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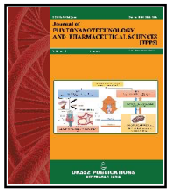

Review Article : Open Access

Beyond the basics: A comprehensive review of the thyroid gland and its ailments

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Abstract

Thyroid hormones play a vital role in growth and development of the body, as well as in maintaining various bodily functions such as metabolism, heart rate, and body temperature. Imbalance in thyroid hormone levels can indeed lead to hypothyroidism or hyperthyroidism, which can cause a range of symptoms and health issues. Hypothyroidism arises when the thyroid gland fails to produce an adequate amount of thyroid hormones, whereas hyperthyroidism occurs when the gland produces an excessive quantity of these hormones. Both of these conditions can lead to complications such as goitre, Hashimoto thyroiditis, subclinical hypothyroidism (SCH), polycystic ovary syndrome (PCOS), thyroid nodules and thyroid cancer. Tests such as TSH, T3 and T4, thyroid antibodies, ultrasound, and thyroid scans can help diagnose these conditions. TSH tests are usually the first line of testing for thyroid dysfunction. While most thyroid disorders are chronic and cannot be prevented, they can be managed with proper treatment and care. Stress, depression, anxiety, and other factors can worsen thyroid problems, so managing overall health is important to minimize symptoms. There are several treatment options available, including thyroidectomy (thyroid removal surgery), radioactive iodine, thyroid hormone supplements, antithyroid medications, external radiation, and recombinant human TSH. The selection of treatment is influenced by the particular condition, its intensity, and considerations such as the patient's age, overall health, and individual preferences. It is important to work closely with a healthcare provider to manage any thyroid disorder and to discuss any questions or concerns about treatment options.

1. Introduction

The thyroid gland, an essential endocrine gland located in the neck region of vertebrates, secretes hormones such as thyroxine (T4) and triiodothyronine (T3). These hormones play a crucial role in regulating various physiological processes, including growth, development, metabolism, and energy production (Kumar and Clark, 2017). Nevertheless, any imbalance in thyroid hormone levels can lead to disorders such as hypothyroidism and hyperthyroidism. Hypothyroidism is characterized by insufficient production of thyroid hormones, while hyperthyroidism involves the overproduction of hormones. These disorders can manifest with symptoms such as weight gain or loss, fatigue, mood changes, and, in severe cases, life-threatening complications (Jean, 1998; Hanish, 2022).

Thyroid disorders are typically diagnosed through tests such as thyroid stimulating hormone (TSH) tests, thyroid antibodies, ultrasound, and thyroid scans (Grebe, 2019). While many thyroid disorders are chronic, they can be effectively managed with appropriate treatments, including thyroid hormone supplements, antithyroid medications, thyroid removal surgery, radioactive iodine, external radiation, and recombinant human TSH (Laura *et al*., 2023).

Furthermore, women are more susceptible to thyroid disorders, especially after pregnancy and menopause. Stress, depression, anxiety, and other factors can also exacerbate thyroid problems (Marjorie *et al*., 1987). The thyroid gland plays a crucial role in maintaining overall health, and any imbalance in its hormones can lead to significant health problems. Understanding the causes, symptoms, and treatments of thyroid disorders is essential for maintaining good health and overall quality of life.

2. Synthesis and release of thyroid hormones

The thyroid gland synthesizes and releases two main hormones: thyroxine (T4) and triiodothyronine (T3). The synthesis of thyroid hormones is a complex process that involves several steps and requires the trace element iodine (Bianco and Kim, 2006). First, the follicular cells in the thyroid gland take up iodide ions (I^-) from the blood, which are then oxidized to iodine (I_2) and attached to the amino acid tyrosine to form the precursor molecule thyroglobulin (Tg). Next, within the follicular cells, two tyrosine residues in Tg are coupled together to form either T4 (two iodine atoms attached) or T3 (one iodine atom attached). Finally, T4 and T3 are cleaved from Tg, and the free hormones are released into the bloodstream (Bianco and Kim, 2006). The regulation of thyroid hormone release involves a feedback loop that includes the hypothalamus, pituitary gland, and thyroid gland (Fliers and Boelen, 2019). Thyrotropin-releasing hormone (TRH) is produced by the hypothalamus, prompting the pituitary gland to release thyroid-stimulating hormone (TSH). TSH, in response, stimulates the synthesis and release of T4 and T3 from the thyroid gland. When the levels of T4 and T3 in the blood are sufficient, they act on the pituitary gland and hypothalamus to decrease the secretion of TSH and TRH, respectively, thus maintaining a balance of thyroid hormones in the body (Fliers and Boelen, 2019). In summary, the intricate process of synthesizing and releasing

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thyroid hormones includes iodine uptake by the thyroid gland, the formation of precursor molecules, and the subsequent release of T4 and T3 into the bloodstream. This entire process is intricately regulated through a feedback loop that incorporates the hypothalamus, pituitary gland, and thyroid gland, ensuring the maintenance of appropriate thyroid hormone levels in the body.

