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Original Article

Association of Severity of Diabetic Foot Ulcer with Glycated Hemoglobin A1C Levels

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ABSTRACT

Diabetic foot ulcer is a well-documented complication of uncontrolled diabetes and its association with the variables involved in Diabetes like FBS, RBS and HBA1C has been thoroughly researched. This research aims to identify the association of diabetic foot ulcer under Wagner classification with HBA1C classes. **Objectives:** To determine the severity of diabetic foot ulcer at various level of HBA1C and determine the association. **Methods:** A cross-sectional study with 360 diabetic patients who after giving consent filled questionnaires. The information was analyzed using SPSS v26 (IBM) through Chi Square test. The results were tabulated and inferred from. **Results:** Our work depicts a statistically significant correlation between grades of diabetic foot ulcer and HBA1C levels of the patients (p-value <0.001). Patients with higher levels of HBA1C suffered foot ulcer of higher grades. Specifically, patients with Grade 1 foot ulcers primarily had HBA1C levels of ≤ 11.00 with 6(50%) falling in the group "7.01-9.00" while patients with Grade 5 ulcers had higher HBA1C levels with bulk of patients having levels of >11.00. **Conclusions:** This research further supplemented an already strongly established association between uncontrolled diabetes and diabetic foot ulcer. We focused on specifically HBA1C and how increased lab values are linked with different grades of Diabetic Foot ulcer and found a strong association demanding a proactive approach towards patient care and education.

INTRODUCTION

The chronic state of impaired glucose metabolism can affect immune system [1]. Glycated hemoglobin is a measure of average blood sugar concentration in past few months [2]. Elevated level of glycated hemoglobin is recognized as marker of predicting the severity of diabetes mellitus [3]. Hyperglycemia is also documented with adverse outcomes after surgery. Long term glucose control is being recognized for postoperative complications. In foot and ankle literature, poor glycemic control is not well studied [4]. Diabetic foot has high prevalence, peripheral neuropathy and peripheral vascular disease; the main causes of diabetic foot; are appears to be increasing. A study conducted in Africa showed: 4 -84 % peripheral neuropathy; 2.9 to 78.7 % peripheral vascular disease; frequency of patient presenting with diabetic foot [5]. Diabetic foot infections are common in diabetes mellitus complicated by diabetic foot ulcer and can be classified in different categories based on severity. It

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demands timely actions, close collaboration with different specialty and patient cooperation [6]. Chronic diabetic complication, including diabetic foot complications remain prevalent and challenging to treat. Diabetic foot ulcer recurs, and the importance of routine surveillance and multidisciplinary approach is essential. Diabetic foot ulcer can lead to Charcot foot, if not diagnosed early and treated effectively can lead to mortality and morbidity [7]. Diabetic foot complications occurring throughout the world, resulting in devastating economic crises for the patients, family and society. It has progressive prevalence rate in developing countries. Economic burden may be carefully examined [8]. Pre patient's incremental outcomes (e.g., amputations and medical sources outcomes) and health care cost (2012 US dollars) per 12 months follow-up periods. Increased utilization in diabetic foot patients having $11,710 incremental annual health care cost for Medicare. Privately insured matched diabetic foot patients incurred excess work cost of $ 3,257. Diabetic foot imposes burden public and private payers, ranging from $ 9- 13 billion in addition to the cost associated with diabetes [9]. Studies regarding diabetic foot ulcer with poor glycemic control on basis of various levels of Hba1c are not conducted. Every patient being admitted in tertiary care can have glycated hemoglobin level to asses' glycemic control. The main purpose of this study to find severity of diabetic foot ulcer with different level of glycated hemoglobin.

METHODS

This study was conducted in department of medicine and surgery, Khyber Teaching Hospital Peshawar. This was a cross sectional study of six months duration. A sample of 360 achieves 100 % power to detect an effect size(W) of 0.5000 using a 10 degrees of freedom chi-square with a significance level(alpha) of 0.05000 (10) via nonprobability consecutive sampling technique. All patient with presenting with diabetic foot ulcer with HBA1C level above 6.5% of either gender were included in the study. Non diabetic patients, those with traumatic foot ulcers were also excluded from the study. This study was conducted after approval from ethical and research committee. All patient fulfilling inclusion criteria were enrolled after informed consent. The purpose, benefit of study was explained to the patients. Detailed history was taken, and detail examination of diabetic foot was performed. Diagnosis of diabetes mellitus was made on basis of clinical symptoms plus random blood sugar, fasting blood sugar or HBA1C according to WHO criteria. Diabetes mellitus was diagnosed if diabetic symptoms of polyuria, polydipsia and polyphagia with random blood sugar above 200mg/dl or fasting blood sugar above 110 mg/dl or HBA1C above 6.5% or anyone with preexisting disease. Diabetic foot was examined properly and graded according to WAGNER classifications from 1 to 5. Wagner grade 1 means superficial ulceration, Wagner Grade 2 means ulcer extending to tendons or joints, Wagner grade 3 means ulcer involving bones and deeper tissues causing osteomyelitis or abscess formation, Wagner grade 4 means forefoot gangrene and Wagner 5 means full foot gangrene. The above information was gathered on basis of questionnaire keeping demographic variable of name, age, gender socioeconomic status with strict inclusion and exclusion criteria. Data were analyzed using SPSS 26.0. Mean and SD were calculated from continuous variables. Frequency and percentages were calculated from categorical variables after stratification, Chi square test was applied, value of <0.05 was taken as significant. Results were shown in the form of charts and tables.

