

PITUITARY GLAND (hypophysis) "Master Gland"

Anterior Lobe (adenohypophysis)

Somatotropin

- **Growth Hormone (GH)** – protein hormone that increases protein synthesis in many tissues, increases the breakdown of fatty acids in adipose tissue & increases the glucose level in blood. Stimulates growth especially bones & skeletal muscle. *↓ metabolism CHO*

Stress, exercise, & low blood glucose levels increase the secretion.

Regulated by: growth hormone-releasing hormone (GH-RH) & growth hormone-inhibiting hormone (GR-IH; somatostatin).

GH drugs not given orally – inactivated by GI enzymes. Given SQ or IM. GH acts on new forming bone – must administer before epiphyses fuse.

GH therapy can antagonize insulin secretions & cause DM.

Growth Hormone Deficiency:

Dwarfism

To treat growth failure in children

somatotropin (Humatrope) – identical amino acid sequence as human GH

*contraindicated for children with Prader-Willi syndrome, severely obese, & severe respiratory impairment.

somatrem (Protropin) – identical as GH + add'l amino acid

Growth Hormone Excess:

Gigantism – excessive growth during childhood

Acromegaly – excessive growth after puberty

octreotide (Sandostatin) – potent somatostatin to suppress GH release

- **Adrenocorticotropic Hormone (ACTH)** – stimulates release of glucocorticoids (cortisol) & mineralcorticoids (aldosterone) & androgen from adrenal cortex.
*follow diurnal rhythm – higher in early AM & decrease thru the day.

Posterior Lobe (neurohypophysis)

- **Antidiuretic Hormone (ADH)/vasopressin** *saves H₂O*

Controls the excretion of H₂O by the kidneys. Stimulated by an increase in the osmolarity of the blood or by a decrease in BP. Promotes water reabsorption in the renal tubules to maintain water balance.

Problems:

Diabetes Insipidus – large volumes of H₂O excreted by the kidneys as a result of deficient production of vasopressin or failure of the renal tubules to respond to ADH. Can lead to severe fluid volume deficit & electrolyte imbalances. Patient tends to drink 2-20L of fluid daily & craves cold H₂O.

Diagnostic Test for DI: Fluid deprivation test

Inability to increase specific gravity & osmolality of the urine.

Syndrome of Inappropriate ^{Anti}Diuretic Hormone (SIADH) Secretion

Cannot excrete a dilute urine. Patients retain fluid & develop Na deficiency called dilutional hyponatremia.

- **Oxytocin**

Secretion is stimulated during pregnancy & childbirth.

Facilitates milk ejection during lactation & increases the force of uterine contractions during labor & delivery.

*ADH & aldosterone
keeping everything
in balance.*

- **Thyroid-Stimulating Hormone (TSH)**

Thyroid Releasing Hormone (TRH) release from the hypothalamus →
 TSH release from the pituitary gland → thyroxine (T4) &
 triiodothyronine (T3) release by the thyroid gland
 Excess TSH = hyperthyroidism TSH deficit = hypothyroidism

- **Gonadotropins – Follicle-stimulating Hormone (FSH) & Luteinizing Hormone (LH)** (follicle maturation, estrogen production, sperm production)

- **Prolactin (PL)** – milk formation in breast tissue

- **Melanocyte-Stimulating Hormone (MSH)**

*Calcitonin - keeps
 PTH - pulls*

THYROID GLAND

T3 & T4 regulate protein synthesis & enzyme activity, stimulate mitochondrial oxidation, influences cell replication & important in brain development. Controls metabolic rate & activity of almost every tissue/organ. Increase in CO₂, O₂ consumption, CHO use, protein synthesis, lipolysis. Influences heat regulation & menstrual cycle. **NECESSARY FOR NORMAL GROWTH.**

T3 is more potent than T4. Iodine is essential to thyroid gland for synthesis of hormones.

**Powerpoints: T3 & T4 increase absorption of glucose from GI tract & acts as insulin antagonist.

**Smeltzer: Thyroid hormones increase BG levels which may necessitate adjustment of insulin.

Calcitonin – important hormone secreted by thyroid. Reduces high plasma levels of Ca by increasing depositing in bone.

Euthyroid = hormone production within normal limits.

