Pituitary Gland and Tropic Hormones

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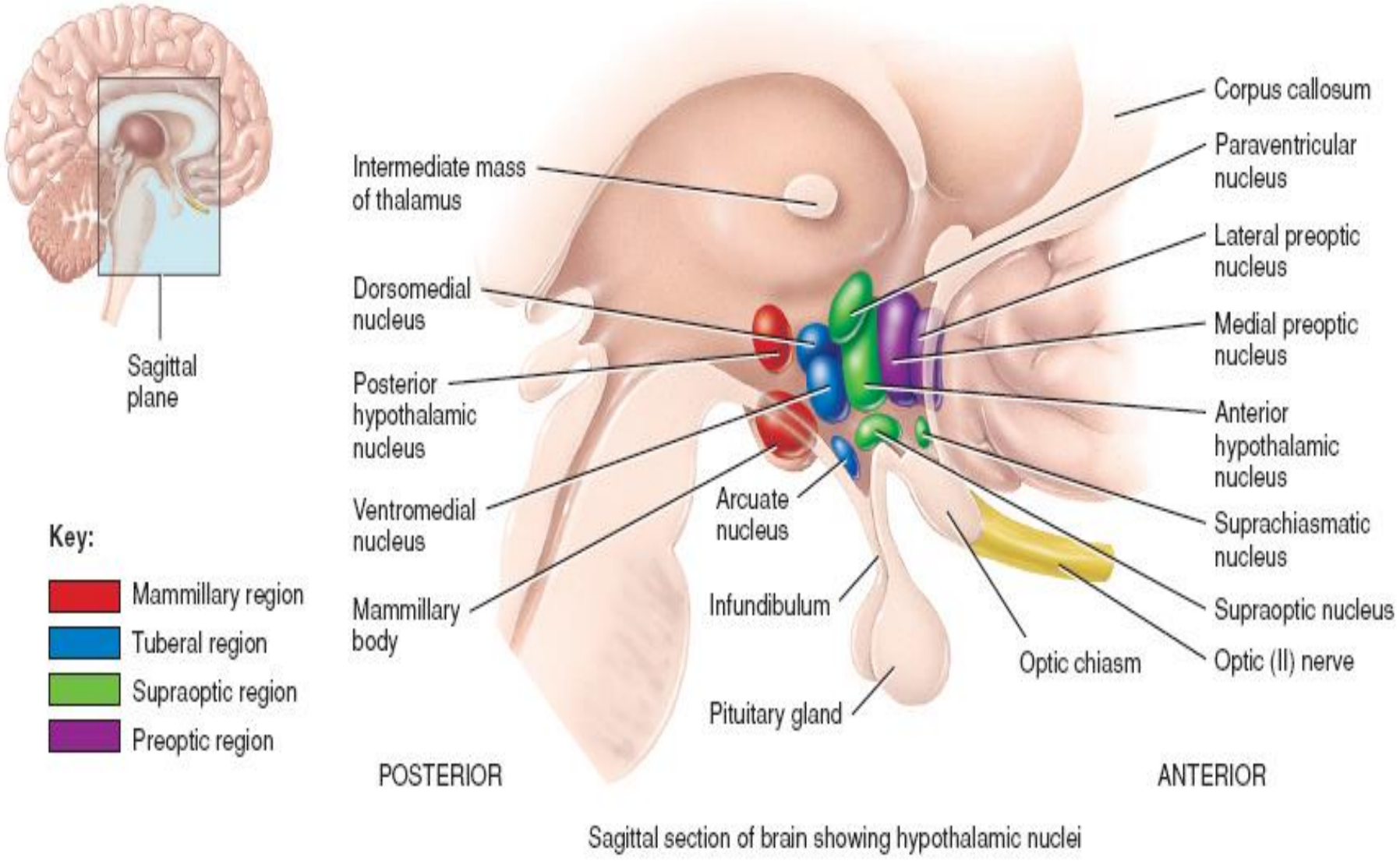
Introduction

- The **hypothalamus** is a portion of the brain that contains a number of small nuclei with a variety of functions. One of the most important functions of the hypothalamus is to link the nervous system to the endocrine system via the pituitary gland (hypophysis).
- The hypothalamus is located below the thalamus and is part of the limbic system.
- The hypothalamic Functions

Hypothalamic nuclei



Sagittal section of brain showing hypothalamic nuclei

Introduction

- Hypothalamus is connected to Anterior Pituitary via Hypothalamic-Hypophysial Portal System (HHPS):
- HHPS are capillaries that carries blood from Hypothalamus to Anterior Pituitary and back to Hypothalamus;
- **Releasing Hormones produced in the Ventral Hypothalamic Neurons are carried via the Hypothalamic Portal System into the Anterior Pituitary where they stimulate or inhibit the production of Anterior Pituitary hormones;**

