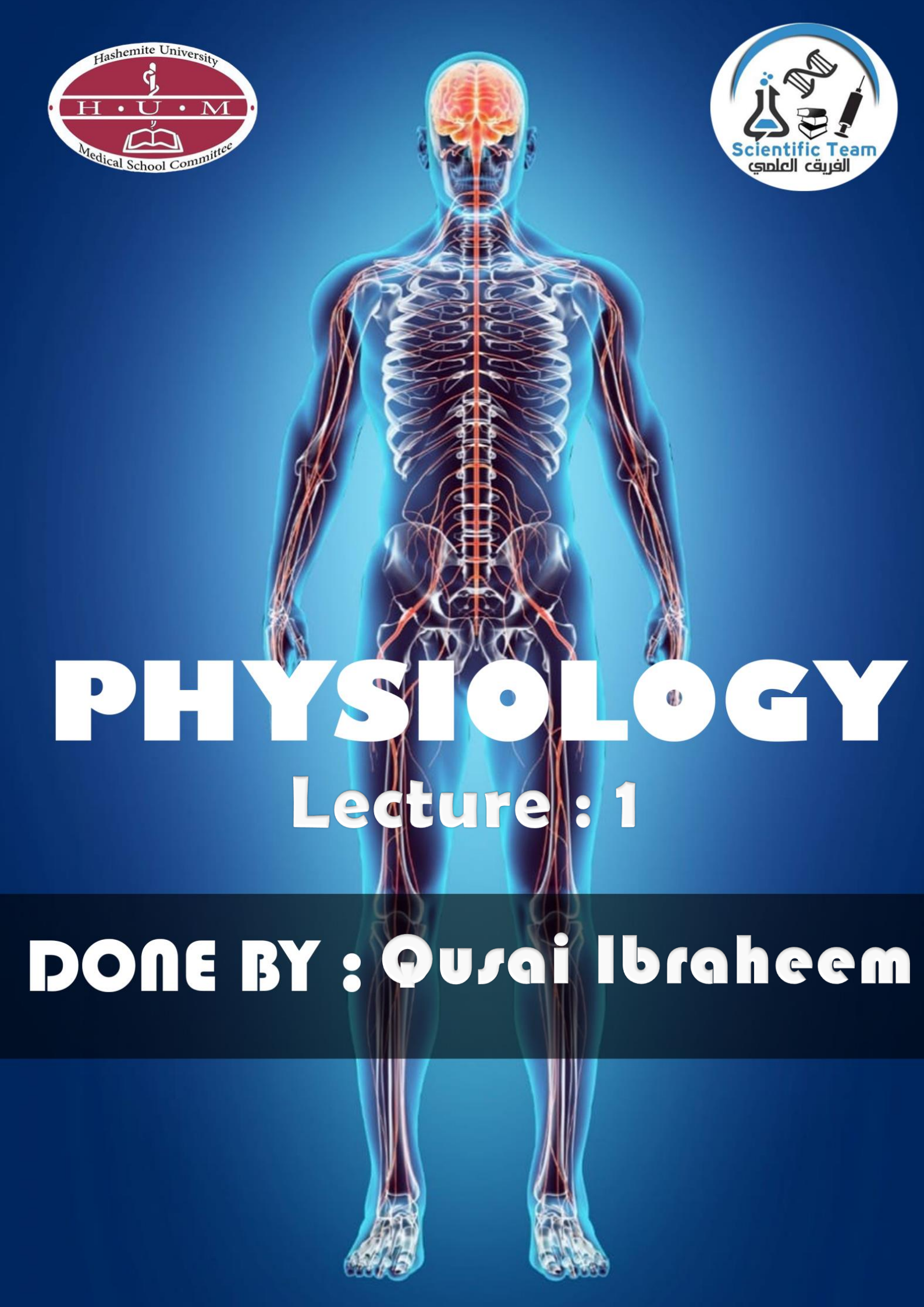


PHYSIOLOGY

Lecture : 1

DONE BY : Qusai Ibraheem

The Urinary System: Functional Anatomy And Formation by the Kidneys

to the kidney many important function :

1-excreation the body waste material that either ingestion or produced by metabolic like:

Urea (from protein metabolism)

• Uric acid (from nucleic acid)

• Creatinine (from muscle) which is the gold standard test to detect proper renal function

