Glycemic Control and Self-Monitoring of Blood Glucose in Type 2 Diabetic Patients on Insulin and Prevalence of Candidiasis in these Patients at Dschang District Hospital, Cameroon: A cross-sectional study

ABSTRACT.

Background: The number of deaths attributed to diabetes was estimated at nearly 1.5 million worldwide in 2012, making this disease one of the 15 most deadly pathologies in the world. Self-monitoring of blood glucose is not widely used in type 2 diabetics on insulin.

Objective: to evaluatethe level of glycemic control and identified some factors that may influence it as well as determining the prevalence of candidiasis in these patients.

Methodology: A descriptive cross-sectional study was conducted on a population of type 2 diabetic patients on insulin followed at Dschang District Hospital with an average age of 58 years treated with insulin for at least 2 months and the predictors of poor glycemic control were measured (HbA1c higher than 7%) and the search for three species of *Candida* carried out in 3 different types of samples (urine, blood and oral cavity). Furthermore,a questionnaire was used to collect information on self-monitoring of blood glucose.

Results: This study included 66 diabetic patients with a mean age of 58 years and a male predominance (51.5%). The majority of patients had been diabetic for at least 6 years with a mean duration of insulin therapy of 6 months. 90.1% of the participants reported having a glucometer and 54.5% reported performing self-monitoring of blood glucose twice a day as recommended by the physician. This study found that 78.8% of these patients had inadequate glycemic control. Factors such as Body mass index,duration of diabetes and coexistence with hypertension influenced this glycemic control. Similarly, a prevalence of 15.2%, 12.1% and 00% were recorded for urinary, oral and systemic candidiasis respectively with *Candida albicans* being thespecies most involved in these infections.

Conclusion: Poor glycemic control is common among type 2 diabetic patients on insulin at Dschang District Hospital and is due to poor use and lack of training of patients on the practice of self-monitoring of blood glucose . This poor glycemic control favours the development of candida infections, especially urinary and oral.

Keywords: Diabetes, glycemic control, candidiasis,Dschang District Hospital

1. INTRODUCTION

Diabetes corresponds to a prolonged increase in blood sugar level (hyperglycemia) it is defined by a chronic elevation of fasting blood sugar above 7 mmol/L (1.26 g/L). The incidence of this diseaseis always increasing in Cameroon where its prevalence has increased from 1.5 to 6.6% between 1997 and 2013 [1,2]. The number of deaths attributed to it was estimated at nearly 1.5 million worldwide in 2012, making this disease one of the 15 most deadly pathologies in the world [3]. Type 2 diabetes or non-insulin dependent diabetes occurs as a result of insufficient insulin production in the face of increased demand from the body caused by an increase in the resistance of certain target tissues to insulin [4]. Several therapeutic strategies are available in the fight against diabetes, and insulin therapy is one of them widely used; indeed, while it is imperative in type 1 diabetes mellitus, type 2 diabetes only requires insulin treatment at a more advanced stage of its evolution [5] or when oral treatments do not allow the recommended glycemic objective (HbA1c lower than 7%) to be reached [6]. Compared to non-insulin-treated type 2 diabetes mellitus patients, those treated with insulin are more difficult to monitor and have poorer glycemic control despite the fact that insulin is an effective treatment for diabetes [7], hence the need for self-monitoring of blood glucose. Studies conducted in China [8] and Thailand [9] have shown that self-monitoring of blood glucoseis not widely used and observed by thesepatients, resulting in high proportions of poor glycemic control. Poor glycemic control is associated with an increased prevalence of diabetic complications according to United Kingdom Prospective Diabetes Study, and the immunodeficiency caused by diabetes and the presence of glucose promote the pathogenicity and severity of infections caused by *Candida* yeast [10,11].The spectrum of candidiasis is particularly broad, ranging from cutaneous superinfection to disseminated infection, affecting several vital organs such as the kidneys and liver, with the possibility of leading to renal and hepatic damage [12]The aimof this work was therefore to study the status of glycemic control and self-monitoring of type 2 diabetic patients treated with insulin and to identify some factors predictive of poor glycemic control as well as the prevalence of candidiasis in the district hospital of Dschang.