Lab/Diagnostic:

Serum TSH concentration	single best screening
Serum Free T4	used to confirm abnormal TSH
Serum T3 & T4	measure concentration of T3 & T4 in blood; generally increase or decrease together, T3 is a more accurate indicator of hyperthyroidism (increased with hyper, decreased with hypo)
T3 Resin Uptake Test	to determine the amt of thyroid hormone bound to TBG & number of available binding sites. Provides an indication to the amt of thyroid hormone in circulation.

Tyroid Antibodies

Radioactive Iodine Uptake	measure rate of iodine uptake by the thyroid gland (increased uptake with hyper, decreased uptake with hypo)
Fine Needle Aspiration Biopsy	accurate method of detecting malignancy. 1 = negative (benign) 2 = positive (malignant) 3 = indeterminate (suspicious) 4 = inadequate (nondiagnostic)
Thyroid Scan, Radioscan, or Scintiscan	identify areas of increase function ("hot" areas) & areas of decreased function ("cold" areas) to assist in dx.
Serum Thyroglobulin (Tg)	to detect persistent or recurrent thyroid carcinoma

Hypothyroidism	Hyperthyroidism
<p>Decrease in thyroid hormone secretion.</p> <ul style="list-style-type: none">• Primary hypothyroidism: thyroid gland dysfunction (95%)• Secondary hypothyroidism: pituitary d/o• Central hypothyroidism: dysfunction of the pituitary, hypothalamus, or both• Tertiary hypothyroidism: hypothalamus d/o resulting in decreased secretion of TSH <p>Cretinism = thyroid deficiency present at birth</p> <p><u>Characteristics:</u> extreme fatigue, hair loss, brittle nails, dry skin, menstrual disturbances, loss of libido, puffy eyelids & face, thick tongue, slow speech with hoarseness, lack of perspiration, mental processes dulled, constipation, and decrease in temp, HR, BP. (May have elevated cholesterol, atherosclerosis, & CAD with long periods of hypothyroidism. Also, bone loss & osteoporosis.)</p> <p>Most frequently in older women, most often 40-70 yrs.</p> <p>Avoid foods that can inhibit thyroid secretion (strawberries, peaches, pears, cabbage, turnips, spinach, kale, Brussels sprouts, cauliflower, radishes & peas).</p> <p>Myxedema = severe hypothyroidism in the adult Caused by: untreated hypo, rapid w/d of thyroid meds, exposure to cold/surgery/infections/trauma. S/S: hypothermia, bradypnea, hypotension, lethargy.</p>	<p>2nd most prevalent endocrine d/o after DM.</p> <p>Increase in circulating T4 & T3 levels. May be mild or severe.</p> <p>Graves' Disease (thyrotoxicosis): most common type of hyperthyroidism</p> <ul style="list-style-type: none">• Caused by hyperfunction of the thyroid gland, excessive production of hormones & gland enlargement.• Characterized by tachycardia, palpitations, chest pain, excessive perspiration, heat intolerance, nervousness, irritability, exophthalmic (bulging eyes), dry skin, hand tremors, increased appetite but weight loss, increased systolic BP. <p>Thyroid Storm: from untreated or poorly controlled hyper, post thyroidectomy. Measure VS & CO, EKG, ABGs, pulse ox.</p> <p><u>Treatment:</u> Tx can cause hypothyroidism.</p> <ul style="list-style-type: none">• Radioactive iodine therapy (most common) Decrease secretion by destroying thyroid tissue.• Antithyroid drugs• Beta Blockers (for BP control) Thyroidectomy Can be total or subtotal (indicated for large goiter or lack of response to drug therapy).• Thyroidectomy Can be total or subtotal (indicated for large goiter or lack of response to drug therapy). Complications include hypocalcemic tetany from

Drug Therapy:

S/S alleviated within 2-4 wks.

Take before breakfast – food hampers absorption rate.

levothyroxine sodium (Levothroid, Synthroid) – increase the levels of T3 & T4; drug of choice.

- Increases metabolic rate, CO, protein synthesis, glycogen use.

liothyronine (Cytomel) – initial therapy for treating myxedema.

Objective: to restore normal metabolic state by replacing missing hormone.

accidental removal of parathyroids, thyroid crisis/storm.

