocytopenia
- Rapidly progressive glomerulonephritic
- Systemic vasculitis
Plasma Requirements

- ABO-type-specific FFP
- Appropriate dose of FFP
  - plasma volume of patient
  - the desired increase in factor activity
  - the expected half-life of the factors
Cryoprecipitate: Indication

- Severe hypofibrinogenemia (100 mg/dL)
- Uremia with severe bleeding unresponsive to dialysis and DDAVP
- Topical fibrin glue
- F XIII deficiency
- vWD
WBC Concentrate

Good prognosis

Fever (infection) fail antibiotic

WBC: Neutrophil < 0.5⁹/L

ABO & HLA matched
Complications

- Hemolytic transfusion reactions
- Reaction due to WBC & platelet Abs
- Allergic & anaphylactic reactions
- Circulatory overload, thrombophlebitis, air embolism
- Reaction due to bacterial pyrogens and bacteria
Complications

- Complication of massive transfusion
- Disease transmitted by blood transfusion
- Transfusion hemosiderosis
- Immunological sensitization
Pseudohemolytic transfusion reaction

Recipient cell hemolysis

- Drugs: Penicillin, quinidine
- Hemolytic anemia
- Infections: Malaria
- Large hematoma
- Mechanical trauma: Prosthesis heart valve
Donor cell hemolysis

- Thermal extremes
- Cardiopulmonary bypass
- Bacterial infected blood
- Drugs administration
- Hypotonic solution
Noncardiogenic Pulmonary Edema

- Pulmonary hypersensitivity reaction
- Allergic pulmonary edema
- Transfusion-related acute lung injury
Intravascular RC Destruction

- Lumbar pain
- Feeling of constriction in the chest
- Tachycardia & BP ↓
- Anaesthetized patient
  1\textsuperscript{st} sign = bleeding at a previously dry operative site
Red Cells Lysed

- Thromboplastin-like substances
- Hemoglobinemia
- Hemoglobinuria
- Fibrin Clot
- Oliguria Anuria
- Acute defibrination Syndrome
- Thrombocytopenia
- Hypofibrinogenemia
- Fibrinolysis
- MAHA
Immediate HTR

- Most dangerous type
- Due to antibodies
- Rate of destruction
  - Potency and type of Ab
  - Strength of Ag
  - Quantity of incompatible RC
Immediate HTR

- Preventable
  - Personal errors
  - Incorrect labeling
  - Failure to check the labels
  - Errors of identification of the patients
Febrile Non-Hemolytic Transfusion Reaction

Multiple Transfusion

Leukoagglutinin

Blood transfusion with WBC

Leukocyte lysis

Pyrogen

Fever, Chill, N-V, Hypotension
Headache, Myalgia
Reaction Due to WBC & Platelet Antibodies

Febrile Reactions

- Ab in plasma against Ag on WBC & Platelets
- Onset 0.5 - 3 h
- BT 38-40°C $< 8$ h normal
- Chill & headache
- Blood pressure normal
ให้เลือดแล้วมีไข้ขึ้น

- ผู้ป่วยมีไข้เพียงอย่างเดียว
- การให้เลือดอาจไม่จำเป็นต้องหยุดทันที
- ให้เลือดให้ช้าลง
- เก็บตัวอย่างเลือดจากผู้ป่วยตรวจ
  Antiglobulin test → negative
  ให้เลือดต่อ
- ดู free hemoglobin → No free Hb
Reaction Due to WBC & Platelet Antibodies

Treatment:

- ASA before transfusion
- Slow rate of transfusion
- Antihistamine intravenous
Allergic Transfusion Reaction

- Anaphylactoid
- Urticaria
- พบประมาณ 3%
- Ig A deficiency → severe anaphylaxis

Rx WASHED RED BLOOD CELL
Post Transfusion Purpura

- Male > Female
- Occur 1 week posttransfusion
- Spontaneous recover 1-6 weeks
- Rx exchange transfusion, plasmapheresis, corticosteroid, platelet conc.
- Anti BaK\(^a\), Anti PI\(^{A2}\), Anti GP 120, Anti GP IIb
- Anti PIA1
Post-transfusion purpura

- 7-14 days post PRC or platelet transfusion
- Severe thrombocytopenia (< 10 x 10^9/L)
- Lab: Anti-HPA antibody, HPA typing (National blood center)
- Avoid transfusion if possible, IVIg, plasma exchange
Volume Overload

- Elderly people with degenerative vascular disease
- The first warning signs
  - Dry Cough
  - ↑ Jugular venous pressure
  - Acute pulmonary edema
- Severe chronic anemia c CHF
  - Partial exchange transfusion
  - PRC 200 mL
- Treatment as treat CHF
Bacterial contamination

