SNS COLLEGE OF ALLIED HEALTH SCIENCES

SNS Kalvi Nagar, Coimbatore - 35

Affiliated to Dr MGR Medical University, Chennai

DEPARTMENT: ALLIED HEALTH SCIENCES

COURSE NAME: PHYSIOLOGY

Unit: Physiology of Kidney

Topics: Functions, Glomerular Filtration Mechanism, Rate, Regulation of GFR Rate

SYNOPSIS

Functions of Renal System

Process of Urine Formation

- Glomerular Filtration
  - ❑ Glomerular Filtration Occurs by
  - ❑ Normal Glomerular Filtration Rate
  - ❑ Regulation of Glomerular Filtration Rate
  - ❑ Factors affecting GFR
- Tubular Reabsorption
- Tubular Secretion

FUNCTIONS OF RENAL SYSTEM

Regulation of body fluid osmolality & volume:

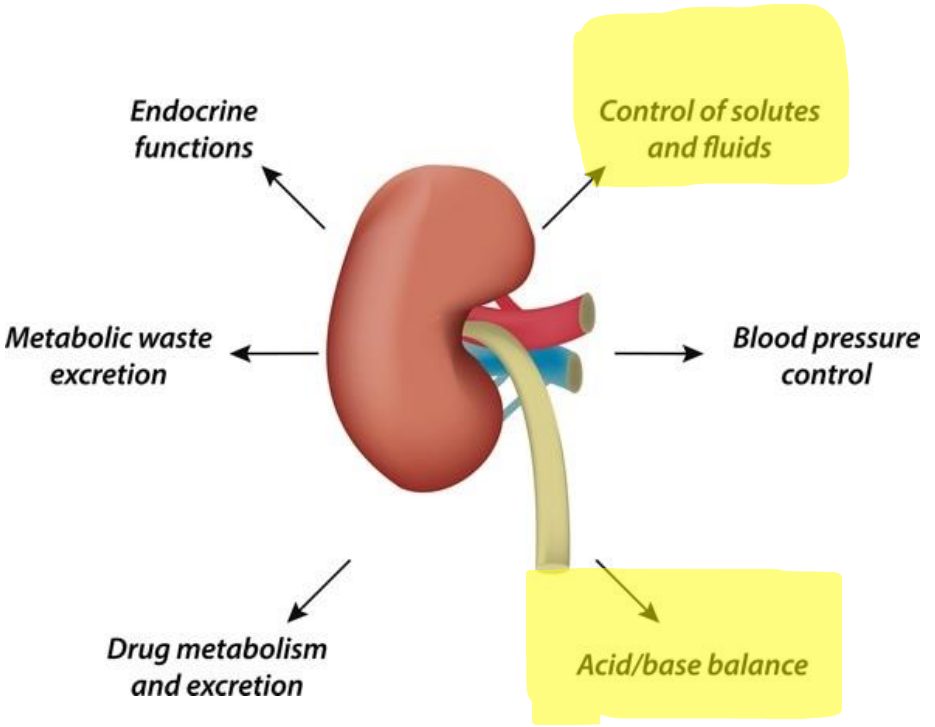
Excretion of water and NaCl is regulated in conjunction with cardiovascular, endocrine, & central nervous systems

Regulation of electrolyte balance:

- Daily intake of inorganic ions (Na+, K+, Cl-, HCO3-, H+, Ca2+, Mg+ & PO43-)
- Should be matched by daily excretion through kidneys.

Regulation of acid-base balance:

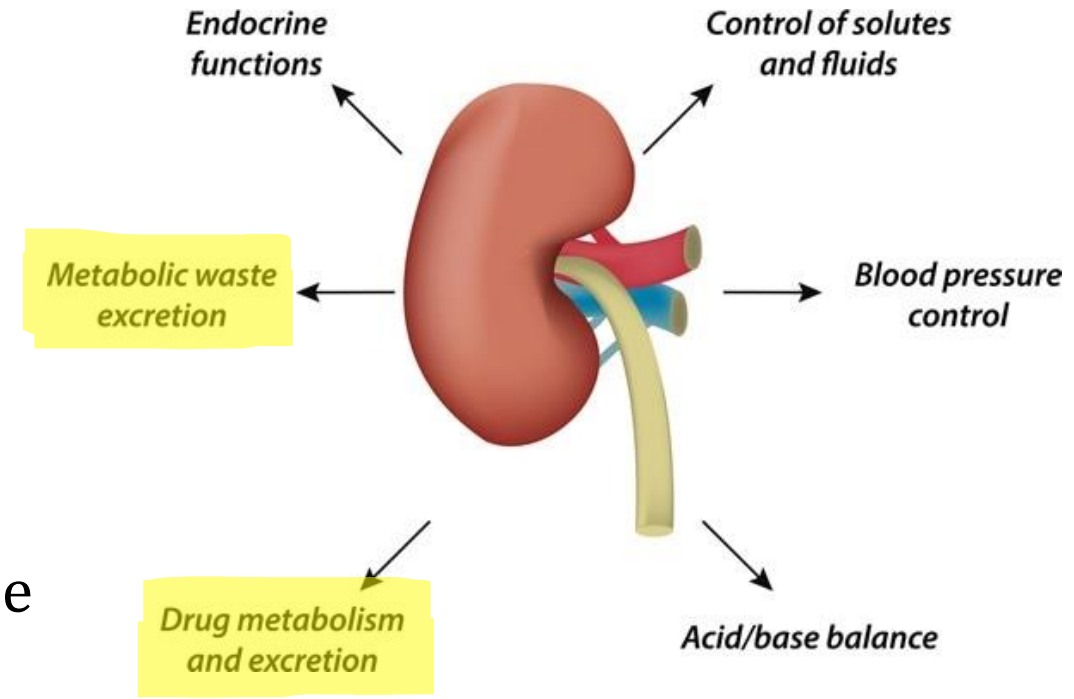
Kidneys work in concert with lungs to regulate the pH in a narrow limits of buffers within body fluids.



