BHARATHIDASAN UNIVERSITY

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Tamil Nadu, India

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Course Title : CLINICAL BIOCHEMISTRY

Course Code: BC303CR

UNIT – IV

DISORDERS OF LIVER AND KIDNEY

Dr. KALAIARASI A
Dept. of Biochemistry
BDU. Trichy

HEPATOBILIARY SYSTEM
METABOLISM OF BILIRUBIN

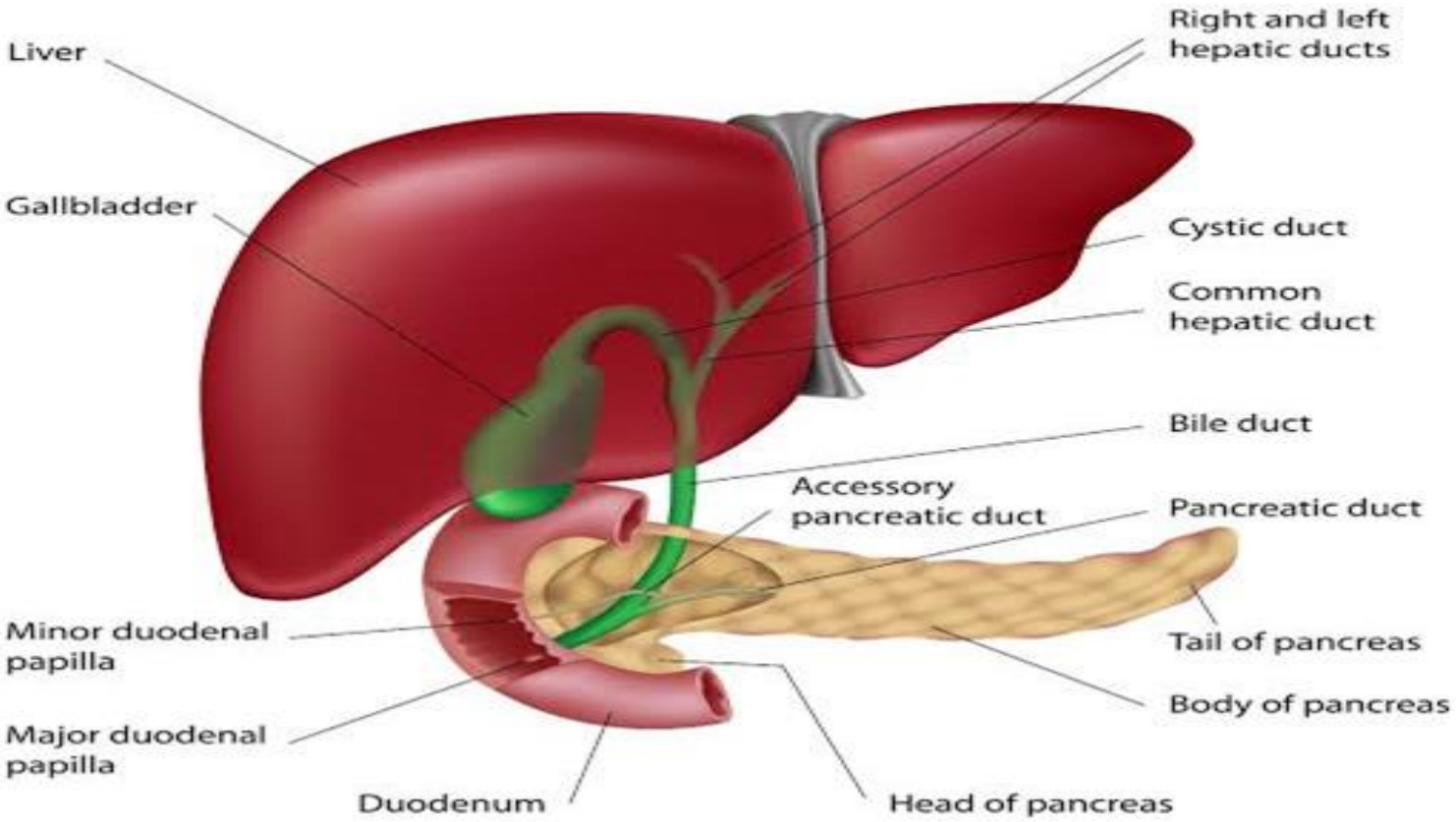
Hepatobiliary system

The hepatobiliary system is a complex organ system primarily involved in the production, storage, and transport of bile

It is also involved in the detoxification of harmful substances.

It includes the liver, gallbladder, and bile ducts.

Liver, Gallbladder, Pancreas and Bile Passage



Liver

The largest organ in the hepatobiliary system, located in the upper right abdomen.

Functions:

- **Bile production**: The liver produces bile, a fluid necessary for fat digestion.
- **Metabolism**: It plays a crucial role in metabolizing carbohydrates, proteins, and fats.
- **Detoxification**: It processes and detoxifies drugs, alcohol, and other harmful substances.
- **Storage**: It stores glycogen (a form of glucose), vitamins, and minerals.
- **Synthesis**: Produces proteins like albumin and clotting factors.

Gallbladder

- A small, pear-shaped organ located under the liver.

Functions:

- **Bile storage and concentration**: It stores bile produced by the liver and concentrates it.
- **Bile release**: Upon eating, especially fatty foods, the gallbladder releases bile into the small intestine to help digest fats.

Bile Ducts

A network of tubes that transport bile from the liver to the gallbladder and small intestine.

- Structures:
  - **Intrahepatic ducts**: Small bile ducts within the liver that collect bile from liver cells.
  - **Extrahepatic ducts**: These include the hepatic duct (from the liver), cystic duct (from the gallbladder), and the common bile duct, which transports bile to the duodenum (the first part of the small intestine).

Function of the Hepatobiliary System:

- **Digestion of Fats**: Bile emulsifies fats, making them easier to absorb in the intestines.
- **Waste Elimination**: Bile helps in excreting bilirubin, a byproduct of the breakdown of red blood cells, and cholesterol.
- **Detoxification**: The liver metabolizes toxins and drugs, turning them into harmless substances that are either excreted in bile or processed by the kidneys.

Hepatobiliary function tests

Hepatobiliary function tests are laboratory tests used to evaluate the health and function of the liver, gallbladder, and bile ducts.

These tests help diagnose diseases like hepatitis, cirrhosis, bile duct obstruction, and gallbladder disorders

Liver function test

- Liver enzyme tests are commonly used to assess liver function and diagnose liver damage or disease.
- These tests measure the levels of enzymes produced by liver cells (hepatocytes).
- When liver cells are injured or stressed, these enzymes leak into the bloodstream, and their elevated levels can provide valuable information about the underlying condition.

Alanine Aminotransferase (ALT)

ALT is an enzyme found primarily in the liver. It plays a role in breaking down proteins into smaller molecules for energy production.

The typical range for ALT levels is between 7 to 56 units per liter (U/L)

Causes

Hepatitis (viral or autoimmune): Inflammation of the liver raises ALT significantly.

Non-Alcoholic Fatty Liver Disease (NAFLD): Fat accumulation in liver cells can cause chronic low-level ALT elevation.

Alcoholic Liver Disease: Chronic alcohol consumption may cause an increase in ALT, though AST is often more elevated in alcohol-related damage.

Aspartate Aminotransferase (AST)

AST is an enzyme found in the liver, heart, skeletal muscles, kidneys, and brain. Like ALT, AST is involved in amino acid metabolism.

The typical range is between 10 to 40 U/L

Alcoholic liver disease: AST is often more elevated than ALT in alcohol-induced liver damage.

Muscle injury: Since AST is found in muscles, conditions like muscle trauma, strenuous exercise, or muscle diseases (e.g., muscular dystrophy) can elevate AST levels.

Heart disease: Myocardial infarction (heart attack) can cause a rise in AST since the enzyme is also present in heart muscle.

Alkaline Phosphatase (ALP)

ALP is an enzyme found in the liver, bile ducts, and bones. It is involved in the breakdown of proteins and plays a role in the transport of fats.

The typical range is between 45 to 115 U/L,

Cholestasis: Conditions that block bile flow, such as gallstones, bile duct tumors, or primary biliary cirrhosis, lead to elevated ALP.

Bone disorders: Because ALP is produced by bone cells, elevated levels can indicate bone growth (in children),

Gamma-Glutamyl Transferase (GGT)

GGT is an enzyme involved in bile production and is found in the liver, bile ducts, and pancreas

The typical range is between 9 to 48 U/L.

Alcohol use: Chronic alcohol consumption often raises GGT

Pancreatic or bile duct disorders: GGT is often elevated in pancreatic or bile duct cancer.

Lactate Dehydrogenase (LDH)

LDH is an enzyme involved in the conversion of lactate to pyruvate in cells. It's found in many tissues, including the liver, heart, muscles, kidneys, and blood cells.

The typical range is between 140 to 280 U/L.

Heart attack: LDH is released into the blood when heart cells are damaged.

Hemolytic anemia: LDH is elevated when red blood cells break down rapidly.

Bilirubin Tests

Total Bilirubin:

Bilirubin is a waste product formed from the breakdown of red blood cells and is processed by the liver for excretion in bile.

Elevated bilirubin levels can indicate liver dysfunction, bile duct obstruction, or excessive red blood cell breakdown (hemolysis).

Direct (Conjugated) Bilirubin:

Measures the portion of bilirubin that has been processed by the liver and is ready to be excreted in bile.

High levels suggest liver disease or a bile duct problem (e.g., cholestasis or bile duct obstruction).

Indirect(Unconjugated)bilirubin

Measures bilirubin that has not yet been processed by the liver.

Increased levels are often seen in hemolytic conditions where red blood cells are destroyed faster than the liver can process

Prothrombin Time (PT) and International Normalized Ratio (INR)

The liver produces proteins necessary for blood clotting. PT measures how long it takes for blood to clot.

