ADRENAL GLAND

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Introduction

- Among most important and vital endocrine organ
- Small bilateral yellowish retroperitoneal organ
- Lies just above kidney in gerota’s fascia
The Adrenal Gland

Anatomy was first described in 1563.
Is located above (or attached to) the upper pole of the kidney.
Is pyramidal in structure and weights about 4-5 grams.
Consists of the adrenal cortex and adrenal medulla
Activities are regulation of fluid volume and stress response
Anatomy

- Right adrenal is triangular, related to upper pole Right kidney
  - Size : 3 - 6cm long, 0.9 – 3.6cm
  - Weight : 3-5 gm app
  - Width : 2-3 cm

- Left adrenal is crescent shaped, related to upper and medial part Left kidney
Adrenal Histology
Adrenal Cortex

- Is divided into 3 zones in the adult gland:
  - Zona Glomerulosa,
  - Zona Fasciculata,
  - Zona Reticularis.

- Is divided onto 4 zones in the fetal gland.

- The three zones of the permanent cortex constitutes only 20% of the fetal gland’s size.
- The remaining zone (fetal cortex) comprises up to 80% of gland’s size during fetal life.
Adrenal Cortex: Steroid Hormone Production

- Aldosterone, sex hormones, cortisol
- Synthesized from cholesterol—steroid ring
Adrenal Cortex: Steroid Hormone Production

**Adrenal steroids**

ACTH → Ketoconazole

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<th>Steroid</th>
<th>Synthesis Pathway</th>
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<td>Cholesterol</td>
<td>Desmolase → Pregnenolone → 3α-HSD → Progesterone → 17α-HSD → Androstenedione → 17β-HSD → Estrone</td>
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**Adrenal Cortex**

Cholesterol → DHEA → Testosterone → DHT → Estrone → Estradiol

**KEY**

DHEA = dehydroepiandrosterone

**Congenital Adrenal Hyperplasia**


B = 21α-Hydroxylase deficiency. Most common form. 1: cortisol (increased ACTH), 2: mineralocorticoids, 3: sex hormones. Cx = hypertension, male pseudohermaphroditism, HypeRension, hyperaldosteronism, plasma renin activity, and volume depletion. Salt wasting can lead to hypovolemic shock in the newborn.

C = 11β-Hydroxylase deficiency. 1: cortisol, 2: aldosterone and corticosterone, 3: sex hormones. Cx = masculinization, HypeRension (11β-deoxycortisol is a mineralocorticoid) and is secreted in excess.

*All congenital adrenal enzyme deficiencies are characterized by an enlargement of the adrenal glands due to an ↑ in ACTH stimulation.*
Adrenal Cortex

Region of adrenal gland
- Adrenal medulla
  - Zona reticularis
- Adrenal cortex
  - Zona fasciculata
  - Zona glomerulosa
  - Capsule

Secretes
- Catecholamines
- Sex hormones
- Glucocorticoids
- Aldosterone

Adrenal Cortical Pathway

Cholesterol → Progesterone → 17α-Hydroxyprogesterone → Androstenedione → Testosterone → Aldosterone

Mineralocorticoid Pathway

Cortisol → 11-Deoxycorticosterone → 18-Hydroxy corticosterone

Glucocorticoid Pathway

Corticosterone → 11-Deoxycorticol → Androstenedione
Adrenal Medulla

phenylethanolamine-N-methyltransferase

Norepinephrine → Epinephrine

Physiology

• Adrenal cortex produces

  - Glucocorticoids (Zona Fasciculata)
  - Mineralocorticoids (Zona Glomerulosa)
  - Adrenal androgens (Zona Reticularis)
**Physiology**

- Adrenal medulla produces
  - Epinephrine (adrenaline)
  - Norepinehrine (noradrenaline)

- Help increase cardiac output, vascular resistance and mediate stress response

- All are absolutely required for life

**Functions**

- Aldosterone helps in Na reabsorption & potassium excretion & preventing dehydration

- Cortisol stimulate protein breakdown, inhibition of tissue response in injury & antagonism to action of insulin