Drug Therapy:

S/S alleviated within 1-3 wks.

SE: skin rash, hives, nausea, alopecia, loss of hair pigment, petechiae & ecchymoses, & weakness.

Thiourea derivatives (thioamides) – drugs of choice. Prolonged use can cause goiter. May take several weeks for relief of symptoms because it does not interfere with activity of previously released thyroid hormones.

- prophythiouracil (PTU) – block conversion of T4 to T3
- methimazole (Tapazole) – does not inhibit conversion but is 10 x more potent & has a longer half-life than PTU.
- Strong iodine solution (Lugol's solution) – suppress thyroid fx for pt who have undergone subtotal thyroidectomy.

Thyroiditis: inflammation of thyroid gland.

Acute thyroiditis – (rare) infection of thyroid gland caused by bacteria, fungi, mycobacteria, or parasites.

Subacute thyroiditis – usually women 40-50, associated with a viral respiratory infection, painful swelling in anterior neck, no thrill or bruit.

Chronic thyroiditis (Hashimoto's disease) – usually women 30-50 yrs, accompanied by px, pressure symptoms & fever, thyroid activity normal – low rather than high.

Thyroid Tumors: thyroidectomy is tx of choice

Simple/Colloid Goiter: swelling in the neck caused by iodine deficiency or large amt of iodine or lithium.

Nodular Goiter: overgrowth

Thyroid Cancer: less prevalent than other forms of ca but accounts for 90% of endocrine malignancies.

Diagnostic: Thyroid function tests, needle biopsy, ultrasounds, MRI, CT, thyroid scans, radioactive iodine uptake studies, thyroid suppression tests.

Surgery + radioactive iodine = higher survival rate.

High daily caloric intake necessary for increased metabolism activity & rapid depletion of glycogen reserves. Avoid coffee, tea, soda, etc.

PARATHYROID GLANDS

Secrete Parathyroid Hormone (PTH) "parathormone" – regulates Ca levels in the blood by: promoting Ca absorption from the intestine, reabsorption of Ca from the renal tubules, and mobilizing Ca from bone. Decrease in Ca → stimulates release of PTH → increase in Ca absorption
 Also lowers blood phosphorus levels. Actions of hormone increased by the presence of vitamin D.

PTH agents = treat hypoparathyroidism

Calcitonin = treats hyperparathyroidism; mgmt of hypocalcemia

Hypoparathyroidism	Hyperparathyroidism
<p>Inadequate secretion of parathormone after interruption of blood supply or surgical removal of parathyroid glands during thyroidectomy.</p> <p>Decreased parathormone → hyperphosphatemia & hypocalcemia</p> <p><u>Characteristics:</u> *tetany (serum Ca levels 5-6 mg/dL), anxiety, irritability, depression, EKG changes, hypotension.</p> <p>Latent tetany suggested by + Trousseau's sign: carpopedal spasm induced by occluding blood flow to the arm for 3 min with a BP cuff. + Chvostek's sign: sharp tapping over the facial nerve causes spasm of the mouth, nose, or eye.</p> <p>A diet high in Ca & low in phosphorus is prescribed.</p>	<p>Overproduction of parathormone causing bone decalcification & development of renal calculi (kidney stones).</p> <p><u>Characteristics:</u> apathy, fatigue, muscle weakness, N, V, HTN, cardiac dysrhythmias. 2-4 x greater in women than men, ages 60-70.</p> <p>Increase in Ca = decrease in the excitation potential of nerve & muscle tissue.</p> <p>Important complication: kidney stone formation in one or both kidneys due to increased urinary excretion of Ca and phosphorus.</p> <p>Daily fluid intake of 2,000mL + will help prevent calculus formation. Cranberry juice is suggested because it may lower urinary pH.</p> <p><u>Diagnostic:</u> Double-antibody parathyroid hormone test: distinguishes between primary hyperthyroidism & malignancy as a cause of hypercalcemia. Ultrasound MRI Thallium scan Fine needle biopsy</p> <p>Hypercalcemic Crisis: extreme elevations in serum Ca levels (> 15 mg/dL) result in neurologic, cardiovascular & renal symptoms that can be life threatening.</p> <ul style="list-style-type: none"> • Tx – rehydration with large vol of IV fluids, diuretics to promote excretion of excess Ca, & phosphate therapy to correct hypophosphatemia & decrease serum Ca by promoting deposit in bone & reducing GI absorption of Ca.

