Alterations of Renal and Urinary Tract Function

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Self Risk Assessment of Renal Disease and Renal Failure

	YES	NO
History of kidney disease in your family.	☐	☐
Are you suffering from		
(i) Diabetes	☐	☐
(ii) Hypertension	☐	☐
(iii) Kidney diseases such as Recurrent kidney tract infection, kidney stones, kidney inflammation (nephritis)	☐	☐
Do you have the following symptoms		
(i) Blood in urine / tea color urine	☐	☐
(ii) Frothy urine	☐	☐
(iii) Turbid urine	☐	☐
(iv) Pain and frequency when passing urine	☐	☐
(v) Difficulty / slow in passing urine	☐	☐
(vi) Passing gravel or stone with urine	☐	☐
(vii) Passing urine at night (very frequent)	☐	☐
(viii) Loin / back pain	☐	☐
(ix) Swollen ankles or puffy face	☐	☐

If you have answered "YES" to any of the above questions on risk and symptoms which may be due to kidney disease, you should seek advice from your family doctor.

Are your kidneys OK?

Outline:

1. Summary of Normal Renal and Urologic Structures and Functions
2. Renal Dysfunction
    A. Acute Renal Failure
    B. Chronic Renal Failure
3. Kidney Stones
4. Glomerular disorders
5. Pyelonephritis
6. Urinary tract obstruction
7. Urinary tract infection

LEARNING OUTCOMES:

1. Identify the pathogenesis of the different urologic and renal function alterations
2. Discuss the etiologic factors of the different alterations in urologic and renal functions
3. Explain the clinical manifestations of these conditions.

Sources/References:

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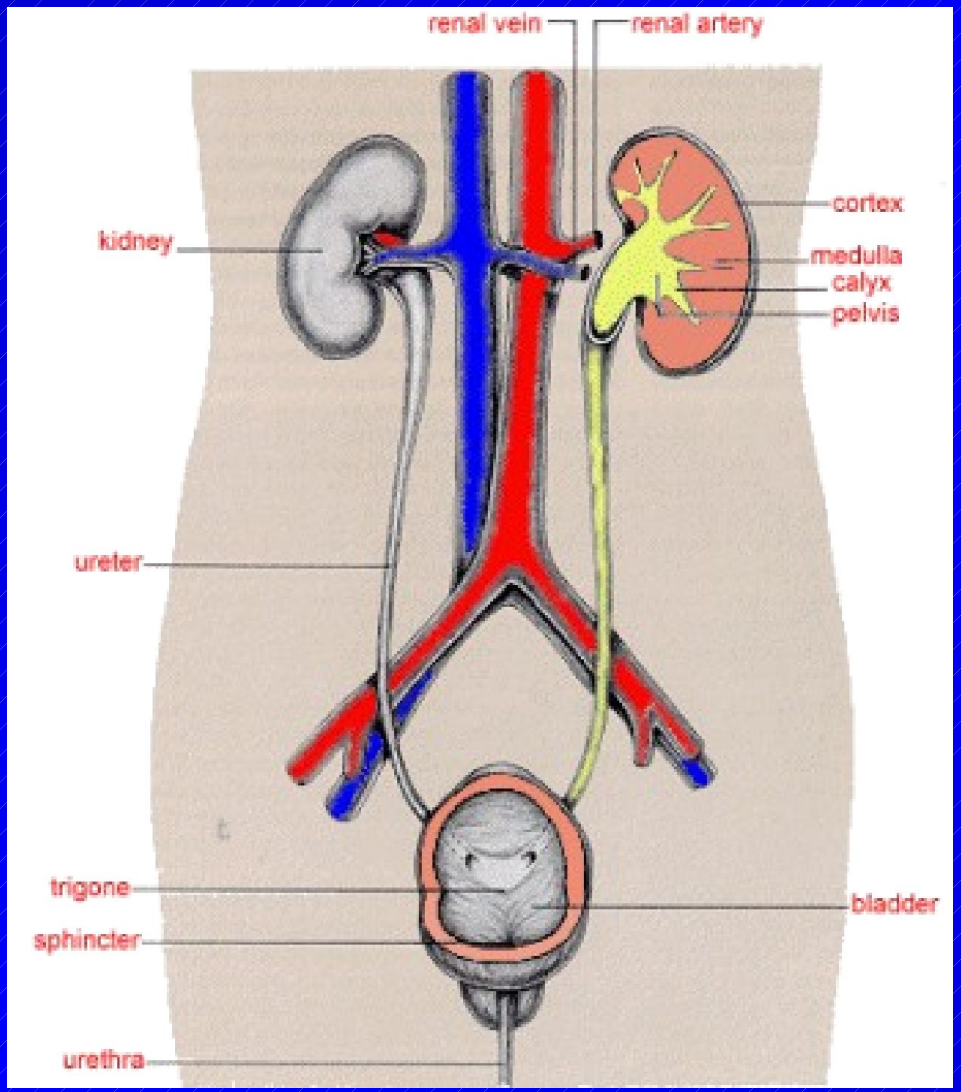
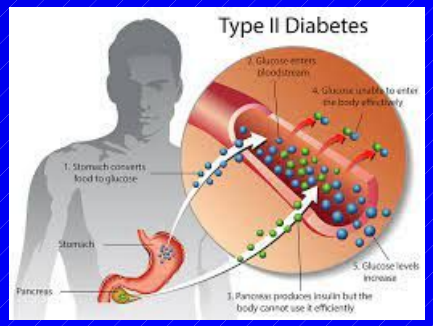
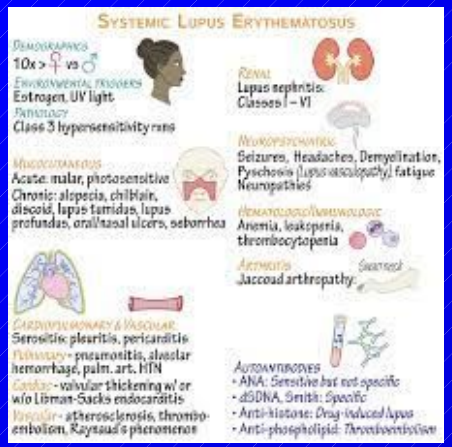
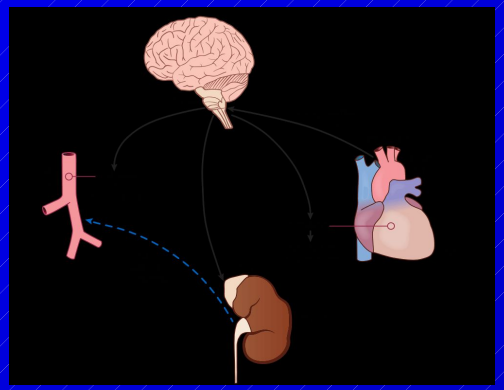


Normal Structures and Functions of kidneys and urinary tract

- Kidney disease contributes significantly to the global burden of disease, both in developing and developed countries. It is important for us to be aware of the various risk factors and causes of kidney disease to prevent the onset.
- Renal disease can develop from long standing diabetes and hypertension, and also from autoimmune diseases like systemic lupus erythematosus





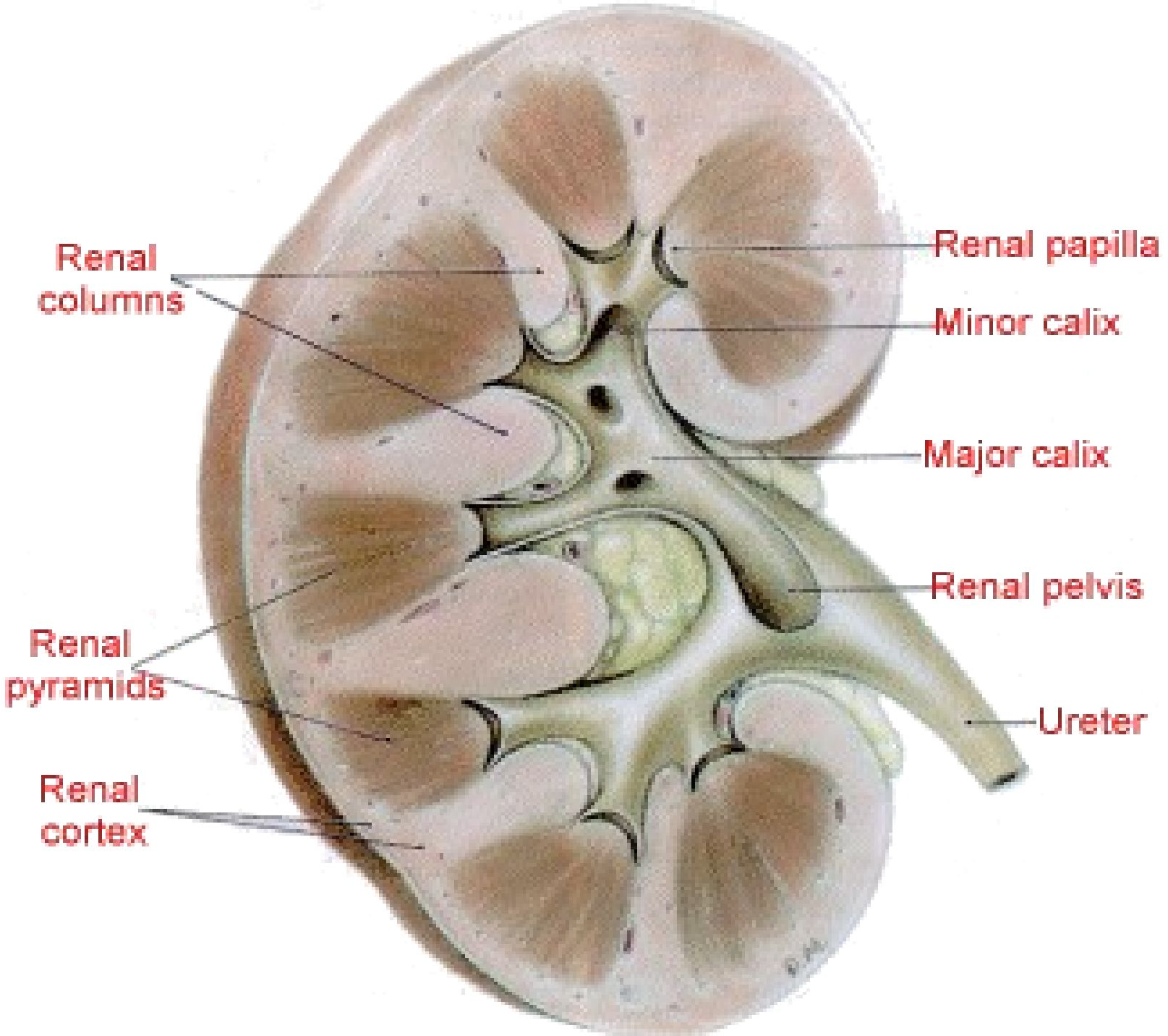


- The kidneys are essentially regulatory organs which maintain the volume and composition of body fluid by filtration of the blood and selective reabsorption or secretion of filtered solutes.