- Androgens helps in early development of male sex organ in childhood
Functions

- Nerve signal
- ACTH
- Epinephrine
- Increased heart rate, breathing rate, blood sugar
- Liver releases glucose

Adrenal Glands

Corticotropin-Releasing Hormone (CRH)

Simulated by:
- Plasma Cortisol Level
- Hypoglycemia
- Pyrogens, and Stress

Suppressed by:
- Plasma Glucocorticoid Level

Corticotropin (ACTH)

- Adrenal Cortex
- Addison's Disease
- Cushing's Disease
- 17-Hydroxysteroids
- Free Cortisol
- 17-Ketosteroids

Liver
Cortisol Effects: Body Responses to Stress

- Permissive effect on glucagon
- Memory, learning & mood
- Gluconeogenesis
- Skeletal muscle breakdown
- Lipolysis, calcium balance
- Immune depression
- Circadian rhythms

Figure 23-4: Circadian rhythm of cortisol secretion
Control of Cortisol Secretion: Feedback Loops

- External stimuli
- Hypothalamic
- Anterior Pituitary
- Adrenal cortex
- Tissues

Cortisol: Role in Diseases and Medication

- Use as immunosuppressant
  - Hyperimmune reactions (bee stings)
  - Serious side effects
- Hypercortisolism (Cushing's syndrome)
  - Tumors (pituitary or adrenal)
  - Iatrogenic (physician caused)
- Hypocortisolism (Addison's disease)
Aldosterone

- Exclusively synthesized in Z. Glomerulosa
- Essential for life.
- Promotes sodium retention and Potassium elimination by the kidney.
- Expands ECF volume
Aldosterone: Role in diseases

• Complete failure to secrete aldosterone leads to death (dehydration, low blood volume).

• Hyperaldosterone states: Contribute to hypertension associated with increased blood volume.

Adrenal Medulla: A Modified Sympathetic Ganglion

• Sympathetic stimulation
  ▫ Catecholamine release to blood
    • Epinephrine
    • Norepinephrine
  ▫ Travel to:
    • Multiple targets
    • Distant targets
Adrenal Medulla: A Modified Sympathetic Ganglion

Mechanism: Norepinephrine Release and Recycling

Figure 11-10: The adrenal medulla

Figure 11-9: Norepinephrine release at a varicosity of a sympathetic neuron
Review of Efferent Pathways: Motor & Autonomic

Catecholamines: Activity

- Stimulates the “fight or fight” reaction
- Increased plasma glucose levels
- Increased cardiovascular function
- Increased metabolic function
- Decreased gastrointestinal and genitourinary function
Aldosterone

*MOA:* transcription of enzymes and proteins

*Major actions:* ↑ Na reabsorption in distal tubule

*Extrarenal effects:* Na reabsorption in saliva, sweat, stool
Hypersecretion of Aldosterone

1° aldosteronism – Conn’s syndrome

2° aldosteronism – liver/kidney disease

SXS: hypertension

hypokalemia

metabolic alkalosis

Primary Hyperaldosteronism

↑Aldosterone → ↑Na retention → [↑ECF volume + ↑Renal perfusion pressure] →

↓Renin

Secondary Hyperaldosteronism

↑Na

retention ↓Renal perfusion → ↑Renin → ↑Aldosterone →

↑ volume → ECF
Pathophysiology

**Hyposecretion of Aldosterone**

1° hyposecretion – Addisons’ dse
2° hyposecretion – kidney damage

SXS: hypovolemia
    hyponatremia
    hyperkalemia

Happy New Year!!!
Anatomy

The Adrenal Gland

Anatomy

Adrenal gland with adrenal medulla and adrenal cortex labeled. Diagram illustrating sympathetic pathway with neurotransmitters and blood vessels labeled.
Conn's syndrome [adenoma adrenal glands]

**Biologic Actions - Glucocorticoids**

- Stress response
  - Increased vascular tone
- Immunosuppressive and anti-inflammatory actions
- Fat cells
  - Increased lipolysis
- Connective tissue
- Connective tissue and other tissues
- Increased mobilization of glycogen and fatty acids
- Liver
  - Increased ammonia production, gluconeogenesis, glycogen storage, and enzyme activity
  - Increased mobilization of amino acids