Chapter 19

Blood Types
What is an antigen?

- Antigens are glycoprotein and glycolipid molecules which are part of the plasma membrane (i.e. part of the glycocalyx)

- These molecules maybe imbedded into the plasma membrane of human cells, microbes, parasites, and viruses. A toxin produced by a cell can also act as an antigen to stimulate immune cells

- Antigens are “identity molecules”. Antigens allow your immune system to recognize self vs non-self cells. Our immune system uses antigens to distinguish between self and non-self in order to attack non-self antigen and not our cells with self-antigen.

- We also use a special group of antigens to give identity to our RBCs. (e.g. ABO system & Rh // however there are many different RBC antigens --- but ABO and Rh are the most common and therefore the most problematic)

- Foreign antigens are “masked or covered” by our immune system’s antibodies // this then prevents non-self antigen from harming our tissues but also renders the foreign antigen harmless and tags the pathogen for destruction.
Antigen & Antibodies in Blood Types

- blood types and transfusion compatibility is a matter of interactions between antibodies (blood plasma proteins) and antigen (on erythrocytes)

- Karl Landsteiner discovered blood types A, B and O in 1900 // won Nobel Prize for discovery

- blood types are based on interactions between antigens and antibodies

- agglutinogens also called antigens (located on plasma membrane)

- agglutinins also called antibodies (located in plasma circulating in blood, lymph, tissue fluid)
Blood Antigens and Antibodies

• Agglutinogens or antigens
  – complex molecules on surface of cell membrane that are unique to every individual (accept identical twins!)
  
  – agglutinogens (antigens) on the surface of the RBC is the basis for blood typing
  
  – Antigens are also used to distinguish self from non-self (foreign cells)
  
  – foreign antigens are able to generate an immune response
Blood Antigens and Antibodies

• Agglutinin or antibodies associated with blood typing
  
  – In blood chemistry we make antibodies only if we do not have the antigen on our RBC!
  
  – Antibody A and antibody B are the two antibodies
  
  – If RBC has neither A or B agglutinogen then we will have both antibody A and antibody B circulating in our blood
  
  – Mismatch blood transfusions can lead to organ damage and death // agglutinins in the recipient’s plasma will bind to donor’s RBC
Blood Antigens and Antibodies

- Agglutination
  - antibody molecule binding to antigens (e.g. A antibody binds to A antigen) // one antibody can bind to several different RBC
  - causes clumping together of red blood cells
  - clumped cells block capillaries // infarctions occur that damage organs // kidneys especially vulnerable to this type of damage
  - each antibody can attach to several foreign antigens on several different RBCs at the same time
  - agglutinated RBCs block small blood vessels, hemolyze, and release their hemoglobin over the next few hours or days
  - Hb blocks kidney tubules and causes acute renal failure
Agglutination of Erythrocytes

Antibodies (agglutinins)
Transfusion Reaction

Blood from type A donor

Type B (anti-A) recipient

Donor RBCs agglutinated by recipient plasma

Agglutinated RBCs block small vessels
Agglutinogens VS Agglutins

<table>
<thead>
<tr>
<th>BLOOD TYPE</th>
<th>TYPE A</th>
<th>TYPE B</th>
<th>TYPE AB</th>
<th>TYPE O</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red blood cells</td>
<td>A antigen</td>
<td>B antigen</td>
<td>Both A and B antigens</td>
<td>Neither A nor B antigen</td>
</tr>
</tbody>
</table>

Plasma

- Anti-B antibody
- Anti-A antibody
- Neither antibody
- Both anti-A and anti-B antibodies
Agglutinogens VS Agglutins

- RBC antigens called agglutinogens
  - called antigen A and B
  - determined by carbohydrate moieties found on RBC surface
- antibodies called agglutinins
  - found in plasma
  - anti-A and anti-B
ABO Group

- your ABO blood type is determined by presence or absence of antigens (agglutinogens) on RBCs

  - blood type A person has A antigens
  - blood type B person has B antigens
  - blood type AB has both A and B antigens
  - blood type O person has neither antigen

- most common - type O (universal donor)
- rarest - type AB (universal recipient)
ABO Blood Typing

Aglutinin A
(antibody A)

Aglutinin B
(antibody B)

