Transfusion Medicine
Kristine Krafts, M.D.
Transfusion Medicine Outline

- Blood groups
  - Introduction
  - ABO system
  - Rh system
  - Other systems

- Blood transfusion
  - Blood products
  - Testing
  - Dangers
Transfusion Medicine Outline

- Blood groups
  - Introduction
Q. What determines a blood group?
Q. What determines a blood group?
A. The antigens on the red cell surface.
Red Cell Antigens

- Antigens are inherited (Mendelian pattern)
- Real function unknown
- Damn important during transfusion
- Lots of antigens exist (grouped into systems)
- Most important systems: ABO and Rh
Transfusion Medicine Outline

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  - ABO system
What are the antigens?

- A and B
- Some people have A antigen ("type A")
- Some people have B antigen ("type B")
- Some people have both A and B ("type AB")
- Some people have neither A nor B ("type O")
Type A

Type B

Type AB

Type O
How do you make the antigens?

- Start with a protein precursor
- Add fucose to make H antigen
- Add N-acetylgalactosamine to H Ag to make A Ag
- Add galactose to H Ag to make B Ag
H antigen  
A antigen  
B antigen
What are the genes?

H gene
- Everyone* has this one
- Codes for an enzyme that makes H antigen

A, B, and O genes
- Everyone has two genes
- Six possible genotypes: AA, BB, AB, AO, BO, OO
- A and B code for enzymes that make A and B antigens
- O has no gene product.*

* Almost
<table>
<thead>
<tr>
<th>Genotype</th>
<th>Antigens</th>
<th>Blood type</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>AO</td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>BB</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>BO</td>
<td></td>
<td>B</td>
</tr>
<tr>
<td>AB</td>
<td>A and B</td>
<td>AB</td>
</tr>
<tr>
<td>OO</td>
<td>None</td>
<td>O</td>
</tr>
</tbody>
</table>
How common is each blood type?

<table>
<thead>
<tr>
<th>Blood type</th>
<th>Percent of population</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>40%</td>
</tr>
<tr>
<td>B</td>
<td>12%</td>
</tr>
<tr>
<td>AB</td>
<td>6%</td>
</tr>
<tr>
<td>O</td>
<td>42%</td>
</tr>
</tbody>
</table>
So what?

• We have antibodies to the antigens we don’t have!
• Anti-A antibodies lyse type A red cells.
• Anti-B antibodies lyse type B red cells.
• This is very important during blood transfusion.
<table>
<thead>
<tr>
<th>Genotype</th>
<th>Antigens</th>
<th>Blood type</th>
<th>Antibodies</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA</td>
<td>A</td>
<td>A</td>
<td>anti-B</td>
</tr>
<tr>
<td>AO</td>
<td></td>
<td>A</td>
<td>anti-B</td>
</tr>
<tr>
<td>BB</td>
<td>B</td>
<td>B</td>
<td>anti-A</td>
</tr>
<tr>
<td>BO</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AB</td>
<td>A and B</td>
<td>AB</td>
<td>none</td>
</tr>
<tr>
<td>OO</td>
<td>None</td>
<td>O</td>
<td>anti-A, anti-B</td>
</tr>
</tbody>
</table>
## Compatible blood types

<table>
<thead>
<tr>
<th>Recipient blood type</th>
<th>Donor blood type</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>A or O*</td>
</tr>
<tr>
<td>B</td>
<td>B or O</td>
</tr>
<tr>
<td>AB</td>
<td>AB, A, B, or O</td>
</tr>
<tr>
<td>O</td>
<td>O</td>
</tr>
</tbody>
</table>

* type O = universal donor!
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  - Rh system
What are the antigens?

