Cardiovascular Regulation

Regulation of hemodynamics occurs via local autoregulation, neural control and hormones.
Autoregulation of Blood Flow

- Local regulation of blood flow occurs by vasoconstriction and vasodilation.
- Both occur at the site of arteriolar branches, usually into capillary beds (precapillary sphincters).
- Smooth muscle contraction closes lumen of the blood vessel.
- Response is a direct effect of conditions within local environment.
  - Local vasodilation can be caused by:
    - Uptake of $O_2$ (local decrease) by local cells and release of $CO_2$ (local increase).
    - Fall in pH.
    - Injury / inflammation.
  - Local vasoconstriction can be caused by:
    - Decrease in temperature.
    - Release of various chemicals in response to trauma (shock).
    - Response to certain localized activities (digestion –vs- exercise, etc).
Neural Control of Blood Flow

- Cardiac centers and the vasomotor centers within medulla oblongata are responsible for monitoring and regulating cardiovascular activities.
  - Cardioacceleratory center (sympathetic excitation to increase cardiac output).
  - Cardioinhibitory center (parasympathetic inhibition of cardiac output).
  - Vasomotor centers cause vasodilation (inhibition) or vasoconstriction (excitation).
- Cardiovascular centers detect changes in pH, blood pressure and dissolved gas concentrations.
- Two types of “transducers” sense these parameters:
  - Baroreceptors (pressure sensors)
  - Chemoreceptors (chemical sensors).
The Baroreceptor Reflexes

Autonomic reflexes that adjust cardiac output and peripheral resistance to regulate and maintain normal blood pressures.

Baroreceptors are situated at:
- Aortic sinuses (immediately distal to aortic valve).
- Carotid sinuses (within carotid arteries of neck).
- Right atrial walls.
Chemoreceptor Reflexes

- Found in aortic arch and carotid sinuses.
- Additional chemoreceptors in medulla oblongata monitor CSF composition.
- Activation occurs via a rise in CO₂ or drop in pH.
- Produces activation of cardioacceleratory and vasomotor centers.
- Increases cardiac output and vasoconstriction.
Hormones and Cardiovascular Function

Endocrine system provides acute and chronic regulation.

Short term:
- Epinephrine released immediately upon activation of adrenal medulla.

Long term:
- Angiotensin II:
  - Produced via enzymatic reaction initially catalyzed by renin produced by kidneys in response to lower pressure.
  - Causes powerful vasoconstriction and elevation of blood pressure.
  - Activates other hormones that act to retain water.
- Antidiuretic Hormone
  - Also responds to increase in plasma solute concentration.
  - Water retention at kidneys; Vasoconstriction.
- Erythropoietin:
  - Released by kidneys in response to decreased O_2 or blood pressure.
  - Increases RBC production.
- Atrial Natriuretic Peptide
  - Released by cells in RA in response to increased blood pressure.
  - Responds to increased venous filling by promoting loss of Na+ and water at kidneys, inhibiting sympathetic activation of adrenal medulla, and vasodilation.
Cardiovascular Response to Exercise

- Cardiac output at rest ranges from 4.5 – 6 L/min.
- Exercise produces substantial increase.
- Effects of exercise:
  - Vasodilation at skeletal muscle vasculature.
  - Increase in venous return.
  - Increase in cardiac output as a function of the Frank-Starling law and as a reflex response to atrial stretching.
  - Arterial pressure are therefore maintained despite decrease in downstream resistance.
  - Advanced stage of exercise produces sympathetic stimulation.
  - Produces vasoconstriction for non-essential vasculature.
  - Blood supply to brain remains unaffected.
  - Chronic exercise produces mild to moderate hypertrophy of cardiac muscle.
  - Significant chronic exertion coupled with genetic predisposition can cause hypertrophic cardiomyopathy.
Response to Hemorrhage

- Hemorrhage → significant loss of blood volume.
- **Short term responses:**
  - Baroreceptor reflexes stimulate cardiac output and initiate peripheral vasoconstriction.
  - Mobilization of the venous reserve.
  - Sympathetic stimulation of heart rate.
- **Longer term responses:**
  - Decline in capillary blood pressure reverses pressure gradient and moves interstitial fluid into capillaries.
  - Hormones (ADH, aldosterone) released to promote fluid retention at kidneys.
  - Erythropoietin released to stimulate RBC formation.
  - Thirst reflexes triggered.
- Significant blood loss (> 35%) leads to circulatory shock.