Original Article

Evaluation of Cardiovascular Status by Electrocardiogram and Echocardiography in Hypothyroidism: A Case Control Study

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Abstract

Introduction: Thyroid plays an important role in the orchestration of various metabolic functions in the body and thus thyroid dysfunction can produce dramatic cardiovascular effects, often mimicking primary cardiac disease.

Aims and Objective: The aim was to study the spectrum of electrocardiographic (ECG) and echocardiographic changes in hypothyroidism.

Materials and Methods: The present study included 50 cases that presented with hypothyroidism in Department of Medicine, Kasturba Hospital, BHEL, Bhopal. 20 age- and sex-matched euthyroid controls were also included in the study for comparison. Serum free T3, T4, and thyroid-stimulating hormone were done using sensitive chemiluminescence technology. Twelve lead ECG was done in each patient along with echocardiography.

Results: The predominant abnormality found on ECG study of hypothyroid cases was sinus bradycardia that was found in 32 (64%) cases ($P < 0.03$). ST-T changes in the form of T-wave inversion or ST segment depression and flattening was present in 14 cases (28%) Low voltage complexes were found in eight cases (16%) pericardial effusion (PE) was present in 12 (24%) patients of hypothyroidism ($P < 0.04$) diastolic dysfunctions was present in four cases (8%). Mean interventricular septal (IVS) and left ventricular posterior wall (LVPW) thickness is increased.

Conclusion: Sinus bradycardia is the commonest ECG change in hypothyroidism. Low voltage complexes, prolonged QTc interval in hypothyroidism were the other ECG changes. IVS and LVPW thickness was significantly increased in patients of hypothyroidism. Diastolic dysfunction was observed in a significant number of patients with overt hypothyroidism. PE occurs in a significant number of patients suffering from overt hypothyroidism.

Keywords: Bradycardia, Echocardiography, Electrocardiography, Hypothyroidism

INTRODUCTION

Thyroid plays an important role in the orchestration of various metabolic functions in the body and thus thyroid dysfunction can produce dramatic cardiovascular effects, often mimicking primary cardiac disease.[1] In hypothyroidism sinus bradycardia, ectopic rhythms, i.e. atrial flutter/fibrillation, ventricular arrhythmias, and conduction disturbances, i.e., A-V block, and bundle branch blocks are not uncommon. Documented cases of ventricular tachyarrhythmias though uncommon do occur. Prolonged QT interval, occurs in 48% of myxedema patients.[2] Since most of the arrhythmias and blocks revert after thyroxine, hypothyroidism is thought to be a causative factor of these abnormalities. However, the mechanism of the above-mentioned arrhythmias are unclear. In hypothyroidism, also there is a decrease in stroke volume, contractility, and cardiac output. Pericardial effusion (PE) is one of the most common findings in hypothyroidism. Ventricular isovolumic relaxation time is prolonged. Interventricular septal (IVS)

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and left ventricular posterior wall (LVPW) thickness are significantly increased, and there is impairment of left ventricular function more in diastole and patient may have reversible or irreversible dilated cardiomyopathy. Left ventricular mass index may be increased. Other associated changes found in cases of hypothyroidism are mitral valve prolapse (MVP), mitral regurgitation, tricuspid regurgitation and pulmonary regurgitation.[3] With the technological advancement in the recent years leading on to better insight of mechanism of heart diseases, attention has been drawn for the use of non-invasive techniques like M-mode echocardiography and Doppler echocardiography for evaluating myocardial functions. Their use in the assessment of cardiovascular status in patients with thyroid diseases will go a long way in reducing the morbidity and mortality caused by them.[4]

Hence in the current study, patients with hypothyroidism were assessed clinically and biochemically, and their electrocardiographic (ECG) and echocardiographic changes were recorded, with the aim to determine the effect of thyroid dysfunction on the cardiac status.

MATERIALS AND METHODS

The present study included 50 cases that presented with hypothyroidism in Department of Medicine, Kasturba Hospital, BHEL, Bhopal. 20 age and sex matched euthyroid controls were also included in the study for comparison.

Inclusion Criteria for Study Group

All patients having deranged thyroid hormonal levels i.e. hypothyroidism.

Exclusion Criteria for Study Group

Patients of ischemic heart disease, hypertension or diabetes. Patients taking drugs (such as digitalis, lithium, theophylline. Verapamil, tricyclic antidepressants, cisapride, atropine, adriamycin, quinidine, amiodarone, trimethoprim-sulfamethoxazole), which results in ECG changes. Patients of cardiac diseases such as rheumatic heart disease or congenital heart disease.

