**Lecture # 14**

**Endocrine System:**

Endocrine system is a collection of glands that produce hormones that regulate body's growth, metabolism, and sexual development and function. The hormones are released into the bloodstream and transported to tissues and organs throughout the body. Although there are eight major endocrine glands scattered throughout the body, they are still considered to be one system because they have similar functions, similar mechanisms of influence, and many important interrelationships.

- Endocrine glands are known as the “Managers of Human Body”.
- Endocrine system is the system in which a number of glands secretes numerous hormones directly into the bloodstream which regulate:
  - Body’s growth
  - Metabolism
  - Sexual development and functions, and
  - Other vital functions of the body

Endocrine glands are ductless glands that secrete their hormones directly into the bloodstream.

- Hormones act as chemical messenger controlling various functions, reaching to the tissues and other vital organs of the body.

1. **Pineal Gland:**
   - The pineal gland, also known as pineal body, is found in the brain stem.
   - It is small and cone-shaped in structure
   Main function:
   - Affects reproductive development
   - Daily physiologic/ biological cycles

2. **Pituitary Gland:**

   ➢ **Size and shape:**
   It is a small gland diameter of about 1 centimeter or size of a pea.

   ➢ **Location:**
   - It is connected with the hypothalamus by a slender stalk and also surrounded by bone.
   - Secretes a number of different hormones that influence/affect various other endocrine glands.
   - There are two distinguishable regions in the gland that have different secretions and functions:
     a. The anterior lobe
     b. The posterior lobe

   a. **Hormones of Anterior Lobe:**
   i. **Growth Hormone:** Protein that regulates and also stimulates the:
O growth of bones,
O muscles, and other organs of the body by promoting protein synthesis.
• The effect of this hormone is important and very much apparent because it affects height.

**Growth Hormonal Problems:**

**Dwarfism:**
If there is very little or no secretion of this hormone in a child, then the child may become a pituitary dwarf—small in stature.

**Gigantism:**
• If there is too much secretion of this hormone in the body, then there is exaggerated bone growth in a person and the person become exceptionally tall or a giant.
• This rare condition is usually caused by a pituitary tumor and can be treated by removing the tumor.
• When the pituitary gland fails to produce adequate amounts of growth hormone, a child's growth in height is impaired/disturbed.

• Hypoglycemia (low blood sugar) may also occur in children who have deficiency of this growth hormone—affects particularly infants and young children with this condition.

**ii. Thyroid-stimulating hormone:** Affects the glandular cells of the thyroid so that it secretes thyroid hormone. The thyroid gland become enlarged and secretes too much thyroid hormone if there is hyper secretion of thyroid-stimulating hormone.

**iii. Adrenocorticotropic hormone:** Cortical hormones especially cortisol are secreted when it reacts with the receptor cells in the cortex of the adrenal gland.

**iv. Gonadotropic hormones:** Regulate the development, growth, and function of gonads and ovaries by reacting along with receptor cells present in these organs.

iv. **Prolactin Hormone:** Helps in promoting the development of glandular tissues in the female breasts during pregnancy and as a result stimulates milk production after the birth of the infant.

**b. Hormones of The Posterior Lobe:**
These hormones are:

i. **Antidiuretic hormone:**
• Helps in the reabsorption of water by the kidney tubules—as a result of which less amount of water is lost from the body as urine.
• This system/mechanism conserves water for the body.

ii. **Oxytocin:**
• Helps in the contraction of smooth muscles in the walls of the uterus.
• It also stimulates the ejection of milk from the lactating breast.

3. **Hypothalamus:**
• Part of the central nervous system that is involved in controlling and activating involuntary functions of the body such as,

O Hormonal system
O Other body functions as well—regulating sleep and stimulating appetite

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4. Thyroid Gland:

Type, Location and Lobes:

- Very vascular organ and is located in the neck.
- Consists of two parts/lobes, one on each side of the trachea, just below the larynx or voice box.
- These two lobes are connected by a narrow band of tissue, called the ‘isthmus’.
- This gland consists of follicles, which produce thyroxin and triiodothyronine hormones.
- These hormones contain iodine--- about 95% of most functioning hormone is thyroxin and the remaining 5% is triiodothyronine--- both require iodine for their synthesis.
- Secretion is regulated by a negative feedback mechanism.

