RESEARCH ARTICLE / *Araştırma Makalesi*

Relationship Between Subclinical Hyperthyroidism and Ventricular Repolarization Markers

Subklinik Hipertiroidizm ile Ventriküler Repolarizasyon Belirteçleri Arasındaki İlişki

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Abstract

Objective To evaluate repolarization defects and arrhythmogenic predisposition through ventricular repolarization markers in patients with subclinical hyperthyroidism (sHT).

Materials and Methods Patients with asymptomatic endogenous sHT and healthy participants with similar age and demographic characteristics were included in our study. Laboratory tests and echocardiographic evaluations were performed. Specific ventricular repolarization markers,such as QT, QTc (corrected QT interval by Bazett formula) dispersion, Tpeak-Tend (Tp-e) interval, and Tp-e/QT and Tp-e/QTcratios were obtainedwith manually on electrocardiography.

Results A total of 90 participants were included in our study. The mean age was 59.04±13.28 years for the 45 patients in the sHT group and mean 57.13±15.87 years for the 45 controls. The PR, QT, and QTc dispersions were found to be significantly higher in the sHT group ($p<0.05$ for all). While the PR and QT intervals did not significantly differbetween the groups, QTc ($p<0.05$) was significantly higher in the sHT group. Tp-e, Tp-e/QT,and Tp-e/QTc were also found to be at higher levels in the sHT group than in the control group($p<0.001$ for all). A statistically significant negative correlation was detectedbetween thyroid-stimulating hormone (TSH) and the Tp-e interval, QT,QTc dispersion, Tp-e/QT,and Tp-e/QTc ratio, with Tp-/QT having the highest correlation coefficient (r: -0.298, p=0.004).

Conclusion Compared with healthy subjects, patients with sHT had a longer Tp-e interval and higher Tp-e/QT and Tp-e/QTc ratios. The TSH levels were negatively correlated with the Tp-e interval and Tp-e/QT and Tp-e/QTc ratios.

Keywords Tp-e interval; Tp-e/QT ratio; subclinical hyperthyroidism; ventricular repolarization markers

Öz

Amaç *Subklinik hipertiroidili (sHT) hastalarda ventriküler repolarizasyon belirteçleri ile repolarizasyon defektlerini ve aritmojenik yatkınlığı değerlendirmek.*

Gereç ve Yöntemle *Asemptomatik endojen (sHT)'li hastalar ve benzer yaş ve demografik özelliklere sahip sağlıklı katılımcılar çalışmamıza dahil edildi. Laboratuvar testleri ve ekokardiyografik değerlendirmeler yapıldı. Elektrokardiyografide QT, QTc (Bazett formülü ile düzeltilmiş QT inteval) dispersiyonu, Tpeak-Tend (Tp-e) aralığı ve Tp-e/QT ve Tp-e/ QTc oranları gibi spesifik ventriküler repolarizasyon belirteçleri elde edildi.*

Bulgular *Çalışmamıza toplam 90 katılımcı dahil edildi. sHT grubundaki 45 hasta için yaş ortalaması 59.04 ± 13.28 yıl, 45 kontrol grubu katılımcısı için ortalama 57.13 ± 15.87 yıl idi. PR, QT ve QTc-dispersiyonlarının sHT grubunda anlamlı derecede yüksek olduğu bulundu (tümü için $p<0.05$). PR ve QT aralıkları gruplar arasında anlamlı farklılık göstermezken, QTc ($p<0.05$) sHT grubunda anlamlı olarak daha yüksekti. Tp-e ,Tp-e/QT ve Tp-e/Qtc'nin de sHT grubunda kontrol grubuna göre daha yüksek seviyelerde olduğu bulundu (tümü için $p<0.001$). Tiroid uyarıcı hormon (TSH) ileTp-e aralığı, QT, QTc dispersiyonu, Tp-e/QT veTp-e/QTc oranı arasında en yüksek korelasyon katsayısına sahip Tp-/QT ile istatistiksel olarak anlamlı negatif korelasyon saptandı (r: -0.298, p=0.004).*

Sonuç *Sağlıklı bireylerle karşılaştırıldığında, Sht'li hastalar daha uzunTp-e aralığına ve daha yüksek Tp-e / QT ve Tp-e / QTc oranlarına sahipti. TSH düzeyleri Tp-e aralığı veTp-e/QT veTp-e/QTc oranları ile negatif korelasyon gösterdi.*

