Prevalence of Microvascular Complications in Type 2 Diabetics Attending a Primary Healthcare Centre in Sudan

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Abstract

Background: Diabetes mellitus (DM) has become a global public health challenge. The increasing urbanisation and the significant lifestyle changes have resulted in an unprecedented rise in the rates of type 2 DM and, consequently, its microvascular complications which are the major outcome of the disease. It is the low- and middle-income countries where 80% of the diabetic patients live that face the greatest burden of the disease. Study Objectives: Our primary objective was to estimate the frequency of microvascular complications among patients diagnosed with type 2 DM. Our secondary objective was to investigate the relationship between the microvascular outcomes and the different characteristics and potential variables among patients with type 2 DM. Methodology: An observational descriptive clinic-based cross-sectional survey was conducted to calculate the prevalence of microvascular complications of type 2 DM and the associated risk factors in a lower middle-income country, Sudan. The study was carried out at Shambat Primary Healthcare Clinic during the period between May and June 2018. All patients aged 20 years and above visiting the clinic were included. Patients excluded from selection were those on steroid therapy and those having bilateral eye cataract. A total of 209 patients constituted the sample and were selected through systemic random sampling. Statistical analysis was carried out using SPSS software version 21. For the continuous variables, the mean was used as a measure of central tendency and the standard deviation as a measure of dispersion. The associations between the microvascular complications and the other variables were analysed using the \( \chi^2 \) test. The \( p \) value was used as a test for statistical significance.

Results: The response rate to the survey was 72.6%. The age of the enrolled subjects ranged from 24 to 88 years. Males constituted 61.7% of the study sample and females 38.3%. The mean body mass index (BMI) was 26.92 ± 2.06. Out of 209 patients known to have type 2 DM, 96 (45.9%) developed any of the microvascular complications. Nephropathy was the most frequent with a prevalence of 38.8%, followed by retinopathy and neuropathy with a frequency of 23.9 and 22.5%, respectively. The presence of other co-morbidities, namely hypertension, ischaemic heart disease, chronic kidney disease and dyslipidaemia, was a predictor for the occurrence of the small-vessel conditions.
Conclusions: This study is probably the first of its kind to shed light on the magnitude of the microvascular complications of DM in Sudan. The yielded results reveal a significant burden caused by microvascular complications in the country. The concurrent presence of other chronic medical disorders, namely hypertension, ischaemic heart disease, chronic kidney disease and dyslipidaemia, amplifies the risk for the development of microvascular sequelae. The mean BMI of the sample reflects an overweight trend. Facing the high tide of the metabolic syndrome and its sequelae requires a holistic perspective and a multidisciplinary approach. The health authorities and other stakeholders need to prioritise healthcare expenditure and invest more in DM research. A national diabetes registry will serve as a key player in guiding the efforts.

Introduction

Diabetes mellitus (DM) can have long-term implications for the vital organs of the body. These complications are broadly divided into micro- and macrovascular. The fact that type 2 of the disease has a pre-symptomatic phase that can extend for years further amplifies the risk for the development of these complications.

Microvascular complications are a major outcome in patients with type 2 DM. They have a significant burden on the patient’s quality of life. They are also a leading cause of morbidity and mortality. Besides, they impose a substantial economic burden on the patient and the healthcare system.

The microvascular complications of DM are classified into:

1. Retinopathy
2. Nephropathy
3. Neuropathy

Diabetic Retinopathy

Diabetic retinopathy can result in various degrees of visual impairment and is a leading cause of blindness worldwide [1]. The global prevalence of diabetic retinopathy varies considerably. This is attributable to the population characteristics, screening methods used and the type of study conducted. In the regional context, a recently published study to estimate the frequency of the chronic complications of type 2 DM in previously diagnosed and recently discovered patients in Egypt found that the prevalence of diabetic retinopathy was 34.6%. In fact, the eye condition was detected in 10.4% of the newly diagnosed patients [2]. Thus, recently discovered diabetics are also at risk of developing the eye complication. In Saudi Arabia, Alaboud et al. [3] found the prevalence of diabetic retinopathy among patients with type 2 DM to be 14.8%.

Diabetic Nephropathy

Diabetic nephropathy is a leading cause of end-stage renal disease (ESRD) requiring dialysis. In fact, it constitutes a significant workload in dialysis centres [4]. It manifests as albuminuria or impaired glomerular filtration rate.