FUNCTIONS OF RENAL SYSTEM

Excretion of metabolic products & foreign substances: -

- Urea from amino acid metabolism
- Uric acid from nucleic acids
- Creatinine from muscles
- End products of haemoglobin metabolism
- Hormone metabolites - Foreign substances(e.g., Drugs, pesticides, & other chemicals ingested in the food)



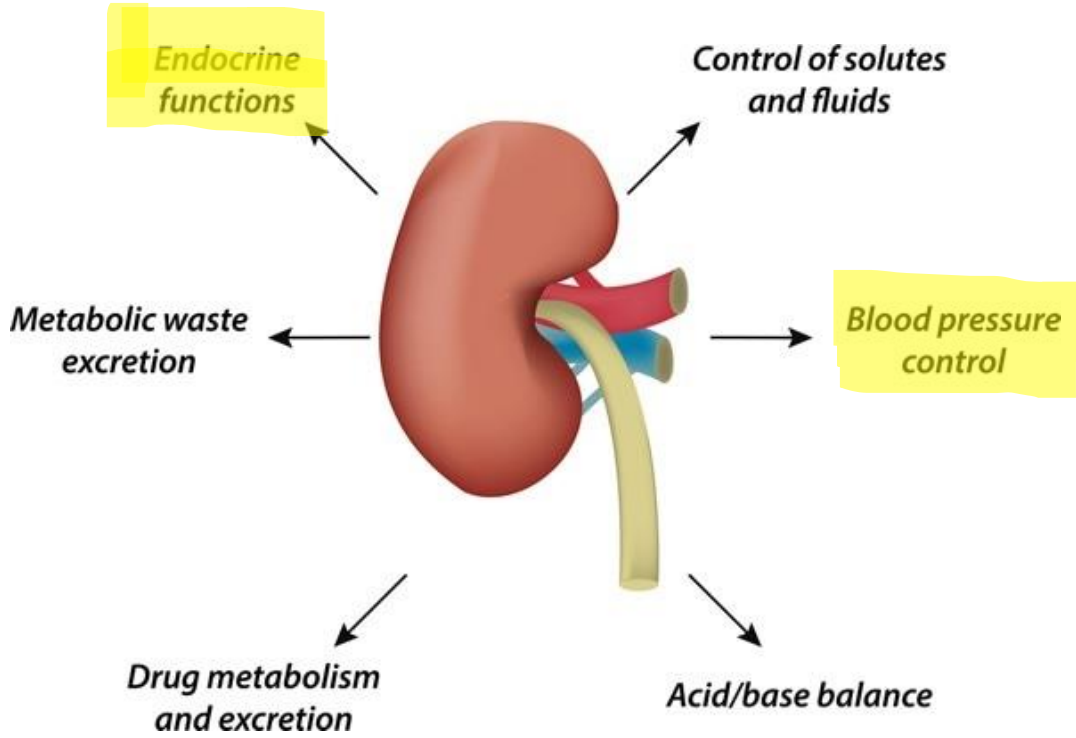
FUNCTIONS OF RENAL SYSTEM

Production and secretion of hormones:

- Renin -activates the renin-angiotensin-aldosterone system, thus regulating blood pressure & Na+, K+ balance

- Prostaglandins/kinins - bradykinin = vasoactive, leading to modulation of renal blood flow & along with angiotensin II affect the systemic blood flow

