Chemical Examination of Urine

Renal Block
Dr Rana Hasanato

Learning objectives:

1. To understand the normal and abnormal chemical composition of urine in relation to renal diseases and conditions

2. To differentiate between pre-renal, renal and post-renal proteinuria with clinical examples of each

3. To acquire knowledge on the types of Glycosuria, hematuria and hemoglobinuria

- **Urine** is a fluid excreted by most animals including humans
- It is formed in the kidneys (renal glomeruli)
- The fluid undergoes chemical changes before it is excreted as urine

- **Normal urine excretion by a healthy person is** about 1.5 L per day

Normal composition of urine

Urine contains organic and inorganic constituents:

- **Major inorganic salts:**
  - **Sodium**
  - **Potassium**
  - **Chlorides**
  - **Small amounts of Ca, Mg, S & phosphates**
  - **Traces of Fe, Cu, Zn and I_2**

- **Major organic constituents:**
  - **Non-protein nitrogen (NPN) compounds**
  - **Organic acids**
  - **Sugars**
  - **Traces of proteins, vitamins, hormones, and pigments**

Abnormal composition of urine

Proteins:

- Normal urine contains very little protein (< 200 mg/day)
- More than this level leads to a condition called **Proteinuria**

Causes:

Pre-renal
Renal
Post-renal

Abnormal composition of urine

Prerenal proteinuria:

Some abnormal conditions increase plasma protein levels before reaching the kidneys

Causes increased filtration of these proteins in the kidneys

This exceeds the normal reabsorptive capacity of renal tubules

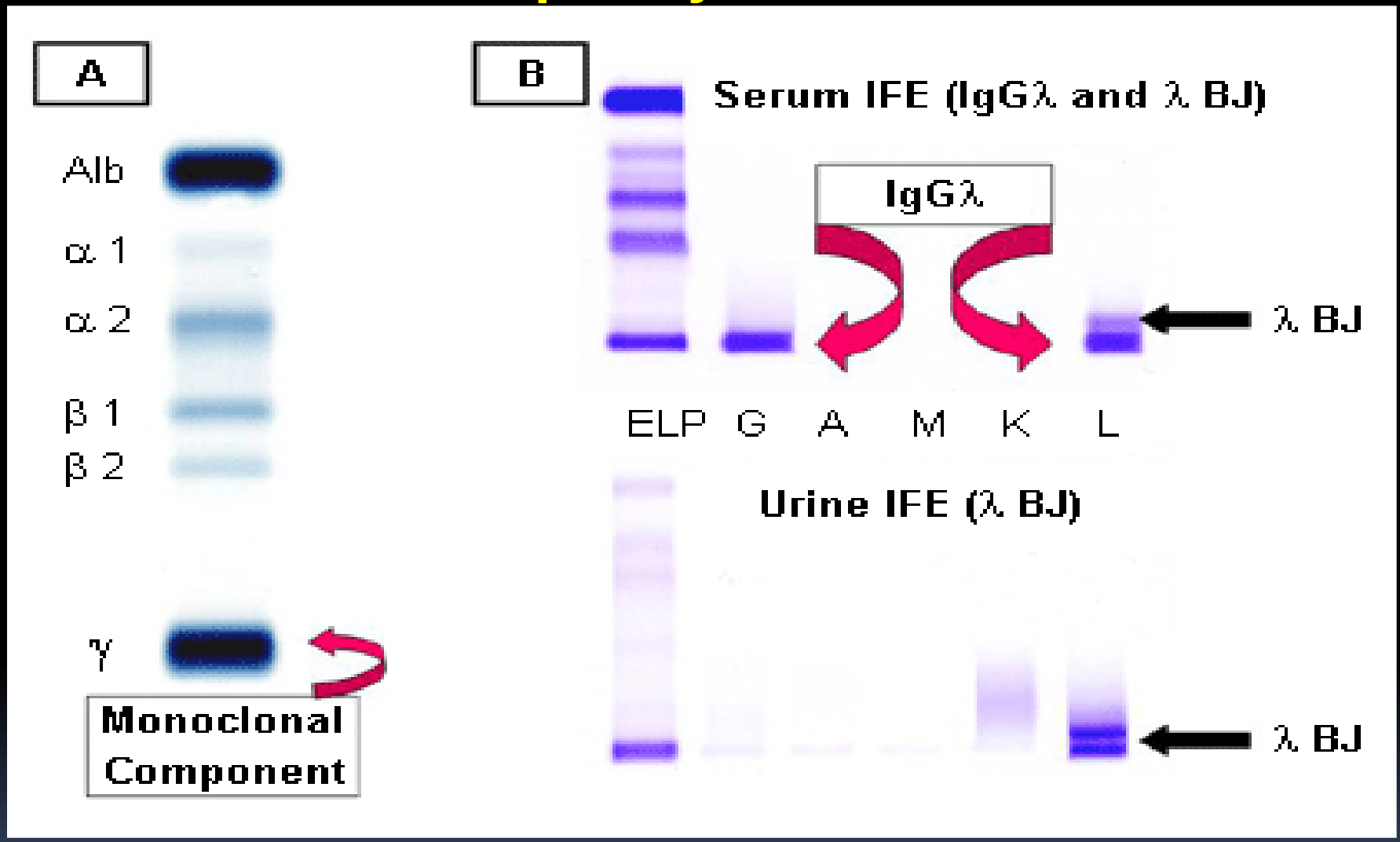
Results in overflow of proteins in the urine

