Cardiovascular Physiology and Adaptations

Components of the Cardiovascular System

**Cardiovascular system** - composed of *blood*, the *heart*, and the *vasculature* within which blood is pumped throughout the body.

**Pulmonary circulation** - concerning blood flow to, within and from the lungs

**Systemic circulation** - concerning blood flow to, within and from the remainder of the body, and consists of tissue/organ specific circulation beds, eg: *renal*, *hepatic*, *cranial*, *gastric*, *intestinal*, *skeletal muscle*, *cutaneous*, etc.
Blood

- water, clotting proteins, transport proteins, lipoproteins, glucose, fatty acids, antibodies, transferrin, waste products (eg. urea, ammonia, etc.)

**plasma** - the liquid component of blood and all of its non-cellular content

**serum** - what remains of plasma after blood has clotted

**polycythemia** - excess production of red blood cells

**anemia** - abnormally low red blood cell counts

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**Constituent** | **Concentration** |
---|---|
Packed cell volume (hematocrit, %) | 35 - 50 |
Red blood cells (erythrocytes, cells/mm³) | 4.3 - 5.8 x 10¹² |
Platelets | |
White blood cells (leukocytes, cells/mm³) | 4 - 11 x 10⁹ |
Granulocytes | |
- Neutrophils | 3 - 7 x 10³ |
- Basophils | 100 - 400 |
- Eosinophils | 20 - 50 |
Lymphocytes | 1.5 - 3.0 x 10³ |
Monocytes | 100 - 700 |

**Plasma Volume (%)** | 50 - 65 |

**Cations**
- Sodium (mEq/L) | 135 - 145 |
- Potassium (mEq/L) | 3.5 - 5.0 |
- Calcium (mEq/L) | 2.2 - 2.5 |
- Magnesium (mEq/L) | 1.5 - 2.0 |

**Anions**
- Chloride (mEq/L) | 95 - 107 |
- Bicarbonate (mEq/L) | 22 - 46 |
- Sulfate (mEq/L) | 10 - 18 |
- Phosphate (mEq/L) | 1.0 |
- Protein | |
- Albumin (g/L) | 34 - 50 |
- Total globulin (g/L) | 22 - 44 |
- Transferrin (mg/L) | 2500 |
- Ferritin (μg/L) | 15 - 300 |
- Total Protein (g/L) | 60 - 80 |
- Osmolality (mOsm/kg H₂O) | 265 - 295 |
Cardiac Cycle
- Preload
- Afterload
- Systole
- Diastole
- EDV
- Ejection Fraction
- Stroke Volume
- Heart Rate
- Cardiac Output
- ECG
- Heart Sounds
- Valve Function
- Response to Exercise
### Catecholamine Action on α and β Receptors of Heart and Bronchial Tree

- **Epinephrine**
  - Action on heart: 
    - $\beta_1$: increased rate and force of contraction
  - Action on bronchial tree: 
    - $\beta_2$: dilatation and decreased secretion of mucus

- **Nor-epinephrine**
  - Action on heart: 
    - $\beta_1$: increased rate and force of contraction
  - Action on bronchial tree: 
    - $\alpha$: contracts

- **Isoproterenol**
  - Action on heart: 
    - $\beta_1$: increased rate and force of contraction
  - Action on bronchial tree: 
    - $\beta_2$: dilatation and decreased secretion of mucus

### Circulatory Component

<table>
<thead>
<tr>
<th>Circulatory Component</th>
<th>Sympathetic Regulation</th>
<th>Parasympathetic Regulation</th>
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<tbody>
<tr>
<td>SA Node</td>
<td>$\beta_1$, $\beta_2$: increased rate of depolarization</td>
<td>M2: decreased rate of depolarization</td>
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<td>Myocardium</td>
<td>$\beta_1$, $\beta_2$: increased contractility</td>
<td>M2: decreased contractility</td>
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<tr>
<td>AV Node</td>
<td>$\beta_1$: increased rate of conduction</td>
<td>M2: decreased rate of conduction</td>
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<td>Vascular smooth muscle</td>
<td>M3: Contracts $\alpha$: Contracts $\beta_2$: Relaxes</td>
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Resting heart rate is inherently variable!
Heart Rate Can Detect Steady vs. Non-Steady State

Recovery Heart Rate Is Influenced by Fitness
Relative Heart Rate Can Be Used to Express Intensity

\[
\text{%HR}_{\text{max}} = 0.525 \times \text{(%VO}_{\text{2max}}) + 45.3; \ r = -0.95
\]
\[
\text{%HRR} = 0.9118 \times \text{(%VO}_{\text{2max}}) + 9.259; \ r = 0.97
\]
### Table

<table>
<thead>
<tr>
<th>%VO₂max</th>
<th>%HRR</th>
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</table>

%HRR = 0.9118(%VO₂max) + 9.259
%HRmax = 0.525 (%VO₂max) + 45.3

### Diagram

Heart Rate Slope May Change at Metabolic Threshold

HRmax = 182 beats/min
Redistribution of Cardiac Output