- Erythropoietin -stimulates red blood cell formation by bone marrow

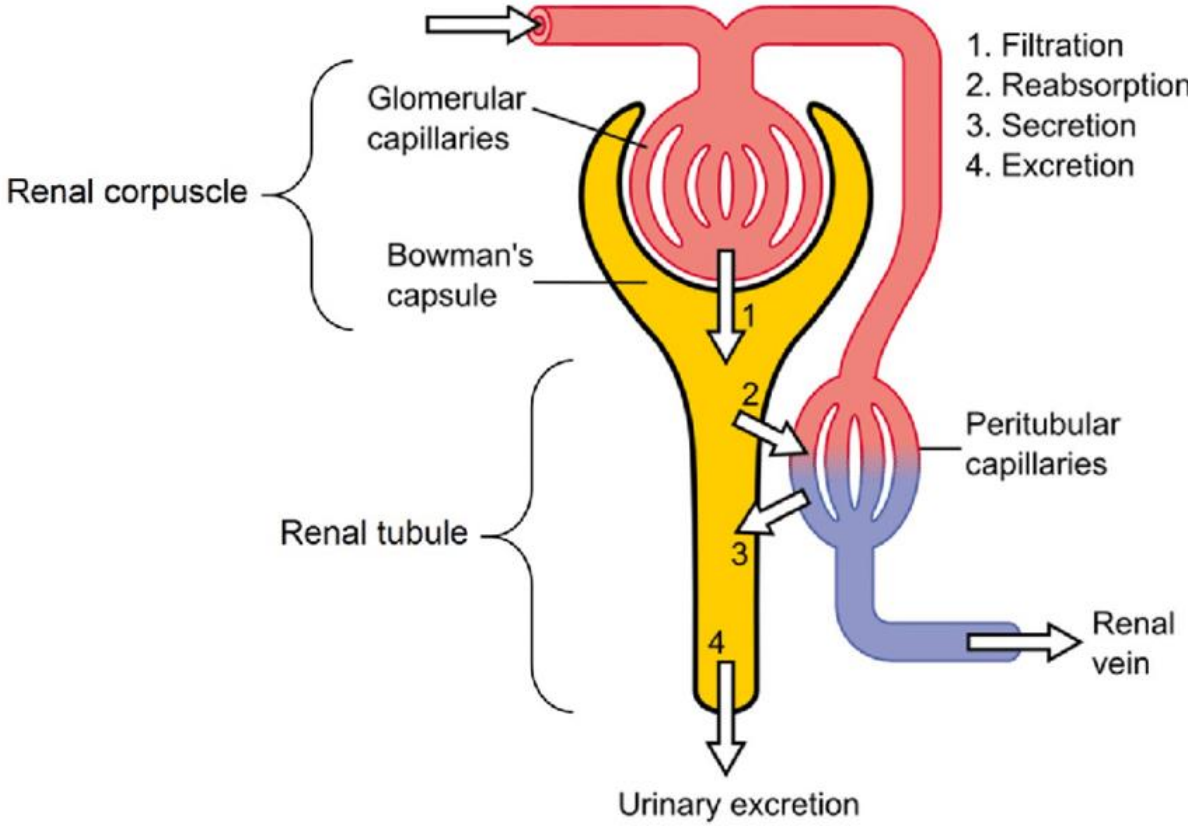


PROCESS OF URINE FORMATION

- **Glomerular Filtration** – process of filtrate leaving glomerular capillaries and entering Bowman's Capsule

- **Tubular Reabsorption** – filtrate from convoluted tubule moves into peritubular capillary (from the tubular fluid into blood)

- **Tubular Secretion** – filtrate from peritubular capillary moves back into convoluted tubule (from the blood into the tubular fluid)



ASSESSMENT – I

- Functional unit of Kidney?
- Parts of Nephron?
- Juxtaglomerular Apparatus consists of ----------
- Function of erythropoietin
- Function of renin

WASTE EXCRETION

Amount Excreted in Urine = Amount Filtered through glomeruli into renal proximal tubule **MINUS** amount reabsorbed into capillaries **PLUS** amount secreted into the tubules

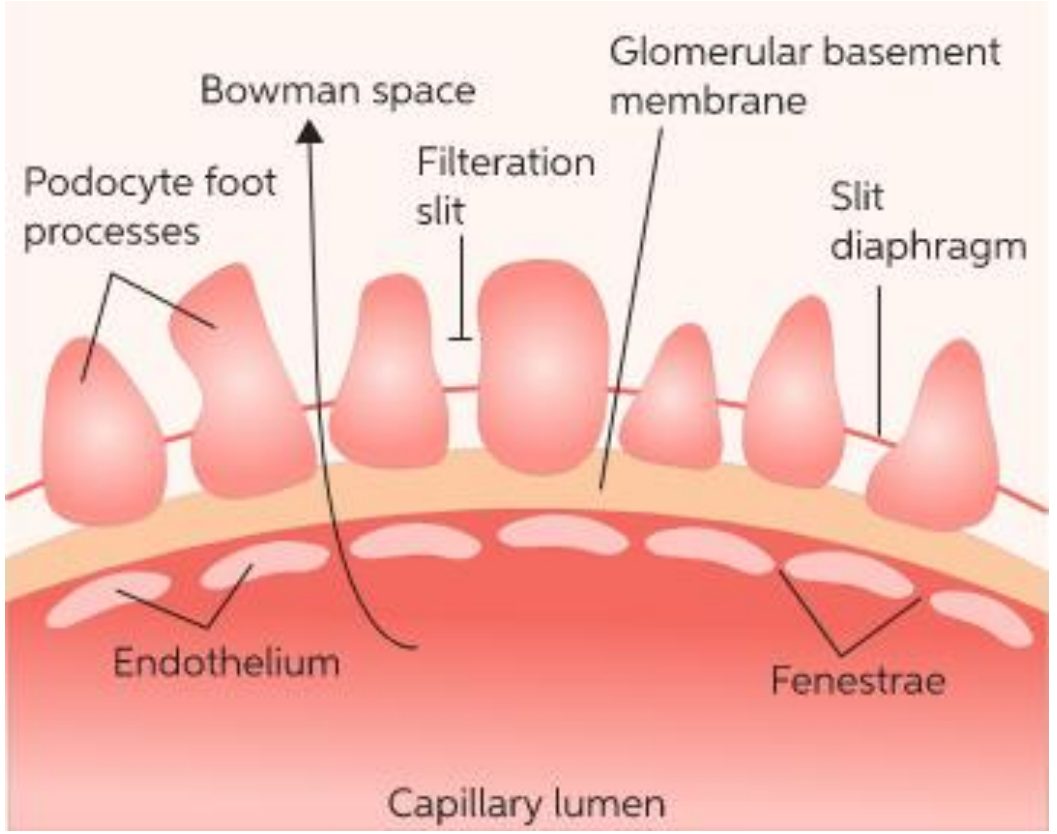
How is urine formed?