Inclusion Criteria for Control Group

Healthy subjects matched for age and sex, not satisfying inclusion criteria of study group and having no evidence of hypertension, cardiovascular disease and diabetes.

Study Protocol

History and clinical examination

History was taken in detail to evaluate the symptoms and duration of thyroid disorder (hypothyroidism). Special emphasis was given to the history to rule out known cardiac disease (like ischemic heart disease, rheumatic heart disease), hypertension, diabetes and any other disease which can modify electrocardiogrphic or echocardiogrphic findings. History was also taken to rule out any drug intake, which can modify the findings. Detailed general and systemic examination was done to detect any abnormality/ systemic involvement, care was taken to record pulse, blood pressure, weight as per the standard norms. Thyroid gland was examined in every patient.

Laboratory methods

Following investigations were done in all patients: Thyroid hormonal profile (free T3, free T4 and thyroid-stimulating hormone [TSH]), complete blood picture, fasting blood sugar, blood urea, serum creatinine. Urine examination, serum electrolytes, ECG and echocardiography (including two-dimensional [2D]echo, M-mode and color Doppler) serum free T3, T4 and TSH was done using sensitive chemiluminescence technology.

Normal values of T3, T4 and TSH are free T3-2.3-4.2 pg/ml, free T4-0.89-1.79 ng/dl, TSH-0.400-4.000 micro IU/ml.

ECG

Twelve lead ECG was done in each patient. ECG was analyzed in detail for the rate, rhythm, QRS axis, P-wave, PR interval, QRS complex, ST segment, T-wave, voltage of complexes, QT and QTc interval and for ectopic. Corrected QT interval was measured by using Bazzett's formula (Schamroth and Schamroth, 1990).[5]

Echocardiography

All the patients in this study were subjected to 2D, M-mode and Doppler echo in the Department of Cardiology Kasturba Hospital BHEL, Bhopal. Equipment used was ACCUSON ultrasound and echocardiographic system advanced model equipped with Doppler imaging. All echo were recorded in the supine and left lateral position taking all four views, i.e. parasternal long axis view, parasternal short axis view, apical four-chamber view and apical long axis and two-chamber views. Detailed echo analysis was performed as per standard protocol to see for chamber dimensions and volumes, wall dimensions and motions, vavular structures, left ventricular volume and ejection fraction, diastolic dysfunction and pericardial abnormality.

Statistical Analysis

Statistical analysis was performed for significance by comparing data of hypothyroid with the control group using the Student's *t*-test.[6]

Observations

The study of comprises of 50 patients suffering from hypothyroidism. Most of these patients attended the OPD

in the Department of Medicine of Kasturba Hospital, BHEL, Bhopal. Observation was made in terms of their age, sex, clinical presentations, biochemical profile, ECG and echocardiographic parameters. To compare the findings, 20 age and sex-matched euthyroid controls were selected.

The Observations in Different Parameters of Study as Follows

Rates: The heart rate varied from 48/min to 96/min. Sinus bradycardia was present in 32 (64%) cases ($P < 0.03$). Sinus tachycardia was present in one patient who had heart failure. Rhythm: No rhythm disturbances were found in hypothyroid cases, it was sinus in all cases. QRS frontal plane axis-it was normal in all cases except in one case that showed left axis deviation. P-wave and PR interval - The P-wave and PR interval was normal in all patients. ST segment and T-wave - ST segment flattening and depression was present in six cases (12%), while T-wave inversion was present in eight cases (16%) T-wave was inverted in lead II, III aVF and in some cases T-wave was also inverted in precordial leads.

QTc interval: QTc interval was normal in all patients except one, who had prolonged QTc interval. QTc interval was measured by using Bazett's formula. Low voltage complexes was present in eight cases (16%). In the control group, no abnormality was detected except 2 (10%) cases had ST-T changed in form of T-wave inversion in lead III (Table 1).

Echocardiographic Findings in Hypothyroidism

The distribution of LVPW thickness in diastole amongst the hypothyroid and the controls are shown in Table 2 (Figure 1). None of the patients or the control had LVPW thickness below the range. Eight patient (16%) of hypothyroidism and had LVPW thickness above the normal range (>11 mm). The mean for hypothyroid, and controls were 10.07 mm and 9.12 mm respectively. Hence using standard statistical technique.