- The kidneys take their blood supply directly from the aorta via the renal arteries; blood is returned to the inferior vena cava via the renal veins.

- Urine (the filtered product containing waste materials and water) excreted from the kidneys passes down the fibromuscular ***ureters*** and collects in the ***bladder***. The bladder muscle (the ***detrusor muscle***) is capable of distending to accept urine without increasing the pressure inside; this means that large volumes can be collected (700-1000ml) without high-pressure damage to the renal system occurring.

- When urine is passed, the ***urethral sphincter*** at the base of the bladder relaxes, the detrusor contracts, and urine is voided via the urethra.

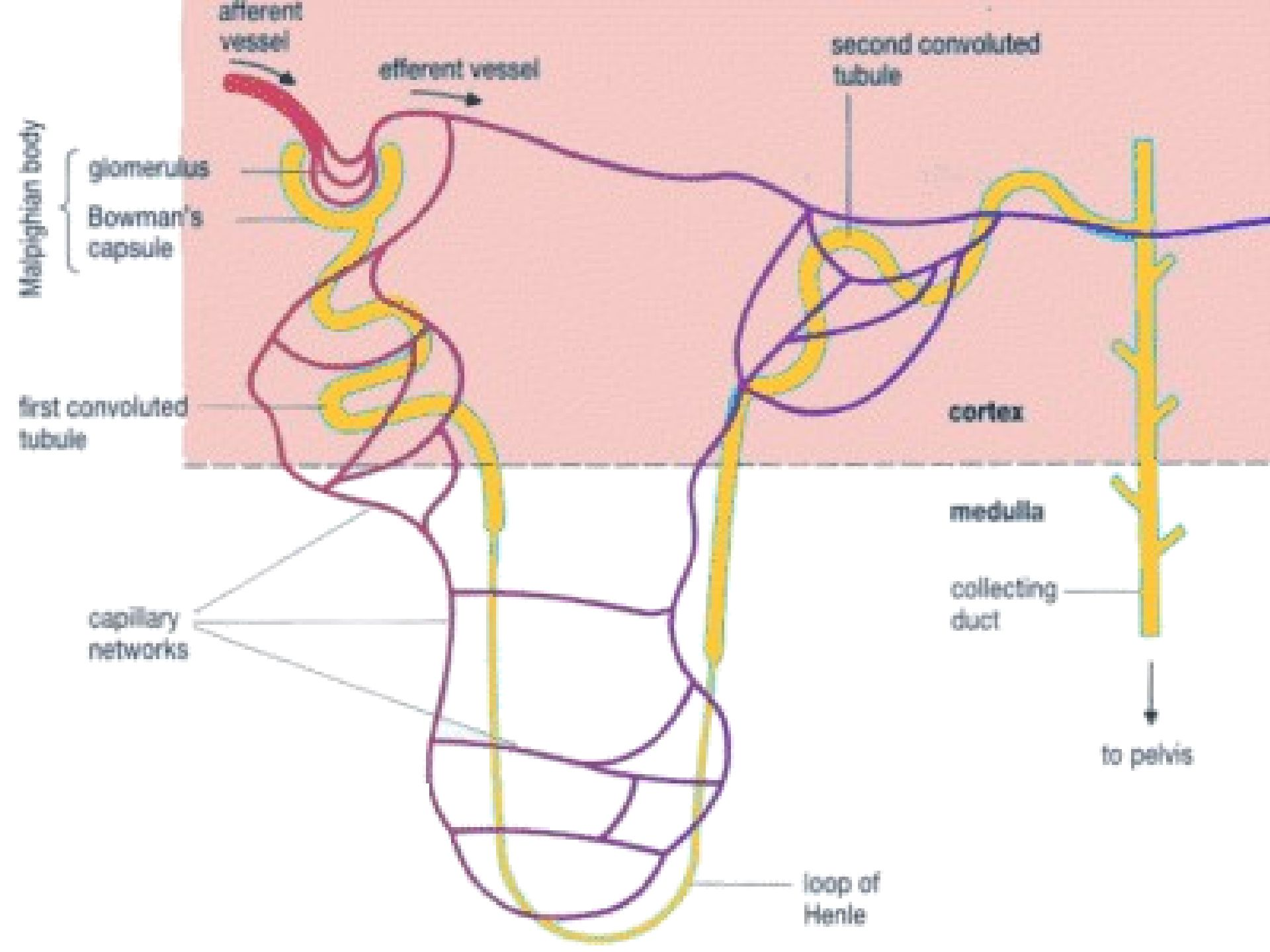

Renal columns
Renal papilla
Minor calix
Major calix
Renal pelvis
Renal pyramids
Ureter
Renal cortex

- On sectioning, the kidney has a pale outer region- the ***cortex***- and a darker inner region- the medulla.
- The ***medulla*** is divided into 8-18 conical regions, called the ***renal pyramids***; the base of each pyramid starts at the corticomedullary border, and the apex ends in the ***renal papilla*** which merges to form the ***renal pelvis*** and then on to form the ureter.

- In humans, the renal pelvis is divided into two or three spaces -the ***major calyces***- which in turn divide into further ***minor calyces***.
- The walls of the calyces, pelvis and ureters are lined with smooth muscle that can contract to force urine towards the bladder by peristalsis.
- The cortex and the medulla are made up of ***nephrons***; these are the functional units of the kidney, and each kidney contains about 1.3 million of them.

Structure of the Nephron

- The nephron is the unit of the kidney responsible for ultrafiltration of the blood and reabsorption or excretion of products in the subsequent filtrate. Each nephron is made up of:
- A filtering unit- the ***glomerulus***. 125ml/min of filtrate is formed by the kidneys as blood is filtered through this sieve-like structure. This filtration is uncontrolled.


afferent vessel
efferent vessel
second convoluted tubule
Malpighian body
glomerulus
Bowman's capsule
first convoluted tubule
cortex
medulla
collecting duct
capillary networks
to pelvis
loop of Henle

- The ***proximal convoluted tubule***. Controlled absorption of glucose, sodium, and other solutes goes on in this region.
- The ***loop of Henle***. This region is responsible for concentration and dilution of urine by utilising a counter-current multiplying mechanism- basically, it is water-impermeable but can pump sodium out, which in turn affects the osmolarity of the surrounding tissues and will affect the subsequent movement of water in or out of the water-permeable collecting duct.

- The ***distal convoluted tubule***. This region is responsible, along with the collecting duct that it joins, for absorbing water back into the body- simple maths will tell you that the kidney doesn't produce 125ml of urine every minute. 99% of the water is normally reabsorbed, leaving highly concentrated urine to flow into the collecting duct and then into the renal pelvis.

COMMON DISEASES IN RENAL

- Acute renal failure, a sudden loss of renal function
- Chronic kidney disease, declining renal function, usually with an inexorable rise in creatinine.
- Hematuria, blood loss in the urine
- Proteinuria, the loss of protein especially albumin in the urine
- Microalbuminuria, slight increase in urinary albumin excretion

Acquired

- Diabetic nephropathy
- Glomerulonephritis
- Hydronephrosis is the enlargement of one or both of the kidneys caused by obstruction of the flow of urine.
- Interstitial nephritis
- Kidney stones are a relatively common and particularly painful disorder.
- Kidney tumors – Wilms tumor, Renal cell carcinoma

- Lupus nephritis
- Minimal change disease
- In nephrotic syndrome, the glomerulus has been damaged so that a large amount of protein in the blood enters the urine. Other frequent features of the nephrotic syndrome include swelling, low serum albumin, and high cholesterol.
- Pyelonephritis is infection of the kidneys and is frequently caused by complication of a urinary tract infection.