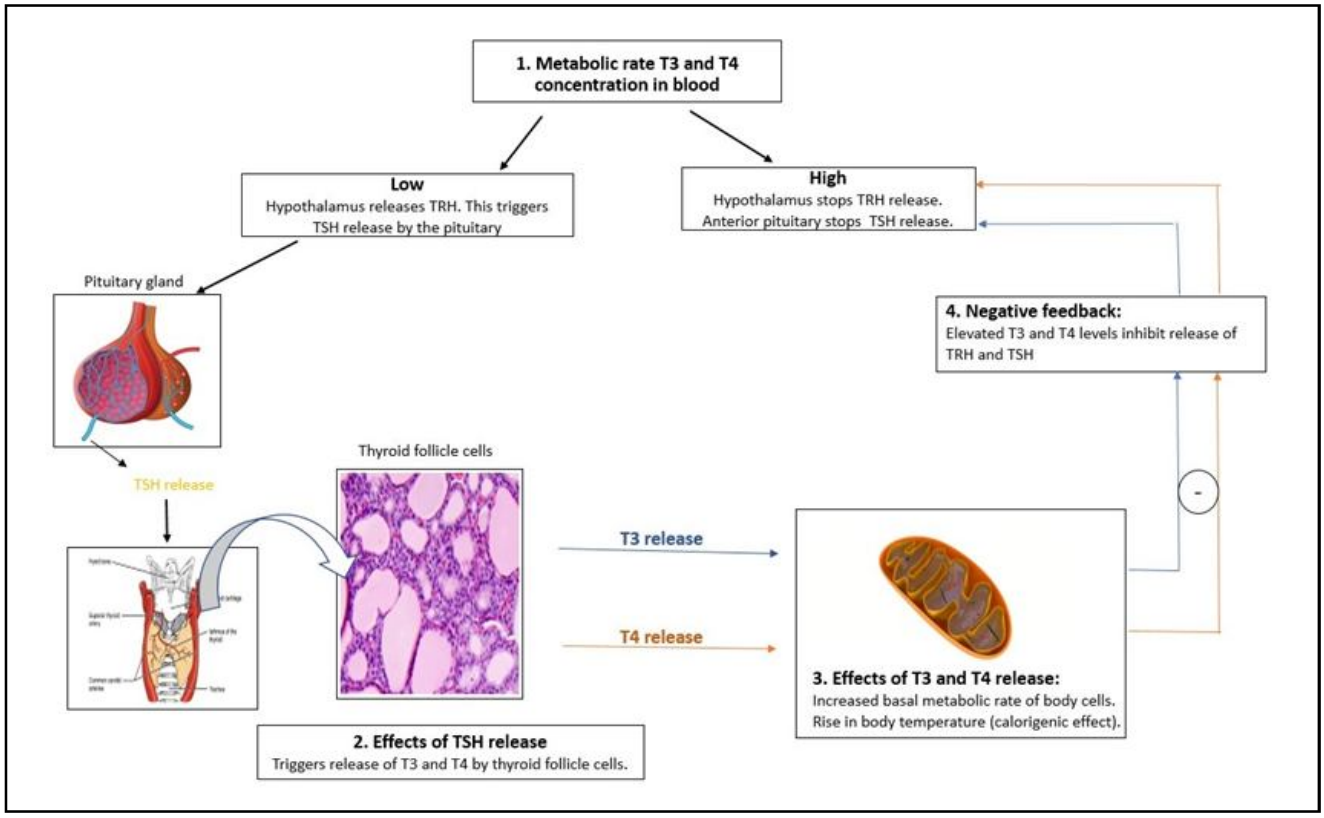

Figure 1: Synthesis and release of thyroid hormones.

