The ABO System

Objectives
- Discuss the significance of the ABO system in transfusion medicine
- Discuss the discovery of the ABO system
- State the frequency of the ABO groups in Black and White populations
- Explain the inheritance of the A, B and H genes
- Predict all the possible genotypes of children, given the ABO phenotype of the parents

More Objectives
- Outline the development of A, B, and H antigens including the specific transferases and terminal sugars
- State the comparative concentrations of H substance in each ABO phenotype
- Apply Landsteiner’s Law to antibody formation
- Describe the reciprocal relationship between ABO antigens and antibodies
- Evaluate characteristics of ABO antibodies

Clinical Importance

THE
MOST IMPORTANT
BLOOD GROUP
SYSTEM IN
TRANSFUSION
MEDICINE!!!!!

Antibodies directed against ABO antigens are:
- Consistently & predictably present
- Not stimulated by exposure to red blood cells
- Able to activate complement, leading to intravascular lysis of RBCs
- Transfusion of ABO mismatched RBCs causes severe, acute hemolytic transfusion reactions

<table>
<thead>
<tr>
<th></th>
<th>Group A serum</th>
<th>Group B serum</th>
<th>Group O serum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A cells</td>
<td>0</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Group B cells</td>
<td>+</td>
<td>0</td>
<td>+</td>
</tr>
<tr>
<td>Group O cells</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Discovery
- Karl Landsteiner – 1901
ABO Antigens and Antibodies

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>O</th>
<th>AB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
</tbody>
</table>

Blood Group Distribution (%)

<table>
<thead>
<tr>
<th></th>
<th>White</th>
<th>Black</th>
<th>Mexican</th>
<th>Asian</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>45</td>
<td>49</td>
<td>56</td>
<td>43</td>
</tr>
<tr>
<td>A</td>
<td>40</td>
<td>27</td>
<td>27</td>
<td>27</td>
</tr>
<tr>
<td>B</td>
<td>11</td>
<td>20</td>
<td>13</td>
<td>25</td>
</tr>
<tr>
<td>AB</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

3 Main Antigens

- A
- B
- H

3 Genes Control Antigen Expression

- Hh
- ABO
- Se/se (secretor)

Inheritance - Hh

- Controls expression of H antigen
  - Chromosome 19
  - H is dominant; h is recessive
  - Inheritance of hh = Bombay phenotype (Oh)
- A and B antigens can only be produced if the H antigen is present first.

Inheritance - ABO

- Chromosome 9
- A and B genes inherited codominantly
- O gene recessive
  - Amorph
  - H antigen expressed on RBCs
Determining Genotypes
- My father was Group O
- My mother was Group B
- What are the possible ABO genotypes for my sisters and I?

<table>
<thead>
<tr>
<th>Dad</th>
<th>Mom</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>B</td>
<td>B</td>
<td></td>
</tr>
</tbody>
</table>

Determining Genotypes
- Possible genotypes of offspring
  - BO
  - OO
- Possible phenotypes of offspring
  - B
  - O
- Can we tell which genotype a person has when we know the phenotype?

Inheritance Se se
- Secretor gene
- Controls expression of H antigen in body fluids
  - Chromosome 19
  - Se dominant over se
  - Closely linked to Hh gene
- 80% of population are "secretors"

Genes code for enzymes
- ABH genes code for transferases, not antigen
- These enzymes add sugar to a precursor substance
  - H gene = L-fucosyl transferase; adds fucose to precursor molecule
  - A gene = N-acetylgalactosaminyl transferase; adds N-acetylgalactosamine to H
  - B gene = D-galactosyl transferase; adds D-galactose to H
  - O gene = amorph (no sugar added)

ABO Genetic Pathway – Group O
- Precursor substance (paragloboside) → H antigen (Group O)
- Fucose

ABO Genetic Pathway – Group A
- Precursor substance (paragloboside) → H antigen (Group A)
- N-acetylgalactosamine

MLS 411 Introduction to Clinical Immunohematology
ABO System
**Antigen Characteristics**

- Found throughout the body
  - On cell membranes - glycolipids, glycosphingolipids or glycoproteins
  - In body fluids - glycoproteins
- Not fully developed until 2 – 4 years old

**H Antigen**

- All RBCs have some H antigen
- In order from most H to least H:
  - O
  - B
  - A
  - AB
- O_0 is the exception - no H antigen produced

**Antibodies of the ABO System**

*Aka isohemagglutinins*

**Landsteiner’s Law**

An antibody will not develop in an individual’s plasma unless the corresponding antigen is absent from the red blood cells.
Antibodies

• Naturally occurring
• Normal finding in the plasma of Group A, B and O individuals
• Not present at birth; detectable at 3 - 6 months
• IgM
  – Small amount of IgG in Groups A and B
  – Group O individuals have predominantly IgG
• React best at room temperature or colder but have a wide thermal amplitude

More about ABO Antibodies

• Able to activate complement (intravascular hemolysis)
• May weaken with age and in certain disease states

Name That Antibody!

• Group A
• Group B
• Group AB
• Group O

• Anti-B
• Anti-A
• No ABO antibodies
• Anti-A, Anti-B, Anti-AB

Clinically Significant? Yes

• Hemolytic Transfusion Reactions (HTR)
  – ABO incompatible RBCs transfused
  – Recipient’s ABO antibodies recognize and react with donor RBCs
  – Complement activated which leads to intravascular lysis of donor RBCs

• Hemolytic Disease of the Fetus and Newborn (HDFN)
  – Group O mothers have IgG form of anti-A, anti-B and anti-AB
  – Antibodies cross placenta and attack RBCs of A or B infants
  – Antibody-coated RBCs are cleared by mononuclear phagocytic system in infant

The End

STRETCH