SNS COLLEGE OF ALLIED HEALTH SCIENCES

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Affiliated to Dr MGR Medical University, Chennai

DEPARTMENT : PHYSICIAN ASSISTANT

COURSE NAME : PHARMACOLOGY

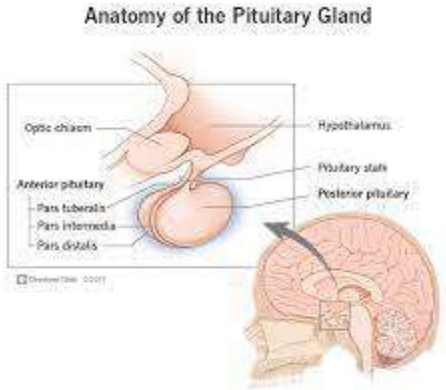
UNIT : HORMONES OF PITUITARY AND THYROID

TOPICS : HORMONES, FUNCTIONS, REGULATION, DISORDERS, DIAGNOSIS, TREATMENT

PITUITARY GLAND

- The pituitary gland is a small, pea-sized gland located at the base of the brain, just below the hypothalamus. Often referred to as the "master gland" due to its essential role in regulating various bodily functions, the pituitary gland plays a crucial part in controlling growth, metabolism, reproduction, and other endocrine functions.

- It consists of two main parts: the anterior pituitary (also known as the adenohypophysis) and the posterior pituitary (or neurohypophysis).



HORMONES OF PITUITARY GLAND

Anterior Pituitary: The anterior pituitary synthesizes and secretes several important hormones that regulate various physiological processes throughout the body. Some of the hormones produced by the anterior pituitary include:

- **Growth Hormone (GH):** Stimulates growth, cell reproduction, and regeneration.

- **Adrenocorticotropic Hormone (ACTH):** Regulates the production and release of cortisol from the adrenal glands, which is involved in stress response and metabolism.

- **Thyroid-Stimulating Hormone (TSH):** Controls the function of the thyroid gland and the production of thyroid hormones.

- **Follicle-Stimulating Hormone (FSH) and Luteinizing Hormone (LH):** Regulate reproductive functions such as the production of sperm in males and ovulation and menstrual cycles in females.

- **Prolactin:** Stimulates milk production in the mammary glands after childbirth.

Posterior Pituitary: Unlike the anterior pituitary, the posterior pituitary does not synthesize hormones but stores and releases two hormones produced by the hypothalamus:

- **Oxytocin:** Plays a role in uterine contractions during childbirth, milk ejection during breastfeeding, and social bonding and behavior.

- **Antidiuretic Hormone (ADH) or Vasopressin:** Regulates water balance in the body by controlling the reabsorption of water in the kidneys, thus influencing urine concentration and blood pressure.

GROWTH HORMONE

Growth hormone (GH), also known as somatotropin, is a peptide hormone produced by the anterior pituitary gland. It plays a pivotal role in various physiological processes, particularly in growth, development, and metabolism throughout life.

Functions of Growth Hormone (GH):

- Stimulating Growth
- Regulating Metabolism
- Supporting Tissue Repair and Regeneration
- Maintaining Healthy Body Composition

Regulation of Growth Hormone Secretion:

- GH secretion is regulated by the hypothalamus through the release of growth hormone-releasing hormone (GHRH) and growth hormone-inhibiting hormone (GHIH or somatostatin).

- These hormones control the release of GH from the anterior pituitary gland.

Factors Influencing GH Secretion:

- Sleep
- Exercise
- Stress and Nutritional Factors

Abnormalities in Growth Hormone:

Deficiency: In children, GH deficiency can lead to growth failure and short stature. In adults, GH deficiency may result in reduced muscle mass, increased body fat, decreased bone density, and changes in lipid metabolism.

Excess: Excessive levels of GH, often due to a tumor in the pituitary gland (acromegaly if occurring in adults or gigantism in children), can lead to abnormal growth of bones and tissues, enlargement of organs, and various health complications.

Treatment

- GH-related disorders may involve hormone replacement therapy with synthetic GH for those with deficiencies or medications, surgery, or other interventions to manage excessive GH production caused by tumors or other conditions.

- Diagnosis and management of GH-related disorders usually involve endocrinologists and specialized healthcare providers.