2. RESEARCH DESIGN AND METHODOLOGY

2.1 Study population and site

This study was conducted over a period of 4 months from March to June 2021 during which patients with type 2 diabetes treated with insulin for at least 2 months, of both sexes and ages, were recruited for consultation or admission to the Diabetes Department of the Dschang District Hospital in the West Cameroon Region. Patients were informed of the purpose of the study and those who gave informed consent were enrolled in the study. Participants with missing data as well as those on antifungals were excluded, thus the data of 66 patients were analyzed.

2.2 Methods

The participants who gave their informed consent and thus were included in the study, were first subjected to a questionnaire that allowed us to know their socio-demographic status and clinical characteristics, which included their ages, duration of diabetes, duration of insulin therapy, practice of self-monitoring of blood glucose,possession of a blood glucose meter and many others.

In a second step, anthropometric parameters were measured (weight and height) and fewmilliliters of blood were taken for blood culture and the dosage of fasting glycemia and glycated hemoglobin (HbA1c) by immunochromatography via the specific automatons " DIACHECK Pro " and " BIOHERMES A1c EZ 2.0" respectively and finally an oral and urinary sample was taken and seeded on CHROMagar Candida medium for the search and identification of yeasts of the *Candida* genus.

2.3 Ethical consideration

This study was carried out after obtaining a research authorization from the ethics committee of the Dschang District Hospital, the free and informed consent of each participant as well as the ethical clearance from the national research ethics committee for human health.

2.4 Statistical analysis

The data recorded on the survey sheets were then entered and analyzed by SPSS version 26 and Excel 2016 software. The parameter values were expressed as mean ± standard error at the mean. The calculation of odds ratio and correlation coefficients were performed.

The X^2 test was used for comparisons of means between groups with dependent variables and the Pearson correlation test to establish correlations between quantitative variables.Values of $p < 0.05$ were considered statistically significant.

3. RESULTS

The participants in this study ranged in age from 36 to 80 years with a mean age of 58.27 ±11.46 years, with the 60 to 80 age group being the most represented and constituting 54.5% of the population. 75.8% of the participants were living as a married couple against 24% of widowers. In terms of occupation, housewives/retirees and people in the informal sector were the most represented and each accounted for 42.4% of the population. The majority of the participants (51.5%) had stopped their studies at the primary level and lived mostly in urban areas, i.e. 72.7% of the population. Social parameters such as marital status, school level, occupation and area of residence of the participants did not have a significant effect on their glycemic controls because the P values obtained: 0.763, 0.403, 0.482 and 0.500 respectively are not statistically significant (Table 1).

Table 1: Social risk factors potentially related to poor glycemic control

Socio-demographic parameters	Number (%)		X^2,P value
	HbA1c ≤ 7	HbA1c > 7	
Civil status			**0.763**
Married	71.4%	76.9%	
Single	0%	0%	
Widower	28.6%	23.1%	
School level			
Not in school	28.6%	7.7%	**0.403**
Primary	42.3%	30.8%	
Secondary	42.9%	53.8%	
University	14.3%	7.7%	
Profession			
Housewife/ retiree	42.9%	42.3%	**0.482**
Public servant	28.6%	11.5%	
Informal sector	28.6%	46.2%	
Residence			
Urban environment	57.1%	76.9%	**0.500**
Rural areas	28.6%	11.5%	
Other cities	14.3%	11.5%	

HbA1c ≤ 7: good glycemic control; **HbA1c >7**: poor glycemic control

3.1 Distribution by diabetes-specific characteristics

The mean duration of diabetes in our study population was 6.75±6.22. While 75.8% of the cases of diabetes in our participants were discovered during a consultation; polyuria being the main cause of consultation, 24.2% of the cases were discovered incidentally. 39.4% of the patients seen in this study reported a family history of diabetes. Similarly, 30.3% of these patients did not have a known family history of diabeteswhile another 30.3%did not know whether or not they had a known family history of diabetes . While the mean body mass indexin this study was 27.32±4.35, it was found that 42.4% of the study population was overweight and 27.3% obese as shown in table 2 below.

