1 ANATOMY & PHYSIOLOGY OF THE KIDNEY

1. Describe the boundaries of Morris's rectangle?

- **Horizontal Lines:**
  - Upper line: Opposite the spine of **T11**.
  - Lower line: Opposite the spine of **L3**.
- **Vertical Lines:** Drawn **2.5 cm and 7.5 cm** from the median plane.
- **Hilum Location:** The hilum is located **5 cm from the median plane** opposite the first lumbar spine.

2. List the structures related to the posterior surface of the kidneys?

1. **Artery:** Subcostal artery.
2. **Bones: 11th and 12th ribs.**
3. **Nerves:**
   - Subcostal nerve.
   - **Iliohypogastric** nerve.
   - **Ilioinguinal** nerve.
4. **Muscles:**
   - Diaphragm.
   - **Psoas major.**
   - Quadratus lumborum.
   - Transversus abdominis.

3. Define the renal hilum and its contents?

- **Definition:** A **vertical opening** at the middle of the medial border at the level of the **L1 vertebrae.**
- **Contents (Anterior to Posterior):**
  1. **Renal Vein** (most anterior).
  2. **Renal Artery** (middle).
  3. **Renal Pelvis** (posterior and downward).
  4. **Lymphatics and fat.**

4. Describe the branching pattern of the renal arterial supply?

- **Origin:** Arises from the aorta opposite the **L1-2 intervertebral disc.**
- **Divides into:** anterior and posterior branches at the hilum
- **Parenchyma:**
  1. **Interlobar arteries:** Run between renal pyramids.
  2. **Arcuate arteries:** Formed at the corticomedullary junction, running along the base of pyramids.
  3. **Interlobular arteries:** Penetrate the cortex at 90° from arcuate arteries.
  4. **Afferent arterioles:** Arise from interlobular arteries to enter the glomerulus.

5. Classify the types of nephrons based on the location of their renal corpuscles?

1. **Superficial Nephrons:** Renal corpuscles are in the outer cortex; have **short loops** that turn back in the outer medulla or cortex.
2. **Midcortical Nephrons:** Located in the middle of the cortex.
3. **Juxtamedullary Nephrons:** Located near the medulla; have **long loops** that turn back at successive levels of the **inner medulla.**

6. Describe the structural components of the renal corpuscle?

- **Bowman's Capsule:**
  - **Outer (parietal) layer:** Lined by **flat epithelial cells.**
  - **Inner (visceral) layer:** Lined with **podocytes** in contact with the capillary tuft.
  - **Urinary space:** The space between the two layers.
- **Glomerulus:** A **modified capillary tuft** arising from the afferent arteriole.

7. List the layers of the glomerular filtration barrier (GFB)?

1. **Endothelial cells:** Form the inner layer and contain multiple **open fenestrae.**
2. **Glomerular Basement Membrane (GBM):** Formed of **Type IV collagen** and negatively charged glycosaminoglycans; has three histological layers:
   1) **Lamina rara interna.**
   2) **Lamina densa.**
   3) **Lamina rara externa.**
3. **Epithelial cells (Podocytes):** Form the outer layer with **elongated foot processes** and **slit pores.**

8. State the functions of the mesangium?

1. **Support:** Provides structural support for the capillary tuft.
2. **Phagocytic Function:** Helps in **clearing immune complexes** or antigens from the glomerulus.
3. **Contractile Function:** Helps in **modulating renal blood flow** and the capillary filtration surface area.

9. Define the components of the Juxta-Glomerular Apparatus (JGA)?

1. **Macula Densa cells:** Modified cells in the distal convoluted tubule that **detect luminal NaCl concentration.**
2. **Epithelioid cells:** Modified cells in the walls of arterioles containing **renin granules.**
3. **Lacis cells:** Interstitial cells in continuity with mesangial cells.
4. **Peripolar cells:** Present at the vascular pole between podocytes and parietal epithelial cells.

10. Summarize the major functions of the kidney?

1. **Excretory:** Elimination of **waste products and toxins;** control of water and electrolyte balance.
2. **Acid-Base Balance:** Regulation through bicarbonate reabsorption and **H+ excretion.**
3. **Blood Pressure Control:** Through the renin-angiotensin system and pressure regulation.
4. **Hemopoietic:** Role in **erythropoiesis** via erythropoietin secretion.
5. **Endocrine:** Formation/activation/degradation of hormones like **Vitamin D and Renin.**
6. **Metabolic:** Processing various substances.