Adrenocorticotropic hormone (ACTH)

- Adrenocorticotropic hormone (ACTH) is a hormone produced by the anterior pituitary gland. It plays a crucial role in the regulation of the adrenal glands and the production of cortisol, a steroid hormone that helps the body respond to stress and regulates various functions, including metabolism, immune response, and blood pressure.

Functions of Adrenocorticotropic Hormone (ACTH)

Stimulating Cortisol Production: ACTH primarily acts on the adrenal cortex, specifically the zona fasciculata, to stimulate the synthesis and release of cortisol. Cortisol is essential for the body's response to stress, maintaining blood sugar levels, and regulating metabolism.

Regulating Adrenal Hormones: Apart from cortisol, ACTH also influences the production of other hormones in the adrenal cortex, including small amounts of adrenal androgens and aldosterone.

Regulation of ACTH Secretion

- **Hypothalamus:** Produces corticotropin-releasing hormone (CRH), which stimulates the anterior pituitary gland to release ACTH.
- **Anterior Pituitary Gland:** Responds to CRH by secreting ACTH into the bloodstream.
- **Adrenal Glands:** ACTH stimulates the adrenal glands to produce cortisol. Elevated levels of cortisol can exert negative feedback on both the pituitary gland and the hypothalamus, reducing the release of ACTH and CRH, respectively, to regulate the production of cortisol in a feedback loop.

Disorders Related to ACTH

Cushing's Syndrome: This condition results from prolonged exposure to high levels of cortisol. It can be caused by excessive production of cortisol due to an ACTH-secreting tumor in the pituitary gland (Cushing's disease) or by tumors elsewhere in the body that produce ACTH (ectopic ACTH production).

Adrenal Insufficiency: Insufficient production of cortisol due to decreased ACTH secretion or adrenal gland dysfunction can lead to conditions like Addison's disease, characterized by fatigue, weight loss, low blood pressure, and other symptoms related to cortisol deficiency.

Diagnosis and treatment

- ACTH-related disorders involve hormone level measurements, imaging studies, and specific tests to identify the underlying cause.

- Treatment often includes medications, surgery to remove tumors, or hormone replacement therapy, depending on the specific condition causing the hormonal imbalance.

PROLACTIN

- Prolactin is a peptide hormone produced by specialized cells called lactotrophs found in the anterior pituitary gland, a small gland at the base of the brain.

- It plays a crucial role primarily in the female reproductive system, particularly in lactation (milk production after childbirth). However, prolactin also has various other functions in both males and females.

FUNCTIONS OF PROLACTIN

Lactation:

Prolactin's primary function is to stimulate the mammary glands in the breasts to produce milk during pregnancy and breastfeeding. It works in conjunction with other hormones like oxytocin to facilitate the production, secretion, and ejection of milk.

Reproductive Health:

In females, prolactin helps regulate the menstrual cycle by affecting the ovaries and influencing the development and release of eggs (ovulation). Elevated levels of prolactin can interfere with ovulation, leading to irregular menstrual periods and difficulties in conception.

In males, prolactin plays a role in regulating testosterone levels, although its specific impact is not as well understood as in females.

Immune System Modulation:

Prolactin has immunomodulatory effects, influencing the immune system's response. It can affect the function of immune cells and is implicated in autoimmune diseases.

Behavior and Stress Response:

Prolactin has been associated with various behaviors, including parental care and bonding. It may also play a role in stress response and adaptation.

Regulation of Prolactin Secretion

- Prolactin secretion is primarily controlled by the hypothalamus, specifically by the release of the hormone dopamine. Dopamine inhibits the secretion of prolactin; hence, a decrease in dopamine levels can lead to an increase in prolactin secretion.

- Factors such as stress, sleep, exercise, nipple stimulation, and certain medications can affect prolactin levels.

Disorders Related to Prolactin

Hyperprolactinemia: This condition occurs when there's an excess of prolactin in the blood. It can result from various factors such as medications, pituitary tumors (prolactinomas), hypothalamic diseases, and certain physiological conditions.

Symptoms may include irregular menstrual periods, infertility, galactorrhea (abnormal milk production), and in men, decreased libido and erectile dysfunction.