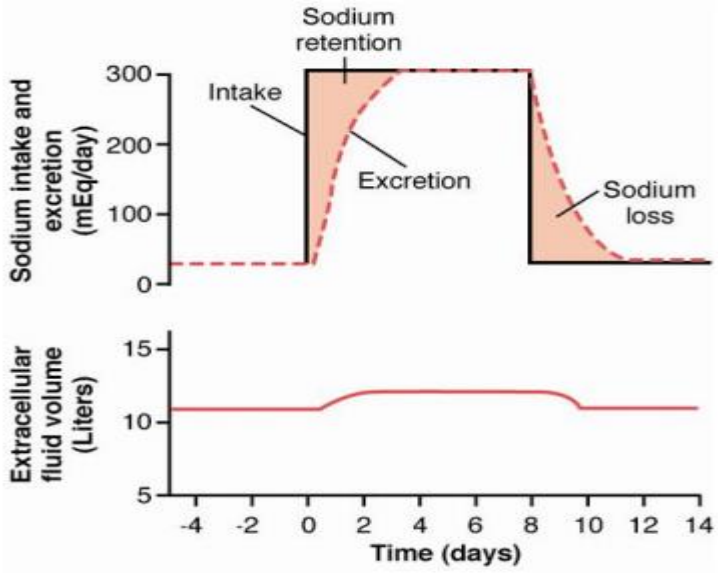
• Bilirubin (from hemoglobin breakdown)

•Hormone metabolites

• and Excretion of Foreign Chemicals and Drugs like: Pesticides, Food additives, Toxins, Drugs

2-regulation of water and electrolyte balance

For water and all electrolyte in the body the balance between intake(by ingestion or metabolic) and output(due to excretion) is maintain by kidney (for maintain homeostasis) so excretion of water and electrolyte must match intake.so, If intake exceed excretion, the amount of that substance will on the body will increase and if intake is less than excretion, the amount of the substance in the body will decrease



these picture shoe the response of the kidney to 10-fold increase in the Na intake from low level of 30mEq\day to 300mEq\day but within 2 to 3 day ,renal excretion also increase to about 300mEq\day so that balance between intake and output. during 2 to 3 day of renal adaptation to high sodium intake there modest accumulation of Na that rise extracellular fluid volume slightly, also increase of Na intake trigger hormonal change and other compensatory response to increase Na excretion

This is also happen in water and other electrolyte such as Cl, K, Ca, H+, Mg and P

3-Regulation of Arterial Pressure

Kidney paly important role in long term regulation of arterial blood pressure by excretion variable amount of Na and H2O. if increase blood pressure ,kidney increase excretion of water and Na but if blood pressure is increase ,decrease excretion water and Na

And contribute to short term regulation by secreting hormone and vasoactive factors or substance

Like renin that lead to secret vasoactive product (angiotensin II) and prostaglandin

4-regulation of acid-base balance

The kidney contribute to acid-base regulation with the lung and body fluid buffer by:

-Excrete acids (kidneys are the only means of excreting sulfuric acid and phosphoric acid that generated by the metabolism of protein

-Regulate body fluid buffers(e.g. Bicarbonate) which can decrease excretion and increase reabsorb in acidosis and increase excretion in alkalosis

5-Regulation of Erythrocyte Production

The kidney secret erythropoietin which stimulate production of RBC from the hematopoietic stem cell in the bone marrow which stimulate by decrease O2 delever to the kidney like in hypoxia or anemia

In people which have sever kidney disease or kidney removal lead to sever anemia develop due to decrease erythropoietin production

6-Regulation of Vitamin D Activity

Kidney produces active form of vitamin D(1,25 dihydroxy vitamin D3) by a 1-hydroxlase enzyme present in the proximal convoluted tubule which stimulation by PTH

Vitamin D3 is important in Ca & P metabolism

Hormones produced in the kidney:

- Erythropoietin
- Thrombopoietin
- 1,25 dihydroxycholecalciferol (Vitamin D)
- Renin
- Prostaglandins

Hormones metabolized and excreted by the kidney

• Most peptide hormones (e.g. insulin, angiotensin II, etc.) in diabetic patient who have kidney failure ,you should to adjustment insulin dose by decreasing the dose

7-Glucose Synthesis

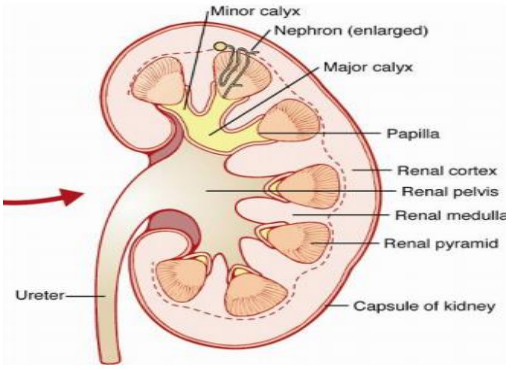
Gluconeogenesis: synthesize glucose from precursors (e.g.amino acids) during prolonged fasting and have the capacity to add glucose to the blood during long period of fasting

physiology anatomy to the kidney

the kidney has two major region are the outer cortex and the inner medulla

the medulla is divide into 8-10renal pyramids the base of these pyramid towered to the cortex and its apex, the renal papilla which is projection into the renal pelvis

the renal pelvis is divide into 2-3 major calyces and each of these divide into 2-3 minor calyces which collect urine from the tubule of each papilla



Renal blood supply

Blood flow to What does ~22% CO = 1100 ml/min.