3. Thyroid disorders

3.1 Hypothyroidism

Hypothyroidism is a common endocrine disorder affecting people of all ages, particularly women and the elderly. The condition is characterized by an inadequate production of thyroid hormones by the thyroid gland, leading to a decrease in the body's metabolic rate and a range of symptoms. Several studies have investigated the underlying causes, diagnosis and treatment of hypothyroidism. For instance, autoimmune thyroiditis (Hashimoto's thyroiditis) stands out as the predominant cause of hypothyroidism in regions where iodine sufficiency is maintained (Unnikrishnan and Menon, 2011). Another study reported that maternal thyroid hormone insufficiency during pregnancy is a significant risk factor for the development of hypothyroidism in children (Pop *et al*., 1999). The diagnosis of hypothyroidism is primarily based on measuring the levels of thyroid-stimulating hormone (TSH) and thyroid hormones in the blood. A study found that the use of a sensitive TSH assay for screening and diagnosis of hypothyroidism is effective and cost-efficient (Canaris *et al*., 2000). The treatment of hypothyroidism involves hormone replacement therapy with synthetic thyroid hormone (levothyroxine). A study revealed that a once-daily dose of levothyroxine is as effective as multiple daily doses in treating hypothyroidism (Sawin *et al*., 1985). Another study reported that personalized levothyroxine dosing based on body weight and lean body mass is associated with improved thyroid hormone levels and patient satisfaction (Jonklaas *et al*., 2014).

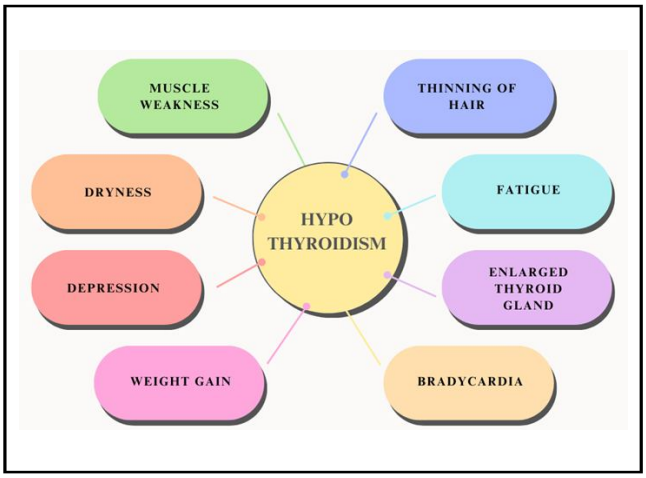

Figure 2: Symptoms of hypothyroidism.

3.2 Hyperthyroidism

Hyperthyroidism is a common endocrine disorder characterized by excessive production of thyroid hormones. It can affect people of all ages, but it is more common in women and people over the age of 60. The symptoms of hyperthyroidism can vary widely, but common

signs and symptoms include weight loss, rapid or irregular heartbeat, increased appetite, anxiety, sweating, and tremors (Garber *et al*., 2012).The most common cause of hyperthyroidism is Graves' disease, an autoimmune disorder that results in the production of antibodies that stimulate the thyroid gland. Other causes of hyperthyroidism include thyroid nodules, inflammation of the thyroid gland (thyroiditis), and excessive iodine intake (Ross *et al*., 2016). The diagnosis of hyperthyroidism relies on a physical examination, blood tests for assessing thyroid hormone levels, and imaging studies like ultrasound or a thyroid scan. Treatment options encompass medication to inhibit thyroid hormone production, radioactive iodine therapy for destroying thyroid cells, and surgery for the partial or complete removal of the thyroid gland. If left untreated, hyperthyroidism can lead to serious complications such as heart problems, osteoporosis, and thyroid storm, a rare but life-threatening condition characterized by high fever, rapid heartbeat, and confusion (Bahn *et al*., 2011).