GLOMERULAR FILTRATION

Glomerular filtrate is produced from blood plasma

Must pass through:

- **Pores** between endothelial cells of the glomerular capillary
- **Basement membrane** - Acellular gelatinous membrane made of collagen and glycoprotein
- **Filtration slits** formed by podocytes



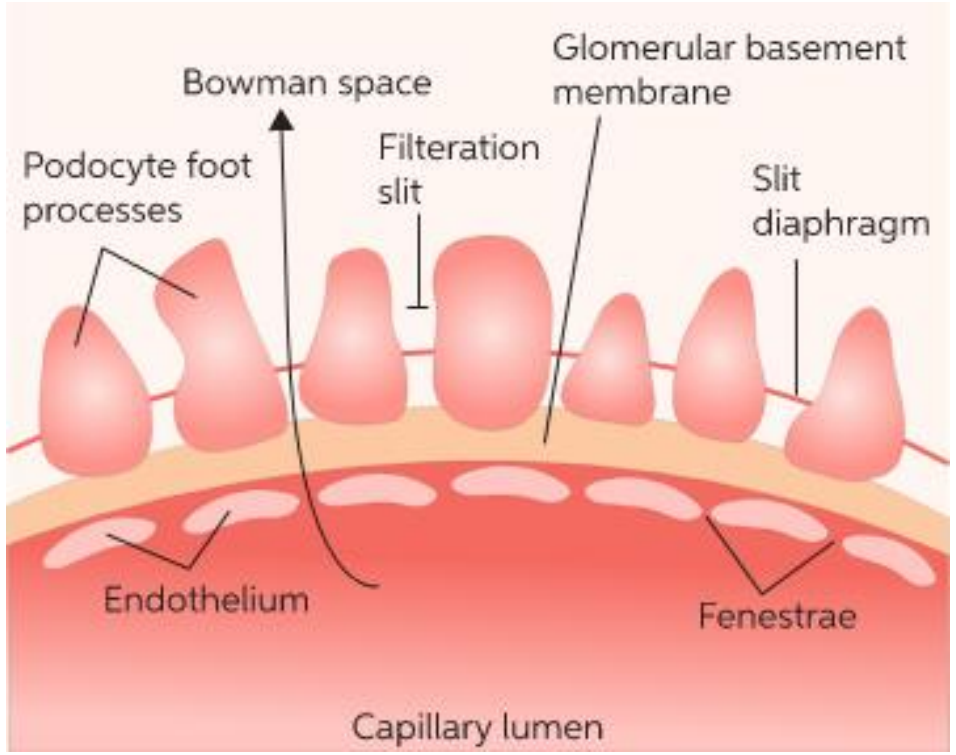
GLOMERULAR FILTRATION

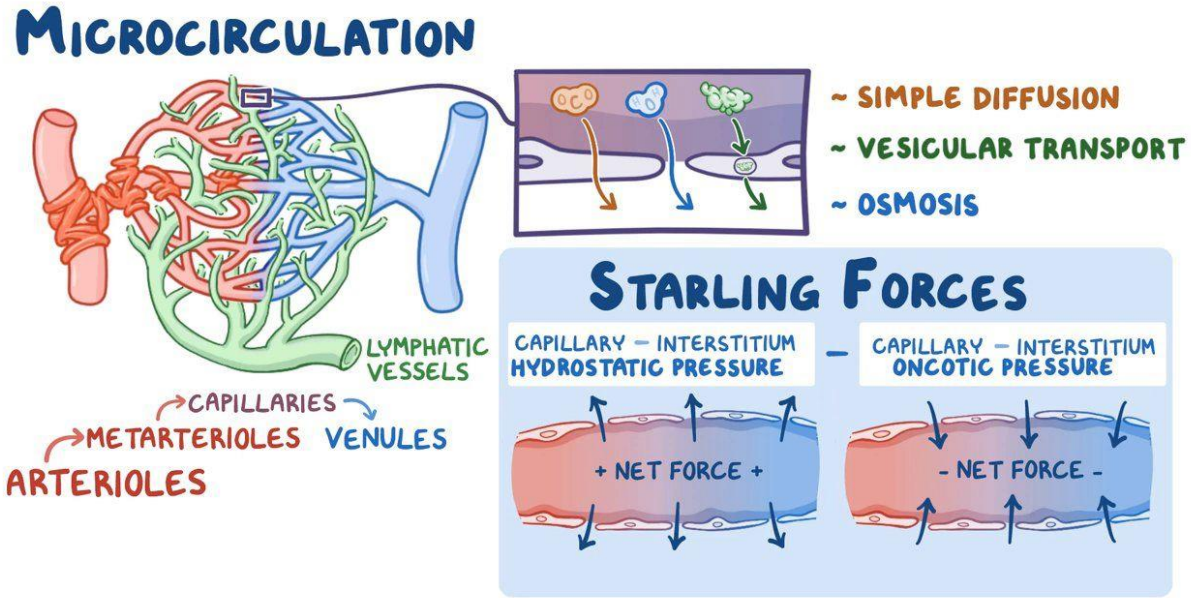
- **Filtrate is similar to plasma** in terms of concentrations of salts and of organic molecules (e.g., glucose, amino acids) except it is essentially protein-free

Neutral solutes:

- Solutes smaller than 180 nanometers in radius are freely filtered
- Solutes greater than 360 nanometers do not
- Solutes between 180 and 360 nm are filtered to various degrees

- **Glomerular filtration barrier restricts the filtration of molecules on the basis of size and electrical charge**





Starling forces are the physical forces that determine the movement of fluid between capillaries and tissue fluid.

Filtration is driven by **Starling forces** across the glomerular capillaries, and changes in these forces and in renal plasma flow alter the glomerular filtration rate (GFR).

The two major forces are, hydrostatic pressure and oncotic pressure.

GLOMERULAR FILTRATION RATE

The total amount of filtrate formed per minute by the kidneys

Filtration rate factors:

- Total surface area available for filtration and membrane permeability **(filtration coefficient = Kf)**
- Net filtration pressure (NFP) - pressure responsible for filtrate formation

NFP = HPg – (OPg + HPc)

