ADRENAL GLANDS

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LSU Health Shreveport | CLPC Spring 2025

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OVERVIEW

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- Physiology
- Adrenal Medulla
- Adrenal Cortex
- Wrap-up

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OBJECTIVES

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1. Identify hormones produced by the adrenal glands.
2. Describe Addison's disease.
3. Describe Cushing syndrome.

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ADRENAL GLANDS

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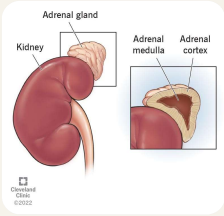
- Small, triangle-shaped glands located on the top of each kidney
- Composed of two main parts:
  1. Adrenal cortex
  2. Adrenal medulla



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ADRENAL MEDULLA

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ADRENAL MEDULLA

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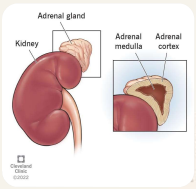
- Inner part of the adrenal gland
- Extension of the autonomic nervous system
- Produces **catecholamines** – adrenaline and noradrenaline
  - Regulate body's response to acute, short-term stress
  - Acts within seconds
  - "Fight-or-flight"



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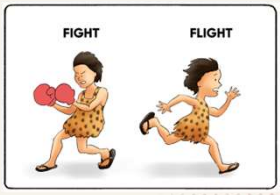
FIGHT-OR-FLIGHT

- The body's response to a stressful situation
- Brain perceives the danger → nerves send signal down the spinal cord → neurotransmitter (NT) norepinephrine sends signal out to the body → NT norepinephrine causes rapid body reactions in the eyes, skin, heart, muscles, liver, and airways → NT norepinephrine reaches adrenal gland → triggers hormones to be released



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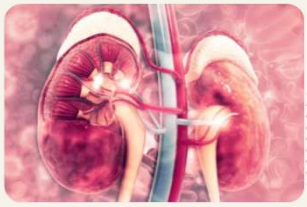
CONDITIONS & DISORDERS

- Rare, but can be life-threatening
- Tumors include:
  1. Ganglioneuroma
  2. Neuroblastoma
  3. Paraganglioma
  4. Pheochromocytoma
     - Hypertensive crisis



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CONDITIONS & DISORDERS

- People with abnormally high adrenal medulla hormones may experience:
  - Addiction
  - Anxiety
  - ADHD
  - Depression
  - Panic disorder
  - PTSD

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PHEOCHROMOCYTOMA

- Rare tumor that grows in an adrenal gland
- Most often benign
- Hypersecretion of epinephrine and norepinephrine
- Exact cause unknown, but may have a genetic component
- Found in people between ages of 20 & 50
- Family history increases risk

- Signs & symptoms:
  - High blood pressure
  - Headache
  - Heavy sweating
  - Rapid heartbeat
  - Nervous shaking
  - Pallor
  - Shortness of breath
  - "sense of doom"
  - Vision problems
  - Weight loss

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PHEOCHROMOCYTOMA

- Symptom "spells" or "attacks"
  - physical hard work, anxiety, stress, changes in body position, labor and delivery, surgery and anesthesia, food high in tyramine, and medications
- Organ damage from high blood pressure → dangerous health conditions
- Diagnosis: 24-hour urine test, blood tests, genetic testing, imaging
- Treatment:
  - dependent on symptoms, severity of condition, age, and overall health of patient
  - Surgery and/or medications

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HOW TO TAKE CARE OF YOUR ADRENAL MEDULLA

- Exercise regularly and living a healthy lifestyle
- Get an adequate amount of sleep
- Eating a diet rich in nutrients
- Consuming plenty of water
- Manage stress
- Listening to music or doing something that brings joy
- Receiving preventative care

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ADRENAL CORTEX

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ADRENAL CORTEX

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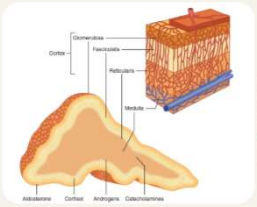
- Outer part of the adrenal gland
- Takes up 85% of adrenal gland tissue
- Three distinct zones – *glomerulosa, fasciculata, and reticularis*
- Three types of **steroid hormones** produced in the adrenal cortex
  - Hormones synthesized from cholesterol
  - Support vital organ function



