University of Jordan - Faculty of Medicine
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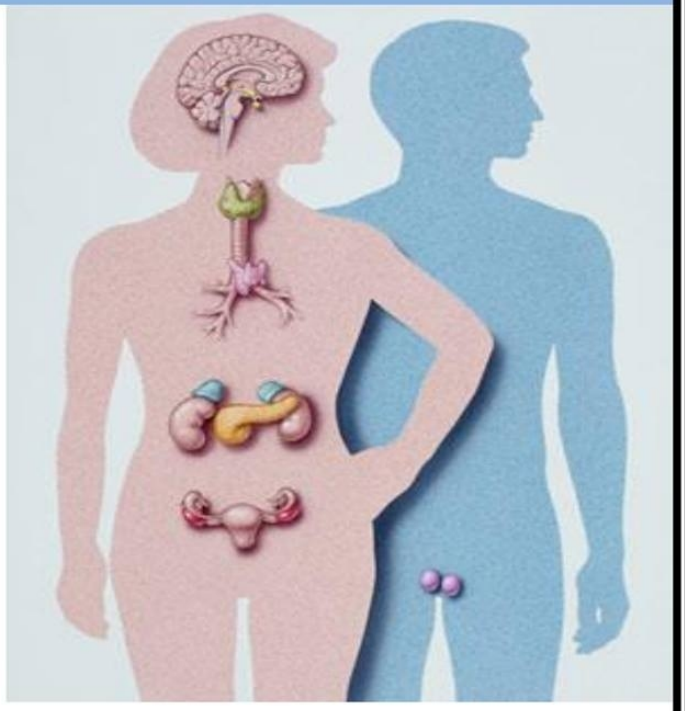
Medical Committee
The University of Jordan

Endocrine System



- ☐ Anatomy/Embryology/Histology
- ☐ Biochemistry
- ■ Physiology
- ☐ Pharmacology
- ☐ Pathology
- ☐ PBL

☐ Slide ■ Sheet ☐ Handout ☐ Other

Lecture #: **2**

Date:

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PITUITARY GLAND PHYSIOLOGY

note: I rearranged some info.

Pituitary Gland (hypophysis)

Small gland, weighs 1 gram only, 1 cm in diameter, lies in cavity at base of the brain called sellaturcica.
It is composed of 2 parts
1-The anterior pituitary (**adenohypophysis**).
2- The posterior pituitary (**neurohypophysis**).

These two parts differ in their embryology, histology and physiology. They are both connected to the hypothalamus either directly or indirectly through the hypothalamic hypophyseal tract.

Posterior Pituitary gland

Neurons extend from the hypothalamus to the posterior pituitary. So, hormones are produced in neurons of the hypothalamus and transferred downwards to the posterior pituitary. (Directly connected)

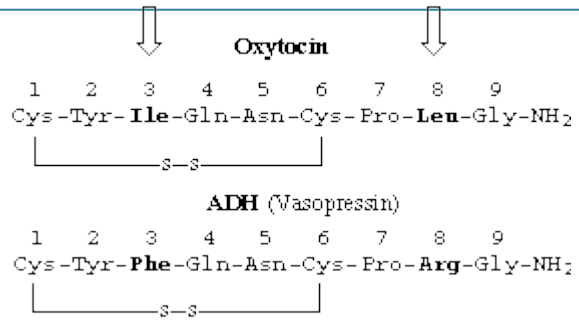
The function of posterior pituitary is only a storage function.

Neurohormones are 2 types:
1- Hormones released by the neurons into the blood.
2- Hormones released by neurons into clefts (synapses).

**** Hormones of posterior pituitary gland (neurohormones)****

- They are produced in 2 nuclei:
  1- paraventricular nucleus produces oxytocin and a little bit ADH
  2- the supraoptic nucleus produces ADH and a little bit of oxytocin

Note: ADH is the same as vasopressin.
- They are stored in the nerve endings and are not released until they're stimulated.



-there is similarity between ADH and oxytocin in structure (they only differ in 2 A.As as shown in the figure to the right) and a very little similarity in function.
That's why the two nuclei can secrete the two types.
So these two hormones can do same functions but with different potencies as the following:
1-As an antidiuretic oxytocine has very little effect where as ADH (vasopressin) has a big effect with a potency ratio between those two of 1:200.
2-As a milk ejector oxytocine has abig effect where as ADH (vasopressin) has a very little effect with a potency ratio between those two of100:1.

