

LEFT VENTRICULAR FUNCTION IN TYPE 2 DIABETES PATIENTS WITHOUT CARDIAC SYMPTOMS IN ZARIA, NIGERIA

Fifty type 2 diabetes patients (25 of them being hypertensive) who had no cardiac symptoms had their left ventricular function assessed. There were 24 female and 26 male diabetes patients evaluated, along with a control group of 50 healthy subjects. The patients and controls underwent full clinical evaluation, which included physical examination, blood biochemistry (urea and electrolyte; creatinine, creatinine clearance; fasting blood and two-hour postprandial glucose levels, lipid profile), electrocardiograph, chest radiograph, and echocardiograph.

The hypertensive diabetes patients had higher cholesterol levels, and 50% had levels >5.0 mmol/L. Sixteen patients had cataracts, 14 had background retinopathy, 12 had peripheral neuropathy, and 7 had peripheral vascular disease.

The subjects had significantly lower ejection fraction than controls, and fractional shortening showed a similar pattern. Eight patients had ejection fraction <50% compared to none of the controls. Sixty-six percent of the subjects and 30% of the controls had diastolic dysfunction (reverse E/A ratio, prolonged deceleration time, and lower deceleration rate), respectively, but the diabetes patients did not show any difference. Diastolic dysfunction correlated significantly with age, fasting blood glucose, and two-hour postprandial glucose. The subjects had higher left ventricular mass (LVM) than controls. The LVM correlated significantly positively with diastolic blood pressure, systolic blood pressure, and pulse pressure. Sub-clinical diabetic cardiomyopathy exists in our patients; in addition, other risk factors for cardiomyopathy and coronary artery disease exist, including hypertension, hypercholesterolemia, and obesity. (*Ethn Dis.* 2005;15:635–640)

Key Words: Function, Left Ventricular, Type 2 Diabetes

Solomon S. Danbauchi, MBBS, FWACP;
Felicia E. Anumah, MBBS, FMCP;

Mohammed A. Alhassan, MBBS, FMCP; Samuel O. David, MBBS;
Prof. Geoffrey C. Onyemelukwe; Imhoagene A. Oyati, MBBS, FMCP

INTRODUCTION

Increased cardiovascular mortality and morbidity that occur in diabetes patients have been attributed to vascular disease.¹ Diabetes mellitus is associated with a multitude of cardiovascular complications, including increased incidence of atherosclerosis, coronary artery disease (CAD), myocardial infarction, congestive heart failure, coronary microangiopathy, and systemic hypertension.² Diabetic cardiomyopathy is a unique entity and not a rare condition.^{3,4} Myocardial involvement in diabetes may occur relatively early in the course of disease, initially impairing early diastolic relaxation, and when more extensive, it causes decreased myocardial contraction.² Prior to the development of symptomatic congestive heart failure, sub-clinical left ventricular dysfunction (systolic or diastolic) exists for some time.⁴ The mechanism of the pathogenesis of cardiomyopathy is still questionable, and several factors have been proposed, including small- and micro-vascular disease, autonomic dysfunction, metabolic derangements, and cardiac interstitial fibrosis.³ Many factors at the cellular level have been implicated, but myopathy, independent of micro-vascular and macrovascular disease, is proposed to be the final common pathway.^{5,6} Literature on diabetic myo-

Myocardial involvement in diabetes may occur relatively early in the course of disease . . . We sought to evaluate cardiac function in type 2 diabetes patients who did not have cardiac symptoms.

cardial function in Nigeria is rare. We sought to evaluate cardiac function in type 2 diabetes patients who did not have cardiac symptoms.

MATERIALS AND METHODS

Fifty patients were recruited from the diabetes clinic at the Ahmadu Bello University Teaching Hospital Zaria; these patients included newly diagnosed and previously known patients in the clinic, regardless of hypertensive status. The 50 subjects were selected by assigning numbers to them as they arrived at the clinic, and odd numbers were picked to enter the study if they satisfied the inclusion criteria. All patients signed an informed consent form. Diabetes was diagnosed according to American Diabetic Association (ADA) criteria,⁷ and hypertension was diagnosed by using the 1999 World Health Organization (WHO) guidelines for the diagnosis of hypertension.⁸ The patients had clinical evaluation (history and physical examination). Special attention was paid to