In Saudi Arabia, where DM represents a public health challenge, the prevalence of diabetic nephropathy has been estimated to be around 11% among adult individuals with type 2 DM. Further analysis revealed that ESRD was present in 1.5%. These results are based on the dataset from the Saudi National Diabetes Registry. Age and disease duration are independent predictors for the development of the small-vessel condition [5].

Although microalbuminuria is commonly used as an indicator for predicting future renal dysfunction among diabetics, it does not always precede worsening of renal function. Thus, the United Kingdom Prospective Diabetess Study (UKPDS) sought to identify other risk factors linked to renal impairment among type 2 diabetics. Increased systolic blood pressure, female gender, decreased waist circumference and Indian-Asian ethnicity were identified as risk factors. The study estimated that 38% of patients with type 2 DM developed albuminuria and 29% renal impairment after 15 years of follow-up [6].

Diabetic Neuropathy

Diabetic neuropathy affects around half of the diabetic population [7]. It has a significant impact on the patient’s functional ability and daily life activities. It is subdivided into peripheral and autonomic neuropathy.

A cross-sectional survey from Bahrain estimated the prevalence of diabetic peripheral neuropathy to be 36.6%. The diagnosis was based on the Neuropathy Disability Score [8]. In Saudi Arabia, the prevalence is lower with 19.9%. However, the diagnosis was symptom based in combination with an objective sensation assessment [9].

Risk Factors

Several risk factors have been linked to the development of the small-vessel complications of DM. Some of these risk factors are related to the presence of other co-
morbidities. However, many of them are modifiable and their effect can be curbed by lifestyle and behavioural changes. These risk factors include age, gender, duration of illness, glycaemic control, obesity, socioeconomic differences and the concurrent presence of hypertension.

**Context and Rationale**

During the past few decades, Sudan has gone through significant demographic and sociocultural changes. Urbanisation has invaded large sections of the society with the adoption of a sedentary lifestyle. Obesity has reached unprecedented rates. Consequently, there has been a significant rise in the rates of non-communicable diseases, including DM.

In 2014, the International Diabetes Federation estimated the prevalence of DM among adults in Sudan to be between 9 and 12% [10]. A recent study to calculate the economic impact of DM in the country revealed that the annual expenditure on healthcare is 4 times higher in diabetics compared to non-diabetics (USD 579 vs. USD 148, respectively). Besides, diabetics were more likely to suffer from other chronic co-morbidities, such as heart disease and peripheral vascular disease [11].

It is the low- and middle-income countries where 80% of the diabetic patients live that face the greatest burden of the disease [10]. The disease figures are projected to increase further. People living with diabetes in these settings have limited access to healthcare services, which renders them at risk of developing the long-term consequences of the disease, such as small-vessel complications.

Microvascular complications are a major outcome of the metabolic syndrome that adversely influence quality of life. Besides, they impose a significant burden on the patient and the healthcare services. Thus, estimating the magnitude of small-vessel disease will guide health-policy makers in the allocation of resources and help the clinicians’ management efforts.

**Study Objectives**

**Primary Objective**

The primary objective was to estimate the frequency of microvascular complications among patients diagnosed with type 2 DM.

**Secondary Objective**

The secondary objective was to investigate the relationship between the microvascular outcomes and the different characteristics and potential variables among patients with type 2 DM.

**Materials and Methods**

**Research Design**

An observational descriptive clinic-based cross-sectional survey was conducted to calculate the prevalence of the microvascular complications of type 2 DM and the associated risk factors. It was carried out in the primary healthcare setting at Shambat Primary Healthcare Clinic (SPHC) located in the city of Khartoum North.

**Study Setting and Population**

The study population included all patients with type 2 DM registered in or visiting the clinic. The variables under study were age, gender, duration of illness, the presence of other co-morbidities, family history of DM, smoking, alcohol intake, adherence to a regular physical exercise, blood pressure, body mass index (BMI) and glycosylated haemoglobin (HbA1C) level. All patients 20 years of age and above were included. Patients excluded from selection were those on steroid therapy and those having bilateral eye cataract. Steroids have a counter-regulatory effect on insulin, thus increasing the blood glucose levels. Cataract is a diabetic sequela affecting the eyes. Its presence is a potential confounding factor when quantifying the prevalence of diabetic retinopathy.

**Exposure and Outcome**

The diagnosis was based on the information given by patients and confirmed by the medical records. Diagnosing patients was not part of the study. However, the diagnosis of DM was based on one of the following criteria adopted by the American Diabetes Association [12]:

1. random blood glucose of 200 mg/dL (11.1 mmol/L) or higher in the presence of the classic symptoms of the disease which are polyuria, polydipsia, polyphagia and weight loss;
2. fasting blood glucose of 126 mg/dL (7.0 mmol/L) or higher;
3. HbA1C of 6.5% or higher.

