

HIGH-YIELD RENAL SYSTEM NOTES

FOR USMLE STEP 1 AND STEP 2

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High-Yield Notes for USMLE Step 1 & Step 2 CK

STEP 1 - PATHOPHYSIOLOGY & BASIC SCIENCE

KIDNEY EMBRYOLOGY

- Ureteric bud (from mesonephric duct) → Ureter, Renal pelvis, Calyces, Collecting ducts
- Metanephric mesenchyme → Glomerulus through DCT
- Aberrant interaction → Renal agenesis, Multicystic dysplastic kidney
- Potter sequence → Bilateral renal agenesis → Oligohydramnios → Pulmonary hypoplasia (fatal) + Twisted face + Limb defects
- Horseshoe kidney → Inferior poles fuse → Trapped under IMA → Associated with Turner, Trisomy 13/18/21

KIDNEY ANATOMY

- Left kidney taken for donor transplant (longer renal vein)
- Ureters pass under uterine artery/vas deferens → "Water under the bridge"
- Ureters: 3 constriction points → Ureteropelvic junction (UPJ), Pelvic brim, Ureterovesical junction
- UPJ obstruction → Most common cause of prenatal hydronephrosis
- Kidney blood flow: Renal artery → Segmental → Interlobar → Arcuate → Interlobular → Afferent arteriole → Glomerulus → Efferent arteriole

Dear IMG

GLOMERULAR FILTRATION

- Glomerular filtration barrier: Fenestrated endothelium (size) → Basement membrane with heparan sulfate (charge + size) → Podocyte foot processes (charge)
- Prostaglandins → Dilate afferent arteriole → ↑ GFR
- Angiotensin II → Constricts efferent arteriole → Maintains GFR
- NSAIDs block prostaglandins → ↓ GFR (especially in volume depletion)
- ACE inhibitors block angiotensin II → ↓ GFR (especially in bilateral renal artery stenosis)

Dear IMG

RENAL CLEARANCE & TUBULAR FUNCTION

- Clearance = (Urine concentration \times Urine flow rate) / Plasma concentration
- If clearance $>$ GFR \rightarrow Net secretion
- If clearance $<$ GFR \rightarrow Net reabsorption
- PAH clearance = Renal plasma flow (RPF)
- Renal blood flow (RBF) = RPF / (1 - Hematocrit)
- Filtered load = GFR \times Plasma concentration
- Glucose reabsorption: PCT (SGLT2 + GLUT2)
 $\rightarrow T_m = 375$ mg/min
- Glycosuria when plasma glucose >180 mg/dL

Dear IMG

NEPHRON SEGMENTS

- PCT → Reabsorbs 65-80% of filtrate + All glucose/amino acids + Most HCO_3^- + Na^+
 - PTH inhibits PO_4^{3-} reabsorption
 - Angiotensin II stimulates Na^+/H^+ exchanger
- Descending loop of Henle → Permeable to water only → Concentrates urine
- Ascending loop (thick) → Impermeable to water
 - Reabsorbs $\text{Na}^+/\text{K}^+/2\text{Cl}^-$ → Dilutes urine
- DCT → PTH → ↑ Ca^{2+} reabsorption
- DCT → Thiazides block Na^+/Cl^- cotransporter
- Collecting duct → Principal cells → Aldosterone
 - ↑ Na^+ reabsorption, ↑ K^+ secretion
- Collecting duct → Intercalated cells → Secrete H^+ (type A) or HCO_3^- (type B)

- ADH acts on V2 receptors → Insert aquaporin-2
→ ↑ Water reabsorption

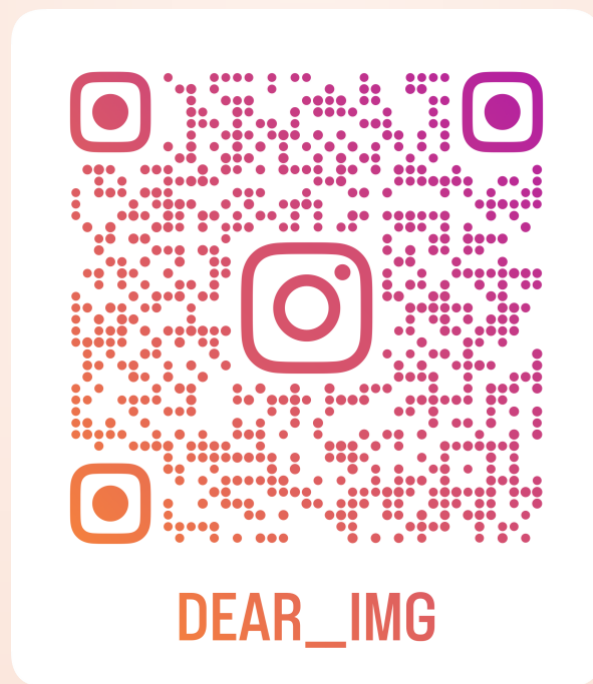
RENIN-ANGIOTENSIN-ALDOSTERONE SYSTEM

- Juxtaglomerular cells (afferent arteriole) → Secrete renin
- Renin secretion stimulated by: ↓ Renal perfusion, ↓ Na⁺ delivery to macula densa, ↑ Sympathetic tone
- **Renin** → Angiotensinogen → Angiotensin I → (ACE in lungs) → Angiotensin II
- **Angiotensin II effects**: Vasoconstriction (↑ BP), Aldosterone secretion, Na⁺ reabsorption (PCT), Efferent constriction (maintains GFR)
- **Aldosterone** → Collecting duct → ↑ Na⁺ reabsorption, ↑ K⁺ secretion



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