- Most important antigen: D!
- “Rh” because discovered using Rhesus monkeys.
- “Rh factor” refers to the D antigen.
- Two alleles: D and d.
- People with the D allele make D antigen and are Rh+.
<table>
<thead>
<tr>
<th>Genotype</th>
<th>Antigens</th>
<th>Blood type</th>
</tr>
</thead>
<tbody>
<tr>
<td>DD</td>
<td>D</td>
<td>Rh +</td>
</tr>
<tr>
<td>Dd</td>
<td>D</td>
<td>Rh +</td>
</tr>
<tr>
<td>dd</td>
<td>none</td>
<td>Rh -</td>
</tr>
</tbody>
</table>
What are the antibodies?

- Antibodies in this system are acquired!
- To make anti-D you must:
  1. lack the D antigen on your red cells
  2. get exposed to D + blood
- Donor and recipient are tested for the D antigen.
Transfusion Medicine Outline

- Blood groups
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  - Rh system
  - Other systems
Don’t tell me there are more systems.

- There are almost a sh*tload of other systems.*
- These are not included in routine testing.
- Antibodies to antigens in these systems are usually acquired (like anti-D), so unless a patient has been transfused or pregnant, you don’t need to worry too much.

* Not quite: a sh*tload is defined as more than 42.
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- Blood transfusion
  - Blood products
What do you mean, products?

• In olden times, there was only whole blood.
• Now, we separate blood into its components
• Better for the patient
• Conserves blood supply
What are the products?

- Whole blood
- Red cells
- Platelets
- Granulocytes
- Cryoprecipitate
- Fresh frozen plasma
Apheresis donation
BLOOD PRODUCTS

Whole Blood

Red Cells

Granulocytes

Platelet-Rich Plasma
BLOOD PRODUCTS

Whole Blood

Contents:
- RBC
- WBC
- platelets
- plasma

Use: massive hemorrhage
BLOOD PRODUCTS

Whole Blood

Red Cells

- RBC
- Contents: a few WBC, a few platelets, a little plasma

Use: low hemoglobin
BLOOD PRODUCTS

Whole Blood

Red Cells

Granulocytes

Contents: neutrophils

Use: sepsis in neutropenic patients
BLOOD PRODUCTS

Whole Blood

Red Cells
Granulocytes
Platelet-rich plasma
Platelet-Rich Plasma

Platelets

Contents: platelets

Use: bleeding due to thrombocytopenia
Platelets

Fresh Frozen Plasma

Use: bleeding due to multiple factor deficiencies (e.g., DIC)
**BLOOD PRODUCTS**

- Whole Blood
  - Red Cells
  - Granulocytes
  - Platelet-Rich Plasma
    - Platelets
    - Fresh Frozen Plasma
      - Cryoprecipitate
        - fibrinogen
        - Contents: von Willebrand factor VIII XIII
        - Use: low fibrinogen, vW disease, hemophilia A, XIII deficiency
BLOOD PRODUCTS

Whole Blood
- Red Cells
- Granulocytes
- Platelet-Rich Plasma
  - Platelets
  - Fresh Frozen Plasma
    - Cryoprecipitate
    - VIII
      - Use: hemophilia A
BLOOD PRODUCTS

Whole Blood

- Red Cells
- Granulocytes
- Platelet-Rich Plasma
  - Platelets
  - Fresh Frozen Plasma
    - Cryoprecipitate
    - VIII
      - IX
        - Use: hemophilia B
BLOOD PRODUCTS

- Whole Blood
  - Red Cells
  - Granulocytes
  - Platelet-Rich Plasma
    - Platelets
    - Fresh Frozen Plasma
      - Cryoprecipitate
        - Albumin
          - Use: hypovolemia with hypoproteinemia
      - VIII
      - IX
BLOOD PRODUCTS

Whole Blood

Red Cells

Granulocytes

Platelet-Rich Plasma

Platelets

Fresh Frozen Plasma

Cryoprecipitate

VIII

IX

Albumin

IvIG

Use: disease prophylaxis, autoimmune disease, immune deficiency states
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  • Rh system
  • Other systems

• Blood transfusion
  • Blood products
  • Testing
Forward typing is done using both anti-A and anti-B antibodies!
Reverse typing is done using both type A and type B reagent cells!
CROSSMATCH

patient serum

donor RBC

AHG

Positive test result
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What can go wrong?

