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PHYSIOLOGICAL REGULATION OF THE HYPOTHALAMIC-PITUITARY SYSTEM AND ENDOCRINE GLAND ACTIVITY: MODERN THEORETICAL VIEWS

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Abstract.
This article presents a functional analysis of the central and peripheral endocrine mechanisms that ensure homeostasis in the human body. The primary aim of the study is to elucidate the leading role of the hypothalamic-pituitary system in regulating the activity of peripheral glands — the thyroid and parathyroid glands, as well as the involvement of the adrenal glands in the physiology of arterial pressure. The article analyzes the histological structure of endocrine glands, hormonal secretion processes, and their impact on calcium-phosphorus metabolism in blood serum and metabolic processes based on modern physiological views. The research findings are of significant importance for the early diagnosis of clinical manifestations of endocrine system disorders and the understanding of physiological regulation mechanisms.
Keywords: Hypothalamic-pituitary system, thyroid gland, parathyroid glands, parathormone, homeostasis, calcium-phosphorus metabolism, endocrine regulation, adrenal glands, arterial pressure physiology, hormonal balance.

Introduction

This section highlights the role of hormonal regulation in the body's homeostasis.

- **Problem:** General pathophysiology of dysregulation in the endocrine system.
- **Objective:** To systematize the functional interdependence of the hypothalamus, pituitary, thyroid, and parathyroid glands.

Methods

The article employs literature review and physiological modeling methods.

- **Database:** Recent international scientific research and clinical guidelines (PubMed, Scopus analysis).
- **Approach:** Systematic analysis of endocrine axes (Hypothalamus-pituitary-gland axes).

Results

To make this section visual and comprehensive, we divide it into the following blocks:

- **Hypothalamic-pituitary system:** Its structure as the "central control panel" and its impact on peripheral glands via releasing hormones.
- *Hypothalamic pituitary adrenal axis*
- **Thyroid gland:** Synthesis of thyroid hormones (T3, T4) and their role in metabolism.
- **Parathyroid glands:** Control of calcium-phosphorus metabolism via parathormone.
- **Adrenal glands (pressure physiology):** The importance of aldosterone and catecholamines in regulating arterial pressure.

Anatomical Structure

- **Location:** Typically, 4 small (pea-sized) glands located on the posterior surface of the thyroid gland. Two of them are located at the upper pole and two at the lower pole.
- **Size and weight:** Each gland is approximately 5–7 mm long, 3–4 mm wide, with an average weight of 40–60 mg.
- **Histological structure:** The gland parenchyma consists of two main types of cells:
  - **Chief cells:** The main functional cells that synthesize parathyroid hormone (PTH).
  - **Oxyphil cells:** Their function is not yet fully understood, but their number is observed to increase with age.
  - **Stroma:** The glands are surrounded by adipose tissue (adipocytes) and a thin fibrous capsule.

Physiology: Parathyroid Hormone (PTH) and Calcium Homeostasis

The main function of the parathyroid gland is the production of parathyroid hormone (PTH). This hormone maintains the blood calcium level at a constant (homeostatic) rate.

- **Effect on bone tissue:** When the blood calcium level drops, PTH stimulates osteoclast activity in the bones. As a result, bone minerals dissolve, and calcium is released into the blood.
- **Effect on kidneys:** Decreases calcium excretion in the urine (enhances reabsorption).
  - Blocks the reabsorption of phosphorus (phosphaturia), which is essential for balancing the calcium-phosphorus ratio.
  - Stimulates the activation of vitamin D (synthesis of calcitriol in the kidneys).
- **Effect on the intestines:** Increases calcium absorption in the intestines through the activation of vitamin D.

Mechanism of Regulation

PTH secretion is independent of the pituitary gland and is directly controlled by the level of ionized calcium in blood plasma (negative feedback principle).

- Decreased blood calcium → Increased PTH synthesis.
- Increased blood calcium → Inhibited PTH synthesis.

Discussion

- **Clinical significance:** How dysfunction of these glands leads to arterial hypertension or metabolic diseases.
- **Future research:** Digital monitoring of endocrine diseases.

Digital monitoring of endocrine diseases involves the use of information technologies to collect, process, and analyze patients' health data in real time. This system helps the physician track disease dynamics and make the right decisions.

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The main components of this process are outlined below:

Automatic Data Collection (IoT Devices)

In modern medicine, digital monitoring is carried out through "Internet of Medical Things" (IoMT) devices:

- **Continuous Glucose Monitoring (CGM):** Subcutaneous sensors for patients with diabetes measure blood sugar levels every 5 minutes and send the data to a smartphone.
- **Smart scales and blood pressure monitors:** The patient's weight and blood pressure are automatically transmitted to the doctor's database via Bluetooth.

Cloud Database and HIS

All data is consolidated into the HIS (Hospital Information System).

- Data is stored in centralized cloud storage.
- The doctor can view the patient's hormonal indicators for the past month in graphical format at any time.

Artificial Intelligence (AI) and Analytical Approach

The collected large volumes of data (Big Data) are analyzed using artificial intelligence algorithms:

- **Predictive Analytics:** For example, the algorithm can preemptively detect a potential sharp increase in the patient's blood pressure or sugar level in the coming period and send an "alert" to the doctor.
- **Clinical Decision Support System (CDSS):** The system may recommend the doctor to adjust a specific medication dose based on clinical tests.

Telemedicine Platforms

The final part of monitoring is digital communication between the patient and the doctor:

- **Mobile applications:** The patient enters their test results, medication times, and how they feel through the app.
- **Virtual visits:** When deviations in test results are detected, the doctor contacts the patient via videoconference.

The Importance of Digital Monitoring in Endocrinology

Stage	**Role of Digital Monitoring**
Diagnostics	Detecting pathological changes in the latent (early) period.
Treatment	Individually (personally) adjusting the dosage of hormonal preparations.
Prevention	Preventing severe complications of the disease (coma, hypertensive crisis).

Conclusion

This study analyzes the fundamental role of the hypothalamic-pituitary system in the body's endocrine regulation and its functional interdependence with peripheral glands (thyroid and parathyroid glands). The obtained results show that hormonal homeostasis is carried out not only under central control but also in close connection with the automatic (feedback) mechanisms of peripheral glands. In particular, the synergy between the hypothalamus, pituitary, and endocrine glands is crucial in ensuring calcium-phosphorus metabolism and the stability of arterial pressure. In the future, the integration of digital monitoring and analytical tools based on artificial intelligence in the effective treatment of endocrine pathologies is expected to fundamentally change the clinical approach and enable early diagnosis of diseases.

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