Histology Lab #1

Slide 3: Cortex of kidney

- As long as we see renal corpuscles scattered everywhere, this indicates that this is the cortex.
    - The renal corpuscle is the glomerulus surrounded by Bowmann's capsule.
        - Both sides of the glomerulus are arterial; which increases the blood pressure inside the capillary and helps filtration.
        - Bowmann's space collects the filtrate (= plasma – proteins).
- If we look around the renal corpuscles, we observe tubules surrounding them.
    - These are the proximal and distal tubules, where the proximal tubule is longer and thus allows for more sectioning.
        - The proximal tubule is 15-16 mm long, with a diameter of 60 um. While the distal tubule is only 8 mm long, with a small diameter as well (about half that of the proximal tubule).
- We see collecting tubules here in the cortex, and these are the medullary rays. They receive the tubular fluid (filtrate) from the nephron.

Slide 4

- We notice a gradual decrease in the number of corpuscles from the outer cortex to the area near the medulla.
    - There are no renal corpuscles in the medulla so the area where we don't see any renal corpuscle is the medulla.

Slide 5: Outer zone of medulla

- We observe a large number of collecting tubules with no corpuscles; this indicates that this is the medulla.
- As we go deeper, the collecting tubules become large and turn finally into collecting ducts.
    - The medulla contains the collecting tubules and ducts, and the loop of Henle. It also contains the vasa recta (blood vessels surrounding the loop of Henle).
- Why do we describe an outer and an inner zone of the medulla?
    - The permeability of the collecting tubules and ducts differs between the outer and inner zones. In the outer part of the medulla, there is little permeability to urea and water; that increases in the presence of ADH. In the inner part of the medulla, there is high permeability to urea and water in the presence of ADH.
        - High permeability of water means that it is reabsorbed from collecting tubules back into the blood.

- High permeability of urea means that it is reabsorbed back into the interstitium; which increases the osmolarity of the interstitial fluid.

  In the absence of ADH, the patient produces a large amount of diluted urine. This is called Diabetes Insipidus.

Slide 6: Medulla of kidney (inner zone)

- Each circular section is a part of a tubule; if small, it is a collecting tubule, and if large, it is a collecting duct.
- We also observe sections in the loop of Henle, with its associating vasa recta.
  - It is hard, however, to differentiate them using a low magnification power.

Slide 7: Inner zone of medulla

- This is a higher magnification of the inner zone of the medulla, where the larger sections are parts of collecting tubules or ducts.
  - If the lining epithelium was cuboidal, then it is a tubule. If the epithelium was columnar, then it is a duct.
  - The collecting duct is the final destination, where the filtrate becomes ready for excretion urine.
- This magnification allows for the observance of the loop of Henle, and the vasa recta.
  - The vasa recta are blood vessels found in the medulla; therefore they must contain red blood cells to be identified.
  - The medulla receives only 5% of the blood supplied to the kidney (5% of 1100 ml). This is convenient because if the amount of blood reaching the medulla was higher, it would have washed away the minerals that are being concentrated there, and distorted the hyperosmolar medium needed for absorption of water.
  - There are two sets of capillaries in the kidney.
    1. The glomerulus: where filtration occurs and produces a filtrate that is basically plasma without proteins. This increases the concentration of proteins in glomerular capillaries.
    2. Peritubular capillaries: surround the proximal and distal tubules, and are responsible for reabsorption. They are the continuation of the efferent arteriole of the glomerulus; which means that their protein concentration is also high. This increases the oncotic pressure and allows for reabsoprtion.

Slide 8: Cortex

- The presence of renal corpuscles means that this is in the cortex.
- Medullary rays are the beginnings of collecting tubules.

- They receive the filtrate from the final part of the nephron, which is the distal tubule.