The distribution of IVS wall thickness in diastole amongst the hypothyroid of patients and the controls are shown in the Table 3 (Figure 2). None of the patients or the control had IVS wall thickness below the range. Ten patients (26%) of hypothyroidism above the normal range (>11 mm). The mean for hypothyroid and controls were 10.52 mm, and 9.27 mm respectively. Hence using standard statistical technique it is statistically significant ($P < 0.03$).

The distribution of ratio of E-wave to A-wave amongst the hypothyroid and the controls are shown in Table 4. None of the patients of the control cases had ration of E-wave to A-wave <1. In hypothyroidism four patient (8%) had a ratio of E-wave to A-wave <1. The mean for hypothyroid and controls is 1.2, 1.37 respectively. Hence, using standard statistical technique it is not statistically significant ($P > 0.05$) (Figure 3).

Table 5 shows the echocardiographic findings other than those shown in previous tables. PE was present in 12 (24%) hypothyroid patients ($P < 0.03$) (Figure 4). Two patient (4% and 5% respectively) of hypothyroidism and control group had MVP left ventricular hypertrophy (LVH) was presently in 10 patients (20%) of hypothyroidism whereas it was absent in control group. Hence using standard statistical technique it is not statistically significant ($P > 0.05$).

DISCUSSION

The manifestations of hypothyroidism are protean. The advent of better investigative modalities and sensitive chemiluminescence assays has made possible, the early detection of thyroid disease and their complications.[7] Hypothyroidism can produce profound cardiovascular effects. The present study was undertaken to investigate the effect of hypothyroidism on cardiac status by means of ECG and echocardiography with particular emphasis on left ventricular functions. Patients were examined clinically, biochemically, and cardiac status was assessed by electrocardiography and echocardiography. It was then compared with euthyroid controls and with the results of various other studies with an aim to determine the effect of thyroid disease on the cardiac function. A total of 50 cases of hypothyroidism were included in the study. A total of 20 euthyroid controls comprising of 4 males and 16 females (M: F-1:4) were also included in the study. The male to female ratio 1:2.7 in the hypothyroid group.

Table 1: ECG analysis of hypothyroid patients

ECG findings	Number of cases in hypothyroidism	Percentage	Number of cases in control	Percentage
Sinus bradycardia	32	64	-	-
ST-T changes	14	28	2	10
Low voltage complexes	8	16	-	-
Prolonged QTc interval	2	4	-	-
LVH	2	4	-	-
Abnormal rhythm	-	-	-	-

ECG: Electrocardiographic, LVH: Left ventricular hypertrophy

Table 2: LVPW thickness in diastole

LVES in mm	*N* (%)	
	Hypothyroidism	Control
Below normal (<6)	-	-
Normal (6-11)	42 (84)	20 (100)
Above normal (>11)	8 (16)	-
Mean	10.07	9.12

LVES: Left ventricular end systolic, LVPW: Left ventricular posterior wall

Table 3: IVS wall thickness in diastole

IVS in mm	*N* (%)	
	Hypothyroidism	Control
Below normal (<6)	-	-
Normal (6-11)	40 (80)	20 (100)
Above normal (>11)	10 (20)	-
Mean	10.52	9.27

IVS: Interventricular septal

Table 4: Distribution of ratio of E-wave to A-wave in cases studied

E/A wave	*N* (%)	
	Hypothyroidism	Control
<1	4 (8)	-
>1	46 (92)	20 (100)
Mean	1.2	1.37

Table 5: Other ECG analysis of hypothyroid patients

Echocardigraphic variables	*N* (%)	
	Hypothyroidism	Control
PE	12 (24)	-
MVP	2 (4)	1 (5)
LVH	10 (20)	-

PE: Pericardial effusion, LVH: Left ventricular hypertrophy, ECG: Electrocardiographic