INR is a standardized version of PT.

Prolonged PT/INR may indicate liver dysfunction, as the liver's ability to produce clotting factors is impaired.

METABOLISM OF BILIRUBIN

Heme Breakdown and Bilirubin Formation (Pre-Hepatic Phase)

Source: Bilirubin originates from the breakdown of hemoglobin, which comes from old or damaged red blood cells.

Heme Degradation: In the spleen, macrophages break down hemoglobin into its components:

- **Heme** is converted to **biliverdin** by the enzyme **heme oxygenase**.
- Biliverdin is then reduced to **unconjugated bilirubin** by the enzyme **biliverdin reductase**.

Unconjugated Bilirubin: This form of bilirubin is **lipophilic** (fat-soluble), making it unable to dissolve in water. It travels in the blood bound to **albumin** to the liver.

Hepatic Conjugation (Liver Phase):

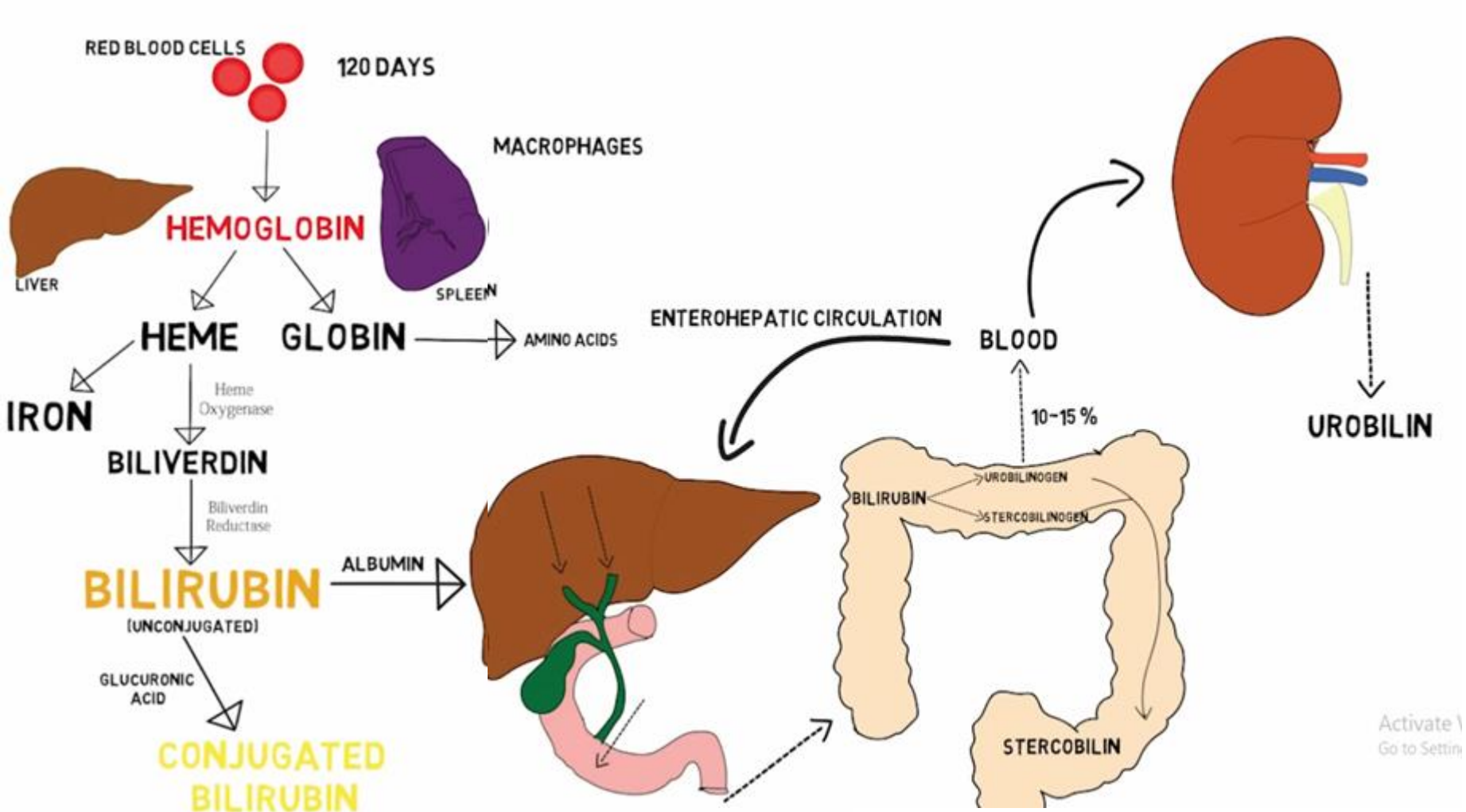
- In the liver, **unconjugated bilirubin** is taken up by hepatocytes (liver cells).
- **Conjugation:** Inside the hepatocytes, unconjugated bilirubin is conjugated with **glucuronic acid** via the enzyme **UDP-glucuronosyltransferase (UGT1A1)**. This creates **conjugated bilirubin** (bilirubin diglucuronide), which is **water-soluble**.
- **Secretion:** Conjugated bilirubin is secreted into the bile and stored in the gallbladder, or directly transported to the small intestine.

Excretion and Enterohepatic Circulation (Post-Hepatic Phase):

- Biliary Excretion: Conjugated bilirubin enters the intestines via bile. In the small intestine, gut bacteria act on conjugated bilirubin, converting it to urobilinogen.

Elimination:

- Fecal Route: Most urobilinogen is further oxidized to stercobilin and excreted in the feces, giving stool its brown color.
- Urinary Route: A small portion of urobilinogen is reabsorbed into the bloodstream, filtered by the kidneys, and excreted as urobilin in the urine, which gives urine its yellow color.

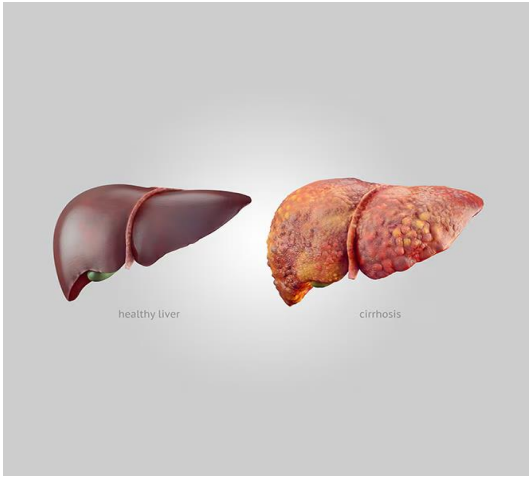

RED BLOOD CELLS
120 DAYS
MACROPHAGES
HEMOGLOBIN
LIVER
SPLEEN
HEME
GLOBIN
AMINO ACIDS
IRON
Heme Oxygenase
BILIVERDIN
Biliverdin Reductase
BILIRUBIN
(UNCONJUGATED)
ALBUMIN
GLUCURONIC ACID
CONJUGATED BILIRUBIN
ENTEROHEPATIC CIRCULATION
BLOOD
10-15 %
UROBILIN
BILIRUBIN
UROBILINOGEN
STERCOBILINOGEN
STERCOBILIN

CIRRHIOSSIS,HEPATIC COMA,HEPATITIS,GALLSTONES, CHOLECYSTITIS AND TUMOURS DISAGNOSTIC ENZYMES-ENZYMES IN HEALTH AND DISEASE.

CIRRHIOSSIS

Definition & Facts

- Cirrhosis is a condition in which your liver is scarred and permanently damaged. As cirrhosis gets worse, your liver begins to fail.
- **Symptoms & Causes**
- Cirrhosis has many signs and symptoms, such as fatigue and severe itchy skin. Symptoms may not appear until the liver is badly damaged.
- Causes include alcohol-associated liver disease, nonalcoholic fatty liver disease, chronic hepatitis C, and chronic hepatitis B.



Diagnosis

- Tests include blood tests, which can show signs of liver damage or infections (ALT , AST , ALP, GGT, Bilirubin)
- imaging tests.
- liver biopsy.

Treatment

- Treating the underlying causes of cirrhosis may keep cirrhosis from getting worse and may help prevent liver failure.
- Surgery, liver transplantation,chemotherapy.

Eating, Diet, & Nutrition

- If you have cirrhosis, avoid foods and drinks that can damage the liver, such as raw shellfish and alcohol.

HEPATIC COMA

- Hepatic encephalopathy (HE) is a decline in brain function that occurs as a result of severe liver disease
- When the liver is damaged and unable to properly filter toxins (like ammonia) from the blood, these toxins can build up in the bloodstream and affect brain function, leading to a variety of mental and physical symptoms.

SYMPTOMS

- Hepatic encephalopathy symptoms can result from liver insufficiency or the redirection of blood flow away from the liver (portosystemic shunting)
- Symptoms of hepatic encephalopathy include confusion, personality alterations, disorientation, and reduced consciousness.

Etiology

In the context of cirrhosis of the liver, hepatic encephalopathy can be triggered by various factors, such as the following:

- renal failure , gastrointestinal bleeding (such as from esophageal varices)
- Constipation, infections ,excessive dietary protein intake
- dehydration (due to factors like fluid restriction, diuretics, diarrhea, vomiting, or excessive paracentesis),electrolyte imbalances
- alcohol consumption ,the use of specific sedatives or medications (like analgesics)

Pathophysiology

Individuals with Acute Liver Failure without Preexisting Liver Disease

- The buildup of ammonia, known as hyperammonemia, disrupts neuronal function, ultimately contributing to encephalopathy.

Individuals with Chronic Liver Failure/Cirrhosis

- In patients with long-standing cirrhosis, another potential factor contributing to hepatic encephalopathy is manganese toxicity.

