Chapter 20
The Endocrine Glands

Learning Objectives (1 of 2)
• Explain normal physiologic functions of pituitary hormones, common endocrine disturbances, and treatment
• Describe major thyroid abnormalities, clinical manifestations, and treatment
• Explain normal physiologic functions of adrenal cortex and medulla, common disturbances, and treatment
• Define causes and effects of parathyroid dysfunction and treatment

Learning Objectives (2 of 2)
• Discuss concept of ectopic hormone production by nonendocrine tumors
• Explain adverse health effects of obesity, surgical procedures for obesity and their rationale
• Explain stress and its effects on the endocrine system

Endocrine Glands (1 of 2)
• Major endocrine glands
  – Pituitary
  – Thyroid
  – Parathyroid
  – Adrenal cortex and medulla
  – Pancreatic islets
  – Ovaries and testes

Endocrine Glands (2 of 2)
• Level of hormone in circulation: controls amount of hormone synthesized and released by an endocrine gland
• Disorders: hypersecretion or hyposecretion
• Determination of clinical effects
  – Degree of dysfunction
  – Age and sex of affected individual

Pituitary Gland (1 of 6)
• Suspended by stalk from hypothalamus at base of brain
  – Anterior lobe
  – Intermediate lobe: rudimentary structure
  – Posterior lobe
• Tropic hormones (regulate other endocrine glands)
  – Regulated by level of hormone produced by the target gland
  – Self-regulating mechanism maintains uniform hormone output
  – Prolactin secretion controlled by prolactin inhibitory factor
  – Thyroid stimulating hormone stimulates release of prolactin and thyroid hormones
Pituitary Gland (2 of 6)

• Anterior lobe hormones
  – Growth hormone: stimulates growth of tissues
  – Prolactin: stimulates milk production
  – Thyroid-stimulating hormone (TSH)
  – Adrenocorticotrophic hormone (ACTH)
  – Follicle-stimulating hormone (FSH)
  – Luteinizing hormone (LH)
• Posterior lobe hormones
  – Antidiuretic hormone (ADH): causes more concentrated urine
  – Oxytocin: stimulates uterine contractions and milk secretion

Normal mechanisms controlling elaboration of tropic hormones by the pituitary gland

Pituitary Gland (3 of 6)

• Panhypopituitarism
  – Anterior lobe fails to secrete all hormones
• Pituitary dwarfism
  – Deficiency of growth hormone
  – Causes retarded growth and development
• Diabetes insipidus
  – Failure of posterior lobe to secrete ADH or failure of kidney to respond to ADH (nephrogenic diabetes insipidus)
  – Unable to absorb H₂O
  – Causes excretion of large amounts of diluted urine
  – From a pituitary tumor

Pituitary Gland (4 of 6)

• Growth hormone overproduction
  – Caused by pituitary adenoma
  – Causes gigantism in children
  – Causes acromegaly in adults
  – May cause visual disturbances from tumor encroachment in optic chiasm
• Prolactin overproduction
  – Result of small pituitary adenoma
  – Also from conditions affecting function of hypothalamus
  – Causes amenorrhea and galactorrhea (milk secretion from non-pregnant breasts)

Pituitary Gland (5 of 6)

• Pituitary tumors
  – Many pituitary endocrine disturbances caused by anterior lobe pituitary tumors
  – Clinical manifestations depend on size of tumor and the hormone produced
    • Functional tumors: produce hormones that cause clinical manifestations
    • Nonfunctional tumors: do not produce hormones but exert other effects
    • May encroach on important structures adjacent to optic chiasm; disrupt hormone-producing functions of anterior lobe cells

Pituitary Gland (6 of 6)

• Pituitary tumors
  – Treatment determined by type, size, and hormone produced by tumor
    • Drugs to suppress tumor growth
    • Surgical resection: usual surgical approach is through the nasal cavity (transsphenoidal resection)
**Acromegaly**

