STUDY OF LEFT VENTRICULAR FUNCTION BY SPECKLE TRACKING ECHOCARDIOGRAPHY AND CONVENTIONAL ECHOCARDIOGRAPHY IN PATIENTS WITH HYPERTHYROIDISM

Namitha Kini U¹, Narasimha D. Pai², J. Kannan³, Thangasheela A⁴, Francis N. P. Monteiro⁵

¹Assistant Professor, Department of Cardiology, Kasturba Medical College (Affiliated to MAHE), Mangalore, Karnataka, India.

²Associate Professor of Cardiology/Interventional Cardiologist, Kasturba Medical College (Affiliated to MAHE), Mangalore, Karnataka, India.

³Interventional Cardiologist, FSCAI, FESC, Senior Consultant, Cardiologist and Electrophysiologist, NHICS, Bangalore, Karnataka, India.

⁴HOD of Adult Ecocardiography, Department of Non-Invasive Cardiology, NHICS, Bangalore, Karnataka, India.

⁵Professor, Department of Forensic Medicine and Toxicology, A. J. Institute of Medical Sciences (Affiliated to Rajiv Gandhi University of Health Sciences), Mangalore, Karnataka, India.

ABSTRACT

BACKGROUND

The main function of Thyroid hormones is to maintain a balance in cardiac function along with the regulation of metabolism. Any alterations in the thyroid hormone levels will further affect the normal functioning of the cardiac muscles. Initial raise in the hormones will result in increased contractility of the left ventricle resulting in the raise of cardiac output, whereas chronicity of the disease will cause reduction in normal behaviour of cardiac function, thereby causing increased risk of arrhythmias, reduction in global function of left ventricle, fibrosis and ultimately will result in heart failure. Cardiac dysfunction is one of the main causes of death in hyperthyroid cases, which is mainly due to remarkable changes in the haemodynamics resulting from abnormal muscle function of heart and diaphragm. Graves' disease was one of the commonest among the metabolic disorders to have its impact on cardiovascular system.

MATERIALS AND METHODS

This cross-sectional study was conducted in Narayana Hrudayalaya Hospital, Bangalore. All known cases of hyperthyroidism, irrespective of the duration of disease, irrespective of the gender and their geographical area of distribution, Males and Females >18 yrs. were all included in our study. The study was performed in the duration between April 2016 - April 2017.

RESULTS

A positive correlation was noted between left ventricular global longitudinal peak strain and left ventricular ejection fraction among 4% of the hyperthyroid cases, describing severe left ventricular systolic dysfunction. In our study, impaired myocardial relaxation was observed in 12% of the samples. Among them the LV systolic function assessed by conventional echocardiography showed normal LV ejection fraction, whereas AFI derived strain showed reduced global longitudinal peak strain values in 4% of the cases. Hence, we conclude that GLPS values are more sensitive than 2D EF to describe the early involvement of myocardial function impairment.

CONCLUSION

As per this study, there was significant correlation between TSH, T3, T4 thyroid hormones and 2D Speckle Tracking Echo in terms of Global Longitudinal peak strain of LV. Abnormal GLPS is a marker of early myocardial disease affecting the longitudinal myocardial fibres, which was found in the study. In terms of systolic and diastolic dysfunction, Tissue Doppler imaging was remarkably reduced in our study, which implies early changes in myocardial impairment.

KEY WORDS

Graves' Disease, Global Longitudinal Peak Strain, Tissue Doppler Imaging.

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Corresponding Author:

Dr. Narasimha D. Pai,

Associate Professor,

Department of Cardiology/Interventional Cardiology,

Kasturba Medical College,

Ambedkar Circle, Affiliated to MAHE,

Mangalore, Karnataka,

India.

E-mail: narasimhapai@yahoo.com

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BACKGROUND

Cardiac dysfunction is one of the main causes for death in hyperthyroid cases, which is mainly due to remarkable changes in the haemodynamics resulting from abnormal muscle function of heart and diaphragm.^{1,2,3}

Among the hyperthyroid patients, only 6% have shown heart failure signs. Among them 50% have shown impaired LV systolic function, whereas the pathologic process may include diastolic dysfunction as well.⁴

Thyroid diseases have become a burden worldwide including Indian population. Multiple studies have estimated that around 42 million of Indian population are exposed to thyroid diseases.⁵

Among the metabolic disorders, Graves' disease had a greater impact on cardiovascular system like increased heart

rate and cardiac output as well as reduced peripheral vascular resistance. Hyperthyroidism may also result in major life-threatening cardiac arrhythmias like atrial fibrillation and which may lead to heart failure.⁶

Thyroid hormones may show their effect on cardiovascular system directly or indirectly. T3 hormones show their effects on heart rate, contractility, systemic vascular resistance and diastolic function.

