Chemical Examination of Urine

Renal Block

1 Lecture

Objectives

Upon completion of this lecture, students should be able to:

- Differentiate between normal and abnormal constituents of urine including: Proteins, sugars, ketone bodies, nitrite, bile pigments, blood etc.
- Know the clinical conditions in different types of proteinuria, blood urea and glycosuria etc.

Overview

- Introduction
- Normal composition of urine
- Abnormal composition of urine
- Proteinuria:
  - Pre-renal (multiple myeloma)
  - Renal
  - Post-renal
- Glycosuria: fructosuria, galactosuria
- Ketonuria
- Hematuria: hemoglobinuria

Urine

- 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 constituents:
  - Sodium
  - Potassium
  - Chloride
  - Small amounts of Ca, Mg, sulfur and phosphates
  - Traces of Fe, Cu, Zn, I
- Major organic constituents:
  - Non-protein nitrogen (NPN) compounds
  - Organic acids
  - Sugars
  - Traces of proteins, vitamins, hormones, pigments

Abnormal composition of urine

Proteins:

- Normal urine contains small amount of protein:
  - < 200 mg/day
- Excretion of more than this level causes proteinuria

Proteinuria:

- Excretion of abnormal amounts of protein in urine
- Proteinuria has three types:
  - Pre-renal
  - Renal
  - Post-renal

Pre-renal proteinuria

- Some diseases or conditions increase plasma protein levels not involving 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:

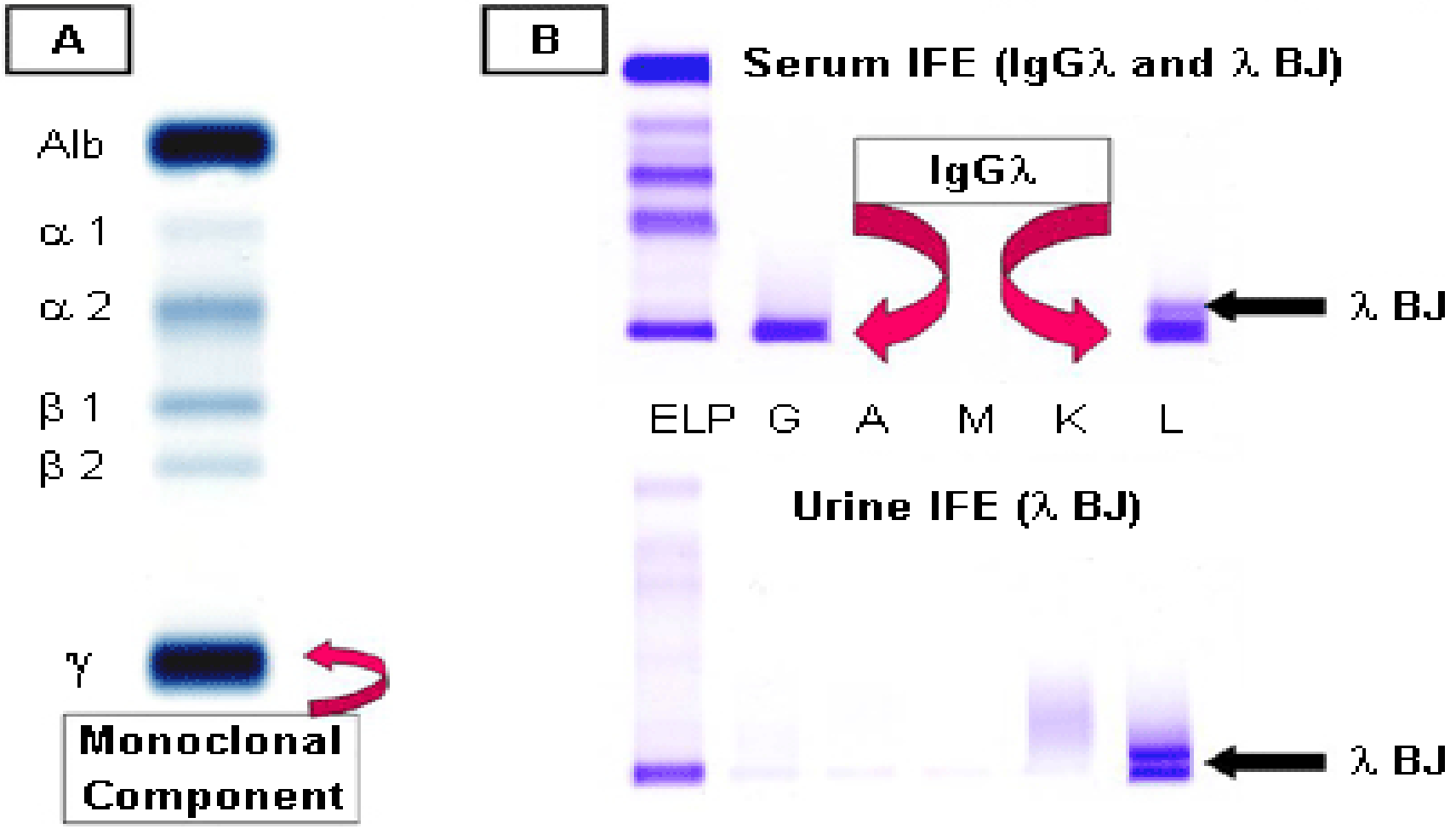
- Cancer of the antibody-producing plasma cells
- Causes pre-renal proteinuria

