C. 6. Regional Circulation

a. Describe the relationship between organ blood flow and demand and the role of autoregulation.

metabolic autoregulation
products of metabolism act as vasodilators
adenosine, PGs, H+, CO2, K+, lactate, osmolarity...
duration of vasodilation after ischaemia depends on the duration of ischaemia
myogenic autoregulation
vascular smooth muscle contracts in response to stretch
prominent in cerebral circulation
acts over seconds
endothelium-mediated autoregulation
longitudinal shear (or flow) causes NO release from endothelium
results in ↑cGMP and dephosphorylation of MLCK
vascular relaxation
neural control
α receptor stimulation
↑ intracellular Ca2+, vasoconstriction
predominantly in skin and gut
increases O2 extraction
O2 extraction remains constant until critical flow is reached
β2 receptor stimulation
↑ intracellular cAMP, vasodilation
predominantly in muscle
5HT, other innervation
specialized role, active in cerebral and coronary circulations

b. Describe the features of the coronary circulation and explain the clinical significance of these.

The coronary circulation consists of the coronary arteries and veins, the arteriosinusoidal, arterioluminal and thebesian vessels. The right and left coronary arteries arise from the root of the aorta behind the right and left cusps of the aortic valve. The right coronary runs along the right A-V margin and supplies the right atrium and ventricle. The left coronary divides near its origin into the circumflex and left anterior descending arteries. They supply the left side of the heart and commonly a little of the right ventricle. Dominance of the coronary vessels is variable.

The arteriosinusoidal vessels originate from the cardiac chambers and penetrate a short distance into the myocardium where they form endothelium-lined sinuses. The arterioluminal vessels similarly arise from the chambers and the thebesian vessels are veins which drain the myocardium into the chambers. These vessels all play a minor role in supplying myocardial oxygen demands.

The major venous drainage of the heart is via the coronary veins which follow a similar distribution to the arteries except that their common drainage is to the coronary sinus on the posterior aspect of the heart, draining into the right atrium.

There is no significant anastomosis between coronary vessels in normal human hearts. Anastomoses will develop in response to gradual stenosis and occlusion of the coronary vessels but acute obstruction will result in infarction.

Cardiac muscle consumes 8-10 ml/min/100 g of oxygen at rest. O2 extraction is quite efficient with cardiac venous blood having about 5 ml/100 ml O2. Thus any rise in myocardial activity must be accompanied by an increase in blood flow. As a pump it is about 18% efficient (net), but is more efficient at volume work than pressure work. This is...
important in aortic stenosis and other high afterload conditions. Myocardium uses both carbohydrate and fatty acids as substrates for energy production and will use ketone bodies or lactate if they are present in high concentrations. Metabolism is aerobic in all but extreme conditions.

The coronary arteries display the same autoregulatory responses as other systemic vascular beds. Local factors are most important in regulating coronary flow. The coronary vessels are best perfused in diastole, as they are not externally compressed by ventricular contraction at this time. The left coronary displays no or retrograde flow at the start of systole as the ventricular pressure compressing the vessels is greater than aortic pressure perfusing them. Later in systole there is anterograde flow which increases dramatically after aortic valve closure and ventricular relaxation when the perfusion pressure is high and external pressure low. The coronary vessels display a very active myogenic mechanism. Right coronary artery flow is more consistent as the right ventricular pressure is lower than aortic pressure throughout the cardiac cycle.

The advantageous perfusion gradient in diastole can be enhanced further by use of an intraaortic balloon pumps. In severe hypotension, perfusion of the endocardial muscle layers is poorest, and this is the site of worst ischaemic damage following hypotension. In tachycardia, the time for perfusion in diastole is reduced, but coronary dilatation from local metabolites is sufficient to maintain perfusion.

Sympathetic innervation of the coronary vessels has a vasoconstrictor effect in isolation, but the increased CO and metabolic demand resulting from the inotropic and chronotropic effects of increased sympathetic tone result in net vasodilation in normal hearts.

c. Describe autoregulation in the cerebral circulation and the factors that may affect it.

in Nervous system (1.G)

d. Describe the renal circulation and explain its significance in maintaining renal function.

anatomy
renal arteries from aorta
→ interlobar, arcuate, cortical radial arteries
→ afferent arterioles, glomerular capillaries, efferent arterioles
→ peritubular capillaries (including vasa recta)
→ progressive rejoicing to form renal veins → IVC

renal blood flow
20% of cardiac output
dependent on CO, MAP and
low net O₂ extraction
most O₂ demand is in tubular reabsorption
countercurrent mechanism of vasa recta reduces medullary PO₂ to ≈20 mmHg
↑ filtrate flow → ↑ metabolic demand → medullary hypoxia
opposed by tubuloglomerular feedback
↑ macula densa flow → adenosine release → ↓ GFR
limits O₂ demand of tubules
analogous to metabolic autoregulation in other tissues
anuria is adaptive in acute stress

e. Describe the hepatic and splanchnic circulation.

anatomy
aorta → coeliac axis, superior and inferior mesenteric arteries → gut
villous countercurrent flow results in better absorption but reduced PO₂ at villus tips
portal venous drainage → liver → hepatic vein → IVC blood flow
hepatic artery supplies \( \frac{1}{3} \) of liver flow but 50% of oxygen delivery
portal flow supplies the remainder, total 30% of CO
oxygen extraction is constant down to a level of critical ischaemia
gut ischaemia results in bacterial translocation
hepatic failure (ischaemia) allows endotoxin to circulate
lack of monitoring options has hampered investigation of gut perfusion

f. Describe the skin circulation.

g. Describe skeletal muscle circulation.

h. Describe uteroplacental circulation.

in Maternal physiology (1.O).