PIPADOR REVISION

MRCOG Part 1 Revision Notes

Renal System Physiology

PHYSIOLOGY • LECTURE 151

VISUAL EXAMINATION REVISION NOTES

2026 Edition

MRCOG PART 1 REVISION NOTES | PHYSIOLOGY

151 Renal System Physiology

Renal blood flow, glomerular filtration, tubular function, hormonal control, acid–base and micturition

≈ 20–25%	≈ 120 mL/min	≈ 20%	≈ 1 million
Cardiac output to kidneys (≈ 1.1 L/min)	GFR (≈ 180 L/day)	Filtration fraction (GFR ÷ RPF)	Nephrons per kidney

■ KEY FACTS: Learning objectives

- Describe renal blood flow, glomerular filtration and its regulation; define clearance.
- Describe the handling of sodium, water, glucose, potassium, calcium and acid–base along the nephron.
- Describe the countercurrent mechanism and the hormonal control of renal function (RAAS, ADH, ANP, PTH, vitamin D, EPO).
- Describe the physiology of micturition and relevant pharmacology.

151.1 Renal blood flow and glomerular filtration

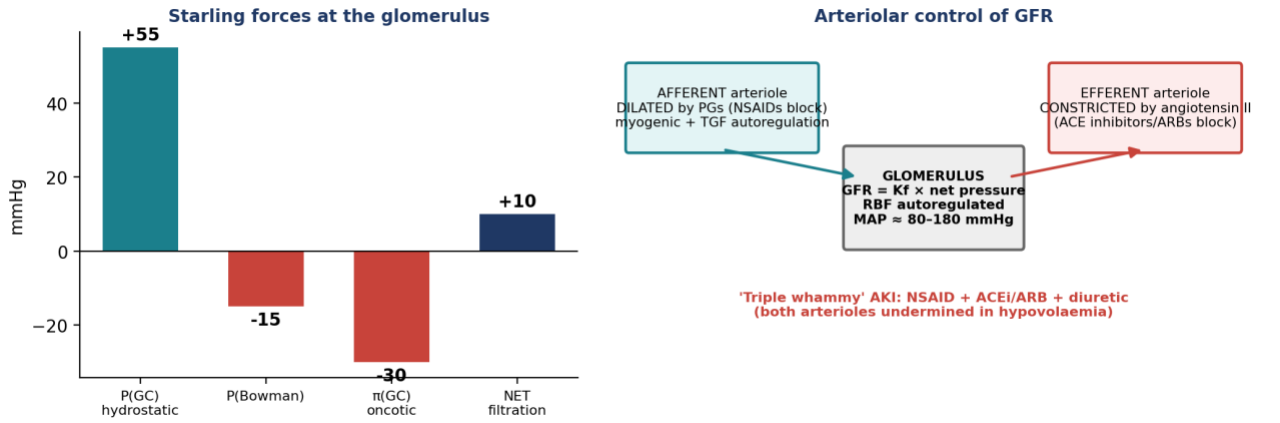


Figure 151.1 — Glomerular Starling forces and arteriolar control of GFR

Topic	Key points
Filtration barrier	Fenestrated endothelium → glomerular basement membrane (negatively charged — type IV collagen, heparan sulphate) → podocyte slit diaphragms (nephrin). Restricts by size (> ≈ 70 kDa) and charge → albumin largely retained
Autoregulation	RBF and GFR constant over MAP ≈ 80–180 mmHg: myogenic response + tubuloglomerular feedback (macula densa senses NaCl → adenosine → afferent constriction)
Arteriolar tone	Afferent dilated by prostaglandins; efferent constricted by angiotensin II — both protect GFR in hypovolaemia (hence NSAID/ACEi AKI)
Distribution	Cortex receives most flow; medulla relatively hypoxic (vulnerable — acute tubular necrosis; preserves osmotic gradient)

■ KEY EQUATIONS

Clearance C = (U × V) ÷ P (mL/min) — volume of plasma completely cleared of a substance per minute.

Inulin clearance = GFR (freely filtered, not reabsorbed or secreted). **Creatinine** clearance slightly **overestimates** GFR (≈ 10–20% secreted). **PAH** clearance ≈ effective renal plasma flow.

eGFR (CKD-EPI) assumes steady state and is **not valid in pregnancy** or AKI. Creatinine rises only after ≈ 50% loss of GFR.

