Original Article

Prevalence and predictive factors for heart failure among Sudanese individuals with diabetes: Population based survey

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Background: Heart failure (HF) is common problem in primary care and one of the leading causes of recurrent hospital admission across the globe. The aim of the present study was to assess the prevalence and risk factors of HF in Sudanese individuals with diabetes.

Methods: This was cross sectional study with 315 participants conducted in Khartoum, Sudan. A questionnaire was used to collect demographic information. In addition to measurement of blood pressure, lipid profile and HbA1c, weight and height measurement for calculation of body mass index.

Results: Among the 315 respondents, male representation in the sample was 184 (59.3%) and only 25 (13.5%) of them has heart failure (HF) while female were 131 (40.7%) and 13 (9.9%) has HF. Therefore the prevalence of HF was 12.06%. The unadjusted risk factors for HF were hypertension and cholesterol level (P value of 0.001 and 0.015 respectively). The presence of retinopathy, albuminuria, duration of diabetes and neuropathy were not associated with HF. In addition, parameters like age, sex, HbA1c, high density lipoprotein (HDL), triglyceride and low density cholesterol (LDL) are also not associated with heart failure. Importantly, hypertension was the only absolute risk factor for HF (P=0.001467).

Conclusions: The prevalence of HF is estimated to be 12.06%. The risk factors are hypertension and high cholesterol. Hypertension was an absolute risk factor for HF. Therefore, further planning and strategies by health authorities in Sudan are needed to prevent, treat and manage hypertension in individuals with diabetes.

Keywords: Heart failure; Sudan; diabetes

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Introduction

Non communicable diseases including metabolic such as diabetes mellitus (DM) and obesity, cardiovascular disorders and cancer represent a major and growing health burden in Sub-Saharan Africa (SSA) including Sudan (1). It was estimated that number of people with diabetes in Africa will increase from 14 million in 2011 to 28 million in 2030 (2-4). Between 2011 and 2030, it was estimated that the number of people with diabetes will increase by 54% (5). The burden of diabetes in urban areas of north Sudan was 19% and 2.5% in urban and rural areas of north Sudan respectively (6,7).

Diabetes control is a real challenge facing health authorities in Sudan since the prevalence of uncontrolled

diabetes was reported in (83.8%) and (85%) of Sudanese individuals with type 1 and type 2 diabetes respectively (8,9). Factors associated with poor glycemic control were age (P<0.072) and sex (P<0.039) in individuals with type 1 diabetes, while prolonged duration of diabetes (P=0.03), high plasma triglyceride (P=0.02), low HDL level (P=0.04) and low glomerular filtration rate (GFR) (P=0.01) in type 2 diabetes (8,9). Interestingly, low glomerular filtration rate (GFR) is independent factor with poor diabetes control (9). Concerning Sudanese population the following were established risk factors for development of DM; family history of diabetes, central obesity, obesity, increasing age, and hypertension (6,7). Diabetic complications such as retinopathy, peripheral neuropathy and diabetic foot were observed in 72.6%, 68.2% and 12.7% respectively (10) Furthermore, longer duration of diabetes (P<0.001) and living in urban areas (P<0.004) were identified as the factors significantly associated with these complications.

The increasing prevalence of diabetes in Sudan is in keeping with the emerging global pandemics of metabolic syndrome and obesity on one hand and diabetes and its complications on the other hand (4,11). In addition, non-alcoholic fatty liver diseases (NAFLD), is associated with diabetes and insulin resistance. In Sudan, the prevalence of fatty liver is thought to be around 20% in individuals without diabetes and risk factors were related to obesity and an increase in age. However, among individuals with type 2 diabetes the prevalence was found to be higher around 50.3% .The risk factors were overweight, obesity, central obesity, high triglyceride level and low HDL-c level. Individuals with three components of the metabolic syndrome revealed higher prevalence of NAFLD (12,13).