Calcitonin
- Secreted by Parafollicular cells of the thyroid gland.
- Opposes the action of the parathyroid glands by reducing the calcium level in the blood.
- If calcium level in the blood becomes too high, calcitonin is secreted until calcium ion levels decreases to normal.

Iodine
Deficiency:

- Thyroid enlargement is called “goiter” or “iodine deficiency goiter”.
- If there is a deficiency of iodine in the body, then thyroid produce insufficient hormones required by the body--- causing the thyroid- stimulating hormone of the pituitary gland (anterior lobe) to secrete its hormone. This results in the increase in size of the thyroid gland but it is unable to make enough hormones, because it is lacking the raw material for production i.e. iodine.

5. Parathyroid Gland:

Location, Type, Amount, Hormone:

- Parathyroid gland consists of four small masses of epithelial tissue that are embedded in the connective tissue capsule, on the posterior side of the thyroid glands.
- Secretes ‘parathyroid hormone’ or ‘parathormone’.
- Most important regulator of blood calcium levels, secreted in response to low blood calcium levels, and its function is to increase calcium levels in the body.

Deficiency/insufficient secretion of parathyroid gland:

- Insufficient secretion of parathyroid hormone ‘hypoparathyroidisms’, leads to increased nerve excitability.
- Low blood calcium level in the body triggers spontaneous and continuous nerve impulses, which in turn stimulate muscle contraction.
6. **Pancreas--- Islets of Langerhans**

- A long, soft organ that lies transversely along the posterior abdominal wall, posterior to the stomach, and extends from the region of the duodenum to the spleen.

  a. **Exocrine portion** of this hormone secretes digestive enzymes that are carried by a duct to the duodenum.

  b. **The endocrine portion** consists of the pancreatic islets, and secretes glucagons and insulin.

**Alpha Cells in Pancreatic Islets**
Secrete hormone called ‘glucagons’ when there is a low concentration of glucose in the blood.

**Beta Cells in the Pancreatic Islets**
After the alpha cells, beta cells secrete hormone called ‘insulin’ as a result of high concentration of glucose in the blood.

6. **Adrenal Gland**

  ➢ **Synthesis and Location:**
  - Developed from different embryonic tissues, it secretes various hormones.
  - The adrenal/ suprarenal is a paired gland and located near the upper portion of each kidney.

**Division of Adrenal Gland:**

- Each gland is divided into two parts
  a. An outer cortex and
  b. An inner medulla

- The cortex and medulla of the adrenal gland are just like the anterior and posterior lobes of the pituitary gland.
- The adrenal cortex is essential to life because it has very important functions to perform, but the medulla may be removed with no life-threatening effects.
• Hypothalamus effects and influences both portions of the adrenal gland but it involves different mechanisms i.e. adrenal cortex is regulated by negative feedback which involves hypothalamus and adrenocorticotropic hormone.
• Medulla is regulated by nerve impulses of hypothalamus.

➢ **Hormones of the Adrenal Cortex:**
  • The adrenal cortex consists of three different portions/regions, each region produce different type of hormones.
  • Chemically, all these cortical hormones are steroid.

  a. **Mineralocorticoids:**
  • Secreted by the outermost region of the adrenal cortex.
  • The main/principal hormone of mineralocorticoid is aldosterone, which acts to store/conserve sodium ions and water in the body.

  b. **Glucocorticoids:**
  • Secreted by the middle region of the adrenal cortex.
  • The main/principal hormone of glucocorticoid is cortisol, which increases blood glucose/sugar level in the body.

  c. **Gonadocorticoids**
  • Also known as the sex hormones.
  • These are secreted by the innermost region of the adrenal cortex.
  • Adrenal cortex hormones, androgens (male hormones) and estrogens (female hormones), are secreted in minimal amounts in both sexes, but their effect is usually influenced by the hormones from the testes and ovaries.
  • In females, the masculinization effect may become more evident after menopause. This occurs because the estrogen levels from the ovaries decrease.

**Hormones of Adrenal Medulla:**
  • Develops from neural tissues.
  • Secretes two types of hormones,

  0 Epinephrine and

  0 Nor epinephrine

  • These are secreted in response to stimulation by sympathetic nerve, especially during stressful situations.
  • Lack of hormones from the adrenal medulla produces no significant effects,
  • Hyper secretion, e.g., in case of a tumor, results in prolonged or continual sympathetic responses.