DIAGNOSIS

- Hepatic function tests
- Psychometric tests
- The number connection test (NCT), also known as the Reitan Test, is one of the most commonly utilized psychometric tests
- Electroencephalogram activity
- Radiologic imaging, such as CT or MRI

Treatment / Management

- Ammonia-lowering therapy.
- Nutritional support: Patients with hepatic encephalopathy should not have protein intake restricted
- Hydration and electrolyte correction.
- Lactulose- Facilitates the conversion of ammonia (NH_3) to ammonium (NH_4^+), reducing the diffusion of NH_3 into the bloodstream.
- Liver transplantation
- Rifaximin:An antibiotic that reduces the number of ammonia-producing bacteria in the gut.

HEPATITIS

- Hepatitis is defined as inflammation of the liver that can result from a variety of causes, such as heavy alcohol use, autoimmune disorders, drugs, or toxins. However, the most frequent cause of hepatitis is due to a viral infection, referred to as "viral hepatitis.“

Etiology

- The majority of cases of viral hepatitis result from hepatotropic viruses A, B, C, D, and E.
- It is unclear whether the hepatitis G virus (HGV) is pathogenic in humans.
- Other less common causes of viral hepatitis are cytomegalovirus (CMV), Epstein-Barr virus(EBV), herpes simplex virus (HSV), and varicella-zoster virus (VZV)..

Pathophysiology

- The pathophysiology of viral hepatitis varies with the type of hepatitis pathogen

Hepatitis A

- The incubation period of HAV is approximately 4 weeks. Symptoms of HAV infection include malaise, anorexia, nausea, vomiting, and jaundice.

Hepatitis B

- The incubation period of an acute HBV infection is approximately 12 weeks, with most patients experiencing mild illness, which is self-limiting within 6 months—less than 1% experience hepatic failure.

Hepatitis C

- The incubation period of HCV is approximately 8 weeks. Most cases of acute HCV infection are asymptomatic.
- Approximately 55% to 85% of patients develop chronic HCV infection

NATIONAL INSTITUTE FOR COMMUNICABLE DISEASES
Division of the National Health Laboratory Service

THE ABCDE OF VIRAL HEPATITIS

HEPATITIS	How it spreads	Prevention	Treatment
A	**Feces** Contaminated food or water	• Vaccine • Practice good hygiene	**No specific medication available** Treated through supportive care (rest, adequate nutrition, and fluids) to help relieve symptoms
B	Through contact with the blood or bodily fluids of an infected person	• Vaccine • Practice safe sex • Blood screening	Combination antiviral therapies (with Tenofovir or Tenofovir derivatives plus lamivudine)
C	Blood-to-blood contact	• Practice safe sex • Avoid sharing needles, toothbrushes, razors or nail scissors	Combination therapies with direct acting antivirals (DAAs)
D	Contact with infected blood (only occurs in people already infected with hepatitis B)	• Hepatitis B vaccine • Avoid sharing needles, toothbrushes, razors or nail scissors	Interferon
E	**Feces** Contaminated food or water	• Practice Good Hygiene • Avoid drinking water that has come from a potentially unsafe source • Cook food well	**No specific medication available** Supportive Care

GALLSTONES

Definition & Facts

- Gallstones are hard, pebble-like pieces of material, usually made of cholesterol or bilirubin, that develop in your gallbladder. When gallstones block your bile ducts, they can cause sudden pain, which means you need medical attention right away. If left untreated, they can cause complications.

Symptoms & Causes

- When gallstones block your bile ducts, bile builds up in your gallbladder, causing a gallbladder attack. Gallbladder attacks usually cause pain in the upper right abdomen , nausea, vomiting, jaundice ,fever.

Dieting

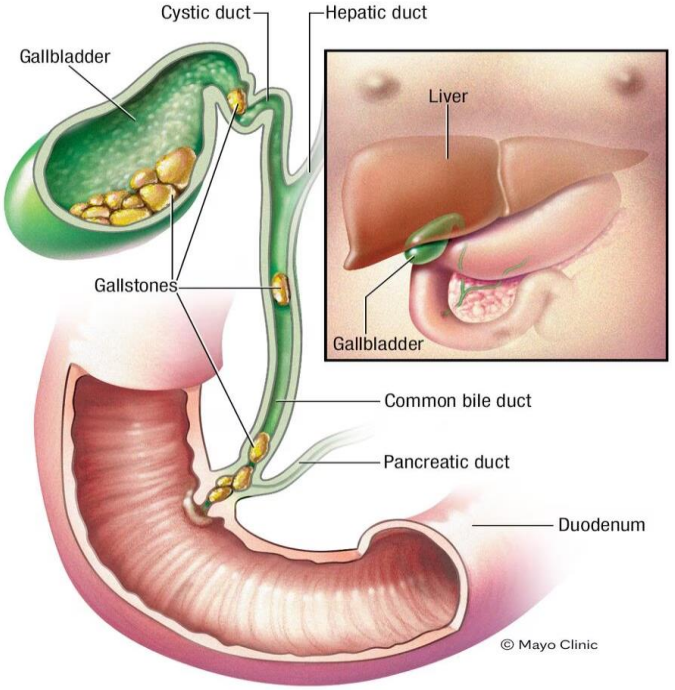
- Being overweight or having obesity may make you more likely to develop gallstones.
- Losing weight very quickly also may raise your chances of forming gallstones.

Diagnosis

- a physical exam and imaging tests to diagnose and find gallstones.
- Blood tests(bilirubin , pancreatic enzymes such as amylase and lipase) can show signs of infection or inflammation of the bile ducts, gallbladder, pancreas, or liver.

Treatment

- The treatment is carried out with surgery to remove the gallbladder.
- Nonsurgical treatments are rarely used.



Cholecystitis

- Cholecystitis is a redness and swelling (inflammation) of the gallbladder. It happens when a digestive juice called bile gets trapped in our gallbladder.
- Normally bile drains out of your gallbladder and into your small intestine. If the bile is blocked, it builds up in your gallbladder. This causes inflammation and can cause infection.

Causes

- When gallstones block this tube, bile builds up in your gallbladder. This causes irritation and pressure in the gallbladder. It can cause swelling and infection.

- **Other causes** of cholecystitis include:
- Bacterial infection in the bile duct system.
- Tumors of the pancreas or liver.
- Reduced blood supply to the gallbladder.
- Gallbladder sludge- The sludge builds up in your gallbladder.

Symptoms

- intense, sudden pain in the upper right part of your belly
- Pain (often worse with deep breaths) that spreads to your back or below the right shoulder blade
- Nausea
- Vomiting
- Fever
- Yellowing of the skin and eyes (jaundice)
- Loose, light-colored bowel movements
- Belly bloating

DIAGNOSIS

- Complete blood count (CBC).
- Liver function tests.
- Ultrasound (also called sonography).
- Belly X-ray. .
- CT scan.
- HIDA scan (cholescintigraphy or hepatobiliary scintigraphy)
- PTC (percutaneous transhepatic cholangiography)
- ERCP (endoscopic retrograde cholangiopancreatography)

TREATMENTS

- Taking bacteria-fighting medicines (antibiotics) to fight the infection
- Taking fluids and pain medicines by IV (through a vein or intravenously)
- **Oral dissolution therapy.** Medicines made from bile acid are used to dissolve the stones
- **Medicines.** These are used to prevent gallstones from forming
- **Low-fat diet.** When you are allowed to eat food again

DISAGNOSTIC ENZYMES-ENZYMES IN HEALTH AND DISEASE

- Enzymes are considered biocatalysts, due to their extraordinary properties and use for medical diagnosis.
- Enzymes are considered cellular damage markers. In the plasma certain amount of enzymes are present and this is basically used for investigating the heart, liver, biliary tract and skeletal muscle disease etc.

Enzymes Application of Diagnostic

Enzymes are basically preferred as various disease markers and for this, there are few diagnostic applications

- Blood Lipids ▪ Liver Function ▪ Diabetes
- Clinical Diagnosis ▪ POCT Bio-sensor Pancreas ▪ Kidney Function

ENZYMES IN DIAGNOSTIC USE

Serum Enzymes	Serum Enzyme's Location	Increased Concentration in	Decreased Concentration in
Trypsin	Stomach	Acute pancreas	–
Amylase	Salvia	Diabetes, Parotitis and Acute pancreas	Liver Disease
Cholinesterase	--	Nephrotic Syndrome	Malnutrition and Liver Disease
Lipase	Pancreas	Pancreatic Carcinoma and Acute pancreas	Diabetes mellitus, Deficiency of Vitamin A and Liver disease
Alkaline Phosphate	Liver and Bone	Kidney disease, Metastatic carcinoma, Jaundice and Rickets	–
Acid Phosphate	Prostrate	"Metastatic Prostatic Carcinoma"	–

Enzyme Therapy

- This therapy is basically referred to major applications of enzymes in terms of treating several medical conditions and enzyme deficiencies in humans

There are some enzymes are available which is used for various kind of treatment of major diseases such as