  Collecting tubule + the surrounding nephrons that drains into it are called a renal lobule, it's defined between two interlobular arteries. (hard to be seen in this slide)

Slide 9: Renal corpuscle

- This is a renal corpuscle at high maginification, formed of a glomerulus inside with a surrounding Bowmann's capsule.
  - The entry of capillaries into Bowmann's capsule is described identically to the entry of the lungs into the pleura. This forms a visceral layer of podocytes, and a parietal layer, with a space in between them named Bowmann's space.
  - Bowmann's space contains an isoosmotic filtrate (has the same osmolarity as the plasma; 300 mlosm/L).
  - This is caused by free filtration of water and solutes. (in the same proportion).
- Surrounding the renal corpuscle are the proximal and distal tubules.
  - The larger section is from the proximal, and the smaller from the distal.
  - The proximal tubule has a brush border (microvilli for reabsorption) that looks like debris found inside the lumen of the specimen. This is only a result of the effect of chemicals used for washing and staining the specimen.

    Proximal tubule cells are between cuboidal and columnar, they are deeply eusinophilic because of large number of mitochondria needed for the energy of Na-K pumps.

    The proximal tubule is the longest part of the nephron.

    The filterate at the end of it is isoosmotic because water and salts were reabsorbed in the same proportion.
  - The distal tubule has a clean lumen because the microvilli are separately spread and don't form a brush border.

    It is divided into
    1. Early distal
       - It resembles the thick segment of the loop of Henle (the structure immediately preceding it) functionally and structurally.
    2. Middle distal is formed of macula densa.
    3. Late distal
       - The late distal part is the one observed in this slide. It resembles the collecting tubule (the structure immediately following it) functionally and structurally.
       - They contain two types of cells: Light principal cells, and dark intercalated cells.
         - The light principal cells reabsorb sodium and secrete potassium under the effect of aldosterone (aldactone).

- The dark intercalated cells reabsorb some potassium and secrete H+; which controls the acid-base balance in the urine.
- When you prescribe a diuretic drug that acts by inhibiting aldosterone (antialdosterone), be careful to that the patient doesn't take K supplement. Otherwise K will accumulate leading to K toxicity.

Slide 10: Late distal tubule (D.T.)

- Similar to the previous slide, we observe the glomerulus, Bowmann's capsule and space, the proximal tubules with debris inside their lumens, and the late distal tubules with clean lumens.
- To differentiate between the nuclei of the podocytes and the glomerular capillaries: it's small in the capillary endothelium, and large in the podocytes.
- No collecting tubules, early distal tubules, or middle distal tubules are seen.

Slide 11: Vascular pole

- Similar to the previous two slides.
- At the edge of the renal corpuscle, we observe blood vessels (differentiated by containing red blood cells). They are the afferent (entering arteriole - larger) and the efferent (exiting arteriole - smaller).
  - This part of the corpuscle, where vessels enter and exit, is called the vascular pole of the corpuscle.
- Remember: in glomerular capillaries there is filteration rather than reabsorption whereas in the peritubular capillaries there is reabsorption rather than filteration.

Slide 12

- The part where Bowmann's capsule opens into the proximal tubule is called the urinary pole.
- Exam question: Compare between the fluid compositions of the pointed structures. Example: Bowmann's capsule and proximal tubule.

Both are isosmotic; as a result of free filtration in Bowmann's capsule, and proportional reabsorption of water and solutes in the proximal tubule.

Slide 13: Urinary pole & Vascular pole

- Urinary pole is large, with the vascular pole opposite to it.
- Other structures as seen in previous slides.

Slide 14

- Similar to previous slide.

- The macula densa is observed, which is the beginning of the distal tubule, a little after the early distal part.
    - It looks like a raw of nuclei next to each other.
    - It is observed in the vascular pole, as it is part of the juxtaglomerular apparatus
        - The juxtaglomerular apparatus also contains the special smooth muscles in the wall of the afferent arterioles, which contain renin granules.
            - Renin acts on angiotensinogen and converts it into angiotensin 1, which is then converted into angiotensin 2 in the lung. Angiotensin 2 releases aldosterone to reabsorb sodium and water back into the blood to compensate for a loss of fluid, or hypotension. Hence the secretion of renin in cases of hypovolemia, hypotension, or ischemia to the kidney.
    - They are specialized cells that can sense the amount of sodium or chloride secreted into the filtrate.

