**Adrenal gland**

*Notes prepared by: Dr. Jonali Devi*

Adrenal gland is a paired organ located adjacent to the kidney, so named as “adrenal” or suprarenal (situated upper pole of the kidney). Adrenal medulla is developed from neural crest, which gives origin to sympathetic nervous system. Adrenal cortex is developed from the mesonephrone, which gives rise to renal tissues. In bird, the gland is single, not paired. Having 2 distinct parts:

1) **Adrenal cortex:** Outer layer (80%). Having 3 distinct layers:
   i) Zona glomerulosa (outer layer) - secret mineralocorticoids, helps in metabolism of the electrolytes or minerals of the extracellular fluid specially Na and K.
   ii) Zona fasciculate (middle layer) - secret glucocorticoids (major secretion), small amount of sex steroids also secreted.
   iii) Zona reticularis (inner layer) – secret sex steroids, slight amount glucocorticoids also secreted.

Mineralocorticoids are: 11 deoxycorticosterone and aldosterone

Glucocorticoids are: Cortisol, corticosterone, cortisone and hydrocortisone

Sex steroids are: dehydroepiandrosterone, androstenedione, testosterone, estrogen and progesterone

2) **Adrenal medulla:** inner layer (20%)
   - Abel (1902), called father of pharmacology, first to crystallize the hormone epinephrine from adrenal medulla
   - In 1904, epinephrine is synthesized by Stolz and Dakin, first hormone to be chemically identified and synthesized.
   - In 1910, Nor-epinephrine is discovered and synthesized by Barger and Dale.

Adrenal medulla have chromaffin cells which secret adrenaline (90%) and nor-adrenaline (10 %). Another hormone secreted from adrenal medulla is dopamine (type of cell secreting dopamine is not known). These three hormones are called catecholamines (because they are derivatives of catechol).

**Synthesis, transport and fate of adrenocortical hormones:**

All adrenocortical hormones are steroid in nature and they are derivatives of cholesterol (from blood, some produce within the cortical cell from acetate).

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Acetate
   ↓
Cholesterol
      ↓
Pregnenolone
           ↓
17-hydroxyl progesterone  Progesterone
                          ↓
Cortisol  11-deoxy corticosterone  Dehydroepiandrosterone
               ↓
Cortisone  Corticosterone  Androstenedione
                   ↓
Aldosterone  Testosterone  →  Estrogen
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**Transport:** Aldosterone + Plasma protein (globulin)

Cortisol + plasma protein (cortisol binding globulin or transcortin)

**Fate:** degraded mainly in the liver, excreted in bile & faeces.

**Functions of different hormones:**

**Mineralocorticoids:** are also called “life saving hormone” (mainly aldosterone)

Mineralocorticoids causes reabsorption of Na+ and excretion of K+ in the renal tubule. It also increases secretion of H+.

**Regulation of secretion:**

![Regulation of aldosterone secretion by the renin–angiotensin–aldosterone (RAA) pathway.](image)

Loss of aldosterone causes death within 3 days to 2 weeks because, due to lack K⁺ in ECF and decrease Na⁺ and Cl⁻ rapidly, so water volume decrease, so total blood volume and ECF volume also decrease rapidly, which causes cardiac dysfunction, ultimately leads to shock like state and finally death occurs.

It helps in Maintenance of blood pressure. It also increases Na⁺ reabsorption in sweat gland as well as in the colon.
Function of glucocorticoids: It is called life protecting hormone, because it helps in withstand the stress and trauma in life.

a) **It increases blood glucose level:** Cortisol causes hyperglycemia, glucosuria and adrenal diabetes by increasing gluconeogenesis in liver from amino acid and by decreasing glucose uptake and utilization by peripheral cells. This is called **ANTI-INSULIN LIKE EFFECT** or antagonistic action.

b) **Effect on protein metabolism:** It decrease protein in cell and increase plasma amino acid and protein content in the liver by
i) Except liver, protein synthesis reduced by inhibiting amino acid transport into the cell and inhibition of formation of RNA.
ii) Same time protein catabolism increase causes release of amino acid from the tissue
iii) Transport of amino acid into hepatic tissue.
So, hypersecretion of glucocorticoids, there is reduction in growth occur (mobilization of protein from other tissue into the liver causes decrease growth as well as muscular wasting and negative N₂ balance).

c) **Effect on fat metabolism:** It causes mobilization and redistribution of fat by
i) Fatty acid mobilize from adipose tissue
ii) Concentration increase in the blood
iii) Utilization of fat for energy is increased.
Sometimes ketone bodies are found called ketogenic effect.

d) **Action against stress:** A CTH secreted immediately causes secretion of glucocorticoids, which causes
i) immediate release of amino acid for synthesis of new protein essential for cellular function.
ii) Fatty acid release supply of more energy.
iii) Increase vascular reactivity to catecholamines
iv) Prevent severing of other changes caused by stress.

e) **Anti-inflammatory effect:**

i) Inflammatory reaction (heat, redness, swelling etc.) are reduced
ii) It suppress the activity of fibroblast and formation of granulomus
iii) Prevent histamine and proteolytic enzyme release from affected tissue
iv) Reduction of capillary permeability, so that loss of plasma fluid in to affected tissue is prevented.
v) Inhibition of leucocyte migration in to affected areas
vi) Supression of T cells and other leucicocyte so that there is reduction of recation on tissue.
vii) If inflammation occurs, it causes early resolution and rapid healing

f) **Other functions:** Maintain mineral metabolism, water metabolism, on muscle (release of amino acid from muscle), on blood cells (increase neutrophil, RBC and platelets & decrease eosinophil, basophil and lymphocyte), alti-allergic reaction and immunosuppressive effect (decrease T lymphocyte used in organ transplantation to prevent immunological reaction).
Adrenal-medullary hormones:

Catecholamines: adrenaline, nor-adrenaline and dopamine

These hormones are derived from amino acid tyrosine.
Functions:

1. Emergency theory was articulated by Cannon (1932), commonly referred as” fight and flight” hypothesis.

   It is a coordinated result of increased output of adrenal medullary secretions or in increased activity of the sympathetic nervous system. The reaction establishes in the body the optimal condition for defense of the animal’s life, whether to stand or to run away.

2. General metabolism: Increase oxygen consumption and CO₂ release. Increase BMR.
3. Carbohydrate metabolism: Increase blood glucose level.
4. Fat metabolism: mobilization of fatty acid.
5. NE- circulatory adjustment; E- metabolic changes
6. Both hormones decrease renal blood flow and causes constriction of skin capillaries (thereby causes pallor)
7. NE causes vasoconstriction except coronary artery
8. On skeletal muscle: causes glucogenolysis and formation of lactic acid during energy release.