1000ml\min يعني تقريبا 22% kidneyال بوصل 5000 ml\min تقريبا cardiac outputال هسا

-the renal artery enter the kidney through the hilum and then branch to segmental then branch to form interlobar then arcuate artery then branch into interlobule then afferent arterioles which lead to glomerular capillary where large amount of fluid and solutes are filter then the end of the capillary of each glomerular fuse to form efferent arterioles which lead to second capillary network called peritubular capillary which surround proximal tubule an distal renal tubule in renal cortex which responsible reabsorption and secretion

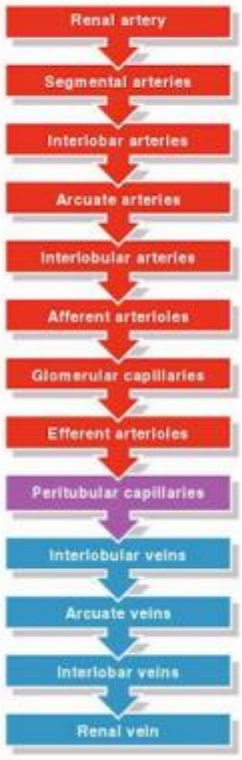
There are 2 capillary beds

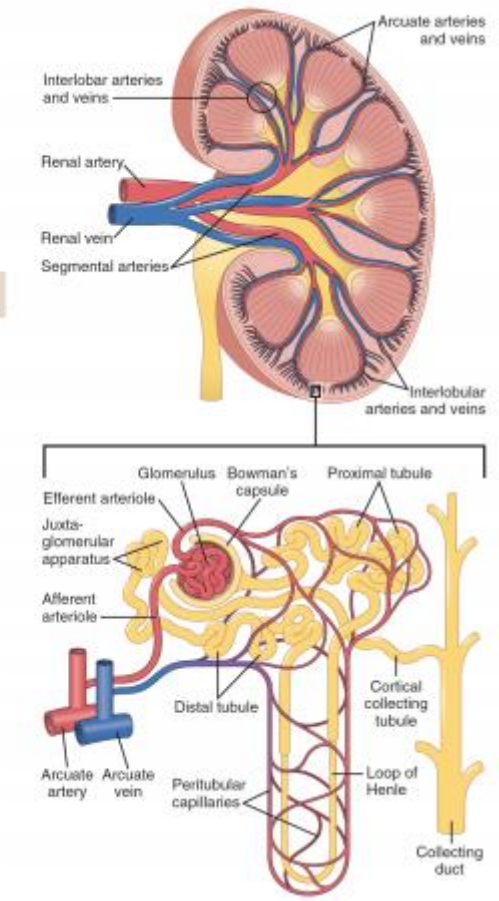
1- glomerular (60 mm Hg) so high hydrostatic pressure cause rapid fluid filtration

2-peritubular (13 mm Hg) is low hydrostatic pressure cause rapid fluid reabsorption

By adjustment the resistance of the afferent and efferent arterioles ,the kidney can regulate hydrostatic pressure in both glomeruli and peritubular capillary

Then the peritubular empty into the venous system…..





Nephron Tubular Segments

Nephron is the functional unit of the kidney. Each kidney has 800,000 to 1,000,000 nephrons

The kidney cannot generate new nephron.by the age the nephron is decrease but it is not life threating because adaptive change in the remaining nephron allow them to excrete the proper amount of water, electrolyte and waste product

Each nephron contain :

Tuft of glomerular capillary called glomerulus through which large amount of fluid are filter

And long tubule in which fluid is converted to urine

So fluid filter from the glomerular capillary flow into the proximal tubule which lie in the cortex of the kidney then from proximal tubule fluid flow into the loop of henle which drop into the medulla

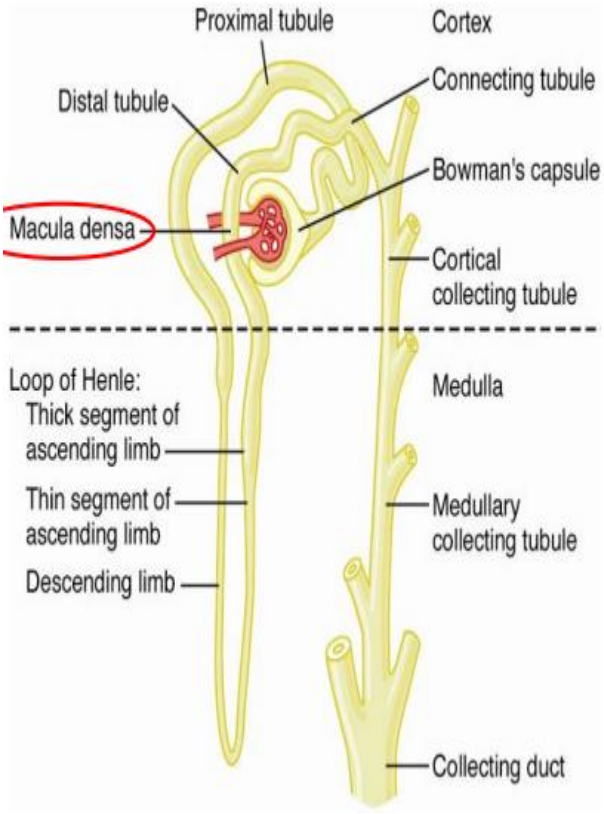
Loop of henle consist ascending and descending limb . the descending and lower part of descending is thin so called thin segment of loop of henle then after the ascending loop of