3.3 Diseases/disorders associated with thyroid hormone imbalance

Thyroid disorders can have a significant impact on overall health and are often associated with several other medical conditions. Some of the conditions that are commonly associated with thyroid disorders are: Cardiovascular disease: Both hypothyroidism and hyperthyroidism can increase the risk of developing cardiovascular disease, including hypertension, atherosclerosis, and heart failure (Chaker *et al*., 2017). Osteoporosis: Hypothyroidism can lead to decreased bone density and an increased risk of fractures, especially in postmenopausal women (Vestergaard, 2009). Depression and anxiety: Thyroid disorders have been linked to an increased risk of depression and anxiety (Bunevicius *et al*., 2015). Infertility: Both hypothyroidism and hyperthyroidism can interfere with reproductive function and increase the risk of infertility in both men and women (Krassas *et al*., 2010). Eye disorders: Graves' disease, a type of hyperthyroidism, is often associated with eye disorders such as Graves' ophthalmopathy and thyroid eye disease (Marcocci *et al*., 2011). Metabolic disorders: Thyroid disorders can also affect glucose and lipid metabolism, leading to an increased risk of diabetes and dyslipidemia (Duntas, 2010). Pregnancy complications: Thyroid disorders can increase the risk of complications during pregnancy, including miscarriage, preterm birth, and preeclampsia (Stagnaro, 2011).

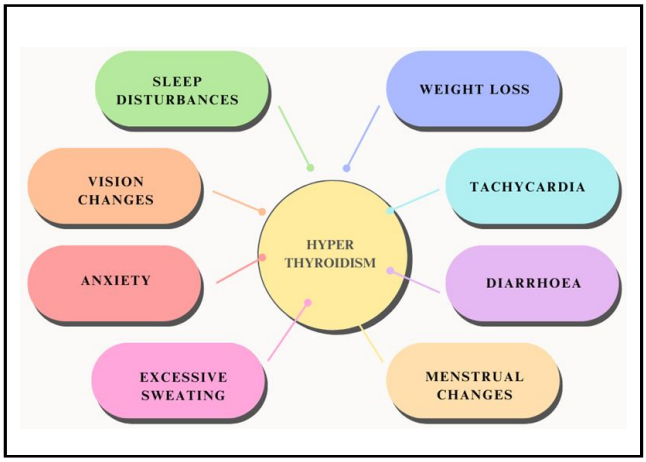

Figure 3: Symptoms of hyperthyroidism.

Thyroid imbalance can lead to various diseases and disorders. Some of the commonly associated diseases and their brief descriptions are:

3.3.1 Hypothyroidism

Hypothyroidism is characterized by an insufficient production of thyroid hormones by the thyroid gland, leading to symptoms like fatigue, weight gain, dry skin, hair loss, and depression. Hashimoto's thyroiditis, an autoimmune disorder, is the predominant cause of hypothyroidism. The standard treatment involves levothyroxine, with regular monitoring of thyroid hormone levels essential for dosage adjustments (Garber *et al.,* 2012).

3.3.2 Hyperthyroidism

Hyperthyroidism is a condition characterized by an excessive production of thyroid hormones by the thyroid gland, resulting in symptoms like weight loss, anxiety, tremors, and heart palpitations. Graves' disease, an autoimmune disorder, is the leading cause of hyperthyroidism. Treatment options encompass antithyroid medications, radioactive iodine therapy, or thyroid surgery (Ross *et a*l., 2016).

3.3.3 Goiter

Goiter is an enlargement of the thyroid gland. It can be caused by iodine deficiency, autoimmune disorders, or other factors. Treatment depends on the underlying cause and may include iodine supplements, thyroid hormone replacement therapy, or surgery.

3.3.4 Thyroid nodules

Thyroid nodules are growths on the thyroid gland. Most nodules are benign, but some can be cancerous. Treatment options depend on the size and characteristics of the nodules and may include observation, biopsy, or surgery (Ruggeri *et al*., 2021).

3.3.5 Thyroid cancer

Thyroid cancer is an infrequent form of cancer originating in the thyroid gland, with papillary and follicular thyroid cancer being the most prevalent types. Treatment options encompass surgery, radioactive iodine therapy, and chemotherapy.

3.3.6 Thyroiditis

Thyroiditis is inflammation of the thyroid gland. It can be caused by viral infections, autoimmune disorders, or other factors. Treatment depends on the underlying cause and may include medications, such as corticosteroids or nonsteroidal anti-inflammatory drugs.

3.3.7 Thyroid eye disease

Thyroid eye disease, an autoimmune condition frequently linked to Graves' disease, impacts the eyes and may lead to symptoms such as bulging eyes, double vision, and eye pain. Treatment options comprise medications to manage inflammation, surgery, or radiation therapy (Haugen *et al*., 2015).