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CONDITIONS & DISORDERS

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- Conditions can be:
  - Functional → causing abnormally high hormone levels
  - Nonfunctional → no hormone production
- Disorders & conditions include:
  - **Addison's disease (adrenal insufficiency)**
  - Adrenal tumors
  - Adrenocortical carcinoma
  - **Congenital adrenal hyperplasia (CAH)**
  - **Conn's syndrome (primary aldosteronism)**
  - **Cushing syndrome (hypercortisolism)**
  - Hyperaldosteronism
- Symptoms affect:
  - Appetite
  - Blood pressure
  - Blood sugar
  - Heart health
  - Mood
  - Muscle strength
  - Skin
  - Weight

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ADRENAL CORTEX G-ZONE

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ADRENAL CORTEX G-ZONE

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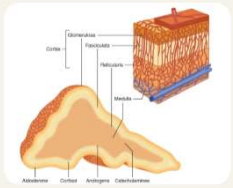
I **Zona Glomerulosa** (G-zone)
- Outer 15% of the cortex
- Mineralcorticoids: **aldosterone**
- Function:
  - Electrolyte balance (sodium reabsorption and potassium excretion)
  - Blood pressure regulation
- Aldosterone is regulated by the renin-angiotensin-aldosterone system (RAAS)



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ALDOSTERONE

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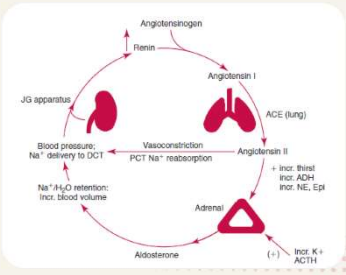
Function

Regulate blood pressure by managing the levels of Na^+ and K^+ in the blood.

Regulated by

Renin-angiotensin-aldosterone-system (RAAS)



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PRIMARY ALDOSTERONISM (PA)

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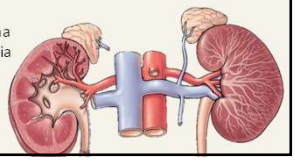
- Conn's syndrome
- Excessive secretion of aldosterone that can't be suppressed with salt or volume replacement
- Hypernatremia, hypokalemia = electrolyte imbalance
- Symptoms: high blood pressure, headache, muscle weakness, extreme thirst, frequent urination
- Causes of PA
  - Aldosterone-producing adrenal adenoma
  - Unilateral or bilateral adrenal hyperplasia
  - Familial hyperaldosteronism
  - Ectopic aldosterone secretion



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PRIMARY ALDOSTERONISM (PA) DIAGNOSIS

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- Tests: plasma aldosterone concentration (PAC) & plasma renin activity (PRA)
- PAC >15 ng/dL AND PAC/PRA ratio of 30 or greater suggestive of PA
- 2008 Endocrine Society guidelines:
  - Draw labs in the morning after patient has been up for at least 2 hours
  - Patient should be seated for 5-15 minutes before the draw
  - Unrestricted sodium intake
- Initial screening suggests PA? Confirm with aldosterone measurement following either oral salt loading or IV saline infusion.
- Follow biochemical evaluation with adrenal imaging.

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PRIMARY ALDOSTERONISM (PA) TREATMENT

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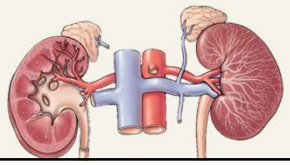
- Aldosterone-producing adenoma → surgery
- Adrenal hyperplasia → mineralocorticoid antagonists
- Familial hyperaldosteronism → prednisone



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HYPOALDOSTERONISM

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- Lower than normal aldosterone levels
- Lack of or impaired function of aldosterone
- Low levels of aldosterone = hyponatremia, hyperkalemia, metabolic acidosis
- Can be caused by several conditions:
  - **Addison's disease (primary adrenal insufficiency)**
  - **Congenital adrenal hyperplasia (CAH)**
  - Health conditions such as diabetes, kidney disease, lead poisoning
  - NSAIDs, heparin, medications to treat heart failure
- Symptoms: low blood pressure (hypotension), muscle weakness, nausea, heart palpitations, arrhythmia

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ADDISON'S DISEASE

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- **Primary adrenal insufficiency**
- Rare and chronic condition
  - Affects 1 in 100,000 people in the U.S.
- Affects people of all age groups, most commonly people 30 to 50
- People with type 1 DM, pernicious anemia, Graves' disease, chronic thyroiditis, myasthenia gravis are at a higher risk for developing Addison's

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ADDISON'S DISEASE SYMPTOMS

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- Steadily worsening fatigue
- Hyperpigmentation
- Abdominal pain, nausea, and vomiting
- Diarrhea
- Loss of appetite
- Unintentional weight loss
- Muscle pain, muscle spasms, and/or joint pain
- Dehydration
- Low blood pressure
- Mood and behavior changes
- Craves salty food
- Low blood sugar
- Females – abnormal menstruation and lose body hair