Anahtar Kelimeler *Tp-e aralığı; Tp-e/QT oranı; subklinik hipertiroidizm; ventriküler repolarizasyon belirteçleri.*

INTRODUCTION

It has been scientifically proven that overt and symptomatic thyroid dysfunctions can cause compensatory changes on the cardiovascular system that can reach pathological levels.[1-3] Data obtained from studies conducted over the years have led researchers to evaluate asymptomatic patient groups in which hormonal disorders have been detected. In this context, it is now known that subclinical hyperthyroidism (sHT) presents withlower serum thyroid stimulating hormone (TSH) levels than the normal reference ranges andnormal free thyroid hormone values and its prevalence varies between 0.6% and 2% in the general population.[4] sHT can have endogenous or exogenous causes. The most common cause of exogenous sHT is the excessive suppression of TSH due to hypothyroid replacement therapy. Endogenous sHT may be associated with autonomic thyroid dysfunction, such as diffuse goiter, toxic adenoma, and toxic multinodular goiter. Clinical studies have shown that sHT increases cardiovascular morbidity and mortality in patients.[5-7] One of the parameters most affected by sHT is cardiovascular performance. It has been found that sHT predisposes ventricular arrhythmias by increasing heart rate and blood pressure.[8,9] Tpeak-Tend (Tp-e) is defined as the time between the projection of the T wave peak on the isoelectric line and the end of the T wave, and is an indicator for the global repolarization distribution.[10] Tp-e and other repolarization markers (QT interval, QTc interval, QT dispersion, QTc dispersion, Tp-e/QT ratio, and Tp-e/QTc ratio) have been associated with malignant cardiac arrhythmias in can increase the incidence of both supraventricular and many patient groups.[11,12] However, there are insufficient data to evaluate the status of ventricular repolarization markers in patients with sHT.Therefore, in this study, we aimed to evaluate ventricular repolarization defects and indirectly arrhythmogenic susceptibility in patients with asymptomatic endogenous sHT in comparison with ahealthy population.

MATERIALS and METHODS

Thestudy was conducted with 45 patients aged >18 years who presented to our internal medicine and endocrinology outpatient clinics in 2021 and were newly diagnosed with sHT and 45 healthy participants with similar age and demographic characteristics. None of the participants hada history of anychronic or cardiac disease. The inclusion criteria applied when determining the healthy participants in the control group are as follows: healthy participants with a similar age range to the case group, no history of chronic and cardiac disease, no history of drug use that could affect the thyroid hormone panel and electrocardiographic measurements, and whose thyroid hormone panel was found to be within the normal range. The inclusion criteria applied when determining the healthy participants in the control group are as follows: healthy participants with a similar age range to the case group, no history of chronic and cardiac disease, no history of drug use that could affect the thyroid hormone panel and electrocardiographic measurements, and whose thyroid hormone panel was found to be within the normal range. The participants' body mass index (BMI), systolic and diastolic blood pressures, echocardiographic measurements [ejection fractions (EF%)], electrolyte levels, biochemical test results, hemogram data, and serum TSH, free triiodothyronine (FT3) and free thyroxine (FT4) levels were recorded. sHT was diagnosed according to the following laboratory profile: (i) a serum TSH level belowthe lower limit of the normal reference range (<0.36 mIU/L) in at least two measurements performed six weeks apart and (ii) normal serum FT3 (3.5–7.9 pmol/L) and FT4 (7.64–19.7 pmol/L) levels in at least two measurements madesix weeks apart.[8] The etiological distribution of the sHT group was as follows: 25 patients haddiffuse goiter, 12 hadtoxic adenoma, and eighthadmultinodular goiter. Cardiovascular risk factors are an important criterion for the initiation of treatment when making a treatment decision in patients followed up with sHT and without the severe suppression of TSH level (0.1< TSH < 0.5 mIU/L). Therefore, we also performed the cardiovascular evaluation of the asymptomatic patients with sHT. For this purpose, we selected our study group according to the following exclusion criteria:

presence of persistent arrhythmia, diabetes mellitus, hypertension, congestive heart failure, chronic obstructive pulmonary disease, or coronary artery disease; permanent pacemaker use; ischemic changes in ECG or the left bundle branch block;use ofantiarrhythmic agents or drugs that could affect thyroid hormone levels;presence of cardiomyopathies or moderate-to-severe valvular disease;presence of euthyroid sick syndrome; history oftreatment for thyroid disease;presence ofan acute psychiatric disease; severe weight loss; pregnancy;and a history of glucocorticoid or dopamine use. In addition,patients who followed up with hypothalamic and pituitary insufficiency were excluded from the study since they could present with a misleading hormone profile like sHT.Considering that TSH secretion shows a circadian rhythmand TSH levels are the highest in early morning,the thyroid hormone measurements were performed in the early morning hours. At study acceptance from all subjects, the serum TSH and free thyroid hormone concentrations were assessed using commercially available AutoDELFIA kits.

ECG records were obtained ata speed of 25 mm/s and a width of 10 mm/mV by placing electrodes in standard anatomical localities after the patients had rested for 10 minutes in the supine position (Cardiofax GEM, model 9022 K, Nihon Kohden, Tokyo, Japan). To improve the accuracy and reliability of our measurements, ECGs were recorded usingour local online imaging program. Manual ECG measurements were evaluated by two cardiologists using calipers and magnifying lenses. These cardiologistshadno conflict of interest concerning the study and were blinded to the demographic data of the patients. The interobserver coefficient of variation was 2.12%. The baseline heart rate (HR), PR interval, QRS interval, QT interval, and QTc (corrected by the Bazett Formula:cQT=QT$\sqrt{}$(R–R interval)) interval values were manuallycalculated. The interval between the endpoint of the T wave obtained during the measurement of the QT interval and the projection of the T wave peak to the isoelectric line was measured as the Tp-e interval (Figure 1). Measurements were calculated by averaging the values obtained separately from each derivation of the 12-lead ECG. The dispersion results were obtained by takingthe difference betweenthe maximum and minimum PR, QT and QTc intervals. One measurement was performedfor each derivation, but at least two consecutive measurements were averaged to improve accuracy in derivations where the image quality was not good. ECGs were included in the study data if at least eight of the 12 leads could be measured. Ventricular repolarization markersincludedQT and QTc intervals, QT and QTc dispersions, Tp-e interval, and Tp-e/QT and Tp-e/QTc ratios. The study protocol was designed in accordance with the principles of the Helsinki Declaration and approved by the Ethics Committee of Ordu University Medical Faculty (Approval number:2022/18, approval date: 28.01.2022).Written consent was obtained from all participants.

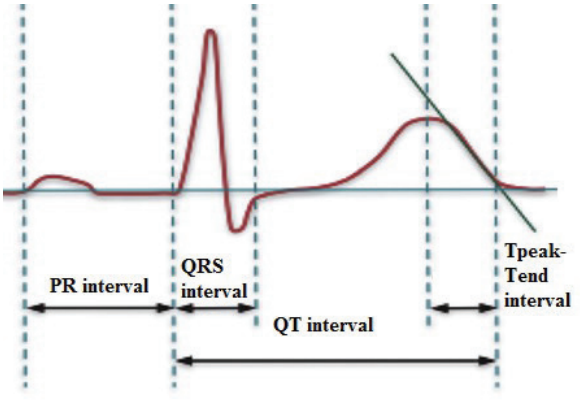

Figure1. Measurement of the T-peak and T-end intervalon ECG

Statistical Analysis

Continuous variables were given as mean ± standard deviation, and categorical variables as percentages (%). The Kolmogorov-Smirnov test was used to evaluate the normality of the distribution of continuous variables. According to the evaluation of the normality distribution, non-normally distributed data were presented as the median with 25-75 percentages. The chi-square test was used for categorical variables. The statistical analysis of the clinical data between the two groups was performed using Stu-

dent'st-test. The Mann-Whitney U test was conductedas a post hoc test to compare the two groups. The Pearson correlation coefficient was used for the correlations between TSH and ventricular repolarization markers. Scatter plots were obtainedto evaluate the relationship between TSH and ventricular repolarization markers. Statistical analyses were performed using SPSS v. 22 (SPSS/IBM, Chicago, IL, USA), and apvalue of <0.05 was considered statistically significant.