4. Role of diet in the treatment of thyroid disorders

Several trace elements play a crucial role in maintaining normal thyroid function, and researchers have explored their supplementation in various contexts. The introduction of iodine supplementation on a national scale, primarily through universal salt iodization, has proven highly successful in preventing severe thyroid diseases. However, excessive iodine intake can lead to thyroid disorders. Selenium and

zinc supplementation has shown benefits in specific populations, although these findings may not be broadly applicable. In contrast, minerals such as vitamin B12, low-dose naltrexone, and ashwagandha root extract lack substantial evidence supporting their impact on thyroid disorders. The positive effects of avoiding gluten and dairy are observed mainly in individuals with sensitivities to these substances, potentially enhancing levothyroxine absorption. Conversely, there is limited evidence supporting the benefits of avoiding cruciferous vegetables and soy in patients with thyroid disorders (Larsen *et al*., 2022)

5. Role of herbs in the treatment

The traditional knowledge held by tribal and rural communities regarding plant wealth and its impact on human health serves as a foundational element in contemporary drug discovery strategies for various ailments (Bushra *et al*., 2020). Developing countries have witnessed a growing interest in phytomedicine due to the widespread use of numerous products derived from natural sources (Sanjeev and Divya, 2021). The effectiveness and safety of polyherbal formulations in managing various diseases or disorders are currently under investigation (Padmanabha *et al*., 2021).

The role of fruits and vegetables in promoting human health is crucial, providing the human body with defensive capabilities (Hanish, 2022). Various methods have been developed and validated for the quantitative determination of herbal medicine purity using UV-visible spectrophotometry (Sai Krupa *et al*., 2022).

5.1 Lemon balm

Lemon balm exhibits efficacy in blocking the binding of TSH to the receptor, acting on both the hormone and the receptor itself. Traditionally, it has been used to address symptoms associated with hyperthyroidism, such as tachycardia, insomnia, and hyperactivity.

5.2 *Convolvulus pluricaulis*

This herb strongly influences certain liver enzymes, improving symptoms of hyperthyroidism. With antiulcer properties, it proves helpful in alleviating hyperthyroidism symptoms and shows potential benefits in treating hypothyroidism.

5.3 *Leonurus cardiaca* L.

In autoimmune diseases, reducing inflammation is crucial, making motherwort a viable option in treating hyperthyroidism. Additionally, it inhibits the enzyme 5-deiodanase.

The aqueous leaf extract of *A. squamosa* has been reported to ameliorate hyperthyroidism, a major causative factor for diabetes mellitus. *Rauvolfia serpentina* root extract, administered to T4-induced hyperthyroid mice, significantly decreased both serum T3 and T4 concentrations. *Emblica officinalis* fruit extract decreased both serum T3 and T4 concentrations by inhibiting the peripheral conversion of T4 to T3 in extra-thyroid tissues. *Trigonella graceum* seed extract induced a reduction in T3 levels, possibly due to the inhibition of peripheral conversion of T4 to T3 in extra-thyroidal tissues. *Aegle marmelos* plays a specific role in regulating thyroid functions and maintaining thyroid hormone levels. *Ocimum sanctum* leaf extract, when administered to male mice, significantly inhibited only T4 concentration. *Moringa oleifera* leaf extract treatment of female rats decreased serum T3 concentration and increased serum T4 concentration. This observation suggests the inhibitory activity of the plant extract in the peripheral conversion of T4 to T3 (Bharthi *et al*., 2017).

6. Conclusion

The thyroid gland plays a crucial role in regulating various body functions and maintaining overall health. Imbalance in thyroid hormone levels can lead to a range of disorders and diseases, including hypothyroidism, hyperthyroidism, goiter, hashimoto's thyroiditis, and thyroid cancer. These conditions can have a significant impact on an individual's physical and mental well-being, and early diagnosis and appropriate treatment are essential for managing symptoms and preventing complications. Various diagnostic tests are available to evaluate thyroid function, including TSH, T3, T4, thyroid antibodies, and imaging studies such as ultrasound and thyroid scans. Treatment options for thyroid disorders include medication, surgery, radioactive iodine, and hormone replacement therapy. It is also important to manage overall health, including stress levels and diet, to minimize symptoms and improve quality of life. With proper management, most thyroid disorders are chronic but manageable conditions. Further research is needed to better understand the mechanisms underlying thyroid dysfunction and to develop more effective treatments.

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Conflict of interest

The authors declare no conflicts of interest relevant to this article.

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