Walker et al showed that by adrenergic stimulation, T3 hormones enhances the contractility.⁷ Due to the simultaneous increase in the contractility of left ventricle and reduced systemic vascular resistance, the patients with hyperthyroidism are prone to have significantly higher level of cardiac output than normal individuals. From the literature we have learnt that more than 42 million of the population suffer from various thyroid diseases in India and the prevalence of hyperthyroidism disease is 0.6 - 1.2%.⁸

The functional reserve is decreased in hyperthyroidism patients, having a highly stressed cardiovascular system at rest. Therefore, it may lead to impairment of the cardiovascular system efficiency resulting in heart failure. Persistent increase in the myocardial contractility may result in deterioration of cardiac performance with time.⁹

Aim of the present study was to assess the left ventricle function in patients with hyperthyroidism. The objectives of the study was to assess the prevalence of left ventricular systolic dysfunction in patients with hyperthyroidism by conventional ECHO, 2D strain. To assess the prevalence of left ventricular diastolic dysfunction in patients with hyperthyroidism by conventional ECHO.

MATERIALS AND METHODS

This was a cross-sectional study conducted at Narayana Hrudayalaya Hospital, Bangalore between April 2016 and April 2017. Study population was 50 subjects having hyperthyroidism using Universal Sampling.

All known cases of hyperthyroidism, irrespective of the duration of disease, irrespective of the gender and their geographical area of distribution, Males and Females, >18 yrs. were all included in our study.

Subjects having significant cardiomyopathies, valvular lesions, congenital heart diseases, coronary artery diseases and implanted prosthetic valves were excluded from the study.

The study was started after receiving the ethical clearance from the Ethics Committee. All the cases were consecutively enrolled in this study after receiving the informed consent.

The diagnosis of hyperthyroidism is made on the basis of a review of patient's history, physical examination, blood serum test, thyroid scan, ECG and echocardiography.

ECG was analysed for cardiac evaluation. Echocardiographic imaging was done using vivid echocardiography system (GE) with a 2.5 MHz transducer, ECG gated. Minimum of 3 cardiac loop images were acquired.

Echocardiographic data has been stored on personal computer with dedicated software for the offline analysis. Use of Conventional Echocardiography (LVEDD, LVESD, LVEDV, LVESV, EF, FS, LV MASS, MAPSE, IVCT, IVRT, ET, Tie Index, DT, TDI) and Advanced Echocardiography (Global Longitudinal Peak Strain) was used for left ventricular function assessment.

Global Longitudinal Peak Strain (GLPS) is defined as a more sensitive parameter in comparison with the Left Ventricular Ejection Fraction (LVEF) to measure systolic function. Myocardial velocities have more advantages than conventional Doppler parameters for left ventricular diastolic filling.

The study variables included demographic details of age and gender, physical examinations of BSA, duration of hyperthyroidism, pulse rate, blood pressure, blood investigations of thyroid function test, ECG reports, Conventional echo parameters, Doppler measurements and advanced echocardiography.

The statistical analysis was performed by SPSS version 17.0. Descriptive statistics like mean, standard deviation, minimum, maximum; frequency and percentage were calculated for all study variables. The correlation coefficient was found by Pearson's correlation coefficient. $P < 0.05$ was considered to be significant.

RESULTS

In our study of 50 samples, 54% (n= 27) were females and 46% (n= 23) were males.

	Frequency	Percent
Female	27	54.00
Male	23	46.00
Total	50	100.00
Gender Distribution		

Descriptive Statistics		
	Mean	Std. Deviation
Age	44.68	12.70
Systolic BP	126.64	18.66
Diastolic BP	75.24	11.01
Heart rate	93.56	21.10
Body surface area	1.66	.20
Duration of Disease	4.84	5.20
T3 Hormones	226.40	73.51
T4 Hormones	2.54	1.69
TSH Hormones	.003	.002

Our study included 50 samples, between age group of 20–60 years. 48% of the samples had elevated systolic BP. 46% of the samples had sinus tachycardia. All the samples had elevated thyroid hormone levels.