- Transfusion reactions
  - hemolytic
  - non-hemolytic
- Other complications
  - infections
  - circulatory overload
  - iron overload
Acute Hemolytic Transfusion Reactions

• Happen when patient has ABO antibodies against the donor red cells.
• Most common reason: clerical error!
• Symptoms: fever, chest pain, hypotension.
• Hemoglobin in serum, urine.
• Labs: ↓ haptoglobin, ↑ bilirubin, DAT positive.
• Type and cross-match shows ABO mismatch.
donor type A
anti-B
recipient type B
anti-A
clumping of donor cells
donor cells burst
kidney damage
small vessels blocked
reduced blood supply
Delayed Hemolytic Transfusion Reactions

- Hemolysis occurs days after transfusion.
- Caused by antibodies to non-ABO antigens.
- Hemolysis usually extravascular.
- Presentation: falling Hgb after transfusion.
- Usually not severe.
- DAT +. Antibody screen identifies the antibody.
Febrile Transfusion Reactions

- Caused by recipient antibodies against donor WBC.
- Cytokines $\rightarrow$ fever, headache, nausea, chest pain.
- Diagnosis: rule out everything else
- Treatment: Tylenol. Leukocyte-reduced components.
Allergic Transfusion Reactions

- Probably a host reaction to donor plasma proteins
- Symptom: hives
- Treatment: antihistamines
- Rarely, reaction is severe (anaphylaxis)
What do you do if you suspect a transfusion reaction?

- Stop the transfusion!
- Check if right blood went to right patient
- Monitor vitals
- Send blood, urine, and bag to blood bank
What does the lab do?

- Check paperwork
- Look for hemoglobinuria
- Do a DAT
- Repeat ABO, Rh testing
Infections

- Transfusion-related bacterial infection is an uncommon but serious risk.
- Patients suddenly develop fever and shock.
- Patient – and blood unit – must be tested.
- Treatment: aggressive resuscitation and antibiotic therapy.
Infections

- Donor tests: HIV, HTLV, Hepatitis B and C, syphilis.
- Despite testing, these diseases are still transmitted.
- Other transmissible infections:
  - viruses (EBV, CMV)
  - parasitic diseases (malaria, Lyme disease)
Circulatory Overload

- Happens when too much blood is given too quickly
- Symptoms: hypertension, congestive heart failure
- Stop transfusion, give diuretics
Iron Overload

- Too much iron can damage heart, liver
- Patients with chronic anemias are at biggest risk
- Give iron-chelating agents
What’s the risk of getting an infection?

<table>
<thead>
<tr>
<th>Bug</th>
<th>Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bacterial infection</td>
<td>One in 50,000 - 500,000 *</td>
</tr>
<tr>
<td>Hepatitis B</td>
<td>One in 300,000</td>
</tr>
<tr>
<td>Hepatitis C</td>
<td>One in 2 million</td>
</tr>
<tr>
<td>HIV</td>
<td>One in 2 million</td>
</tr>
</tbody>
</table>

* 1 in 50,000 platelet transfusions; 1 in 500,000 RBC transfusions
What’s the risk of other complications?

<table>
<thead>
<tr>
<th>Complication</th>
<th>Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allergic reaction</td>
<td>One in 100 (severe: one in 20,000)</td>
</tr>
<tr>
<td>Febrile reaction</td>
<td>One in 200</td>
</tr>
<tr>
<td>Circulatory overload</td>
<td>One in 3,000</td>
</tr>
<tr>
<td>Delayed hemolysis</td>
<td>One in 4,000 (fatal: one in 4 million)</td>
</tr>
<tr>
<td>Acute hemolysis</td>
<td>One in 20,000 (fatal: one in 600,000)</td>
</tr>
</tbody>
</table>