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ADDISON'S DISEASE ADDISONIAN CRISIS

- Life threatening event
- Medical emergency
  - If not treated, can lead to shock and death
- Symptoms of Addisonian crisis:
  - Extreme weakness
  - Sudden, severe pain in lower back, belly, or legs
  - Mental changes
  - Severe vomiting and diarrhea
  - Low blood pressure
  - Loss of consciousness

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ADDISON'S DISEASE CAUSES

- Autoimmune response
  - ↓ Aldosterone and cortisol
  - Symptoms develop after 90% of the cortex has been damaged
  - ~75% of cases
  - May happen by itself or as part of a rare, inherited syndrome
- Tuberculosis
- Repeated infections
- Cancer cells from another part of the body invade the adrenal glands
- Bleeding into adrenal glands
- Surgical removal of adrenal glands
- Amyloidosis

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ADDISON'S DISEASE DIAGNOSIS & TREATMENT

- Delayed diagnosis
- Testing: blood tests, ACTH stimulation tests, Insulin-induced hypoglycemia test, imaging
  - ↓ cortisol, ↓ aldosterone, ↑ ACTH
- Treatment: Lifelong hormone replacement therapy

Outlook
- Good prognosis
- Medication dosage needs to be closely monitored to prevent over- or under-treatment

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CONGENITAL ADRENAL HYPERPLASIA (CAH)

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- Group of genetic disorders
- Enzyme deficiencies
  - May not produce enough cortisol
  - May not produce enough aldosterone
  - May produce too much androgen
- Classic CAH
  - Salt-wasting CAH
  - Non-salt wasting CAH
- Nonclassic CAH

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ADRENAL CORTEX F-ZONE

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ADRENAL CORTEX F-ZONE

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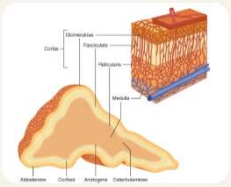
Zona Fasciculata (F-zone)
- Middle 75% of the cortex
- Glucocorticoids: **cortisol**
- Function:
  - Blood sugar regulation
  - Modulates immune system
  - Regulates the metabolism of fat, protein, and carbohydrates
- Cortisol is regulated by adrenocorticotropic hormone (ACTH)



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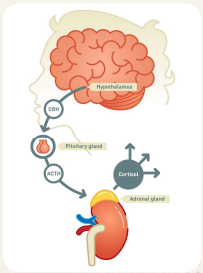
CORTISOL

Functions

- Helps body respond to stress
- Regulates metabolism
- Regulate body response to inflammation
- Regulate blood pressure
- Regulate blood sugar
- Regulates sleep-wake cycles

Regulated by

Adrenocorticotropic hormone (ACTH)



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HOW TO REDUCE CORTISOL

- Get quality sleep
- Exercise regularly
- Learn to limit stress and stressful thinking patterns
- Practice deep breathing exercises
- Enjoy yourself and laugh
- Maintain healthy relationships

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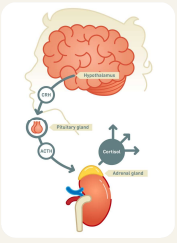
CUSHING SYNDROME vs DISEASE

Syndrome

- A constellation of clinical abnormalities caused by chronic high blood levels of cortisol or related corticosteroids



Disease

- Is Cushing syndrome that results from excess pituitary production of adrenocorticotropic hormone (ACTH) secondary to a pituitary adenoma

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CUSHING SYNDROME:
DEPENDENT OR INDEPENDENT?

1. **ACTH-dependent hyperfunction**
   May result from:
   - Cushing disease
   - Ectopic ACTH syndrome
   - Administration of exogenous ACTH

2. **ACTH-independent hyperfunction**
   Usually results from:
   - Therapeutic administration of corticosteroids
   - Adrenal adenomas or carcinomas

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CUSHING SYNDROME

Signs & Symptoms:
- Central obesity
- "Moon face"
- "Buffalo hump"
- Purple striae
- Muscle weakness
- High blood sugar
- High blood pressure
- Excessive hair growth
- Weak bones & fractures
- Easy bruising

Cushing Syndrome - Endocrine and Metabolic Disorders - MSD Manual Professional Edition