Multiple myeloma causes pre-renal proteinuria

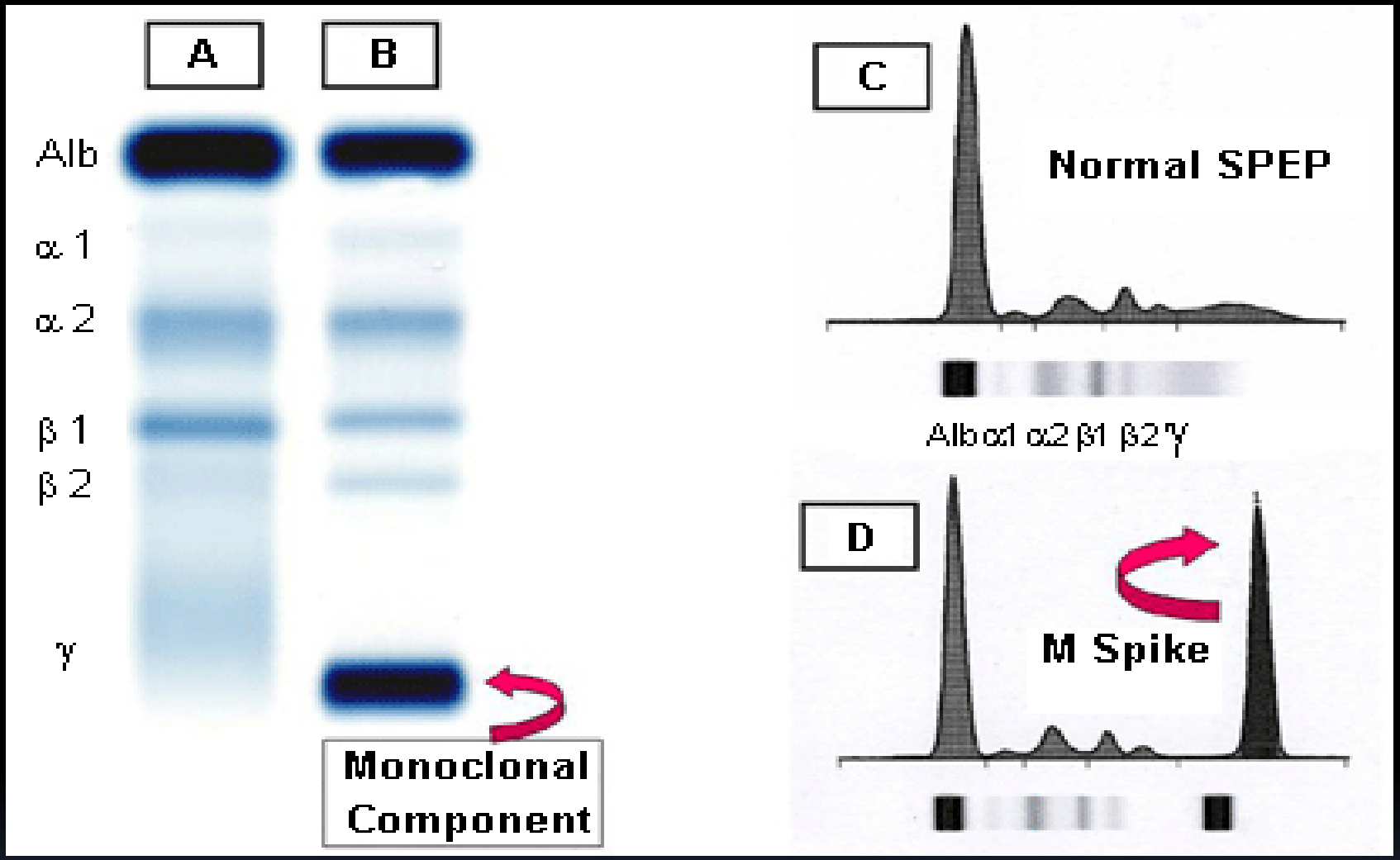
- A proliferative disorder of the immunoglobulin-producing plasma cells
- The serum contains elevated levels of monoclonal light chains antibodies (Bence-Jones protein)
- Bence-Jones protein is filtered in kidneys in high amounts
- Exceeding the tubular reabsorption capacity
- Hence excreted in the urine

