Achievable

USMLE STEP 1 DUMP SHEET

Cardiovascular and respiratory physiology

Hemodynamics

- **Flow:** $\Delta P = Q \times R$: MAP = CO × TPR (arterioles set TPR)
- **Poiseuille:** $R = 8\eta l/\pi r^4$; halve the radius, R rises 16-fold
- **MAP** = diastolic + ⅓ pulse pressure. **Wide PP:** stiff arteries, aortic regurgitation. **Narrow:** aortic stenosis
- **SV** = EDV − ESV; **CO** = SV × HR; **EF** = SV ÷ EDV (55—70%)
- **Fick:** $\dot{V}O_2 = \text{flow} \times (C_aO_2 - C_vO_2)$
- **Velocity** lowest in capillaries (largest total area). **Turbulence** (Reynolds over 3000): anemia, stenosis (bruit)

Cardiac action potentials

Phase	Ventricle, Purkinje	SA and AV node
0	Fast Na+ in	L-type Ca2+ in (slow)
1	Na+ inactivates; K+ out	Absent
2	Plateau: Ca2+ in, K+ out	Absent
3	K+ out	K+ out
4	Stable, about −85 mV	Funny current: sets HR

- **Conduction:** Purkinje fastest, AV node slowest. **Treppe:** ↑ HR → ↑ force
- **E-C coupling:** L-type Ca2+ → ryanodine receptor → troponin C. Phospholamban (PKA) ↑ SERCA: relaxation

Cardiac cycle

Phase	Valves	Events
Atrial systole	AV open	P wave, S4, a wave
Isovolumetric contraction	All closed	QRS, S1, c wave
Ejection	Aortic open	T wave; ends at ESV
Isovolumetric relaxation	All closed	S2, dicrotic notch
Rapid filling	AV open	S3, y descent
Diastasis	AV open	Longest; shorter at ↑ HR

- **S4:** stiff ventricle. **S3:** volume overload (normal in children, pregnancy). **Cannon a:** complete AV block; no a wave in AF
- **ECG:** PR under 0.20 s (AV node); ST = plateau; QT shortens at fast HR. Diastole is ⅔ of the cycle

Pressure-volume loop

- **↑ Preload:** wider to the right, ↑ SV (Frank-Starling: stretch sensitizes troponin C)
- **↑ Afterload:** taller, narrower; ↑ ESV. **↑ Contractility:** wider, ↓ ESV, ↑ EF
- **Mean systemic pressure:** vascular curve x-intercept; ↑ volume shifts it right

Blood pressure control

- **Carotid sinus** (CN IX): senses rises and falls. **Aortic arch** (CN X): rises only. Both → NTS
- **↓ BP:** ↑ sympathetic, ↓ vagal → ↑ HR, contractility, TPR, venoconstriction
- **Hemorrhage:** baroreflex + renin + ADH (V2 water, V1 vasoconstriction); heart and brain spared
- **ANP** (atria), **BNP** (ventricles): stretch → cGMP; natriuresis, ↑ GFR, ↓ aldosterone and ADH
- **Cushing:** ↑ ICP → hypertension + bradycardia. **Bainbridge:** ↑ atrial volume → ↑ HR
- **Exercise:** ↑ HR, SV, systolic BP; ↓ TPR (metabolites)

Capillaries and organ flow

- **Starling:** $J_v = K_f[(P_c - P_i) - \sigma(\pi_c - \pi_i)]$
- **Edema:** ↓ πc (nephrotic, cirrhosis), ↑ Pc (heart failure), ↑ Kf (burns)
- **Heart:** adenosine, hypoxia. **Brain:** CO2. **Lung:** hypoxia constricts. **Skin:** sympathetic. **Muscle:** metabolites

Lung volumes and mechanics

- **FRC** = RV + ERV; **VC** = TV + IRV + ERV; **TLC** = VC + RV. Spirometry cannot measure RV, FRC, TLC
- $\dot{V}_A = (V_T - V_D) \times RR$; dead space 150 mL. FEV1 ≈ 80% of FVC
- **Compliance** lowest at extremes of volume. ↓ restrictive (↓ FRC); ↑ emphysema (↑ FRC)
- **Surfactant:** type II cells, DPPC; ↓ surface tension. **Resistance:** highest in medium bronchi

V/Q and gas exchange

- **Zone 1** PA > Pa > Pv; **zone 3** Pa > Pv > PA (base). Apex: highest V/Q and PO2
- **V/Q = 0:** shunt. **V/Q = ∞:** dead space (PE). Average 0.8
- **Perfusion-limited:** CO2, O2 at rest. **Diffusion-limited:** CO, fibrosis
- **Haldane:** deoxy-Hb carries more CO2. Altitude: ↑ 2,3-BPG

Hypoxemia and control

- **A-a gradient** $= P_AO_2 - P_aO_2$, normal 5—10 mm Hg
- $P_AO_2 = F_iO_2(P_{atm} - P_{H_2O}) - P_aCO_2/R$
- **A-a normal:** altitude, hypoventilation. **↑:** V/Q, diffusion, shunt (no O2 response)
- **Central chemoreceptors:** CSF pH. **Carotid body:** PaO2 under 60