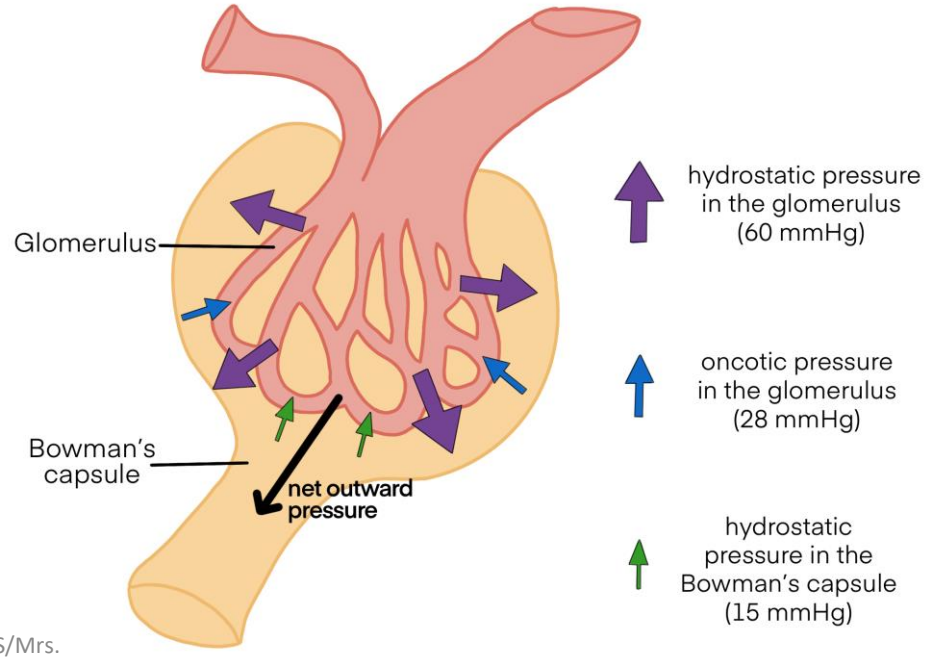
NEP = Net Filtration Pressure

HPg = Glomerular Hydrostatic Pressure

Opg = Glomerular Osmotic Pressure

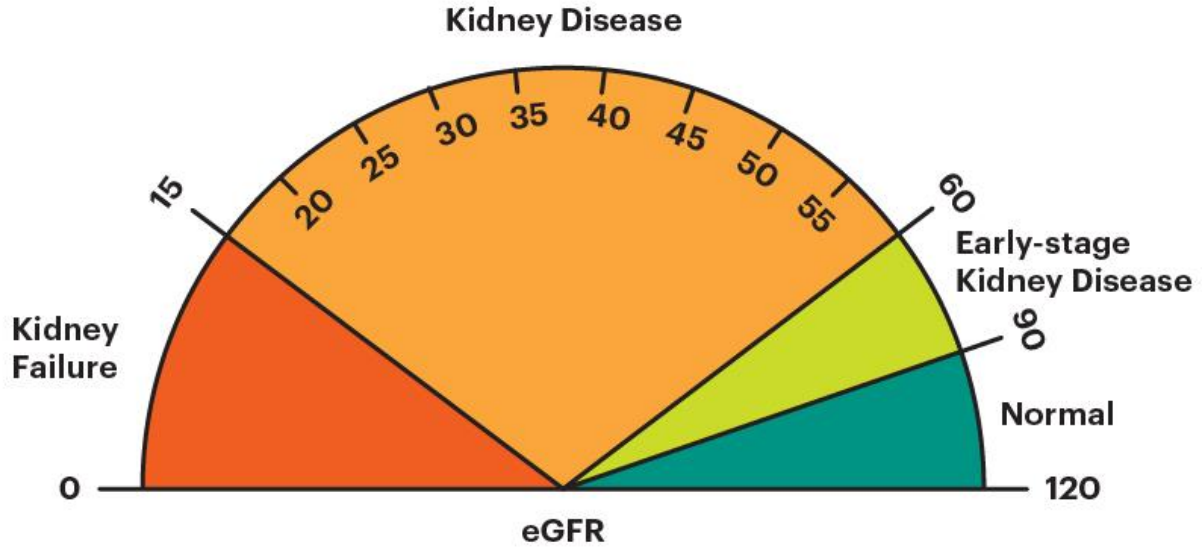
HPc = Capillary Hydrostatic Pressure

- **GFR = Kf x NFP**
- GFR is directly proportional to the NFP



- **Kidney's Receive 20-25% of CO**

- The normal range of Kidney **Glomerular Filtration Rate** is 100 to 130 mL/min/1.73m2 in men and 90 to 120mL/min/1.73m2 in women below 40. GFR decreases progressively after the age of 40 years.



REGULATION OF GFR RATE

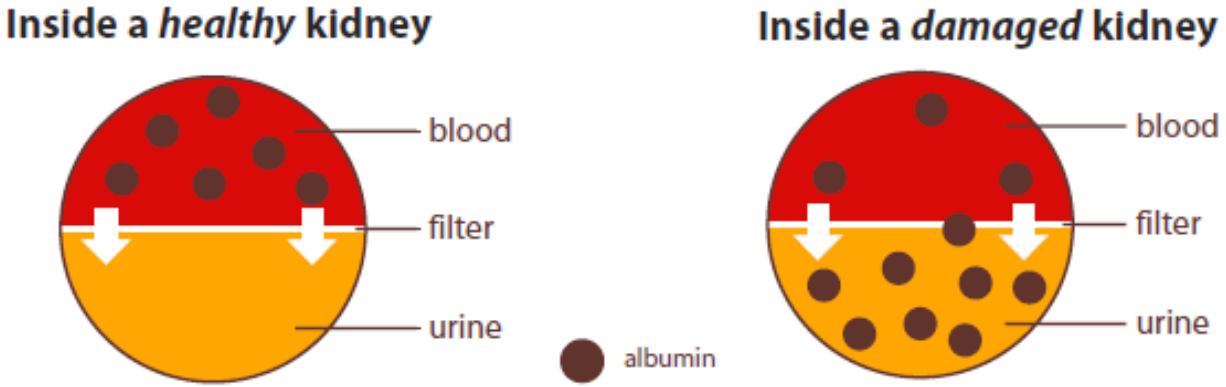
If the **GFR is too high**, needed substances cannot be reabsorbed quickly enough and are lost in the urine

If the **GFR is too low -** everything is reabsorbed, including wastes that are normally disposed of

Control of GFR normally result from adjusting glomerular capillary blood pressure

3 mechanisms control the GFR

- **Renal autoregulation (intrinsic system)**
- **Neural controls**
- **Hormonal mechanism (the renin-angiotensin system)**



ASSESSMENT – II

- Filtrate is similar to ----------
- What is Net Filtration Pressure ?
- What is normal GFR?
- What happens when GFR is too low?

RENAL AUTOREGULATION

- Under normal conditions (MAP =80-180mmHg) renal autoregulation maintains a nearly constant glomerular filtration rate