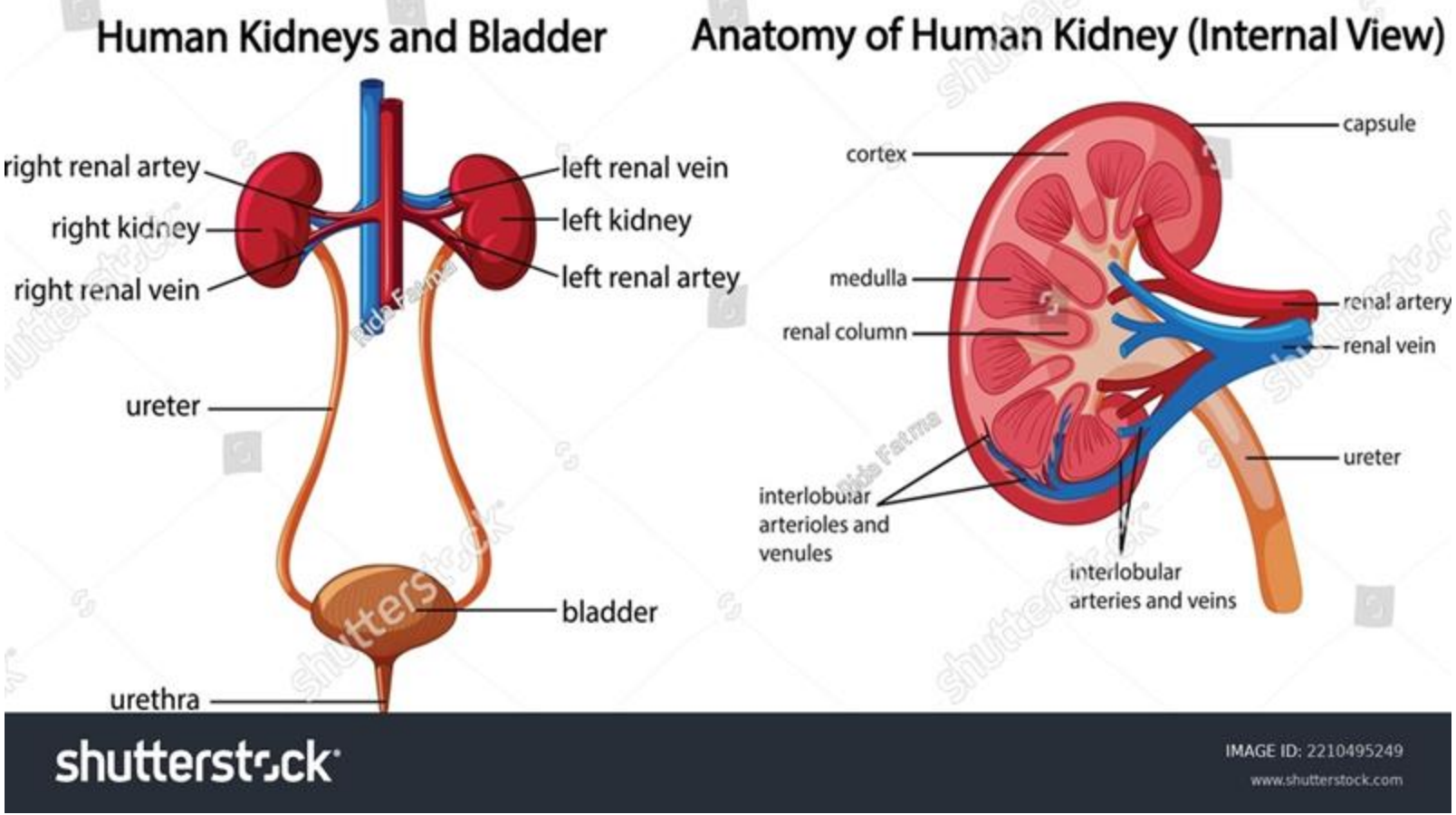
- **Trypsin peptidase, amylase , elastase, lipase and pepsin** is basically used in chronic pancreatitis and GIT disorders
- **Urokinase and Streptokinase** are basically used in the myocardial infarction which dissolves purulent material or the clot
- **Penicillinase** has been used for that patient who has a penicillin allergy.
- **Hyaluronidase** has been used for promoting drugs absorption which is injected subcutaneously
- **Collagenase** is basically used to clean up wounds and this process is done by removing dead tissues of severe burns and dermal ulcers
- **Chymotrypsin** is usually used in ophthalmology in terms of dissolving the ligaments of the lens at the time of extraction
- **Bacteria asparaginase** has been used for the treatment of leukemia

RENAL FUNCTION TESTS,ACUTE AND CHRONIC RENAL FAILURE

EXCRETORY SYSTEM

- The **excretory system** is responsible for removing waste products from the body and maintaining homeostasis by regulating the balance of water and electrolytes.
- The key organs involved in the excretory system includes;
  - Kidneys
  - Ureters
  - Bladder
  - Urethra

Human Excretory System



KIDNEYS

- **Function**: Filter blood to remove excess water, salts, and waste products (like urea), forming urine.
- **Structure**: The kidneys contain millions of tiny filtering units called **nephrons**, which are the functional units that help filter and purify the blood.
- **Role in Homeostasis**: The kidneys regulate blood pressure, electrolyte balance, and red blood cell production.

ORGANS

Ureters:

- **Function**: Transport urine from the kidneys to the bladder.
- **Structure**: Thin muscular tubes that connect each kidney to the bladd

Bladder:

- **Function**: Store urine until it is excreted from the body.
- **Structure**: A muscular sac capable of expanding as it fills with urine.

Urethra:

- **Function**: A tube through which urine is expelled from the bladder to

ADDITIONAL ORGANS

Skin: Removes waste through sweating.

Lungs: Expel carbon dioxide and water vapor during respiration.

Liver: Converts toxic ammonia (produced during protein metabolism) into urea, which is then filtered by the kidneys.

FUNCTIONS

- Removal of waste products (like urea, creatinine, and excess salts).
- Regulation of water balance (osmoregulation).
- Regulation of electrolytes (sodium, potassium, calcium, etc.).
- Maintenance of pH balance in the blood
- .Regulation of blood pressure through the renin-angiotensin system.

Renal function tests

- **Renal function tests (RFTs)** are a group of tests that evaluate how w the kidneys are working. These tests help assess the kidneys' ability filter waste products from the blood, maintain electrolyte balance, a produce urine

Blood Urea Nitrogen (BUN)

- **Purpose**: Measures the amount of urea nitrogen in the blood, which i waste product of protein metabolism.
- **Normal Range**: 7–20 mg/dL.
- **High Levels**: Indicate poor kidney function or dehydration.
- **Low Levels**: May be seen in malnutrition or liver dysfunction.

Serum Creatinine

- **Purpose**: Measures the amount of creatinine in the blood, a waste product generated from muscle metabolism.
- **Normal Range**:
  - Men: 0.6–1.2 mg/dL
  - Women: 0.5–1.1 mg/dL.
- **High Levels**: Suggest impaired kidney function, as the kidneys are not filtering creatinine effectively.
- **Low Levels**: May indicate reduced muscle mass or conditions

Glomerular Filtration Rate (GFR)

- **Purpose**: Estimates how well the kidneys are filtering blood by calculating the rate at which blood passes through the glomeruli (tiny filtering units in the kidneys).
- **Normal Range**: 90–120 mL/min.
- **Decreased GFR**: Indicates kidney disease or kidney failure. It is a critical indicator of kidney health.
- **Stages**:
  - **GFR ≥90**: Normal function.
  - **GFR 60–89**: Mild decrease.
  - **GFR 30–59**: Moderate decrease (chronic kidney disease stage 3).
  - **GFR <30**: Severe decrease (possible kidney failure).

TESTS

Urine Albumin-to-Creatinine Ratio (ACR)

- **Purpose**: Detects small amounts of albumin (a protein) in urine. Elevated albumin levels indicate kidney damage.
- **Normal Range**: <30 mg/g.
- **High Levels**: Suggest early signs of kidney disease, particularly in diabetes and hypertension.

Urinalysis

- **Purpose**: Examines the physical, chemical, and microscopic properties of urine to detect abnormalities such as protein, blood, bacteria, or glucose.
- **Findings**: Proteinuria (protein in urine), hematuria (blood in urine), or glucose in urine can indicate kidney issues.

Creatinine Clearance Test

- **Purpose**: Measures the amount of creatinine cleared from the blood by the kidneys over a 24-hour period. It gives a direct measurement of GFR.
- **Normal Range**: 90–140 mL/min.
- **Low Clearance**: Indicates reduced kidney function or impaired filtration capacity.

TESTS

Serum Electrolytes

- **Purpose**: Assesses the balance of important electrolytes such as sodium, potassium, calcium, and phosphate, which are regulated by the kidneys.
- **Imbalance**: Electrolyte disturbances can indicate kidney dysfunction (e.g., high potassium levels in kidney failure).

Cystatin C

- **Purpose**: An alternative marker to creatinine for estimating GFR. It may provide a more accurate

Importance of Renal Function Tests:

- **Early Detection**: Identifies kidney disease early before symptoms appear.
- **Monitoring**: Helps track kidney function in chronic conditions such as diabetes and hypertension.
- **Guiding Treatment**: Assists in adjusting medication doses and dietary recommendations based on kidney function.
- **Diagnosing Kidney Disorders**: Helps identify acute kidney injury (AKI), chronic kidney disease (CKD), and other renal pathologies.

Kidney Disease in Pets: Acute vs Chronic

AMC SINCE 1910 | Schwarzman Animal Medical Center
Usdan Institute for Animal Health Education

Acute Kidney Injury (AKI)

- Comes on suddenly
- Has a direct cause, i.e. toxin ingestion, infection, urethral obstruction
- Clinical signs are immediate
- Requires emergency treatment to prevent dehydration and maintain balance of electrolytes in the body
- May disappear completely once underlying cause is treated. Can also lead to permanent kidney damage

Chronic Kidney Disease (CKD)

- Develops slowly over time
- Can be present from birth or develop as a result of other conditions that damage the kidneys, including AKI
- Clinical signs do not appear until later stages of the disease
- Treatment depends on the stage of the disease, but can include administering fluids, proper medication, and specialized diets
- Has no cure, but pets can maintain a good quality of life as long as the disease is properly managed

Acute renal failure

Acute renal failure, also known as **acute kidney injury (AKI)**, is characterized by a rapid decline in kidney function, leading to an accumulation of waste products, electrolyte imbalances, and disruptions in fluid balance.