Table 2: Distribution by diabetes-specific characteristics

Parameters	Frequency (%)
Family history of diabetes	
Yes	39.4%
No	30.3%
no idea	30.3%
Circumstances of discovery	
Consultation	75.8 %
Random	24.2%
diabetes duration	
0-5 years	57.6%
6 - 10 years	15.2%
11 - 15 years old	18.2%
>15 years old	9.1%
weekly sports activity	
Yes	51.5%
No	48.5%
Age of diabetes (years) 6.75±6.22	
0-5 years	57.6%
6 - 10 years	15.2%
11 - 15 years old	18.2%
< 15 years	9.1%
Body mass index (BMI) 27.32±4.36	
18.5 à 24.9	30.3%
25 à 29.9	42.4%
30 à 40	27.3%

BMI between 18.5 and 24.9: normal weight; between 25 and 29.9: overweight and 30 to 40: obese

3.2 Potential Risk Factors for Poor Blood Sugarcontrol

For this study, only patients treated with insulin were included and the mean duration of insulin therapy was 6.44±5.34 months. While 90.9% of our study population reported having a blood glucose meter for self-monitoring, 9.1% did not.

The average HbA1c level observed in these patients was 9.8±2.7% and the patients were separated into two groups according to their HbA1c level, those with a level below 7% representing 21.8% of the population and those with a level above 7% representing 78.8% of the population. Table 3 below summarizesthe distribution of patients as a function of parametersthat may influence the patient's glycemic control.

Table 3: Distribution of patients as a function ofparametersrelated to glycemic control

Frequency ofparameters (%)	
duration of insulin therapy (months) Avg+SD 6.44±5.34	
between 2 and 5 months	57.6%
between 6 and 9 months	18.2%
more than 10 months	21.2%
Possession of the glucometer	
Yes	90.9%
No	9.1%
Combination of insulin therapy and oral antidiabetics	
Yes	18.2%
No	81.8%
Fasting blood glucose(mg/dl) Avg+ET 1.8±0.93	
< 0.8 mg/dl (hypoglycemia)	9.1%
0.8 - 1.26mg/dl (normal)	18.2%
> 1.26 mg/dl (hyperglycemia	72.7%
HbA1c value (%) Avg+SD 9.8 ± 2.7	
HbA1c ≤ 7	21.2%
HbA1c > 7	78.8%

Avg+SD: mean plus standard deviation ;
HbA1c ≤ 7: good glycemic control; **HbA1c >7**: poor glycemic control

Table4 shows that 57.10% of patients with good glycemic control were female compared to 42.9% of male participants.From this table we can notice that gender, hypertension, as well as the practice of sports seem to be factors which negatively influence glycemic control, while the possession of a glucometer, the combination of oral anti-diabetics and insulin therapy during treatment positively influence glycemic control, although p-values are not significant.

Table 4: Potential factors influencing glycemic control.

Parameters		HbA1c control		Odds ratio	X^2,P value
		HbA1c ≤ 7 :	HbA1c > 7 :		
Sex	Female	57.1%	46.2%	1.55	0.533
	Male	42.9%	53.8%		
Possession of a glucometer	Yes	100%	88.5%	0.769	0.183
	No	00%	11.5%		
Weekly sport practice	Yes	28.6%	57.7%	2.2	0.256
	No	71.4%	42.3%		
Combination of insulin and oral antidiabetic **therapy**	Yes	26.6%	15.4%	0.293	0.053
	No	71.4%	84.6%		
Known hypertension	Yes	42.9%	19.2%	3.15	0.067
	No	57.1%	80.8%		