- The Bence-Jones protein coagulate at 40–60 ^{o}C
- Dissolves at 100 ^{o}C
- Multiple myeloma cases are diagnosed by using:
  - Serum electrophoresis
  - Immunoelectrophoresis

Multiple myeloma



A: serum protein electrophoresis demonstrating the M component.
B: serum and urine immunofixation electrophoresis



A: normal serum.
B: multiple myeloma showing M component in the gamma region.
C: densitometry tracing of A showing the 5 zones of the high resolution agarose electrophoresis.
D: densitometry of the M component of B, termed the M Spike

Renal Proteinuria

- Associated with renal disease

Glomerular proteinuria

- High glomerular permeability
- Causes filtration of high molecular weight proteins (e.g. glomerulonephritis)

Tubular proteinuria

- Low tubular reabsorption with normal glomerular permeability
- Causes excretion of low molecular weight proteins (e.g. chronic nephritis)

Orthostatic (Postural) Proteinuria

- Persistent benign protenuria
- Occurs frequently in young adults due to periods spent in a vertical posture
- Increased pressure on the renal vein in the vertical position causes orthostatic proteinuria
- Disappears in horizontal posture

Microalbuminuria:

- Presence of **small amounts of albumin in the urine (20– 200 mg/L)**
  - Cannot be detected by ordinary urine testing
  - Needs special tests for detection
- **Early indicator of glomerular dysfunction** due to uncontrolled diabetes mellitus or hypertension

3 - Post renal proteinuria:

Proteins added to the urine as it passes through the structures of the lower urinary tract (ureters, bladder , urethra, prostate and vagina)

- Due to Lower urinary tract infection, trauma, tumors and stones

Glycosuria : *(Presence of sugar in urine)*

1 - **Glucosuria:** Presence of detectable amount of glucose in urine

- **Uncontrolled DM** :The concentration of glucose in the plasma exceeds the renal threshold

- **Renal glucosuria** : Normal plasma glucose concentration with proximal tubular malfunction $\rightarrow \downarrow$ renal threshold (gestational diabetes and Fanconi's syndrome)