They have multiple nuclei that are densely packed together on one side of the cell.

Slide 15

- High magnification of a glomerulus and surrounding structures.
- Similar to previous slides.
- The late distal tubules have the same structure and function of the collecting tubules. They are made of light principal and dark intercalated cells.

Slide 16

- Macula densa is observed, which means we are near the vascular pole (between the afferent and efferent arterioles).

Slide 17

- Macula densa is seen, along with proximal tubules, late distal tubules (or could be collecting ducts), and a renal corpuscle.

Slide 18

- Macula densa is seen, meaning that we are at the vascular pole.
- Opposite to the vascular pole is the urinary pole, where it opens into the proximal tubules.

Slide 19

- Similar to previous slide.

Slide 20: Juxtaglomerular apparatus

- The juxtaglomerular apparatus is made of:
    1. The macula densa.
    2. Special smooth muscle cells in the walls of afferent arterioles, called juxtaglomerular cells. (JG cells).
    3. Extraglomerular mesangial cells: connective tissue found in between the afferent and efferent arterioles.
        - No known function.
        - Sometimes called **Polkissen cells**.
        - The intraglomerular mesangium (connective tissue between the podocytes and the capillaries), however, contains monophagocytic cells that phagocytize proteins or microbes that might leak into the filtrate.

Slide 21: Juxtaglomerular apparatus

- Similar to previous slide.
- Macula densa observed, near vascular pole.

Slide 22: Cortex

- Medullary rays contain two types of cells: light principal cells, and dark intercalated cells.
    - Similar to late distal tubules structure and function.

Slide 23

- Proximal tubules are seen.
- Collecting tubules forming a medullary ray.
  Most of its cells are pale light principal cells.

Slide 24: Cortex. Basement membrane (P.A.S. rxn.)

- The basement membrane of proximal and distal tubules is stained with P.A.S. because it contains glycogen.

Slide 25: Cortex. Basement membrane (P.A.S. rxn.)

- The pale lines seen in this slide are basement membranes.
- PAS slides are not important.

Slide 26: Medulla of kidney

- Collecting tubules, not ducts, are seen. We know this because their lining epithelia are cuboidal.
    - As the length of the epithelium increases, the tubule becomes more duct-like.
    - Collecting tubules are found in:

        - The outer medulla: permeability to urea and water is low, depends on levels of ADH.
        - The inner medulla: as we go nearer to the minor calyx, collecting ducts become more permeable to water and urea by action of ADH. This is vital for concentration of urine and subsequently, maintenance of body fluids.
    - Question: Is the filtrate in the collecting tubules/ducts hyposmolar, hyperosmolar, or isosmolar?
        - It could be hyperosmolar, under the effect of high levels of ADH, especially during dehydration. It could be isosmolar, when ADH levels are within normal and water intake is normal. It could be hyposmolar in cases of diabetes insipidus.
- Vasa recta must contain red blood cells to be identified.
- The thin segment of loop of Henle is found in both descending and ascending loops. It is identified by its bulky nucleus bulging into its lumen, and that it does not contain any blood.
    - Question: Is the pointed structure (thin segment) permeable to water?
        - We are not able to answer since it is not clear if the thin segment is part of the ascending or descending limb. However, if specified, it is permeable to water in the descending limb (which is almost impermeable to Na and Cl) and impermeable to water in the ascending limb (which absorbs solutes only).
    - Transport is passive in the thin segment, as it contains a minimal amount of organelles.
    - Question: Was this section made in the diluting or concentrating portion of the medulla?
      Our answer depends on which part of the thin segment is present. If it's in the descending limb, we are in the concentrating part; since only water passes. And if it's in the ascending limb, we are in the diluting part; since only solutes pass

Slide 27

- Collecting tubules have grown into ducts as they go deeper towards the papilla. Their lining epithelia are low columnar.
- Sections with bulging nuclei are the thin segments of loop of Henle.
- Thick segments are not found in this slide.
- Question in the exam: does the pointed structure contain hyper-, hypo-, or isoosmotic fluid?