Elevated Serum Creatinine

- **Mechanism**: Creatinine is a byproduct of muscle metabolism that is normally filtered by the kidneys. In AKI, the filtration capacity of the kidneys decreases, leading to elevated serum creatinine levels.
- **Significance**: A rise in serum creatinine by at least 0.3 mg/dL within 48 hours or a 50% increase from baseline is a key diagnostic criterion for AKI.
- **Normal Range**: 0.6–1.2 mg/dL (varies by age, sex, and muscle mass).
- **Elevated Levels**: Indicate impaired glomerular filtration rate (GFR) and reduced kidney function.

Electrolyte Imbalances

Hyperkalemia (Elevated Potassium)

- **Mechanism**: Impaired excretion of potassium by the kidneys results in elevated serum potassium.
- **Normal Range**: 3.5–5.0 mEq/L.
- **Significance**: High potassium levels can lead to dangerous cardiac arrest.

Hyponatremia (Low Sodium)

- **Mechanism**: Due to impaired water excretion, there may be dilution of sodium or inappropriate renal sodium retention.
- **Normal Range**: 135–145 mEq/L.
- **Significance**: Hyponatremia can cause neurological symptoms like confusion, seizures, or coma.

Electrolyte Imbalances

Hyperphosphatemia (Elevated Phosphate)

- **Mechanism**: Decreased phosphate excretion by the kidneys.
- **Normal Range**: 2.5–4.5 mg/dL.
- **Significance**: Hyperphosphatemia can cause itching, and bone and mineral disorders

Hypocalcemia (Low Calcium)

- **Mechanism**: Phosphate retention and reduced vitamin D activation in the kidneys lead to low calcium levels.
- **Normal Range**: 8.5–10.2 mg/dL.
- **Significance**: Hypocalcemia may result in muscle cramps, tetany, and cardiac issues.

Oliguria or Anuria

- **Mechanism**: AKI can cause a significant reduction in urine output (oliguria: <400 mL/day) or complete cessation of urine production (anuria).
- **Urine Findings**:
  - **Low Urine Output**: Indicates decreased glomerular filtration.
  - **Urine Sodium**: Low in pre-renal causes (indicating sodium retention), high in intrinsic renal damage.

Anemia

- **Mechanism**: The kidneys produce erythropoietin, a hormone that stimulates red blood cell production. In AKI, erythropoietin production is reduced, leading to anemia.
- **Laboratory Findings**: Low hemoglobin and hematocrit levels.
- **Significance**: Anemia can cause fatigue, weakness, and pallor, often worsening in chronic cases.

Chronic renal failure

- **Chronic renal failure (CRF)**, also known as **chronic kidney disease (CKD)**, is characterized by a gradual and irreversible decline in kidney function over months or years.
- As kidney function deteriorates, various biochemical and physiological imbalances occur due to the kidneys' inability to adequately filter waste, regulate electrolytes, and maintain fluid balance.

Reduced Glomerular Filtration Rate (GFR)

- **Mechanism**: GFR measures the rate at which the kidneys filter blood. In CKD, GFR progressively declines.
- **Stages of CKD Based on GFR**:
  - Stage 1: GFR ≥90 mL/min/1.73 m² (with kidney damage).
  - Stage 2: GFR 60–89 mL/min/1.73 m².
  - Stage 3: GFR 30–59 mL/min/1.73 m².
  - Stage 4: GFR 15–29 mL/min/1.73 m².
  - Stage 5: GFR <15 mL/min/1.73 m² (end-stage renal disease or ESRD).
- **Significance**: GFR is the most important marker for assessing the stage of CK

Proteinuria (Albuminuria)

- **Mechanism**: Damage to the glomerular filtration barrier in CKD allows proteins, primarily albumin, to leak into the urine.
- **Laboratory Findings**:
  - **Urine Albumin-to-Creatinine Ratio (ACR)**:
    - Normal: <30 mg/g.
    - Moderately increased albuminuria: 30–300 mg/g.
    - Severely increased albuminuria: >300 mg/g.
- **Significance**: Persistent proteinuria is a marker of kidney damage and is used to predict the progression of CKD.

Hyperlipidemia

- **Mechanism**: CKD, especially in the advanced stages, is often associated with dyslipidemia, including elevated cholesterol and triglycerides.
- **Laboratory Findings**:
  - **Elevated LDL Cholesterol**.
  - **Elevated Triglycerides**.
- **Significance**: Hyperlipidemia increases the risk of cardiovascular diseases, which are a leading cause of morbidity and mortality in CKD patients.

Parathyroid Hormone (PTH) Elevation

- **Mechanism**: In CKD, impaired phosphate excretion, low calcium levels, and reduced activation of vitamin D lead to secondary hyperparathyroidism, where the parathyroid glands secrete more PTH to maintain calcium balance.
- **Laboratory Findings**:
  - **Elevated PTH Levels**.
- **Significance**: Secondary hyperparathyroidism contributes to bone disease (renal osteodystrophy) and calcium-phosphate imbalance in CKD patients.

DISORDERS OF LIVER AND KIDNEY

- *EXCRETORY SYSTEM CLEARANCE TESTS URINARY CALCULI, RENAL HYPERTENSION PRINCIPLES OF PERITONEAL AND HEMODIALYSIS.*

CLEARANCE TESTS

- Creatinine tests are used to measure the level of a waste product, known as creatinine, in your blood and urine.
- Creatinine is produced during the normal breakdown of muscle tissue,
- Because it is produced at a relatively steady rate, labs can use it as a marker to see how well your kidneys are functioning.

What to Expect During a Creatinine Test

1

Height and weight recorded to calculate BMI

Body Mass Index (BMI)

2

Phlebotomist draws blood

3

Do 24-hour urine collection at home

WHY THE TEST IS PERFORMED

- **Creatinine is a chemical waste product of creatine.**
- **Creatine is a chemical the body makes to supply energy, mainly to muscles.**
- **This test is done to see how well your kidneys work. Creatinine is removed by the body entirely by the kidneys.**
- **If kidney function is not normal, the creatinine level in your urine decreases.**

Serum creatinine (SCr)

- **Blood test, reveals how much creatinine is circulating in the bloodstream.**
- **Since the rate of production and excretion is relatively steady, any increases above the expected range can be considered a reliable indication of renal impairment**

Creatinine clearance (CrCl)

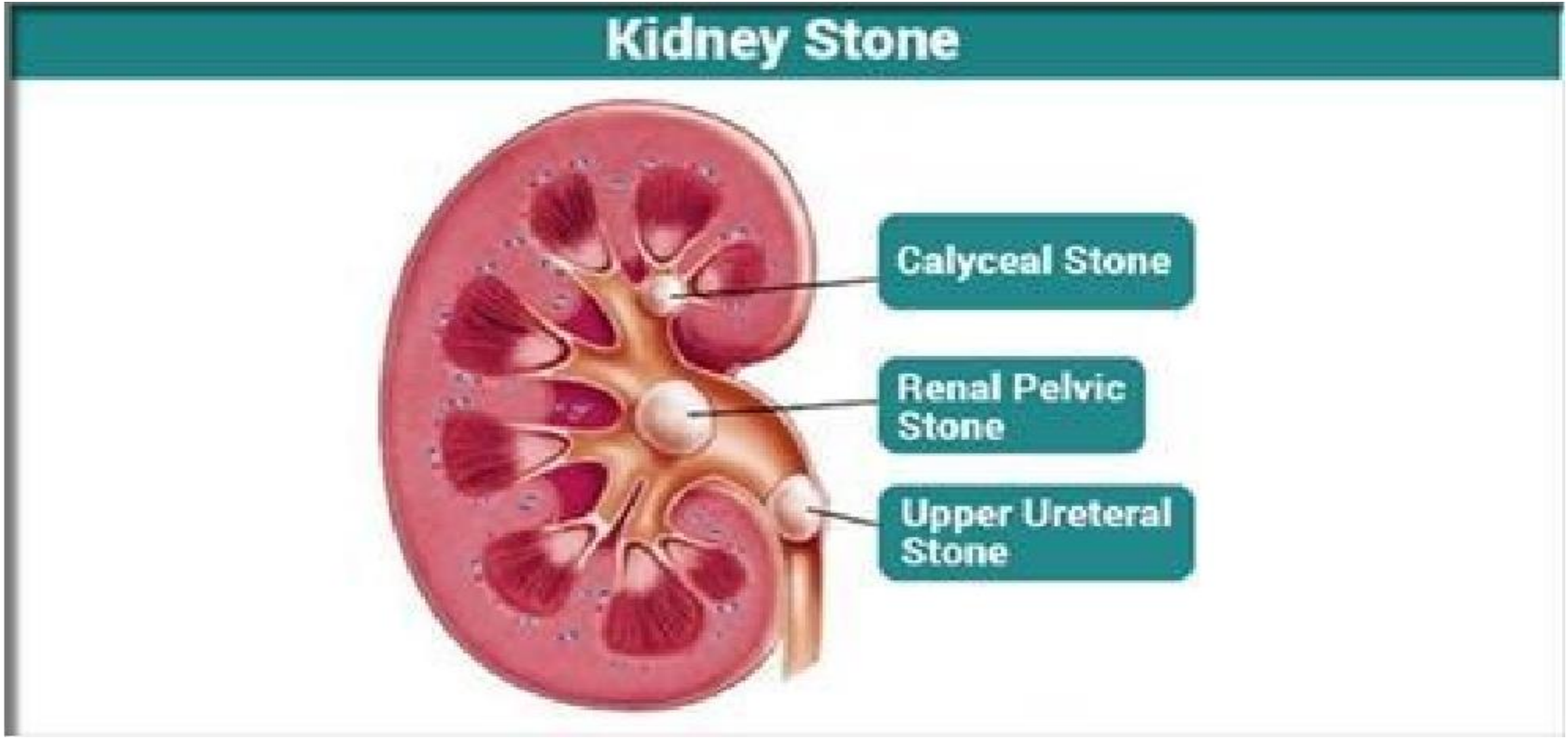
- **a urine test, compares the SCr with the amount of creatinine excreted in urine over 24 hours.**

Normal Level

- **Male: 97 to 137 mL/min (1.65 to 2.33 mL/s).**
- **Female: 88 to 128 mL/min (1.467 to 2.18 mL/s).**

URINARY CALCULI

- **Renal Calculi, also called Kidney Stones, are a solid mass of crystals that block the urinary tract.**
- **These crystals are primarily formed when calcium and oxalate coalesce.**
- **These stones originate in the kidney and exit through the urine system.**



Most stones may not cause any sign or symptoms until it starts moving toward the uterus. Once the size of the stone exceeds more than 0.2 inches, one may experience severe pain in the abdomen or lower back as a result of a blocked ureter.

