Nephrology

USMLE/COMLEX Review Notes

Acute renal failure

Objectives of learning

Definition

Hyperuricemia effects

Renal failures

Diagnosis of pre-renal azotemia

Diagnosis of post-renal azotemia

Definition

1- Increase in serum BUN or creatinine levels in the serum for many hours or days.
2- There is renal insufficiency or azotemia i.e. increased concentration of nitrogenous compounds in the blood.
3- Uremia i.e. increases amounts of urea in the blood.

Hyperuricemia effects

1. Uremic encephalopathy
2. Pericarditis
3. Bleeding diathesis because urea surrounds the platelets
4. Hyperkalemia because renal function is compromised
5. Hypocalcemia

Renal failures

There are three causes of renal failure

Pre-renal cause include any pathology that reduces the perfusion of kidneys. For example, hypovolemia that may be due to burns, hemorrhage, poor oral water intake, vomiting, diarrhea and diuretics. Hypotension reduces the blood pressure and hence blood supply to the kidneys. Shock can also damage the kidney i.e. anaphylactic shock, septic shock and cardiogenic shock.

Renal cause

Post-renal cause

Obstruction due to stones

Bilateral hydronephrosis

Bladder cancer

Benign prostatic hypertrophy

Neurogenic bladder

Strictures formation

Diagnosis of pre-renal azotemia

BUN/creatinine ratio may be higher than 20:1 in pre-renal azotemia

Fractional excretion of sodium may be less than 1%

Urine sodium concentration may be low

Urine osmolality may be higher than normal because urine is concentrated with specific gravity more than 1.010

Diagnosis of post-renal azotemia

BUN/creatinine ratio may be lower than 10:1 in post-renal azotemia

Fractional excretion of sodium may be less than 1%

Urine sodium concentration may be low

Ultrasound of kidneys may show huge bilateral hydronephrosis

CT scan of kidney, ureter and bladder may confirm the diagnosis

Chronic renal failure

Objectives of learning

Definition

Causes

Clinical features

Diagnosis

Treatment

Definition

Chronic renal failure is gradual reduction of renal function due to progressive decline of GFR. When the glomerular filtration rate (GFR) is less than 10ml/min then it is termed as end stage renal disease.

Causes

The common causes are

Diabetes

Hypertension

And some minor causes include

Glomerulonephritis

Interstitial nephritis

Clinical features

Neurological: lethargy, confusion, asterixix (flapping tremors), restless leg syndrome

Cardiovascular: Hypertenison/ CAD (coronary artery disease), congestive heart failure/pulmonary edema, pericarditis

Hematological: Bleeding (deficiency of protein C/S, antithrombin III), infection, anemia (due to erythropoietin deficiency and Normocytic, normochromic in nature)

Genitourinary: decreased libido, amenorrhea, hyperprolactinemia and infertility.

Endocrine: Low vit. D, hyperphospatemia, calciphylaxis, secondary hyperparathyroidism

GIT: Nausea, vomiting and anorexia

Electrolytes: Hypocalcemia, hyperphosphatemia, hyperkalemia, hyperman

Skin: Pruritis

Diagnosis

Urinanalysis

Creatinine clearance to estimate GFR (

CBC (anemia, WBC, thrombocytopenia)

Serum electrolytes i.e. Na, K, Ca etc.

Renal ultrasound

Renal biopsy

Treatment

Diet: Low protein, low sodium, low potassium, low phosphate diet

ACE inhibitor

Furosemide

Glucose control

Calcium citrate for binding phosphate

Vitamin D for calcium metabolism

Bicarbonate for fixing acidosis

Erythropoietin for curing anemia

Capscacin/cholestyramine for uremia induced itching

Desmopressin for uremia induced bleeding

Dialysis: Hemodialysis, peritoneal dialysis

Renal transplant is the ultimate treatment

Acute tubular necrosis

Objectives of learning

Definition

Causes

Clinical features

Diagnosis

Treatment

Definition

If there is severe hypoperfusion or toxicity of the kidney then the resulting ischemia leads to infarction and necrosis of the kidney tubules.

Causes

Hypotension or decreased blood supply to kidney tubules in conditions like sepsis, cardiac surgery, aortic surgery etc.