- ADH has two main functions:

1. Affects the renal tubules to increase reabsorption of water.
2. Constriction of blood vessels.

** Of course receptors of renal tubules differ from blood vessels receptors.

** Sometimes, ADH is called vasopressin because it causes constriction of blood vessels.

- Major ADH stimuli:
1. Increased serum osmolarity.
2. decreased extracellular fluid volume.

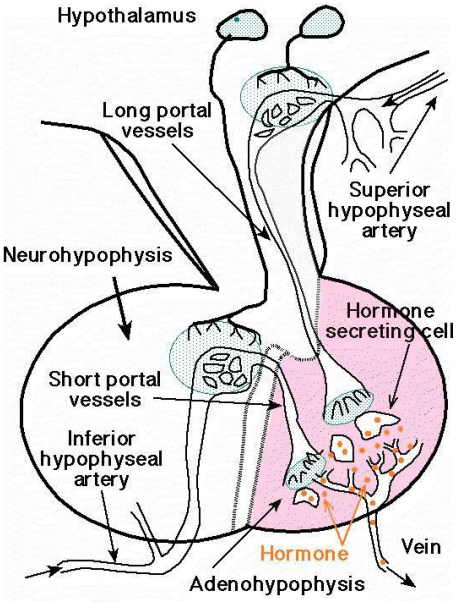
- Major ADH inhibitor:
1. Decreased serum osmolarity.
2. increased extracellular fluid volume.

* Other factors such as pain, nausea, hypoglycemia and nicotine have very little effects.

Anterior Pituitary gland

It is connected indirectly to the hypothalamus. The releasing or inhibiting hormones are first produced by neurons in the hypothalamus and released into the capillaries at the median eminence, then move to the anterior pituitary.

Unlike the posterior pituitary, none of the hormones secreted by the anterior pituitary are of hypothalamic origin. Also, the cells that produce anterior pituitary hormones are NOT innervated and, therefore, they're not under direct neural control. Rather, releasing and inhibiting hormones, which are synthesized by neural cell bodies in the hypothalamus, control anterior pituitary hormone secretion. Hormones synthesized by hypothalamic neurons could reach the anterior pituitary by 2 routes via 2 types of neurons:



1. Neurons that release their hormones in the median eminence capillary bed and then travel by long portal vessels to the adenohypophysis.This long pathway is used when we need slow action.
2. Neurons that release their hormones in the posterior pituitary and travel to the anterior pituitary by short portal blood vessels.This short pathway is used when we need fast action.

Correction note: READ ONLY →Blood supply to the anterior lobe is provided by the hypothalamic-hypophysial portal blood vessels which are the long and short hypophysial blood vessels. The superior and inferior hypophyseal arteries bring blood to the hypothalamic-pituitary region. The superior hypophyseal arteries deliver blood to the hypothalamus and from there the blood is distributed to the median eminence through the primary capillary plexus. The capillaries converge into LONG veins that run down the pituitary stalk (infundibulum) and empty into the blood sinusoids in the anterior lobe. They're considered to be PORTAL veins because they deliver blood to the anterior pituitary rather than joining the venous circulation that carries blood to the heart; therefore they're called long hypophyseal portal vessels.

However, the inferior hypophyseal arteries provide arterial blood to the posterior lobe. They also penetrate into the lower infundibular stem, where they form another important capillary network. The capillaries of this network converge into SHORT hypophyseal portal vessels, which also deliver blood into the sinusoids of the anterior pituitary.

To sum up: Superior hypophysial artery-> primary capillary plexus in median eminence-> plexus converges to form long portal vessels down the infundibulum-> anterior pituitary Inferior hypophysial artery in posterior pituitary -> capillaries converge to form short hypophysial vessels -> anterior pituitary

Through these hypophyseal portal vessels, the hypothalamic regulatory (releasing & inhibitory) hormones are delivered to the endocrine cells of the anterior pituitary.

- Cells of the Anterior Pituitary:
1. Somatotrophs (30 – 40%): produce growth hormones (the most abundant cell type)
2. Corticotrophs (20%): produce ACTH.
3. Thyrotrophs: produce TSH.
4. Gonadotrophs: produce FSH and LH.
5. Lactotrophs (mammotrophs): produce prolactin.