Hypoprolactinemia: This is a less common condition characterized by lower than normal levels of prolactin. It might be associated with certain medical conditions or medications.

Diagnosis and Treatment

- Blood tests are used to measure prolactin levels to diagnose hyperprolactinemia or other related conditions.

- Treatment for hyperprolactinemia often involves addressing the underlying cause. Medications such as dopamine agonists (e.g., bromocriptine, cabergoline) may be prescribed to lower prolactin levels and manage associated symptoms.

THYROID STIMULATING HORMONE

- Thyroid-Stimulating Hormone (TSH), also known as thyrotropin, is a hormone produced by the anterior pituitary gland, a small gland located at the base of the brain.

- It plays a critical role in regulating the function of the thyroid gland, which is responsible for producing thyroid hormones that are essential for various bodily functions.

Functions of TSH

Stimulation of Thyroid Hormone Production: TSH's primary role is to stimulate the thyroid gland to produce its hormones—triiodothyronine (T3) and thyroxine (T4). These thyroid hormones are crucial for regulating metabolism, growth, and development throughout the body.

Regulation of Thyroid Gland Size and Activity: TSH helps maintain the size and activity of the thyroid gland. Elevated TSH levels can signal the thyroid gland to grow (resulting in goiter) or produce more hormones, compensating for low thyroid hormone levels in the blood.

Regulation of TSH Secretion

- TSH secretion is regulated by a feedback mechanism involving the hypothalamus and the thyroid gland.
- The hypothalamus releases thyrotropin-releasing hormone (TRH) in response to low levels of thyroid hormones in the blood or other stimuli. TRH stimulates the pituitary gland to release TSH.
- TSH, in turn, stimulates the thyroid gland to produce T3 and T4. Increased levels of T3 and T4 in the blood negatively feedback to the pituitary and hypothalamus, reducing the release of TRH and subsequently TSH, maintaining a balance in thyroid hormone levels.

Disorders Related to TSH

Hypothyroidism: This condition occurs when the thyroid gland doesn't produce enough thyroid hormones. It can be caused by various factors such as autoimmune diseases (like Hashimoto's thyroiditis), iodine deficiency, surgical removal of the thyroid, or certain medications. In hypothyroidism, TSH levels are often elevated as the body attempts to stimulate the thyroid gland to produce more hormones.

Hyperthyroidism: This condition results from an excess production of thyroid hormones by the thyroid gland. It can be caused by conditions like Graves' disease. In hyperthyroidism, TSH levels are typically low as the body tries to reduce the stimulation of an already overactive thyroid gland.

Diagnosis and Treatment

- Blood tests are used to measure TSH levels, along with thyroid hormone levels (T3 and T4), to diagnose thyroid disorders.

- Treatment for thyroid disorders aims to restore normal hormone levels. For hypothyroidism, synthetic thyroid hormone replacement therapy is prescribed. For hyperthyroidism, treatments may include medications to suppress hormone production, radioactive iodine therapy, or surgery.

Follicle-Stimulating Hormone (FSH)

- Follicle-Stimulating Hormone (FSH) is a vital hormone produced by the anterior pituitary gland, which is located at the base of the brain.

- FSH plays a key role in the reproductive system, specifically in both males and females, although its functions vary between the sexes.

Functions of FSH

In Females:

a. Follicular Development: FSH is essential for the growth and development of ovarian follicles in the ovaries. Each follicle contains an immature egg (oocyte) and surrounding cells. FSH stimulates the follicles to grow and mature during the menstrual cycle.

b. Ovulation: FSH, along with luteinizing hormone (LH), contributes to the final maturation of the dominant follicle, leading to its release (ovulation) of a mature egg from the ovary.

c. Estrogen Production: FSH stimulates the follicular cells to produce estrogen, a hormone crucial for regulating the menstrual cycle and preparing the uterus for potential pregnancy.

In Males:

a. Spermatogenesis: FSH plays a critical role in the production of sperm cells (spermatogenesis) within the testes. It stimulates the Sertoli cells in the testes to support and nourish developing sperm cells.

b. Regulation of Testosterone: While testosterone production is primarily regulated by luteinizing hormone (LH) in males, FSH also contributes to some extent by enhancing the sensitivity of the testicular cells to LH and aiding in testosterone production.

