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The Association Between Thyroid Dysfunction and Heart Diseases

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Abstract

***Objectives**: Both thyroid hormone excess and deficiency can induce or exacerbate cardiovascular disorders, including atrial and ventricular arrhythmias, atherosclerotic vascular disease, dyslipidemia, and heart failure, thereby contributing to higher risk of premature morbidity and death.*

In this article, we will go through the changes in cardiac output, cardiac contractility, vascular resistance, blood pressure, and rhythm disturbances that result from thyroid diseases.

***The association between hyperthyroidism and heart diseases:** Heart Failure, Pulmonary Hypertension, Atrial Fibrillation, Amiodarone-Induced Hyperthyroidism Lipid metabolism*

***The association between hypothyroidism and heart diseases:** Heart Failure, arrhythmias, pericardial effusion*

***Conclusion:** Thyroid hormones have an important role in regulating cardiac, vascular, and metabolic physiology. Physiologic alterations from both overt and subclinical Thyroid dysfunction have varied cardiovascular effects, and treatment may reverse some, if not all, of the effects.*

***Keyword:** Hyperthyroidism, Hypothyroidism, heart diseases*

Introduction

Thyroid dysfunction is quite common, lead to cardiovascular signs and symptoms. In this article, we will go through the changes in cardiac output, cardiac contractility, vascular resistance, blood pressure, and rhythm disturbances that result from thyroid diseases.

Both thyroid hormone excess and deficiency can induce or exacerbate cardiovascular disorders, including atrial and ventricular arrhythmias, atherosclerotic vascular disease, dyslipidemia, and heart failure, thereby contributing to higher risk of premature morbidity and death. Moreover, a growing body of observational data suggests that cardiovascular risk may also be increased in subgroups of patients with subclinical thyrotoxicosis or subclinical hypothyroidism.

Risk factors for thyroid problems [1,2]

Gender: Women are five to eight times more likely to have thyroid problems than men.
Family history: People whose first-degree relatives (parents or siblings) have an underactive or overactive thyroid face a higher risk of a similar problem**.**
Race: Whites have higher rates of hypothyroidism than Hispanic Americans and African Americans.
Age: The prevalence of hypothyroidism rises with age, especially after age 60**.**
Health history: Thyroid problems are more likely among people with type 1 diabetes, Addison's disease, pernicious anemia, rheumatoid arthritis, premature gray hair, radiation treatments to the head and neck, and vitiligo.

Thyroid Hormones [3,4]

Thyroid hormones greatly impact energy homeostasis in the heart, and excess thyroid hormone leads to a hyper metabolic state. The thyroid gland produces two hormones,

thyroxine (T4) and triiodothyronine (T3). The major form of thyroid hormone is thyroxine, which acts mostly as a prohormone.1 the set point for thyroid hormone production and secretion by the thyroid gland is regulated by the hypothalamic thyrotropin-releasing hormone (TRH).

Hemodynamic Changes in Hyperthyroidism

Hyperthyroidism is characterized by increases in resting heart rate, blood volume, stroke volume, myocardial contractility, and ejection fraction and an improvement in diastolic relaxation, which is similar to a state of increased adrenergic activity.5

In addition, the therapeutic benefits of β-blockers suggest that the cardiac manifestations of hyperthyroidism are caused by increased catecholamine action.6 In thyrotoxicosis, plasma catecholamines are unchanged or low, and the β-adrenergic receptor density is altered in a time- and tissue-dependent manner, resulting in increased tissue sensitivity to catecholamines.6

The association between hyperthyroidism and heart diseases:

Heart Failure HF

Hyperthyroid patients complain of exercise intolerance and dyspnoea during effort due to the inadequate increase in cardiac output during exercise [1,2,3,4].

Thus, impaired exercise tolerance can be interpreted as the first symptom of HF in hyperthyroid patients; it is the sign that the hyperthyroid heart cannot further accommodate the increase in cardiovascular demand during physical exercise [5,6]. The onset of negative changes in the loading conditions**,** the loss of sinus rhythm or the depression of myocardial contractility may further impair the efficiency of the cardiovascular system in hyperthyroid patients, thereby inducing congestive HF. The development of orthopnoea, paroxysmal nocturnal dyspnoea, peripheral oedema and neck vein distension may indicate the progression to advanced HF. However, the clinical manifestations and degree of HF in hyperthyroid patients depend on a variety of factors, mainly the patient's age, the cause and severity of hyperthyroidism and the underlying cardiac conditions. Many groups have assessed the association of overt hyperthyroidism with HF**.** Patients with severe hyperthyroidism may develop a 'high-output HF'.

Pulmonary Hypertension PAH

Approximately 20% of patients with pulmonary hypertension have thyroid disease as a comorbidity, which is more frequent than the general population.7 Pulmonary artery hypertension (PAH) is an increase in mean pulmonary arterial pressure ≥ 25 mm Hg at rest.4 A recent study suggests a correlation between TSH receptor antibodies and PAH, providing support for a possible autoimmune-mediated pulmonary vascular remodeling in this condition.9 All patients with PAH should be screened for hyperthyroidism, and all patients with hyperthyroidism and dyspnea should be screened for PAH [7].

