

# TBL 4: Transfusion

## PART 1

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# Session plan

## Part 1 – Blood groups and their clinical significance

- Blood group systems
- RBC antigens and antibodies against RBC antigens
- Haemolytic transfusion reaction
- Haemolytic disease of the fetus and newborn
- Naturally occurring antibodies
- Acquired alloantibodies

## Part 2 – ABO and Rh blood group systems

- ABO – Antigens, Antibodies, Selecting blood components for transfusion
- RH – Antigens, Antibodies, Selecting blood components for transfusion
- Other blood group systems

## Part 3 – Pre-transfusion compatibility testing

- ABO grouping
- RhD grouping
- Antibody screen
- Crossmatch

## Part 4 – Donor selection and testing

- Blood donors
- Tests undertaken on donations

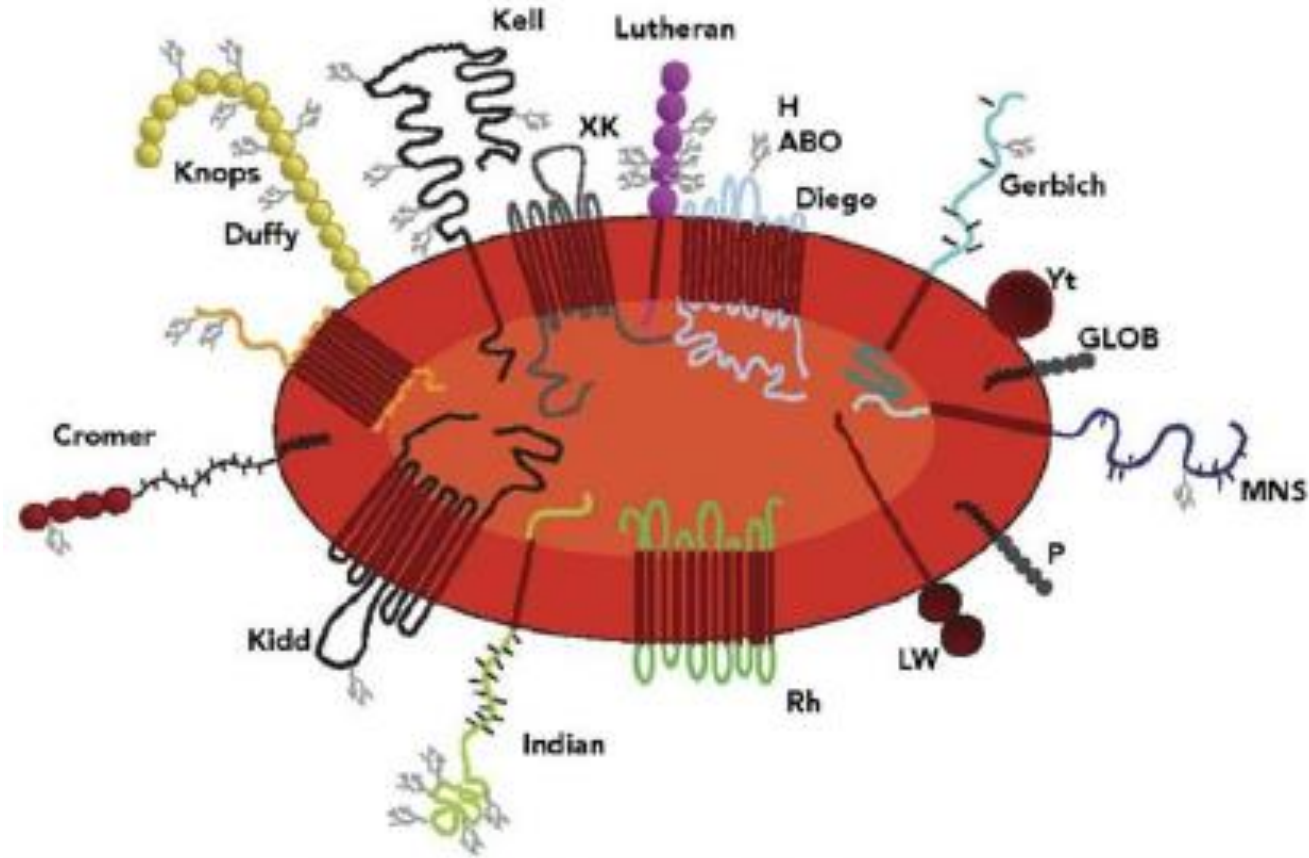
## Part 5 – Blood components and why we use them

- Whole blood donation
- Apheresis
- Red cells
- Platelets
- FFP
- Cryoprecipitate
- Plasma derived medicinal products



# Blood groups

- Red blood cell (RBC) antigens are specific sites on different proteins and glycoproteins that form part of the RBC membrane
- An individual's 'blood group' refers to the combination of RBC antigens present
- RBC antigens differ depending on their specific sequence of oligosaccharides or amino acids but can be collated into different 'blood group systems'
- A 'blood group system' is a collection of one or more RBC antigens under the control of a single gene or a cluster of closely linked homologous genes.