Heart failure (HF) is considered as the commonest DM related cardiovascular complication (14,15). Type 2 DM and insulin resistance are well documented risk factors for HF (16,17). This is partially explained by the shared common pathogenetic factors of DM and HF. The strong association between DM and HF that reflected in increased incidence of heart failure in diabetic subjects may in part be attributed to structural and functional dysfunction of diabetic myocardium (18). Beside insulin resistance other factors like myocardial fibrosis, microvascular disease, impaired calcium homeostasis and autonomic neuropathy, were factors thought to involved in the association of diabetes and HF (19).

Methods

Study design

The study was conducted in Khartoum which is the capital of Sudan between September and December 2015. This is a hospital based cross-sectional study and enrolled 315 individuals with diabetes.

Data collection

We have used the WHO stepwise approach for collection of data in non-communicable diseases surveillance. The stepwise approach is made of questionnaire (demographic data), physical examination (anthropometric and blood pressure) and biochemical tests. For example demographic and background factors: age, gender, smoking, alcohol intake, diabetes duration and medications, and heart failure was included. We measured height and weight to calculate BMI. Blood tests for measurement of HbA1c, cholesterol and triglycerides levels.

Laboratory measures

The blood samples collected from individuals agreed to participate on the study. These samples were kept in Ethylenediaminetetraacetic acid (EDTA) reagent for HgA_{1c} and lithium reagent for renal function test (RFT) and lipid profile. Analysis of samples was performed using Cobas c 111 analyzer.

Data analysis

After the data was organised and cleaned, we used the Statistical Package for Social Science SPSS software program [version 21.0 computer program (SPSS, Inc., Chicago, IL, USA)]. Chi-squared test was used to test for significance between variables like age, sex, BMI, blood glucose level, retinopathy, neuropathy, albuminuria, blood pressure and a family history of diabetes mellitus, duration of diabetes, cholesterol, triglyceride and HbA1c. Then we used logistic regression analysis to establish absolute risk factors. P value <0.05 was considered statistically significant.

Ethical approval

The ethical clearance of this study was obtained from the Ethical Committee of the Faculty of Medicine – University

of Medical Sciences and Technology, Khartoum, Sudan (IRB No. 00008867).

Results

Sociodemographic variables

The study is a retrospective observational analysis of 315 Sudanese individuals with an established diagnosis of diabetes. Prevalence of heart failure was 12.06% in this sample [95% confidence interval (CI): 8.44–15.61%].

The mean age was 58.7 years [standard deviation (SD) =10.5 years]. Range between 25 and 90 years). The median age was 60 years. The mean age for HF group was 61.2 years, whereas the mean age for those with no HF was 58.4 years. This 2.8 years difference was only weakly statistically significant (t=1.9927, degrees of freedom =58.186, P value =0.051). Male representation in the sample was 184 (59.3%) and only 25 (13.5%) of them has HF while female were 131 (40.7%) and 13 (9.9%) has HF. However, this association between males and increased risk of HF was not statistically significant (X-squared =0.6257, df =1, P value =0.4289).The mean BMI was 26.2 (SD =4.23; range, 14.06–43.00). The median BMI was 26.47. The mean BMI for HF group was 26.4, whereas the mean BMI for those with no HF was 26.1. This 0.3 units difference was not statistically significant (t=0.423, degrees of freedom =53.475, P value =0.674). Out of the total participants with HF, there were 25 with family history of diabetes (Prevalence of HF =12.02%) and 13 without (Prevalence of HF =12.15%). However, this association between positive family history and increased risk of HF was not statistically significant (X-squared =0, df =1, P value =1).

Correlates and unadjusted risk factors for HF

Cholesterol

The mean cholesterol was 162.9 (SD =62.1; range, 4.35–514.6). The median cholesterol was 157.6. The mean cholesterol for HF group was 144.5, whereas the mean cholesterol for those with no HF was 165.4. This 21.9 units difference was statistically significant (t=2.4841, degrees of freedom =58.372, P value =0.01588).

