**Physiology sheet 27:**

* Urine formation is one of the most imp. Functions of renal system and it has 3 process:

1. glomerular filtration
2. tubular reabsorption
3. Urine secretion and excretion.

* **Slide#4 (Body fluid regulation)**

We know that the kidney output is about 1.5L of urine that comes from plasma filtration through the kidneys.

* **Slide#5 (Summary of Kidney functions)**

-Main function that we are going to discuss is urine formation/renal system/making urine.

-However kidneys have other functions such as production of erythropoietin which is a very imp. Controller for RBC formation in the bone marrow and it also responds to hypoxia; when there is hypoxia there is an increase in the secretion of erythropoietin from kidneys which will stimulate bone marrow to produce more RBCs.

- In endochrine, the parathyroid hormone in the kidney converts in active vitamin D (25-hydroxycholecalciferol) into 1,25 dihydroxycholecalciferol this coversion occur in the kidney.

🡪 So if you say someone has anaemia the cause could be kidney failure because there is lack in the production of erythropoietin or if we say someone has problem in calcium concentration then we also might say he has kidney failure.

-The kidney also excretes toxic substances such as pesticides, food additives and evidence to that if we eat coloured food our urine might also get coloured.

-And also another imp. Function is regulation of acid-base balance.

-Gluconeogenesis: glucose synthesis from amino acids.

-Control of arterial pressure (kidney is very important part of regulating blood pressure through secretion of rennin and rennin acts of Angiotensinogen which is an [α-2-globulin](http://en.wikipedia.org/wiki/Alpha_globulin) found in plasma and convert it to Angiotensin I and angiotensin l primarily circulates in the lung by endothelium in the lung it is converted to angiotensin II( angiotensin ll is the most imp. Vasoconstrictor, people who suffer from hypertension produce alot of angiotensin ll they can be treated by [angiotensin-converting enzyme](http://en.wikipedia.org/wiki/Angiotensin-converting_enzyme) inhibitor like ).

- Through talking about urine formation we are going to talk about water and electrolyte excretion, some hormones are direct the kidney on water resorption and electrolytes.

* **Slide#6(Excretion of Metabolic Waste Products)**

-Same as the slide.

* Extra notes: 1) creatinine conc. In the blood is a sign of how much is the function of kidney, there is a normal level if the creatinie is increased (above 2-3 mg/100ml of plasma) we say the kidney is not functioning well.

2) bilirubin increase or decrease is maybe due to liver failure (liver is not metabolizing hemoglobin) thus it's not an accurate measure of kidney function.

* **Slide#7(Excretion of Foreign Chemicals)**

-same as slide

* **Slide#8(Secretion, Metabolism, and Excretion of Hormones)**

-same as slide

-extra note: metabolites of steroids can also be excreted in the kidneys

* **Slide#9(Regulation of Erythrocyte Production)**

Hypoxia (decreased O2 delivery to the kidney) will increase erythropoietin secretion; erythropoietin is a hormone that will stimulate RBC production in bone marrow and by this mechanism there is a negative feedback between how much RBC we have and how much oxygen carrying capacity we have.

* **Slides#10/11/12**

-same as slide

* **Slide#13(Regulation of Arterial Pressure**
* We already talked about renin-angiotensin system; imp. In regulating blood pressure
* Prostaglandin and kallikrein-kinin system are very imp. Products that are very important in the regulation of the renal blood flow(local).
* **Slide#14(Regulation of Water and Electrolyte Balances)**

-same as slide

* **Slide#15(Organs of the urinary system)**

-Now as we know renal system consist of two kidneys that are connected to the ureter(which connects kidney to the urinary bladder) at the pelvis of kidney and also at this site we have renal artery and vein.

-Urinary bladder is storage area for the urine formed and then it's excreted to the outside by urination (micturition).

-The mechanism of defecation is the same as micturition.

* **Slide#16(Internal anatomy of the kidneys)**

-The picture shows a sagital through the kidney, the kidney is divided into lobes and it's striated but its striation is not the same as the striations in the skeletal muscle, these stiations are in the fact the tubular structure of the nephrons.

- Inside each lobe we have nephrons which are the structural and functional unit of renal system through these lobules they open through calyces (minor and major), minor and major calyces end at the pelvis of the kidney and then connected to the ureter and then to urinary bladder.

-Some nephrons are located in the cortex thus they are called cortical nephrons while some others are located very deep in the cortex just close to the medulla and are called juxtamedullary nephron.

-Although juxtamedullary nephrons form less than 20-30% of nephrons there function is very important in making urine concentrated.