- ER Tx – combo of calcitonin & corticosteroids to reduce serum Ca level by increasing absorption in bone.

ADRENAL GLANDS

Adrenal Medulla (inner)

Secrete 2 catecholamines:

- **Epinephrine** – participates in fight-or-flight response of the sympathetic nervous system. (90% of medulla secretion)

Increases HR, contracts blood vessels (decreased blood flow to tissue that are not needed in ER situations, like GI & greater flow to cardiac & skeletal muscle) & dilates air passages by relaxing smooth muscle.

Catecholamines also induce the release of free fatty acids, increase BMR, & elevate BG.

Binding to alpha-adrenergic receptors:

- Inhibits insulin secretion by the pancreas
- stimulates glycogenolysis in the liver & muscle
- stimulates glycolysis in muscle

Binding to beta-adrenergic receptors:

- glucagon secretion in the pancreas
- increased ACTH secretion by the pituitary gland
- increased lipolysis by adipose tissue

All the above lead to increase in blood glucose & fatty acids = providing substances for energy production within cells.

- **Norepinephrine** – underlies fight-or-flight response

Increases HR, triggers release of glucose from energy stores, & increases blood flow to skeletal muscles. Can also suppress neuroinflammation.

Adrenal Cortex (outer)

Produce 2 types of corticosteroids (promote Na retention & K excretion) & make it possible for the body to adapt to all types of stress.

- **Glucocorticoids (cortisol)** – influenced by ACTH
Influence on electrolytes and metabolism of CHO, P, & fat; and muscle & blood cell activity.
Cause Na reabsorption from the kidney = water retention, K loss, & increased BP.

Cortisol (main glucocorticoid) has anti-inflammatory, antiallergic & antistress effects. Elevates BG levels.

Decreased serum cortisol → increase ACTH secretions → stimulate adrenal glands to secrete & release cortisol.

SE (from high doses or prolonged use of glucocorticoids): increased blood sugar, “moon face” and “buffalo hump”, decreased extremity size, muscle wasting, edema, Na & H₂O retention, hypertension, psychosis, thinned skin with purpura, glaucoma, peptic ulcers, growth retardation.

Problems:

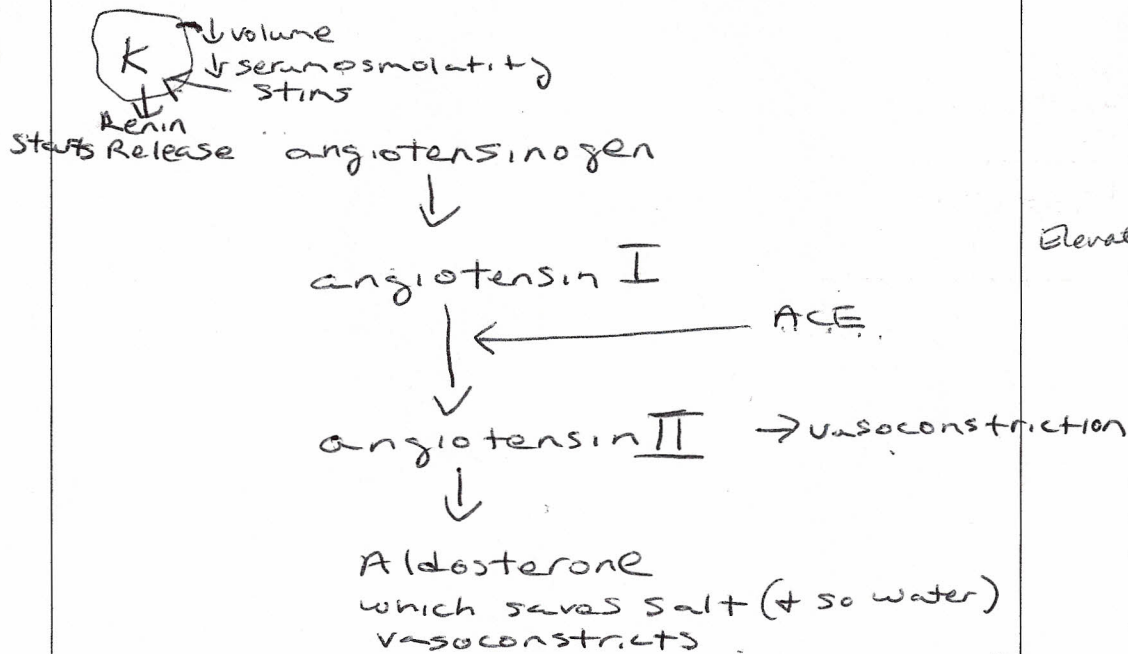
Adrenocortical Insufficiency “Addison’s Disease”