Address correspondence and reprint requests to Solomon S. Danbauchi; Cardiology Unit; Department of Medicine; Ahmadu Bello University Teaching Hospital; Zaria, Nigeria; danbauchi@skannet.com; danbau59@yahoo.com

From the Cardiology Unit (SSD, MA) and Endocrinology Unit (FA), Department of Medicine (SOD, GO), Ahmadu Bello University Teaching Hospital; Zaria, Nigeria.

duration of the disease, associated hypertension, and complications (retinopathy, neuropathy, nephropathy, diabetic foot or hand, etc). Fasting blood glucose (FBG) and two-hour postprandial glucose levels were measured. The subjects were instructed to fast for at least eight hours and report to the hospital to have fasting blood glucose measured. Immediately after blood was taken for this measurement, the subjects were given 75 mg of glucose drink and asked to report two hours later to have blood taken for two-hour postprandial glucose levels. Participants were also instructed to skip their morning medications for diabetes mellitus and hypertension. Diabetes control is classified into good, acceptable, and poor with ADA criteria.⁷ The other investigation included serum electrolyte, urea, creatinine, lipid profile, uric acid, chest radiograph, and electrocardiograph (ECG). All patients had echocardiography (two-dimensional, Doppler, color flow) by a cardiologist. The cardiac parameters measured were left atrial diameter (LAD), left ventricular dimensions and function (including left ventricular internal diameter in diastole/systole [LVIDd/s]), interventricular septal thickness in diastole/systole (IVSd/s), left ventricular posterior wall thickness in diastole/systole (LVPWd/s), ejection fraction (EF), fractional shortening (FS), end diastolic volume (EDV), end systolic volume (ESV), and stroke volume (SV). Doppler studies were conducted in the mitral inflow area at the tips of the mitral valve leaflets to determine E- and A-wave velocities, E-wave/A-wave ratio, and deceleration time and rate (DT and DR). The right ventricle was also evaluated but did not form part of this report. The parameters examined included ejection fraction, fractional shortening, left ventricular mass, left ventricular mass index, diastolic or systolic dysfunction. The electrocardiographic tracing was evaluated for arrhythmias, ST-T wave changes, left ventricular

Table 1. General clinical and laboratory characteristics of subjects and controls

Features	Subjects	Controls	P Value
Age (years)	51.3 ± 11.2	48.8 ± 8.1	.10
Sex	27-F, 23-M	26-F, 24-M	.10
BMI kg/m ²	26.1 ± 4.8	25.3 ± 4.2	.1
DBP (mm Hg)	85.8 ± 11.4	78.1 ± 10.1	.025*
SBP (mm Hg)	145.33 ± 31.38	125.2 ± 9.1	.05*
Pulse pressure (mm Hg)	56.5 ± 18.6	46.2 ± 7.5	.01*
FBS (mmol/L)	8.2 ± 4.1	4.0 ± 0.8	.01*
Two hours PP glucose (mmol/L)	14.0 ± 6.7	6.6 ± 0.7	.005*
Total cholesterol (mmol/L)	5.4 ± 3.1	3.8 ± 1.4	.05*
Serum creatinine (µmol/L)	96.4 ± 29.2	82.3 ± 14.8	.05*

* P value is significant.

M=male; F=female; BMI=body mass index; DBP=diastolic blood pressure; SBP=systolic blood pressure; FBS=fasting blood glucose (venous); PP=postprandial.

hypertrophy, and left atrial hypertrophy. The patients were divided into subgroups of purely diabetes patients and diabetic hypertensive patients, and the diabetes patients were divided into those with overt clinical complications and those without. The effect on left ventricular function of duration of the disease, diabetes control, levels of serum glucose at fasting and levels two hours postprandial was evaluated. EPI inform version 2000 was used for the data and analysis, quantitative data were reported as mean \pm standard deviation (SD), and non-quantitative data were reported as percentages. The subgroups were compared by using the student *t* test; chi-square test and correlation coefficient were applied to quantitative data.

RESULTS

Fifty subjects comprised 24 females and 26 males, and their ages ranged from 34 to 75 years with a mean of 47.13 ± 11.31 years. Controls were apparently normal individuals working in the hospital or members of the hospital patient's family (diabetic and hypertensive relatives were excluded). Their ages ranged from 31–70 years with a mean of 47.26 ± 8.02 . No statistically significant difference was seen between the mean ages and body

mass index of the subjects and controls (Table 1). The duration of diabetes mellitus ranged from less than a month to 22 years with a mean of 4.20 ± 5.20 years. Forty-one percent of the subjects had good diabetes control (blood sugar levels ≤ 6.5 mmol/L), and 36% had good two-hour postprandial glucose. Treatment included oral hypoglycemic drugs such as chlorpropamide and metformin alone or in combination; other drugs used included glibenclamide and insulin. The hypertensive patients were on atenolol, nifedipine, lisinopril, captopril, bendrofluzide, amlodipine, and low-dose aspirin in various combinations.