SIGNS AND SYMPTOMS OFRENAL CALCULI

- **Pain in the lower abdomen**
- **Sweating**
- **Brown, Red and Pink Urine**
- **Foul-smelling urine**
- **Cloudy Urine**
- **Experiencing pain during urination**
- **Vomiting and Nausea**
- **Restlessness**
- **Severe pain in the ribs**
- **Urinary Urgency**
- **Discharge of blood in the urine**

PREVENTION AND DIETARY MEASURES FOR RENAL CALCULI

- **Moderate intake of calcium.**
- **Limit consumption of soft drinks and sodium.**
- **Increase intake of fluid and citric acid.**
- **Avoid intake of vitamins and minerals in large dosages.**

Risk Factors for Renal Calculi

- **Dehydration is one of the main factors in stone formation.**
- **A high intake of animal protein (egg, chicken, meat) also increases the risk of kidney stone formation.**

TREATMENT FOR RENAL CALCULI

Allopurinol

- **Allopurinol is one of the best treatments to reduce kidney stone recurrences.**
- **This drug can also be used with people having hyperuricemia or gout, calcium stones and hyperuricosuria.**
- **This treatment interferes with the production of uric acid in the liver.**
- **This drug is adjusted to minimize the urinary excretion of**

RENAL HYPERTENSION

"High blood pressure resulting from kidney disease"

- **High blood pressure (hypertension) is a leading cause of kidney disease and kidney failure (end-stage renal disease).**
- **Kidney disease can also cause a type of high blood pressure called renal hypertension.**

Symptoms

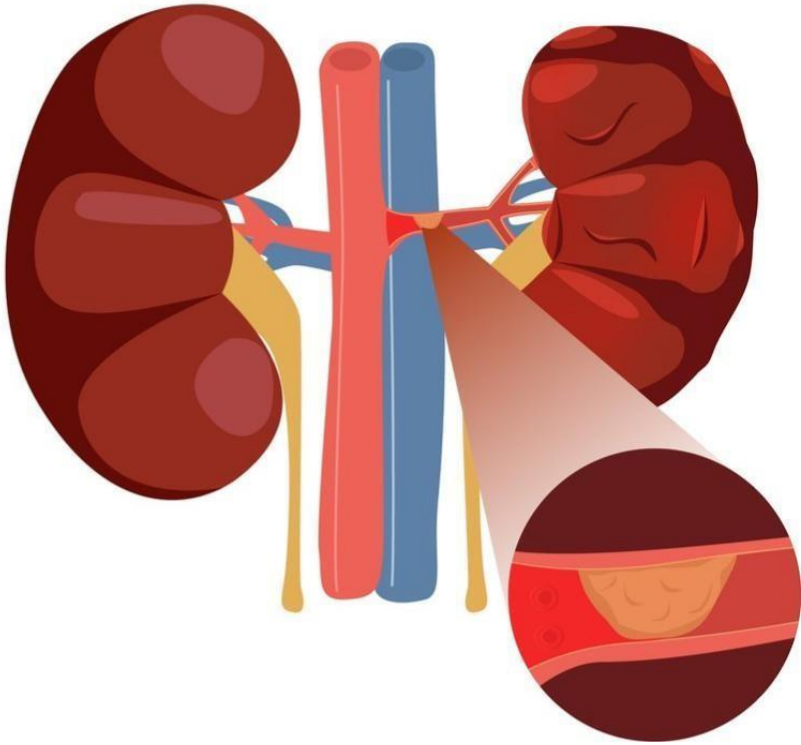
- High/worsening blood pressure
- Decrease in amount of urine or difficulty urinating
- Edema (fluid retention), especially in the lower legs
- A need to urinate more often, especially at night Prevent

Kidney Disease

- Try to keep your blood pressure controlled.
- Make sure you get your blood pressure checked on a regular basis.

RENAL STENOSIS

- **Decrease in the diameter of the renal arteries**
- **Atherosclerosis; fat, cholesterol, calcium and other material found in the blood**
- **Fibromuscular dysplasia; abnormal development or growth of cells on the renal artery walls**



