The Endocrine System

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Lecture Overview

- The Big Picture - The system as a whole
- The Players - A gland-by-gland look
- When good glands go bad - Endocrine emergencies

The Endocrine System - Big Picture

Endocrine Glands

- Controls many body functions
  - exerts control by releasing special chemical substances into the blood called hormones
  - Hormones affect other endocrine glands or body systems
- Ductless glands
- Secrete hormones directly into bloodstream
  - Hormones are quickly distributed by bloodstream throughout the body

Hormones

- Act on target organs elsewhere in body
- Control/coordinate widespread processes:
  - Homeostasis
  - Reproduction
  - Growth & Development
  - Metabolism
  - Response to stress
    - Overlaps with the Sympathetic Nervous System

Hormones

- Hormones are classified as:
  - Proteins
  - Polypeptides (amino acid derivatives)
  - Lipids (fatty acid derivatives or steroids)

Hormones

- Amount of hormone reaching target tissue directly correlates with concentration of hormone in blood.
  - Constant level hormones
    - Thyroid hormones
• **Variable level hormones**
  • Epinephrine (adrenaline) release
• **Cyclic level hormones**
  • Monthly: Reproductive hormones
  • Daily: Cortisol

### The Players

- Pituitary
- Hypothalamus
- Thyroid
- Parathyroid
- Adrenal
- Gonads

### The Pituitary Gland

**Pituitary Gland**

- Small gland located on stalk hanging from base of brain - *AKA*
- “The Master Gland”
  - Primary function is to control other glands.
  - Produces many hormones.
  - Secretion is controlled by hypothalamus in base of brain.

#### Pituitary Gland

- **Two areas**
  - Anterior Pituitary
  - Posterior Pituitary
- Structurally, functionally different

#### Pituitary Gland

- **Anterior Pituitary**
  - Thyroid-Stimulating Hormone (TSH)
    - stimulates release of hormones from Thyroid
    - released when stimulated by TSH or cold
    - abnormal conditions
      - hyperthyroidism: too much TSH release
      - hypothyroidism: too little TSH release

#### Pituitary Gland

- **Anterior Pituitary**
  - Growth Hormone (GH)
• stimulates growth of all organs and increases blood glucose concentration
  – decreases glucose usage
  – increases consumption of fats as an energy source
• Adreno-Corticotrophic Hormone (ACTH)
  • stimulates the release of adrenal cortex hormones

**Pituitary Gland**

• Anterior Pituitary
  • Follicle Stimulating Hormone (FSH)
    • females - stimulates maturation of ova; release of estrogen
    • males - stimulates testes to grow; produce sperm
  • Luteinizing Hormone (LH)
    • females - stimulates ovulation; growth of corpus luteum
    • males - stimulates testes to secrete testosterone

**Pituitary Gland**

• Anterior Pituitary
  • Prolactin
    • stimulates breast development during pregnancy; milk production after delivery
  • Melanocyte Stimulating Hormone (MSH)
    • stimulates synthesis, dispersion of melanin pigment in skin

**Pituitary Gland**

• Posterior Pituitary
  • Antidiuretic hormone (ADH)
    • Stimulates water retention by kidneys
      – reabsorb sodium and water
    • Abnormal conditions
      – Undersecretion: diabetes insipidus (“water diabetes”)
      – Oversecretion: Syndrome of Inappropriate Antidiuretic Hormone (SIADH)
  • Oxytocin
    • Stimulates contraction of uterus at end of pregnancy (Pitocin®); release of milk from breast

**The Hypothalamus**

• Produces several releasing and inhibiting factors that stimulate or inhibit anterior pituitary’s secretion of hormones.
• Produces hormones that are stored in and released from posterior pituitary

**Hypothalamus**

• Also responsible for:
  • Regulation of water balance
  • Esophageal swallowing
- Body temperature regulation (shivering)
- Food/water intake (appetite)
- Sleep-wake cycle
- Autonomic functions

**Pineal Gland**

- Located within the Diencephalon
- Melatonin
  - Inhibits ovarian hormones
  - May regulate the body’s internal clock

**The Thyroid Gland**

**Thyroid**

- Located below larynx and low in neck
  - Not over the thyroid cartilage
- Thyroxine (T₄) and Triiodothyronine (T₃)
  - Stimulate metabolism of all cells
- Calcitonin
  - Decreases blood calcium concentration by inhibiting breakdown of bone