Laboratory Findings (Table 1)

The subjects' FBG ranged from 3 to 18.3 mmol/L with a mean of 8.2 ± 4.1 , and 60% of the subjects had FBG > 6.5 mmol/L. The difference between the subjects' FBG and that of controls was statistically significant. The two-hour postprandial blood glucose showed a similar pattern to that of fasting blood glucose ($P=.0005$). The subjects seemed to have higher serum creatinine levels than the controls. The creatinine clearance of the subjects ranged from 27.0 to 157.4 with a mean of 101.6 ± 76.6 ml/min. Subjects had significantly higher total serum cholesterol levels than the controls ($P=.05$). Thirty three percent of subjects had total cholesterol > 5.0 mmol/L.

Table 2. Echocardiographic characteristics of subjects and controls

Features	Subjects	Controls	P Value
Aortic root (cm)	2.8 ± 0.5	2.7 ± 0.4	.10
LAD (cm)	3.2 ± 0.4	3.11 ± 0.6	.025*
IVSd (cm)	1.3 ± 0.3	0.99 ± 0.15	.005*
LVPWd (cm)	0.91 ± 0.20	0.92 ± 0.22	.10
LVIDd (cm)	4.3 ± 0.7	4.1 ± 0.6	.10
LVIDs (cm)	2.94 ± 0.47	2.96 ± 0.47	.10
EDV (mL)	85.3 ± 41.8	75.1 ± 29.4	.10
ESV (mL)	37.0 ± 29.9	29.4 ± 17.2	.1
EF (%)	57.7 ± 12.2	66.3 ± 8.4	.01*
FS (%)	26.0 ± 7.3	30.8 ± 6.2	.02*
E/A ratio	1.0 ± 0.34	1.22 ± 0.34	.02*
DT (m/s)	210.3 ± 44.1	182.4 ± 30.0	.01*
DR (m/s ²)	3.1 ± 1.3	3.64 ± 1.1	.1
LVM (g)	193.3 ± 66.8	160.2 ± 52.1	.05*
LVMi (g/m ²)	114.4 ± 37.8	89.5 ± 26.3	.01*

* P value is significant.

LAD=left atrium diameter; IVSd=interventricular septum diastole; LVIDd=left ventricular internal diameter diastole; LVIDs=left ventricular internal diameter in systole; EDV=end diastolic volume; ESV=end systolic volume; EF=ejection fraction; FS=fractional shortening; DT=deceleration time; DR=deceleration rate; LVM=left ventricular mass; LVMi=left ventricular mass index.

Cardiomegaly on chest radiograph was noted in 14 out of 50 patients, of whom 10 were hypertensive. Eighteen patients had left ventricular hypertrophy by voltage criteria (SV1 + RV5/6 >35 mm) on ECG against four controls, and 15 had evidence of left atrial enlargement. Complications included 16 subjects with cataract at different stages, which impeded proper fundoscopic evaluation; 14 with background

retinopathy; 12 with peripheral neuropathy; and macroangiopathy was noted in three patients, two of whom presented with diabetic foot.

Echocardiographic Features (Table 2)

The left atrial diameter (LAD) of the subjects ranged from 2.0 to 4.2 cm, with a mean of 3.2 ± 0.4, which was larger than that of the controls

Table 3. Comparison between diabetics and hypertensive diabetics (with Student t test)