Drugs i.e. Aminoglycosides (neomycin, amikacin, tobramycin), cisplatin, amphotericin B

Clinical features

Prodromal phase: Acute phase injury

Oliguria: Low urine output i.e. <400 mL/24hours or anuria i.e. <100mL/24hours

Polyoliguric: Polyuria and muddy brown casts in the urine

Diagnosis

BUN/creatinine ratio may be elevated

Urine osmolality less than 300 mEq/L

FeNa (fractional excretion of sodium) may be greater than 1

Urine sediment containing dead renal tissues i.e. muddy brown casts

Urine sodium excretion may be greater than 40 mEq/L

Treatment

No definite treatment once the tissues are dead

Treat the underlying cause i.e. antibiotic should be banned

Hydration with IV fluids is not a good option

If there is severe renal failure, then dialysis should be done

Acid base balance

The normal pH of human blood is 7.35-7.45

The normal bicarbonate HCO_3^- concentration is 24

The normal arterial carbon dioxide concentration P_ACO_2 is 40 mmHg

Formula:

pH = HCO_3^- (metabolic component) / P_ACO_2 (respiratory component)

From the above equation, it can be concluded that:

pH is directly proportional to HCO_3^-

pH is inversely proportional to P_ACO_2

The metabolic component in acid-base balance is controlled by the kidney while respiratory component is controlled by lungs.

Whenever one component is disturbed in the blood, the other component tries to compensate it. For example, if metabolic component decreases or increases in size then respiratory component tries to overcome this by changing its value and vice versa.

Metabolic acidosis

Objectives of learning

Definition

Pathophysiology

Causes

Clinical features

Treatment

Definition

Any change that decreases the bicarbonate or pH of the blood is called metabolic acidosis.

Normal bicarbonate concentration is 24

Normal pH ranges from 7.35-7.45

Pathophysiology

Decreased tissue perfusion is actual cause of metabolic acidosis. When the tissues are deprived of enough oxygen, they start anaerobic respiration. The pyruvate is metabolized to lactate which release hydrogen ions in the blood. The bicarbonate ions neutralize the hydrogen ions and form carbonic acid. This dissolves immediately to form water and carbon dioxide. The carbon dioxide is exchanged with oxygen in the lungs.

Causes

Increased anion gap	Normal anion gap
Methanol	Hyperventilation
Uremia	Acetazolamide
DKA	Renal tubular necrosis
Paraldehyde poisoning	Diarrhea
Iron ingestion	Ureterosigmoidostomy
Lactic acidosis	Pancreatic fistula
Ethanol	

Salicylic (aspirin)	

Clinical features

Rapid deep breathing (Kussmaul respiration)

Treatment

Put the patient on ventilator if needed.

Find the underlying cause and treating it will treat the acidosis.

Metabolic alkalosis

Objectives of learning

Definition

Clinical features

Diagnosis

Causes and treatment

Definition

Anything that increases bicarbonate or pH of the blood is termed as metabolic alkalosis.

The normal bicarbonate concentration is 24

The normal pH of blood is 7.35-7.45

Clinical features

Fatigue

Weakness

Nausea

Vomiting

Diagnosis

Serum electrolytes disturbed i.e. HCO_3 is high

Causes and treatment

Urine chloride <10mEq/L	Urine chloride >20mEq/L
Saline sensitive	Saline resistant
Vomiting (bulimia, anorexia, gastritis)	Hyperaldosteronism
Diuretics	Bartter's syndrome
	Treatment: Unilateral adrenelectomy Spironolactone

Respiratory acidosis

Objectives of learning

Definition

Causes

Clinical presentation

Compensation

Treatment and management

Definition

Increase in CO_2 concentration in the blood decreases the pH of blood. This is respiratory acidosis.

Causes

Hypoventilation is the root cause of retention of excess CO_2 in the blood. This may be due to:

1. COPD (chronic obstructive pulmonary disease)
2. Airway obstruction due to accidental swallowing of object into the trachea
3. Neuromuscular disease i.e. myasthenia gravis
4. Brainstem injury due to hemorrhage or infarct affecting the respiratory system
5. Drug overdose i.e. opioid overdose, morphine

Clinical presentation

Patient usually present with CNS symptoms like headache, somnolent, confusion or coma. This is due to increased CO_2 concentration in the brain leading to hyperemia which ultimately increase the CSF. Papilledema confirms the diagnosis.

