Special circulations, Coronary, Pulmonary...

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Objectives

- Describe the control of blood flow to different circulations (Skeletal muscles, pulmonary and coronary)
- Point out special hemodynamic characteristic pertinent to each circulation discussed
Muscle blood flow can increase tenfold or more during physical activity as vasodilation occurs

- Low levels of epinephrine bind to $\beta$ receptors
- Cholinergic receptors are occupied

Intense exercise or sympathetic nervous system activation result in high levels of epinephrine

- High levels of epinephrine bind to $\alpha$ receptors and cause vasoconstriction
- This is a protective response to prevent muscle oxygen demands from exceeding cardiac pumping ability
Exercise and Muscle Blood Flow

[Graph showing blood flow in ml/min over time with specific emphasis on Rhythmic exercise and Calf flow]
Muscle Blood Flow During Exercise

- Can - 20 fold during exercise.
- Muscle makes up a large portion of body mass and great effect on Cardiac output.
- Resting blood flow = 3 to 4 ml/min/100 gm muscle.
- Oxygen delivery can be increased by increasing the extraction ratio from 25% up to 75%.
- Capillary density increases markedly.
- Most blood flow occurs between contractions.
O₂ during exercise affects vascular smooth muscle directly \(\Rightarrow\) vasodilation.

Vasodilators (which ones?)

1. \(K^+\)
2. Adenosine
3. Osmolality
4. EDRF (nitric oxide)
Nervous Regulation

- Sympathetic release of norepinephrine (mainly $\alpha$).
- Adrenals release epinephrine ($\beta$ and $\alpha$) norepinephrine ($\alpha + \text{a little } \beta$).
  - $\beta$ receptors $\Rightarrow$ vasodilation mainly in muscle and the liver.
  - $\alpha$ receptors $\Rightarrow$ vasoconstriction in kidney and gut.
Arteriole Resistance: Control of Local Blood Flow

(a) Active hyperemia

-↑ Tissue metabolism

-↑ Release of metabolic vasodilators into ECF

-Dilation of arterioles

-↓ Resistance creates ↑ blood flow

-\(O_2\) and nutrient supply to tissue increases as long as metabolism is increased

(b) Reactive hyperemia

-↓ Tissue blood flow due to occlusion

-Metabolic vasodilators accumulate in ECF

-Dilation of arterioles, but occlusion prevents blood flow

-Remove occlusion

-↓ Resistance creates ↑ blood flow

-As vasodilators wash away, arterioles constrict and blood flow returns to normal
Blood Flow: Brain

- Blood flow to the brain is constant, as neurons are intolerant of ischemia.
- Metabolic controls – brain tissue is extremely sensitive to declines in pH, and increased carbon dioxide causes marked vasodilation.
- Myogenic controls protect the brain from damaging changes in blood pressure.
  - Decreases in MAP cause cerebral vessels to dilate to insure adequate perfusion.
  - Increases in MAP cause cerebral vessels to constrict.
Blood Flow: Brain

- The brain can regulate its own blood flow in certain circumstances, such as ischemia caused by a tumor.
- The brain is vulnerable under extreme systemic pressure changes:
  - MAP below 60mm Hg can cause syncope (fainting)
  - MAP above 160 can result in cerebral edema
Blood Flow: Skin

Blood flow through the skin:
- Supplies nutrients to cells in response to oxygen need
- Aids in body temperature regulation and provides a blood reservoir

Blood flow to venous plexuses below the skin surface:
- Varies from 50 ml/min to 2500 ml/min, depending upon body temperature
- Is controlled by sympathetic nervous system reflexes initiated by temperature receptors and the central nervous system
Characteristics of the **Pulmonary Circulation**

[Diagram showing the pulmonary and systemic circulations with pressure values and flow directions]
Blood Flow: Lungs

- Blood flow in the pulmonary circulation is unusual in that:
  - The pathway is short
  - Arteries/arterioles are more like veins/venules (thin-walled, with large lumens)
    - They have a much lower arterial pressure (24/8 mm Hg versus 120/80 mm Hg)
  - The autoregulatory mechanism is exactly opposite of that in most tissues
    - Low oxygen levels cause vasoconstriction; high levels promote vasodilation
    - This allows for proper oxygen loading in the lungs
Effect of $P_{O_2}$ on Blood Flow

![Graph showing the effect of alveolar $P_{O_2}$ on blood flow as a percentage of control.](image-url)
Distribution of Blood Flow
Hydrostatic Effects on Blood Flow

![Diagram showing different zones (Zone 1, Zone 2, Zone 3) with changes in capillary pressure (Ppc) and alveolar pressure (PALV)].

- **Zone 1**: Artery, PALV, Vein. Ppc is shown.
- **Zone 2**: Artery, PALV, Vein. Ppc is shown, and PALV is constant.
- **Zone 3**: Artery, PALV, Vein. Ppc is shown, and PALV is constant.

- **Ppc** = capillary pressure
- **PALV** = alveolar pressure

Distance vs. Flow graph with a downward trend indicating decrease in flow with increase in distance.
Blood Flow: Heart

- Small vessel coronary circulation is influenced by:
  - Aortic pressure
  - The pumping activity of the ventricles

- During ventricular systole:
  - Coronary vessels compress
  - Myocardial blood flow ceases
  - Stored myoglobin supplies sufficient oxygen

- During ventricular diastole, oxygen and nutrients are carried to the heart

- Extraction ratio is maximum (75%) during rest so an increase demand for oxygen means an increase blood flow
CORONARY CIRCULATION

(a) Anterior view of coronary arteries

(b) Anterior view of coronary veins
(a) Anterior view of coronary arteries
(b) Anterior view of coronary veins
Epicardial and Subendocardial Vasculature
Figure 10-3 - Comparison of phasic coronary blood flow in the left and right coronary arteries.
Coronary bypass operation

grafted veins carry arterial blood

blocked vessels
Angioplasty

a. Artery is closed.
b. Balloon is released.
c. Balloon is inflated.
(a) Coronary artery bypass grafting (CABG)

(b) Percutaneous transluminal coronary angioplasty (PTCA)

(c) Stent in an artery
Thank You