- Electrolyte disorders or acid/base imbalance
- Kidney stones, usually only recurrent stone formers.
- Nephrosis, degeneration of renal tubular epithelium.
- Nephritis, inflammation of the kidneys
- Chronic or recurrent urinary tract infections
- Hypertension that has failed to respond to multiple forms of anti-hypertensive medication or could have a secondary cause

Acute Renal Failure

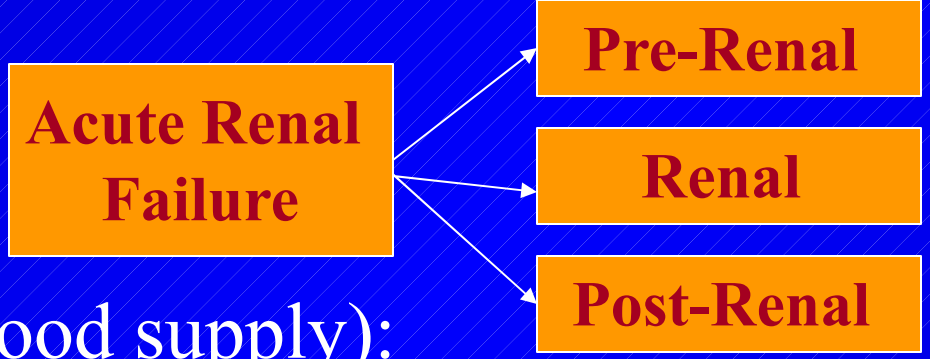
- Acute renal failure (ARF) is the rapid breakdown of renal (kidney) function that occurs when high levels of uremic toxins (waste products of the body's metabolism) accumulate in the blood.
- ARF occurs when the kidneys are unable to excrete (discharge) the daily load of toxins in the urine.
- Based on the amount of urine that is excreted over a 24-hour period, patients with ARF are separated into two groups: Oliguric: patients who excrete less than 500 mL/day. Nonoliguric: more than 500 mL/day

- In nonoliguric patients, the urine is of poor quality (i.e., contains little waste) because the blood is not well filtered, despite the fact that an adequate volume of urine is excreted.
- Both kidneys are failing when ARF occurs. One normally functioning kidney can maintain adequate blood filtering.

Incidence

- ARF affects approximately 1% of patients on admission to the hospital, 2-5% during the hospital stay, and 4-15% after cardiopulmonary bypass surgery.

CAUSES



Pre-renal (causes in the blood supply):

- hypovolemia (decreased blood volume), usually from shock or dehydration and fluid loss or excessive diuretics use.
- hepatorenal syndrome in which renal perfusion is compromised in liver failure
- vascular problems, such as atheroembolic disease and renal vein thrombosis (which can occur as a complication of the nephrotic syndrome)
- infection usually sepsis, systemic inflammation due to infection

Renal (damage to the kidney itself):

- toxins or medication (e.g. some NSAIDs, aminoglycoside antibiotics, iodinated contrast, lithium)
- rhabdomyolysis (breakdown of muscle tissue) - the resultant release of myoglobin in the blood affects the kidney; it can be caused by injury (especially crush injury and extensive blunt trauma), statins, stimulants and some other drugs

- hemolysis (breakdown of red blood cells) - the hemoglobin damages the tubules; it may be caused by various conditions such as sickle-cell disease, and lupus erythematosus
- multiple myeloma, either due to hypercalcemia or "cast nephropathy" (multiple myeloma can also cause chronic renal failure by a different mechanism)
- acute glomerulonephritis which may be due to a variety of causes, such as anti glomerular basement membrane disease/Goodpasture's syndrome, Wegener's granulomatosis or acute lupus nephritis with systemic lupus erythematosus

Post-renal (obstructive causes in the urinary tract) due to:

- medication interfering with normal bladder emptying.
- benign prostatic hypertrophy or prostate cancer.
- kidney stones.
- due to abdominal malignancy (e.g. ovarian cancer, colorectal cancer).
- obstructed urinary catheter.

Signs and Symptoms: ARF does not produce a classic set of symptoms. The most common symptom is decreased urine output, which occurs in 70% of patients.

Diagnosis: ARF is most easily diagnosed by an increase in blood levels of creatinine and blood urea nitrogen (BUN). The blood level of creatinine typically increases by 0.5 milligrams per tenth of a liter (mg/dL) every day.

Treatment: There are several modalities of renal replacement therapy (RRT) for patients with acute renal failure:

- Intermittent hemodialysis
- Continuous hemodialysis (used in critically ill patients)
- Peritoneal dialysis (rarely used)

Prognosis

- Before the development of renal replacement therapy (RRT), many people with ARF died from severe electrolyte imbalance (hyperkalemia, acidosis) or from the uremic toxins themselves.
- Patients with ARF are at risk for numerous complications that may lead to death, such as seizures, bleeding, and coma.
- Since dialysis effectively treats the life-threatening complications of ARF, advanced age and underlying diseases are more likely to determine the risk for a patient's dying from ARF.

- Oliguric ARF patients continue to have a high mortality rate, despite the availability of RRT.
- Almost uniformly, these patients have other acute and/or chronic medical problems.
- Patients with nonoliguric ARF tend to have a more favorable prognosis and are often easier to treat.
- Nonoliguric ARF patients often have fewer systemwide complications because their condition typically is caused by drug-related toxicity and interstitial nephritis.

Chronic Renal Failure

- Chronic renal failure (CRF) is the progressive loss of kidney function.
- The kidneys attempt to compensate for renal damage by hyperfiltration (excessive straining of the blood) within the remaining functional nephrons (filtering units that consist of a glomerulus and corresponding tubule).
- Over time, hyperfiltration causes further loss of function.

- Chronic loss of function causes generalized wasting (shrinking in size) and progressive scarring within all parts of the kidneys.
- In time, overall scarring obscures the site of the initial damage.
- Yet, it is not until over 70% of the normal combined function of both kidneys is lost that most patients begin to experience symptoms of kidney failure.

CAUSES

- The cause for CRF sometimes can be determined by a detailed medical history, a comprehensive physical examination, and laboratory studies.
- More often than not, determining the cause of CRF is difficult if not impossible.
- Even a kidney biopsy may be inconclusive, because all forms of kidney failure eventually progress to diffuse scarring and look the same on kidney biopsy.
- The most common causes for CRF are diabetes and hypertension.

Pre-Renal CRF

- Some medical conditions cause continuous hypoperfusion (low blood flow) of the kidneys, leading to kidney atrophy (shrinking), loss of nephron function, and chronic renal failure (CRF).
- These conditions include poor cardiac function, chronic liver failure, and atherosclerosis ("hardening") of the renal arteries.
- Each of these conditions can induce ischemic nephropathy.

Post-Renal CRF

- Interference with the normal flow of urine can produce backpressure within the kidneys, can damage nephrons, and lead to obstructive uropathy, a disease of the urinary tract.

Abnormalities that may hamper urine flow and cause post-renal CRF include the following:

- ***Bladder outlet obstruction*** due to an enlarged prostate gland or bladder stone
- ***Neurogenic bladder***, an overdistended bladder caused by impaired communicator nerve fibers from the bladder to the spinal cord
- ***Kidney stones*** in both ureters, the tubes that pass urine from each kidney to the bladder

- ***Obstruction of the tubules***, the end channels of the renal nephrons
  - ***Retroperitoneal fibrosis***, the formation of fiberlike tissue behind the peritoneum, the membrane that lines the abdominal cavity
- ***Vesicoureteral reflux*** (VUR), the backward flow of urine from the bladder into a ureter

Renal CRF : Chronic renal failure caused by changes within the kidneys, is called renal CRF.

- ***Diabetic nephropathy***, kidney disease associated with diabetes; the most common cause of CRF
- ***Hypertension nephrosclerosis***, a condition that occurs with increased frequency in African Americans; the second leading cause of CRF
- ***Chronic glomerular nephritis***, a condition caused by diseases that affect the glomeruli and bring about progressive dysfunction.

- ***Chronic interstitial nephritis***, a condition caused by disorders that ultimately lead to progressive scarring of the interstitium
- ***Renal vascular CRF***, large vessel abnormalities such as renal artery stenosis (narrowing of the large arteries that supply the kidneys)
- ***Vasculitis***, inflammation of the small blood vessels
- ***Cystic kidney disease***, kidney disease distinguished by multiple cysts (lined cavities or sacs)
- ***Hereditary diseases of the kidney***, such as Alport's syndrome (hereditary nephritis)

Signs & Symptoms

- Chronic renal failure (CRF) usually produces symptoms when renal function – which is measured as the glomerular filtration rate (GFR) – falls below 30 milliliters per minute (<30 mL/min). This is approximately 30% of the normal value.
- When the glomerular filtration rate (GFR) slows to below 30 mL/min, signs of uremia (high blood level of protein by-products, such as urea) may become noticeable. When the GFR falls below 15 mL/min most people become increasingly symptomatic.

Uremic symptoms can affect every organ system:

- Neurological system–cognitive impairment, personality change, asterixis (motor disturbance that affects groups of muscles), seizures (rare)
- Gastrointestinal system–nausea, vomiting, food distaste (often described as bland, metallic, "like cardboard")
- Blood-forming system–anemia due erythropoetin deficiency, easy bleeding due to abnormal platelets and bruising to

- Pulmonary system–fluid in the lungs, with breathing difficulties
- Cardiovascular system –chest pain due to inflammation of the sac surrounding the heart (pericarditis) and pericardial effusion (fluid accumulation around the heart)
- Skin –generalized itching

Diagnosis

- CRF is diagnosed by the observation of a combination of symptoms and elevated BUN & creatinine levels.
- Anemia (< red blood cell count)
- High level of parathyroid hormone
- Hypocalcemia (< blood level of calcium)
- Hyperphosphatemia (> blood level of phosphate)
- Hyperkalemia (> blood level of potassium)
- Hyponatremia (< blood level of sodium)
- Low blood level of bicarbonate
- Low plasma pH (blood acidity)

Treatment

- Once CRF has been diagnosed, the physician attempts to determine the cause and, if possible, plan a specific treatment. Nonspecific treatments are implemented to delay or possibly arrest the progressive loss of kidney function.
- Control hypertension
- Restrict dietary protein
- Manage pre-end-stage renal disease
- Identify and Treat Secondary Hyperparathyroidism

Preparation for renal replacement therapy (RRT)

- Hemodialysis—removal of toxic elements from the blood, which is filtered through a membrane while circulated outside of the body
- Peritoneal dialysis—filtration through the lining membrane of the abdominal cavity; fluid is instilled into the peritoneal space, then drained
- Kidney transplantation

- **Prognosis**: CRF is often insidious in its onset and progression. The rate of progression is variable but usually renal function steadily declines resulting in end-stage renal disease (ESRD).