Regulation of FSH Secretion

- FSH secretion is controlled by a feedback loop involving the hypothalamus, the pituitary gland, and gonadal hormones.
- Gonadotropin-releasing hormone (GnRH) released by the hypothalamus stimulates the pituitary gland to secrete FSH and LH.
- In females, rising estrogen levels during the menstrual cycle exert negative feedback on the pituitary gland and hypothalamus, regulating the secretion of FSH and LH.

Disorders Related to FSH

Hypogonadism: Reduced FSH levels can lead to hypogonadism, a condition characterized by impaired development or function of the gonads (testes in males, ovaries in females). This can result in infertility, delayed puberty, or other reproductive issues.

Menstrual Irregularities: Imbalances in FSH levels can contribute to menstrual irregularities, such as irregular periods, anovulation (lack of ovulation), or fertility problems in females.

Diagnosis and Treatment

- Blood tests can measure FSH levels to evaluate fertility issues, menstrual irregularities, or other reproductive health concerns.

- Treatment for FSH-related disorders depends on the underlying cause and may involve hormone therapy to restore normal FSH levels or assist in fertility treatments.

LUTEINIING HORMONE

Luteinizing Hormone (LH) is a hormone produced by the anterior pituitary gland, and it plays a crucial role in the reproductive system of both males and females. Its secretion is controlled by the hypothalamus and is involved in the regulation of reproductive functions.

FUNCTIONS OF LH

In Females:

a. Ovulation: LH surge triggers the release of a mature egg (ovulation) from the ovary. This surge occurs around the middle of the menstrual cycle, typically 12 to 16 days before the next period.

b. Corpus Luteum Formation: After ovulation, LH stimulates the ruptured follicle in the ovary to develop into the corpus luteum. The corpus luteum produces progesterone, which is crucial for preparing the uterus for potential implantation of a fertilized egg.

c. Regulation of Menstrual Cycle: LH, along with follicle-stimulating hormone (FSH), helps regulate the menstrual cycle by supporting follicular development and ovulation.

In Males:

a. Testosterone Production: In males, LH stimulates the Leydig cells in the testes to produce testosterone, the primary male sex hormone. Testosterone is crucial for sperm production (spermatogenesis), male reproductive function, and secondary sexual characteristics.

b. Regulation of Sperm Production: LH plays a role in regulating the production of sperm cells (spermatogenesis) by stimulating the Leydig cells and their production of testosterone, which, in turn, supports the process of spermatogenesis.

Regulation of LH Secretion

LH secretion, like other pituitary hormones, is regulated by a feedback loop involving the hypothalamus and gonadal hormones.

Gonadotropin-releasing hormone (GnRH) released by the hypothalamus stimulates the pituitary gland to secrete LH and FSH.

In females, rising estrogen levels during the menstrual cycle trigger a surge in LH, which results in ovulation.
In males, testosterone exerts negative feedback on the pituitary gland, regulating the secretion of LH and FSH.

Disorders Related to LH

Menstrual Irregularities: Imbalances in LH levels can lead to irregular menstrual cycles, anovulation (lack of ovulation), or fertility issues in females.

Hypogonadism: Reduced LH levels can contribute to hypogonadism, which can manifest as delayed puberty, infertility, or impaired reproductive function in both males and females.

Diagnosis and Treatment

- Blood tests can measure LH levels to evaluate fertility issues, menstrual irregularities, or other reproductive health concerns.

- Treatment for LH-related disorders depends on the underlying cause and may involve hormone therapy or fertility treatments to restore normal hormone levels or address reproductive issues.

Melanocyte-Stimulating Hormone (MSH)

Melanocyte-Stimulating Hormone (MSH) is a peptide hormone primarily recognized for its role in regulating skin pigmentation. It belongs to a family of peptides derived from pro-opiomelanocortin (POMC), a precursor protein that undergoes enzymatic cleavage to produce various bioactive peptides.

Types of Melanocyte-Stimulating Hormone (MSH)

There are several forms of MSH, including α-MSH, β-MSH, and γ-MSH. Among these, α-MSH is the most extensively studied and recognized for its physiological functions, especially in relation to skin pigmentation.