© Courtesy of Leonard Crowley, M.D., University of Minnesota Medical School

---

**Thyroid Gland**

- **Structure**
  - Two lateral lobes connected by isthmus
  - Composed of thyroid follicles that produce and store hormones
  - Hormone production regulated by TSH (thyroid stimulating hormone)
  - Parafollicular cells: secrete calcitonin
- **Actions**
  - Controls rate of metabolic processes
  - Required for normal growth and development

---

**Normal thyroid gland, illustrating two lateral lobes connected by narrow isthmus**

---

**Low-magnification photomicrograph of cellular structure of normal thyroid gland.**

---

**High-magnification photomicrograph of normal thyroid follicles.**

---
Thyroid Gland

<table>
<thead>
<tr>
<th>Hyperthyroidism</th>
<th>Hypothyroidism</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rapid pulse</td>
<td>Slow pulse</td>
</tr>
<tr>
<td>Increased metabolism</td>
<td>Decreased metabolism</td>
</tr>
<tr>
<td>Hyperactive reflexes</td>
<td>Sluggish reflexes</td>
</tr>
<tr>
<td>Emotional lability</td>
<td>Placid and phlegmatic</td>
</tr>
<tr>
<td>GI effect: diarrhea</td>
<td>GI effect: constipation</td>
</tr>
<tr>
<td>Warm, moist skin</td>
<td>Cold, dry skin</td>
</tr>
</tbody>
</table>

Nontoxic Goiter

- Thyroid gland enlarges to increase hormone secretion
- Causes
  - Inadequate hormone output
  - Iodine deficiency
  - Enzyme deficiency
  - Inefficient enzyme function
  - Increased hormone requirements
- Treatment: administer thyroid hormone; may need surgical removal

The pathogenesis of nontoxic goiter

Hyperthyroidism

- Toxic goiter or Graves disease
- Caused by antithyroid antibody that stimulates gland
- Mimics effects of TSH but not subject to normal control mechanisms
- Treatment
  - Antithyroid drugs, thyroidectomy, large doses of radioactive iodine

Toxic Goiter

Large nodular goiter
Hypothyroidism

- In adult
  - Myxedema
  - Causes metabolic slowing
  - Treatment: administration of thyroid hormone
- In an infant
  - Cretinism
  - Causes impaired growth and CNS development
  - Causes hypometabolism
  - Early diagnosis and treatment required for normal development

Chronic Thyroiditis or Hashimoto Thyroiditis

- Autoantibody destroys thyroid tissue
- Results in hypothyroidism
- An immunologic reaction, not from an infection
- Cellular infiltration from an immunologic reaction between antigen and antibody

Thyroid Tumors

- Benign adenoma
- Carcinoma
  - Well-differentiated follicular and papillary carcinoma
    - Good prognosis; treatment by surgical resection
  - Poorly-differentiated carcinoma
    - Poor prognosis; rapidly growing
    - Treatment: surgery, radiation, chemotherapy
  - Medullary carcinoma
    - Rare, secretes calcitonin
**Parathyroid Glands**
- Blood calcium level is in equilibrium with calcium in the bone.
- Actions: Calcium level: regulated by parathyroid glands
  - Low calcium in blood: causes tetany (increased neuromuscular excitability causing spasm of skeletal muscle)
  - High calcium in blood: causes lowered neuromuscular excitability

**Hyperparathyroidism**
- Usually from a hormone-secreting parathyroid adenoma
- Effects
  - Hypercalcemia: blood calcium rises
  - Renal calculi: from excessive calcium excreted in urine
  - Calcium deposition in tissues
  - Decalcification of bone: from excessive calcium withdrawn from bone
- Treatment: Removal of tumor

**Hypoparathyroidism**
- Usually from accidental removal of parathyroid glands during thyroid surgery
- Effects:
  - Hypocalcemia: blood calcium falls precipitously
  - Leads to neuromuscular excitability and tetany
- Treatment: raise calcium levels
  - High-calcium diet
  - Supplementary vitamin D