- Hypothalamus is connected to the Posterior Pituitary via the Hypothalamic Tract;
- **Para-ventricular and Supra-optic nuclei of the Hypothalamus secrete hormones into the Posterior Pituitary for storage and release in the blood;**

- **What are the Hypothalamic Factors (Releasing Hormones)?**
- Hypothalamic factors or releasing hormones are:
- Thyrotropin Releasing Hormone (**TRH);**
- Gonadotrophin Releasing Hormone (**GnRH);**
- Growth Hormone Releasing Hormone (**GHRH);**
- Corticotropin Releasing Hormone (**CRH);**
- Dopamine (**DA) or Prolactin Inhibitory Factor (PIF);**
- Somatostatin (**SS);**

- **What are the functions of the Hypothalamic Factors (Releasing Hormones)?**
- The hypothalamic factors enhances secretion of Pituitary Hormones;
- Specific functions are as follows:
- **TRH: Induces secretion of TSH and Prolactin;**
- **GnRH: Induces secretion of LH and FSH;**
- **GHRH: Induces secretion of GH;**
- **Ghrelin: Peptide hormone released from epithelial cells lining the fundus of the stomach acts on the Anterior Pituitary to enhance secretion of GH;**

- **CRH: Induces production of Proopiomelanocortin (POMC)**

- **Dopamine or Prolactin Inhibitory Factor (PIF):**
- Inhibits release of Prolactin;

- **Somatostatin(SS): Inhibits release of GH, TSH;**

Embryonic Origin

- **The various parts of the pituitary gland have different embryonic origins:**

- **the anterior and intermediate lobes are derived from embryonic ectoderm as an upgrowth from the pharynx while the posterior lobe is neural in origin.**

- **In the early embryo, the roof of the mouth lies adjacent to the third ventricle of the brain and both sheets of tissue bulge towards each other: the buccal cavity bulges upwards to form Rathke's pouch, and the neural ectoderm bulges downwards to form the infundibulum of the hypothalamus.**

- **Eventually, Rathke's pouch pinches off from the rest of the pharyngeal ectoderm and folds around the infundibulum to form the pituitary stalk. Embryogenesis is complete at around 11 or 12 weeks of gestation in humans.**

- **The neural tissue, which remains as part of the brain, forms the posterior pituitary and the non-neural tissue forms the anterior pituitary.**

The hormones of the anterior pituitary

- All the anterior pituitary hormones are proteins or polypeptides. The major hormones are:
- **growth hormone (GH or somatotrophin)**
- **prolactin**
- **adrenocorticotrophic hormone (ACTH or corticotrophin)**
- **thyroid-stimulating hormone (TSH or thyrotrophin)**
- **the gonadotrophins—follicle-stimulating hormone (FSH) and luteinizing hormone (LH).**

- The various cell types that secrete the anterior pituitary hormones line the blood sinusoid. At least five different endocrine cell types may be distinguished.
- The **somatotrophs secrete growth hormone.**
- **The lactotrophs secrete prolactin**
- **The gonadotrophs secrete follicle-stimulating hormone (FSH) and luteinizing hormone (LH).**
- The **corticotrophs secrete adrenocorticotrophic hormone (ACTH)**
- **The thyrotrophs secrete thyroid-stimulating hormone (TSH).**

Growth hormone (GH) and prolactin

- Growth hormone and prolactin have considerable structural similarities. They are both large single chain peptides with prolactin having 198 amino acid residues while the human form of growth hormone (hGH) has 191. Prolactin is synthesized and stored in the anterior pituitary lactotrophs. It has a weakly somatotrophic action (reflecting its structural closeness to GH) but its predominant role is to promote growth and maturation of the mammary gland during pregnancy to prepare it for the secretion of milk during lactation. The secretion of prolactin is normally inhibited by dopamine (previously known as prolactin inhibitory hormone) secreted by hypothalamic neurons

- In lactating women, however, stimulation of the nipple by the baby during breastfeeding inhibits the secretion of dopamine. Prolactin secretion is thus allowed to rise and milk synthesis by the mammary tissue is stimulated (galactopoiesis).
- GH is synthesized and stored in somatotrophs, which are the most abundant pituitary cell type. The anterior pituitary contains around 10 mg of growth hormone, which, in adults, is

- secreted at a rate of around 1.4 mg/day, greater than that of any of the other pituitary hormones.
- It is important to note, however, that over a 24-hour period the rate of GH secretion fluctuates considerably.
- In the plasma, about 70 per cent of GH is bound to various proteins, including a specific GH-binding protein which is derived by cleavage of the extracellular region of the GH receptor present on target cells.