Functions of Melanocyte-Stimulating Hormone (MSH)

- Regulation of Skin Pigmentation
- Anti-inflammatory Properties
- Appetite Regulation
- Sexual Function

Regulation of Melanocyte-Stimulating Hormone (MSH) Secretion

- The hypothalamus regulates the release of MSH. Corticotropin-releasing hormone (CRH) from the hypothalamus stimulates the anterior pituitary to produce pro-opiomelanocortin (POMC).

- POMC is then cleaved into various peptides, including MSH, by enzymatic processes.

CLINICAL SIGNIFICANCE :

Hyperpigmentation or hypopigmentation

OXYTOCIN

Oxytocin is a neuropeptide hormone produced in the hypothalamus, a region of the brain, and released by the pituitary gland. It plays a crucial role in various physiological functions such as social bonding, emotional regulation, childbirth, and breastfeeding.

Functions of Oxytocin

Childbirth: Oxytocin plays a crucial role in stimulating uterine contractions during labor. It helps facilitate the progression of labor and delivery of the baby.

Lactation: Oxytocin is involved in the ejection of milk from the mammary glands (let-down reflex) during breastfeeding. It helps in the contraction of the muscles surrounding the milk-producing cells, allowing the milk to be released.

Social Bonding and Behavior: Oxytocin is associated with social behaviors, trust, empathy, and bonding. It plays a role in forming and maintaining social relationships and interactions.

Regulation of Oxytocin Secretion

- Oxytocin secretion is primarily regulated by nerve signals originating in the hypothalamus and released by the posterior pituitary gland.
- Factors such as positive social interactions, touch, massage, and sexual activity can stimulate the release of oxytocin.

Disorders Related to Oxytocin

- **Labor and Delivery Issues:** Insufficient release or sensitivity to oxytocin can lead to difficulties in labor, causing prolonged labor or stalled progress during childbirth.

- **Breastfeeding Problems:** Oxytocin dysfunction might lead to issues with milk let-down during breastfeeding, causing challenges for nursing mothers.

- **Social and Emotional Disorders:** Research suggests that alterations in oxytocin function might be associated with certain social and emotional disorders like autism spectrum disorders, social anxiety, and difficulties in forming social relationships.

Diagnosis of Oxytocin-Related Disorders

- Clinical Assessment
- Laboratory Tests
- Observational Studies and Behavioral Assessments
- Functional Imaging Studies

Treatment

- Labor and Delivery Management
- Postpartum Hemorrhage Prevention
- Breastfeeding Support
- Research into Mental Health Disorders

ANTIDIURETIC HORMONE

- Antidiuretic Hormone (ADH), also known as arginine vasopressin or simply vasopressin, is a hormone produced by the hypothalamus and released by the posterior pituitary gland.

- It plays a crucial role in regulating the body's water balance by controlling the amount of water excreted by the kidneys and conserving body fluids.

Functions of Antidiuretic Hormone (ADH)

Water Balance Regulation: ADH acts on the kidneys, specifically on structures called nephrons, to control the amount of water reabsorbed back into the bloodstream. It increases the permeability of the kidney's collecting ducts, allowing more water to be reabsorbed. As a result, less water is excreted in the urine, conserving body fluids and maintaining proper hydration levels.

Blood Pressure Regulation: In addition to its role in water balance, ADH can also act as a vasopressor, causing vasoconstriction (narrowing of blood vessels), which can help elevate blood pressure when needed.

Regulation of ADH Secretion

- ADH secretion is primarily regulated by the hypothalamus in response to changes in blood osmolality (concentration of solutes in the blood) and blood volume.

- When the body's fluid levels decrease or blood osmolality increases (indicating dehydration), specialized cells in the hypothalamus sense these changes and signal the posterior pituitary gland to release more ADH. This prompts the kidneys to reabsorb more water, reducing urine output and conserving fluids.

- Conversely, when fluid levels are high or blood osmolality decreases, ADH secretion decreases. This allows more water to be excreted by the kidneys, increasing urine output and helping to maintain proper fluid balance.

Disorders Related to ADH

Diabetes Insipidus: This condition involves either a deficiency in ADH production (central diabetes insipidus) or the kidneys' reduced response to ADH (nephrogenic diabetes insipidus). It results in excessive thirst and the production of large amounts of diluted urine, leading to dehydration if left untreated.