The outcomes of the study were the microvascular complications. The case definition used was: “The development of any of the microvascular complications of DM (retinopathy, nephropathy and/or neuropathy) in an individual known to have type 2 DM who visited SPHC between May and June 2018.”

**Sample Size and Method**

A total of 209 patients diagnosed with type 2 DM attending SPHC were enrolled in the study that was conducted during May and June 2018. The participants were selected through systematic random sampling.

**Data Collection**

The tools used for data collection were a questionnaire and checklist. No names or contact details were required. A code was generated for each participant to allow him/her to withdraw from the study at any time.

The questionnaire was used to collect information on age, gender, duration of illness, presence of other co-morbidities, family history of DM and personal habits. The checklist was used to gather data derived from the physical examination and laboratory findings.

The diabetic patients attending the clinic undergo an eye examination on a regular basis, usually every 6 months. The findings were ticked in the checklist if it was already documented in the medical records that the patient had retinopathy. Otherwise, a direct
fundus examination was carried out following pupillary dilatation (mydriasis) of both eyes with tropicamide eye drops to assess for retinopathy. The presence of at least 1 micro-aneurysm or haemorrhage or exudate in either eye was used to confirm retinopathy [13].

The diagnosis of nephropathy was based on the presence of albuminuria. This was evaluated by examining a midstream urine sample for the albumin-creatinine ratio. Albuminuria was defined as a ratio of $\geq30$ mg/g [14]. If it was already mentioned in the patient’s file that he/she had nephropathy, the finding was recorded in the checklist and the laboratory investigation skipped.

The evaluation of neuropathy was based on the symptoms reported by the patient. This was in the form of abnormal sensations in the lower limbs: pins and needles, cold or warm sensation, ach- ing pain or restlessness.

Data Processing and Analysis

Statistical analysis of the collected data was carried out using SPSS software version 21. Measures of central tendency and dispersion were used to analyse the continuous (numerical) variables. All the categorical (nominal) data were presented in binary form.

The prevalence was used as a measure of the frequency of occurrence of the microvascular complications. The association between the microvascular complications and other variables under study was analysed using the $\chi^2$ test. The $p$ value was used as a test for statistical significance.

Results

Main Characteristics of the Sample

A total of 209 patients diagnosed with type 2 DM attending SPHC were enrolled in the study. The participants were selected through systematic random sampling with a response rate of 72.6%. The age of the study participants ranged from 24 to 88 years with a mean of 55.42 and a standard deviation of 16.46 years. Males represented 61.7% of the study sample, while 38.3% were females. 63.2% reported a family history of the metabolic syndrome. Hypertension was the most frequently reported co-morbidity with 38.8% of the participants having the disease. It was followed by dyslipidaemia and chronic kidney disease (CKD) with 24.4 and 16.7%, respectively. 12.9% had a history of ischaemic heart disease. The baseline characteristics of the sample population are summarised in Table 1.

Prevalence of the Microvascular Complications

Estimation of the microvascular complications revealed that 45.9% of the participants had 1 or more of them. Nephropathy was the most frequent sequel of the disease with a prevalence of 38.8%, followed by retinopathy and neuropathy with a frequency of 23.9 and 22.5%, respectively. The small-vessel conditions were more common in males. Out of 81 patients with nephropathy, 63 were males (77.7%). The relation between gender and nephropathy was of statistical significance with a $p$ value of <0.05. The proportions of males with retinopathy and neuropathy were 68 and 65.9%, respectively. The frequency of the microvascular complications is presented in Table 2.

Associated Risk Factors

A direct relationship was found to exist between hypertension and the occurrence of microvascular complications. Out of the 96 patients who developed 1 or more of the microvascular complications, 77 were hypertensive (80.2%). The association was found to be of statistical significance ($p < 0.05$).

The presence of CKD was also a predictor of the occurrence of microvascular complications. Thirty-four out of the 96 individuals with the disease complications had CKD as well. Like for hypertension, the relationship between CKD and small-vessel complications was statistically significant. Similarly, ischaemic heart disease and dyslipidaemia had a direct influence on the development of microvascular complications of DM with statistically significant relationships. Table 3 presents the risk factors associated with microvascular complications.

