Cardiovascular effects of exercise

Introduction

- An adequate O2 supply is essential for performance of muscular exercise.
- The resting O2 consumption (=250 ml/min) may increase 20 times or more during exercise. The skeletal muscles at rest receive about 20% of the COP.
- This increases to 80-90% during exercise.

Introduction

- The circulatory adjustments during exercise aim at ***increasing the muscular blood flow***.
- This can be increased as result of both:
    I. Systemic circulatory changes.
    II. Local changes in active muscles.

I. Systemic circulatory changes.

- **1- Increase in cardiac output**

Through an increase in both

stroke volume

heart rate (reaches 180-200 beats/min).

Causes of increased stroke volume during exercise:

Increased preload

- Sympathetic activity → venoconstriction → increased venous pressure → increasing venous return to the heart.
- ⇨ Skeletal muscle pump.
- ⇨ Increase depth and rate of respiration.
- ⇨ Arteriolar dilatation at skeletal muscles increases the venous return from them.

Increased myocardial contractility

- By positive inotropic effect of sympathetic stimulation and catecholamine release.
- By effect of increased preload (Frank-Starling law).

Causes of increased heart rate during exercise

1. Sympathetic stimulation →the cerebral cortex and hypothalamus → stimulate CAC.
2. Increase the venous return: distension of right atrium→ increase the HR by Bainbridge reflex.
3. Hyperventilation during the exercise (Respiratory center inhibits the CIC).
4. Hypoxia, hypercapnia & acidosis →stimulate chemoreceptors at aortic and carotid bodies

Causes of increased heart rate during exercise

5. ***Alam smirk reflex***: contraction of skeletal muscles leads to increase in heart rate through muscle proprioceptors.
6. Adrenaline secretion.
7. Increase body temperature.

Increase in the arterial blood pressure:

- ABP is directly proportionate with changes in COP (SV & HR) and changes in the peripheral resistance (PR).
- Increase in **SV & COP increases the systolic blood** pressure mainly
- During exercise, the SV increases leading to an increase in the systolic blood pressure **but diastolic blood pressure changes according to the type of exercise.**
- **In areas other than skeletal muscles, generalized vasoconstriction occurs specially in blood vessels supplying the GIT and skin so blood is redistributed to the active areas (skeletal muscles and the heart).**

Local changes in active muscles

- **There is VD of the muscle arterioles→** increases the skeletal muscle blood flow.
- **<u>Causes of VD of skeletal muscle blood vessels:</u>**

1- Sympathetic stimulation even before the start of exercise.

2- Accumulation of the vasodilator metabolites (K+ and adenosine).

3- Local hypoxia (↓ O2), hypercapnia (↑CO2) and acidic metabolites as lactic acid (↑ H+).

4- Excess heat liberated during exercise.

Coronary Circulation

The coronary circulation concerned with the blood supplying the cardiac muscle.
About 1/3 of the population dies from diseases of coronary arteries.

Coronary vessels

- **1- Arterial supply:**

Left coronary artery: supplies the left atrium, left ventricle & the anterior part of interventricular septum.

Right coronary artery: supplies the right atrium, right ventricle & the posterior part of interventricular septum.

- **2- Coronary venous drainage:**

Superficial system: includes coronary sinus and the anterior cardiac vein They drain mainly left ventricle.

They open into the right atrium.

Deep system: includes the besian veins which drain small amount of the coronary venous blood directly into all chambers of the heart.

Characteristics of the coronary circulation

1) It is very short and very rapid (so it is essential to the heart).

2) The blood flow in this circulation occurs mainly during cardiac diastole.

3) There are no efficient anastomoses between the coronary vessels.

4) It is a rich circulation (5% of the COP while the heart weight is 300gm).

5) Its regulation is mainly by metabolites and not neural

6) The capillary permeability is high (the cardiac lymph is rich in protein).

7) The coronary vessels are susceptible to degeneration and atherosclerosis.

8) There is evident regional distribution: myocardial layer in the left ventricle receives less blood, due to more myocardial compression . This renders this

area more liable to ischemia and infarction.

Coronary blood flow

➔ Under resting conditions coronary blood flow (CBF) in the human heart is about 250 ml/ minute (=5% of the cardiac output).

➔ In severe muscular exercise, the work of the heart increased and the CBF may be increased up to 2 liters/ minute (why?).

Phasic changes in CBF:

During systole

- The CBF in the left ventricle falls to a low value due to strong compression of the left ventricular muscle around the intramuscular vessels during systole.
- The lowest CBF occurs during the isometric contraction phase (the flow may stop completely)

During diastole

- The cardiac muscle relax completely and so, the blood flows rapidly into the coronary arteries.
- The highest CBF occurs during isometric relaxation phase.

Regulation of the coronary blood flow

A. Intrinsic Mechanisms(autoregulation):It is the main mechanism controlling CBF.

Mechanism: It is regulated almost entirely by local need of cardiac muscle for nutrition. O2 demand is the major factor in local blood flow regulation.

O2 lack (due to ↑ heart activity) is followed by coronary VD due to:

1) ↓ O2 tension in the coronary blood has a direct relaxing effect on the smooth muscles in the wall of the coronary arteries.

2) O2 lack→ release of VD substances by the tissues, such as **adenosine(most important)**, K+, H+, CO2, bradykinin and prostaglandin.

B. Extrinsic mechanisms:

1- Nervous regulation

Sympathetic :

Direct action → VC due to stimulation of α1 receptors and mild VD due to stimulation of ß2 receptors.

Indirect action → it ↑ the metabolic activity of the heart → strong VD.

- The net effect of sympathetic ++ is an ↑ in the coronary blood flow

- **Parasympathetic:**

Has an opposite effect to sympathetic stimulation on the coronary arteries.

- **Anrep's reflex:**
- ↑ VR and venous pressure in the right atrium → reflex coronary VD and ↑ the coronary B.F.

Significance: It is important in exercise to supply the cardiac muscle with more O2.

- **Gastro coronary reflex:**

Distension of the stomach with heavy meal produces reflex coronary VC and ↓ CBF → anginal pain may be felt in certain persons after heavy meals

2- Chemical regulation

- **Nitroglycerin:** sublingually has a fast coronary dilating effect, within 2-3 Minutes.

Long acting nitrates as iso-sorbide dinitrate given orally also produce coronary dilatation.

Beta-blockers, e.g. propranolol and atenolol act by reducing myocardial O2 requirements during exertion and stress.

Calcium entry blocking agents e.g. nifedipine and verapamil also reduce myocardial O2 requirements and induce coronary VD.

3- Mechanical regulation

1) Phases of cardiac cycle.

2) Heart rate:

↑HR → ↓ the coronary blood flow by shortening of the diastolic period.

↓ HR → ↑ the coronary blood flow by prolonging the diastole.

3) ABP: ↑ ABP→ ↑ coronary flow. Conversely,↓ diastolic BP e.g aortic regurge à ↓CBF.

4) Cardiac output: Increase COP à increase coronary BF.


Thank you