Features	Diabetic	Hypertensive Diabetic	P Value
Packed cell volume	38.4 ± 3.9	39.4 ± 3.4	.1
Serum creatinine (μmol/L)	91.4 ± 30.6	98.0 ± 36.8	.1
Total cholesterol (mmol/L)	4.0 ± 1.3	4.7 ± 1.2	.1
Triglycerides	1.8 ± 1.0	1.9 ± 0.2	.1
Fasting blood glucose (mmol/L)	9.9 ± 9.0	6.4 ± 1.5	.001*
2 hours postprandial sugar (mmol/L)	15.4 ± 7.3	12.4 ± 5.6	.1
IVSD (cm)	1.2 ± 0.2	1.3 ± 0.3	.1
LVID (cm)	4.1 ± 0.6	4.4 ± 0.7	.1
End diastolic volume (mL)	83.2 ± 40.8	87.3 ± 43.6	.1
End systolic volume (mL)	32.5 ± 5.1	41.5 ± 6.7	.01*
Ejection fraction (%)	61.3 ± 13.4	54.0 ± 9.8	.05*
Fractional shortening (%)	28.7 ± 8.3	23.2 ± 1.0	.1
Deceleration time (m/s)	213.6 ± 35.2	206.7 ± 52.2	.7
Deceleration rate (m/s ²)	3.6 ± 1.1	3.3 ± 1.6	.6
E/A ratio	1.0 ± 0.4	1.0 ± 0.7	.9

* P value is significant.

IVSD=interventricular septum diastole; LVID=left ventricular internal dimension in diastole.

($P=.025$). The subjects had more septal hypertrophy than the controls, and more than half of them were hypertensives. Eight subjects had ejection fraction <50%, compared to none in the control group ($P=.002$). The fractional shortening showed a similar pattern to that of ejection fraction ($P=.02$). The subjects had a longer deceleration time (DT) than did controls ($P=.01$), and the deceleration rate was lower in the subjects but not statistically significant ($P=.1$). Thirty-eight subjects had a deceleration time >200 milliseconds compared to 20 in controls ($P=.0003$). Thirty subjects had deceleration rate of <3 m/s² compared to 15 controls ($P=.002$). Thirty-three subjects had E/A ratio <1 compared to 15 in controls ($P=.0003$) because more subjects had diastolic dysfunction (reversed E/A ratio). Sixty-six percent of the subjects had diastolic dysfunction compared to 30% of controls with similar abnormality (E/A ratio, prolonged DT, and lower DR) ($P=.003$, odds ratio [OR] 4.5, relative risk [RR] 2.2). The subjects had higher left ventricular mass compared to controls, and left ventricular mass index exhibited a similar trend, which was not statistically significant. Thirty-eight patients had left ventricular mass >130 g compared to 15 controls ($P=.0002$).

The patient group was divided into those with diabetes alone and diabetic hypertensive patients (Table 3). Occurrence of diastolic dysfunction was not significantly different in both groups (64% vs 66%, $P=.7$). The same difference was noted in larger end systolic volume and lower ejection fraction in hypertensive diabetes patients. No significant difference was seen when males and females were compared ($\chi^2=1.46$, $P=.4$). The patients with no more than 5 years' history of diabetes were compared to those with diabetes for more than five years; diastolic dysfunction occurrence was not significantly different in the two groups ($\chi^2=0.13$, $P=.5$, RR=

0.925, CI=0.54–1.43 and OR=0.71, CI=−0.08–5.00). The subjects were subdivided into those with two-hour postprandial blood glucose <11.1 mmol/L and those with postprandial glucose \geq 11.1 mmol/L, no statistically significant difference was seen in the occurrence of diastolic dysfunction ($\chi^2=2.08$, $P=.2$). A similar finding was seen when fasting blood glucose was used as a factor ($t=0.13$, $P=.5$). When the subjects were divided into those <50 years and those above; diastolic dysfunction was seen more in subjects \geq 50 years.

Linear regression showed that diastolic dysfunction correlated significantly with age ($r^2=0.07$, $P=.0007$), two-hour postprandial blood glucose ($r^2=.15$, $P=.0001$), fasting blood glucose ($r^2=0.08$, $P=.006$), and total cholesterol ($r=0.06$, $P=.05$). Diastolic dysfunction did not correlate with duration of diabetes mellitus, diastolic blood pressure, systolic blood pressure, or triglycerides. Ejection fraction did not correlate with any of the parameters. Fractional shortening correlated with diastolic blood pressure ($r^2=0.05$, $P=.03$), pulse pressure ($r^2=0.07$, $P=.01$), and systolic blood pressure ($r^2=0.13$, $P=.0003$). Fractional shortening did not correlate with age, duration of diabetes mellitus, fasting blood sugar, two-hour postprandial blood glucose, or total cholesterol. The E/A ratio correlated significantly only with age ($r^2=0.18$, $P=.00001$) but did not correlate with duration of diabetes mellitus, systolic blood pressure, diastolic blood pressure, pulse pressure, fasting blood sugar, or two-hour postprandial blood glucose. The LVM correlated significantly with diastolic blood pressure ($r=0.06$, $P=.01$) and pulse pressure ($r^2=0.07$, $P=.01$). Left ventricular mass index correlated significantly with diastolic blood pressure ($r^2=0.05$, $P=.02$), pulse pressure ($r^2=0.07$, $P=.007$), and systolic blood pressure ($r^2=0.09$, $P=.002$).