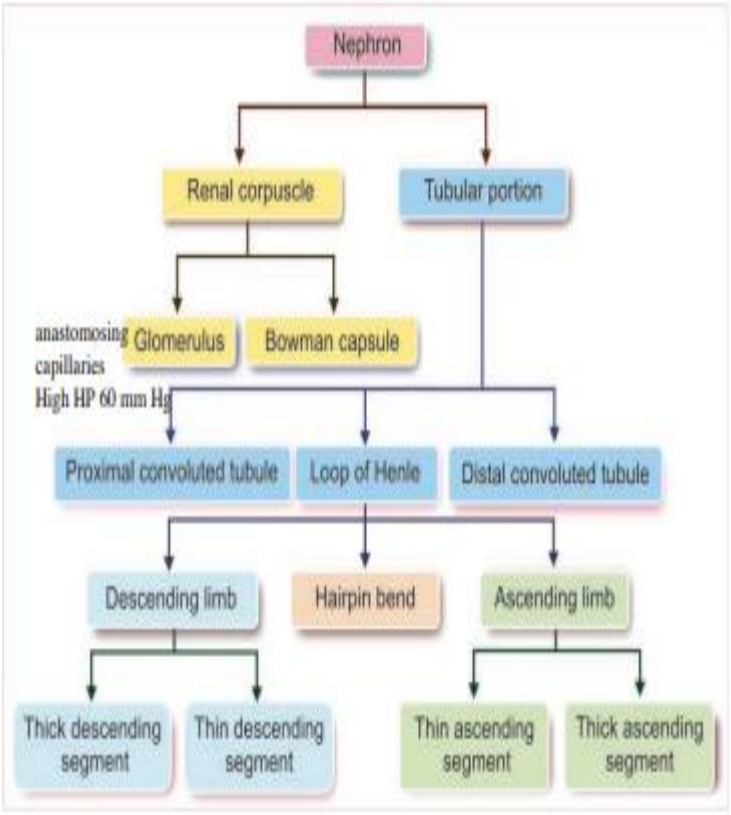
n henle return back to cortex , the wall become thick so called thick segment of the ascending loop of henle

At the end of the thick ascending loop of henle is a short segment that has sepecialized epithelial cell called macula densa which located in the angle between afferent and efferent arterioles which is important role in controlling nephron function

Then fluid enter the distal tubule which lies in the cortex then connected tubule then cortical collecting tubule which lead to cortical collecting duct

Then 8-10 of cortical collecting duct join to form large collecting duct then downword to medullary and become medullary collecting duct which empty on renal papillae





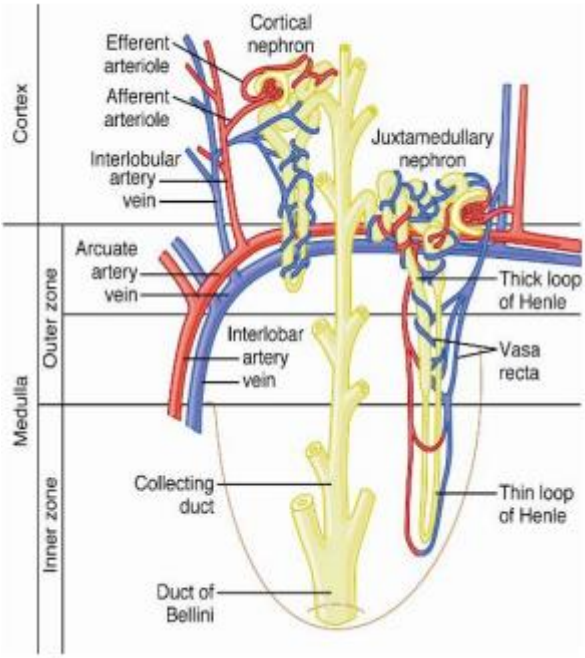
Regional Differences in Nephron Structure: Cortical & Juxtamedullary Nephrons

The nephron that have glomeruli located in the outer cortex called cortical nephron which have short loop of henle that penetrate short distance into the medulla and these is 80 percent of nephron

About 15 percent of the nephron have glomeruli deep in the cortex and near t medulla called Juxtamedullary Nephrons ,these nephron have long loop of henle that dip deeply in the medulla

The vascular structures supplying the juxtamedullary nephrons also differ from those supplying the cortical nephrons. For the cortical nephrons, the entire tubular system is

surrounded by an extensive network of peritubular capillaries. For the juxtamedullary nephrons, long effrent arterioles extend from the glomeruli down into zone outer medulla and then divide into specialized peritubular capillaries called vasa recta that extend downward into the medulla, lying side by side with the loops of Henle. Like the loops of Henle, the vasa recta return toward the cortex and empty into the cortical veins. This specialized network of capillaries in the medulla plays an essential role in the formation of a concentrated urine