HbA1c ≤ 7: good glycemic control; HbA1c >7: poor glycemic control

3.3 Correlation between HbA1c and some diabetes-related parameters

Table 5 below shows the strength of the relationship between some diabetes related parameters and the patient's HbA1c value. A significant relationship can be observed between body mass indexand HbA1c (r= 0.407) and (P =0.019); while the relationship between the variables Age, duration of diabetes and insulin therapy are not statistically significant

Table 5: Correlation between HbA1c and selected variables studied

Variables	HbA1c	
	R	**P value**
Body mass index	0.407	**0.019**
Age	0.122	0.499
Duration of diabetes	- 0.186	0.3
Duration of insulin therapy	0.112	0.536

r = Pearson correlation result; p value= probability value of the test

3.4 Prevalence of diabetes complications

From the table below, it can be seen that in our study population, 39.4% of patients had diabetic retinopathy while the prevalence of diabetic nephropathy was 21.2% (Glomerular filtration rateless than 60 ml/min per 1.73m^2) with the mean glomerular filtration rateof the study

being 76.31±26.043 ml/min per 1.73m^2. High blood pressure was also found in 24.2% of the participants in this study as shown in the table below.

Table 1: Incidence of diabetes complications

Parameters	**Frequency (%)**
Retinopathy	
Yes	39,4%
No	60,6%
Hypertension	
Yes	24.2%
No	75.8%
Diabetic nephropathy (**Glomerular filtration rate** in ml/min per 1.73m^2)	
> 60: no renal failure	78.1%
≤ 60: Renal failure	21.9%

Glomerular filtration rate > 60: no renal failure declared; Glomerular filtration rate ≤ 60: renal failure declared

3.5 Search and identification of candidiasis.

In the study population, 15.2% of the participants were positive for urinary candidiasis and 12.1% had oral candidiasis and given the possible rarity of systemic candidiasis, we did not obtain any cases.

The distribution of candidiasis according to glycemic control shows that candidiasis, whether oral or urinary, is more prevalent in patients with poorly controlled diabetes (HbA1c >7%) (Figure 1).

