Cardiovascular System

BLOOD VESSELS 2
Blood Pressure

- Main factors influencing blood pressure:
  - Cardiac output (CO)
  - Peripheral resistance (PR)
  - Blood volume

*Peripheral resistance is a major factor regulating BP and tissue perfusion*
Figure 19.11

Activity of muscular pump and respiratory pump

Release of ANP

Fluid loss from hemorrhage, excessive sweating

Crisis stressors: exercise, trauma, body temperature

Bloodborne chemicals: epinephrine, NE, ADH, angiotensin II; ANP release

Dehydration, high hematocrit

Body size

Conservation of Na+ and water by kidney

Blood volume

Blood pressure

Blood pH, O₂, CO₂

Body size

Baroreceptors

Chemoreceptors

Venous return

Activation of vasomotor and cardiac acceleration centers in brain stem

Heart rate

Blood vessel length

Diameter of blood vessels

Blood viscosity

Blood volume

Cardiac output

Mean systemic arterial blood pressure

Peripheral resistance

Initial stimulus

Physiological response

Result
Regulation of Peripheral Resistance

- **Local control**
  - Arterioles and capillaries vary diameters = autoregulation
    - A response to the chemical composition of the blood
    - Faster flow = faster removal of wastes
Regulation of Peripheral Resistance

- **Local control**
  - Localized hypoxia $\Rightarrow$ metabolites (CO$_2$, lactic acid, adenosine) $\Rightarrow$ acidic pH $\Rightarrow$ inhibit smooth muscle $\Rightarrow$ vasodilation $\Rightarrow$ increased blood flow
  - Precapillary sphincters
    - Respond to local stimuli and vasoactive hormones
  - Endothelial cells & platelets
    - Vasodilators
      - NO, prostacyclin
    - Vasoconstrictors
      - Endothelians, seratonin, thromboxane A$_2$
Total blood flow during strenuous exercise 17,500 ml/min

Total blood flow at rest 5800 ml/min
**Intrinsic mechanisms (autoregulation)**
- Distribute blood flow to individual organs and tissues as needed

**Metabolic controls**
- Amounts of:
  - pH
  - O₂
- Amounts of:
  - CO₂
  - K⁺
  - Prostaglandins
  - Adenosine
  - Nitric oxide
  - Endothelins

**Myogenic controls**
- Dilates
- Constricts

**Extrinsic mechanisms**
- Maintain mean arterial pressure (MAP)
- Redistribute blood during exercise and thermoregulation

**Nerves**
- Sympathetic
  - α Receptors
  - β Receptors

**Hormones**
- Epinephrine, norepinephrine
- Angiotensin II
- Antidiuretic hormone (ADH)
- Atrial natriuretic peptide (ANP)
Peripheral Resistance

- **Example of autoregulation**
  - **Blood flow to skeletal muscles**
    - During muscle activity, blood flow increases in direct proportion to the metabolic activity
    - Blood flow can increase $10\times$ or more during physical activity
Peripheral Resistance

- Neural control
  - Directed by ANS via sympathetic innervation
    - Vascular smooth muscle lacks parasympathetic input
Peripheral Resistance

- **Neural control**
  - **Vasomotor center**
    - Baroreflex
    - Chemoreflex
    - Ischemic reflex
Peripheral Resistance

- **Baroreflex**
  - Baroreceptors (pressure receptors) in
    - Carotid sinuses
    - Aortic arch
  - *Inhibitory* signals sent to vasomotor center while *stimulatory* signals sent to cardioinhibitory center
Baroreceptors in carotid sinuses and aortic arch are stimulated. Impulses from baroreceptors stimulate cardioinhibitory center (and inhibit cardioacceleratory center) and inhibit vasomotor center.

Baroreceptors in carotid sinuses and aortic arch are inhibited. Impulses from baroreceptors stimulate cardioacceleratory center (and inhibit cardioinhibitory center) and stimulate vasomotor center.

CO and R return blood pressure to homeostatic range.

Blood pressure (arterial blood pressure falls below normal range).

Blood pressure (arterial blood pressure rises above normal range).

CO and R return blood pressure to homeostatic range.