Hematuria

- Hematuria is the presence of blood, specifically red blood cells, in the urine.
- Whether the blood is visible only under a microscope or visible to the naked eye, hematuria is a sign that something is causing bleeding in the genitourinary tract: the kidneys, the tubes that carry urine from the kidneys to the bladder (ureters), the prostate gland (in men), the bladder, or the tube that carries urine from the bladder out of the body (urethra).

- Bleeding may happen once or it may be recurrent.
- It can indicate different problems in men and women.
- Causes of this condition rangefrom non-life threatening (e.g., urinary tract infection) to serious (e.g., cancer, kidney disease).
- Therefore, a physician should be consulted as soon as possible.

Types

- There are two types of hematuria, microscopic and gross (or macroscopic). In microscopic hematuria, the amount of blood in the urine is so small that it can be seen only under a microscope. A small number of people experience microscopic hematuria that has no discernible cause (***idiopathic hematuria***). These people normally excrete a higher number of red blood cells.

- In ***gross hematuria*** the urine is pink, red, or dark brown and may contain small blood clots. The amount of blood in the urine does not necessarily indicate the seriousness of the underlying problem. As little as 1 milliliter (0.03 ounces) of blood will turn the urine red.
- "***Joggers hematuria***" results from repeated jarring of the bladder during jogging or long-distance running.
- ***Reddish urine*** that is not caused by blood in the urine is called pseudohematuria. Excessive consumption of beets, berries, or rhubarb; food coloring; and certain laxatives and pain medications can produce pink or reddish urine.

Causes

- Benign prostatic hyperplasia (BPH) in men over 40
- Kidney stones and bladder stones
- Kidney disease
- Medications (e.g., quinine, rifampin, phenytoin)
- Trauma (e.g., a blow to the kidneys)
- Tumors and/or cancer in the urinary system
- Urinary tract blockages
- Viral infections of the urinary tract and sexually

Rare diseases and genetic disorders:

Systemic lupus erythmatosus (chronic inflammatory disorder of connective tissue)

- von Hippel-Landau disease (hereditary disease in which benign tumors form on the spinal cord, kidneys, testicles, and other organs)

Signs and Symptoms

- Abdominal pain
- Decreased urinary force, hesitance, incomplete voiding
- Fever
- Frequent urination (polyuria)
- Pain during urination (dysuria)
- Pain in the flank or side
- Urinary urgency

Tests

- Cystourethroscopy, or cystoscopy
- Intravenous pyelogram (IVP)
- Ultrasound
- Computer-assisted tomography (CAT scan)

Proteinuria & Microalbuminuria

- Proteinuria is an abnormally high amount of protein in the urine.
- Proteins in the blood, like albumin and immunoglobulin, help coagulation (clotting), balance bodily fluids, and fight infection.
- The kidneys remove wastes from protein-rich blood through millions of tiny filtering screens called glomeruli.
- Most proteins are too large to pass through the glomeruli into the urine.

- The glomeruli are negatively charged, so they repel the negatively charged proteins.
- Thus, a size and charge barrier keeps protein molecules from entering the urine.
- But when the glomeruli are damaged, proteins of various sizes pass through them and are excreted in the urine.

Types

- 1. Microalbuminuria 30 - 150 mg
- 2. Mild 150 - 500 mg
- 3. Moderate 500 - 1000 mg
- 4. Heavy 1000 - 3000 mg
- 5. Nephrotic range more than 3500 mg

Causes and Risk Factors

- Hypertension and diabetes
- Age and weight gain also increase the risk
- Acute glomerulonephritis
- Amyloidosis (protein deposits associated with chronic disease)
- Focal glomerulonephritis
- Hypertension
- IgA nephropathy - (Berger's disease) when the antibody lodges in your kidneys

Signs and Symptoms

- Foamy urine and swelling (edema) are two signs of proteinuria that become more evident as the disease progresses.
- Excess protein can cause the urine to foam in water.
- This occurs because protein changes the surface tension between urine and water.
- Edema usually only occurs in nephrotic range proteinuria.

- Albumin is particularly useful in absorbing bodily fluid into the blood.
- Because the albumin molecule is relatively small, it is often among the first proteins to enter the urine after glomeruli are damaged.
- Therefore, even minor kidney dysfunction is detectable with proper diagnosis of microalbuminuria.
- Reduced albumin level in the blood causes fluid retention and swelling that is first noticeable in the hands, lower legs, and feet. In more serious cases, the abdomen and face may

- Orthostatic proteinuria is a disorder seen occasionally in children and young adults who leak significant amounts of urine when they are upright (orthostatic).
- Presumably, standing increases the pressure on the glomeruli and causes more protein to enter the urine, while lying down relieves pressure and causes less protein leakage.
- This is a benign disorder that most young people outgrow.

Complications

- Hypertensive people who develop proteinuria stand a significant chance for kidney failure.
- African Americans are 20 times more likely than Caucasians to develop hypertensive-related kidney failure.
- Proteinuria in people with diabetes may be a sign that kidney disease is worsening.
- Microalbuminuria is often cited as a risk for coronary artery disease (CAD) and is often diagnostic of it and related cardiovascular conditions.

Electrolyte Imbalance

- Electrolytes are salts that conduct electricity and are found in the body fluid, tissue, and blood.
- Examples are chloride, calcium, magnesium, sodium, and potassium. Sodium (Na+) is concentrated in the extracellular fluid (ECF) and potassium (K+) is concentrated in the intracellular fluid (ICF).
- Proper balance is essential for muscle coordination, heart function, fluid absorption and excretion, nerve function, and concentration.

- Normally, sodium and potassium are filtered and excreted in the urine and feces according to the body's needs.
- Too much or too little sodium or potassium, caused by poor diet, dehydration, medication, and disease, results in an imbalance.
- Too much sodium is called hypernatremia; too little is called hyponatremia.
- Too much potassium is called hyperkalemia; too little is called hypokalemia.

Incidence and Prevalence

- Hyponatremia is the most common electrolyte imbalance.
- It is associated with kidney disease such as nephrotic syndrome and acute renal failure (ARF).
- Men and women with healthy kidneys have equal chances of experiencing electrolyte imbalance, and people with eating disorders such as anorexia and bulimia, which most often affect women, are at increased risk.
- Very young people and old people are affected more often than young adults.

- ***Hyponatremia***, caused by conditions such as water retention and renal failure that result in a low sodium level in the blood.
- ***Pseudohyponatremia*** occurs when too much water is drawn into the blood; it is commonly seen in people with hypoglycemia (low blood sugar).
- ***Psychogenic polydipsia*** occurs in people who compulsively drink more than four gallons of water a day.

- ***Hypovolemic hyponatremia*** (with low blood volume due to fluid loss) occurs in dehydrated people who rehydrate (drink a lot of water) too quickly, in patients taking thiazide diuretics, and after severe vomiting or diarrhea.
- ***Hypervolemic hyponatremia*** (high blood volume due to fluid retention) occurs in people with live cirrhosis, heart disease, or nephrotic syndrome. Edema (swelling) often develops with fluid retention.

- ***Euvolemic hyponatremia*** (decrease in total body water) occurs in people with hypothyroidism, adrenal glanddisorder, and disorders that increase the release of the antidiuretic hormone (ADH), such as tuberculosis, pneumonia, and brain trauma.

Signs and Symptoms

- Symptoms of hyponatremia are related to the severity and the rate at which the conditions develop.
- The first symptoms are fatigue, weakness, nausea, and headache.
- More severe cases cause confusion, seizure, coma, and death.

Treatment

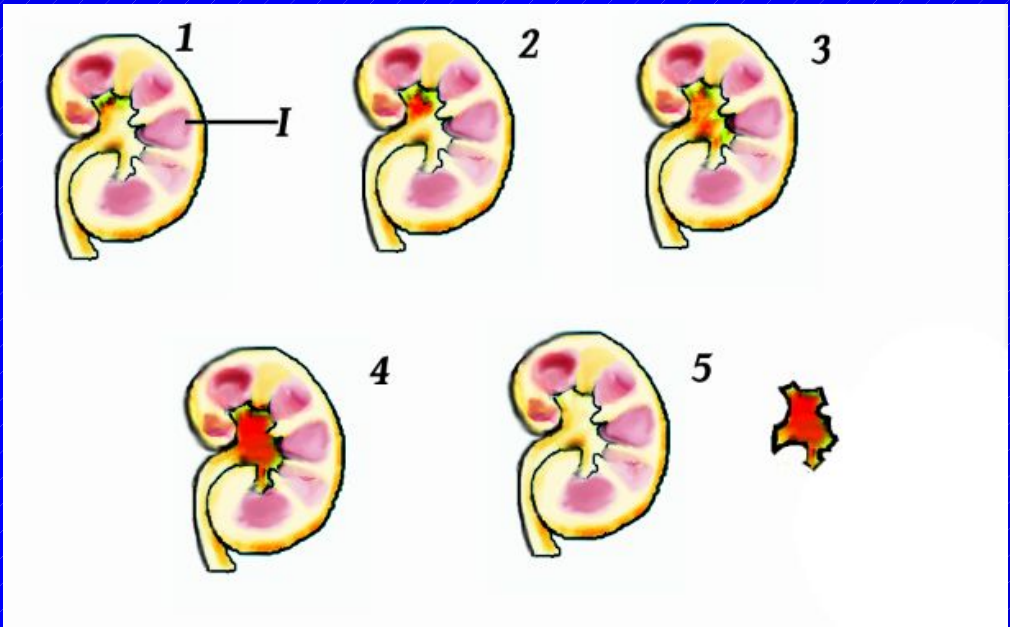
- The goal of treatment is to restore electrolyte balance for proper hydration and use of total body fluid.
- Sodium deficiency must be corrected slowly because drastic change in sodium level can cause brain cell shrinkage and central pontine myelinolysis (damage to the pons region of the brain). Methods include:
- Fluid and water restriction
- Intravenous (IV) saline solution of 3% sodium
- Salt tablets

Kidney Stones

- Kidney stones (calculi) are hardened mineral deposits that form in the kidney.
- They originate as microscopic particles and develop into stones over time.
- The medical term for this condition is nephrolithiasis, or renal stone disease.
- The kidneys filter waste products from the blood and add them to the urine that the kidneys produce.