RESULTS

A total of 90 participants were included in our study. In the sHT group, 26 (57.77%) of the 45 patients were male, and the mean age was 59.04 ± 13.28 years. Of the 45 patients in the control group,28 (62.22%) were male, and the mean age was 57.13 ± 15.87 years. There was no significant difference in the demographic and laboratory results of the participants, except for the serum TSH levels (Table 1).

Table 1. Demographic data and laboratory results of the study groups

Variables	sHT (n = 45)	Controls (n = 45)	P value
Age (years)	59.04 ± 13.28	57.13 ± 15.87	0.098
Gender, male (%)	26 (57.77%)	28 (62.22%)	0.102
BMI (kg/m2)	25.81 ± 1,21	26.04 ± 1,18	0.423
SBP (mmHg)	133.87 ± 8.10	129.12 ± 7.88	0.069
DBP (mmHg)	83.12 ± 4.98	80.57 ± 5.04	0.146
EF (%)	60.22 ± 1.83	59.80 ± 1.28	0.509
BUN, mg/dl	16.37 (8.36 – 20.12)	17.63 (8.45 – 20.91)	0.412
Creatinine, mg/dl	1.02 ± 0.21	1.11 ± 0.27	0.356
Albumin, g/dl	4.57 (3.39 – 5.62)	4.72 (3.47 – 5.69)	0.362
Sodium, mEq/L	140.98 ± 2.10	141.44 ± 1.87	0.077
Potassium, mEq/L	4.48 (3.06 – 5.61)	4.61 (3.27 – 5.84)	0.154
Chlorine, mmol/L	104.17 ± 2.39	104.76 ± 2.80	0.538
Glucose (mg/dl)	118.97 ± 25.12	120.75 ± 33.76	0.271
Hemoglobin, g/dl	14.00 ± 1.77	13.90 ± 1.55	0.247
TSH (mIU/L)	0.25 ± 0.09*	1.27 ± 0.63	**<0.001**
Free T3 (pmol/L)	4.42 ± 0.81	4.10 ± 0.49	0.075
Free T4 (pmol/L)	11.16 ± 0.23	10.18 ± 0.44	0.171

Normally distributed numerical data are expressed as mean ± standard deviation, non-normally distributed data as the median with 25-75 percentages, and categorical data as percentages (%). sHT: Subclinical Hyperthyroidism, BMI: Body Mass Index, SBP: Systolic Blood Pressure, DBP: Diastolic Blood Pressure, EF: Ejection Fraction, BUN: Blood Urea Nitrogen, TSH: Thyroid Stimulating Hormone, T3: Triiodothyronine, T4: Thyroxine

The electrocardiographic analysis results of the participants are presented in Table 2. It was observed that heart rate (p< 0.05) was significantly higher in the sHT group than in the control group. The PR, QT and QTc dispersions were also found to be significantly higher in the sHT group (p < 0.05 for all). While the PR and QT intervals did not significantly differbetween the groups, QTc(p< 0.05) was significantly higher in the sHT group. The Tp-e interval and theTp-e/QT and Tp-e/QTcratios were significantly higher in the sHT group than in the control group(p<0.001 for all).

Table 2. Electrocardiographic measurement results of the study groups

Variables	sHT (n = 45)	Controls (n = 45)	P value
HR (bpm)	75.0 ± 5.22	70.11 ± 4.23	0.009
PR interval (ms)	190.81 (136.16 – 198.84)	186.18 (142.61 – 197.98)	0.201
PR dispersion (ms)	34.87 ± 14.71	29.14 ± 8.44	0.026
QT interval (ms)	389.72 (376.12 – 411.46)	377.58 (368.24 – 410.28)	0.102
QT dispersion (ms)	39.17 ± 18.26	31.96 ± 13.86	0.019
QTc (ms)	420.07 ± 30.77	407.26 ± 32.54	0.011
QTc dispersion (ms)	38.84 ± 18.83	31.54 ± 11.34	0.007
Tp-e (ms)	87.85 ± 8.73	82.60 ± 7.55	<0.001
Tp-e/QT	0.229 ± 0.019	0.211 ± 0.022	<0.001
Tp-e/QTc	0.213 ± 0.024	0.197 ± 0.020	<0.001

Normally distributed numerical data are expressed as mean ± standard deviation, non-normally distributed data as the median with 25-75 percentages. sHT: Subclinical Hyperthyroidism, HR: Heart Rate, QTc: QT corrected by the Bazett formula, Tp-e: T wave peak and end point interval

A negative correlation was observed between ventricular repolarization markers and TSH. It was determined that this negative correlation reached statistically significant levels for theTp-e interval, QT and QTc dispersions, and Tp-e/QT and Tp-e/QTc ratios. The parameter with the highest correlation coefficient among ventricular repolarization markers was the Tp-e/QT ratio (r: -0.298, p = 0.004). The negative correlation between ventricular repolarization markers and TSH is presented in Figure 2 with a scatter plot.