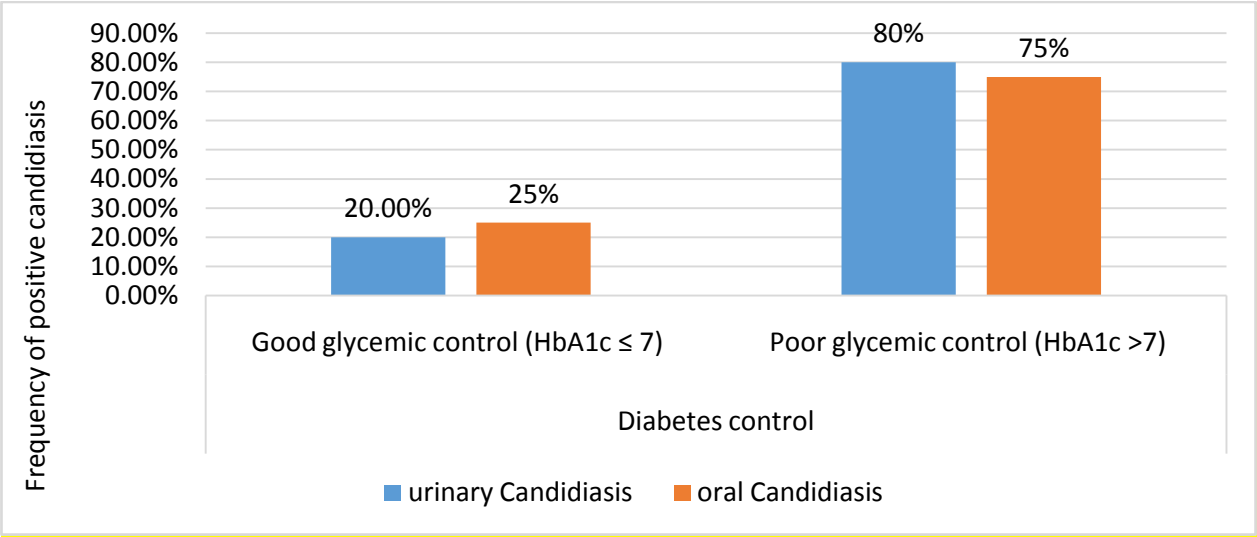

Figure 1: Distribution of candidiasis according to glycemic control

Candida albicans species is the most involved in candiduria with 50.00% of cases followed by *Candida krusei* with 33.33% and finally *C.tropicalis*. *C. albicans* was the only species isolated from oral candidiasis (table 7).

Table 7: *Candida* species frequencies

	Different species of candida	**Percentage**
Urinary candidiasis	*C. albicans*	50.00%
	C. *krusei*	33.33%
	C. tropicalis	16.66%
Oral candidiasis	*C. albicans*	100%
Systemic candidiasis	/	/

4. DISCUSSION

The data from this study indicate that 78.8% of type 2 diabetic patients treated with insulin at Dschang District Hospital had inadequate glycemic control (HbA1c> 7.0%, 53 mmol/mol; which is the ADA recommendation). This high proportion was also found in several studies such as Ji et *al* [8] in China where a prevalence of 75.8% was obtained; Camara et al [13] who obtained 68% in Cameroon and 84% in Guinea and Pragosuntumg [9] in Thailand (73.9%)**.** This high rate of inadequate glycemic control in this study population could have multiple reasons. The association between poor glycemic control and demographic characteristics is controversial. The association between poor glycemic control and demographic characteristics is controversial. Studies conducted in the USA and Morocco [14, 15], have shown that men had better glycemic control than women with type 2 diabetes. However, this study showed that female participants had better glycemic control compared to male participants (odds = 1.55). A French study conducted in a non-diabetic population showed that HbA1C increased with age for both sexes even after adjusting for fasting glucose, with an increase of 0.04% in HbA1C every ten years [16]. This demonstrates a possible increase in HbA1c with age; [17] also reported that the quality of metabolic control decreased with age in their study. In this study, however, the correlation between age and HbA1c was not significant (P=0.135) and this corroborates the results of **Mostafa *et al*** [15] who also obtained a non-significant association between these two parameters. Social parameters such as marital status, educational level, occupation and place of residence were not associated with glycemic control in this study. Duration of diabetes was also associated with poor glycaemic control. Patients with less than 10 years of diabetes had better glycemic control (mean HbA1c = 9.45) compared to those with longer duration of diabetes (mean HbA1c = 10.49), a result that is consistent with that obtained in the USA [18]. This positive association between the duration of diabetes and HbA1c could be explained by the fact that diabetics with a long duration of disease have more difficulty in controlling their blood glucose levels and reaching the recommended targets. This may also be related to the decline in insulin secretion and the increase in insulin resistance observed during the progression of this disease and the development of multiple complications that can worsen glycemic imbalance [19]**.**

Duration of insulin therapy could also be associated with better glycemic control, as participants with duration of insulin therapy longer than 6 months had slightly better glycemic control compared to those with duration shorter than 6 months, but this result was not statistically

significant (p=0.126). The same result was obtained in China [8] and was significantly (p= 0.0139) associated with glycemic control.

Poor glycemic control was significantly associated with patient body mass index(p = 0.019). It was also observed that obese and overweight patients had the highest proportion of poor glycemic control. These results corroborate those obtained by **Mostafa *et al*** and **HU *et al*** in the USA [15, 18]. This could be explained on the one hand by the problem of weight gain with insulin treatment [5] and on the other hand by the fact that overweight and obesity could increase the insulin resistance of the target tissues.