- When waste materials in the urine do not dissolve completely, crystals and kidney stones are likely to form.
- Small stones can cause some discomfort as they pass out of the body.
- Regardless of size, stones may pass out of the kidney, become lodged in the tube that carries urine from the kidney to the bladder (ureter), and cause severe pain that begins in the lower back and radiates to the side or groin.

- A lodged stone can block the flow of urine, causing pressure to build in the affected ureter and kidney.
- Increased pressure results in stretching and spasm, which cause severe pain.



Alteration:

- When the urine becomes supersaturated (when the urine solvent contains more solutes than it can hold in solution) with one or more calculogenic (crystal-forming) substances, a seed crystal may form through the process of nucleation.
- Supersaturation is likely the underlying cause of uric acid and cystine stones, but calcium-based stones (especially calcium oxalate stones) may have a more complex cause
- TYPES:
  - Calcium Stones (70-80%) - oxalate or calcium phosphate
  - Uric Acid Stones (85 - 90%)
  - Struvite Stones (15%) - Mg, NH4, PO4
  - Cystine Stones (rare)
-

Incidence and Prevalence

- People who live near large bodies of water (e.g., Great Lakes, Gulf of Mexico), those who live in "soft" water areas, and those who have a sibling or parent with the condition experience a higher incidence of renal stone disease.
- According to the U.S. National Institutes of Health, 1 person in 10 develops kidney stones during their lifetime and renal stone disease accounts for 7–10 of every 1000 hospital admissions. Kidney stones are most prevalent in patients between the ages of 30 and 45, and the incidence declines after age 50.

Causes and Risk Factors

- Several factors increase the risk for developing kidney stones, including inadequate fluid intake and dehydration, reduced urinary flow and volume, certain chemical levels in the urine that are too high (e.g., calcium, oxalate, uric acid) or too low (e.g., citrate), and several medical conditions.
- Anything that blocks or reduces the flow of urine (e.g., urinary obstruction, genetic abnormality) also increases the risk.

Signs and symptoms

- Blood in the urine (hematuria)
- Increased frequency of urination
- Nausea and vomiting
- Pain during urination (stinging, burning)
- Tenderness in the abdomen and kidney region
- Urinary tract infection (fever, chills, loss of appetite)

Treatment

- Surgically, percutaneous nephrolithotomy involves removing a kidney stone using small telescopes and instruments inserted through a small incision in your back.

  Using a scope to remove stones. To remove a smaller stone in your ureter or kidney, your doctor may pass a thin lighted tube (ureteroscope) equipped with a camera through your urethra and bladder to your ureter. Once the stone is located, special tools can snare the stone or break it into pieces that will pass in your urine.

Tumors

Renal tumors ➢ Renal adenomas (benign)- tumors usually located near renal cortex

➢ Renal cell carcinoma- risk factors include cigarette smoking, obesity, and hypertension

Bladder tumors ➢ Usually transitional cell carcinoma ➢ Risk factor: cigarette smoking, exposure to aniline dyes

➢ Genetics: ras oncogenes (promotes oncogenesis by disturbing a multitude of cellular processes, such as gene expression, cell cycle progression and cell proliferation, as well as cell survival, and cell migration), and TP53 tumor suppressor gene

Glomerular diseases

Can be caused by: (1) primary injury to glomerulus; or (2) from systemic disease

- Membrane damage due to immune-mediated injury⟶ increases glomerular permeability⟶ passage of protein and RBCs
- There is usually increased serum creatinine, and reduced renal creatinine clearance (Normal: 0.7 mg/100ml to 1.5 mg/100 ml)
- Other manifestations include edema, hypertension, metabolic acidosis (increased plasma H+ and lowered pH - bone resorption

Glomerular diseases

Usually a result of immune injury:

➢ Deposition of circulating antigen-antibody complex (Type III hypersensitivity)

➢ Antibodies reacting in situ against planted antigen in glomerulus (Type III)

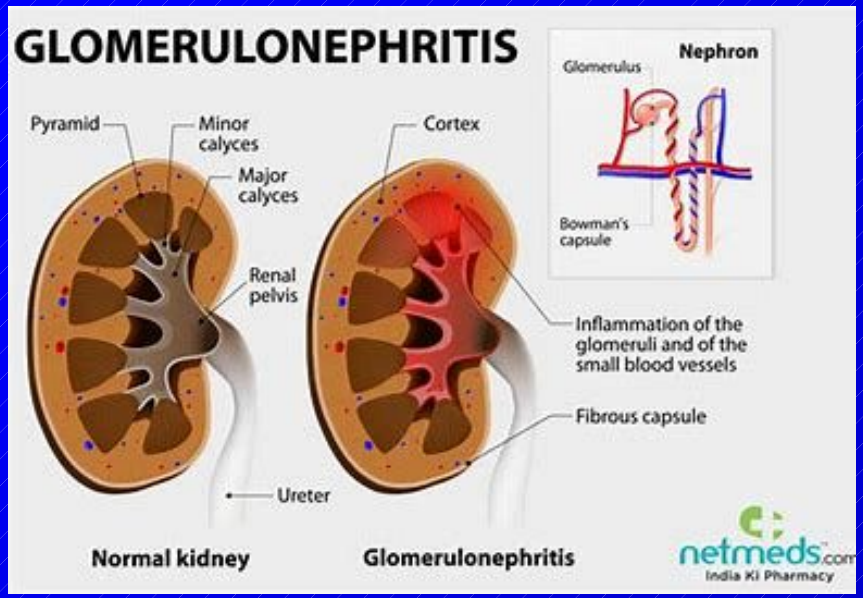
➢ Action of antibodies against glomerular capillary wall (Type II)

➢ Cell-mediated immune injury (Type IV)

Glomerular diseases

Glomerulonephritis ➢ Inflammation of the glomerulus • Immunologic abnormalities (most common) • Drugs or toxins • Vascular disorders • Systemic diseases (e.g., DM, SLE) • Viral causes

➢ Most common cause of ESRD



Acute Glomerulonephritis

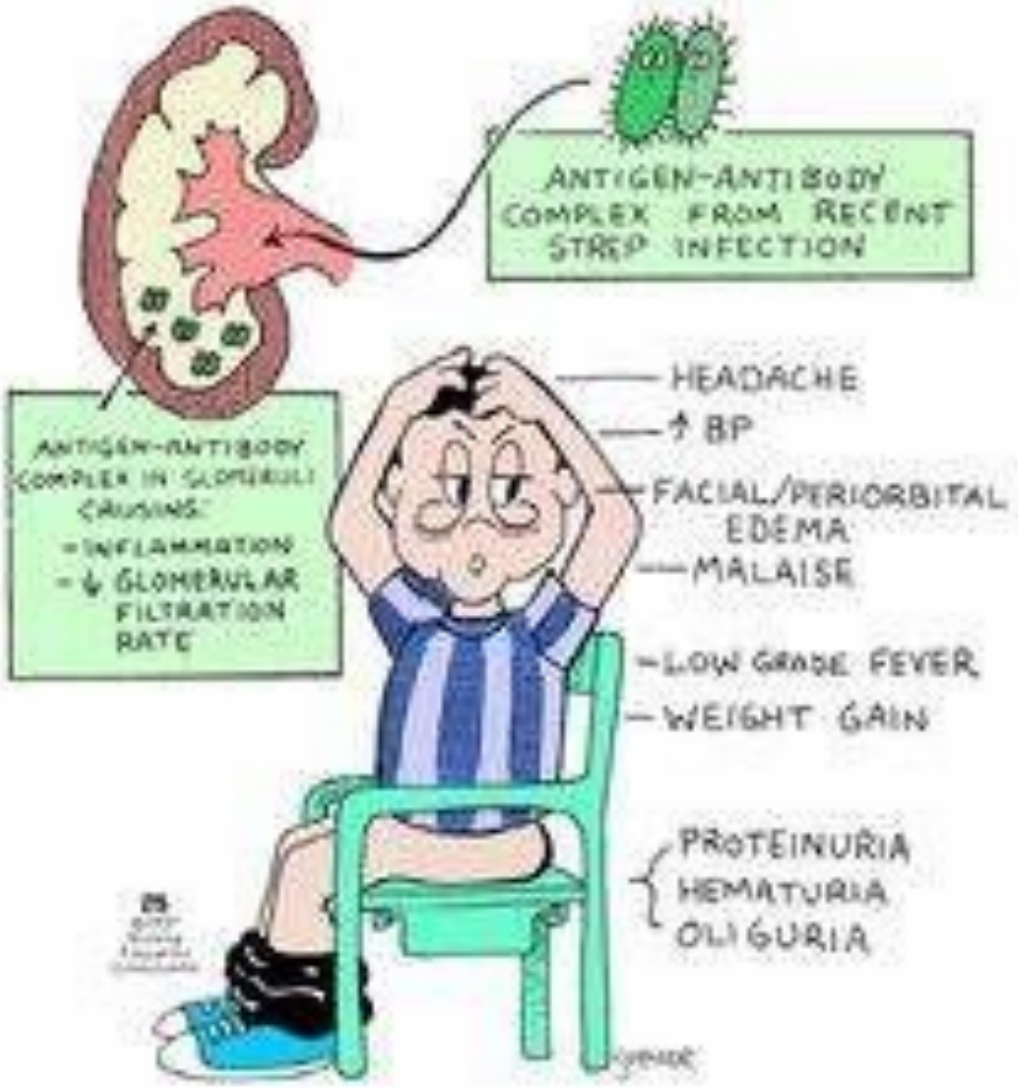
Involves both **structural changes and functional changes**.