Concerning personal habits, 23.4% of the study population smoked. Only 6.2% admitted to drinking alcohol occasionally. None reported consuming alcohol on a regular basis. Both smoking and alcohol drinking were exclusive to males. None of the female participants mentioned a history of smoking or alcohol consumption.
Table 2. Prevalence of microvascular complications

|                      | All patients | Microvascular complications (any of the 3) | Nephropathy | Retinopathy | Neuropathy |
|----------------------|--------------|-------------------------------------------|-------------|-------------|------------|
| **All patients**     | 209 (100)    | 96 (45.9)                                 | 81 (38.8)   | 50 (23.9)   | 47 (22.5)  |
| **Male**             | 129 (61.7)   | 73 (34.9)                                 | 63 (30.1)   | 34 (16.3)   | 31 (14.8)  |
| **Female**           | 80 (38.3)    | 23 (11.0)                                 | 18 (8.6)    | 16 (7.6)    | 16 (7.7)   |
| \chi^2, p value      |              | 15.4, 0.000                               | 14.43, 0.000| 1.09, 0.32  | 0.46, 0.61 |

Values are n (%).

Table 3. Microvascular complications and the associated risk factors

|                      | All patients | Microvascular complications | No microvascular complications | \chi^2, p value |
|----------------------|--------------|----------------------------|-------------------------------|----------------|
| **Total sample**     | 209 (100)    | 96 (45.9)                  | 113 (54.1)                    |                |
| **Gender**           |              |                            |                               |                |
| Male                 | 129 (61.7)   | 73 (34.9)                  | 56 (26.7)                     | 15.4, 0.000    |
| Female               | 80 (38.3)    | 23 (11.0)                  | 57 (27.2)                     |                |
| **Body mass index**  |              |                            |                               |                |
| Normal               | 40 (19.1)    | 14 (6.6)                   | 26 (12.4)                     | 2.38, 0.158    |
| Overweight/obese    | 169 (80.9)   | 82 (39.2)                  | 87 (41.6)                     |                |
| **Family history of DM** |        |                            |                               |                |
| Yes                  | 132 (63.2)   | 47 (22.4)                  | 85 (40.6)                     | 15.38, 0.000   |
| No                   | 77 (36.8)    | 49 (23.4)                  | 28 (13.3)                     |                |
| **HbA1C**            |              |                            |                               |                |
| <7 (tight control)   | 43 (20.6)    | 5 (2.3)                    | 38 (18.1)                     | 25.65, 0.000   |
| \geq 7 (poor control)| 166 (79.4)   | 91 (43.5)                  | 75 (35.8)                     |                |
| **Hypertension**     |              |                            |                               |                |
| Yes                  | 81 (38.8)    | 77 (36.8)                  | 4 (1.9)                       | 128.53, 0.000  |
| No                   | 128 (61.2)   | 19 (9.1)                   | 109 (52.1)                    |                |
| **Chronic kidney disease** | |                            |                               |                |
| Yes                  | 35 (16.7)    | 34 (16.2)                  | 1 (0.47)                      | 44.39, 0.000   |
| No                   | 174 (83.3)   | 62 (29.6)                  | 112 (53.5)                    |                |
| **Dyslipidaemia**    |              |                            |                               |                |
| Yes                  | 51 (24.4)    | 36 (17.2)                  | 15 (7.2)                      | 16.51, 0.000   |
| No                   | 158 (75.6)   | 60 (28.7)                  | 98 (46.9)                     |                |
| **Ischaemic heart disease** |         |                            |                               |                |
| Yes                  | 27 (12.9)    | 27 (12.9)                  | 0 (0)                         | 36.49, 0.000   |
| No                   | 182 (87.1)   | 69 (33.0)                  | 113 (54.1)                    |                |
| **Regular sports or fitness activities** | |                            |                               |                |
| Yes                  | 44 (21.1)    | 7 (3.3)                    | 37 (17.7)                     | 20.23, 0.000   |
| No                   | 165 (78.9)   | 89 (42.6)                  | 76 (36.3)                     |                |
| **Smoking**          |              |                            |                               |                |
| Yes                  | 49 (23.4)    | 31 (14.8)                  | 18 (8.6)                      | 7.74, 0.008    |
| No                   | 160 (76.6)   | 65 (31.1)                  | 95 (45.5)                     |                |

Values are n (%). DM, diabetes mellitus; HbA1C, glycosylated haemoglobin.
The duration of illness did not have a noticeable effect on the HbA1C level, neither did age or BMI. The association between these factors and the HbA1C level did not show a statistical significance. However, the sample population revealed a poor glycaemic control with a mean HbA1C level of 7.85.