Pre-renal proteinuria

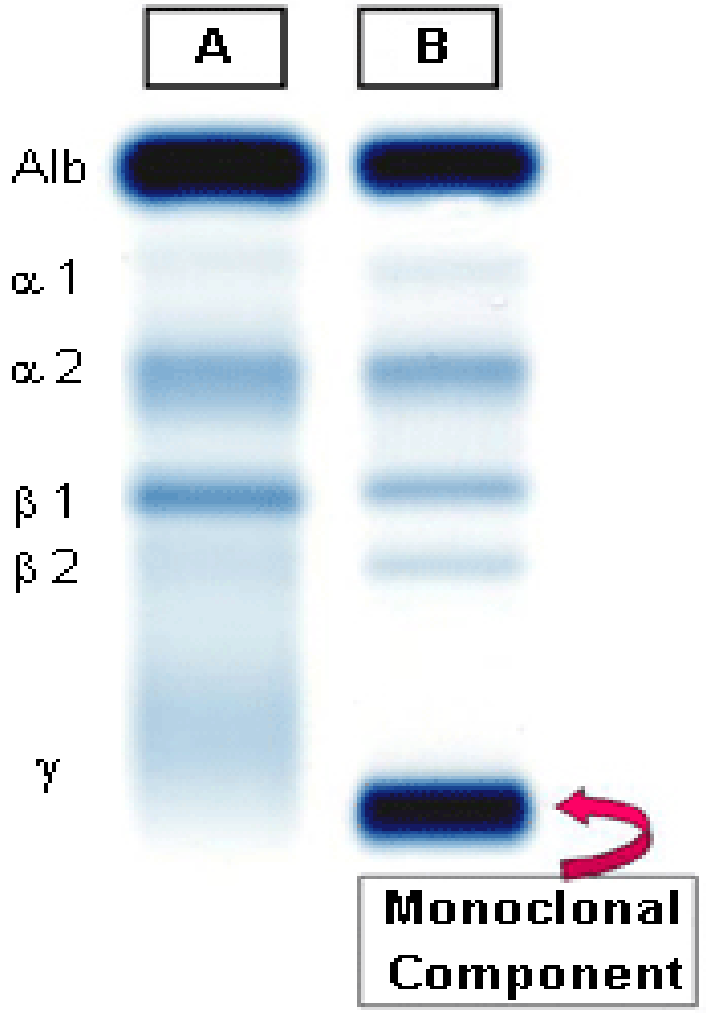
- The serum contains elevated levels of light-chain monoclonal antibodies called Bence-Jones protein
- This protein is filtered in the kidneys in high amounts
- Exceeding the tubular reabsorption capacity
- Hence excreted in the urine
- Bence-Jones protein coagulates at 40–60 °C and dissolves at 100 °C