**Thyroid**

- Works on a feedback loop with the Anterior Pituitary
  - more TSH = more T₃/₄
  - more T₃/₄ = less TSH

**The Parathyroids**

**Parathyroids**

- Located on posterior surface of thyroid
- Frequently damaged during thyroid surgery
- Parathyroid hormone (PTH)
  - Stimulates Ca²⁺ release from bone
  - Promotes intestinal absorption and renal tubular reabsorption of calcium

**Parathyroids**

- Underactivity
  - Decrease serum Ca²⁺
    - Hypocalcemic tetany
    - Seizures
    - Laryngospasm

**Parathyroids**
● Overactivity
  • Increased serum Ca$^{2+}$
  • Pathological fractures
  • Hypertension
  • Renal stones
  • Altered mental status
  • “Bones, stones, hypertones, abdominal moans”

**Thymus Gland**

● Located in anterior chest
● Normally absent by ~ age 4
● Promotes development of immune-system cells (T-lymphocytes)

**The Adrenal Glands**

**Adrenal Glands**

● Small glands located near (ad) the kidneys (renals)
● Consists of:
  • outer cortex
  • inner medulla

**Adrenal Glands**

● Adrenal Medulla
  • the Adrenal Medulla secretes the catecholamine hormones *norepinephrine* and *epinephrine*
  • Epinephrine and Norepinephrine
    • Prolong and intensify the sympathetic nervous system response during stress

**Adrenal Glands**

● Adrenal Cortex
  • Aldosterone (Mineralocorticoid)
    • Regulates electrolyte (potassium, sodium) and fluid homeostasis
  • Cortisol (Glucocorticoids)
    • Antiinflammatory, anti-immunity, and anti-allergy effects.
    • Increases blood glucose concentrations
  • Androgens (Sex Hormones)
    • Stimulate sexual drive in females

**Adrenal Glands**

● Adrenal Cortex
  • Glucocorticoids
    • accounts for 95% of adrenal cortex hormone production
    • ↑ the level of glucose in the blood
- Released in response to stress, injury, or serious infection - like the hormones from the adrenal medulla

**Adrenal Glands**

- Adrenal Cortex
  - Mineralcorticoids
    - work to regulate the concentration of potassium and sodium in the body

**The Gonads**

**Ovaries**

- Located in the abdominal cavity adjacent to the uterus
- Under the control of LH and FSH from the anterior pituitary
- Produce eggs for reproduction
- Produce hormones
  - estrogen
  - progesterone
  - Functions include sexual development and preparation of the uterus for implantation of the egg

**Ovaries**

- Estrogen
  - Development of female secondary sexual characteristics
  - Development of endometrium
- Progesterone
  - Promotes conditions required for pregnancy
  - Stabilization of endometrium

**Testes**

- Located in the scrotum
- Controlled by anterior pituitary hormones FSH and LH
- Produce sperm for reproduction
- Produce testosterone -
  - promotes male growth and masculinization
  - promotes development and maintenance of male sexual characteristics

**The Pancreas**

**Pancreas**

- Located in retroperitoneal space between duodenum and spleen
- Has both endocrine and exocrine functions
  - **Exocrine Pancreas**
    - Secretes key digestive enzymes
  - **Endocrine Pancreas**
Pancreas

- **Alpha Cells**
  - Glucagon
    - Raises blood glucose levels

- **Beta Cells**
  - Insulin
    - Lowers blood glucose levels

- **Delta Cells**
  - Somatostatin
    - Suppresses release of growth hormone

**When Good Glands Go Bad**

**Disorders of the Endocrine System**

**Abnormal Thyroid Function**

- **Hypothyroidism**
  - Too little thyroid hormone

- **Hyperthyroidism**
  (Thyrotoxicosis / Thyroid Storm)
  - Too much thyroid hormone

**Hypothyroidism**

- Thyroid hormone deficiency causing a decrease in the basal metabolic rate
  - Person is “slowed down”

**Causes of Hypothyroidism:**

- Radioactive iodine ablation
- Non-compliance with levothyroxine
- Hashimoto’s thyroiditis - autoimmune destruction