-concentrating urine is very imp. Especially in hot weather we can't spare loss through sweat and urine and concentrating the urine conserve water loss, without these nephrons our body is going to get dehydrated.

* **Slide#17(Blood supply of the kidneys)**

-Blood supply of kidney is through renal artery then we have segmental arteries then interlobar arteries and then interlobular arteries which continue as afferent arteries to supply the nephrons and then these arteries enter Bowman's capsule, inside Bowman's capsule they divide into many glomerulus capillaries the end of these capillaries form efferent arterioles which leads to a second capillary network, the peritubular capillaries which then collects into veins that will end as renal vein.

- The peritubular capillaries are different in juxtamedullary nephron than in cortical nephron, in the juxtamedullary nephron the capillaries form a long straight capillaries parallel to the loop of henle called Vasa recta.

- Blood flow to the two kidneys is normally about one fourth of cardiac output or 1200ml/min, this huge amount is for filtration of plasma to get rid of toxins and to be excreted in the urine.

* **Slide#18(Nephron Tubular Segments)**

-Bowman's capsule is continuous with the proximal tubule and because this tubules is very tortuous we call it proximal convoluted tubule, the proximal tubule then runs straight down to loop of Henle; loop of Henle has two arms ascending arm and descending arm.

-The ascending loop of Henle has a thick part called thick segment of ascending loop of Henle which is very imp. When we talk about concentrating urine, then this part continues as distal convoluted tubule, sometimes the distal convoluted tubules runs between efferent and afferent arteries, they are to some extent forming cistern called juxtaglomerular apparatus, after the distal convoluted tubule we have collecting duct, this duct also collects from many other nephrons, after collecting we have minor calyces and then major calyces🡪ureter.

- Once the fluid reaches the collecting duct we can no more change its composition.

* **Slide#19(Cortical and juxtamedullary nephrons)**
* Compare peritubular capillaries of cortical and juxtamedullary nephron!
* The length of loop of Henle determines how much the concentration of urine will be.
* In Rodents (animals living in desert) there is no water thus they need to concentrate their urine so we suspect them to have a very long loop of Henle humans can concentrate up to 1200 milli osmole in these rodents they reach upto 3000milli osmole.
* **Slide#20(Basic Mechanisms of Urine Formation)**

-How we make urine?

First of all urine receives huge amount of blood supply that's relatively high to its size so there is another reason for this amount and as we said it's for filtration, kidneys receives 1200ml/min coming through afferent arterioles the fluid is filtered through afferent arterioles and epithelium layer of glomerulus and then reaches bowmans capsule lumen.

-How much is filtered?

Usually 20% of plasma flow is filtered and it's called filtration fraction.

- How much is filtered per minute?

If we consider PCV to be 50% of blood then 600ml of plasma flows per one minute

🡪20% of this 600 is filtered so the answer is **100ml/min**.

-This 100ml is called Glomerular Filtration Rate (GFR)

-GFR is also an imp. Abbreviation relating to adrenal cortex because it has 3 layers which are 1)Zona **G**lomerulosa.

2)Zona **F**asiculata.

3)Zona **R**eticularis.

-We said that the filtration rate is 100ml/min how much is per day? 180L per day so imagine if all of this filtrated plasma is excreted then we have a huge problem, so there must be another process which is reabsorption(2nd process after filtration)

-sometimes filtration is not complete, still the concentration of a certain substance in plasma is toxic thus the 3rd  process is secretion of what's left in peritubular capillary and after that the fluid reaches collecting duct at this point we can't change the composition of urine and the urine is going to be excreted (4th process)

**Excretion=Filtration-Reabsorption+Secretion**

* **Slide#21 (Structures and functions of a nephron)**

In this slide we have summary for the 4 processes

* **Slide#22(Excretion = Filtration - Reabsorption + Secretion)**

-Same as the slide.

-extra note the slide is talking about a normal person with no disease, e.g.: a person with diabetes mellitus has high glucose level in urine.

* **Slide#23(Renal Handling of Different Substances)**

-**Substance A** is freely filtered but not reabsorbed nor secreted; therefore its excretion rate is equal to GFR this substance is called inulin.

-**Substance B** is freely filtered but is also partly reabsorbed from the tubules back to the blood, in this case we calculate something called clearance which is plasma volume that gets cleared from inulin.

-**Substance C** is freely filtered but not excreted to the urine it's reabsorbed; clearance of this substance is less than GFR (zero)

-**Substance D** is freely filtered not reabsorbed but additional quantities of this substance is secreted thus its clearance rate is more than its GFR so from this substance I can calculate plasma flow and then blood flow.

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