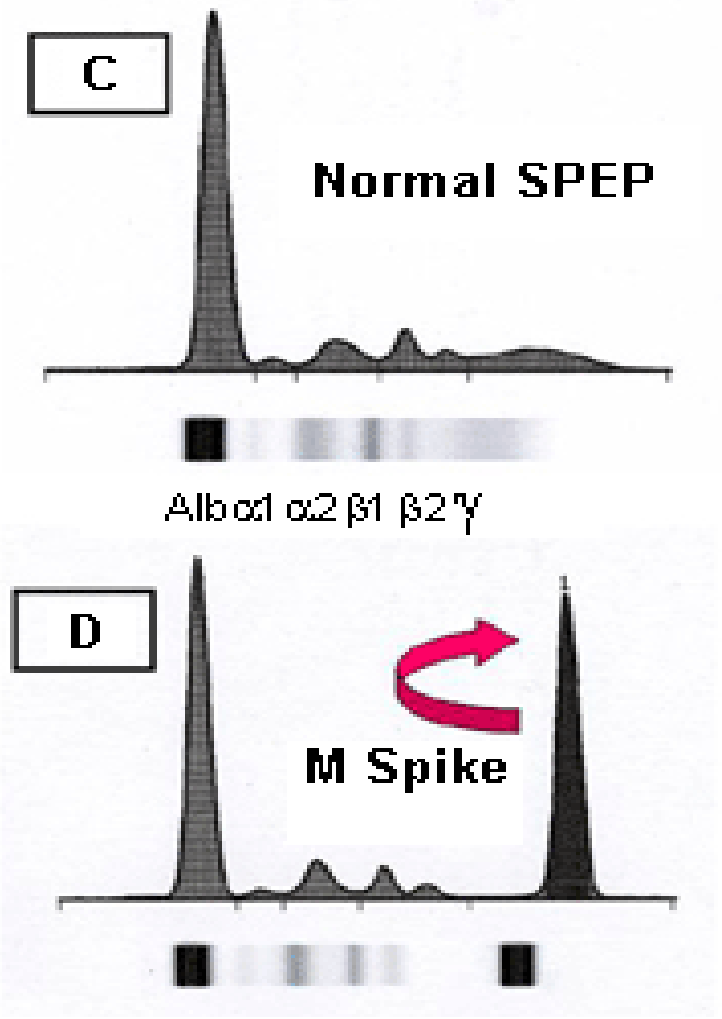
- Multiple myeloma cases are diagnosed by:
  - Serum electrophoresis
  - Immunoelectrophoresis

Multiple myeloma



A: Serum protein electrophoresis showing the M component
B: Serum and urine immunofixation electrophoresis





A: Normal serum

B: Multiple myeloma (M component in γ region)

C: Densitometry of "A"

D: Densitometry of "B" (M component is called M Spike)

Renal proteinuria

- Associated with renal disease

Glomerular proteinuria:

- High glomerular permeability causes filtration of high molecular weight proteins
  - Example: glomerulonephritis

Tubular proteinuria:

- Low tubular reabsorption with normal glomerular permeability
- Causes excretion of low mol. wt. proteins
  - Example: chronic nephritis

Renal proteinuria

Orthostatic (postural) proteinuria:

- A form of benign or physiological proteinuria
- Occurs frequently in young adults due to periods spent in a vertical posture (body position) or during muscular exercise
- Increased pressure on the renal vein in the vertical position causes orthostatic proteinuria
- Disappears in horizontal posture

Renal proteinuria

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
  - Hypertension

Post-renal proteinuria

- Proteins are added to the urine after kidney filtration
- While passing through the lower urinary tract (ureters, bladder, urethra, prostate, vagina)
- Due to:
  - Lower urinary tract infection
  - Trauma
  - Tumors
  - Stones

Glycosuria

Presence of sugar in urine

Glucosuria:

Presence of detectable amount of glucose in urine

- Due to diabetes mellitus
  - Plasma glucose level exceeds the renal threshold
- Due to renal disease (renal glucosuria)
  - Normal plasma glucose level with proximal tubular malfunction
  - Decreased renal threshold as observed in gestational diabetes and Fanconi's syndrome

Glycosuria

Fructosuria:

- Presence of fructose in urine
- Nutritional cause:
  - High fructose intake
- Metabolic cause:
  - Low fructokinase or aldolase B in the liver

Galactosuria:

- Presence of galactose in urine
- Nutritional cause: high galactose intake
- Metabolic cause:
  - Low galactokinase or galactose -1-PO_4 uridyl transferase in the liver

Ketonuria

- Presence of ketones, acetone, acetoacetic acid and β-hydroxybutyric acid in urine

Due to:

- Diabetic ketoacidosis
- Starvation
- Dietary imbalance: high fat and low CHO diet
- Phenylketonuria (PKU)

Choluria

- Presence of bile, bilirubin and bile salts in urine

Bilirubin: normally no bilirubin is detected in urine

- It is detected in:
  - Hepatocellular damage
  - Obstruction of bile duct due to stones (extrahepatic) and hepatic tumors (intrahepatic)

Urobilinogen: normally present in trace amounts

- High urobilinogen is found in:
  - Hemolytic anemia
  - Hepatocellular damage

Nitrites:

- Positive nitrite test indicates bacteria in urine

Hematuria

- Presence of detectable amount of blood in urine

Due to:

- Acute / chronic glomerulonephritis
- Local disorders of kidney and genito-urinary tract
  - Trauma, cystitis, renal calculi, tumors
- Bleeding disorders
  - Hemophilia

Hematuria

Hemoglobinuria:

- Presence of hemolysed blood in urine

Due to:

- Hemoglobinopathies
  - Sickle cell anemia
  - Thalassemia
- Malaria
- Transfusion reaction
  - Blood group incompatibility