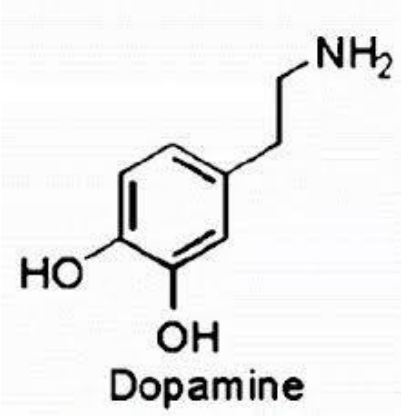
** Each one of the last 3 hormones accounts for 3-5% only. They secrete powerful hormones to control thyroid functions, sexual functions and milk secretion.

**each cell type produces one hormone but sometimes two hormones such as:

A) Somatptrophs produce GH and prolactin
B) Gonadotrophs produce FSH only or LH only normally or abnormally.

****The hypothalamic hormones****
Those stimulate or inhibit the release of the contents of cells of the anterior pituitary and they include the following:

1. CorticotropinReleasing hormone: stimulates**ACTH**secretion.
2. Thyrotropin Releasing hormone: stimulates**TSH**secretion.
3. Growth Hormone Releasing hormone:stimulates**GH**secretion.
4. Somatostatin: inhibits **GH** secretion.
5. Gonadotropin Releasing hormone:stimulates**FSH**, **LH** and **dopamine** secretion.



*All hormones are proteins except dopamine (amylo acid derivative which is called an amyloid).

- For most of Anterior Pituitary hormones, the hypothalamic releasing hormones exert more control. But, for prolactin hypothalamic inhibiting hormone exerts more control as well. Why?
because prolactin is not needed in both sexes and even in females it's not always needed.

Note:
- Stimulation and inhibition of pituitary hormones are complicated because:
1-Both Pituitary glands are controlled by the hypothalamus.
2-the hypothalamus itself is controlled by all centers of CNS.

Now let's start discussing each hormone secreted be the anterior pituitary individually.

Growth Hormones (GH)

They are very important because they target all body cells.

To study the effects of GH:
A rat injected with GH is compared with a control rat.
It was noticed that the weight of the injected rat increased drastically.

So, GHs (somatotropins) which are protein hormones increase the size and number of cells.

- There are other hormones that have roles in growth such as: insulin-like growth factors I and II / insulin / thyroid hormones / glucocorticoids / androgens / estrogen.

- Growth hormones and insulin-like growth factor I are considered as the major determinants of growth in normal post uterine life (after born).
  However, deficiency or excess of each of the other hormones can affect normal growth of musculoskeletal system and maturation of other tissues. So, these hormones play a very important role in growth especially insulin.

- If we have a rat without pancreas and pituitary gland and injected with GH only, we'll notice a small increase in growth. Also, if it's injected with insulin only, we'll have the same result. But if it's injected with the both, GH and insulin, the rat will grow very fast.
  >>insulin& GH act synergistically to promote growth.

Synergistic effect:
It is when two substances combined together can produce an effect higher than the sum of their individual effects.

- GH has direct and indirect effects on body cells.

- It has a direct effects on:
  1. Adipose tissue: ↓ glucose uptake , ↑glycolysis.
  2. Liver: ↑ RNA synthesis, ↑ protein synthesis, ↑ gluconeogenesis, ↑ somatomedinproduction.
- 3. Muscles: ↓ glucose uptake, ↑ A.As uptake, ↑ protein synthesis.

- **Somatomedin**s are proteins, at least 4-5 somatomedins are found in the body, produced by the liver, almost the same structure (they only differ in the number of A.As), almost they do the same function but differ in their potencies. They affect bones, heart, lungs, kidney, pancreas, intestines, islets, parathyroid glands, connective tissue and affects chondrocytes. So as to increase the organ size and function.

** Metabolic Effects of Growth hormones **

1. Increase rate of protein synthesis.
2. Increase mobilization of fatty acids and increase the use of FA for energy
3. Decrease the rate of glucose utilization throughout the body.

   In a nut shell: GH enhances the body protein synthesis, uses body fat stores and conserves carbohydrates (increase blood glucose level).

**Effects of Hypersecretion of Growth Hormones:

1. Diabetogenic effect of GH

- excessive secretion of GH causes diabetes, how?
↑secretion of GH →↑ blood glucose level → exhaustion of β cells that secrete insulin (direct effect of GH on β cells).
-production of insulin affects β cells (indirect effect of GH on β cells).
- The result is diabetes mellitus.

2. Ketogenic effect of GH

- Excessive secretion of GH → great amount of fatty acids are produced + a lot of acetoacetic acid are formed by the liver → released into body fluids → Ketosis (ketogenic effect of the growth hormone).