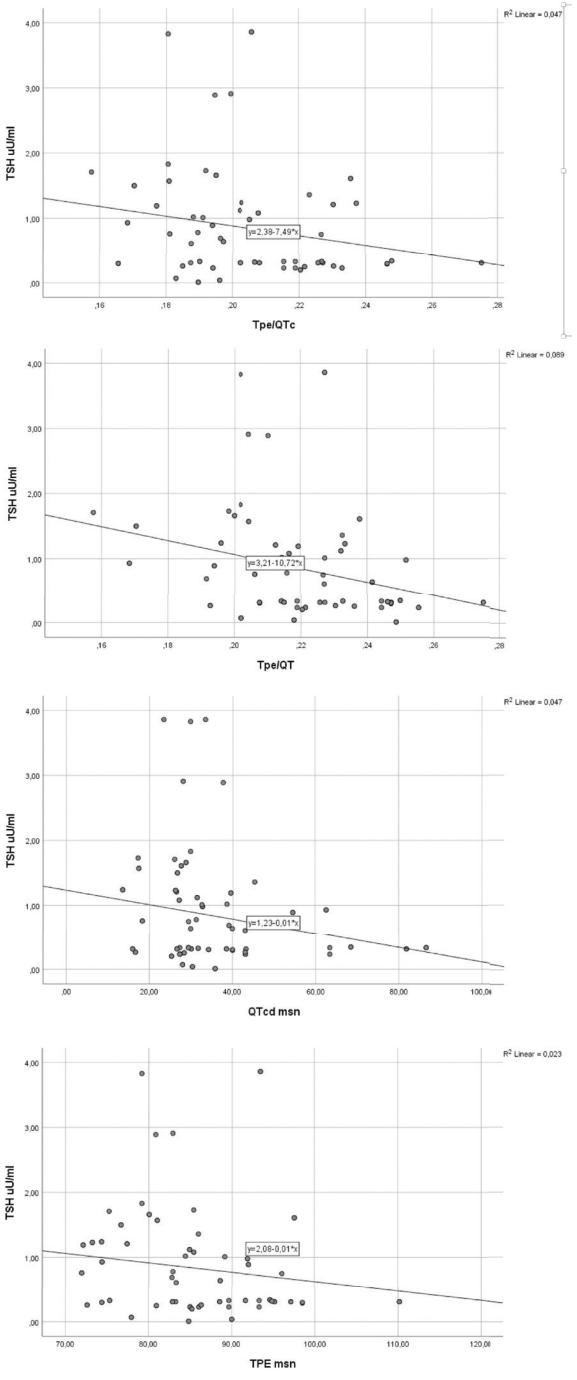

Figure 2. Scatter plot of the negative correlation between TSH and ventricular repolarization markers.TSH: Thyroid Stimulating Hormone, Tp-e: T wave peak and end point interval, QTc: QT corrected by the Bazett formula, QTcd: QT-corrected dispersio

Table 3. Correlation analysis results of TSH levels and electrocardiography findings

Variables	TSH	
	r	P value
HR	-0.88	0.410
PR dispersion	-0.173	0.103
Tp-e	-0.251	0.007
QT	-0.059	0.583
QT dispersion	-0.186	0.039
QTc	-0.097	0.361
QTc dispersion	-0.216	0.041
Tp-e/QT	-0.298	0.004
Tp-e/QTc	-0.218	0.039

TSH: Thyroid Stimulating Hormone, HR: Heart Rate, Tp-e: T wave peak and end point interval, QTc: QT corrected by the Bazett formula

DISCUSSION

In thisstudy, in which we compared patients with asymptomatic endogenous sHT and acontrol group, we found that ventricular repolarization markers were at significantly higher levels in the former compared to the latter. Markers of ventricular repolarization,namely the Tp-e interval, QT and QTc dispersions, and Tp-e/QT and Tp-e/QTc ratios had a statistically significant negative correlation withTSH.