What is the blood type of these blood samples?
ABO Blood Typing

Type A

Type B

Type AB

Type O

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Plasma Antibodies

- antibodies (agglutinins) // anti-A and anti-B
- appear 2-8 months after birth
- maximum concentration at 10 yr.
- antibody-A and/or antibody-B (both or none) are found in plasma
- You will never form plasma antibody to RBC antigen if the antigen is on your RBC!
- You will only make plasma antibody to an RBC antigen if it is not present on the RBC
- These rules only apply to the ABO system (does not apply to Rh factor // different rules apply for Rh factor)
Universal Donors and Recipients

• Universal donor

  – Type O // most common blood type

  – Lack RBC antigens

  – This donor’s plasma will have both plasma antibodies (anti-A and anti-B)

  – Minimize affect of antibodies by giving packed cells (minimal plasma volume)
Universal Donors and Recipients

• Universal recipient
  – Type AB // rarest blood type
  – Lacks any plasma antibodies
  – No anti A or B
Rh Antigen // Blood Type +

- Rh agglutinogens discovered on rhesus monkey’s RBC in 1940 // other “minor” RBC antigen-antibodies discovered
  - Rh D is the most reactive of these groups
  - Patient considered blood type Rh\(^+\) if they have D antigen (agglutinogens) on their RBCs
  - Rh frequencies vary among ethnic groups
  - Note: you may have the AB antigen with the Rh antigen
Rh Blood Type

- Anti-D agglutinins (antibodies) are normally never present in the blood.

- Only a Rh negative person may be sensitized (i.e. exposed to the antigen) and only then will that person form the Rh agglutinin.

- Rh negative individuals may form anti-D under two mechanisms:
  - 1 = Rh⁻ woman with an Rh⁺ fetus
  - 2 = Rh negative person receive transfusion from a Rh⁺ blood

- No problems at time of first transfusion or pregnancy.

- Takes time to develop antibodies only after Rh negative person exposed will they make antibodies so during second exposure there will be antibodies and result in agglutination disease no problem with first exposure.
Hemolytic Disease of Newborn

• Occurs when Rh\(^-\) woman is sensitized to form Rh-D antibodies then becomes pregnant with second fetus which is Rh\(^+\) // now her antibodies will cross placenta and attach fetal Rh\(^-\) RBCs

  – this may happen because:

  • previously pregnant with Rh\(^+\) fetus
  • received blood transfusion Rh\(^+\) RBC

  – now woman has anti-D in plasma

  • Anti-D antibodies can cross placenta
  • forms antigen-antibody complex in fetal blood / hemolyze fetal RBC
Hemolytic Disease of Newborn

• How to prevention

  – RhoGAM // given to pregnant Rh⁻ women before delivery

  – RhoGAM binds fetal agglutinogens // so Rh⁺ RBC can not sensitize or exposed mother to antigen (now masked by RhoGam) during delivery

  – Mother now will not make Anti-D antibodies
If the woman becomes pregnant with another Rh+ fetus, her anti-Rh antibodies will cross the placenta and damage fetal red blood cells.

Hemolytic disease of the newborn.

1. Rh+ father.
2. Rh- mother carrying her first Rh+ fetus. Rh antigens from the developing fetus can enter the mother's blood during delivery.
3. In response to the fetal Rh antigens, the mother will produce anti-Rh antibodies.
4. If the woman becomes pregnant with another Rh+ fetus, her anti-Rh antibodies will cross the placenta and damage fetal red blood cells.
Hemolytic Disease of Newborn

- Rh antibodies attack fetal blood causing severe anemia and toxic brain syndrome // erythroblastosis fetalis
Antibodies Matched to Non-Self Antigen

- This is the humoral adaptive immunity response
- Antibodies are produced by plasma cells against foreign cells
  - Antibodies are proteins (gamma globulins)
  - Activated plasma cells secrete antibodies matched to specific foreign molecules (i.e. toxins) or cells (e.g. bacteria, virus, parasites)
  - This is the humoral part of our immune system response to foreign matter // these antibodies bind to pathogens not inside of our cells!
  - Binding to antigens results in making the antigen either harmless or marking them for destruction
  - forms antigen-antibody complexes