DISCUSSION

The subjects and controls studied had similar mean age and body mass index to control for the effect of age and body mass on the echocardiographic and laboratory parameters. Body mass index is a risk factor for type 2 diabetes mellitus.^{11,12} The relationship between body mass index and diabetes mellitus in African Americans in the literature has not been consistent in several reports when compared to the direct relationship in Caucasians.¹¹ The presence of obesity and overweight are additional risk factors to diabetic cardiomyopathy.¹² Nearly half of the patients had associated diastolic hypertension, and a third had isolated systolic hypertension (ISH). A strong relationship exists between hypertension and type 2 diabetes mellitus, and both diseases play a role in the development of LVH. Hypertension and ischemic heart disease represent independent risk factors in many cardiovascular and non-cardiovascular events, thereby increasing morbidity and mortality in such patients.¹³ In our study group, hypertensive diabetes patients had a significantly lower EF than those without hypertension. Hypertensive diabetes patients also manifested cardiac dysfunction by having higher end diastolic/systolic volumes when compared to those without hypertension. This finding supports the fact that the two factors act independently to affect the heart. The subjects had significantly higher cholesterol levels than the controls, and \approx 50% of them had cholesterol levels higher than normal (2.5–5.0 mmol/L), which is an additional cardiovascular risk factor. The presence of atherosclerotic factors such as hypertension, obesity, and hypercholesterolemia is reported to worsen the prognosis of individuals with type 2 diabetes mellitus.^{14,15} Approximately one third of the subjects studied had good diabetes control according to ADA criteria.⁷ Poor control of diabetes mellitus is associated

Nearly half of the patients had associated diastolic hypertension, and a third had isolated systolic hypertension

with complications, which were also reflected in our participants. The levels of blood sugar, both fasting and two-hour postprandial, did not show a discriminatory effect on ejection fraction, LVM, and LVMI. The use of FBG and two-hour postprandial glucose is less sensitive compared to glycosylated hemoglobin, but the unavailability of tests to detect the latter makes its routine use difficult in developing countries. The subjects had higher serum creatinine levels compared to controls, an indication that such patients have started developing diabetic nephropathy, but microalbuminemia was not estimated, which is a more sensitive indicator of diabetic nephropathy. The presence of both hypertension and diabetes mellitus increases the risk for diabetic nephropathy. The subjects with hypertension and diabetes had a higher serum creatinine when compared to those without hypertension, which corroborates the fact the two act additively as risk factors for nephropathy. Only 10% of the subjects had higher creatinine clearance (>125 mL/min), which indicates hyperfiltration, the first stage of diabetic renal dysfunction, and none of the patients had creatinine clearance <25 mL/min.

Cardiomegaly was noted in $<25\%$ of the subjects, but these individuals did not have symptoms suggestive of overt cardiac decompensation, thereby confirming sub-clinical cardiomyopathy in our diabetic subjects.^{9,10,16} Rhythm disorders were not noted in this group of subjects; their absence in a 24-hour Holter monitoring would have made

the observation more substantive. The presence of left ventricular hypertrophy in the subjects that was twice as high as in controls shows the additive effect of both hypertension and diabetes.¹⁶⁻¹⁸ The evidence of left atrial hypertrophy on ECG is explained by the presences of left ventricular hypertrophy, which creates more work for the left atrium. The presence of cataract in nearly half the patients impeded proper fundoscopy.