**Adrenal Cortex (1 of 2)**
- Adrenals: paired glands above kidneys
- Hormones secreted by adrenal cortex
  - Glucocorticoids
  - Mineralocorticoids
  - Aldosterone: major hormone
  - Renin-angiotensin system is main stimulus
  - Sex hormones
- Overproduction of aldosterone
  - From aldosterone-producing tumor of adrenal cortex
  - High sodium, blood volume, blood pressure
  - Low potassium level leading to neuromuscular manifestations

**Adrenal Cortex (2 of 2)**
- Overproduction of adrenal sex hormones
  - Congenital adrenal hyperplasia
  - Sex-hormone-producing tumors

**Adrenal Medulla**
- Produces catecholamines that stimulate the sympathetic nervous system
  - Norepinephrine (noradrenaline)
  - Epinephrine (adrenaline)
- Pheochromocytoma: increased secretion of catecholamines
  - Produces pronounced CV effects
  - May cause cerebral hemorrhage from hypertension
  - Any emotional stress causes release of hormones
- Treatment: tumor resection
Addison Disease
• An adrenal cortical hypofunction
• Deficiency of all steroid hormones
  – Glucocorticoid deficiency: hypoglycemia
  – Mineralocorticoid deficiency: low blood volume and low blood pressure
  – Hyperpigmentation: from increased ACTH due to loss of feedback inhibition
• Autoimmune disorder
  – Treatment: administration of corticosteroids

Cushing Disease
• Excessive production of adrenal corticosteroids
  – Glucocorticoid excess: disturbed carbohydrate, fat, and protein metabolism
  – Mineralocorticoid excess: high blood volume and high blood pressure
  – Treatment: tumor removal
• Causes
  – Hormone-producing pituitary microadenoma
  – Hormone-producing adrenal cortex adenoma
  – Hyperplastic adrenal glands
  – Administration of large amounts of corticosteroids
  – Other tumors

Cushing’s disease before treatment.

Pancreatic Islets
• Pancreatic tissue that functions as an endocrine gland
• Produce hormones
  – Beta cells: insulin production
  – Alpha cells: glucagon
  – Delta cells: somatostatin

Gonads
• Function
  – Production of germ cells
  – Production of sex hormones: controlled by gonadotropic hormones of pituitary gland FSH and LH
• Tumors may secrete hormones
• Treatment: surgical excision

Nonendocrine Tumors
• Ectopic hormones: hormones secreted by nonendocrine tumors that are identical with or mimic action of true hormones
• Usual origin: produced by malignant tumors
• Lung, pancreas, kidneys, connective tissue
Stress and Endocrine System

• Stress: any event that disturbs homeostasis
• Causes: injury, surgery, prolonged exposure to cold, vigorous exercise, pain, or strong emotional stimulus such as anxiety or fear
• Acute response to stress
  – Fear-fight-flight reaction
  – Mediated by sympathetic nervous system and adrenal medulla
• Chronic response to stress: alters metabolism, taxes CV system, impairs inflammatory and immune responses
  – Involves adrenal cortex; predisposes to illness

Obesity (1 of 2)

• Occurs when caloric intake exceeds requirements
• Usually NOT result of endocrine or metabolic disturbance
• Health consequences
  – Cardiovascular disease
  – Diabetes
  – Cancer
  – Musculoskeletal problems
  – Impaired pulmonary function

Obesity (2 of 2)

• Treatment
• Medical: diet
• Drugs: suppress appetite
  – Combination of fenfluramine and phentermine (fen-phen) causes heart valve damage
• Surgery
  – Ileal bypass: several complications, infrequently performed
  – Gastric bypass
  – Vertical-banded gastroplasty

Types of Bariatric Surgery

Discussion

• What are the major hormones produced by the pituitary gland?
• What are the major effects of abnormal output of thyroid hormone?
• What is the usual cause of obesity and its complications?