Features	Cortical nephron	Juxtamedullary nephron
Percentage	85%	15%
Situation of renal corpuscle	Outer cortex near the periphery	Inner cortex near medulla
Loop of Henle	Short	Long
	Hairpin bend penetrates only up to outer zone of medulla	Hairpin bend penetrates up to the tip of papilla
Blood supply to tubule	Peritubular capillaries	Vasa recta
Function	Formation of urine	Mainly the concentration of urine and also formation of urine

Basic Mechanisms of Urine Formation

1-filtration: -blood pressure forces small molecules from the glomerulus to the capsule

somewhat variable, not selective uric acid, urea (except for proteins), averages 20% of renal plasma flow

احنا خكينا انو تقريبا 22% من ال cardic output بروح للkidney الي هو تقريبا 1000 ml\min هسا هاي الكمية تقريبا400ml عبارة عنcell زي الRBC,WBC, platelet و 600 ml هو plasma تقريبا 20% من الplasma بصيرلهاfiltration يعني تقريبا120 ml

من المواد الي بصيرلها filtration:

Filtrates from: glucose, amino acids, uric acid, urea

هاض الموضوع راح نشرحو بالتفصيل بالمحاضرة الجاي

2- Tubular Reabsorption: -return of filtrates tubules through diffusion and active transport

•highly variable and selective

• most electrolytes (e.g. Na+, K+, HCO3 - , Cl-), nutritional substances (e.g. glucose) are almost completely reabsorbed

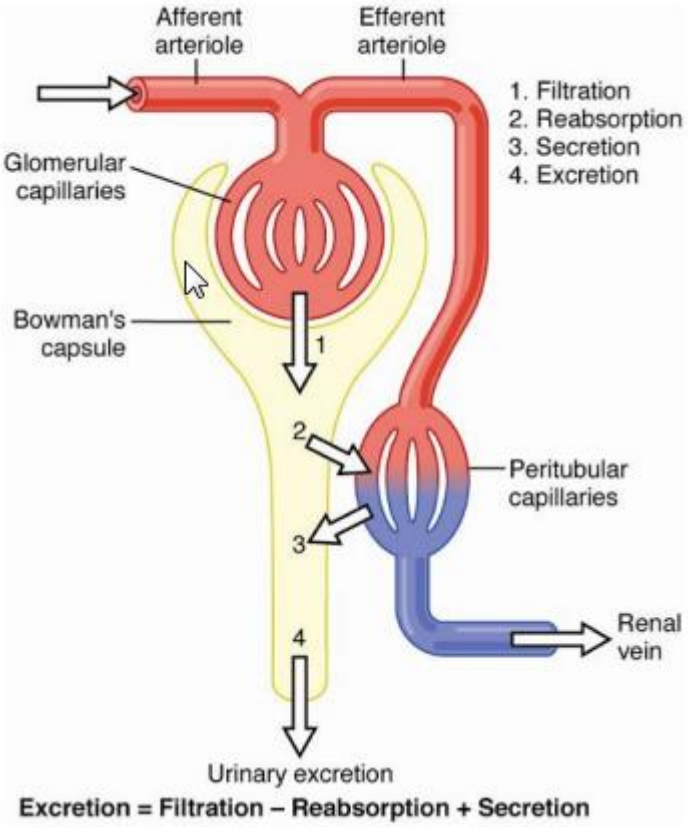
• most waste products (e.g. urea, creatinine, uric acid, urates) poorly reabsorbed

هسا المواد الي صارلها الfiltration بنعملها further proceses وراح تنشرح بالتفاصيل المحاضرات الجاي بس هون بدنا نعرف انو العملية بتكون variable حسب وضع الجسم مثلا ال-HCO3 في حال كان الpH بالblood واطي بصير زيادة بالreabsorb