- In young animals in which the epiphyses have not yet fused to the long bones, growth is inhibited by hypophysectomy and stimulated by growth hormone. When the epiphyses are closed, linear growth hormone is no longer possible and growth hormone produces the pattern of bone and soft tissue deformities known in humans as **acromegaly**. Tumour of the somatotropes of the anterior pituitary secrete large amounts of growth hormone leading to **gigantism** in children. **Dwarfism** occurs when an individual is short in stature resulting from a medical condition caused by slow growth. In humans, dwarfism is sometimes defined as an adult height of less than 4 feet 10 inches
- GH acts on Liver to produce Somatomedins peptides;
- Insulin-like Growth Factor-1 (IGF-1) called Somatomedin C is the major factor produced and IGF-II; promote epiphysial growth, protein synthesis. High levels of IGF-1 and GH stimulate production of Somatostatin in the Hypothalamus, Somatostatin inhibits the secretion of GH; High plasma levels of IGF-1 exert Negative Feedback on Anterior Pituitary to modify action of GHRH and to inhibit secretion of GH;
- Stimulates metabolism and growth of body tissues,
- Stimulates Protein synthesis and Lipolysis,
- **Diabetogenic action: decreases glucose uptake in cells, thus resulting in increase blood glucose level;**

Thyroid stimulating hormone

- Human thyroid stimulating hormone is a glycoprotein that contains 211 amino acids residues. The biologic half-life of human TSH is about 60 minutes. TSH is degraded in the kidney and to lesser extent in the liver. The normal secretion rate is 110µg/d. The average plasma level is about 2µU/mL

Effects of TSH on Thyroid

• When the pituitary is removed, thyroid function is depressed and the gland atrophies; when TSH is administered , within few minutes after TSH injection, there are increases in synthesis thyroid hormone.

• With TSH treatment, the cell hypertrophy and the weight of the gland increases.

• Whenever TSH stimulation is prolong, the thyroid becomes detectably enlarged. Enlargement of thyroid is called **goiter**

Adreno-corticotropic hormone

- ACTH is a single-chain polypeptide containing 39 amino acids.
- It originates from propiomelanocortin in the pituitary.
- The first 23 amino acids in the chain constitute the active core of the molecule. Amino acid 24-29 constitute the tail that stabilizes the molecule
- Its half-life in circulation is 10mins.
- Plasma ACTH concentration is 25pg/ml
- ACTH stimulates the output of glucocorticoids, mineralocorticoids and sex hormones
- Excess androgen secretion causes masculinization, (adrenogenital syndrome) and precocoius pseudopuberty
- Excess glucocorticoid secretion produces a moon faced, trunck obesity, hypertension, osteoporosis, protein depletion, mental abnormalities, diabetes mellitus (**Cushing's syndrome**)
- Excess mineralocorticoid secretion leads to k+ depletion and Na+ retention, usually without edema but with weakness, hypertension, tetany, polyuria, hypokalemic alkalosis (hyperaldosteronism)

Follicle stimulating hormone/Luteinizing hormone

- FSH and LH are glycoproteins with α and β subunits.
- The half life of FSH is about 170minutes; the half-life of LH is about 60 minutes.
- FSH helps maintain the spermatogenic epithelium by stimulating sertoli cells in the male and is responsible for early growth of ovarian follicles in the female.
- LH is tropic to the leydig cells and, in females is responsible for final maturation of ovarian follicles and estrogen secretion from them. It is also responsible for ovulation, the initial formation of corpus luteum and secretion of progesterone.

- **What are the functions of Posterior Pituitary Hormones?**
- Functions of Posterior pituitary hormones:
- **Arginine Vasopressin (AVP):**
- Increases Aquaporins on distal tubules and collecting ducts in Kidneys;
- Action causes Reabsorption of water via distal tubules and collecting ducts;
- Causes constriction of Vascular Smooth Muscle;
- **Oxytocin:**
- Induces contraction of Uterus;
- Increases Milk production by inducing contraction of mammary glands;

- **What factors affect the secretion of Oxytocin?**
- •Oxytocin secretion is regulated by several factors:
- •Secretion is regulated via the Neuro-endocrine reflex arc initiated by suckling;
- •Dilation of the Cervix,
- •Breast-feeding,

- **What factors affect the secretion of Arginine Vasopressin?**
- Factors that causes **increase secretion of AVP:**
- Increased Plasma Osmolality (sensed by Hypothalamic Osmo-receptors),
- Reduction in blood volume (sensed by Cardiac Baro-receptors),
- Reduction in blood pressure,
- Stress,
- Hypoglycemia,
- Nausea,
- Pain,

Thank you