- Structurally, cellular proliferation leads to an increase in the number of cells in the glomerular tuft because of the proliferation of endothelial, mesangial, and epithelial cells.
- triggers inflammation and proliferation of glomerular tissue that can result in damage to the basement membrane, mesangium, or capillary endothelium leading to the leakage of blood and proteins

Acute Glomerulonephritis

Pathophysiology ➢ Formation of immune complexes (antigen/antibody) in the circulation with subsequent deposition in glomerulus ➢ Antibodies produced against the strep organism cross-react with the glomerular endothelial cells (may be related to inadequately treated strep) ➢ Activation of complement ➢ Recruitment/activation of immune cells and mediator

GLOMERULONEPHRITIS



Acute Glomerulonephritis

Decreased GFR ➢ Decreased glomerular perfusion (glomerular blood flow) due to inflammation ➢ Glomerular sclerosis (scarring) ➢ Thickening of the glomerular basement membrane (but with increased permeability to proteins)

Acute Glomerulonephritis

SIGNS/SYMPTOMS:
Hematuria
Smoky, brown-tinged urine
Red blood cell casts
Proteinuria, Low serum albumin
Edema, Eventual oliguria
➢ Oliguria: urine output <30 ml/hour or <400 ml/day

Nephrotic Syndrome

- caused by a variety of conditions including autoimmune, hereditary, and infectious diseases. Nephritic diseases can manifest with varying degrees of severity, ranging from asymptomatic . The urine sediment is typically characterized by red blood cell casts that form in the renal tubule visible on urine microscopy in patients with glomerular damage (e.g., glomerulonephritis)

Nephrotic Syndrome

SIGNS/SYMTOMS

- Urinalysis, mild to moderate proteinuria (< 3.5 g/day), and sterile pyuria (presence of significant leukocyturia that is not accompanied by evidence of bacteria in the urine)
- Common noninfectious causes include contamination of the urine sample (e.g., by vaginal leukocytes), glomerular or tubulointerstitial disease, and inflammation of or trauma to the lower urinary tract e.g., due to uroliths, urinary catheterization

Nephrotic Syndrome

SIGNS/SYMTOMS

- Protein excretion is due to glomerular injury
- Findings ➢ Hypoalbuminemia, edema, hyperlipidemia (result to compensatory lipoprotein synthesis by the liver), and lipiduria

Nephrotic Syndrome

- Certain infections (e.g., gonorrhea, chlamydia, herpes genitalis, trichomoniasis, urogenital tuberculosis, schistosomiasis) can also cause sterile pyuria.
- Diagnostic evaluation of the kidney and urinary tract → History and physical examination
- Diagnosis of the underlying disease is often based on presentation and laboratory values, although renal biopsy may be indicated for confirmation

Nephrotic Syndrome

Pathophysiology

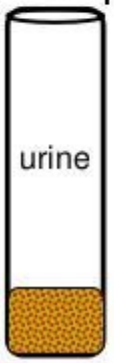
- Starts with altered glomerular permeability
- Increased filtration of plasma proteins
- Proteinuria:

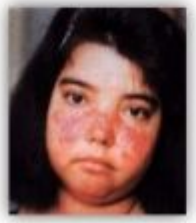
1) Loss of fxn of proteins as transport for vit D and thyroxine
2) Na+ retention in distal tubules and hypoalbuminemia result in edema
3) Decreased immunoglobulins

Nephrotic Syndrome

Nephritic

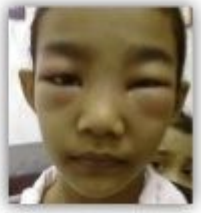
- Oliguria
- Hematuria
- Non selective Proteinuria.
- GFR↓, Cr↑, BUN↑
- Edema (salt and water retention)
- Hypertension
- RBC & Protein casts.





Nephrotic

- Proteinuria ("nephrotic range" >3.5g/24h)
- Edema (retention+Hypoalbuminemia)
- Hyperlipidemia
- Lipiduria
- Protein casts.



	Nephrotic Syndrome	Glomerulonephritis
Main Characteristics	Proteinuria, hypoalbuminemia, edema, hypovolemia; ages 2-7; males	Proteinuria, hematuria, hypertension; school-ages; males
Causes	Idiopathic, glomerular damage, congenital	Primary, streptococcal infection
Glomerular Changes	Membrane damage causes permeability to protein/albumin	Immune complex occludes glomeruli
Signs/Symptoms	Weight gain, fatigue, edema, dec u/o	Edema, urine discoloration, lethargy
Treatment	Corticosteroids	Antihypertensive, diuretics
Prognosis	80% favorable, relapses	Good, reoccurrence rare

Pyelonephrtis

Acute pyelonephritis ➢ Acute infection of the ureter, renal pelvis, and/or renal parenchyma ➢ Contributing factors:

• Cystitis • Urinary tract obstruction with reflux infection • Women are 5 times more likely to develop pyelonephritis • Neurogenic bladder • Instrumentation (e.g., catheter) Female sexual trauma

Pyelonephrtis

Clinical manifestations ➢ Flank pain ➢ Fever ➢ Chills ➢ Costovertebral tenderness ➢ Purulent urine Chronic pyelonephritis- persistent or recurrent infection of the kidney leading to the scarring of the kidney

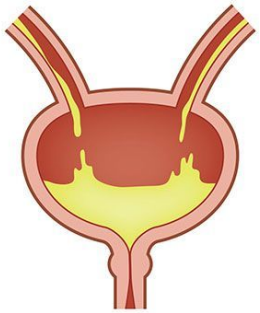
Urinary Tract Obstruction

Neurogenic bladder

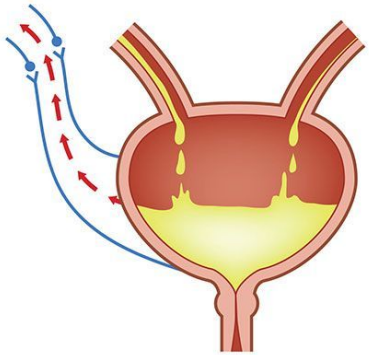
- General term for bladder dysfunction caused by neurologic disorders
  - ➢ Dysfunction depends on the sites in the nervous system that control sensory and motor bladder function

BLADDER FILLING & URINARY INCONTINENCE

SOURCE: WWW.DRELIST.COM

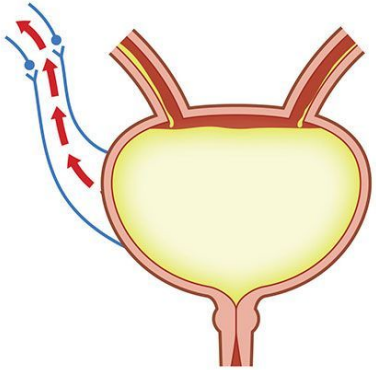


The bladder filling

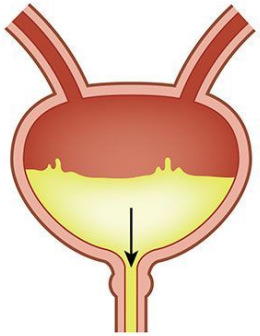


The bladder enlarges and a message is sent along the nerves to the brain

The signal is ignored and the bladder continues to fill



When the bladder is full a more urgent signal is sent to the brain

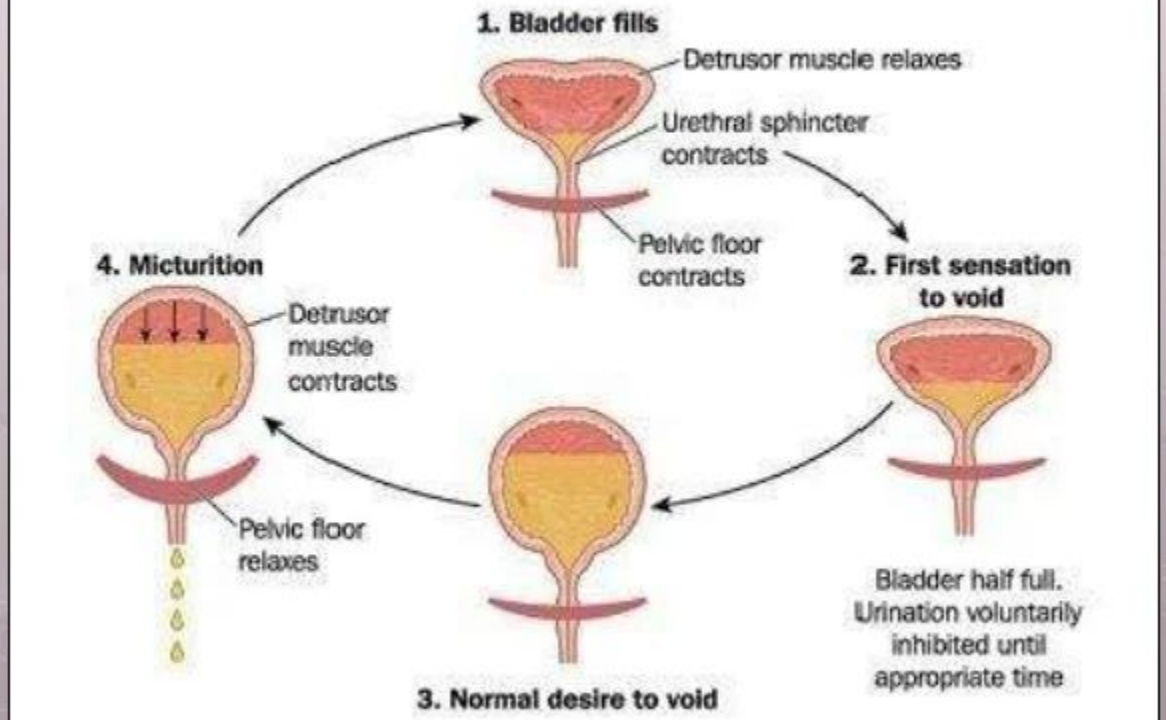


If the signal is not recognised, such as during sleep, the pelvic floor muscles relax and the bladder empties, resulting in a wet bed