151.2 Tubular function

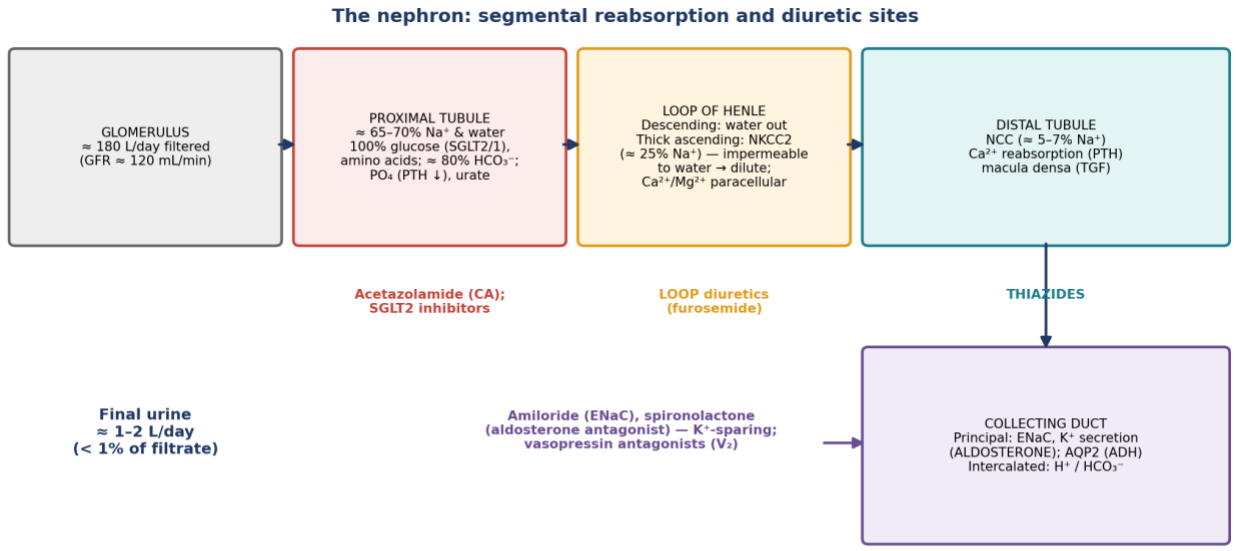


Figure 151.2 — Segmental reabsorption and sites of diuretic action

Substance	Handling	Clinical notes
Glucose	Fully reabsorbed in PCT (SGLT2 ≈ 90%, SGLT1); transport maximum → glycosuria when plasma > ≈ 10 mmol/L	Renal threshold falls in pregnancy (glycosuria common); SGLT2 inhibitors cause glycosuria
Sodium	PCT 65%, loop 25%, DCT 5–7%, CD 2–3% (aldosterone)	Fine-tuning in distal nephron
Water	PCT (iso-osmotic), descending loop; collecting duct only with ADH (aquaporin-2)	Diabetes insipidus: cranial (no ADH) vs nephrogenic (lithium, hypercalcaemia)
Potassium	Reabsorbed in PCT/loop; secreted by principal cells (aldosterone, flow, Na^+ delivery)	Hyperkalaemia: AKI, ACEi, spironolactone, haemolysis
Calcium	PCT ≈ 65%, thick ascending limb (paracellular), DCT (PTH-regulated)	Loop diuretics ↑ Ca^{2+} loss; thiazides ↓ Ca^{2+} excretion
Phosphate	PCT (NaPi-II); PTH and FGF23 ↓ reabsorption	—
Urate	Filtered, reabsorbed and secreted (PCT)	↑ in pre-eclampsia (↓ clearance)
Amino acids, small proteins	PCT (endocytosis of filtered low-MW proteins)	Fanconi syndrome — generalised PCT dysfunction

Concentration of urine — the countercurrent system

Thick ascending limb pumps NaCl out (NKCC2), impermeable to water ▶ Medullary interstitium becomes hypertonic (up to ≈ 1200 mOsm/kg) ▶ **Descending limb** loses water → fluid concentrated at loop tip (multiplier) ▶ **Vasa recta** countercurrent exchange preserves gradient; **urea recycling** adds to it ▶ ADH → aquaporin-2 → water leaves collecting duct → urine up to ≈ 1200 mOsm/kg