Atrial Fibrillation

Atrial fibrillation (AF) is a common dysrhythmia representing an independent risk factor for cardiovascular events [8]. The rapid and irregular heartbeat produced by AF increases the risk of blood clot formation inside the heart. These clots may eventually become dislodged, causing embolism, stroke and other disorders [8,9]. AF is a complex disease with several possible mechanisms. Studies indicate that arrhythmogenic foci within the thoracic veins can be AF initiators [9].

AF in thyrotoxicosis is associated with significant mortality and morbidity resulting from embolic events [10]. The risk factors for AF in patients with hyperthyroidism (age, male sex, ischemic heart disease, congestive heart failure and valvular heart disease) are similar to those in the general population [10]. AF occurs in up to 15% of patients with hyperthyroidism [10] compared with 4% incidence in the general population [11] and is more common in men and in patients with triiodothyronine (T3) toxicosis [10]. Also, subclinical hyperthyroidism is a risk factor that is associated with a 3-fold increase in risk of developing AF [11]. AF incidence increases with advancing age. Although it is rare in patients under 40 years of age, 25% to 40% of hyperthyroid individuals over the age of 60 experience AF, possibly reflecting an age-related reduction in threshold for acquiring this arrhythmia. Of hyperthyroid patients older than 60 years, 25% had AF compared with 5% prevalence in patients younger than 60 years [12]. Patients with toxic nodular goiter also showed, because of their age, an increased prevalence of AF versus younger patients with Graves' disease (43% vs 10%, respectively).

Amiodarone-Induced Hyperthyroidism

Amiodarone is a commonly prescribed medication for the management of both atrial and ventricular arrhythmias. Each 200 mg tablet of amiodarone contains 74.4 mg (37.3%) of iodine with 7.4mg (10%) per day being released as free iodine. This is roughly 50-fold higher than the daily recommended iodine intake for adults, which is approximately 0.15mg (150 mcg). This increase in iodine delivery and uptake can increase thyroid hormone production and release. This is a condition called type I amiodarone induced thyrotoxicosis (hyperthyroidism) [13].

In addition, it can also cause type II amiodarone induced thyrotoxicosis, which occurs from actual thyroid tissue destruction. Patients being started on amiodarone should have a baseline TSH (and in some cases free T4 and T3 levels) which is repeated at least every 6-12 months thereafter or based on the emergence of symptoms of hyperthyroidism. [12,13].

Lipid metabolism

- Thyroid hormones regulate hepatic lipid metabolism in a cell autonomous manner
- Thyroid hormone receptors (THRα and THRβ) differentially regulate hepatic lipid metabolism
- Thyroid hormone induces the expression of genes that encode proteins involved in hepatic lipogenesis
- Thyroid hormone couple's autophagy to mitochondrial fat oxidation to induce ketogenesis
- Thyroid hormone induces reverse cholesterol transport
- Thyroid hormone analogues and/or mimetics offer therapeutic alternatives for treatment of lipid-associated hepatic pathologies 14

The association between hypothyroidism and heart diseases

Heart Failure

Hypothyroidism can affect cardiac contractility, which is often diastolic in nature, and impair cardiac muscle relaxation. Associated diastolic hypertension and sometimes-coexistent coronary artery disease further affect myocardial diastolic function [1,2,3,4,5]

Arrhythmia

As mentioned before that hyperthyroidism is associated with atrial fibrillation (AF). the relationship between hypothyroidism and AF was evaluated in many Heart Studies and was not found to be statistically significant [4,5].

QT prolongation

The QT interval is often prolonged in hypothyroidism due to prolonged ventricular action potential [10].

Torsades de pointes

This is indicative of increased ventricular irritability and in turn can lead to acquired Torsades de pointes.

Heart blocks

Varying degrees of atrioventricular block and low QRS complexes are also seen in patients with hypothyroidism.

Ventricular fibrillation

Generally, the incidence of ventricular fibrillation is decreased in hypothyroidism, and depression of thyroid hormone levels appears to be beneficial in patients with angina and acute myocardial infarction [10,11].

Bradycardia can be beneficial as it raises the arrhythmogenic threshold, especially in patients with underlying cardiovascular disease [11].

In summary, unlike hyperthyroidism, hypothyroidism is linked with a decreased probability of cardiac arrhythmias.12

Pericardial effusion

Mild pericardial effusion is common and generally asymptomatic. Massive pericardial effusion being manifested at presentation primarily as a sign of hypothyroidism is rare. Rarely, hypothyroidism presents with massive pericardial effusion resulting in cardiac tamponade [13,14].

Conclusion

Thyroid hormones have an important role in regulating cardiac, vascular, and metabolic physiology. Physiologic alterations from both overt and subclinical Thyroid dysfunction have varied cardiovascular effects, and treatment may reverse some, if not all, of the effects.

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