**7. Gonads:**
  o Primary reproductive organs are testes in the male and the ovaries in the female.

  o These organs are responsible for producing the sperm and ova, but they also secrete other hormones, and that is why they are considered to be endocrine glands.

  a. **Testes:**
  • Male sex hormones (as groups) are called androgens of which the most important and influential is ‘testosterone’; secreted by the testes.
  • Small amount is also produced by the adrenal cortex.
• Production of testosterone begins before birth. i.e. during fetal development that continues for a short time after birth, nearly ceases during childhood, and then resumes at puberty.

• This steroid hormone is responsible for:
  O The growth and development of the male reproductive organs.
  O Increase in the size of skeleton and muscular growth.
  O Larynx enlargement, accompanied by voice changes.
  O Growth and distribution of body hair.
  O Increased male sexual drive.

• It’s secretion is controlled and regulated by a negative feedback system and involves release of hormones from the hypothalamus and gonadotropins from the anterior pituitary.

b. Ovaries:
• Two groups of female sex hormones are produced in the ovaries i.e.,

  O Estrogens and
  O Progesterone

• Contribute to the development and function of the female reproductive organs and sex characteristics

i. Estrogen:
• Estrogen (on the onset of puberty) activates/promotes:
  o Development of female bodily characteristics.
  o Distribution of fats in the body.
  o Maturation of reproductive organs.

ii. Progesterone:
Causes the uterine lining to become thick, preparing uterus for pregnancy.

• Together both progesterone and estrogen are responsible for a number of changes occurring in the uterus.

8. Other Endocrine Glands:
• In addition to the major endocrine glands and their system, there are various other organs, which are involved, in some hormonal activity or function. These include:

  i. Thymus
  ii. Stomach
  iii. Small intestines
  iv. Heart, and
  v. Placenta

  i. Thymosin:
Hormone produced by the thymus gland, which has an important role in the development of the body's immune system.

  ii. Gastrin:
• Gastric mucosa (lining of the stomach) produces a hormone, called gastrin that is secreted when the food is present in the stomach.
• Stimulates the production of ‘hydrochloric acid’ and the enzyme ‘pepsin’, which are involved in the digestion of food.

iii. **Secretin and Cholecystokinin**: The mucosa of the small intestine secretes these hormones.
  • Secretin stimulates the pancreas to produce a neutralizing agent—bicarbonate-rich fluid that neutralizes the stomach acid.
  **Cholecystokinin**
  • Stimulates contraction of the gallbladder, which result in the releases of bile.
  • Also activate the pancreas to secrete digestive enzyme.

iv. **Atrial Natriuretic Hormone, or Atriopeptin**:  
  • Heart also function as an endocrine organ
  • In addition to its major role of pumping blood, has special cells in the wall of the upper chambers of the heart ‘atria’, secretes hormone called atrial natriuretic hormone, or atriopeptin.

v. **Placenta**:  
  • Develops in the pregnant female
  • It is a source of nourishment and gaseous exchange for the developing fetus
  • Also serves as a temporary endocrine gland
  **Chorionic gonadotropin**: One hormone that placenta secretes in human beings.

**Diseases Resulting from Abnormal Secretion of Endocrine Glands**
  • Too much or too less secretions of endocrine glands can be harmful for the body.
  • These secretions can be treated by controlling the over production, providing the essentials for production, or replacing hormones.
  • Some of such abnormalities are:
    1. **Cretinism**:  
       • Occurs due to the lack of thyroid gland secretions.
       • Prevalent mostly in Southern France, Spain, Italy, and Switzerland.

    • Its symptoms are:
      O Marked dwarfism and imbecility.
      O The adult who remains untreated remains about as large as a four-year-old child and has the mental level/ intelligence of that age.
      O Hair becomes coarse.
      O Feeling no or little emotion.
      O

    2. **Hyperthyroidism**:  
       • Occurs when thyroid becomes overactive
       The major symptoms are:
       O Person becomes restless and thin
       O Shows excessive emotionality
       O Sleeplessness
       O Rapid heart beat
       O Tremors
       O Thyroid becomes swollen (goiter)
       O Nervousness
       O Excessive sweating,
       O Blood pressure
       O Protruding eyes
       O In children and teens, **GRAVES’ DISEASE** usually causes this condition,
an autoimmune disorder in which specific antibodies produced by the child's immune system stimulate the thyroid gland to become overactive.