2 - Fructosuria: (*Presence of fructose in urine)*

- Alimentary causes : High fructose intake

- Metabolic : Low fructokinase or aldolase B in the liver

3 – Galactosuria: (*Presence of galactose in urine)*

- Alimentary : High galactose intake

- Metabolic : Low galactokinase or galactose -1-phosphate uridyl transferase in the liver

Ketonuria : **Presence of ketones, acetone, acetoacetic acid & β -hydroxybutyric acid in urine**

1 – Diabetic ketoacidosis

2 – Starvation

3 – Prolonged vomiting

4 – Unbalanced diet: high fat & Low CHO diet

5 – Phenylketonuria (inborn error of amino acid metabolism)

Choluria : Presence of bile in urine

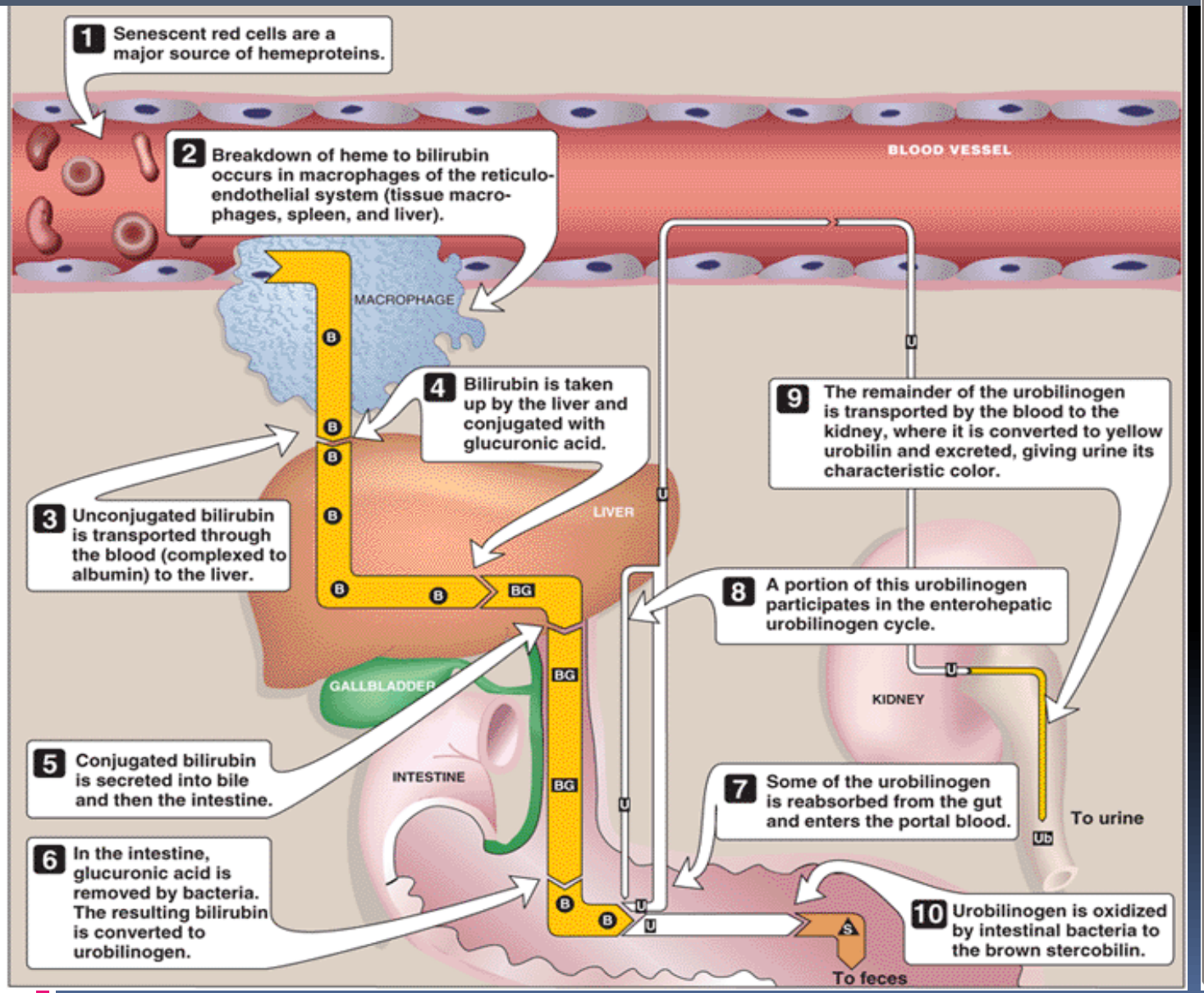
1 – Bilirubin / Bile salts:

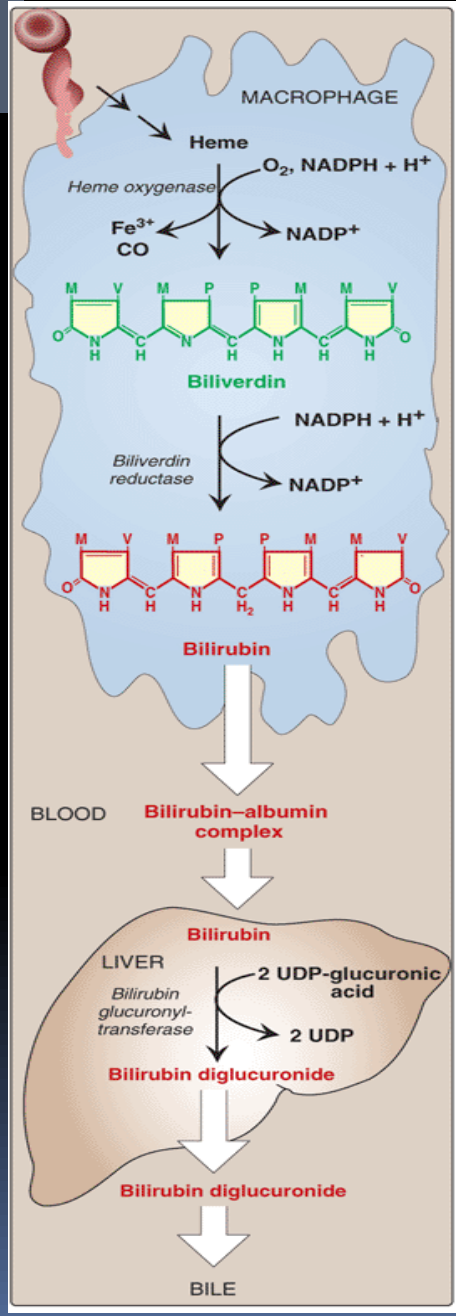
Normally no bilirubin is detected in urine

Bilirubin is detected in:

- **Hepatocellular damage**
- **Obstruction of bile duct:**
  - **Extrahepatic (Stone)**
  - **Intrahepatic (hepatic tumors)**

Catabolism of heme B = bilirubin; BG = bilirubin diglucuronide; U= urobilinogen; Ub = urobilin; S = stercobilin.





2 - Urobilinogen:

- Normally present in trace amounts in urine

High urobilinogen is found in:

- Hemolytic anemia

- Hepatocellular damage

Nitrite :

Positive nitrite test is significant of bacteria in urine

Blood :

I - Hematuria: Presence of detectable amount of blood in urine

a – Acute and chronic glomerulonephritis

b – Local disorders of kidney & genito-urinary tract (Trauma , cystitis , renal calculi and tumors

c – Bleeding disorders (Hemophilia)

II - Hemoglobinuria: Presence of hemolysed blood in urine

a – Hemoglobinopathies: 1. Sickle cell anemia

2. Thalassemia

b – Malaria (P. falciparum)

c – Transfusion reaction (Bl. Incompatibility)