Triglycerides

The mean triglycerides level was 143.9 (SD =91.2; range, 2.12–715.8). The median triglycerides level was 123.3. The mean triglycerides level for HF group was 130.4, whereas the mean triglycerides level for those with no HF was 145.7. This 5.3 units difference was not statistically significant (t=1.097, degrees of freedom =52.124, P value =0.2777).

HDL

The mean HDL level was 37.26 (SD =13.36; range, 2.8–122.2). The median HDL level was 35.13. The mean HDL level for HF group was 36.67, whereas the mean HDL level for those with no HF was 37.34. This 0.6 units difference was not statistically significant (t=0.2634, degrees of freedom =45.223, P value =0.7934).

LDL

The mean LDL level was 115.2 (SD =53.08; range, 2.2–305). The median LDL level was 115.1. The mean LDL level for HF group was 106.0, whereas the mean LDL level for those with no HF was 116.5. This 9.5 units difference was not statistically significant (t=1.1306, degrees of freedom =47.508, P value =0.2639).

HbA1c

The mean HbA1c was 10.01 (SD = 2.2, Range between 4.7 and 17.8). The median HbA1c was 9.9. The mean HbA1c for HF group was 10.52, whereas the mean HbA1c for those with no HF was 9.95. This 0.63 units difference was not statistically significant (w = 3174, P value = 0.1043).

Duration of DM

Out of the total 38 participants with HF, there were 18 (16.5%) who were diabetic for more than 20 years. There were 13 (10.9%) who were diabetic for between 11 and 20 years. There were 5 (9.4%) were living with diabetes for between 6 and 10 years, with 2 (5.8%) from the under 5-year duration group getting the HF complication. This association between the duration of diabetes and increased risk of HF was not statistically significant (X-squared =3.8661, df =3, P value =0.2763).

Hypertension

Out of the total 38 participants with HF, there were 28 with comorbid hypertension diagnosis (prevalence =18.4%) and 10 without (prevalence =6.1%). Clearly, this unadjusted association between comorbid hypertension diagnosis and increased risk of HF was statistically significant (X-squared =10.1894, df =1, P value =0.001412).

Retinopathy

Out of the total 38 participants with HF, there were 20

(9.8%) who developed diabetic retinopathy in both eyes. There were 6 (17.6%) developed diabetic retinopathy in left eye and further 4 (19.0%) who developed diabetic retinopathy in right eye. The rest (n=8, prevalence =15.4%) were free from diabetic retinopathy. However, this association between diabetic retinopathy and increased risk of HF was not statistically significant (X-squared =3.4422, df =3, P value =0.3283).

Albuminuria

Out of the total 38 participants with HF, there were 12 with comorbid albuminuria (prevalence =31.6%) and 26 without (prevalence =32.7%). However, this association between comorbid albuminuria and decreased risk of HF was not statistically significant (X-squared =0, df =1, P value =1).

Neuropathy

Out of the total 38 participants with HF, there were 32 with comorbid neuropathy (prevalence =13.9%) and 6 without (prevalence =7.1%). However, this association between comorbid neuropathy and increased risk of HF was not statistically significant (X-squared =2.0202, df =1, P value =0.1552).

Summary of unadjusted risk factors for HF

The statistical associations between different variables showed that hypertension and cholesterol level were found to have significant association with HF with P value of 0.001 and 0.015 respectively (*Table 1*).

Logistic regression analysis

Utilizing the full logistic regression model that adjusts for all risk factors for HF simultaneously, only the presence of comorbid hypertension was significant statistically. Even after adjusting for all other potential risk factors, comorbid hypertension is associated with an increase in the HF [OR =2.739 (95% CI: 1.167–6.431), P=0.02066]. Notably the unadjusted effect for individual risk factors, utilizing the logistic regression modelling, only comorbid hypertension [OR =3.368 (95% CI: 1.643–7.409), P=0.001467] was significantly associated with HF in the context of diabetes (*Table 2*).