Autoregulation

Myogenic Mechanism

Tubulo-glomerular feedback

MYOGENIC MECHANISM

Mechanism of Myogenic Autoregulation

↑ Arterial Blood pressure

↓

↑ Afferent Arteriolar Blood pressure

↓

↑ Arterial wall stretch

↓

↑ Sensing by myogenic stretch receptors

↓

↑ Opening of voltage gated Calcium channels

↓

↑ Influx of Ca from ECF to Vascular SM cells

↓

↑ Contraction of Vascular Smooth Muscle cells

↓

↑ Vasoconstritction

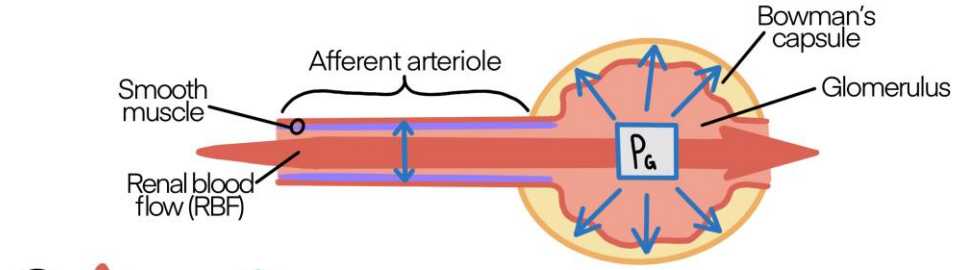
↓

↓ Minimizes changes in Afferent arteriolar blood flow

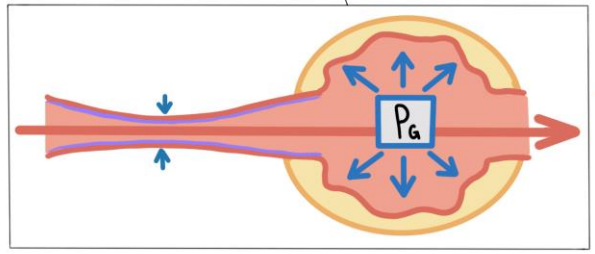
↓

↓ Minimizes changes in GFR

Arterial smooth muscle contracts and relaxes in response to increase / decreases in vascular wall tension.

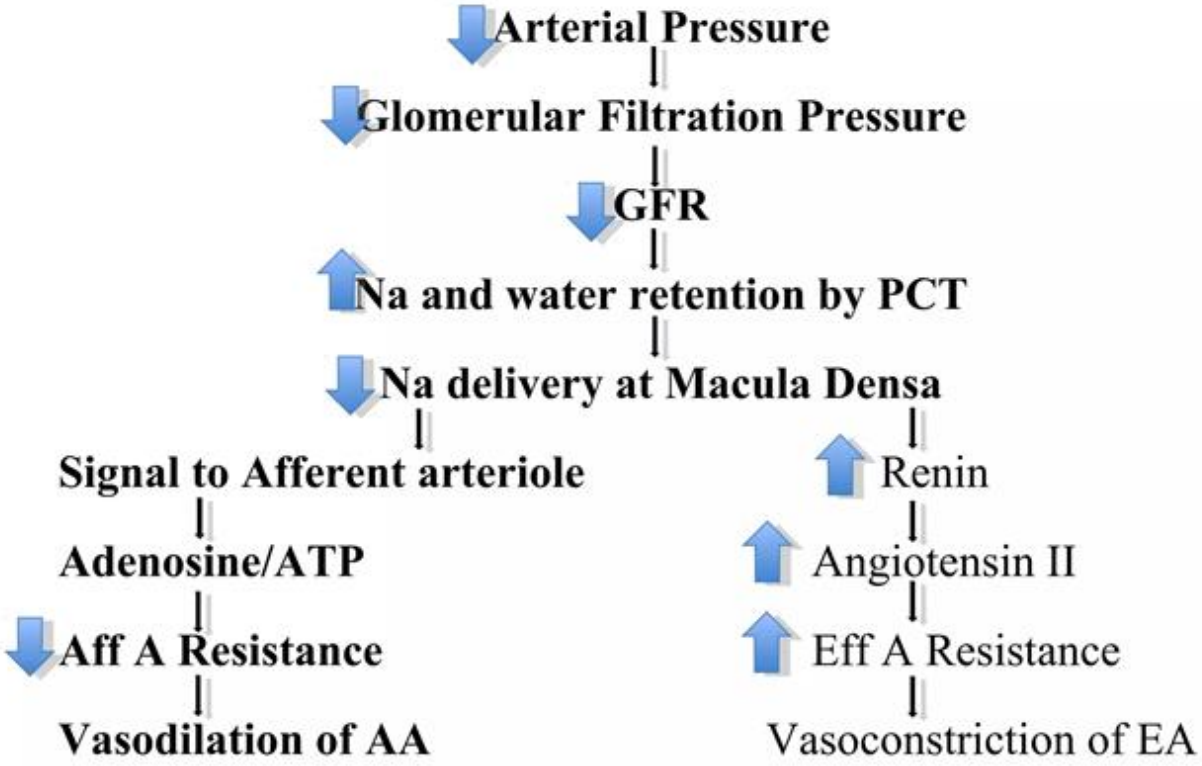


1. ↑ RBF = ↑ pressure against the walls of the afferent arteriole
2. Stretch receptors in smooth muscle initiate *vasoconstriction*
3. ↓ RBF = ↓ P_G = ↓ GFR



TUBULOGLOMERULAR FEED BACK MECHANISM

- Feedback loop consists of a flow rate (increased nacl) sensing mechanism in **macula densa of juxtaglomerular apparatus (JGA)**
- Increased GFR (& RBF) triggers **release of vasoactive signals**
- **Constricts afferent arteriole** leading to a decreased GFR (& RBF)