	Mean	Std. Deviation
LVEDD	41.82	4.83
LVESD	27.28	4.82
IVSD	9.44	1.38
PWD	9.40	1.35
EDV	76.58	22.39
ESV	29.38	13.19
EF	61.74	9.03
FS	33.38	6.00
LV_MASS	90.64	37.18
MAPSE	22.38	4.05
Average Systolic TDI	9.84	1.54
Echocardiographic Data		

Significant systolic and diastolic function impairment have been observed in 4% of 50 samples. Conventional Echocardiography has described the increase in LV end diastolic dimensions (> 54 mm) and systolic dimensions (>45 mm), LV mass ($> 70\pm9$), LV End diastolic volume ($>142\pm21$ mL), LV end systolic volume($>41\pm10$ mL), EF by Simpson's modified method ($< 30\%$), FS ($< 15\%$), MAPSE (< 12 mm), average TDI of all the walls of LV (< 9 cm/s), Tie index (> 0.4).

	Mean	Std. Deviation
IVCT	34.50	6.247
IVRT	75.70	6.701
ET	302.50	21.147
Tie Index	.3650	.04239
E	.930000	.1729103
A	.612	.2125
E Em	10.16	3.316
DT	205.80	28.533
GLS	-18.50	3.019

In our study, GLS was reduced in 4% of the study population that correlated well with a reduced LV ejection fraction of $< 30\%$ indicating LV systolic dysfunction. Hence, EF ($< 30\%$) correlates with GLS (< -10) in 4% of the hyperthyroid patients who were prone to systolic heart failure.

The conventional transmitral Doppler velocities showed grade III diastolic dysfunction ($E \gg A$, E/A ratio 1.3/0.3) and elevated LV filling pressures ($E/e' > 13$), increased DT (>240 msec). As a result, 4% of the study population showed worsened systolic and diastolic function with abnormal thyroid function and had no underlying comorbidities.

In our study, impaired myocardial relaxation was observed in 12% of the samples. The conventional Doppler techniques performed in our study found E and A velocities reversal indicating impaired relaxation. Elevated LV filling pressures were observed in 4% of the samples ($E/e' > 13$). 4% had prolonged deceleration time (> 240 ms).

Among 12% of the cases with impaired relaxation, the LV systolic function assessed by conventional echocardiography showed normal LV ejection fraction, whereas AFI derived strain showed reduced global longitudinal peak strain values with GLPS - 15% in 4% of the study population.

Correlation Graph 1a and 1b: Describing correlation between T3 hormones with GLS/ EF of LV

1a

1b

Correlation Graph 2a and 2b: Describing correlation between T4 hormones with GLS/EF of LV

2a

2b

Correlation Graph 3a and 3b: Describing correlation between TSH hormones with GLS/EF of LV

3a

3b

Bar Graphs 1a, 1b, 1c describing the percentage of tachycardia, systolic and diastolic dysfunction in the given population

1a

1b

1c

DISCUSSION

In the study conducted by K Aroditis et al, which consisted of 44 samples, they investigated the reaction of the elevated levels of thyroid hormones (Graves' disease) on heart and the changes that occur on therapy for 6 months. They considered 43 euthyroid subjects. It was a prospective case control study.¹⁰

Our study consisted of 50 patients with hyperthyroidism between age group of 20 - 60 years included Graves' disease and Thyroiditis (1: 1). It was a time bound cross-sectional study performed over a period of 12 months. The aim of the study was to assess the prevalence of systolic and diastolic dysfunction among all patients with hyperthyroidism with conventional and advanced echocardiography and their comparison which could be an early indicator for the signs of predisposition of the disease. Echocardiographic evaluation was the main modality utilised in our study to screen the cardiac function in the hyperthyroidism patients.

Our study involved patients with tachycardia with exaggerated cardiac output (46%) at rest, heart failure (4%), grade 1 diastolic dysfunction with mildly elevated filling pressures (12%). Among them 4% had normal LV ejection fraction by conventional echocardiography and borderline

global longitudinal strain parameters, which was an early indicator for signs of LV systolic function impairment.