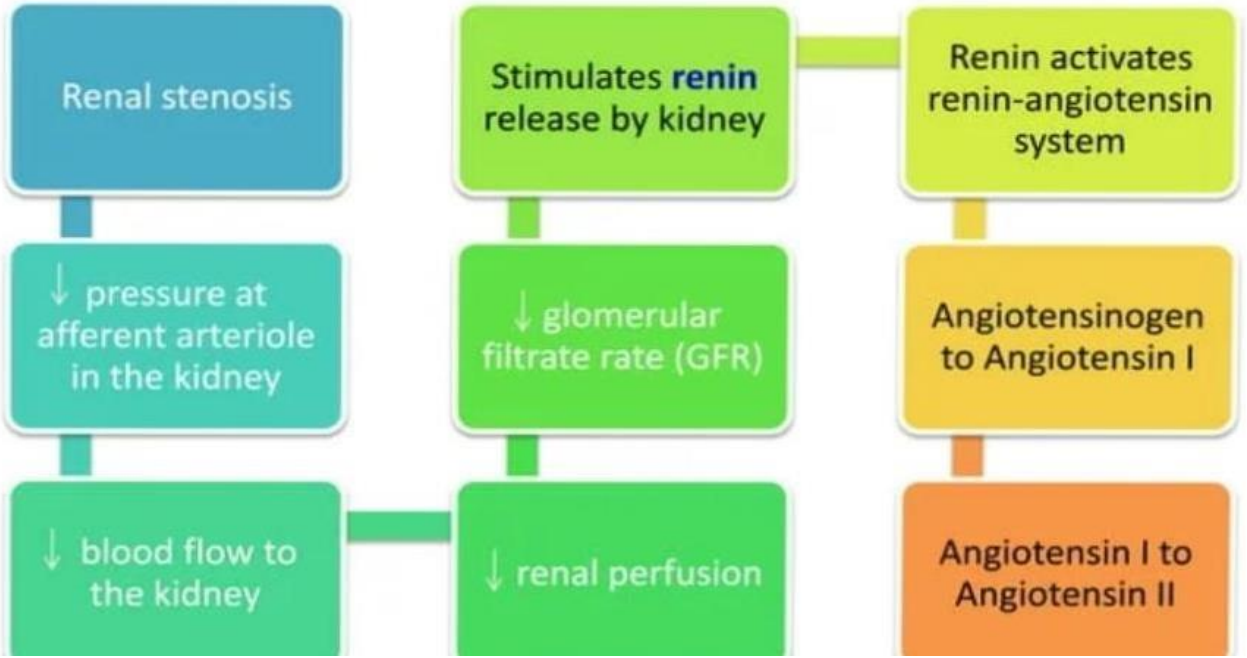
CHRONIC GLOMERULONEPHRITIS

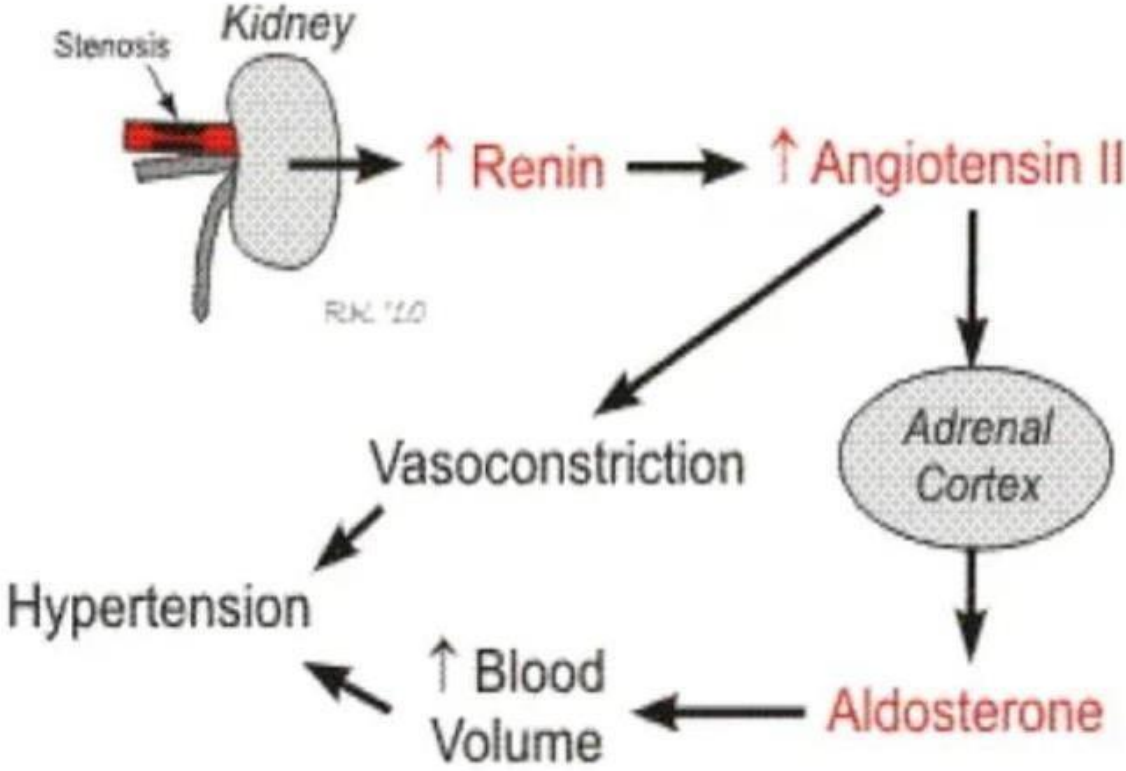
Inflammation of the glomerular

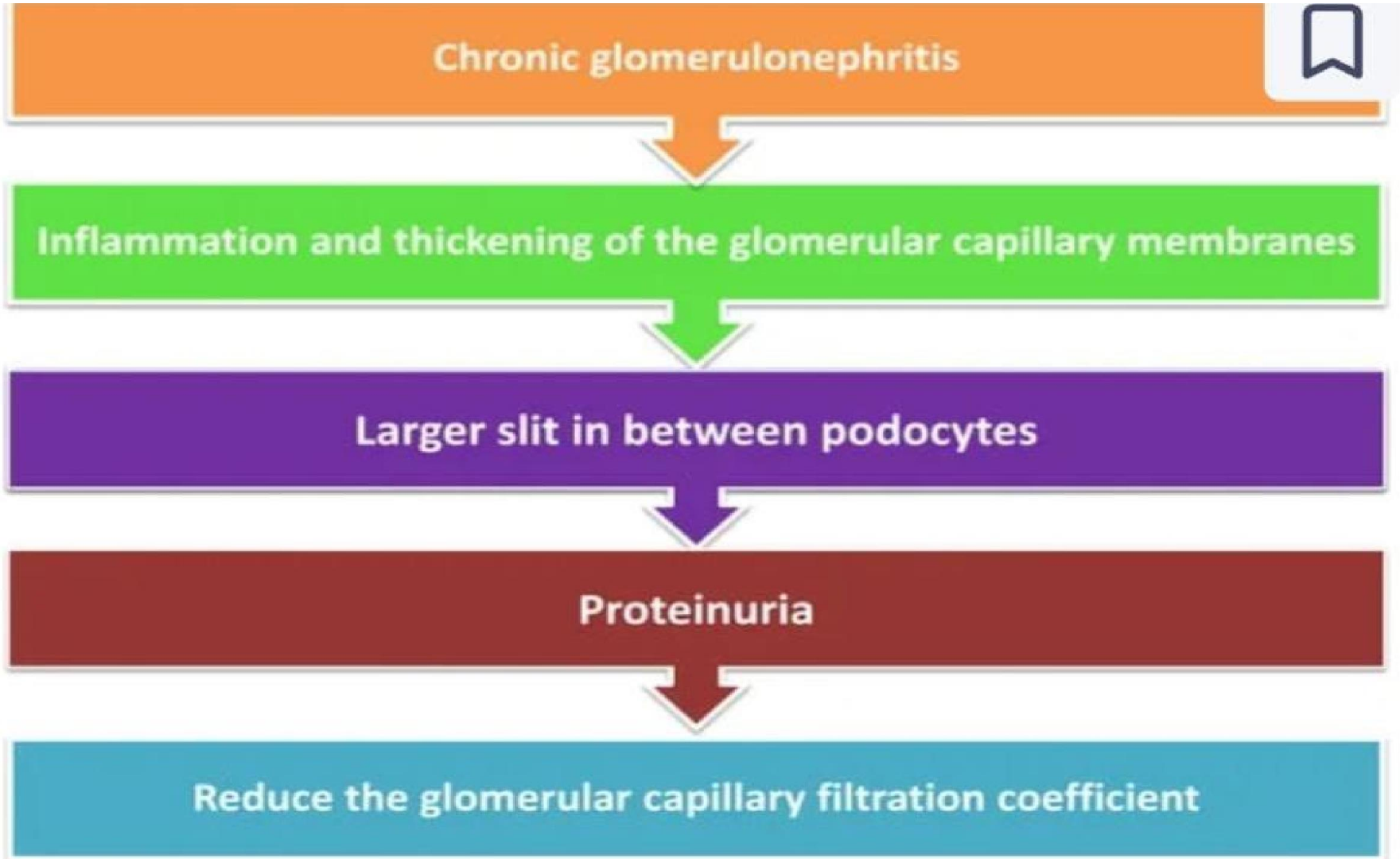
- **Caused by:**
- **Strep throat**
- **Systemic Lupus Erythematosus (SLE)**
- **Goodpasture's syndrome**
- **Amyloidosis**
- **Wegener's granulomatosis**
- **Polyarteritis nodosa**

PATHOPHYSIOLOGY

- **Increased renal vascular resistance**
- **Decreased glomerular capillary function coefficient**




Stenosis
Kidney
↑ Renin
↑ Angiotensin II
Vasoconstriction
Adrenal Cortex
Hypertension
↑ Blood Volume
Aldosterone


Chronic glomerulonephritis
Inflammation and thickening of the glomerular capillary membranes
Larger slit in between podocytes
Proteinuria
Reduce the glomerular capillary filtration coefficient

INVESTIGATIONS

- Renal stenosis
- Blood tests
- Urine tests
- Kidney ultrasound

Glomerulonephritis

- Kidney biopsy
- Abdominal C T Scan
- Kidney ultrasound
- Urinalysis

CLINICAL FEATURES

Renal Glomerulonephritis

- High blood pressure
- Haemouria and proteinuria
- Edema in ankles and face
- Bubbly or foamy urine (from excess protein)

CLINICALFEATURES

RENAL STENOSIS

- **High blood pressure – Hard to control**

GLOMERULONEPHRITIS

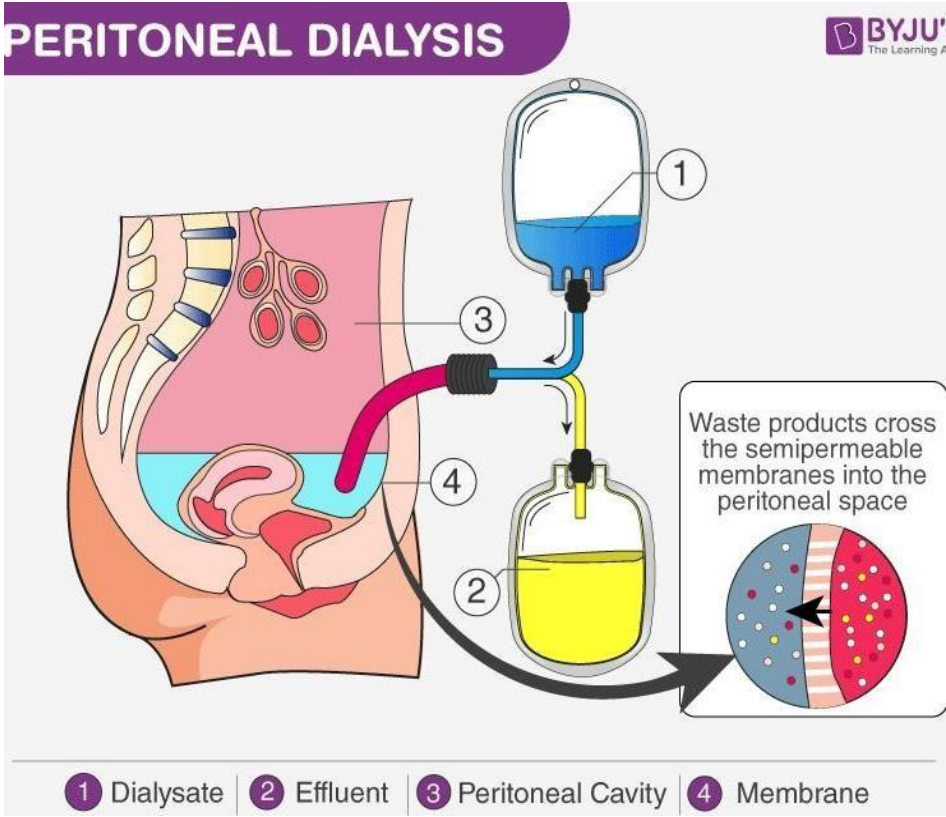
- **High blood pressure**
- **Haemouria and proteinuria**
- **Edema in ankles and face**
- **Bubbly or foamy urine (from excess protein)**

WHAT IS DIALYSIS?

- Dialysis is an artificial process of cleaning the blood by removing toxins, excess amount of water, and other solutes when the person's kidneys could no longer perform the excretion process.

