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Echocardiographic Changes in Type 2 Diabetes Mellitus with Reference to Body Mass Index and Waist Hip Ratio

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ABSTRACT

Background: *Diabetes mellitus (DM) refers to a group of common metabolic disorders that share the phenotype of hyperglycaemia. India alone had 65.1 million diabetics by the year 2013. DM with high BMI & increased central obesity (WHR) have changes in the cardiac geometry evidenced in echocardiography. AIM OF STUDY: Estimation of Body Mass Index (BMI) and Waist Hip Ratio (WHR) & Establish a relationship between obesity, particularly central obesity in type 2 diabetes mellitus patients and cardiac changes with the help of echocardiography.* ***Methods****: 30 Subjects with type 2 DM attending the OPD or admitted in Katihar Medical College indoor department & 30 control patients were also be taken from the same, all of age >40 years. The cases and the controls were examined thoroughly with respect to BMI (>30) & WHR (> 0.85 for females and > 0.95 for males) and echocardiography was done.* ***Results****: The cases i.e. type 2 diabetes with high WHR and BMI had highly significant alteration in LV geometry as compared to the controls & had significantly high mean LV mass 189.10grams as compared to 134.04 grams of the controls. There was significant early diastolic dysfunction found in the cases group while no significant difference was found in systolic dysfunction between cases & controls. The incidence of changes in left ventricular geometry was higher in female type 2 diabetic subjects with high waist hip ratio and BMI as compared to males.* ***Conclusions****: Form the data of the present study it can be concluded that type 2 diabetics with obesity, particularly central type, have an increased predisposition to the development of left ventricular structural or geometrical abnormality. They have significantly higher left ventricular Mass. Obese type 2 diabetics also have higher incidence of diastolic dysfunction. All these abnormalities occur with greater frequency in females. Thus, type 2 diabetics with high BMI and Waist hip ratio have higher risk of development of cardiovascular disease, which is higher for female than males.*

Key words: *Diabetes mellitus, BMI, Metabolic disorders*

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INTRODUCTION

Diabetes mellitus (DM) refers to a group of common metabolic disorders that share the phenotype of hyperglycaemia. The worldwide prevalence of Diabetes Mellitus has risen dramatically over the past two decades from an estimated 30 million cases in 1985 to 382 million in 2013. Based on current trends, the International Diabetes Federation projects that 592 million individuals will have diabetes by the year 2035. India alone had 65.1 million diabetics by the year 2013. The prevalence of type 2 DM is rising much more rapidly, presumably because of increasing

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obesity & reduced activity levels. Obesity is frequently associated with changes in the cardiac structure. Obesity represents a state of excess adipose tissue mass, and currently, overweight and obesity are classified by body mass index (BMI). BMI (weight in kilograms/height2 in meters) is frequently used as a surrogate measure of fatness in children and adults. In adults, overweight is defined as BMI of 25.0 to 29.9kg/m2 while obesity is defined as BMI of ≥30kg/m2.[1]

However BMI does not take into consideration regional distribution of adiposity some of which may correlate with cardiovascular risk. Hence other measures of obesity such as waist circumference (WC) and waist to hip ratio (WHR) were introduced. Waist circumference greater than 90 cm in men and greater than 80cm in women and waist to hip ratios greater than 0.95 in men and 0.85 in women are both used as measures of central/visceral /abdominal types of obesity. Echocardiography (echo) provides visualization of structural and functional changes which appears long before the detection of overt clinical disease. The echocardiographic diagnosis of LVH in obese apparently healthy normotensives and institution of weight loss measures to regress LVH implies early diagnosis and early treatment. This would prevent life threatening complications of obesity and underscores the need for this study.[2]

The existence of a diabetic cardiomyopathy was first proposed by Rubler et al in 1972 on the basis of postmortem findings. In 1974, Framingham study showed that heart failure was more common in diabetes due to diabetic cardiomyopathy. The Framingham Study, which involved 5209 patients followed up for 18 years, demonstrated that patients with diabetes had a greater likelihood of developing clinical heart failure. The study also revealed a marked increase in congestive heart failure, coronary artery disease and myocardial Infarction in diabetic patients. Patients with signs and symptoms of heart failure with preserved left ventricular systolic function i.e., ejection fraction of 60 % are said to have diastolic heart failure (DHF). Diabetes mellitus is one of the major risk factors for DHF.[3]

AIM OF STUDY:

In the present study a modest endeavour has been made to:

1) Study the clinical profile of type 2 diabetes mellitus patients with special reference to cardiac changes.
2) Estimation of Body Mass Index and Waist Hip Ratio.
3) Detect the cardiac changes in type 2 diabetes mellitus with the help of electrocardiography & echocardiography.
4) Establish a relationship between obesity, particularly central obesity in type 2 diabetes mellitus patients and cardiac changes.