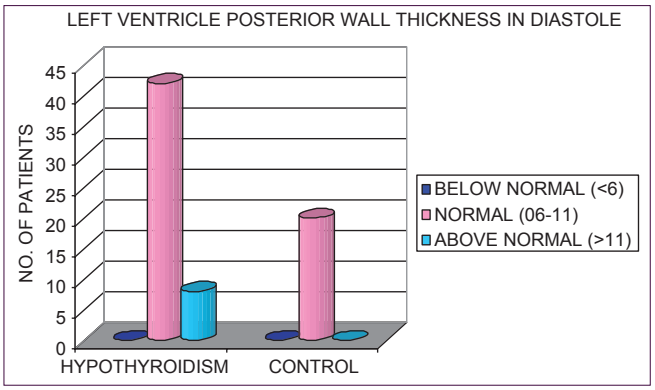

Figure 1: Left ventricular posterior wall thickness in diastole

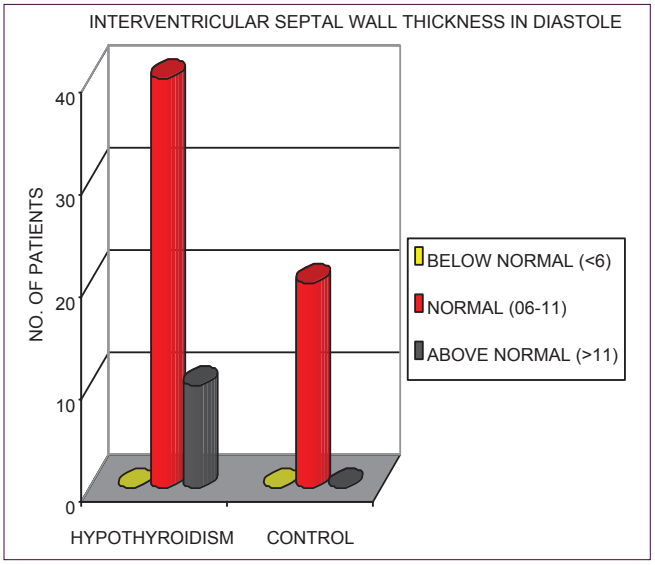

Figure 2: Interventricular septal wall thickness in diastole

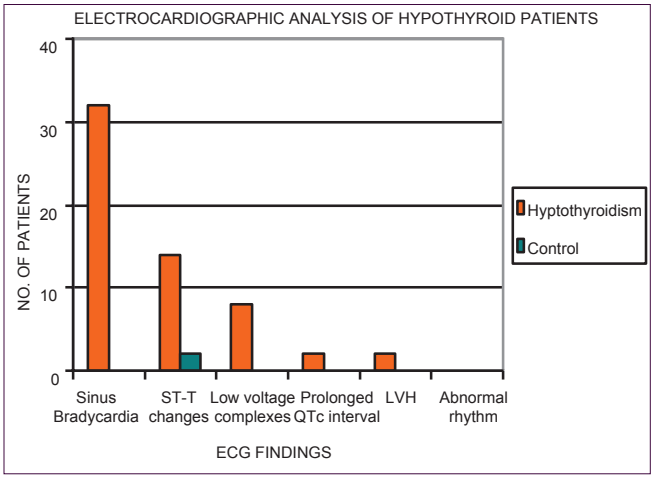

Figure 3: Electrocardiographic analysis of hypothyroid patients

ECG Abnormalities

In the present study, the predominant abnormality found on ECG study of hypothyroid cases was sinus bradycardia, which was found in 32 (64%) cases (Figure 1) ($P < 0.03$). Sinus bradycardia is most common manifestation, in hypothyroidism (Fahr 1925).[8] Douglas and Samuel (1960) in his study found heart rate varied from 42 to 90/min in cases of hypothyroidism.[9] In the present study heart rate varied from 46 to 98/min, this is in accordance with the result of the study by Douglas and Samuel (1960). The presence of the normal rate in the rest of the patients may be related to factors accelerating the heart rate such as anemia and cardiac failure. Of 18 cases of normal that, 4 had severe anemia, 4 had cardiac failure.

The other common ECG abnormalities observed were ST-T changes and low voltage complexes. These were described as ECG signs of myxedema heart by Zondek in 1918.[10] ST-T changes in the form of T-wave inversion or ST segment depression, and flatening was present in 14 cases (28%). T-wave abnormalities were noticed not only in inferior leads

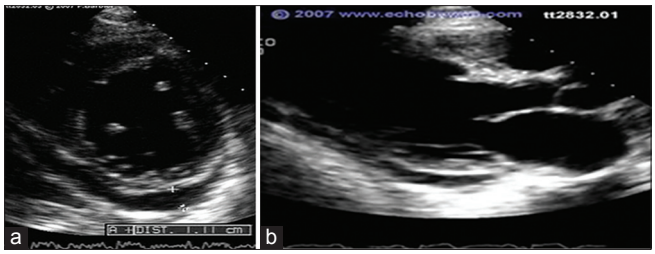

Figure 4: Echocardiographic picture of pericardial effusion, (a) parasternal short axis view, (b) parasternal long axis view

but also in precordial leads. Low voltage complexes were found in eight cases (16%). These observations were almost similar with the study conducted by Douglas and Samuel (1960). LVH was present in two patient (4%).