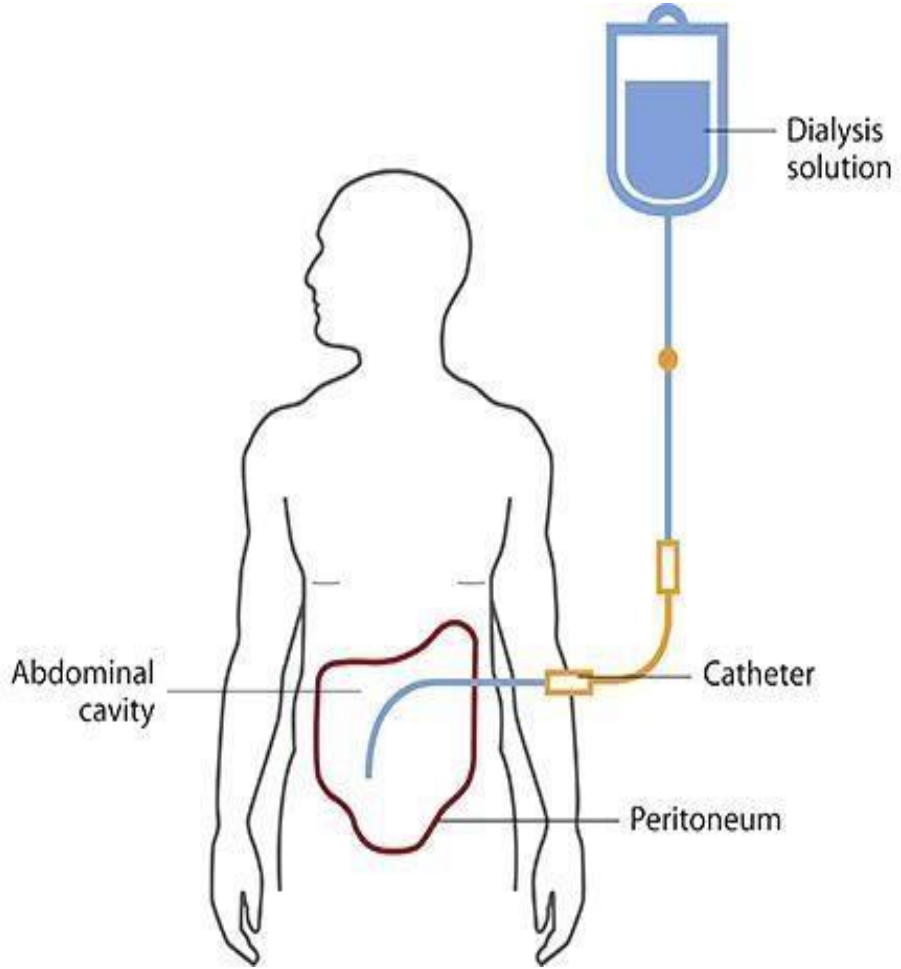
Types of Dialysis

- Hemodialysis.
- Peritoneal dialysis.



PERITONEAL DI

- **Peritoneal dialysis is a treatment for kidney failure that uses the lining of your abdomen, or belly, to filter your blood inside your body.**
- **Health care providers call this lining the peritoneum.**
- **A few weeks before you start peritoneal dialysis, a surgeon places a soft tube, called a catheter, in your belly.**



Principle of Peritoneal Dialysis

- **Peritoneal dialysis is the technique in which the peritoneal membrane is used as a semipermeable membrane.**
- **Through the peritoneal membrane, the fluid and dissolved substances are exchanged with the blood.**

Types of Peritoneal Dialysis

- **Automated Peritoneal Dialysis (APD)**
- **Continuous Ambulatory Peritoneal Dialysis (CAPD)**

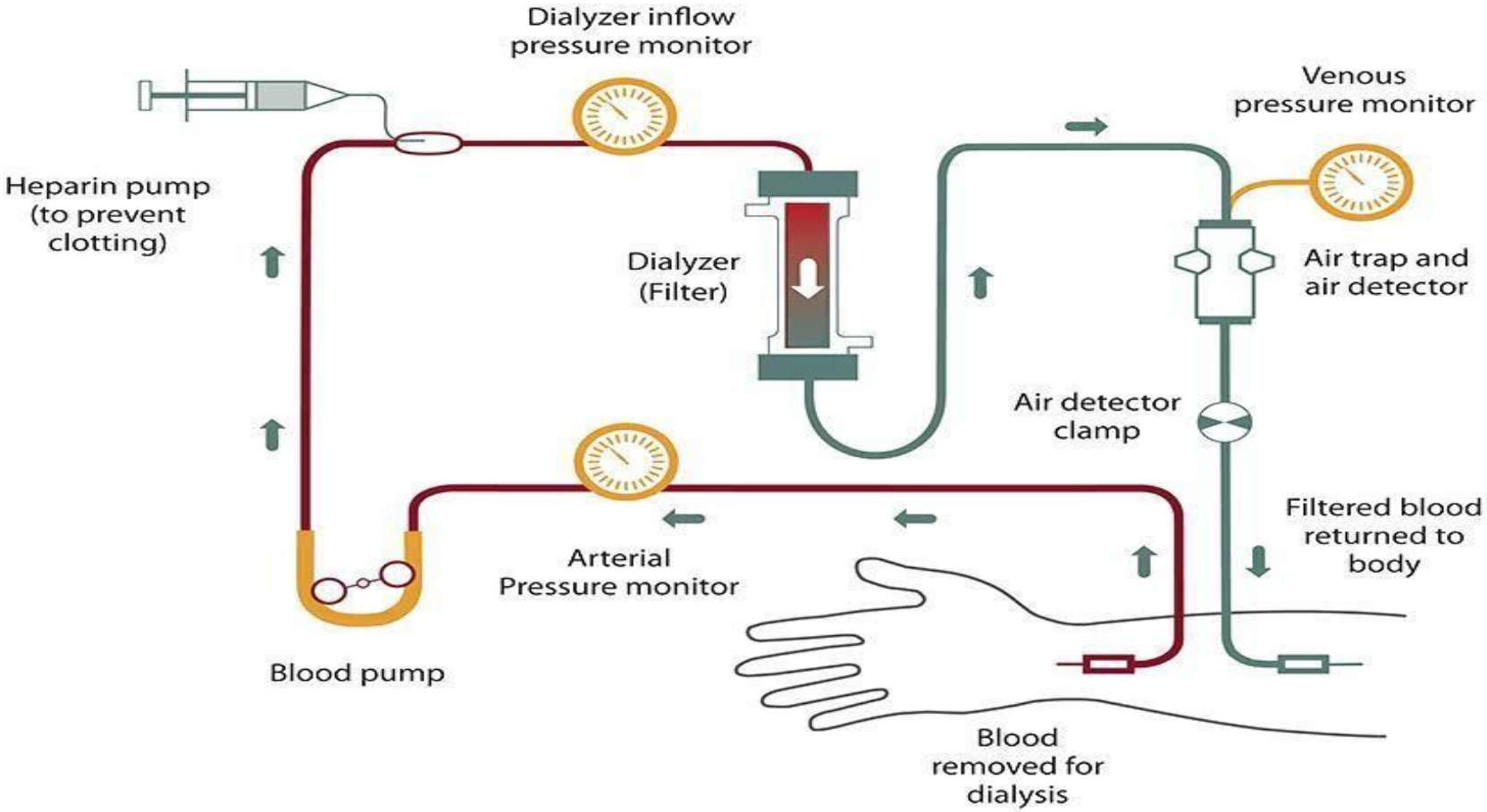
- **This process involves minor surgery to implant peritoneal dialysis – a catheter into the abdomen.**
- **This process takes a few hours and is repeated for three to five times per day**
- **Process of dialysis, the implanted catheter helps in filtering the blood through the abdominal membrane called the peritoneum**

Advantages and disadvantages

- **Peritoneal dialysis is a simple, convenient and less expensive technique, compared to hemodialysis.**
- **However, it is less efficient in removing some of the toxic substances and it may lead to complications by infections.**

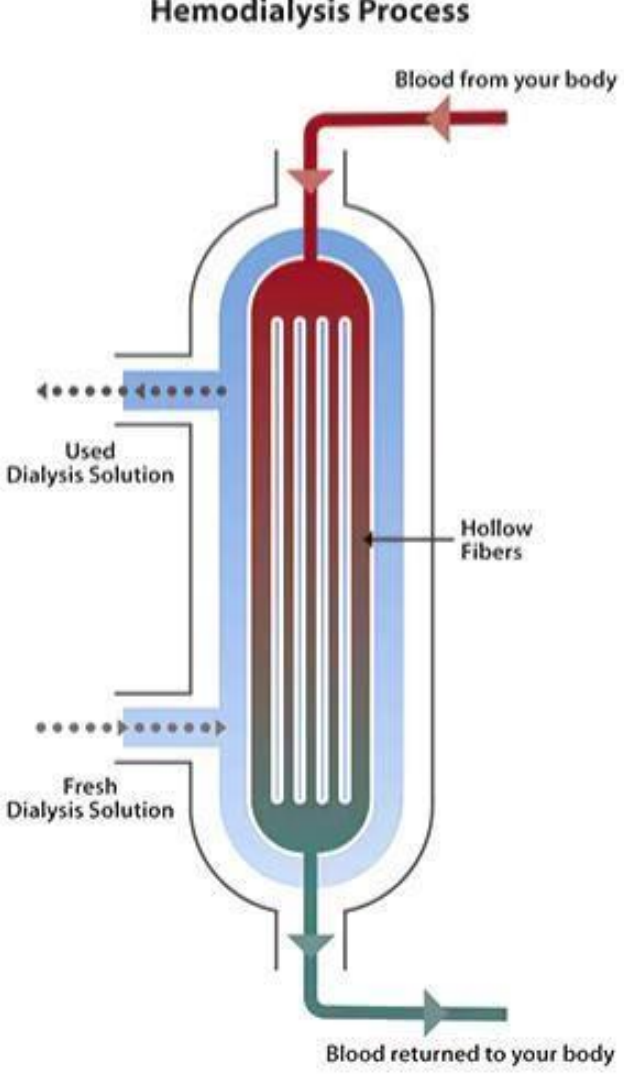
HEMODIALYSIS

- Hemodialysis is a treatment to filter wastes and water from your blood, as your kidneys did when they were healthy.
- Hemodialysis helps control blood pressure and balance important minerals, such as potassium, sodium, and calcium, in your blood.
- Hemodialysis can help you feel better and live longer, but it's not a cure for kidney failure.



During hemodialysis, your blood is pumped through a filter, called a dialyzer.

- **The dialysis machine pumps blood through the filter and returns the blood to your body.**
- **During the process, the dialysis machine checks your blood pressure and controls how quickly**
- **blood flows through the filter**
- **fluid is removed from your body**
- **The filter, your blood flows inside hollow fibers that filter out wastes and extra salt and water.**



- The dialysis solution contains water and chemicals that are added to safely remove wastes, extra salt, and fluid from your blood.
- Your doctor can adjust the balance of chemicals in the solution.
- your blood tests show your blood has too much or too little of certain minerals, such as potassium or calcium
- you have problems such as low blood pressure or muscle cramps during dialysis.

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THANK YOU