11. Explain the hemopoietic function of the kidney?

- **Erythropoietin (EPO) Production:** The kidney produces **90% of the body's EPO,** primarily in the renal cortex.
- **Role:** Regulates **RBC development** in the bone marrow.
- **Stimulus:** The primary stimulus for secretion is **tissue hypoxia.**

- **Clinical Abnormalities:**
  - **Deficiency:** Leads to **anemia** in Chronic Kidney Disease (CKD).
  - **Excess:** Leads to **polycythemia** (e.g., in renal artery stenosis or renal cell carcinoma).

12. Classify hormones based on their interaction with the kidney?

Hormones Synthesized by Kidney	Hormones Degraded by Kidney	Hormones Acting on Kidney
Renin	Insulin	AVP (Vasopressin)
Prostaglandins	PTH	ANP
Active Vitamin D	Prolactin	Mineralocorticoids
Erythropoietin	Glucagon	Glucocorticoids

13. Describe the mechanisms of renal autoregulation?

- **Myogenic Reflex:** Increased renal perfusion pressure causes **automatic vasoconstriction** of the preglomerular vessels.
- **Tubulo-glomerular Feedback (TGF):**
  4) Increased perfusion pressure leads to **increased NaCl delivery** to the macula densa.
  5) This triggers **afferent arteriolar constriction.**
  6) Result is a reduction in the single-nephron GFR (SNGFR) to maintain stability.

14. List the factors affecting glomerular filtration?

1. **Filtration Coefficient (Kf):** Depends on **surface area,** slit pores of podocytes, and fenestrae of endothelium.
2. **Filtration Pressure:** The net pressure resulting from hydrostatic and oncotic gradients.
3. **Molecular Properties:** The **size and charge** of the molecule.
4. **Basement Membrane:** The **negative charges** of the GBM repel like-charged proteins.

15. Describe the functions of the different segments of the renal tubule?

1. **Proximal Convoluted Tubule (PCT): Reabsorption of 65-80%** of water, Na+, K+, and Cl-; active reabsorption of **glucose and amino acids.**
2. **Loop of Henle:** Acts as a **countercurrent multiplier system;** reabsorbs 25% of filtered Na+ in the thick ascending limb.
3. **Distal Convoluted Tubule (DCT):** Reabsorption of **NaCl and calcium;** impermeable to water.
4. **Collecting Duct:** Reabsorption of **Na+ (aldosterone controlled)** and **water (ADH controlled);** excretion of K+ and H+.

16. List the different methods used for urine examination?

1. **Physical characteristics:** Examination of **color, odour, transparency,** and froth.
2. **Microscopic examination:** Detection of **cells** (RBCs, leukocytes), **casts** (hyaline, red cell, granular), and **crystals.**
3. **Dip-stick test:** Plastic strips with enzyme paper that react to **glucose, albumin, nitrite, Hb,** etc., showing color changes.

17. Detail the indications and contraindications for a kidney biopsy?

- **Indications:**
  1. **Adults with nephrotic syndrome.**
  2. Steroid-resistant/dependent nephrotic syndrome in children.
  3. **Renal impairment of unknown etiology.**
  4. **SLE** with renal involvement.
  5. Rapidly Progressive Glomerulonephritis (**RPGN**).
- **Contraindications:**
  1. **Solitary kidney** or multiple cysts.
  2. **Uncontrolled bleeding diathesis.**
  3. **Uncontrolled blood pressure.**
  4. Acute pyelonephritis or perinephric abscess.

18. Summarize the uses of renal ultrasonography (US)?

1. **Renal Size and Contour:** Identifying small or enlarged kidneys.
2. **Obstruction:** Detecting **stones and back pressure** (hydronephrosis).
3. **Masses:** Identifying **renal masses or cysts.**
4. **Vascular Integrity:** Using **Doppler flow** to assess renal artery stenosis or vein thrombosis.
5. **Procedural Aid:** Guiding needles for **renal biopsy** or aspiration.