Compensation

The compensation of respiratory acidosis is brought about by the kidneys. Both kidneys try to reabsorb most of the bicarbonates (alkali) in order to neutralize the [pH]. But this compensation require few days. So we need to intervene earlier in order to save the life of the patient.

For example, in acute condition, for every 10 mmHg rise in pCO_2 there is increase of bicarbonate concentration by 1. In chronic conditions, for every 10 mmHg rise in pCO_2 concentration, there is increase in bicarbonate concentration by 4.

Treatment and management

Airway maintenance
Sufficient oxygen

Respiratory alkalosis

Objectives of learning

Definition

Cause

Symptoms

Compensation

Definition

Increase in pH of the blood due to decrease in PCO_2 i.e. less than 40 mmHg.

Cause

Hyper ventilation is the root cause of increase CO_2 exhalation which may be due to

1. Anxiety
2. Pulmonary embolism
3. Sepsis
4. Mechanical ventilation
5. Aspirin toxicity

Symptoms

Light headedness due to decreased perfusion to the brain

Dizziness

Tingling sensation

Paresthesia

Compensation

Kidney compensates the increased pH by increasing the excretion of bicarbonate. But this compensation requires greater time i.e. several days.

Nephritic syndrome

Objectives of learning

Definition

Clinical features

Types of nephritic syndrome

Diagnosis

Definition

Inflammation of the glomerular capillaries by the immunoglobulins results in nephritic syndrome

Clinical features

Proteinuria i.e. <2.5g per day

Hypertension

Azotemia

RBC casts

Oliguria

Hematuria

	Post streptococcal	Goodpasture	RPGN “crescentic”	IgA nephropathy	Membranoproliferative glomerular nephritis
Light microscopy	Hypercellular PMN	Hypercellular PMN Crescents	Hypercellular PMN Crescents	Hypercellularity Mesangial cell proliferation	GBM proliferation and splitting
Immunofluorescence	Granular IgG/C3	IgG/C3 Smooth and linear BM	Crescents	IgA/C3 deposit at mesangial cells	Low C3
Electron microscope	Subepithelial deposits			Mesangial deposits	Tram track appearance
Other		Hemoptysis, shortness of breath, fever, myalgia	Renal failure	Dermatitis herpetiform Henosch schnolein	Cryoglobulinemia Patients may have HCV, HBV or syphilis
	Impetigo, cellulitis	More common in Males 20-40 years old			
Treatment	Supportive IV fluids Diuretic	Steroid Plasmapheresis	Dialysis	No treatment	

Diagnosis

Urinanalysis

Renal parameters i.e. creatinine, BUN

Renal biopsy is best and most accurate

Nephrotic syndrome

Definition

The protein losing renal pathology due to large holes in the basement membrane is called nephrotic syndrome.

Clinical features

Protein loss of more than 3.5 gram per day

Hypoalbuminemia i.e. less than 3 g/dl of proteins

Generalized edema

Lipiduria

	Membranous	Minimal change disease	Focal segmental glomerulosclerosis	Amyloidosis	Nodular sclerosis

Light microscopy	Membrane like thickening of capillary walls. Membranous spikes on silver stain	X	Sclerosis of segments of kidney	Extracellular amorphous pink protein on congo red stain	Sclerosis of glomerulus in the form of nodules along with thick basement membrane
Immunofluorescence	IgG/C3 deposits	X	X	X	X
Electron microscope	Deposits	Podocyte foot process effacement	X	Amyloid fibrils in the mesangial cells and basement meembrane	X
Other		Common in children	Associated with HIV, African American, sickle cell disease, IV drug abuser	Other systemic diseases i.e. TB, multiple myeloma, Rheumatoid arthritis can also cause this	Diabetes Wilson disease Hypercoagulable state

NSAIDs nephropathy

Objectives of learning

Definition

Pathophysiology

Risk factors

Clinical features

Diagnosis

Treatment

Definition

The side effects of NSAIDs on kidney are predominant in elderly patients with diabetes mellitus or hypertension which manifest itself in the form of nephropathy.

