Original Articles

PATTERN AND FACTORS ASSOCIATED WITH GLYCEMIC CONTROL OF SAUDI DIABETIC PATIENTS

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Background: The pattern and factors which can be associated with the glycemic control of Saudi adult diabetic patients were examined in this study.
Patients and Methods: Confirmed diabetic patients from all regions of Saudi Arabia constituted the study population. Random blood glucose <10 mmol/L and >10 mmol/L was used to categorize patients into good and poor glycemic control patients, respectively.
Results: There were 613 confirmed non-insulin dependent diabetic patients (NIDDM), 50% with good glycemic control. Patients with poor glycemic control were significantly older than patients with good glycemic control (51.5 vs. 47 years, *P*=0.0001). The insulin-treated diabetic population amounted to 13%, compared with 43% and 44% for oral agent and diet, respectively. The rate of insulin users among poor glycemic control diabetic population was 18%, compared with 50% for oral agents. There was a significant relationship between glycemic control and age, and treatment modalities of DM. Subjects who had good glycemic control of DM were younger and following a diet regimen, while those who had poor glycemic control were older and on insulin treatment. Multivariate analysis comprising 415 individuals was conducted to find out the factors that can potentially influence, or may be associated with, the control of DM.
Conclusion: The association of insulin therapy with poor glycemic control is not a cause-effect relationship. Insulin therapy in our study population is underutilized, given the high rate of poor glycemic control and high rate of relative occurrence of complication among the Saudi diabetic population. There is a need to address the importance of maintaining good glycemic control, and the reason for the low rate of insulin users. Close periodic monitoring of glycemic control, utilizing laboratories and home glucose monitoring devices, is required. Effective implementation of these measures, in addition to diabetes education, will have an impact on the future outcome of the Saudi diabetic population.
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Key Words: Diabetes mellitus, glycemic control.

Diabetes mellitus (DM) is a disease with a high prevalence worldwide, and in the last few years its prevalence has become more widespread in the third world or developing countries.[1] This is especially the case in the Middle Eastern countries, which have experienced an upward surge in the prevalence of DM over the last 20 years.[2] This is the likely result of economical development and changes in lifestyle, especially in nutritional habits.[3] The long-term microvascular and macrovascular complications of diabetes are responsible for significant morbidity and mortality. Diabetes is the leading cause of blindness in adults, the most common cause of end-stage renal disease, accounting for 30%-40% of this population, is responsible for 40% of all non-traumatic amputations of the lower extremities in adults, and is a major risk factor for cardiac and cerebrovascular diseases.[4,5]

Saudi Arabia has an estimated population of 13.2 million, 70% of whom are under 30 years of age.[6] DM-related complications are a frequent occurrence among Saudi diabetic patients. A review of 1000 consecutive Saudi diabetic patients in a general hospital showed an incidence rate of 32% for retinopathy, 26% for hypertension, 11.3% for ischemic heart disease, and 6.9% for renal insufficiency.[7] Diabetes-related hospital admissions are frequent and tend to occupy hospital beds for a longer time, as compared to other diseases.[8]

Epidemiological studies have established a relationship between hyperglycemia and the development of the long-term complications of diabetes.[9-11] The importance of tight glycemic control with respect to delay or in the prevention of complications was not established until recently. The Diabetes Complication Control Trial (DCCT) has proved

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the importance of tight glycemic control for the prevention of control complication among insulin-dependent DM patients.[12] The conclusions of the DCCT study are probably applicable to the non-insulin dependent diabetes mellitus (NIDDM) patients as well. Several factors were recognized as playing a role in glycemic control, among which are duration of DM, obesity and hypertension.[13-15]

This paper is part of a population-based epidemiological study of chronic metabolic disorder among Saudi adult subjects from all regions of Saudi Arabia. It focuses on the pattern and factors affecting glycemic control of non-insulin dependent diabetic patients.

Patients and Methods

The National Epidemiological Household Survey for Chronic Metabolic Diseases, which included DM, was conducted among Saudi subjects over the age of 15 years in different regions of Saudi Arabia between 1990 and 1993. This was a national study with several objectives, among them to measure the prevalence of DM, hypercholesterolemia and obesity at national, regional and tribal levels. Based on this, a sample size of 37,000 was calculated in order to study the pattern of glycemic control of Saudi diabetic patients. A multistage stratified cluster random sampling technique was used for the selection of the study population. The assigned population sample of the study was distributed between the different regions in accordance with the regional population distribution as provided by the National Population Council (NPC). There was an initial adjustment for type of area (urban or rural), and population distribution in each region, as per the NPC. Cities and villages of each region were listed and a random selection of a certain number of cities and villages conducted in accordance with the allocated share of each region in the national sample. The administrative maps of the selected cities and villages were reviewed and a random selection of a number of districts in these cities and villages was made.