151.3 Hormonal regulation

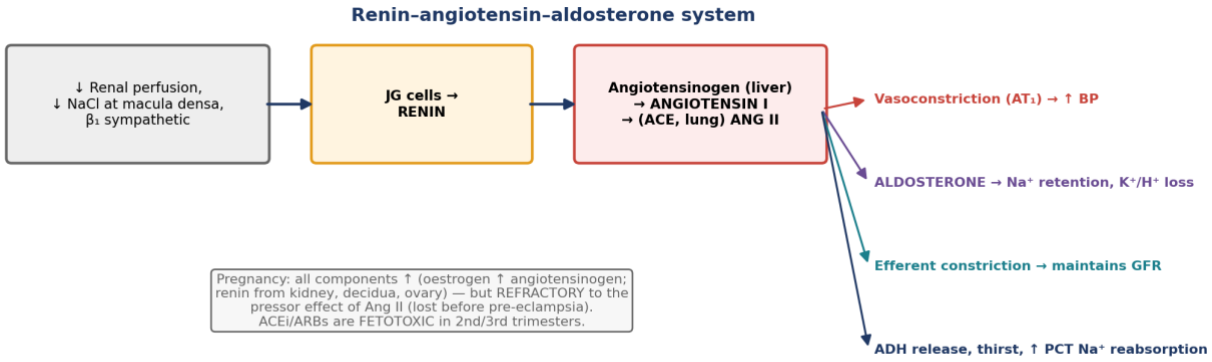


Figure 151.3 — Renin–angiotensin–aldosterone system

Hormone	Source / stimulus	Renal action
ADH (vasopressin)	Posterior pituitary; ↑ plasma osmolality (> ≈ 285 mOsm/kg; osmoreceptors) or ↓ volume	V_2 receptor → aquaporin-2 insertion → water reabsorption; V_1 vasoconstriction
Aldosterone	Adrenal zona glomerulosa; Ang II, ↑ K^+	ENaC + Na^+/K^+-ATPase → Na^+ retention, K^+ and H^+ secretion
ANP / BNP	Atria / ventricles; stretch	Natriuresis, ↑ GFR, ↓ renin and aldosterone
PTH	↓ Ionised Ca^{2+}	↑ Ca^{2+} reabsorption (DCT), ↓ PO_4 reabsorption, ↑ 1α-hydroxylase
Produced by kidney	Erythropoietin (peritubular fibroblasts; hypoxia); calcitriol; renin; prostaglandins	Anaemia of CKD; renal bone disease

151.4 Acid–base handling

- **Reclaim filtered bicarbonate**: ≈ 80% in PCT (H^+ secretion via NHE3 + **carbonic anhydrase**).
- **Generate new bicarbonate**: excrete H^+ as **titratable acid** (HPO_4^{2-} → $H_2PO_4^-$) and **ammonium** (glutamine metabolism — the main adaptive response to acidosis).
- Renal tubular acidosis: **type 1** (distal — cannot secrete H^+; urine pH > 5.5, stones), **type 2** (proximal — bicarbonate wasting; Fanconi), **type 4** (hypoaldosteronism — hyperkalaemic).

151.5 Micturition

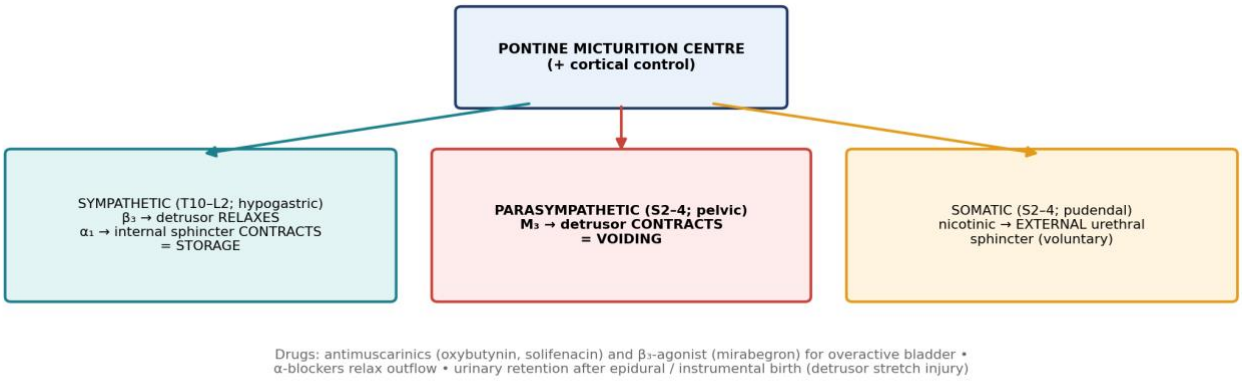


Figure 151.4 — Neural control of the bladder

Bladder fills at low pressure (compliance); first desire to void ≈ 150–250 mL, capacity ≈ 400–600 mL. The **pontine micturition centre** coordinates detrusor contraction with sphincter relaxation; the cortex provides voluntary

inhibition. Upper motor neurone lesions → detrusor–sphincter dyssynergia; sacral/pelvic nerve injury (e.g. radical hysterectomy) → atonic bladder and retention.

151.6 Must-know summary

■ EXAM TIP

- Kidneys receive **20–25% of CO**; GFR ≈ 120 mL/min (180 L/day); filtration fraction ≈ 20%.
- Ang II constricts the **efferent**; prostaglandins dilate the **afferent** arteriole.
- PCT reabsorbs ≈ 65–70% of filtrate, all glucose and most bicarbonate; loop diuretics act on **NKCC2**, thiazides on **NCC**.
- ADH → **aquaporin-2** (collecting duct); aldosterone → **ENaC** (Na^+ in, K^+/H^+ out).
- Parasympathetic **S2–4 (M_3)** = voiding; sympathetic **T10–L2** = storage; pudendal = external sphincter.

■ MNEMONIC / MEMORY AID

Kidney endocrine functions — 'A WET BED': Acid–base, Water, Electrolytes, Toxin removal, BP (renin), Erythropoietin, vitamin D activation.

'Parasympathetic Pees, Sympathetic Stores'.