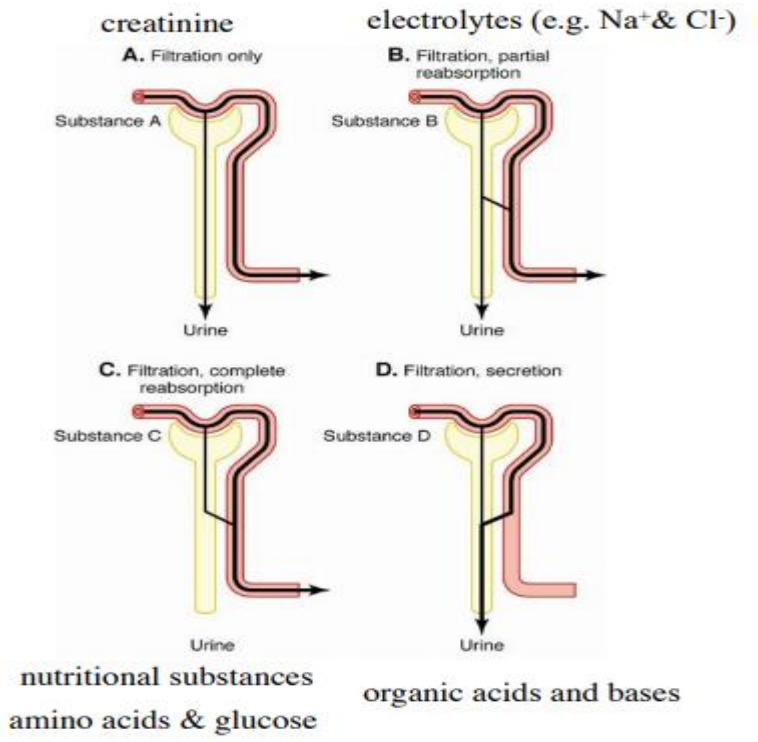
وكمان شغلة انو الglucose بصيرلو complete reabsorb فلو كان في glucose بالurine بكون في مشكلة

3-Tubular Secretion: movement of molecules from blood into the tubule

highly variable; important for rapidly excreting some waste products (e.g. H+),Molecules: drugs and toxins



Renal Handling of Different Substances



هسا الcreatinin بس بصيرلو filtration ما بصيرلو reabsorption

اما زي الamino acid and glucoseبصيرلو filtration بس بصيرلو complete reabsorption من الproximal convoluted tubule فوجودو بالurine دليل على وجود مشكلة

اما الelectrolyte بصيرلهاfiltration بس الreabsorption بكون partial حسب حاجة الجسم

-Glomerular filtration, tubular reabsorption, & tubular secretion are regulated according to needs of body

هسا حكينا انو الcreatinin بصيرلو بس filitration بس هسا مثلا زي الNa او الH2O..... يصيرلوreabsoption و filtration حسب حاجة الجسم

-Changes in glomerular filtration and tubular reabsorption usually act in a coordinated manner to produce the necessary changes in renal excretion

هسا اذا زاد الglomeruli filtration راح يزيد الurine فالkidney الهاregulatory mechanism بحيث اذا صار زيادة بالfiltration بصير زيادة بالreabsorption

Micturition

Process by which Urinary Bladder empties, when it becomes filled

This involve two main step: 1-When tension in its walls above a threshold level this elicits 2-micturition reflex

• the smooth muscle of the bladder is detrusor muscle, Contraction of detrusor muscle→↑pressure in bladder to 40-60 mm Hg →is a major step in emptying the bladder

• Internal sphincter→prevents emptying of bladder until pressure in bladder >threshold level

• External sphincter→ voluntary skeletal muscle, used to consciously prevent urination