Pathophysiology

Ibuprofen, ketorolac, aspirin are COX2 inhibitors and they cause insult to the kidney due to:

1. Direct toxic effects
2. Decrease prostaglandin secretions lead to poor vasodilation and blood supply to the medullary nephrons is somewhat compromised leading to ischemia
3. Chronic interstitial nephritis

Risk factors

Sickle cell disease

Diabetes mellitus

Urinary obstruction

Chronic pyelonephritis

Clinical features

Fever

Flank pain

Hematuria

Pyuria

Diagnosis

Elevated BUN or urea levels

Pyuria i.e. pus in the urine

CT scan may show bumpy contours on the renal pelvis

Treatment

No definite treatment.

Avoid further NSAID intake.

IV fluids

If patient has urinary obstruction, treat the obstruction.

If patient has sickle cell, treat underlying sickle cell disease

Acute interstitial nephritis

Objectives of learning

- Definition
- Causes
- Clinical features
- Diagnosis
- Treatment

Definition

Sudden inflammation of tubules and interstitium of the nephrons is called acute interstitial nephritis.

Causes

Allergic reactions are most common cause

Drugs i.e. penicillin, NSAIDS

Diuretics i.e. furosemide, thiazide

Phenytoin, sulfa drugs

Anticoagulants i.e. heparin, warfarin

Infections i.e. legionella, streptococcus sp.

Systemic disease i.e. sarcoidosis

Clinical features

Fever

Rash

Eosinophilia

Pus/blood in the urine

Acute renal failure

Diagnosis

Renal function tests may reveal elevated BUN and creatinine

Urinalysis may reveal eosinophil

Treatment

Find and treat the underlying cause

If infection is the cause, treat with antibiotics

Rhabdomyolysis

Objectives of learning

Definition

Causes

Lab investigation

Treatment and management

Definition

Breakdown of skeletal muscles is called rhabdomyolysis.

Causes

Crushing injury

Seizures

Severe exertion

Lab investigations

Electrocardiography may show signs of hyperkalemia

Urine analysis

Creatine phosphokinase value lies in 10,000-100,000

Treatment and management

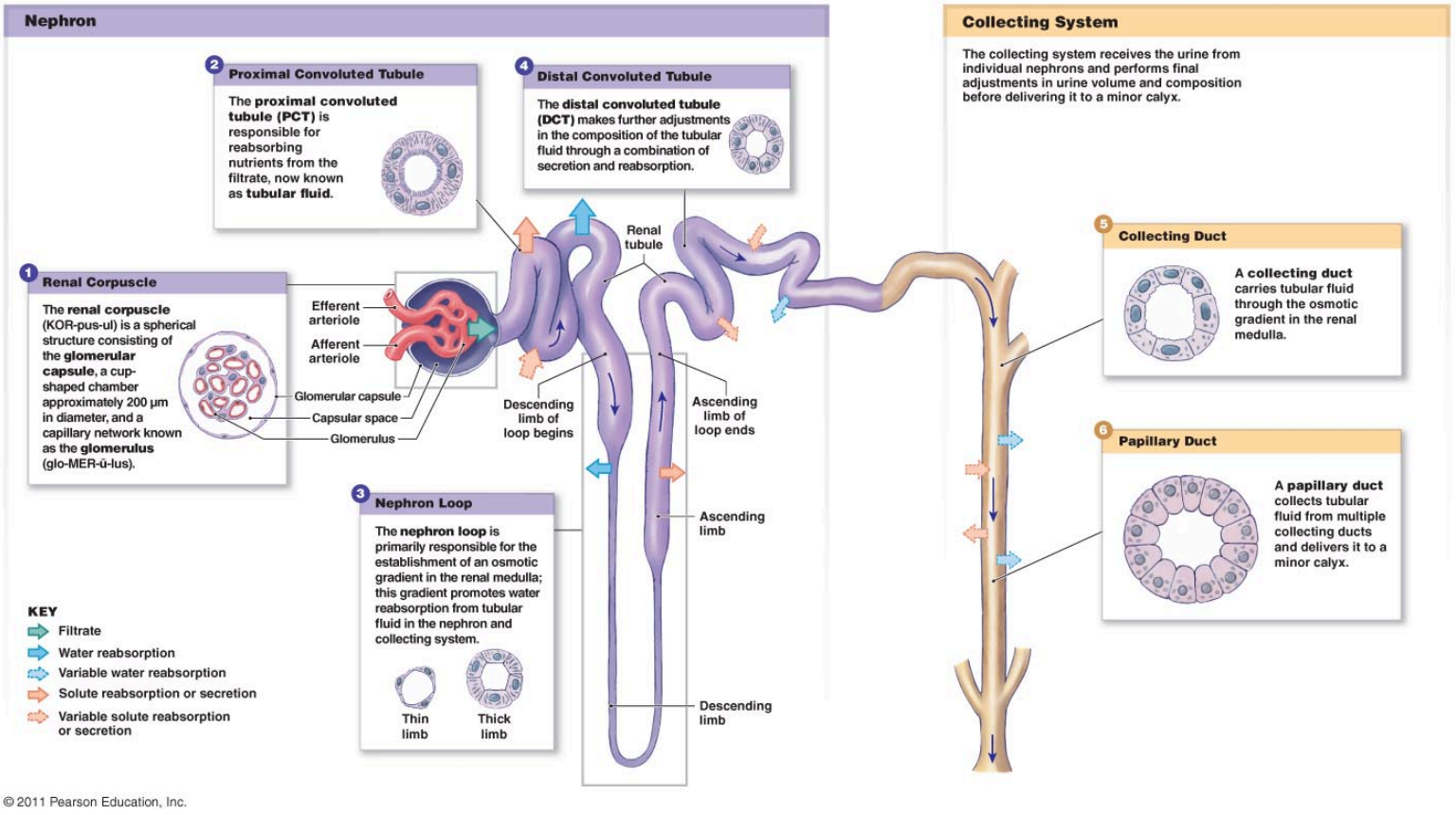
Give calcium gluconate/calcium chloride for hyperkalemia