**Method of treatment:**
- Removal of some of the gland surgically.
- Radiotherapy
  
  In early times, the entire gland was also removed, but by doing this, the chances of myxoedema become probable.
  
  With the proper dosage of the gland substance i.e. iodine, the patient remains normal, but with low dosage the person becomes dull and stupid. When too much is given, become unstable and emotional.

3. **Hypothyroidism**  
Condition in which the levels of thyroid hormones in the blood are abnormally low. Symptoms are:
- Slows body processes that may lead to fatigue
- Slow heart rate
- Dry skin
- Weight gain
- Constipation
- In children, it may result in
- Slow growth and delayed puberty

“Hashimoto thyroiditis” results from an autoimmune process that damages the thyroid and blocks thyroid hormone production/secretions. It is the most common cause of hypothyroidism in children.

- Infants can also be born with an absent or underdeveloped thyroid gland, resulting in hypothyroidism.
- The condition can be treated with oral thyroid hormone replacement.

4. **Myxoedema:**
- Occurs particularly in women also due to a deficiency in the thyroid gland’s secretion.
- When it occurs, the patient, who was earlier a bright, capable, energetic person, full of the eager purposes and emotions of life, gradually becomes,
  - Dull
  - Stupid
  - Apathetic
  - Without fear, anger, love, joy or sorrow
  - Without purpose or striving
  - Hair becomes coarse and scanty
  - Skin thick and swollen (hence the name of the disease) and
  - Various changes take place in the sweat secretion, the heart action, etc

5. **Acromegaly:**
Occurs due to an abnormality/change in the pituitary gland.
The major and apparent symptoms are:
- Melancholic tendencies
- Loss of memory and
- Mental and physical torpor
- Profound effect on character and personality, exclusive of intelligence, and that of sex glands
6. Adrenal insufficiency:
- Condition occurring due to the decreased function of the adrenal cortex, and consequently underproduction of adrenal corticosteroid hormones.
- The symptoms of adrenal insufficiency may include,
  - Weakness
  - Fatigue
  - Abdominal pain
  - Nausea
  - Dehydration
  - Skin changes

Treatment:
- Doctors treat adrenal insufficiency by giving replacement corticosteroid hormones.

7. Cushing syndrome:
- When excessive amounts of glucocorticoid hormones are secreted in the body, then it causes this syndrome.
- If this condition is due to a tumor in the pituitary gland that produces excessive amounts of corticotropin and stimulates the adrenals to overproduce corticosteroids, then it is known as Cushing disease.
- In children, it most often occurs when a child has been given large doses of synthetic corticosteroid drugs (such as prednisone) to treat autoimmune diseases such as lupus.
- Symptoms that may take years to develop include:
  - Obesity
  - Growth failure
  - Muscle weakness
  - Easy bruising of the skin
  - Acne
  - High blood pressure
  - And psychological changes

Treatment:
Depending on the specific cause, doctors may treat this condition with:
- Surgery
- Radiation therapy
- Chemotherapy
- Or drugs that block the production of hormones

8. Diabetes:
   a. Type 1 Diabetes:
      - Develops when pancreas fails to produce enough insulin.
      - Symptoms include excessive:
        - Thirst
        - Hunger
        - Urination, and
        - weight loss
In children and teens, the condition is usually an ‘autoimmune disorder’ specific immune system cells and antibodies produced by the child's immune system that attack and destroy the cells of the pancreas that produces insulin.

- Can cause long-term complications such as:
  - Kidney problems
  - Nerve damage
  - Blindness
  - And early coronary heart disease and stroke

**Treatment:**
In order to control blood sugar levels and reduce the risk of developing diabetes complications, children with this condition need regular injections of insulin

a. **Type 2 diabetes:**
In this, the body is unable to respond to insulin normally, like in type 1 diabetes
- Children and teens with this condition are overweight.
- It is also believed that excess body fat plays a role in the insulin resistance that characterizes the disease.
- In recent years the rising prevalence of this type of diabetes in children played a crucial role in increasing rates of obesity among children and teens.
- The symptoms and possible complications of type 2 are the same as those of type 1.
Some children and teens can control their blood sugar level with:
  - Dietary changes
  - Exercise
  - Oral medications
  - But many have need to take insulin injections like patients with type 1 diabetes.