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CUSHING SYNDROME DIAGNOSIS

- Diagnosis is complicated; signs may be associated with other disorders
- Diurnal variation
  - Highest concentration between 6a-8a
  - Lowest concentration between 10p-12a
- Diagnosis: Urinary free cortisol measurement, Dexamethasone suppression test, Midnight cortisol measurements, Plasma ACTH measurement, imaging
  - ↑ 24° free cortisol, ↑ serum cortisol
  - ↑ ACTH (ACTH-dependent) or ↓ ACTH (ACTH-independent)

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CUSHING SYNDROME TREATMENT & OUTLOOK

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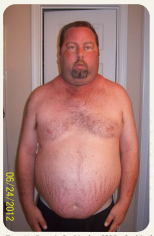
- Treatment depends on underlying cause
  - Glucocorticoid use → decrease med or prescribe non-glucocorticoid medication
  - Tumor → surgery or radiation
  - Hypercortisolism after surgery → medical therapy
- Outlook
  - Usually curable
  - Lengthy treatment
  - Without proper treatment, Cushing syndrome will worsen. Can be fatal.



Tony H., Ectopic Cushing's - CSRF - Cushing's Support & Research Foundation

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ADRENAL CORTEX R-ZONE

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ADRENAL CORTEX R-ZONE

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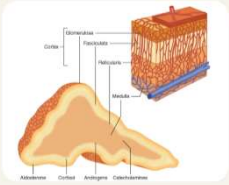
Zona Reticularis (R-zone)
- Inner 10% of the cortex
- Adrenal androgens: **DHEA**
  - Precursor
- Function:
  - development of secondary sexual characteristics
- Regulated by adrenocorticotropic hormone (ACTH)



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ADRENAL ANDROGENS

- Regulated by ACTH
- Primary hormone produced – DHEA
- DHEA sulfated to DHEA-S by sulfotransferase
  - Secreted daily
- DHEA & DHEA-S → precursors
  - Minimal androgenic activity
  - Adverse effects caused by conversion to active androgens
- Men: <5% of testosterone from adrenal or peripheral sources
- Women: 40-65% of testosterone from adrenals

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ANDROGEN EXCESS

- Stimulate organ development, linear growth, and epiphyseal fusion. Excess may cause:
  - Precocious puberty
  - Premature sexual maturation
  - Exaggerated male characteristics
  - Virilization
  - Short stature
  - Amenorrhea & infertility
  - Hypogonadal symptoms

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ANDROGEN EXCESS DIAGNOSIS

- <10% of DHEA and DHEA-S produced in gonads
  - ↑ DHEA-S and DHEA suggest adrenal hyperandrogenism
  - ↑ testosterone seen with adrenal or gonadal hyperandrogenism
- Plasma DHEA-S, DHEA, urinary 17-ketosteroids

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WRAP-UP

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RECAP

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- Adrenal gland has two parts: medulla and cortex
- Medulla produces catecholamines which are released in response to acute, short-term stress. Catecholamines include epinephrine and norepinephrine.
- Cortex has three structurally and functionally different zones. The glomerulosa produces aldosterone which is regulated by RAAS; fasciculata produces cortisol which is regulated by ACTH; reticularis produces androgens also regulated by ACTH.

- Pheochromocytoma → excessive epinephrine and norephinephrine
- Conn's syndrome → excessive aldosterone
- Addison's disease → aldosterone deficiency
- Cushing syndrome → chronic high cortisol

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TAKING CARE OF YOUR ADRENALS

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- Prioritize sleep and rest
- Adopt a balance, anti-inflammatory diet
- Incorporate adaptogenic herbs
- Stay hydrated with electrolytes
- Manage stress through mindfulness practices
- Supplement wisely
- Exercise in moderation
- *Bonus tip: Build a consistent routine*

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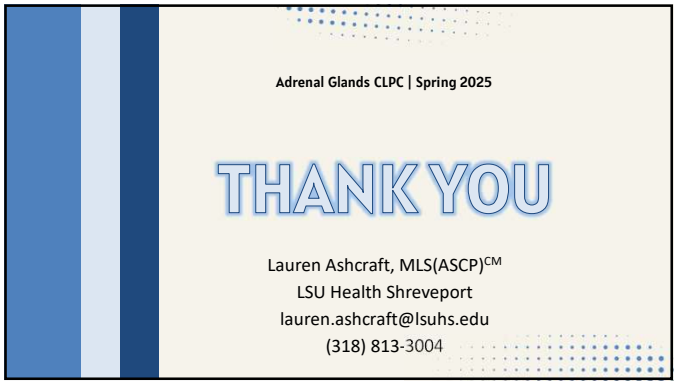
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