### Discussion/Conclusions

The study revealed some alarming figures about the magnitude of the microvascular complications of type 2 DM among adult patients in Sudan. 45.9% of the study participants had features of 1 or more of the microvascular complications. A prevalence of nephropathy, retinopathy and neuropathy was detected in 38.8, 23.9 and 22.5% of the sample population, respectively. Unfortunately, searching several electronic databases, including PubMed, Google Scholars and ResearchGate, did not yield much information on the extent of the problem in the country. Thus, it is difficult to compare these figures with those from a local context.

The absence of local figures makes it difficult to compare the study results with those from a local context. However, comparison of the results with others from the regional setting shows that these numbers are close to the ones recorded in Egypt [2], which is one of the top countries affected by the disease globally, and higher than the numbers reported in Saudi Arabia [3].

The magnitude of diabetic nephropathy in the study is higher when compared to the global figures. This finding seems to be a characteristic of the Sudanese population. In 1995, Elbagir et al. [15] estimated the prevalence of CKD among diabetics to be 22%. Banaga et al. [16] suggest that DM is the third most common cause of ESRD in Sudan, accounting for around 13% of the cases. In Saudi Arabia, it was estimated at 11% [5].

Hypertension was the most frequent co-morbidity with 38.8% of the patients having it. In fact, hypertension is the most common co-morbidity in patients with type 2 DM and its presence hastens the development of the microvascular complications [17]. 80.2% of the patients who developed 1 or more of the microvascular complications were hypertensive. The disease was present in 87.6, 92 and 87.2% of the patients who had nephropathy, retinopathy and neuropathy, respectively.

Out of the 96 study participants who showed features of 1 or more of the microvascular complications, 91 had poor glycaemic control (94.8%). The association between the glycaemic control, as reflected by HbA1C, and the risk of development of the microvascular complications is statistically significant.

The mean BMI of the sample population was 26.92 ± 2.06. Thus, the study participants were more likely to be overweight. This can be due to the influence of an obesogenic environment that promotes obesity [18].

All 209 patients used cars and motor vehicles as a method of transportation and commutation. None of them walked to reach their travel destinations, nor used bicycles. This reflects the invasion of the sedentary lifestyle and the change in the behavioural patterns in the local community. Besides, only 21.1% of those enrolled in the research were involved in regular sports or fitness activities.

Sudan has been facing an exponential rise in the rates of DM and its sequelae in the past few decades. This can be partially attributed to the improvements in the screening and diagnostic techniques. However, the cause for the widespread occurrence of DM is multifactorial, namely urbanisation, momentous sociocultural changes, invasion of the sedentary lifestyle and adverse nutritional habits.

The results of this study reflect the extent of the burden of the microvascular complications of DM in the capital state of the country. The figures may vary depending on the geographical location. Besides, differences may occur depending on the level of the healthcare facility being primary, secondary or tertiary.

The study revealed an association between specific variables and the development of small-vessel conditions. However, it is difficult to confirm a causal relationship in such types of studies. The reason for this is that both the exposure and outcome are measured simultaneously.

The selection bias that can occur with systematic random sampling can represent a limitation to the study. Respondent bias is also a possible drawback. None of the females who participated in the survey gave a history of smoking or alcohol drinking. This can be influenced by social norms.

Microvascular complications are a major outcome among diabetics. Screening for small-vessel conditions can help in detecting them in the early stages and, thus, improve the treatment options and, consequently, the quality of life. It is important to evaluate the long-term complications of the disease in the different parts of the country. More research needs to be conducted for an in-depth analysis and understanding of the possible causal and risk factors. Thus, research in the field of diabetes needs to be intensified.
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Statement of Ethics

Ethical approval from SPHC has been obtained prior to conducting the study. Any individual who met the inclusion criteria and was selected as a potential subject for the research was given a participant information sheet that included a debrief and consent forms. The sheet clearly stated the study title and the purpose of carrying it out. The selection process was also explained. Participation in the research was completely voluntary and the participant had the right to withdraw from it at any time without giving a reason. All the potential psychological, physical, professional, legal and other risks were acknowledged and fully explained to the participant. Besides, all the possible measures to minimise these risks were taken. All the examinations and investigations carried out during the survey were routine and not specific for the research. Each potential participant was given adequate time to review the information sheet and ask questions before giving consent. No signature was required on the consent for privacy protection. Submitting a complete questionnaire was regarded as consent for participating.

Disclosure Statement

The authors have no conflicts of interest to declare.

Author Contributions

M.H. designed the questionnaire and checklist, collected the sample, carried out the study, analysed the data and drafted the manuscript. S.M. revised the manuscript. Both authors read and approved the final manuscript.

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