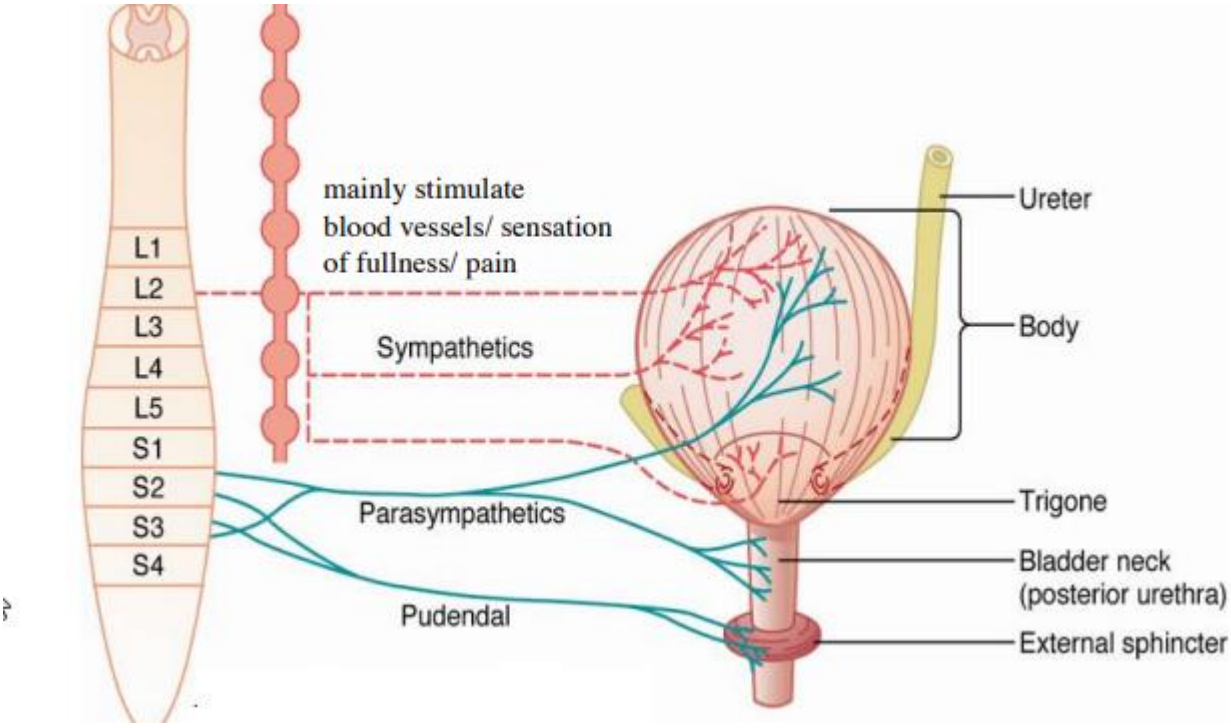
Innervated of the bladder

The nerve supply come from spinal cord through the sacral plexus mainly S2 and S3,These are both sensory and motor nerve fiber

Sensory nerve fiber detect the stretch of the wall of the bladder

And there other type of innervation is pudendal nerve to the external sphincter ,these are somatic nerve fiber that innervated and and control the voluntary skeletal muscle of the sphincter

And sympathetic innervation from the through hypogastric nerve connect to the L2 segment there are some sensory nerve pass by a way of the sympathetic and it is important to sensation of the fullness and in some instances pain



Transport of urine to urinary bladder

Urine that is expelled from the bladder has the same composition as fluid flowing out from of the collecting duct ,there is no significant change in the composition of urine as it is flow through the renal calyces and ureter to bladder

Urine from Collecting Duct into the renal Calyces ,lead to stretch the calyces and increase their inherent Pacemaker activity this lead to start peristalsis this speared to renal Pelvis then Ureter towered Urinary bladder

The wall of ureter is smooth muscle and are innervated by both sympathetic and parasympathetic so:

Sympathetic stimulation:↓Peristalsis

Parasympathetic stimulation:↑Peristalsis

Peristalsis in ureters forces urine into urinary bladder

The ureter inter the bladder through the detrusor muscle and normally ureter enter obliquely course for several centimeter and the normally detrusor compress the ureter to prevent back flow of urine

In some people , the distance of the ureter course through the bladder less than normal so contraction of the bladder during micturition dose not always lead to complete occlude of the ureter so some urine in the bladder propelled backward into the ureter a condition called vesicouretral reflex ,such reflex lead to enlargement of ureters +if sever can ↑pressure in renal calyces & medulla and cause damage in these region

Pain sensation in Ureters

•the ureters are Well supplied with pain nerve fibers

•when ureter become Irritation/ block (e.g. stone) → intense stimulation of pain nerve fibers → Intense contraction of ureters (severe pain)

Also the pain impulses Sympathetic reflex back to kidney To ↓the urine output this called Ureterorenal reflex→ preventing excessive flow of fluid into pelvis

Filling of Bladder and Bladder Wall Tone; Cystometrogram

Tonic pressure changes

• No urine in bladder→intravesicular pressure is about 0

• 30-50 ml of urine have collected→ the pressure rises to 5 -10 cm H2O

• 200-300 ml—only small additional rise in pressure; caused by intrinsic tone of the bladder wall.

• Beyond 300-400 ml→pressure rise rapidly

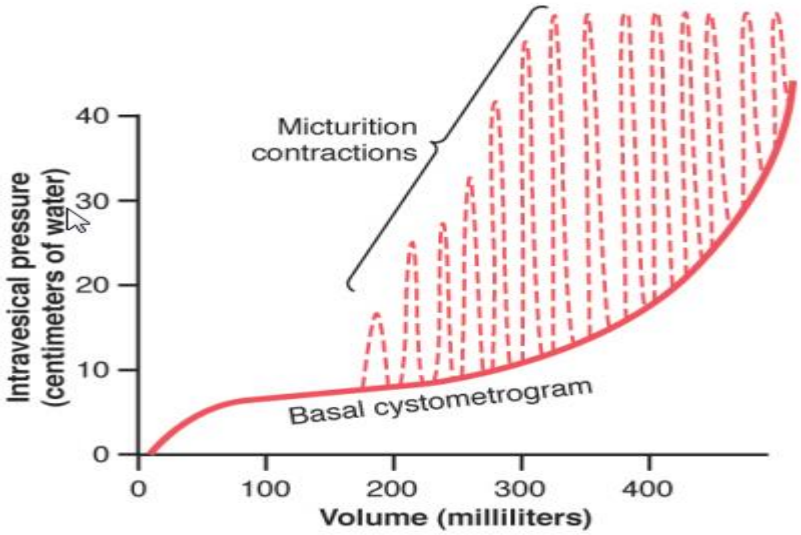
Micturition waves

• Superimposed on the tonic pressure changes during filling the bladder

• these lead to Periodic acute increases in pressure ,the pressure peak may rise only few centimeter of water or may rise to more than100 cm H2O

• Caused by the micturition reflex

At low volum the inter vesicular pressure is less may less that the 10cm H2O but more than 200 volum the pressure increase sharbly which stimulation miscturition contraction and stimulate the strech receptor these pressure contraction at low volum the magnitude ,intesity and frequenty is little but if increase volum the magnitude and frequency increase