**Figure: RBC membrane with blood group antigens**  
(Image taken from ISBT Science Series 2020 – Blood group systems )



# Blood group systems

- Currently identified: 47 blood group systems (genetically determined by 52 genes) containing 366 red cell antigens (ISBT Oct 2024)
- There are 10 major blood group systems.
- The **ABO** and **Rh** blood group systems are the **most clinically significant**.

ISBT no.	Name of blood group system	Major antigens	Chromosome location no.
001	ABO	A, B, A <sub>1</sub>	9
002	MNS	M, N, S, s, U	4
003	P1PK	P1, P <sup>k</sup>	22
004	Rh	D, C, E, c, e	1
005	Lutheran	Lu <sup>a</sup> , Lu <sup>b</sup>	19
006	Kell	K, k, Kp <sup>a</sup> , Kp <sup>b</sup> , Js <sup>a</sup> , Js <sup>b</sup>	7
007	Lewis	Le <sup>a</sup> , Le <sup>b</sup>	19
008	Duffy	Fy <sup>a</sup> , Fy <sup>b</sup> , Fy3	1
009	Kidd	Jk <sup>a</sup> , Jk <sup>b</sup> , Jk3	18
027	I	I	6

Figure: The 10 major blood group systems

(Image taken from ISBT Science Series 2020 – Blood group systems )



# RBC antigens and antibodies against RBC antigens

- The clinical importance of a blood group system depends on the capacity of **antibodies against the specific RBC antigens** to cause **haemolysis** (destruction) of the RBCs.
- Not all antibodies against RBC antigens can cause haemolysis.
- **Antibodies against RBC antigens are clinically significant if they can cause haemolysis resulting in either:**
  - **haemolytic transfusion reactions (HTRs)**

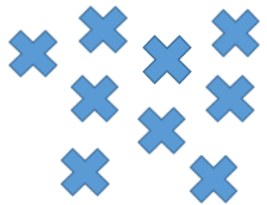
OR

- **haemolytic disease of the fetus and newborn (HDFN)**
- The interaction between RBC antigens and antibodies against RBC antigens also forms the basis of the serological pre-transfusion compatibility tests.

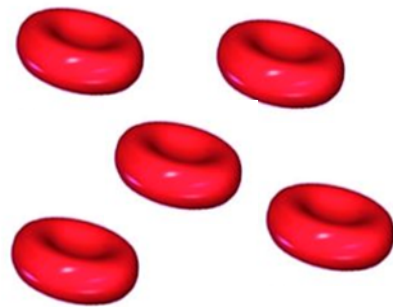


# Haemolytic transfusion reaction (HTR)

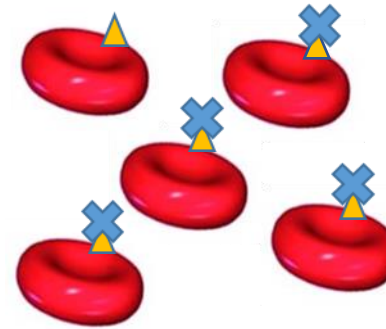
▲ = RBC antigen  
✕ = Antibody against RBC antigen



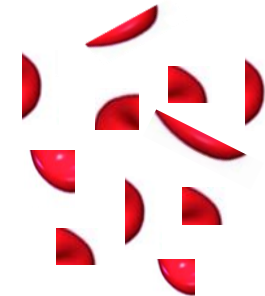
Recipient antibodies  
against a RBC antigen



Transfused red cells  
with the corresponding  
RBC antigen



Antibodies bind to  
RBC antigens



Haemolysis

- Intravascular
- Extravascular

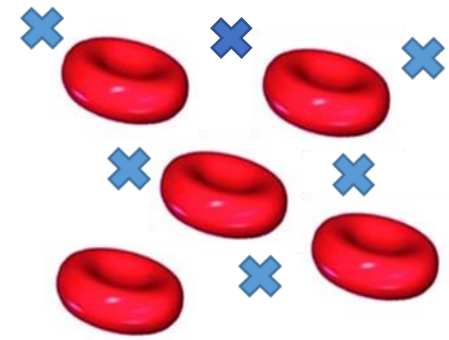
## **Destruction of transfused red cells due to incompatible blood transfusion**