Primary care physicians who work in these localities were assembled and given orientation lectures and workshops on different aspects of the study, such as filling out the forms that include personal, demographic, social and medical history, specifically data relating to DM, such as present history of self-reporting. The medical records of these patients were reviewed to confirm the diagnosis of DM. The primary care physicians were also trained on the proper method of blood handling, and measurement of height and weight, which is done at the Primary Care Clinic (PCC), usually two or three days after the patient's initial visit.

Every third parallel street in any of these localities was selected, and then every third house was included in this study. All subjects over the age of 15 years in these houses were asked to participate in this study. All the interviewed subjects were requested to attend the PCC for weight, height and blood measurements. Random blood samples were drawn in an EDTA tube, centrifuged, and the serum stored frozen until completion of the target sample. The samples were sent frozen to the Central Laboratory, King Saud University, Riyadh, from all over the country. Samples were stored at –20 °C until assayed. Upon reaching the target number of 100 subjects per physician in each district or city, or 50 subjects per physician in each village, the records were sent to the central office in Riyadh for data entry. A computer program was designed, using DBase IV software package for data entry. After the completion of data entry, there was a final adjustment for gender, age, region, urban or rural population distribution, in accordance with the NPC, using Statpack Gold software package, of a number of records from different regions and age groups.

Serum samples were used for glucose analysis on a glucose analyzer (Beckman Paragon, Fullerton, CA, USA). The method depends on the rate of oxygen consumption by the enzyme glucose oxidase. The instrument was calibrated prior to glucose determination, using quality control samples provided with the solutions. The mean values obtained on the controls were within the values quoted by the manufacturer. The results were expressed by SI units (mmol/L). The intra- and interassay coefficients of variation were 1.7% and 2.6%, respectively.

A cutoff of random blood glucose (RBS) of 10 mmol/L was used to categorize patients into good (RBS<10 mmol/L) and poor glycemic control (RBS>10 mmol/L). The WHO criteria for definition of obesity (BMI>30) was adopted.[16]

There are many variables which are believed to influence the glycemic control of diabetic patients. These include age, gender, body mass index, region, place of residence (urban or rural), duration of DM, and treatment modalities of DM (diet, oral agents and insulin).

Various types of univariate analyses were employed to assess the distribution of observations, to provide an understanding of the relationships between variables, and to select the variables suitable for inclusion in multivariate analyses. Chi-squared test, Student's *t*-test, and Fisher's exact test were performed to assess the significance of the relationships between variables. The 5% level was set as the level of significance.

Multiple logistic analysis was used to examine the association between the odds of glycemic control and any predictor believed to influence it, adjusting it for the other predictors included in the Schlesseman model, 1982.[17]

$$\text{Logit}(p) = a + b_1x_1 + b_2x_2 + \dots + b_kx_k$$

A backward elimination was employed to select the best-fitting model. The initial model included all main effects. The effect with the smallest *Z*-ratio was removed and the model refitted with the remaining effects. The analysis had proceeded by deleting effects one at a time until the best-fitting model was reached. The adequacy of fit of a given model was assessed by both the likelihood ratio test and the goodness of fit chi-square. In multivariate analysis, only the observation that has information on all variables included in the multivariate equation would be accounted for in the analysis. Hence, out of 613 individuals, only 415 were included in the multivariate analysis.

Statistical analyses were performed by using Statpack Gold,[18] and subroutine of the BMDP LR software computer package.[19]

Results

There were 613 sampled subjects who were confirmed as diabetic patients, 50% of whom had good glycemic control (Table 1). The mean (and standard deviation) of age for subjects who had good control of DM were 47.0 (14.8) years, compared with 51.5 (13.8) years for those who had poor control (T=3.88, DF=611, P=0.0001).

There was normal age distribution, hence there was no need for transformation or categorization, and the variable age was used as a continuous one. The distribution of age was as follows: median, mean (SD) 49, 48.92 (12.8) years, mode 45 years, standard error 0.48 years, variance 163.89 years squares, skewness and kurtosis 0.06 and 0.2.

There was no specific difference of means of BMI between good and poor glycemic control patients, 28.7 (5.4) and 28.3 (5.5), respectively. The prevalence of obesity was high among the patients of the two groups, 39% and 34% for good and poor glycemic control patients, respectively. There was, however, no significant difference.

There was no specific pattern for means of RBS for each age group of male and female patients with good and poor glycemic control. There was no significant difference between means of RBS of male and female patients of each age group, whether among good or poor glycemic groups.

There was a significant relationship between glycemic control and age (Table 1), and treatment modalities of DM (Table 2). Subjects who had good glycemic control of DM were younger and following a diet regimen, while those who had poor glycemic control were older and on insulin treatment.

Multivariate analysis comprising 415 individuals was conducted to find out the factors that can potentially influence or are associated with the control of DM, and 45.8% were found to have good glycemic control. The initial model included the following factors: age, gender, BMI, region, place of residence, urban vs. rural, duration of DM, and treatment modalities of DM. The treatment modality of DM was the only factor which had significant association with glycemic control. Compared to patients on the diet regimen, those on insulin and oral agent treatment were at 164% and 65% more risk of having poor glycemic control, respectively (Table 3).