QT interval may be prolonged in patients of hypothyroidism, which is well known risk factor for the development of ventricular arrhythmias. It was found to be prolonged in 46% of patients in a study conducted by Douglas and Samuel (1960) but QTc interval was normal in most of the patients. In the present study prolonged QTc interval was present in two patient (4%), and result are comparable with the results of Douglas and Samuel.

Whenever ECG abnormalities are observed in a patient with hypothyroidism question arises whether these changes are due to hypothyroidism *per so* or due to ischemic heart disease or due to an ischemic process mediated by hypothyroidism or due to another pathology. Very often, the true etiology can only hypothyroidism or due to another pathology. Very often, the true etiology can only be made out retrospectively after hormonal replacement therapy. Initially, evidence of regional dyskinesia in echocardiography supports the diagnosis of ischemic heart disease. Global dyskinesia and PE would favor the diagnosis of hypothyroidism.[11]

Echocardiographic Findings

In the present study the various echocardiographic measurements which were analyzed were aortic root dimension, left ventricle end-diastolic, left ventricular internal diameter in diastole left ventricular end systolic volume, left ventricular internal diameter in systole, right ventricular dimension, LVPW thickness, interventricualr septal wall thickness, left ventricular ejection fraction (LVEF %), E-wave to A-wave (E/A), right ventricular systolic pressure and EF slope. Other associated abnormalities were also carefully looked for. These findings were then compared with age, sex matched controls and with the results of other studies. In the present study LVPW diastole (LVPWD) was normal (6-11 mm) in 42 (84%) patients. Eight patients (16%) of hypothyroidism had LVPW thickness above the normal range. The mean for hypothyroid patients was 10.07 mm. The mean LVPWD value for controls was 9.12 mm and all controls had LVPWD within normal range. When compared with the control patients in the present study the mean LVPWD was higher for hypothyroid group and the difference was found significant ($P < 0.04$).

In the present study 40 (80%) cases of hypothyroidism and all the controls (100%) showed the IVS thickness to be within the normal range with a mean value of 10.52 mm and 9.79 mm respectively. 10 (20%) cases of hypothyroidism had IVS thickness values exceeding the normal. Mean value of IVS in the hypothyroid group was 11 mm. These values were significant in the hypothyroid group when compared with controls ($P < 0.03$). Santos *et al.* (1980) have reported a mean IVS thickness of 15.4 mm in 19 hypothyroid cases with a range of 9-20 mm. 16 out of 19 patients studied (84%) had an abnormally increased IVS thickness.[12] Of the 10 who returned to euthyroid the state following thyroxine replacement, the IVS thickness was demonstrated to return to normal in 9 patients (90%). In the present study, 12 patients (24%) of hypothyroidism had PE. In the patients with significant overt hypothyroidism (TSH >25 mU/ml), the incidence was (10 out of 12 patients) ($P < 0.04$).

The present study findings of a 24% prevalence of PE is almost similar to the result of Gupta and Sinha (1996).[13]

In the present study, the mean ejection function of hypothyroid cases was found to be 59.8%. 14 patients (28%) had ejection fraction below normal. When compared with the control group the EF in the hypothyroid group was statistically insignificant ($P > 0.05$).

CONCLUSIONS

Sinus bradycardia is the most common ECG change in hypothyroidism. Low voltage complexes, prolonged QTc interval in hypothyroidism were the other ECG changes. IVS and LVPW thickness was significantly increased in patients of hypothyroidism. Hypothyroid patients show decreased myocardial contractility as evidenced by LVEF. Diastolic dysfunction was observed in a significant number of patients with overt hypothyroidism. PE occurs in a significant number of patients suffering from overt hypothyroidism. ECG parameters are less reliable indicators for diagnosis of PE. Echocardiography is the most useful to assess the cardiovascular profile of patients suffering from hypothyroidism.

Thus, it is now known that patients with hypothyroidism suffer from various abnormalities of the cardiovascular system. Echocardiography offers a sensitive, non-

invasive, easily available, bedside means of assessing the cardiac status of patients with hypothyroidism. Hence, all patients with hypothyroidism should be subjected to echocardiography in-order to pick up these abnormalities and institute appropriate management at the earliest.

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