- e.g. Recipient with group A red cells (anti-B antibodies) transfused with group B red cells
- e.g. Recipient with group B RhD negative and anti-D antibodies transfused with group B RhD positive red cells

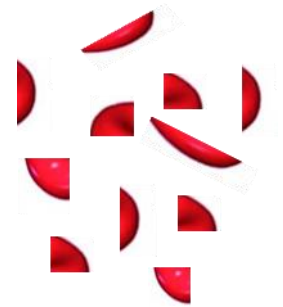
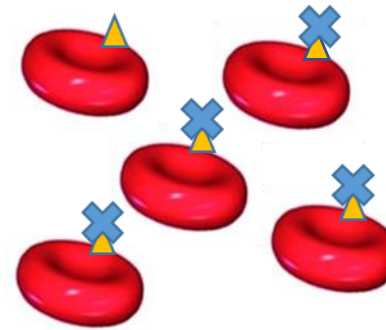
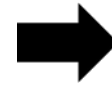
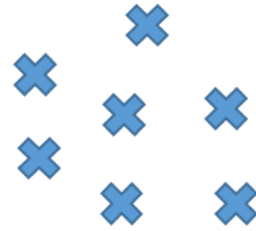


# Haemolytic disease of the fetus and newborn (HDFN)

Maternal antibodies (IgG) against a RBC antigen can cross the placenta and bind to baby's red cells if they have the corresponding RBC antigen  
e.g. baby is group O RhD positive



Maternal blood with antibodies against a RBC antigen  
e.g. mum is group O RhD negative and has anti-D antibodies



Antibodies bind to RBC antigens leading to haemolysis of baby's red cells

**Destruction of baby's red cells by maternal red cell antibodies due to incompatibility between maternal and baby RBC antigens**

▲ = RBC antigen  
✕ = Antibody against RBC antigen



# Antibodies against RBC antigens

2 types:

- **Naturally occurring antibodies**
- **Acquired alloantibodies**



# Antibodies against RBC antigens – naturally occurring

2 types:

- **Naturally occurring antibodies**
- **Acquired alloantibodies**

## **ABO antibodies: anti-A, anti-B**

- Production of ABO antibodies is stimulated when the immune system encounters the 'missing' ABO blood group in foods or in microorganisms
  - Happens within the first few months of birth because sugars that are identical to, or very similar to, the ABO blood group antigens are found throughout nature
- ABO antibodies are mostly **IgM antibodies** that **remain as IgM antibodies** throughout life and do not class switch
  - IgM antibodies are made up of 5 Y-shaped units forming a pentameric structure
  - The interaction between the pentameric IgM antibody and RBC antigens *in vitro* produces direct easily visualised clumping (**agglutination**) of red cells which is the basis of ABO blood grouping
- IgM ABO antibodies can cause **acute HTRs** through activation of the **complement** system resulting in **massive intravascular haemolysis**
- IgM ABO antibodies **cannot cross the placenta** to cause HDFN



# Antibodies against RBC antigens - acquired

2 types:

- Naturally occurring antibodies

- **Acquired alloantibodies**

- Acquired alloantibodies are formed as a result of active immunisation (**alloimmunisation**) to 'non-self' RBC antigens following exposure to RBCs from another individual
  - Exposure arises due to incompatible blood transfusion or during pregnancy when some fetal RBCs can enter the maternal blood system (fetomaternal haemorrhage)
- Acquired antibodies can potentially be produced against antigens of all the other blood group antigen systems, which the individual lacks on their own RBCs
  - However, **not all alloantibodies are clinically significant**
  - **Alloimmunisation to the Rh system is particularly important clinically**
- Acquired alloantibodies are usually **IgG antibodies**
  - IgG antibodies have a Y-shaped structure
  - *In vitro*, the interaction between the IgG antibody and RBC antigens cannot be directly visualised so demonstrating their presence requires a different approach that forms the basis of the 'antibody screen'
- IgG antibodies generally do not cause massive intravascular haemolysis and death but do still cause **haemolysis (mainly extravascular)** resulting in **delayed HTRs**
- IgG antibodies are also **able to cross the placenta** and cause HDFN