Discussion

Cardiovascular diseases (CVD) are the most prevalent cause of mortality and morbidity in diabetic populations (20). The burden of HF was estimated to be 26 million patients worldwide, with 1–4% of all hospitalized patients as percentage of total hospital in-patients (21,22). In United States, for example, around 5.7 million adults have HF, almost one tenth of deaths in 2009 attributed to HF and half of people who develop HF die within 5 years of diagnosis (23). The prevalence of CVD in Sudan was reported as 2.5% following the community-based household survey representing all states of Sudan (24). In this study we have shown that the prevalence of heart failure among Sudanese individuals with diabetes was 12.06% (95% CI: 8.44–15.61%). Nichols GA et al revealed almost the same prevalence of HF (11.8%) among subjects registered with type 2 DM at baseline in USA (25). Interestingly, the Framingham Heart Study showed that the frequency of HF was twice as high in men with diabetes and five times higher in women with diabetes compared with control subjects (26). There is high prevalence of prediabetes and diabetes in individuals with heart failure. For instance, prediabetes was reported in more than one-third of patients who are hospitalized for heart failure. The prevalence of diabetes in patients with heart failure was high and this estimated to be between 25% and 40% (27). The cardiovascular mortality is increased by 11% for every 1% increase in HbA1c in individuals with poor glycemic control (28). Both, the high susceptibility of CV risk factors and direct well established pathological effects of diabetes on the CV system make individuals with diabetes at increased risk of developing CV complications such as increased prevalence of MI, revascularization, stroke and HF (20). Unfortunately, optimizing diabetes control will decrease CV events but will not abolish it and this due the complex and multifaceted nature of the relationship linking DM to CVD. While obesity, hypertension (HT) and dyslipidaemia are common risk factors for CVD, still they are prevalent particularly in patients with type 2 DM. According to our results, the unadjusted risk factors for HF were hypertension and cholesterol level (P value of 0.001 and 0.015 respectively). No surprise as the prevalence rates of HT among patients with type 1 DM (T1DM) and type 2 DM (T2DM), are 30% and 60%, respectively (20,25,27). Comparatively, in Sudan HT was found in 39.9% and high cholesterol and triglyceride noted in 59.9%, 32.5% among individuals with diabetes respectively (10). Importantly, hypertension in Sudan was shown to one of the leading cause of heart failure and cardiovascular disease (29,30). Logistic regression analysis showed that only hypertension was absolute risk factor for HF (P=0.001467).

Table 1 Characteristics of the respondents according to established diagnosis of heart failure

Factor/covariate	Heart failure (n=38)	No heart failure (n=277)	Total (n=315)	P value
Gender, n (%)				0.429
Men	25 (65.8)	159 (57.4)	184 (58.4)	
Women	13 (34.2)	118 (42.6)	131 (41.6)	
Age (mean), years	61.2	58.4	58.7	0.051
BMI (mean)	26.4	26.1	26.2	0.674
Family history, n (%)				1.000
Positive	25 (65.8)	182 (65.7)	207 (65.7)	
Negative	13 (34.2)	95 (33.9)	108 (34.3)	
Duration of DM, n (%)				0.276
Up to 5 years	2 (5.3)	30 (10.8)	35 (11.1)	
6 to 10 years	5 (13.2)	44 (17.3)	53 (16.8)	
11 to 20 years	13 (34.2)	104 (37.5)	119 (37.8)	
More than 20 years	18 (47.4)	99 (35.7)	108 (34.3)	
Hypertension, n (%)				0.001412
No	10 (26.3)	153 (55.2)	163 (51.7)	
Yes	28 (73.7)	124 (44.8)	152 (48.3)	
Cholesterol (mean)	144.5	165.4	162.9	0.01588
HbA1c (mean)	10.52	9.95	10.01	0.1043
Triglycerides (mean)	130.4	145.7	143.9	0.2777
HDL (mean)	36.67	37.34	37.3	0.7934
LDL (mean)	106.0	116.5	115.2	0.2639
Retinopathy, n (%)				0.3283
Both eyes	21 (55.3)	186 (67.1)	207 (65.7)	
Left eye	6 (15.8)	29 (10.5)	35 (11.1)	
Right eye	4 (10.5)	18 (6.5)	22 (7.0)	
Negative	7 (18.4)	44 (15.9)	51 (16.2)	
Albuminuria, n (%)				1.000
Negative	26 (68.4)	187 (67.5)	213 (67.6)	
Positive	12 (31.6)	90 (32.5)	102 (32.4)	
Neuropathy, n (%)				0.1552
Negative	6 (15.8)	78 (28.2)	84 (26.7)	
Positive	32 (84.2)	199 (71.8)	231 (73.3)	
Smoking, n (%)				0.5609
No	23 (60.5)	185 (66.8)	208 (66.0)	
Yes	15 (39.5)	92 (33.2)	107 (34.0)	