Thyroid hormones have important effects on cardiovascular hemodynamics via the myocardium, peripheral circulation, and sympathetic nervous system. Thyroid hormones basically increase heart rate, cardiac contractility, systolic and mean pulmonary arterial pressure, cardiac output, diastolic relaxation, and myocardial oxygen consumption andreducesystemic vascular resistance and diastolic pressure.[3] The cellular activities of thyroid hormones are mediated by the binding of T3 to nuclear receptors. T3 is transported into cardiac myocytes. The binding of the T3-receptor complex to DNA regulates gene expression, particularly affecting the cardiac myocyte calcium cycle. Some effects of thyroid hormones on the cardiovascular system produce clinical findings consistent with beta-adrenergic stimulation. The relationship betwe-

en thyroid hormones and the adrenergic nervous system can be exemplified by the relief of some hyperthyroidism symptoms and signs with beta-blocker treatments.[13] The chronotropic and inotropic effects of thyroid hormones are aimed at increasing heart rate and cardiac contractility. It has been suggested that these cardiac function changes may be associated with an increase in the expression of myocardial sarcoplasmic reticulum calcium-dependent adenosine triphosphatase, a decrease in the expression of its inhibitor, phospholamban, and a decrease in systemic vascular resistance.[14] It has been reported that hyperthyroid patients with normal cardiac function have more premature supraventricular depolarization, premature atrial complexes, more non-sustained supraventricular tachycardias, increased heart rate, and decreased heart rate variability. This has been primarily attributedto the decreased parasympathetic function in these patients.[15] There is a negative relationship between TSH and free thyroid hormone levels. This raises the question whether this negative relationship is only related to the hormone level or increased free T3 hormonal activity or the sensitivity of the receptor at the cellular level also suppresses the TSH level. Undoubtedly, answers to these questions willprovide an understanding of the cardiovascular effects of subclinical thyroid dysfunctions and shed light on the pathophysiology of the disease.

Electrocardiographic ventricular repolarization markers are measurement methods developed to evaluate the arrhythmogenic susceptibility of patient groups and can be easily applied in clinical practice.[12] The detection of arrhythmogenic predisposition in non-cardiac chronic disease groups may provide clinicians with additional ideas for making treatment decisions or acting more quickly at the beginning of treatment, especially ingray zone patients. TSH suppression is important in the treatment decision ofasymptomatic sHTcases, but cardiovascular risk factors are a decisive factor in the initiation of treatment in thosethathave not been exposed to severe suppression. In this respect, a possible arrhythmogenic predisposition to be detected in this patient group may help clinicians in their treatment decision or in determining the frequency of follow-up. In overt hyperthyroidism, susceptibility to cardiac arrhythmias, especially atrial fibrillation (AF) has been demonstrated by many different models. However, Auer et al. detected AFin2.3% of the general population, 13.8% of the patients with hyperthyroidism, and 12.7% of the patients with sHT,[16] suggesting that sHT does not lag behind overt hyperthyroidism in arrhythmogenic predisposition. Cardiovascular findings in sHT may vary, possibly depending on the degree of TSH suppression, the underlying disease, and the individual's susceptibility to thyroid hormone hyperfunction. In a meta-analysis from prospective cohort studies, it was reported that the risk of AF wasincreased in patients with sHT, and this risk washigher in cases where the TSH hormone levelwas<0.1 mU/L.[17]

In our study, while the PR and QT intervals did not significantly differbetween the sHT and control groups, the QTc interval was significantly higher in the sHT group. Owecki et al.evaluated variationsinthe QT and QTc between 32 patients with sHT and 39 healthy participants with similar age and demographic characteristics and no history of chronic or cardiac disease.[18] The authors found that heart rate and QTc were significantly higher in the sHT group, consistent with our study data. They also reported that the QT interval did not significantlydifferbetween the two groups, which is also in line with our findings.However, they only measured QT from lead II in their study. In order to increase sensitivity and accuracy, we preferred to make our ECG measurements from each lead separately and take their average.