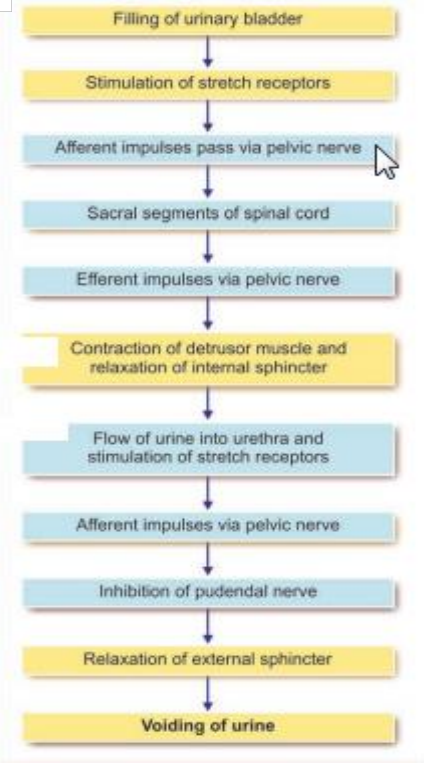
Micturition Reflex

micturition, or emptying of the bladder, is under voluntary control because the external sphincter is composed of skeletal muscle. However, the micturition reflex itself is controlled by the autonomic nervous system. This reflex occurs when the bladder is sensed as being full. The detrusor muscle of the bladder wall and the internal bladder sphincter are composed of smooth muscle; each has both sympathetic and parasympathetic innervations.

The sympathetic innervation of the detrusor muscle and the internal sphincter originates in the lumbar spinal cord (L1–L3), and the parasympathetic innervation originates in the sacral spinal cord (S2–S4).

When the bladder is filling with urine, sympathetic control predominates. This sympathetic activity produces relaxation of the detrusor muscle, via β2 receptors, and contraction of the internal sphincter muscle, via α1 receptors. The external sphincter is simultaneously closed by trained voluntary action. When the muscle wall is relaxed and the sphincters are closed, the bladder can fill with urine.so When bladder is partially filled →micturition contractions usually relax

When the bladder is continues to fill → Micturition reflexes become more Frequent and Powerful, this fullness is sensed by starch receptor in the bladder wall, and afferent neurons transmit this information to the spinal cord and then to the brain stem. The micturition reflex is coordinated by centers in the midbrain, and now parasympathetic control predominates. Parasympathetic activity produces contraction of the detrusor muscle (to increase pressure and eject urine) and relaxation of the internal sphincters. Simultaneously, the external sphincter is relaxed by a voluntary action.



Self-Regenerative Reflex:

When initial contraction of the bladder activate the stretch receptor to cause greater increase in sensory impulse from the bladder and posterior urethra which cause further increase in reflex contraction of the bladder thus cycle repeated again and again until bladder reach a strong degree of contraction ,then after few second to more than minute the self-generative reflex become fatigue and the self-generative reflex stop and bladder relax

a single complete cycle of:

i.Progressive and Rapid increase of Pressure

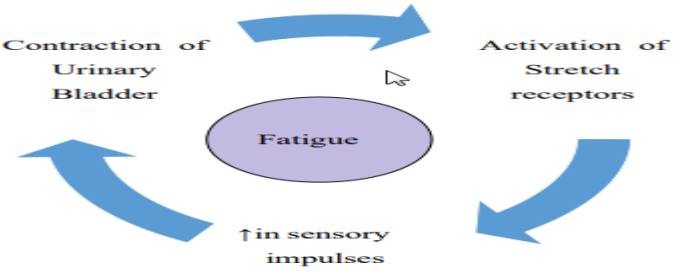
ii.Sustained Pressure

ii. Relaxation

after that if the bladder not empty ,this reflex usually remain in an inhibition .as the bladder become more and more fill ,the micturition cycle occur more and more and often more and more powerfully

once the micturition cycle become powerful ,it cause another reflex which pass through pudendal nerve to external sphincter to inhibit it

if this inhibition signal more potent in the brain than the voluntary constriction the urination occur



-Control by Higher Centers

Ø from brain stem mainly Pons: Facilitative & inhibitory

Ø Cerebral cortex :Normally inhibits the External sphincter

-Higher centers normally exert final control of micturition

• Partial inhibition of micturition reflex, except when micturition is desired.

• Prevent micturition, even if micturition reflex occurs, by tonic contraction of external urinary sphincter until a convenient time presents itself.

• Cortical centers can facilitate sacral micturition centers to initiate micturition reflex & inhibit external sphincter

voluntary urination

voluntary contraction of abdominal muscles which ↑pressure in the bladder and allow extra urine to enter the bladder neck and posterior urethra under pressure thus stretching their wall an this stimulation stretch receptor which excites micturition reflex and this inhibt external urethral sphincter relaxation