METHODS

30 Subjects with type 2 DM attending the OPD or admitted in Katihar Medical College indoor department & 30 control patients were also be taken from the same, all of age >40 years. 18 of the patients were on oral hypoglycemic agents and 12 were on insulin. The period of study was one and a half year from December 2015 to May 2017.

Selection Criteria for cases

1. Patients were diagnosed as having diabetes mellitus based on the criteria laid down by the WHO diagnosis and classification of diabetes mellitus, 1999.

a) Fasting plasma glucose > 7.0 mmol/l (or 126 mg/dl) (Fasting defined as no caloric intake for at least 8 hours).

Or

b) 2 hour plasma glucose > 11.1 mmol/l (200mg/dl) during an oral glucose tolerance test using a glucose load containing the equivalent of 75 g anhydrous glucose in water.

Or

c) Symptoms of diabetes plus random plasma glucose concentration > 11.1 mmol/l (200 mg/dl).

2. In addition to the above American Diabetes Association adds:

a) Glycated haemoglobin (HbA1c) ≥ 6.5% (4)

These were confirmed on a second occasion.

3. Age more than 40 years.

An objective response to oral hypoglycemic drugs at some time during the period of study and the absence of a history of diabetic ketoacidosis were the parameters used to rule out type 1 diabetes mellitus.[5]

All the patients meeting above criteria and having a BMI > 30 and/or Waist Hip Ratio >0.85 for females and > 0.95 for males.

Criteria for Exclusion

Patients with pancreatic calcification, recent history of severe malnutrition were excluded from the study. Also excluded were patients with history of gestational diabetes, other endocrinological disorders, chronic renal disease, liver disease and chronic obstructive pulmonary diseases. Patients with history of symptomatic heart disease, angina stable or unstable. Patients with structural heart disease, alcoholic patients, dyslipidemia of genetic origin, hereditary cardiac disease; rheumatic heart disease, tuberculosis, collagen vascular diseases, drug induced diabetes were also excluded.

Selection of controls

Controls were selected from the patients attending the Out Patients Department of Medicine and admitted in the Medicine Ward of Katihar Medical College. They were non-diabetics and non-obese but matching with age & sex of the cases.

Investigations

1. Biochemical analysis: Fasting and postprandial venous plasma glucose level, Glycosylated haemoglobin, Serum urea levels, serum creatinine, lipid profile.
2. Electrocardiography - Left ventricular anatomy and geometry of all the cases and controls were assessed. Major echocardiographic parameters used for assessment of left ventricular geometry were:

i) Left ventricular internal diameter in diastole (LVIDD)
ii) Inter ventricular septal wall thickness (IVST)
iii) Left ventricular posterior wall thickness (LVPWT).

iv) Left ventricular Mass: - Left ventricular mass was calculated using the formula: 0.8 (1.04) ([LVIDD + IVST + LVPWT] 3 –LVIDD3) + 0.6 (in grams)(6).

Statistical Methods Used

For testing the test of significance the chi- square test was used. Another statistical method used was the standard error of difference between the two means.

RESULTS

The BMI was higher >30 for cases compared controls and so is the waist hip ratio.

Table 1: Showing Incidence of various haematological abnormalities (n=80)

	Cases (n=30)	Controls (n=30)
Weight kg	76±12	58± 6
BMI	31 ± 2	23 ± 2
Waist circumference	96.4 ±11.6	76.6 ±9
Hip circumference	96.8±10	86±6.9
WH Ratio	1.00±0.08	0.78±0.06

Table 2: Left Ventricular Internal Dimensions of cases and controls.

Study group	LVIDD (cm)	IVST (cm)	LVPWT (cm)
Cases-30	5.16±0.60	1.00 ±0.25	0.98 ± 0.15
Control-30	4.50±0.52	0.92 ±0.20	0.85 ±0.12

Table 3: Left ventricular Mass of the cases and controls.

Study group	LV Mass (g)
Cases (n=30)	189.10 ± 55
Controls (n=30)	134.04± 45

Table comparing the LV mass of cases and controls. P value obtained on applying chi square test was < 0.05. The observations were statistically significant with P values < 0.05. Thus the cases i.e. type 2 diabetes with high WHR and BMI had significantly high mean LV mass 189.10grams as compared to 134.04 grams of the controls.