Cold growing bacteria Gram-ve

↓

Endotoxin

↓

Pyrexia, Hemoglobinuria, Renal failure
Shock, DIC

↓

Pharmaceutical incompatibility
Transfusion of Heavily Infected Blood

immediated reaction

BT°C prostration peripheral circulatory failure persistent hypotension

Acute Defibrination Syndrome
Reactions Due To Bacterial Pyrogens and Bacteria

- Fever from pyrogens → almost never nowadays
- Reaction due to infected blood
  - Very serious complication
  - Worse than ABO incompatibility
  - Often fatal outcome
  - Gram-ve bacteria
Reactions Due To Bacterial Pyrogens and Bacteria

Prevention >>> Treatment

• All blood should be kept at 2-6°C
• One unit should be issued at time
• ห้ามเก็บเลือดไว้ที่ room temperature
• เปลี่ยน set ให้เลือด ทุก 8 ชั่วโมง
Diagnosis:

- Culture at 4°C, 20°C, 37°C

Treatment:

- Maintain BP & broad spectrum antibiotics
Massive Transfusions

- ให้เลือด > total blood volume in 24 h
- Cardiac irregularities, ventricular fibrillation, arrest
- Cause
  - excess citrate in the blood
  - low temperature
  - biochemical changes
- Excess citrate $\rightarrow \text{Ca}^{2+}$
- Citrate $\rightarrow \text{Liver} \rightarrow \text{HCO}_3^-$
Massive Transfusions

- Blood 1 L + 1 g calcium
- Low pH NaHCO$_3$ 44.6 mEq/blood 2.5 L
- ↓ Platelet, coagulation factor

Recommend

- ให้เลือด < 10 days
- 20% ของเลือด ควรเป็น fresh blood
- After 2.5 L of blood + NaHCO$_3$
# UTHSC-H MT Guideline

## Adult Trauma Massive Transfusion Guidelines

<table>
<thead>
<tr>
<th>Component</th>
<th>Instructions</th>
</tr>
</thead>
</table>
| **FFP**     | As soon as the need for massive transfusion is recognized.  
              For every 6 RBCs, give 6 FFP (1:1 ratio)  
              NOTE: 1 Jumbo FFP = 3 FFP                                                               |
| **Platelets** | As soon as the need for massive transfusion is recognized.  
                   For every 6 RBCs, give 1 dose of platelets (1:1 ratio)  
                   NOTE: 1 dose of platelets are equal to either 6 Random-Donor plt units or 1 apheresis plt unit |
| **Cryoprecipitate** | After first 12 RBCs, check fibrinogen level. If <100 mg/dL, give 10 units cryo.  
                                   Repeat as needed, depending on fibrinogen level, and request appropriate amount of cryo.  
                                   NOTE: FFP also contains fibrinogen and thus cryoprecipitate may not be frequently needed. |
rVIIa in Trauma - Summary

- rVIIa is a wonder drug, but...
  - rVIIa will not stop surgical bleeding
  - rVIIa does not replace the need to correct the cause of the bleeding & coagulopathy
    › Shock
    › Acidosis
    › Hypothermia
    › DIC
    › “Substrate”- vitamin K, platelets, FFP, cryo
    › Continued mechanical source of bleeding
  - It is a temporary plug, at best

- Patient selection, timing and dosing are the billion dollar questions
Diseases Transmissible by Blood Transfusion

Syphilis ... 1°C - 6°C เชื้อตาย

Fresh blood & platelet conc. (22°C) นำเชื้อไปได้
Diseases Transmissible by Blood Transfusion

Parasites
- African trypanosomiasis
- Kala-azar
- Chagas disease
- Microfilaria
- Toxoplasmosis
Virus

Post Transfusion Hepatitis

- Most common
- Asymptomatic → Dead
- Hepatitis B, C, non-A non-B
- Incubation period 15-18 days
- NANB 90% incubation period 4-10 weeks
Virus

Post Transfusion Hepatitis

WBC conc.  เสี่ยงที่สุด
Frozen red cell ปลอดภัยที่สุด
กลุ่มเสี่ยง Immunocompromised host,
Exchange transfusion,
Massive transfusion,
Infant,
Open heart surgery
Virus

Human Parvovirus Infection
- Aplastic crisis
- F VIII concentrate
Other Disease

- Herpes virus
- Infectious mononucleosis
- Brucellosis
- Typhus
- Measles
- Salmonellosis
Other Reactions

- Thrombophlebitis
- G-6-PD deficiency
- Hemochromatosis
- Air embolism
- Isoimmunization
Optimal Use

- Indication
- Efficacy
- Complication
Thank you