Course Name: physiology

TOPIC: Adrenal gland, Pancreas & Gonads

Instructor: Dr. Ayad Sameen
• Adrenal glands – paired, pyramid-shaped organs atop the kidneys
• Structurally and functionally, they are two glands in one
  – Adrenal medulla – neural tissue that acts as part of the SNS
  – Adrenal cortex – glandular
Adrenal Cortex

• Synthesizes and releases steroid hormones called corticosteroids
• Different corticosteroids are produced in each of the three layers
  – Zona glomerulosa – mineralocorticoids (chiefly aldosterone)
  – Zona fasciculata – glucocorticoids (chiefly cortisol)
  – Zona reticularis – gonadocorticoids (chiefly androgens)
Adrenal Cortex

(a) Diagram showing the layers of the adrenal cortex:
- Capsule
- Zona glomerulosa
- Zona fasciculata
- Zona reticularis
- Adrenal medulla

(b) Microscopic view of the adrenal cortex.
Mineralocorticoids

- Regulate electrolytes in extracellular fluids
- Aldosterone – most important mineralocorticoid
  - Maintains Na\(^+\) balance by reducing excretion of sodium from the body
  - Stimulates reabsorption of Na\(^+\) and secretion of K\(^+\) by the kidneys
Mineralocorticoids

• Aldosterone secretion is stimulated by:
  – Rising blood levels of $K^+$
  – Low blood $Na^+$
  – Decreasing blood volume or pressure
Mechanisms of Aldosterone Secretion

- Renin-angiotensin mechanism – kidneys release renin, which is converted into angiotensin II that in turn stimulates aldosterone release
- Plasma concentration of sodium and potassium – directly influences the zona glomerulosa cells
- ACTH – causes small increases of aldosterone during stress
- Atrial natriuretic peptide (ANP) – inhibits activity of the zona glomerulosa
Mechanisms of Aldosterone Secretion

- Increased K⁺ (or decreased Na⁺) in blood
- Decreased blood volume and/or blood pressure

ACTH

- Kidney
- Renin
  - Initiates cascade that produces Angiotensin II
  - Direct stimulating effect

- Angiotensin II
  - Zona glomerulosa of adrenal cortex
  - Enhanced secretion of aldosterone
  - Targets kidney tubules

- Increased absorption of Na⁺ and water; increased K⁺ excretion
  - Increased blood volume and blood pressure

Stress

- Hypothalamus
  - CRH

Increased blood pressure or blood volume

Inhibitory effect

Atrial natriuretic peptide (ANP)
Glucocorticoids (Cortisol)

• Help the body resist stress by:
  – Keeping blood sugar levels relatively constant
  – Maintaining blood volume and preventing water shift into tissue

• Cortisol provokes:
  – Gluconeogenesis (formation of glucose from noncarbohydrates)
  – Rises in blood glucose, fatty acids, and amino acids
Excessive Levels of Glucocorticoids

• Excessive levels of glucocorticoids:
  – Depress cartilage and bone formation
  – Inhibit inflammation
  – Depress the immune system
  – Promote changes in cardiovascular, neural, and gastrointestinal function
Gonadocorticoids (Sex Hormones)

• Zona Reticularis produces mainly androgens that are converted to testosterone in the testes
• Androgens contribute to:
  – The onset of puberty
  – The appearance of secondary sex characteristics
  – Sex drive in females
• Androgens can be converted into estrogens after menopause
Stress and the Adrenal Gland

Short-term stress response:
1. Increased heart rate
2. Increased blood pressure
3. Liver converts glycogen to glucose and releases glucose to blood
4. Dilation of bronchioles
5. Changes in blood flow patterns leading to decreased digestive system activity and reduced urine output
6. Increased metabolic rate

Long-term stress response:
1. Retention of sodium and water by kidneys
2. Increased blood volume and blood pressure
3. Proteins and fats converted to glucose or broken down for energy
4. Increased blood glucose
5. Suppression of immune system
Pancreas

- A triangular gland, which has both exocrine and endocrine cells, located behind the stomach
- Acinar cells produce an enzyme-rich juice used for digestion (exocrine product)
- Pancreatic islets (islets of Langerhans) produce hormones (endocrine products)
- The islets contain two major cell types:
  - Alpha (α) cells that produce glucagon
  - Beta (β) cells that produce insulin
Glucagon

• Its major target is the liver, where it promotes:
  – Glycogenolysis – the breakdown of glycogen to glucose
  – Gluconeogenesis – synthesis of glucose from lactic acid and noncarbohydrates
  – Release of glucose to the blood from liver cells
Insulin

- Synthesized as part of proinsulin and then excised by enzymes, releasing functional insulin
- Insulin:
  - Lowers blood glucose levels
  - Enhances transport of glucose into body cells
  - Counters metabolic activity that would enhance blood glucose levels
Function of Insulin

• The insulin receptor is a tyrosine kinase enzyme

• After glucose enters a cell, insulin binding triggers enzymatic activity that:
  – Catalyzes the oxidation of glucose for ATP production
  – Polymerizes glucose to form glycogen
  – Converts glucose to fat (particularly in adipose tissue)
Homeostasis: Normal blood glucose level (about 90 mg/100 ml)

Stimulus: Rising blood glucose level

Stimulates glycogen formation

Blood glucose rises to normal range

Stimulates glycogen breakdown

Stimulates glucose uptake by cells

Blood glucose falls to normal range
Gonads: Female

- Paired ovaries in the abdominopelvic cavity produce estrogens and progesterone
- They are responsible for:
  - Maturation of the reproductive organs
  - Appearance of secondary sexual characteristics
  - Breast development and cyclic changes in the uterine mucosa
Gonads: Male

- Testes located in an extra-abdominal sac (scrotum) produce testosterone
- Testosterone:
  - Initiate maturation of male reproductive organs
  - Causes appearance of secondary sexual characteristics and sex drive
  - Is necessary for sperm production
  - Maintains sex organs in their functional state
Pineal gland

• Small gland hanging from the roof of the third ventricle of the brain
• Secretory product is melatonin
• Melatonin is involved with:
  – Day/night cycles
  – Physiological processes that show rhythmic variations (body temperature, sleep, appetite)
Thymus gland

- Lobulated gland located deep to the sternum
- Major hormonal products are thymopoietins and thymosins
- These hormones are essential for the development of the T lymphocytes (T cells) of the immune system
Thanks