Table 4: Left Ventricular Systolic Function Study

Study group	EPSS	EF (%)	F S
Cases (n=30)	0.30 ± 0.06	61 ± 6	33 ±2
Controls (n=30)	0. 32 ± 0.08	62± 6	34 ± 2

Table comparing the systolic function of the cases and the controls. There was no significant difference in the various parameters. (P value > 0.05, on applying chi square test. Table comparing the parameters of diastolic function of the cases and the controls. The mean IVRT of the cases was significantly raised (97.76 msec). A flow velocity, E flow velocity, and E/A ratio were significantly altered in the cases. The P value for IVRT in the cases group was P < 0.05 whereas for E flow velocity, a flow velocity and E/A ratio was highly significant P < 0.01.

Table 5: Left Ventricular Diastolic Function Study at rest

Study group	IVRT (msec)	E flow velocity (cm/s)	A flow velocity (cm/s)	E/A
Cases (n=30)	97.76 ± 10.30	63.08 ± 15.90	64.5 ± 12	0.965 ± 0.255
Controls(n=30)	81.45 ± 10.50	62. 40± 5.40	45.6 ± 12.6	1.25 ± 0.28
P	< 0.05	< 0.01	< 0.01	< 0.01

Thus significant early diastolic dysfunction was found in the cases group.

Table 6: LV geometry of cases and controls in relation to sex distribution

Study group	Sex	LVIDD	IVST	LVPWT	LV Mass
Cases-15	F	4.90 ± 0.50	1.00 ± 0.20	0.97 ± 0.13	197±48
Controls-15	F	4.48 ± 0.46	0.92 ±0.12	0.82± 0.11	137 ±43
P value		P < 0.01	< 0.01	<0.05	<0.01
Cases-15	M	5.30± 0.56	1.00 ± 0.30	0.98 ± 0.17	180± 60
Controls-15	M	4.52 ± 0.54	0.96 ± 0.18	0.89 ± 0.12	131±60
P value		< 0.05	< 0.05	<0.05	<0.05

1) Table comparing LV geometry of cases and controls in relation to sex distribution. The LV geometry was significantly altered in the cases as compared to controls.
2) The P value obtained by chi square test for females was < 0.01 for LVIDD, IVST and LV mass and < 0.05 for LVPWT. Thus the female cases had highly statistically significant alterations in LV geometry as compared to female controls.
3) The P value for males was <0.05. The male cases also had significant alteration in LV geometry as compared to the male controls.

DISCUSSION

In the present study a total of 30 diabetic patients were chosen. The diagnostic criteria were based on the revised criteria for diagnosing diabetes mellitus, laid down by WHO and the National Diabetes Data group in 1999(4).

None of the patients had any radiological evidence of pancreatic calcification. None of the cases had any recent or past history of severe malnutrition. Thus fibrocalcific pancreatic disease was excluded. All the patients selected had shown an objective response to oral hypoglycemic agents and none had any history of diabetic ketoacidosis. None of the patients were suffering from heart, kidney or liver diseases.

The patients with well-controlled diabetes were selected to minimize the role of hyperglycemia as confounding factor. The lipid profiles of the cases and controls were comparable

and under control. Some of the cases were on lipid lowering agents.

The blood pressures of the cases and controls were comparable and matched.

All of the 30 cases selected had altered waist hip ratio, > 0.85 for females and >0.95 for males reflecting large proportion of abdominal fat distribution. All the 30 patients had high BMI > 30.

Left ventricular Geometry: In the present study abnormalities in left ventricular geometry were detected in the form of increased inter-ventricular septal wall thickness, increased left ventricular posterior wall thickness and increased left ventricular mass.

Increased inter-ventricular septal wall thickness was found in 60% of the cases as compared to 5% of the controls. Among the cases in the present study incidence of increased IVST was higher in females (60%) as compared to males (45%).

Increased left ventricular posterior wall thickness was found in 55% of cases whereas none of the controls had an increase in left ventricular posterior wall thickness. Among the cases in the present study incidence of increased LVPWT was slightly higher in females (60%) as compared to males (40%).

The mean left ventricular mass of the cases in the present study was 189.10 grams, which was significantly higher than that of controls, 134.04 grams. 70% of the cases in the present study had a high left ventricular mass. Among the cases incidence of higher left ventricular mass in females was 60% as compared to 45% in males.

Ronald M et al, in the Hoorn study in 2004,[7] found a significantly higher left ventricular mass, inter-ventricular septal wall thickness and left ventricular posterior wall thickness in female type 2 diabetes mellitus patients. The mean left ventricular mass in their study was 169 grams. The results of this study are similar to the present study. However, the mean left ventricular mass calculated in the present study was higher i.e. 189.10 grams. This difference could be due to the higher waist hip ratio and BMI of the type 2 diabetic subjects in the present study.

The Framingham Study Cohort[8] concluded that diabetic individuals, particularly women, had greater left ventricular wall thickness and greater cardiac mass. In a re-examination of 2623 participants in the Framingham Offspring study who had no history myocardial infarction or heart failure, worsening glucose intolerance was associated with increasing left ventricular mass, a finding that was more significant in women than in men. In the present study also females had a higher incidence of greater left ventricular wall thickness and LV mass, which is in accord with the Framingham study.