**Hypothyroidism**
- Confusion, drowsiness, coma
- Cold intolerant
- Hypotension, Bradycardia
- Muscle weakness
- Decreased respirations
- Weight gain, Constipation
- Non-pitting peripheral edema
- Depression
- Facial edema, loss of hair
- Dry, coarse skin

**Hypothyroidism**

- **Myxedema Coma**
  - Severe hypothyroidism that can be fatal
- **Management of Myxedema Coma**
  - Control airway
  - Support oxygenation, ventilation
  - IV fluids
  - Later
    - Levothyroxine (Synthroid®)
    - Hydrocortisone

**Hyperthyroidism**

- Excessive levels of thyroid levels cause hypermetabolic state
  - Person is “sped up”.
- **Causes of Hyperthyroidism**
  - Overmedication with levothyroxine (Synthroid®) - Fad diets
  - Goiter (enlarged, hyperactive thyroid gland)
  - Graves Disease

**Hyperthyroidism**

- Nervousness, irritable, tremors, paranoid
- Warm, flushed skin
- Heat intolerant
- Tachycardia - High output CHF
- Hypertension
- Tachypnea
- Diarrhea
- Weight loss
- Exophthalmos
- Goiter

**Hyperthyroidism**

- Treatment
  - Airway/Ventilation/Oxygen
• ECG monitor
• IV access - Cautious IV fluids
• Acetaminophen for fever
• Beta-blockers
• Consider benzodiazepines for anxiety
• PTU (propylthiouracil)
  • Usually short-term use prior to more definitive treatment
• SSKI® (potassium iodide)

Thyroid Storm/Thyrotoxicosis

• Severe form of hyperthyroidism that can be fatal
  • Acute life-threatening hyperthyroidism

Thyroid Storm/Thyrotoxicosis

• Severe tachycardia
• Heart Failure
• Dysrhythmias
• Shock
• Hyperthermia
• Abdominal pain
• Restlessness, Agitation, Delirium, Coma

Thyroid Storm/Thyrotoxicosis

• Management
  • Airway/Ventilation/Oxygen
  • ECG monitor
  • IV access - cautious IV fluids
  • Control hyperthermia
    • Active cooling
    • Acetaminophen
  • Inderal (beta blockers)
  • Consider benzodiazepines for anxiety
  • Potassium iodide (SSKI®)
  • Propylthiouracil (PTU)

Abnormal Adrenal Function

• Hyperadrenalism
  • Excess activity of the adrenal gland
  • Cushing’s Syndrome & Disease
  • Pheochromocytoma

• Hypoadrenalism (adrenal insufficiency)
  • Inadequate activity of the adrenal gland
  • Addison’s disease
Hyperadrenalism

- **Primary Aldosteronism**
  - Excessive secretion of aldosterone by adrenal cortex
    - Increased Na⁺/H₂O
  - Presentation
    - headache
    - nocturia, polyuria
    - fatigue
    - hypertension, hypervolemia
    - potassium depletion

Hyperadrenalism

- **Adrenogenital syndrome**
  - “Bearded Lady”
  - Group of disorders caused by adrenocortical hyperplasia or malignant tumors
  - Excessive secretion of adrenocortical steroids especially those with androgenic or estrogenic effects
  - Characterized by
    - masculinization of women
    - feminization of men
    - premature sexual development of children

Hyperadrenalism

- **Cushing’s Syndrome**
  - Results from increased adrenocortical secretion of cortisol
  - Causes include:
    - ACTH-secreting tumor of the pituitary (Cushing’s disease)
    - excess secretion of ACTH by a neoplasm within the adrenal cortex
    - excess secretion of ACTH by a malignant growth outside the adrenal gland (esp small cell lung ca)
    - excessive or prolonged administration of steroids

Hyperadrenalism

- **Cushing’s Syndrome**
  - Characterized by:
    - truncal obesity
    - moon face
    - buffalo hump
    - acne, hirsutism
    - abdominal striae
    - hypertension
    - psychiatric disturbances
    - osteoporosis
    - amenorrhea
Hyperadrenalism

- **Cushing’s Disease**
  - Too much adrenal hormone production
    - adrenal hyperplasia caused by an ACTH secreting adenoma of the pituitary
  - “Cushingoid features”
    - striae on extremities or abdomen
    - moon face
    - buffalo hump
    - weight gain with truncal obesity
    - personality changes, irritable