Syndrome of Inappropriate Antidiuretic Hormone (SIADH): In this disorder, the body retains too much water due to excessive ADH secretion, leading to a decrease in sodium levels in the blood (hyponatremia) and potential fluid overload.

Diagnosis and Treatment

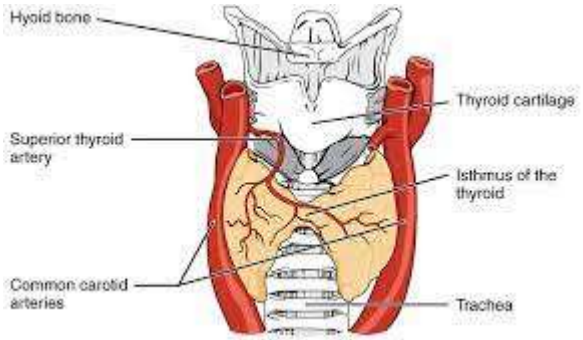
Diagnosis of disorders related to ADH involves assessing symptoms, fluid balance, urine output, and specific tests measuring ADH levels, urine concentration, and blood electrolyte levels.

Treatment for conditions like diabetes insipidus may involve hormone replacement therapy with synthetic ADH (desmopressin) or medications that improve the kidneys' response to ADH. SIADH treatment focuses on correcting the underlying cause and managing fluid balance.

THYROID HORMONES

- Thyroid hormones refer to the hormones produced by the thyroid gland, a small butterfly-shaped gland located in the neck.

- The two main hormones produced by the thyroid gland are thyroxine (T4) and triiodothyronine (T3), both of which play crucial roles in regulating various bodily functions.



Thyroxine (T4)

- Thyroxine (T4) is the predominant hormone secreted by the thyroid gland. It contains four iodine atoms and is considered a prohormone.

- T4 is less biologically active than T3 but serves as a reservoir for the more active T3.

- The conversion of T4 to T3 occurs in peripheral tissues, primarily the liver and kidneys, where one iodine atom is removed from T4 to generate the more potent T3 hormone.

Triiodothyronine (T3)

- Triiodothyronine (T3) is the more biologically active form of thyroid hormone. It contains three iodine atoms and is more potent than T4.

- T3 directly influences metabolism, energy production, and numerous physiological processes throughout the body.

Functions of Thyroid Hormones

- **Regulation of Metabolism:** Thyroid hormones play a central role in regulating the body's metabolic rate. They control how quickly the body burns calories and converts oxygen and calories into energy.

- **Growth and Development:** Thyroid hormones are crucial for normal growth and development, especially in infants and children. They are essential for brain development, bone growth, and the maturation of various organs.

Regulation of Body Temperature: Thyroid hormones help regulate body temperature by influencing heat production and utilization in the body.

Maintenance of Heart Function: They affect heart rate and the strength of heart contractions, contributing to cardiovascular function.

Digestive Function: Thyroid hormones influence digestive processes and help maintain a healthy gastrointestinal tract.

Regulation of Thyroid Hormone Secretion

- The hypothalamus-pituitary-thyroid (HPT) axis regulates the release of thyroid hormones. The hypothalamus produces thyrotropin-releasing hormone (TRH), which signals the anterior pituitary gland to release thyroid-stimulating hormone (TSH).

- TSH stimulates the thyroid gland to produce and release T3 and T4.

- When T3 and T4 levels are sufficient in the bloodstream, they negatively regulate TRH and TSH release, maintaining a balance of thyroid hormone levels.

Clinical Conditions Associated with Thyroid Hormones

Hypothyroidism: Low levels of thyroid hormones result in symptoms such as fatigue, weight gain, cold intolerance, and cognitive impairment.

Hyperthyroidism: Excessive thyroid hormone levels can cause symptoms like weight loss, rapid heartbeat, heat intolerance, and anxiety.

DIAGNOSIS AND TREATMENT

- Diagnosis of thyroid disorders involves blood tests to measure levels of TSH, T3, and T4.

- Treatment often includes medication, such as synthetic thyroid hormones (levothyroxine) or antithyroid drugs, depending on the specific condition to restore hormone balance.

ASSESSMENT

- What all are the Pituitary hormones ?
- How is the regulation of Thyroid hormones ?