Slide 28: Medulla of kidney

- Longitudinal section of a collecting duct.
- There are barely any thin segments, while there are many thick segments in this slide.

- Thick segments resemble early distal tubules in structure and function.
- Active reabsorption of minerals occurs here, where 1 sodium, 2 chloride and 1 potassium enter using one carrier.
- The thick segment is impermeable to water. It is largely responsible for the hyperosmolar interstitium around it.
- Question: How does the thick segment of loop of Henle increase the osmolarity of the interstitium around it?
  - By allowing reabsportion of solutes through carriers, and being impermeable to water at the same time.

Slide 29

- A collecting duct is observed with some thin segments surrounding it (recognized by the bulging nuclei).
- No thick segments are seen.

The loop of Henle is responsible for concentrating the urine by creating a hyperosmolar environment around it, so that the collecting duct can allow reabsorption of water.

Slide 31: Ureter

- The ureter is a muscular tube with a thick wall, it has three layers:
  1. Mucosa
     - Transitional epithelium (urinary epithelium).
     - The lamina propria is connective tissue containing macrophages, lymphocytes, and plasma cells.
  2. Muscularis
     - Two layers of muscle in the upper two thirds of the ureter; inner longitudinal and outer circular unlike the gut.
     - In the lower third of the ureter and in the urinary bladder, one more muscle layer is seen. The order becomes inner longitudinal, middle circular, then outermost longitudinal.
     - The muscularis layer of the ureter functions in peristalsis. It’s supplied by sympathetic innervation.
  3. Adventitia
     - Connective tissue in the area that isn’t covered by peritoneum.
- The ureter is retroperitoneal, thus some serosa (simple squamous epithelium) could be seen.

Slide 31

- Starting from the inside, we see transitional epithelium, inner longitudinal muscle, outer circular muscle.

Slide 32: Inner longitudinal & outer circular smooth muscle layers

- Transitional epithelium and lamina propria together form the mucosa.
- The inner longitudinal muscles and outer circular muscles can be observed.
- Some part of the adventitia can be seen.

Slide 33

- The inner longitudinal muscles (to the left) are cut transversely. While the outer circular muscles (to the right) are cut longitudinally.

Slide 34: Transitional epithelium

- Transitional epithelium has dome shaped cells (oval) on the surface.
- When the bladder is distended, the transitional epithelium flattens out and appears as if it has fewer layers than when the bladder is relaxed.

In cells near the lumen, the cell membrane is very thick. This is to prevent osmotic equilibrium between the concentrated urine and the blood in the surrounding blood vessels. Otherwise water will move from blood out to the ureter.

Slide 35

- Similar to previous slide.

Slide 36

- These cells are very clearly dome shaped.

Slide 38: Urinary bladder

- We see the transitional epithelium resting on a lamina propria, followed by the muscularis, then the adventitia.
- The muscularis is largely irregular although it forms three layers (inner longitudinal, middle circular, outer longitudinal).
    - The purpose of this irregularity is emptying the bladder efficiently and thoroughly.
    - This is the detrusor muscle, which is rich in muscuranic receptors.
        - The parasympathetic system allows this muscle to contract and empty the urinary bladder.
        - We should be cautious when prescribing anticholinergic drugs to elderly male patients, since they might have an enlarged prostate. The combination of an enlarged prostate, and a relaxed detrusor muscle, as a result of the anticholinergic, could cause serious urinary retention and then a urinary stone.
- Only the upper surface of the urinary bladder is covered in peritoneum where the outermost layer is serosa.

Slide 39

- Here we can see the transitional epithelium, the lamina propria, and the muscularis.

Slide 40

- The transitional epithelium on the left is resting on a layer of lamina propria.

Slide 41

- The transitional epithelium is dome shaped when the bladder is empty and flat when the bladder is distended.
- They have a thick plasma membrane that prevents osmotic equilibrium between urine and blood.

Slide 42

Similar to previous slide.

Slide 43: Smooth muscle

- Irregularity of muscular layers is apparent.

Slide 44: Serosa of urinary bladder

Only found on the upper part of the urinary bladder.