IV fluids including mannitol which causes osmotic diuresis

Alkalization of urine will prevent the renal tubular damage.

Urine formation

The functional anatomy of a nephron



- Humans have two excretory organs called kidney located in the upper rear region of the abdominal cavity
- The urine they produce is carried to the urinary bladder through ureters
- The urethra drains the bladder
- The internal structure of the kidney contains outer cortex and inner medulla
- The ureter divides into branches the ends of which envelop medullary tissues called renal pyramids
- The basic unit of kidney is called nephron
- There are 1 million nephrons in each kidney
- Each nephron consists of vascular and tubular component
- Afferent arteriole carries blood to the glomerulus

- Glomerulus is the tuft of capillaries surrounded by Bowmen's capsule
- Efferent arteriole carries blood away from the kidney and also form peritubular capillaries
- Bowmen's capsule is the blind end of the nephron in which filtration takes place
- The glomerulus, Bowmen's capsule and proximal convoluted tubules are located in the cortex
- The portion of tubules in the medulla is called loop of Henle
- There are three portions of loop of Henle i.e. descending limb, thin ascending limb and thick ascending limb
- The distal convoluted tubule is the continuation of loop of Henle
- The distal convoluted tubules of many nephrons join a common collecting duct in the cortex
- The collecting ducts run parallel down to medulla and collect at renal pyramids to form ureter
- A few peritubular capillaries run down into the medulla around the loop of Henle to form a network of capillaries called vasa recta
- Nephrons regulate the composition of blood and urine by filtration, excretion and reabsorption
- Proximal convoluted tubules absorb most of the water and solutes from the glomerular filtrate but filtrate entering the proximal convoluted tubules have the same osmolality as that of plasma
- The ascending thick loop of Henle is permeable to salts but not to the water. This results in high concentration of salts around the proximal convoluted tubules and water come out of proximal tubules.
- As the peritubular fluid gets diluted with water, the distal thick loop excrete more salts and again make it concentrated. Thus more water is reabsorbed from proximal convoluted tubules. This is called counter current multiplier
- The distal convoluted tubule has water with low sodium chloride but high urea and creatinine.
- As the water passes through collecting duct, more sodium and water is reabsorbed under the influence of antidiuretic hormone.