Discuss the factors that influence coronary blood flow. 28%

List the determinants of coronary artery blood flow. Briefly compare phasic coronary blood flow in the left and right coronary arteries. 51%

**Background**

Heart is supplied by the *coronary circulation*

Aortic root → coronary arteries → left and right coronary arteries + branches → capillaries → veins → coronary sinus + anterior cardiac veins → right atrium

Thebesian veins drain capillaries → cardiac chambers

Arteriosinusoidal and arterioluminal vessels drain arterioles → cardiac chambers

Generally,

Left coronary artery supplies LEFT side of heart + septum + part of posterior

Right coronary artery supplies RIGHT side of heart + part of septum + posterior

The heart is highly metabolic and has **high** \( \text{O}_2 \) extraction ratio of 70 ~ 80% at rest

Therefore, \( \text{O}_2 \) delivery could only be significantly increased by increasing coronary blood flow

Coronary blood flow at rest ≈ 5% \( \text{CO} \) = 250 mL/min

**Factors that influence coronary blood flow (CorBF)**

Following Ohm’s law → Flow = Pressure / Resistance

\[ \therefore \text{CorBF} = \frac{\text{Cor Perfusion Pressure}}{\text{Cor Vascular Resistance}} \]

Where, CorPP = arterial pressure – intraventricular pressure

Therefore the main factors that influence CorBF are:

1. Arterial pressure
2. Intraventricular pressure
3. Coronary vascular resistance
4. Cardiac cycle
(5) LV vs RV

Note: CorBF is not constant and varies throughout cardiac cycle and between LV/RV

(1) Arterial pressure
Depends on cardiac output, systemic vascular resistance, etc
Low arterial pressure contributes to low coronary perfusion pressure

(2) Intraventricular pressure
Greater intraventricular pressure contributes to low coronary perfusion pressure

Example of interplay of above factors is in aortic stenosis $\rightarrow$ low arterial pressure + high LV intraventricular pressure $\rightarrow$ reduced left coronary perfusion pressure

(3) Coronary vascular resistance
Coronary vascular resistance (CorVR) governed by Poiseuille equation
\[ R = \frac{8\eta L}{\pi r^4} \]
CorVR increases with high blood viscosity (e.g., with high haematocrit)
CorVR increases with more tortuous coronary anatomy
CorVR governed by factors that alter coronary artery radius, which include:

(i) metabolic autoregulation $\rightarrow$ vasodilator (NO, PGI2) release triggered by local metabolites ($\downarrow$ O2, $\uparrow$ CO2, $\uparrow$ H+, $\uparrow$ K+, $\uparrow$ adenosine, etc)

(ii) myogenic autoregulation $\rightarrow$ smooth muscle stretch results in contraction and vice versa

(iii) autonomic + hormonal control $\rightarrow$ SNS, PSNS + adrenaline, ADH

(iv) extrinsic compression

(v) intrinsic narrowing $\rightarrow$ coronary artery disease, vasospasm

Coronary artery is a **Starling resistor**

**Definition** = a conduit where resistance to flow increases as its transmural pressure decreases

\[ \therefore \text{ coronary vascular resistance depends on transmural pressure (across coronary art.)} \]
Increased intraventricular pressure → reduced transmural pressure → more extrinsic compression → reduced vessel radius → increased CorVR → reduced CorBF

(4) Variation throughout cardiac cycle

CorPP and CorVR varies with cardiac cycle

<table>
<thead>
<tr>
<th></th>
<th>CorPP</th>
<th>CorVR</th>
<th>CorBF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systole</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Diastole</td>
<td>High</td>
<td>Low</td>
<td>High</td>
</tr>
</tbody>
</table>

∴ more time in diastole → greater CorBF → more myocardial perfusion

(5) Variation between LV and RV

<table>
<thead>
<tr>
<th></th>
<th>LV</th>
<th>RV</th>
<th>Aorta</th>
<th>LV CorPP</th>
<th>RV CorPP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systole</td>
<td>120</td>
<td>25</td>
<td>120</td>
<td>0</td>
<td>95</td>
</tr>
<tr>
<td>Diastole</td>
<td>0</td>
<td>0</td>
<td>80</td>
<td>80</td>
<td>80</td>
</tr>
</tbody>
</table>

For LV, there is a large difference between CorPP in systole and diastole

∴ there is minimal CorBF to LV during systole and LV perfusion predominantly occurs during diastole

For RV, there is a smaller difference between CorPP in systole and diastole

∴ CorBF to RV is more continuous and maintained throughout both systole and diastole
Examiner’s comments

This question was passed by 28% of candidates. Many candidates did not perform well in this question as a result of failing to develop a structured answer.

In order to pass, candidates were required to provide normal values for coronary blood flow, a basic anatomical outline of the coronary blood supply, note the high oxygen extraction and its consequence, and demonstrate an understanding of Ohm’s law. Having demonstrated Ohm’s law, the factors affecting pressure and resistance (within both the left and right ventricles) could then be further explained.

Further marks were allocated for clinical applications and the consequences of common pathophysiological disturbances, including hypo/hypertension, coronary artery disease, and severe valvular disease. Common errors included discussing oxygen flux rather than coronary blood flow, and failing to apply Ohm’s law to the coronary circulation. Many applicants spent significant time explaining all the factors of the Hagen-Poiseuille equation, which gained minimal marks.

A well labelled graph of the right and left coronary blood flow with respect to the cardiac cycle often scored more highly than attempts to explain the flows in prose. The description of coronary blood flow differs between the different recommended text books, especially with respect to values and labelling of graphs. All variations were considered acceptable within the examiner’s marking scheme.