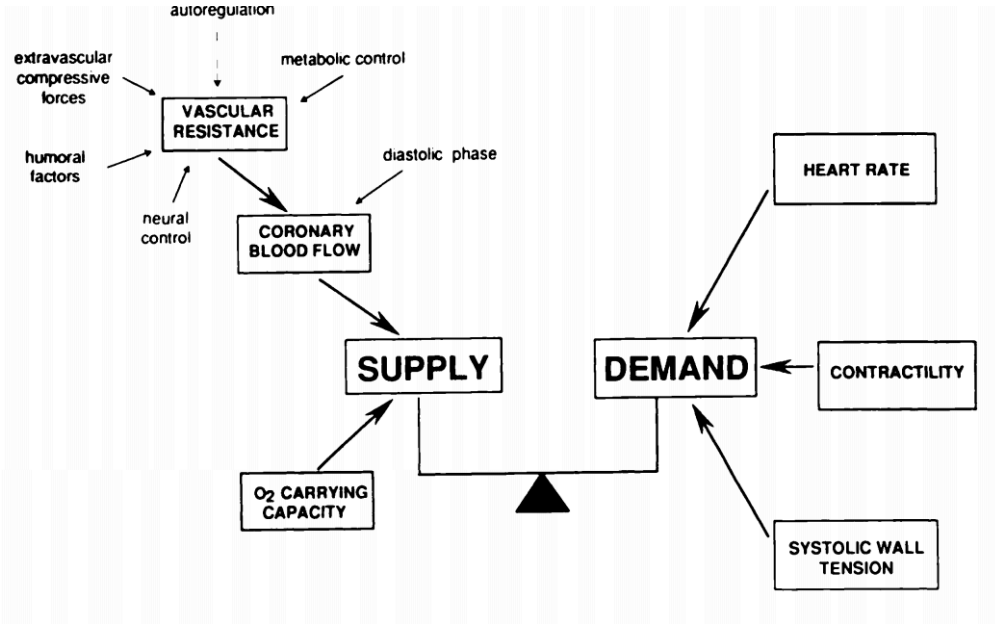
Physiol-12A16 Describe the factors involved in the balance between left ventricular myocardial oxygen supply and demand.

Overview



Factors affecting LV myocardial oxygen supply

1. Coronary blood flow (CorBF)

$$CorBF = \frac{AoP - LVP}{CorVR}$$

where,
AoP = aortic root pressure
LVP = left ventricular pressure
CorVR = coronary vascular resistance

AoP – LVP gradient is governed by:
- aortic valve/LVOT pressure gradient (e.g. AS, HOCM → ↓perfusion pressure → ↓CorBF)
- systemic vascular resistance (e.g. septic shock → ↓SVR → ↓AoP → ↓CorBF)

CorVR is governed by Hagen-Poiseuille law (assuming laminar flow): $R = \frac{8\eta L}{\pi r^4}$
i.e. ↑coronary vessel radius → ↓CorVR to 4th power; ↑blood viscosity → ↑CorVR

Regulation of coronary vessel radius depends on:
- ***metabolic control*** – ↑metabolic demand → ↑local metabolites (K^+, H^+, CO_2, adenosine, etc) → vasodilatation → ↑CorBF
- ***myogenic control***
- ***humoral control*** – circulating hormones (ATII, TxA, PGI_2)
- ***neural control*** – sympathetic innervation (α constricts, β dilates)

- ***extravascular compression*** – during LV systole, coronary vessels compressed → ↓CorBF (esp. subendocardial layer, epicardial vessels less affected)
- ***diastolic:systolic time*** – more diastole time → less time for coronary vessels being compressed → ↑CorBF

2. Arterial oxygen content

Hypoxaemia from whatever cause → ↓arterial oxygen content → ↓myocardial oxygen supply
Myocardial cells have ***very high*** oxygen extraction

Factors affecting LV myocardial oxygen demand

1. Heart rate (HR)

Each cardiac cycle performs work and thus consumes energy/O_2
∴↑HR → ↑myocardial oxygen demand

2. Contractility

Generally (in the normal heart), ↑contractility → ↑force of LV contraction → ↑LV work → ↑myocardial oxygen demand

3. LV (systolic) wall tension

LV wall tension is governed by Laplace's law

$$T = \frac{P \times r}{h}$$

where,
T = LV systolic wall tension
P = intraLV pressure
r = LV radius
h = LV wall thickness

↑LV afterload → ↑P → ↑T → ↑O_2 demand
↑LV preload → ↑r → ↑T → ↑O_2 demand
LV hypertrophy → ↑h → ↓T → ↓O_2 demand

Balance between supply and demand

Normally,
- resting coronary blood flow ≈ 250 mL/min *(5% total cardiac output)*
- resting myocardial oxygen demand ≈ 25 mL/min *(approx 80 mL/min/kg heart)*

Many factors governing LV myocardial oxygen demand and supply are inter-related
e.g. ↑HR can ↓supply (via ↓diastolic time) but ↑demand
e.g. exercise → ↑↑demand; autoregulation/sympathetic stimulation → ↑↑supply

Examiner's comments – 54.1% of candidates passed this question.

The question had two inter-related parts: supply and demand. Better answers discussed the points of conflict, particularly that increased heart rate both increases demand and decreases supply; the role of high extraction; and that the clinical determinants of cardiac output: heart rate, preload, afterload, and contractility are a good way to discuss demand.

While, the Hagen–Poiseuille equation for flow is useful, better answers acknowledged that radius to the power of 4 is the dominant factor and then the factors that change radius. Further, better answers described both the flow and oxygen content components of oxygen supply and clearly described the role of systole and diastole.

Candidates are reminded that this examination is syllabus based questions, with the required information being obtained from the listed reference texts. Exam marking schemes are based on these reference texts. The reading list of reference texts is regularly reviewed, and assessed for their relevance to the basic sciences in anaesthesia. Non-recommended sources of information may be inaccurate.

Source

For succinct review see ***Ardehali, Ports Chest 1990, 98(3), p699***