Echocardiographic findings showed no difference in aortic root size, but the subjects' left atria were larger than those of the controls, although the difference was not statistically significant. The effect of hypertension and diabetes was expected to produce an enlargement of the aortic root. The increased hypertrophy of the interventricular septum could be explained by coexisting hypertension and diabetes mellitus,^{17,18} though when the subjects were divided into diabetes patients with and without hypertension, the interventricular septal thickness between the two groups was not significantly different. This finding explains the independent role of diabetes and hypertension on the heart in diabetic cardiomyopathy. The lower EF in diabetes patients, even though none had symptoms, supports the fact that diabetic cardiomyopathy is largely a sub-clinical disorder. The hypertensive diabetes patients had a lower ejection fraction, which shows the effect of the two risk factors on the heart. This finding confirms the existence of sub-clinical diabetic cardiomyopathy before overt cardiac failure^{3,10} but the effect on fractional shortening was not as manifest in ejection fraction. The longer DT, lower DR, and E/A ratio in diabetes patients confirms that diastolic dysfunction is the first cardiac function change that occurs. Two thirds of the patients had diastolic dysfunction, and even when hypertensive patients were excluded, diastolic dysfunction was seen in 64% of diabetes patients, which confirms the independence of the two risk factors. The cause of diastolic

dysfunction has been attributed to many factors in diabetes patients, including microangiopathy, fibrosis, deposition of glycoprotein, and atherosclerosis.^{3,19-22} The presence of hypertension is an additional risk factor for diastolic dysfunction. Diabetic control as classified by ADA and duration of diabetes mellitus did not seem to affect the incidence of diastolic dysfunction, but age, systolic blood pressure, diastolic blood pressure, fasting blood glucose, and two-hour postprandial glucose had significant effects in our subjects. Some authors have reported that diabetic control and duration did not affect incidence of diastolic dysfunction; these authors claim that the process starts early in the disease, even though some have reported the contrary.^{9,16,19} Redfield reported 52% of diastolic dysfunction in a community study, and Poirier reported 60% of diastolic dysfunction in well-controlled type 2 diabetes patients.²³⁻²⁵ Our finding of 64% and 66% in the two subgroups of subjects is similar. The presence of complications like cataract and neuropathy seemed to correlate with diastolic dysfunction. The relationship between macroangiopathy and diastolic dysfunction was difficult to determine because of the small number that had peripheral vascular disease. Some authors have reported a relationship between microangiopathy and diastolic dysfunction.^{3,18,21} The higher LVM and LVMI seen in diabetes patients may be explained by left ventricular hypertrophy and deposition of glycoprotein.^{2,23,24} The LVM seemed to increase by diastolic, systolic, and pulse blood pressure, but controls did not show a difference. The LVMI was affected by similar factors as LVM, but blood glucose levels did not show any effect because some authorities have explained that these findings occur early in the disease process.^{16,19}

This study had some limitations, which included non-estimation of glycosylated hemoglobin as a measure of control of diabetes mellitus and micro-

albuminuria for renal dysfunction. The estimation of glycosylated hemoglobin is known to be a better way of assessing blood sugar control over some time ranging to three months as opposed to blood glucose that is dynamic. In control sample selection, the use of patients' relatives could have introduced some bias because they could have the potential of being diabetic. The non-diabetic family members could have been introduced to hyperlipidemia and glucose that can also affect the echocardiographic parameters. This could have affected the comparison sort in the statistics.

CONCLUSION

Diabetic cardiomyopathy in our patients is usually asymptomatic. The coexistence of hypertension increases the risk of developing diabetic cardiomyopathy. The most prevalent cardiovascular disorder noted was diastolic dysfunction, which may be caused by hyperglycemia, hypertension, and insulin-resistance syndrome. The high prevalence of diastolic dysfunction calls for early screening in the course of the disease.

REFERENCES

1. Spector KS. Diabetic cardiomyopathy. *Clin Cardiol*. 1998;21:885-887.
2. Devereux RB, Roman MJ, Paranicas M, et al. Impact of diabetes on cardiac structure and function: the STRONG heart study. *Circulation*. 2000;101:2271-2276.
3. Bell DSH. Diabetic cardiomyopathy [editorial]. *Diabetes Care*. 2003;26:2949-2951.
4. Panja M, Sarkar C, Kumar S, et al. Diabetic cardiomyopathy. *JAPI*. 1998;46(7):635-639.
5. Somers JR, Epstein M, Froehlich ED. Diabetes, hypertension, and cardiovascular disease. Review article update. *Hypertension*. 2000;37:10-53.
6. Giancetrini A, De Gaetano GA, Mingrone G, Grisali D, Liverman E, Capristo E, Greco AV. Acetyl-L-carnithine increases glucose storage in type 2 diabetic patients. *Metabolism*. 2000; 49:704-708.
7. Report of the Expert Committee on the diagnosis and classification of diabetes mellitus. *Diabetes Care*. 1997;20:1183-1197.