Hyperadrenalism

- **Cushing’s Syndrome**
  - Management
    - Airway/Ventilation/Oxygen
    - Supportive care
    - Assess for cardiovascular event requiring treatment
      - severe hypertension
      - myocardial ischemia

Hyperadrenalism

- **Pheochromocytoma**
  - Catecholamine secreting tumor of adrenal medulla
  - Presentation
    - Anxiety
    - Pallor, diaphoresis
    - Hypertension
    - Tachycardia, Palpitations
    - Dyspnea
    - Hyperglycemia

Hyperadrenalism

- **Pheochromocytoma**
  - Management
    - Supportive care based upon presentation
    - Airway/Ventilation/Oxygen
    - Calm/Reassure
    - Assess blood glucose
    - Consider beta blocking agent - Labetalol
    - Consider benzodiazepines

Hypoadrenalism

- Adrenal Insufficiency
• decrease production of glucocorticoids, mineralcorticoids and androgens

**Causes**

• Primary adrenal failure (Addison’s Disease)
• Infection (TB, fungal, Meningococcal)
• AIDS
• Prolonged steroid use

**Hypoadrenalism**

**Presentation**

• Hypotension, Shock
• Hyponatremia, Hyperkalemia
• Progressive Muscle weakness
• Progressive weight loss and anorexia
• Skin hyperpigmentation
  • areas exposed to sun, pressure points, joints and creases
• Arrhythmias
• Hypoglycemia
• N/V/D

**Hypoadrenalism**

**Management**

• Airway/Ventilation/Oxygen
• ECG monitor
• IV fluids
• Assess blood glucose - D50 if hypoglycemic
• Steroids
  • hydrocortisone or dexamethasone
  • florinef (mineralcorticoid)
• Vasopressors if unresponsive to IV fluids

**Case Study #1**

• You are dispatched to a college residence hall to see a 20-year-old female complaining of fever and a fluttering in her chest. You find her awake but she appears very anxious.
  • Airway - Open without assistance
  • Breathing - Slightly increased ventilatory rate; No obvious abnormal sounds of breathing
  • Circulation - Rapid, strong, regular radial pulse; Skin warm and pink

**Case Study #1**

• You direct your partner to assess vital signs while you place the patient on Oxygen 15 lpm by NRB mask. Your physical exam findings are:
  • trembling, nervous
  • warm, flushed skin
  • clear and equal lung sounds
• Your partner relays the following vital signs to you:
  • Pulse - 120, regular, strong
• BP - 144/88
• Ventilatory rate - 20, regular with adequate TV
• Glucose - 110 mg/dl
• ECG - Sinus tachycardia with occasional PACs

Case Study #1
• The patient states this has occurred before but never lasted this long. She has not been ill lately other than some recurrent diarrhea and weight loss. She has attributed these to worrying about finals. She has no significant medical history and takes no meds. She denies use of any drugs. She has no family history of pulmonary disease, diabetes or heart disease. Her mother, however, does have a problem with something in her neck for which she takes medication.

Case Study #2
• You are dispatched to a residence to see a 44-year-old man who has fainted. You arrive to find him semi-reclined in bed. He is awake and very wide-eyed but appears very tired.
  • Airway - Maintained without assistance
  • Breathing - No obvious distress; No obvious, unusual sounds
  • Circulation - Rapid, weak, irregular radial pulse

Case Study #2
• Your partner assesses vital signs while you obtain the following history:
  • Hx of Present Illness: For the past month, he has felt very weak and dizzy; He has not felt like eating and has been losing weight. He has also experienced N/V/D on a few days this month.
  • Past Medical Hx: Has been fairly healthy all of his life; Three months ago he became ill with bacterial meningitis for which he was successfully treated.

Case Study #2
• Vital signs are:
  • Pulse: 110-126, irregular
  • BP: 92/62
  • Ventilatory rate: 20, regular
  • Skin: cool, clammy
  • ECG: Atrial fibrillation
  • Blood glucose: 74 mg/dl

Case Study #2
• Your partner is a brand new, naïve paramedic. He comments to the patient, “That is a great tan you have. Have you been on a tropical vacation lately?”