NEURAL CONTROLS

- **Sympathetic nerve fiber** innervate afferent and efferent arterioles

Under stress:

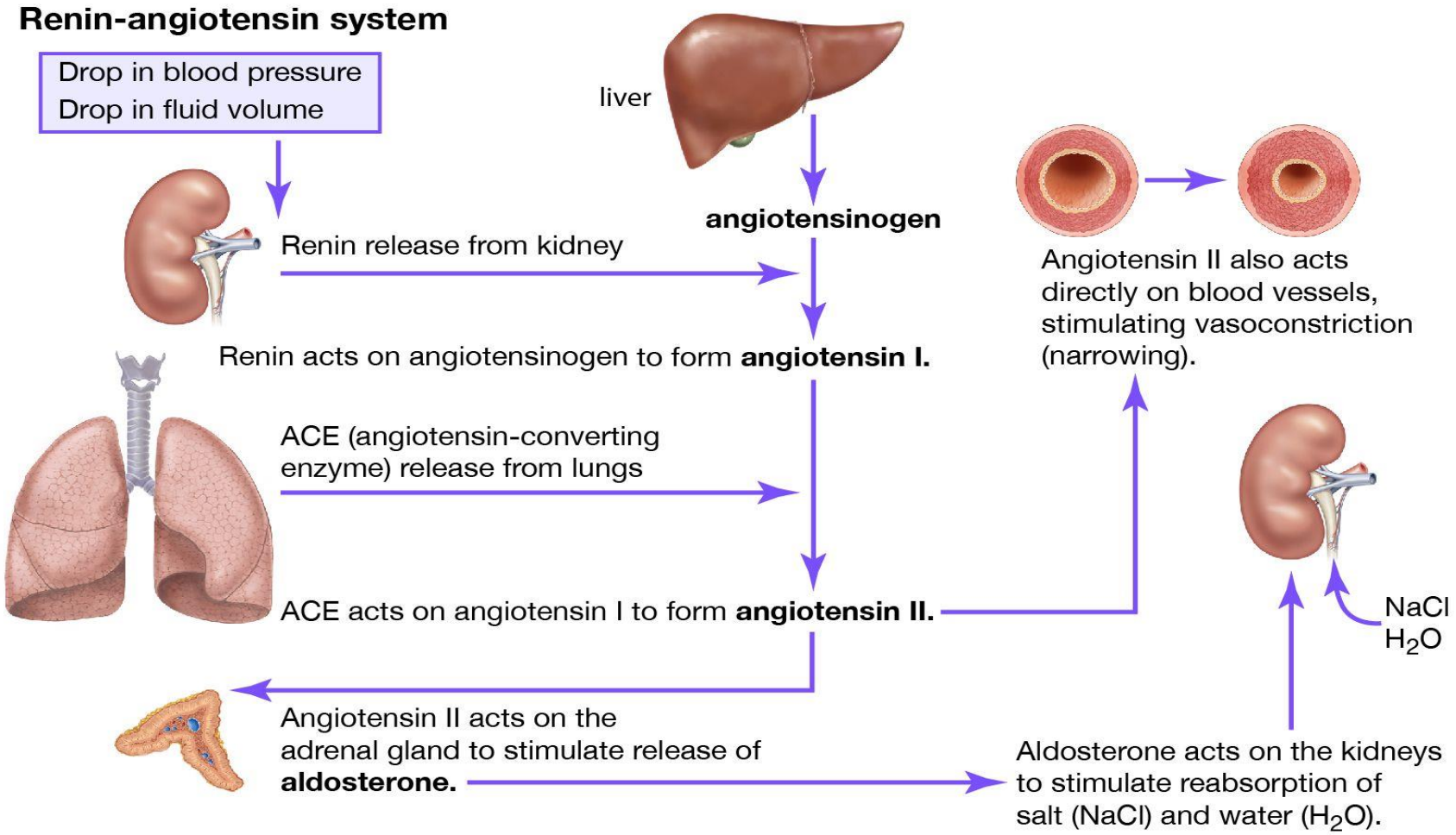
- **Norepinephrine** is released by the sympathetic nervous system
- **Epinephrine** is released by the adrenal medulla
- Afferent arterioles constrict and filtration is inhibited
- The sympathetic nervous system also stimulates the **renin-angiotensin mechanism**
- A drop in filtration pressure stimulates the Juxtaglomerular apparatus (JGA) to release renin and erythropoietin

Parasympathetic Nervous System – Acetylcholine causes release of **NO** from endothelial cells, leads to vasodilation

RENIN ANGIOTENSIN MECHANISM

- Renin is an enzyme secreted into the blood by the Juxtaglomerular Apparatus **(Macula Densa)**

- Decreased blood flow to the kidney, stimulates renin production



ASSESSMENT – III

- What are the two autoregulation mechanism?
- Feedback mechanism is initiated by which cells?
- Sympathetic nerve fibers helps in secretion of ----------
- Renin angiotensin is initiated because of----------
- Angiotensin converting enzyme is released from ----------

THANK YOU

References

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