We used conventional echo as well as advanced echo for the assessment of both systolic and diastolic function of left ventricle. In the study which was conducted by K Aroditis et al left ventricular internal dimensions during systole and diastole were increased, RV function was reduced among these subjects. The Left Ventricular (LV) mass index and Left Atrium (LA) volume index were also increased in Graves' disease group.¹⁰

In our study 4% of heart failure cases were middle-aged males, who were known cases of Graves' disease, not on any medical management showed elevated levels of free T3 hormone level (> 480 pg/mL), free T4 hormone level (>1.53 ng/dL) and reduced TSH level (< 0.35). According to our observational study, the changes in the Thyroid hormone levels correlate with the LV myocardial function impairment. Significant systolic and diastolic function impairment have been observed in 4% of 50 samples. Conventional echocardiography has described the increase in LV internal dimensions during diastole (> 54 mm) and systolic dimensions (> 45 mm), LV mass ($> 70 \pm 9$), LV end diastolic volume ($> 142 \pm 21$ mL), LV end systolic volume ($> 41 \pm 10$ mL), EF by Simpson's modified method ($< 30\%$), FS ($< 15\%$), MAPSE (< 12 mm), average TDI of all the walls of LV (< 9 cm/s), Tie index (> 0.4). The Global Longitudinal Strain (GLS) is a sensitive parameter than Left Ventricular Ejection Fraction (LVEF) to measure LV systolic function. Normal range is $< -18\%$.

A positive correlation was noted between Left Ventricular Global Longitudinal Peak Strain and Left Ventricular Ejection Fraction among 4% of the Hyperthyroid cases, describing severe left ventricular systolic function impairment. In our study, GLS was reduced in 4% of the study population that correlated well with a reduced LV ejection fraction of $< 30\%$ indicating LV systolic dysfunction. Hence, EF ($< 30\%$) correlates with GLS (< -10) in 4% of the hyperthyroid patients who were prone to systolic heart failure.

The conventional transmitral Doppler velocities showed grade III diastolic dysfunction ($E > A$, E/A ratio 1.3/0.3) and elevated LV filling pressures ($E/e' > 13$), increased DT (> 240 msec). As a result, 4% of the study population showed worsened systolic and diastolic function with abnormal thyroid function and had no underlying comorbidities.

In the study conducted by K Aroditis et al, the Diastolic impairment was assessed. 2D-STE analysis showed that at isovolumic relaxation time there is an increase in the strain rate. Comparison was made with the case controls. Also described that on restoring euthyroidism there was an improvement in both systolic and diastolic function.

Subjects who were newly diagnosed with Graves' disease showed improvement in the diastolic function, RV systolic function and other structural parameters with 6 months thyrostatic therapy.¹⁰

In our study impaired myocardial relaxation was observed in 12% of the samples, male-to-female ratio of (1:1), elevated T3 and T4 hormone levels with reduction in TSH levels which included Graves' disease and thyroiditis (1:2). The conventional Doppler techniques performed in our study found E and A velocities reversal indicating impaired relaxation. Elevated LV filling pressures were observed in 4% of the samples ($E/e' > 13$). 4% had prolonged deceleration

time (> 240 ms). Myocardial tissue velocities is said to be more advantageous over conventional Doppler indices of left ventricular diastolic filling.

Among 12% of the cases with impaired relaxation, the LV systolic function assessed by conventional echocardiography showed normal LV ejection fraction, whereas AFI derived strain showed reduced global longitudinal peak strain values with GLPS 15% in 4% of the study population. Though the LV contractility was preserved by conventional echocardiography, AFI derived GLPS was more sensitive parameter to assess longitudinal myocardial fibre dysfunction. Hence, an abnormal GLPS is a marker of early myocardial disease affecting the longitudinal myocardial fibres. Hence, conventional 2D parameters is less sensitive for the early detection of preclinical cardiac disease.

CONCLUSION

1. There was a significant correlation between TSH, T3, T4 thyroid hormones and 2D Speckle Tracking Echo in terms of Global Longitudinal LV strain.
2. Abnormal GLPS is a marker of early myocardial disease affecting the longitudinal myocardial fibres, which was found in the study.
3. In terms of systolic and diastolic dysfunction, TDI was remarkably reduced in our study, which implies early changes in myocardial impairment.
4. Early diagnosis of Hyperthyroidism and application of non-conventional echocardiographic parameters should be useful to prevent the deterioration of myocardial function.

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