- Deficiency of glucocorticoids & sometimes mineralcorticoids.
- Causes: TB & histoplasmosis (infection that affect the lungs) are most common infections that destroy adrenal gland tissue; Autoimmune destruction is primary cause of Addison’s; L/T high dose steroid therapy; damage to adrenals from necrosis, sepsis, hemorrhage.
- Characteristics: muscle weakness, fatigue, hyperpigmentation,

↓ Na ↓ aldosterone
↑ K

Renin angiotensin aldosterone System

RAAS



↓ Na causes cerebral edema

- orthostatic hypotension, low BG, low serum Na, high serum K, mental changes, confusion, chronic dehydration. GI symptoms
- Confirmed by labs: increased plasma ACTH (>22.0 pmol/L) & decreased serum cortisol (<165 pmol/L), hypoglycemia, hyponatremia, hypercalcemia, & increased WBC (leukocytosis).
- Tx: fluid replacement, oral hormone therapy (long acting glucocorticoids). stabilize electrolyte imbalance

Adrenal Crisis (Severe hypo) Sudden ↓ adrenal hormones caused by acute stress

- Severe decrease in production of cortisol.
- S/S: N, V, severe fluid & electrolyte imbalance, tachycardia, dysrhythmias, seizures, coma, death.

Elevate legs, restore fluids, hydrocortisone IV, antibiotics for infection prep, adrenal glands

- Cushing's Syndrome** hypokalemia
- Hypersecretion of glucocorticoids (cortisol) & androgens.
 - Characteristics: central obesity, buffalo hump/kyphosis, muscle wasting, osteoporosis, backache, moon face, oily skin, susceptibility to infection, hyperglycemia, weight gain, slow healing of cuts, bruises, virilization, & change in mood or mental activity. HTN
 - More often in women 20-40 yrs.
 - Diagnostic: dexamethasone suppression test
 - Indicators: increase in serum Na & BG, decrease in serum K, decrease in eosinophils, & disappearance of lymphoid tissue.
 - Tx: removal of tumor, radiation therapy, drug therapy.



- **Mineralcorticoids (aldosterone):** Increases Na absorption in exchange for excretion of K & H.

Controlled by the renin-angiotensin system:

Angiotensin II in the bloodstream → elevates BP by constricting arterioles → renin released from the kidney in response to decreased perfusion → increased aldosterone levels to promote Na reabsorption by kidneys & GI tract to restore BP to normal.

Hypovolemia → aldosterone secreted to increase Na & H₂O retention and restore fluid balance. (decrease in systolic pressure (20 mm Hg or more)

Severe decrease in aldosterone = hypotension, vascular collapse.

Primary Aldosteronism ("Conn's Syndrome")

Hypersecretion of aldosterone.

Hypokalemia, decline in H (alkalosis), increase in pH, and increase in $\text{HCO}_3 \rightarrow$ metabolic alkalosis

HTN is most prominent sign.

Goals: reverse HTN, correct hypokalemia, prevent kidney damage.

- **Androgens** (mostly testosterone, some estrogen)
Secondary sex characteristics

PANCREAS

Exocrine <i>HCO₃</i>	Endocrine <i>Somatostatin</i>
<i>(pancreatic)</i> Secretes digestive enzymes into the duodenum.	Cell clusters "Islets of Langerhans" Alpha: produce glucagon (breaks glycogen to glucose in the liver) Beta: secrete insulin (regulates glucose metabolism)