Urinary Tract Obstruction

Neurogenic bladder ➢ Detrusor hyperreflexia- upper motor neuron disease; lesion is above pontine

SIGNS/SYMPTOMS: urine leakage and incontinence ➢ Detrusor hyperreflexia and vesicosphicter dyssynergia- lesion below pontine micturition center but above sacral micturition • Overactive bladder syndrome with increase frequency, urgency, urge incontinence, and increased risk of UTI ➢ Detrusor areflexia- lesion below sacral micturition • Stress and overflow incontinence


1. Bladder fills
Detrusor muscle relaxes
Urethral sphincter contracts
Pelvic floor contracts
2. First sensation to void
Bladder half full. Urination voluntarily inhibited until appropriate time
3. Normal desire to void
4. Micturition
Detrusor muscle contracts
Pelvic floor relaxes

URINARY OBSTRUCTION

Lower Urinary Tract Obstruction Anatomic causes of lower tract obstruction: ➢ Prostate enlargement- caused by acute inflammation, BPH, and prostate cancer ➢ Urethral stricture- narrowing of tract lumen; occurs with infection, surgical procedure ➢ Severe pelvic organ prolapse- occurs in women; downward protrusion of the bladder to the vagina

URINARY TRACT INFECTION

Inflammation of the urinary epithelium following invasion and colonization by some pathogen within the urinary tract

At risk: premature newborns, prepubertal children, sexually active and pregnant women, women treated with antibiotics that disrupt vaginal flora, estrogen-deficient postmenopausal women, individuals with indwelling catheter, those with DM, neurogenic bladder, or urinary tract obstruction

URINARY TRACT INFECTION

Complicated UTI- occur with defects in urinary system or those with comorbidities
Uncomplicated UTI- occur in a normally functioning urinary system

URINARY TRACT INFECTION

Cystitis ➢ An inflammation of the bladder and most common site of UTI ➢ Manifestations • Frequency, dysuria, urgency, and lower abdominal and/or suprapubic pain

Cause:

Frequent UTI

DIAGNOSTIC TESTS RELATED TO RENAL AND GUT DISORDERS

Laboratory tests are almost always aimed at:

- Blood Urea Nitrogen (BUN),
- Creatinine,
- Electrolytes, and
- Urinalysis – specific gravity, pH, ketone bodies, protein, urobilinogen, bilirubin, glucose, RBC number, WBC number, hCG, Pyroluria.

- More specialized tests can be ordered to discover or link certain systemic diseases to kidney failure such as
- Hepatitis b or hepatitis c,
- Lupus serologies,
- Paraproteinemias such as amyloidosis or multiple myeloma or various other systemic diseases that lead to kidney failure.

- ***Renal biopsy***, to obtain a tissue diagnosis of a disorder when the exact nature or stage remains uncertain.;
- ***Ultrasound scanning*** of the urinary tract and occasionally examining the renal blood vessels;
- ***CT scanning*** when mass lesions are suspected or to help diagnosis nephrolithiasis;
- ***Scintigraphy*** (nuclear medicine) for accurate measurement of renal function (rarely done), and MAG3 scans for diagnosis of renal artery disease or 'split function' of each kidney;
- ***Angiography*** or MRI angiography when the blood vessels might be affected

THERAPY

- Many kidney diseases are treated with medication, such as steroids, DMARDs (disease-modifying antirheumatic drugs), antihypertensives (many kidney diseases feature hypertension).

- Often erythropoietin and vitamin D treatment is required to replace these two hormones, the production of which stagnates in chronic kidney disease.

- When chronic kidney disease progresses to stage five, dialysis or transplant is required.
- If patients proceed to transplant, nephrologists will continue to follow patients to monitor the immunosuppressive regimen and watch for the infection that can occur post transplant.

DIALYSIS

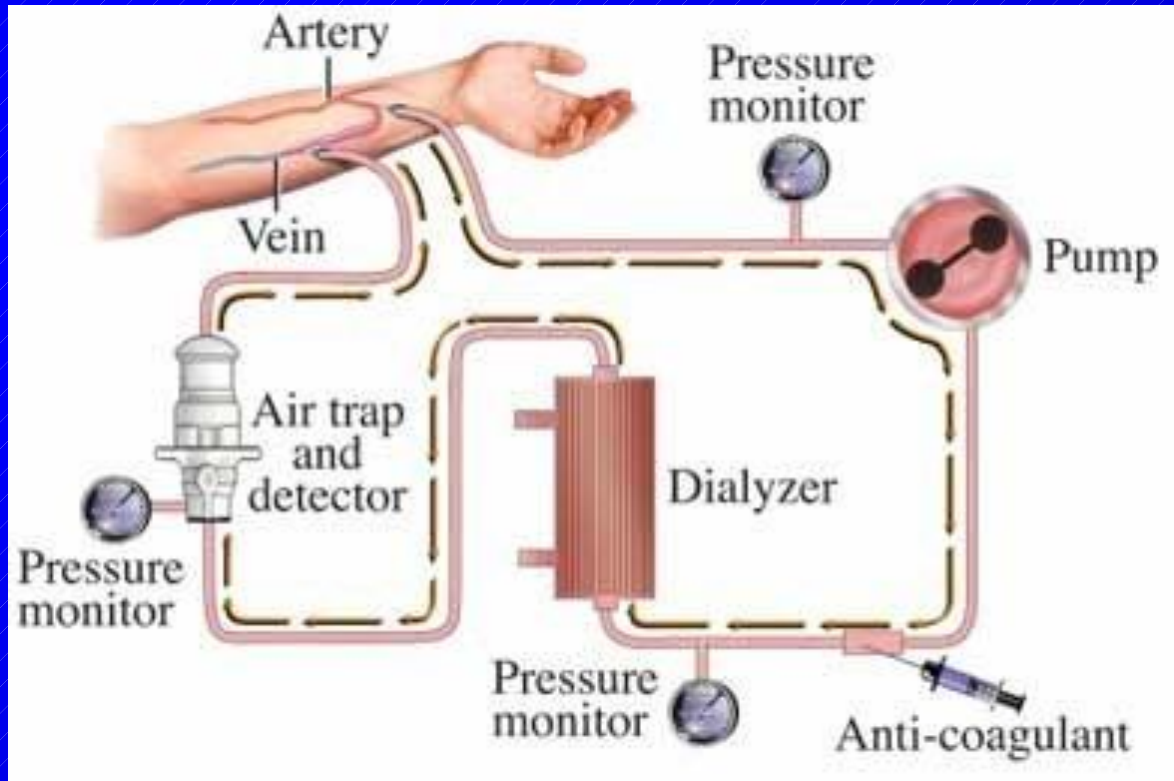
- Dialysis works on the principles of the diffusion and osmosis of solutes and fluid across a semi-permeable membrane.
- Blood flows by one side of a semi-permeable membrane, and a dialysate or fluid flows by the opposite side.
- Smaller solutes and fluid pass through the membrane.
- The blood flows in one direction and the dialysate flows in the opposite.

- The concentrations of undesired solutes (for example potassium, calcium, and urea) are high in the blood, but low or absent in the dialysis solution and constant replacement of the dialysate ensures that the concentration of undesired solutes is kept low on this side of the membrane.
- The dialysis solution has levels of minerals like potassium and calcium that are similar to their natural concentration in healthy blood.

- For another solute, bicarbonate, dialysis solution level is set at a slightly higher level than in normal blood, to encourage diffusion of bicarbonate into the blood, to neutralise the metabolic acidosis that is often present in these patients

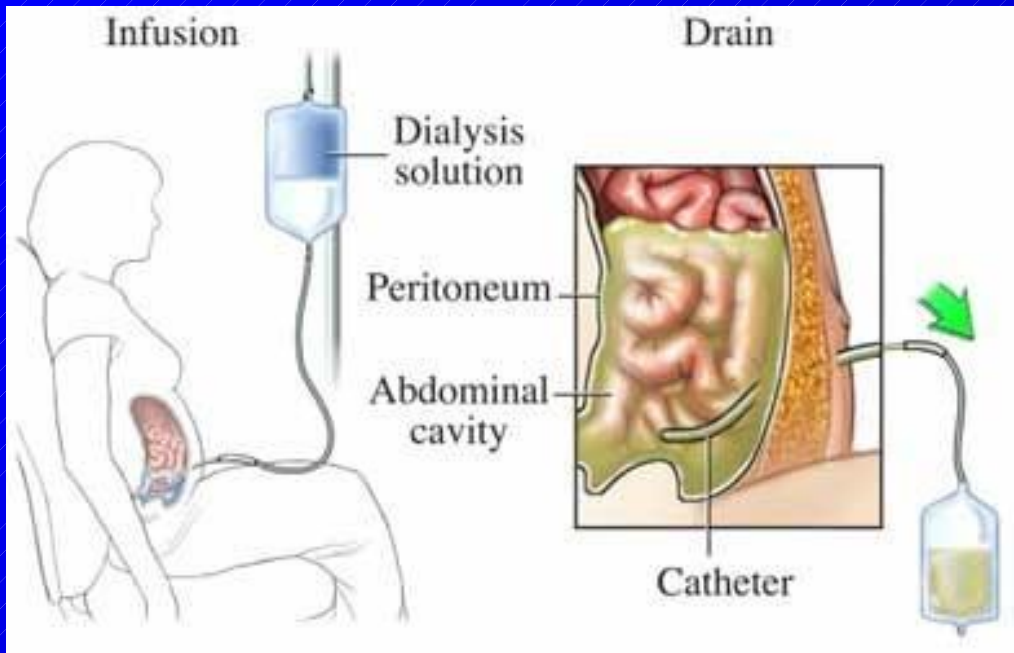
There are 3 types of dialysis

- ***Hemodialysis***, Dialysis of soluble substances and water from the blood by diffusion through a semipermeable membrane; separation of cellular elements and colloids from soluble substances is achieved by pore size in the membrane and rates of diffusion.