Value <0.05 are considered significant; Pearson chi squared and t-test tests were used to check for significance between variables.

Table 2 Logistic regression analysis for risk factors for heart failure

Factor/covariate	OR	Lower 95% CI	Upper 95% CI	P value
Male gender	1.395	0.702	2.883	0.3541
Age	1.026	0.993	1.062	0.1243
BMI	1.016	0.937	1.099	0.7032
Family history	0.973	0.488	2.018	0.9390
DM duration (over 10 years)	1.733	0.788	4.297	0.2001
Hypertension	3.368	1.643	7.409	0.001467
Cholesterol	0.994	0.988	1.000	0.05161
HbA1c	1.125	0.954	1.323	0.1569
Triglycerides	0.998	0.993	1.002	0.4185
HDL	0.997	0.970	1.022	0.8326
LDL	0.996	0.990	1.003	0.2676
Albuminuria	0.967	0.458	1.946	0.9263
Neuropathy	1.967	0.864	5.182	0.1345
Smoking	1.323	0.654	2.613	0.4274

Value <0.05 are considered significant. Hypertension was the only absolute risk factors for heart failure.

High prevalence of hypertension among rural and urban population in Sudan was noted. For example, the prevalence of hypertension in Urban areas in north of Sudan was estimated to be more than 30%, in rural population was 15% to 38% and in Nubia ethnic population in South of Sudan was around 50% (31-34). Furthermore, cholesterol was associated with heart failure only in unadjusted risk analysis, but not with logistic regression analysis. Hypertension can be associated with hyperlipidaemia, diabetic nephropathy, nephrotic syndrome and increase in risk of CVD (4,6). The presence of retinopathy, albuminuria, duration of diabetes and neuropathy in this study were not associated with HF. HF was not significantly associated with age, sex, HbA1c, HDL, triglyceride and low LDL. Many clinical studies showed evidences that supported the impact of glycemic control in improving the CV outcomes in patients with DM (35,36). Tighter controls with tailored individualized patient-centred HbA1c targets are recommended in the recent guidelines in younger patients free of diabetic complications, while remain looser in diabetic patients with established cardiovascular complications (37).

The limitation of the study can be attributed to the cross-sectional design of the study, and the fact that we could not take into account the temporal relationship between potential risk factors and outcomes. Furthermore, we have not assessed whether tight glycaemic control may reduce the prevalence of heart failure with diabetes or late diagnosis of diabetes may enhance the process of diabetes induce heart failure. Despite these limitations we believe our study is novel and is the first one to report the prevalence of heart failure among Sudanese individuals with diabetes.

Conclusions

The prevalence of HF is estimated to be 12.06% among Sudanese individuals with diabetes. The risk factors are hypertension and high cholesterol. Hypertension was an absolute risk factor for HF. Therefore, further planning and strategies by health authorities in Sudan are needed to prevent, treat and manage hypertension in individuals with diabetes.

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Footnote

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at http://dx.doi.org/10.21037/jphe.2018.04.03). MHA serves as an unpaid editorial board member of *Journal of Public Health and Emergency* from Aug 2017 to Jul 2019. The other authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by Ethical Committee of the Faculty of Medicine – University of Medical Sciences and Technology, Khartoum, Sudan (IRB No. 00008867). Informed consent was taken from all subjects.

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