TABLE 1. *Comparison of demographic and physical data of good and poor glycemic control diabetic patients.*

Variable	Glycemic control: Good control group (mean±SD)	Glycemic control: Poor control group (mean±SD)	P-value
No. of records*	309	304	
Age (years)	47.0 (14.8)	51.5 (13.8)	<0.0001
BMI	28.7 (5.4)	28.3 (5.5)	0.34
Prevalence of obesity	39%	34%	0.19

*Number of records with available data.

TABLE 2. *Comparison of different factors which can affect glycemic control.*

Factors	Glycemic control: Good control group no. (%)	Glycemic control: Poor control group no. (%)	χ*	df**	P-value
Region			6.24	4	0.18
West	90 (52.3)	82 (47.7)			
North	24 (40.7)	35 (59.3)			
South	47 (47.0)	53 (53.0)			
Central	55 (46.6)	63 (53.4)			
East	93 (56.7)	71 (43.3)			
Residency			0.02	1	0.89
Urban	213 (50.6)	208 (49.4)			
Rural	96 (50.0)	96 (50.0)			
Sex			0.29	1	0.59
Male	158 (49.4)	162 (50.6)			
Female	151 (51.5)	142 (48.5)			
Treatment modalities			40.77	2	0.000
Insulin	23 (29.1)	56 (70.9)			
Oral agent	113 (42.8)	151 (57.2)			
Diet	172 (64.2)	96 (35.8)			

*Chi-squared; **degree of freedom.

Discussion

This is an epidemiological population-based study which reflects the pattern and factors which can potentially affect glycemic control of Saudi diabetic patients at the national level. Several observations can be made with respect to the glycemic control: the high rate of patients with poor glycemic control, which amounts to 50% of the study diabetic population, is rather an alarming rate which probably reflects the inadequacy of services provided, including education, and lack of insight into the importance of good glycemic control, whether from the physicians, patients or both. Insulin-treated diabetic patients amount to 13%, compared with 43% and 44% for oral agents and diet, respectively. In spite of having a significantly higher rate of insulin users among the poor glycemic control group when compared with good glycemic control diabetic patients (71% vs. 29%), the rate of insulin users was lower than that of oral agents among patients with poor glycemic control (18% vs. 50%). Poor glycemic diabetic patients were significantly older than good glycemic control diabetic patients.

Multiple logistic regression analysis has shown that treatment modalities are the only significant factors which can be associated with degree of glycemic control, where

TABLE 3. *Logistic regression analysis for the factors which can affect glycemic control (Fit Model).*

Factors	Coefficient	Odds ratio	95% CI	P-value
DM treatment				
Insulin	0.972	2.64	1.41-4.96	0.005
Oral agent	0.504	1.65	1.08-2.55	
Constant	–0.230	0.79	0.57-1.11	0.18

CI=confidence interval.

insulin therapy was significantly associated with poor glycemic control.

The contribution of obesity to glycemic control in our study population was not significant. Other studies have shown the deleterious effect of obesity on glycemic control.[20] Obesity is highly prevalent among the general Saudi population, 16% and 23% for male and female subjects, respectively.[21] The prevalence was even higher for the two groups of our study diabetic population. Obesity was more prevalent among the younger diabetic population, <50 years old, than in the older diabetic population, >50 years (41% vs. 31%, P=0.01), respectively. This is in contrast to the pattern of obesity distribution with respect to age among the population of Western communities, where it is more prevalent among the elderly population. This may account for the lack of significant association between obesity and poor glycemic control, which is commonly found among elderly diabetic patients.

The significant association between insulin therapy and poor glycemic control is of interest. It is unlikely to be a cause-effect relationship. The diabetic patients who were selected for insulin therapy were the ones who had had diabetes for a longer period of time, had worse glycemic control and who did not respond to diet and/or oral agent.

We believe that insulin therapy is underutilized among our study population. It is recognized that, on average, for any given diabetic population, approximately 25% of patients are on insulin therapy. Given the high rate of patients with poor glycemic control and the high relative occurrence of complication among Saudi diabetic patients, as shown in our study population, there is a need to have more patients on insulin therapy for better glycemic control.

The causes of the rather low rate of insulin users, whether due to physician inertia for timely reaction, or because of insulin phobia by patients, have probably contributed to the high rate of poor glycemic control among diabetic patients.

Finally, there is a need to address the issue of the importance of maintaining good glycemic control by all means through utilizing different treatment modalities in order to prevent or retard diabetes complications at the national and individual levels. Periodic monitoring of glycemic control and utilizing laboratories and home glucose monitoring devices are crucial for better glycemic control. Although obesity has not at present been associated with poor glycemic control, it needs to be actively dealt with in order to prevent future precipitation of other diseases, such as cardiovascular disease and hypertension.

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