Left Ventricular Function: Both systolic and diastolic functions were assessed in the present study.

Systolic Function: The ejection phase indices such as ejection fraction (EF) and fractional shortening (FS) of the cases were nearly same as that of controls. The mean ejection fraction of the cases in the present study was 60% and that of controls was 62%. The mean fractional shortening of the cases was 34% whereas that of controls was also 34%. Both the observations lacked any statistical significance. A sizable number of cases showed reduced FS<34%. However, this was also observed in the control group. Thus making the observation inconclusive.

Many studies[9-12] have demonstrated systolic dysfunction in diabetic subjects. The systolic function is impaired in the most severe form i.e. stage 3 of diabetic cardiomyopathy. However, a number of studies have failed to demonstrate systolic dysfunction in diabetic subjects.[13,14]

Diastolic Function: The present study, using echocardiographic and Doppler studies demonstrated abnormalities in diastolic function of type 2 diabetes mellitus patients with high waist hip ratio and BMI in the form of increased isovolumetric relaxation time, reversal of E/A ratio and pseudonormalization.

In the present study, the mean isovolumetric relaxation time of the cases was 97.70 msec whereas that of controls was 78.69 msec. 65% of the cases in the present study had a high isovolumetric relaxation time as compared to 10% of the controls. Thus the incidence of early diastolic dysfunction was significantly higher in the present study. Among the cases 60% of the males had increased isovolumetric relaxation time as compared to 70% of the females.

In the present study, reversed E/A ratio (i.e. E/A < 1) was found in 65% of the cases as compared to 10% of the controls. Among the cases 60% of the males had reversed E/A ratio as compared to 70% of the females. The reversed E/A ratio is also a marker for early diastolic dysfunction.

The cases and controls in the present study were subjected to further Doppler assessment during valsalva manoeuvre to differentiate between normal pattern and pseudonormal pattern.

On subjecting the study groups to valsalva manoeuvre 95% of the cases had reversed E/A ratio whereas the number of controls with reversed E/A ratio remained the same. This increase in number of cases with reversed E/A ratio was due to unmasking of diastolic dysfunction by valsalva manoeuvre, representing the pseudonormalization pattern. Thus 30% of the cases had pseudonormalization pattern, the more advanced stage of diastolic dysfunction. Among the cases, 40% of the females had pseudonormalization pattern as compared to 20% of the males.

Thus in the present study, type 2 diabetes mellitus patients with high waist hip ratio and BMI had a significantly higher incidence of early diastolic dysfunction and pseudonormalization as compared to non-diabetics with normal waist hip ratio and BMI. The present study found diastolic dysfunction in 95% of the cases that included 65% with early diastolic dysfunction and 30% with the more advanced form of diastolic dysfunction i.e. pseudonormal pattern. The female subjects in the present study had higher incidence of the more advanced pseudonormal pattern of the diastolic dysfunction.

Several studies have demonstrated a strong association between type 2 diabetes mellitus and diastolic dysfunction.

Porier et al,[15] have demonstrated that diastolic dysfunction is a frequent finding in type 2 diabetic subjects without symptoms and signs of heart disease. Using conventional Doppler as well as measurements of pulmonary venous flow and trans-mitral flow during valsalva manoeuvre in 46 well controlled type 2 diabetics, they demonstrated diastolic dysfunction in 60% of subjects of whom 32% had impaired relaxation and 28% had pseudonormalization pattern. The incidence of diastolic dysfunction in the present study was much higher (95%), which could be due to the profile of type 2 diabetic subjects who had higher waist hip ratio and BMI. Tarumi N et al,[16] in their study demonstrated left ventricular diastolic dysfunction in 32% of type 2 diabetics. In this study valsalva manoeuvre was not used to differentiate between normal and pseudonormal pattern. Hence pseudonormalization pattern was not reported in their study. The much higher incidence of diastolic dysfunction in the present study could be due to the assessment of trans-mitral flow during valsalva manoeuvre to unmask the pseudonormalization pattern and the profile of the patients who had high waist hip ratio and BMI.

CONCLUSION

Form the data of the present study it can be concluded that type 2 diabetics with obesity, particularly central type, have an increased predisposition to the development of left ventricular structural or geometrical abnormality. They have significantly higher left ventricular Mass. Obese type 2 diabetics also have higher incidence of diastolic dysfunction. All these abnormalities occur with greater frequency in females.

Thus type 2 diabetics with high BMI and Waist hip ratio have higher risk of development of cardiovascular disease, which is higher for female than males.

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