Patients with known diabetes and hypertension showed better glycemic control than those without hypertension. Thus, diabetes coupled with hypertension is associated with good glycemic control but this association is not significant (p=0.067). The same is true for patients combining insulin therapy and oral antidiabeticscompared to those on insulin therapy without oral antidiabeticswhich is significant (p= 0.053). This result does not corroborate that reported by **Bahalou** [20] where patients with poor glycaemic control were mostly treated with oral antidiabetic drugs combined with insulin. However, this may be because, in addition to the ability of insulin to significantly reduce blood glucose levels, some oral antidiabeticssuch as metformin are able to inhibit hepatic glucose production to help maintain acceptable blood glucose levels. Similarly, the United Kingdom Prospective Diabetes Studyalso showed that the addition of insulin to sulfonamides taken at maximal doses significantly improved glycemic control without increasing hypoglycemic risk. However, the frequency of daily blood glucose monitoring, the frequency of hospital monitoring, and weekly sport practice had no significant effect on blood glucose control. The case of sport can be justified by the fact that any intense sport activity can lead to hypoglycemia [21]. This could justify inadequate sports practice to improve glycemic control, as it is established that in type 2 diabetes mellitus patients, regular sports activity leads to an increase in tissue insulin sensitivity even at rest and thus improves glucose tolerance [21]. Although the frequency of daily and in-hospital blood glucose monitoring has been associated with poor glycaemic control, this is consistent with a study in France that found that regardless of the number of weekly blood glucose measurements, self-monitoring of blood glucosedoes not improve HbA1c [**22**].

Candidiasis is an infection caused by yeasts of the genus *Candida spp.* These yeasts are basically saprophytes of the digestive tract, but in pathological situations such as diabetes, they can become pathogens that cause various infections. Thus, in this study, a prevalencesof urinary and oral candidiasis of 15.2 and 12.1% were obtainedrespectively. Both oral and urinary candidiasis were significantly associated with fasting hyperglycaemia for urinary candidiasis (p= 0.0041) and not significant (p= 0.090) for oral candidiasis. Although the correlation was not significant, oral and urinary candidiasis were more prevalent in patients with poorly controlled diabetes (HbA1c >7%) with proportions of 80 and 75% compared to 20 and 25% for urinary and oral candidiasis respectively. This could be explained by the fact that in hyperglycemic situation, salivary and urinary sugar levels can be removed; sugar being a preferential substrate for the multiplication of microorganisms and fasting blood glucose reflecting the HbA1c level. This prevalence of urinary candidiasis is much lower than that obtained in Morocco in 2010 in a similar study reporting 28.3% [23]**.** Similarly, another study on oral candidiasis in type 2 diabetes mellitus in the same country also reported a prevalence of 47% and was correlated with the wearing of dentures [24]. The absence of this risk factor in our study could also explain our lower prevalence. This could be explained by the fact that it is very rare with an incidence of 2.5 cases per 100,000 people according to a study conducted in France by the National Reference Centre for invasive and antifungal mycoses (CNRMA) and the high lethality rate of the latter (40%) [25].

5. CONCLUSION

The most common candida species found in urinary candidiasis in this study were *C. albicans* in 50.00%, *C. krusei* 33.33% and *C. tropicalis* 16.66% of cases respectively. As far as oral candidiasis is concerned,*C. albicans* was the main species found. The increase of the population size as well as the exploration of other health centres will surely bring more light in how self-monitoring of blood glucose in type 2 diabetic patients is handled.

CONSENT

As per international standards or university standards, patients written consent has been collected and preserved by the author(s)

ETHICAL APPROVAL

The National Human Health Ethics Committee of Cameroon has issued approval ref: 2019/05/30/CE/CNERSH/SP.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

AUTHORS' CONTRIBUTION

GSSN designed and supervised the study. DFK performed experiments, analyzed the data, and wrote the first draft of the manuscript. LYC,JF , LMM,AJA and JKTM were involved in analyzes of data and manuscript correction. All authors read and approved the final manuscript.

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