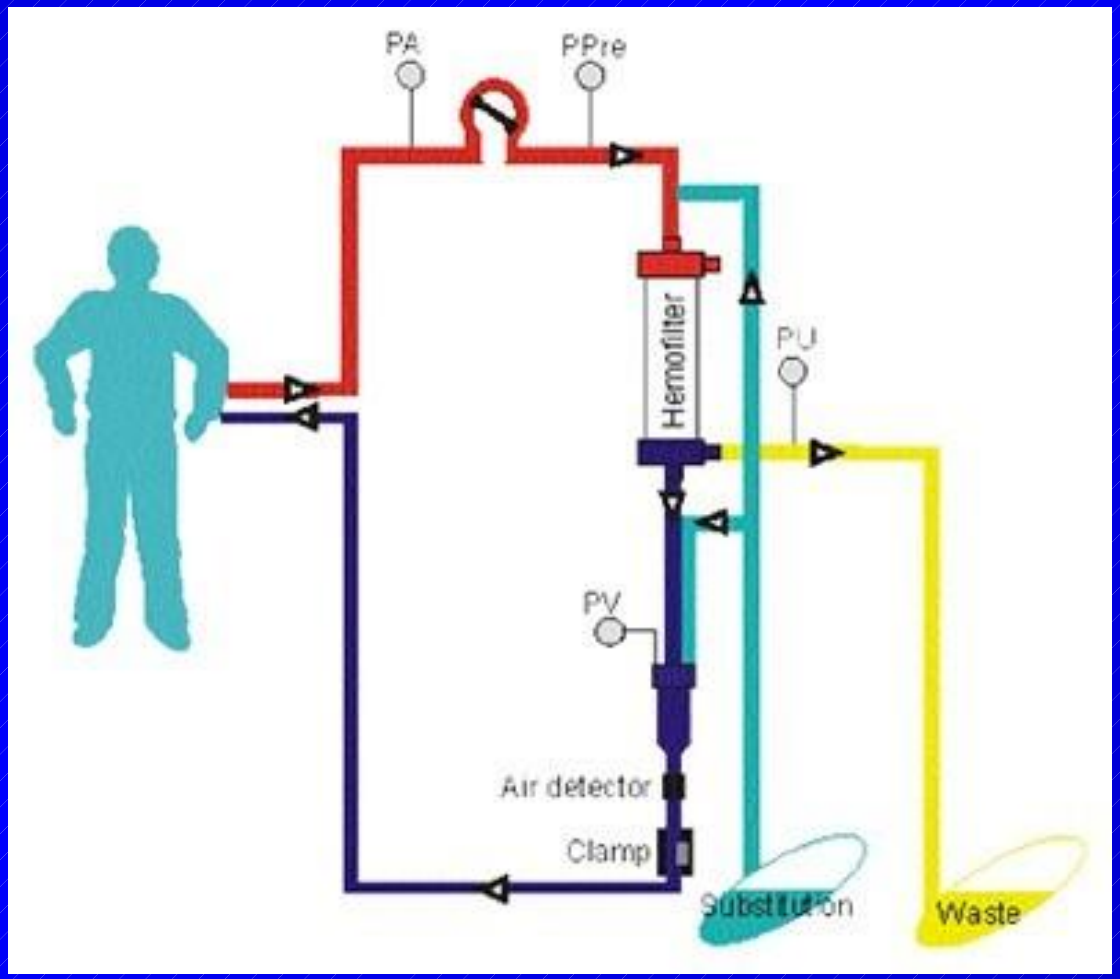


Hemodialysis Machine

- ***Peritoneal dialysis***, removal from the body of soluble substances and water by transfer across the peritoneum, utilizing a dialysis solution which is intermittently introduced into and removed from the peritoneal cavity; transfer of diffusable solutes and water between the blood and the peritoneal cavity depends on the concentration gradient between the two fluid compartments.



- ***Hemofiltration***, A process, similar to hemodialysis, by which blood is dialyzed using ultrafiltration, and usually to remove a specific product of fluid volume.



Starting indications

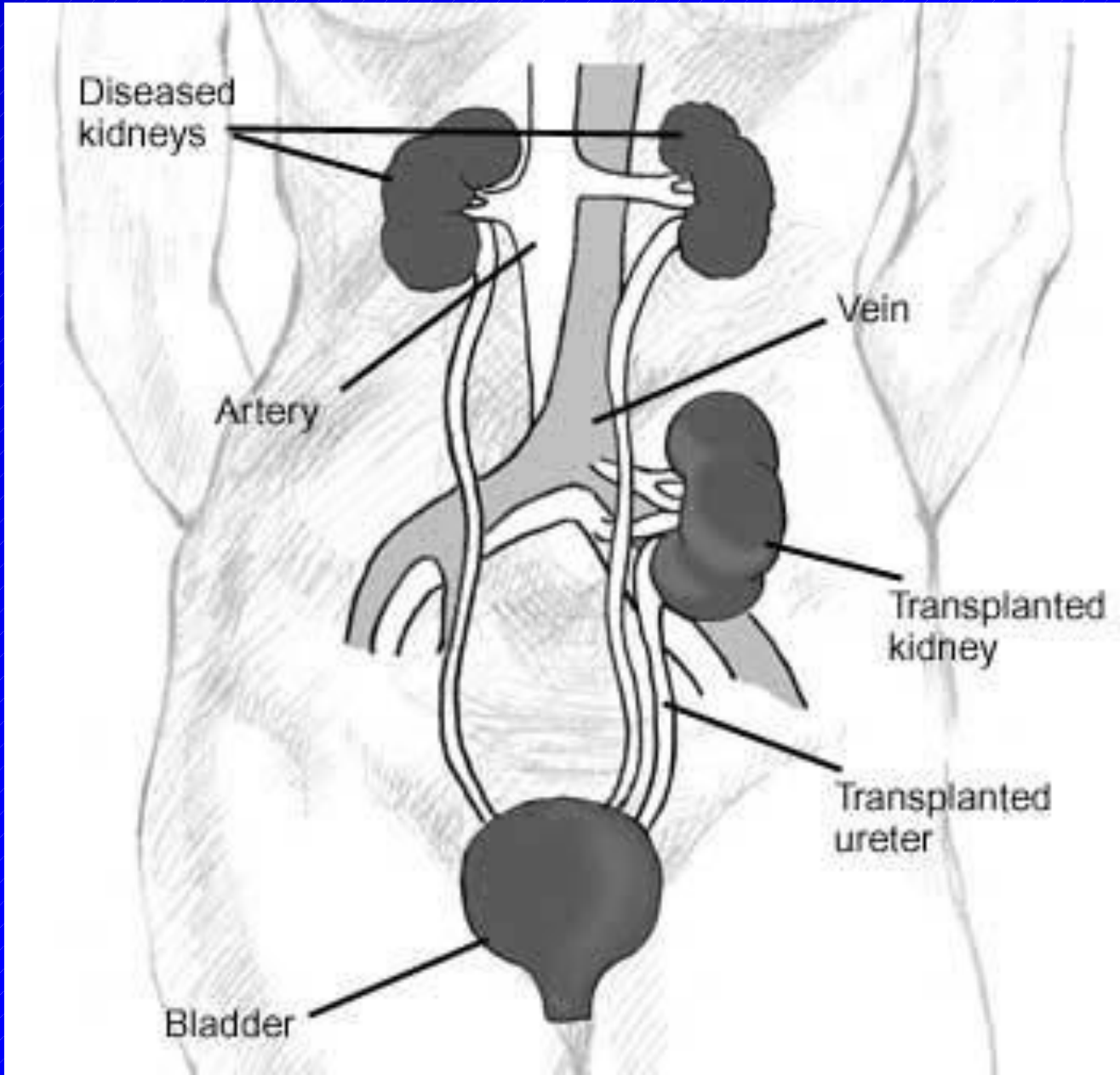
Acute Indications for Dialysis/Hemofiltration:

- Hyperkalemia
- Metabolic Acidosis
- Fluid overload (which usually manifests as pulmonary edema)
- Uremic complications, such as uremic pericarditis and uremic encephalopathy.
- And in patients without renal failure, acute poisoning with a dialysable drug, such as lithium, or aspirin.

Chronic Indications for Dialysis:

- Symptomatic renal failure.
- Low glomerular filtration rate (GFR) (RRT often recommended to commence at a GFR of less than 10-15 mls/min/1.73m2)
- Difficulty in medically controlling serum phosphorus or anaemia when the GFR is very low

KIDNEY TRANSPLANTATION



Procedure

- in most cases the barely functioning existing kidneys are not removed because this has been shown to increase the rates of surgical morbidities, the kidney is usually placed in a location different from the original kidney (often in the iliac fossa), and as a result it is often necessary to use a different blood supply:

- The renal artery of the kidney, previously branching from the abdominal aorta in the donor, is often connected to the external iliac artery in the recipient.
- The renal vein of the new kidney, previously draining to the inferior vena cava in the donor, is often connected to the external iliac vein in the recipient

Thank you!