Vasomotor fibers stimulate vasoconstriction, causing \( R \)

Sympathetic impulses to heart cause \( \uparrow \) HR, \( \uparrow \) contractility, and \( \uparrow \) CO.

Impulses from baroreceptors stimulate cardioacceleratory center (and inhibit cardioinhibitory center) and stimulate vasomotor center.

Homeostasis: Blood pressure in normal range

Stimulus: Blood pressure (arterial blood pressure falls below normal range).
Peripheral Resistance

- **Chemoreflex**
  - Excitatory or inhibitory signals to vasomotor center
  - Chemoreceptors are located in the
    - Carotid bifurcation
    - Aortic arch
    - Large arteries of the neck
Figure 19.11

- **Activity of muscular pump and respiratory pump**: ↑
- **Release of ANP**: ↓
- **Fluid loss from hemorrhage, excessive sweating**: ↓
- **Crisis stressors: exercise, trauma, ↑ body temperature**: ↓
- **Bloodborne chemicals: epinephrine, NE, ADH, angiotensin II; ↓ ANP release**: ↓
- **Dehydration, high hematocrit**: ↓
- **Body size**: ↑

- **Conservation of Na⁺ and water by kidney**: ↑
- **Blood pressure**: ↓
- **Blood volume**: ↓
- **Blood pH, ↓O₂, ↑CO₂**: ↓
- **Baroreceptors**: ↓
- **Chemoreceptors**: ↓

- **Venous return**: ↑
- **Activation of vasomotor and cardiac acceleration centers in brain stem**: ↓
- **Heart rate**: ↑
- **Stroke volume**: ↑

- **Cardiac output**: ↑
- **Blood vessel length**: ↑
- **Blood viscosity**: ↑
- **Blood volume**: ↑
- **Peripheral resistance**: ↑

- **Mean systemic arterial blood pressure**: ↑
Peripheral Resistance

- **Medullary Ischemic Reflex**
  - Triggered by low perfusion of the medulla
  - Hypoxia and hypercapnia ➔ vasoconstriction in extremities
    ➔ blood flow directed to head and upper body
Peripheral Resistance

- **Hormonal controls**
  - **Angiotensin II**
    - Generated by kidney release of renin
    - Causes vasoconstriction
  - **Atrial natriuretic peptide/factor**
    - Causes blood volume and blood pressure to decline
    - Causes generalized vasodilation
  - **Antidiuretic hormone (ADH, vasopressin)**
    - Causes intense vasoconstriction in cases of extremely low BP
  - **Epinephrine**
    - Causes generalized vasoconstriction and increase cardiac output
Figure 19.10

**Arterial pressure**

- **Direct renal mechanism**
  - Baroreceptors
  - Sympathetic stimulation promotes renin release
  - Kidney
  - Renin release
  - Angiotensin II
  - ADH release by posterior pituitary
  - Water reabsorption by kidneys
  - Blood volume
  - Vasoconstriction (↓ diameter of blood vessels)

- **Indirect renal mechanism (hormonal)**
  - Baroreceptors
  - Sympathetic stimulation promotes renin release
  - Kidney
  - Renin release
  - Angiotensin II
  - Aldosterone secretion by adrenal cortex
  - Sodium reabsorption by kidneys
  - Water reabsorption by kidneys
  - Blood volume
  - Vasoconstriction (↓ diameter of blood vessels)

**Result**: ↓ Arterial pressure
Figure 19.11

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Dehydration, high hematocrit

Body size

↑ Conservation of Na\(^{+}\) and water by kidney

↑ Blood volume

Blood pressure

↓ Blood pH, ↓ O\(_2\), ↑ CO\(_2\)

Baroreceptors

Chemoreceptors

Activation of vasomotor and cardiac acceleration centers in brain stem

Blood volume

↑ Venous return

↑ Stroke volume

↑ Heart rate

Heart rate

↑ Cardiac output

↓ Diameter of blood vessels

↑ Blood viscosity

↑ Blood vessel length

↑ Peripheral resistance

↓ Mean systemic arterial blood pressure

Initial stimulus

Physiological response

Result
Questions?

• Don’t forget Homework #1 for lab!