8. Guidelines subcommittee. 1999 World Health Organization-International Society of Hypertension. Guidelines for the management of hypertension. *J Hypertens.* 1999; 17:151-183.
9. Iribarren C. Does poor glycemic control predict heart failure in diabetes. *Cardiol Rev.* 2002;19:27-29.
10. Muller T. Diabetic cardiomyopathy; pathways from insulin resistance to cardiovascular disease; new insights into management and prevention. Paper presented at: 6th Scientific Session ADA; June 4-8, 2004; Orlando, Florida.
11. Manson JE, Willet WE, Stampfer MI, et al. Body weight and mortality among women. *N Engl J Med.* 1995;333:677-685.
12. Stevens J, Keil JE, Rust PF, et al. Body mass index and body girths as predictors of mortality in Black and White men. *Am J Epidemiol.* 1992;135:1137-1146.
13. Gurwitz JH, Field TS, Glynn RI, et al. Risk factors in non-insulin dependent diabetes mellitus requiring treatment in the elderly. *J Am Geriatric Soc.* 1994;42:1235-1240.
14. Hense WH, Gneiting B, Muscholl M, et al. The association between body size, and body composition with left ventricular mass: impact for indexation in adults. *J Am Coll Cardiol.* 1998;32:451-457.
15. Himeno E, Nishino K, Okazaki T, et al. A weight reduction and weight maintenance program with longstanding improvement in left ventricular mass and blood pressure. *J Am Hypertens.* 1999;12:682-690.
16. Arvan S, Singal B, Knapp B, Vagnucci A, et al. Sub clinical left ventricular abnormalities in young diabetics. *Chest.* 1988;93:1031-1034.
17. Ghanem Wisam MA, Murin J, Steiman O, et al. Relation of left ventricular hypertrophy to cardiovascular complications in diabetic hypertensives. *Bratisl Lek Listy.* 2001;102(2): 564-569.
18. Nielsen FS, Ali S, Rossing P, et al. Left ventricular hypertrophy in non-insulin dependent diabetic patients with or without diabetic nephropathy. *Diabet Med.* 1997;14: 538-546.
19. Zabsonne P, Ouedraogo S, Dyemkouma FX, et al. Prevalence et caracteristiques de l'hypertension arterielle dans une population de diabetiques. *Trop Cardiol.* 1999;25:12-15.
20. Mathew P, John L, Jose J, Krishna Swami S. Assessment of left ventricular diastolic function in young diabetics. A two dimensional echodoppler study. *Indian Heart J.* 1992;44:29-32.
21. Osunkwo DR, Okeahialam BN. Left ventricular dysfunction in non-insulin dependent diabetes. *Trop Cardiol.* 2001;27:61-64.
22. Strauer BE, Schwartzkoff B. Left ventricular hypertrophy and coronary microcirculation in hypertensives. *Blood Press.* 1997;6(suppl 2): 6-12.
23. Redfield MM, Jacobsen SJ, Burnett JC, Mahoney DW, Bailey KR, Rodeheffer RJ. Burden of systolic and diastolic ventricular dysfunction in the community. *JAMA.* 2003; 289(2):194-202.
24. Poirier P, Bogaty P, Garneau C, Marois L, Dumesnil JG. Diastolic dysfunction in normotensive men with well controlled type 2 diabetics; importance of maneuvers in echocardiographic, screening for preclinical diabetic cardiomyopathy. *Diabetes Care.* 2001;24(1): 5-10.
25. Bauters C, Lamblin N, McFadden EP, et al. Influence of diabetes mellitus on heart failure risk and outcome. *Cardiovasc Diabetol.* 2003; 2(1):1.

AUTHOR CONTRIBUTIONS

Design and concept of study: Danbauchi, Anumah
Acquisition of data: Danbauchi, Anumah, Alhassan, David
Data analysis and interpretation: Danbauchi, Anumah, Alhassan, David, Onyemelukwe
Manuscript draft: Danbauchi, Anumah, Alhassan, David, Onyemelukwe
Statistical expertise: Anumah, Alhassan, David, Onyemelukwe
Acquisition of funding: Anumah, Alhassan
Administrative, technical, or material assistance: Danbauchi, Anumah, Alhassan, David, Onyemelukwe
Supervision: Danbauchi, Anumah, Alhassan, David, Onyemelukwe