- There are other hormones of the Anterior pituitary hormonesthat have diabetogenic effects such as:
  1. TSH 2. Prolactin 3. ACTH 4. Cortisol.

** The level of GH, insulin and Somatomedin in:
1. Protein intake: ↑ GH / ↑insulin (has role in AAs entry to cells) /↑Somatomedin
2. Carbohydrate intake: ↑ insulin only (No need for GH and Somatomedin)
3. Fasting: ↑ GH only (No need for insulin and Somatomedin)

- Some Stimulants of GH:
  1. Decreased blood glucose
  2. Decreased fatty acids
  3. Increased Amino Acids
  4. Starvation and fasting
  5. Protein deficiency
  6. Stress and excitement
  7. Ghrelin

  ***Ghrelin** is a hormone produced by the stomach especially during fasting, it stimulates appetite.

- Some Inhibitor factors of GH:
  1. Increased blood glucose
  2. Increase fatty acids
  3. Aging
  4. Obesity (important)

- Levels of GH during stages of life (childhood, puberty, adult life, senescence) show developmental rhythm.

- Stretch receptors in the stomach activate sensory afferent pathways in vagus nerve and inhibit blood food intake. But, if the stomach is too large, it needs too much food for the receptors to be activated.

- Peptide YY, cholecystokinin and insulin are GI hormones that are released by ingestion of food and suppress further food intake.

- Renin hormone released by the stomach during fasting and induces apatite.

- Leptin is produced by fat cells. It is higher in obese people and inhibit food intake and inhibit the release of growth hormone.

- So we can classify them into two groups depending on weather they induce or inhibit the apatite.

** Hyposecretion of Pituitary gland

(is NOT pathologic, it's a physiological condition)

A) Panhypopituitarism (deficiency of all pituitary hormones as if you removed the whole gland) results in:

1- diabetes insipidus because of ADH deficiency (water isn't reabsorbed back to the blood → excretion a lot of urine). It's similar to diabetes mellitus but the urine in diabetes insipidus is pale but in diabetes mellitus the urine is dark.

* Note: oxytocin deficiency doesn't produce serious problems.

2- Absence of gonadotropins (FSH/ LH):

in males: no testosterone → decreased libido (sexual desire) , NO sperms, loss of body hair

In females: no progesterone and estrogen → decreased libido and amenorrhea (NO menstrual cycles).

3- TSH deficiency → atrophy of thyroid gland
4- ACTH deficiency → atrophy of adrenal cortex
5- MSH (melanocyte-stimulating hormone) deficiency → pallor color
6- GH (somatotropin) deficiency → dwarfism (it affects sexual ability and fertility), the mental ability isn't affected significantly.

B)Severe anterior pituitary deficiency

*It's similar to Panhypopituitarism except those of the post. Pituitary hormones are normal. So sexuality, thyroid, adrenal cortex, color and also tall (dwarfs) will be affected.

C) Moderate anterior pituitary deficiency

*Gonadotropins & TSH are deficient; ACTH & MSH are partially deficient, GH is normal.

D) Mild anterior pituitary deficiency

* only Gonadotropins are deficient ,the others are normal.

we can notice that in ALL conditions "A-->D" Gonadotropins are deficient

**So gonadotropins are affected in both moderate and mild anterior pituitary deficiencies.

**** Hypersecretion of Pituitary gland** (copied from 2012 batch website because it contains the same info. that are mentioned in our lecture)

A) Giantism or gigantisma

*If the over-secretion occurs before being adult (during the childhood), almost all the organs will be affected & become larger than normal.
*These individuals will:
-Be 8-9 feet height.

-The giants have hyperglycemia, 10% develop diabetes mellitus.
-If the giants remain without treatment, they'll develop panhypopituitarism.
*All parts of the body develop in appropriate proportion.
-Also the organs will be enlarged.

B) Acromegaly

*If the over-secretion occurs after being adult, after the fusion of the long bones, the person cannot grow taller (bones cannot grow), but the soft tissues can continue growing and the bones can grow in thickness leading to osteopetrosis.

***These individuals will:**
-Suffer from enlargement of the small bones of hands, feet, cranium, nose, forehead, supraorbital ridges, the lower jaw bone and portions of the vertebrae.
-Many soft tissues or organs such as: liver, tongue, kidneys are enlarged. "Also the heart but it's a little bit enlargement."
*There's NO appropriate proportion in the development.