Cardiovascular System
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*
Activity of muscular pump and respiratory pump

↓ Release of ANP

↑ Conservation of Na⁺ and water by kidney

↑ Blood volume

↑ Venous return

↑ Blood volume

Baroreceptors

Blood volume

Blood pressure

↓ Blood pH, ↓O₂, ↑CO₂

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

Dehydration, high hematocrit

↑ Body size

↑ Blood volume

Blood pressure

Blood volume

Baroreceptors

Chemoreceptors

Activation of vasomotor and cardiac acceleration centers in brain stem

Venous return

Heart rate

↑ Stroke volume

Heart rate

Cardiac output

↑ Mean systemic arterial blood pressure

Peripheral resistance

Diameter of blood vessels

Blood viscosity

Blood vessel length

Initial stimulus

Physiological response

Result

↑ Activity of muscular pump and respiratory pump

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

Copyright © 2010 Pearson Education, Inc.
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 (CO2, lactic acid, adenosine)

$\Rightarrow$ acidic pH $\Rightarrow$ inhibit smooth muscle $\Rightarrow$ vasodilation

$\Rightarrow$ increased blood flow
Regulation of Peripheral Resistance

- Local control
  - Precapillary sphincters
    - Respond to local stimuli and vasoactive hormones
  - Endothelial cells & platelets
    - Vasodilators
      - NO, prostacyclin
    - Vasoconstrictors
      - Endothelins, serotonin, thromboxane A₂
Total blood flow during strenuous exercise 17,500 ml/min

Total blood flow at rest 5800 ml/min

Brain: 750 ml/min
Heart: 750 ml/min
Skeletal muscles: 1200 ml/min
Skin: 500 ml/min
Kidney: 1100 ml/min
Abdomen: 1400 ml/min
Other: 600 ml/min

Figure 19.13
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
**Intrinsic mechanisms (autoregulation)**
- Distribute blood flow to individual organs and tissues as needed

**Metabolic controls**
- Decrease amounts of: pH, O₂
- Increase amounts of: CO₂, K⁺, Prostaglandins, Adenosine, Nitric oxide, Endothelins

**Myogenic controls**
- Dilates when stretch occurs
- Constricts

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

**Nerves**
- Sympathetic
- α Receptors
- β Receptors
- Epinephrine, norepinephrine

**Hormones**
- Angiotensin II
- Antidiuretic hormone (ADH)
- Atrial natriuretic peptide (ANP)
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.

Baroreceptors in carotid sinuses and aortic arch are inhibited.

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

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

CO and return blood pressure to homeostatic range.

CO and return blood pressure to homeostatic range.

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

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

Homeostasis: Blood pressure in 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

Conservation of Na⁺ and water by kidney

Blood volume

Blood pressure

Blood pH, O₂, CO₂

Crisis stressors: exercise, trauma, body temperature

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

Dehydration, high hematocrit

Body size

Blood volume

Baroreceptors

Chemoreceptors

Activation of vasomotor and cardiac acceleration centers in brain stem

Venous return

Blood viscosity

Peripheral resistance

Diameter of blood vessels

Blood vessel length

Heart rate

Stroke volume

Heart rate

Cardiac output

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
Hormonal controls cont.
- 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**
    - ↓ Filtration
    - ADH release by posterior pituitary
    - Aldosterone secretion by adrenal cortex
    - ↑ Water reabsorption by kidneys
    - ↑ Sodium reabsorption by kidneys
    - ↑ Blood volume
    - Vasoconstriction (↓ diameter of blood vessels)

- **Indirect renal mechanism (hormonal)**

**Result**

- Initial stimulus
- Physiological response
- Result
- 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

Baroreceptors

Chemoreceptors

Activation of vasomotor and cardiac acceleration centers in brain stem

↑ Stroke volume

↑ Heart rate

↑ Venous return

↑ Cardiac output

↓ Diameter of blood vessels

↑ Blood viscosity

↑ Blood vessel length

↑ Mean systemic arterial blood pressure
Activity

• Complete the chart on CV 27, #7
Questions?

- Due in Lab 1
  - PreLab 1
  - Homework #1: Artery Labeling
- Due Tuesday 4/9
  - Homework #2: Vessel Chart