Electrocardiographic dispersions are important markers of ventricular repolarization. In our study, it was observed that the PR, QT and QTc dispersions were higher in the sHT group, andthe QT and QTc dispersions had a negative correlation with the TSH level. Kaminski et al.evaluated 44 patients with endogenous sHT (37 female and seven male) with a mean age of 45.9 ± 11 years, who developed euth-

yroidism after radioiodine treatment and provided valuable information for understanding and interpreting the cardiovascular effects of sHT. The researchers applied 24-hour rhythm and blood pressure Holter, exercise ECG and perfusion scintigraphy in this patient group during sHT and euthyroidism periods. After euthyroidism was restored, the end-diastolic volume, end-systolic volume, stroke volume, and cardiac indices significantly decreased and effort capacity significantly increased during the sHT period. In addition, it was found that systolic blood pressure, diastolic blood pressure, and mean arterial pressure decreased after euthyroidism was achieved in the patients. In the same studygroup, the QT interval dispersion, incidence of ventricular extrasystoles, and mean heart rate were found to be significantly higher in the sHT period than in the euthyroidism period.[8,19] The electrocardiographic findings obtained by the authors are consistent with our results. These changes in cardiovascular hemodynamics caused by the normalization of TSH hormone levels may play a role in the pathophysiological basis of ventricular repolarization defects that are likely to be detected in patients during the SHT period. On the other hand, in astudy including 43patients with sHTand healthy participants, Kandel et al. found that the QT dispersion was significantly higher in the patientgroup. In addition, the authors found a positive correlation between the TSH level and QT dispersion.[20] This suggests that the TSH hormone level has a confidence interval in which ventricular repolarization defect is created. Clarifying this issue with appropriate designs and defining cut-off values for TSH hormone arrhythmogenic susceptibility will be a valuable step in the follow-up of subclinical thyroid dysfunction.

Another ventricular repolarization marker,Tp-e, and its ratios with QT-QTc are valuable parameters with high diagnostic power in the determination of ventricular arrhythmogenic predisposition. High levels of Tp-e andTp-e/QT and Tp-e/QTc ratios are indicative of ventricular repolarization defects and arrhythmogenic predisposition.[12] In the current study, the Tp-e interval andTp-e/QT and Tp-e/QTc ratios were found to be significantly higher in the sHT group than in the control group. In addition, these markers had a significant negative correlation with the TSH level. We werenot able to identify a reference study associated with relevant ventricular repolarization markers in patientswith sHT. Therefore, we can only interpret our results by comparing them with designs related to patient population with subclinical hypothyroidism. In astudyevaluating[28] patients with subclinical hypothyroid and healthy participants, the authors found that Tp-e, Tp-e/QT, and Tp-e/QTc were higher in the patient group. They also showed a positive correlation between the TSH level and the Tp-e interval andTp-e/QT and Tp-e/QTc ratios.[21]These results and our inferences support the idea that TSH levels have upper and lower limits with a confidence interval that affects ventricular repolarization markers.Briefly, we can conclude that the QT dispersion, Tp-e interval, Tp-e/QT ratio, and Tp-e/QTc ratio, which are the most specific markers of ventricular repolarization, are significantly higher in the patients with sHT, whileHeart rate and the QTc interval have a negative relationship with the TSH level in patients with subclinical thyroid dysfunction. On the other hand, the relationship ofthe QTc dispersion, Tp-e interval, Tp-e/QT ratio, and Tp-e/QTc ratio with the TSH level in subclinical thyroid dysfunction is not a simple linear relationship. It can be argued that TSH hormone has a confidence interval in which it can cause arrhythmogenic predisposition or ventricular repolarization defect.

Limitations

Our study is a medium-sized study designed on the subject. Further prospective studies are necessary to determine the predictive value of ventricular repolarization markers in the development of malignant cardiac arrhythmia.

CONCLUSION

In thisstudy, we found that ventricular repolarization markers were significantly higher in the sHT group. We also observeda negative relationship between TSH and ventricular repolarization markers. In order to be more careful

in the follow-up and treatment of patients with sHT and to plan earlier interventions, high ventricular repolarization markers should alert clinicians because of the indirect arrhythmogenic predisposition.

Ethics Committee Approval

The study protocol was designed in accordance with the principles of the Helsinki Declaration and approved by the Ethics Committee of Ordu University Medical Faculty (Approval number:2022/18, approval date: 28.01.2022).

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