RESULTS

A profile of our 360 patients is depicted in table 1 showing that minimum age was 45 and the maximum of 91 with a mean of 66.21 and standard deviation of 11.306. Similarly, the mean for RBS was 313.64, FBS 214.27 and HBA1C 11.32.

Variables	Minimum	Maximum	Mean ± SD
Age (years)	45	91	66.21 ± 11.31
HBA1C (%)	6.99	17.00	11.32 ± 2.48
Random Blood Sugar (mg/dL)	171	480	313.64 ± 2.48
Fasting Blood Sugar (mg/dL)	71	371	214.27 ± 54.729

Table 1: Baseline Profile of Patients

Major portion (43.61%) of our subjects had grade 4 ulcers as delineated, portraying a simple pie distribution of foot ulcer groups according to Wagner classification (Figure 1).

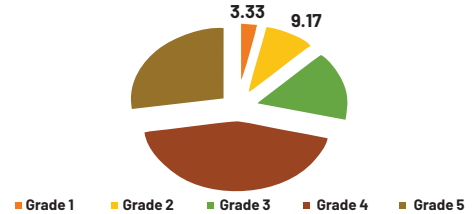

Figure 1: Distribution of Diabetic foot ulcer grades according to Wagner classification

Further investigation depicts a statistically significant correlation between grades of diabetic foot ulcer and HBA1C levels of the patients (p-value <0.001). Patients with higher levels of HBA1C suffered foot ulcer of higher grades.

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Specifically, patients with Grade 1 foot ulcers primarily had HBA1C levels of ≤11.00 with 6(50%) falling in the group "7.01-9.00" while patients with Grade 5 ulcers had higher HBA1C levels with bulk of patients having levels of >11.00. Summarized result is given in Table 2.

Foot ulcer (Wagner Grades)	HBA1C (%)						p-value
	<7.00	7.01-9.00	9.01-11.00	11.01-13.00	13.01-15.00	>15.01	
grade 1	3(25.0%)	6(50.0%)	3(25.0%)	0(0.0%)	0(0.0%)	0(0.0%)	<0.001
grade 2	12(36.4%)	19(57.6%)	2(6.1%)	0(0.0%)	0(0.0%)	0(0.0%)	
grade 3	0(0.0%)	18(30.5%)	25(42.4%)	16(27.1%)	0(0.0%)	0(0.0%)	
grade 4	0(0.0%)	15(9.6%)	40(25.5%)	90(57.3%)	9(5.7%)	3(1.9%)	
grade 5	0(0.0%)	15(15.2%)	6(6.1%)	35(35.4%)	25(25.3%)	18(18.2%)	

Table 2: Correlation of Grades of diabetic foot ulcer with HBAIC

Figure 2 further clarifies the relation between diabetic foot ulcer and HBA1C levels having patients with higher grader ulcers scattered along the higher HBA1C levels as compared to those of lower grades scattered at the lower HBA1C levels.

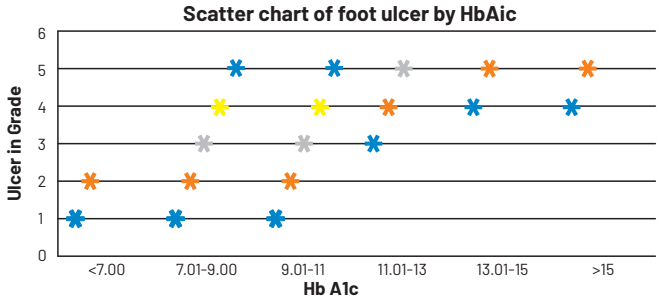

Figure 2: Scatter line graph correlating Diabetic foot ulcer with HBA1C

DISCUSSION

There have been numerous literatures linked to the effect of HBA1C on Diabetic foot ulcer. The scale, we employed for assessing the grade of diabetic foot ulcer was Wagner's classification [11]. The link between Wagner's classification and HBA1C, advancing age and duration of diabetes was studied by Shah *et al.*, in her study [12]. A similar cross-sectional study was carried out in Karachi, Shaheed Benazir Abad Hospital in Karachi in which a total of 88 patients were documented and the correlation between HBA1c and DFU was found statistically significant with a significant p-value (<0.001) which complements our findings with p-value (<0.001) [13]. National Glycohemoglobin Standardization Program (NGSP), which standardizes glycated hemoglobin test results so that values reported by clinical laboratories are comparable to those reported in the two largest clinical trials on the effects of intensive diabetes treatment, namely the Diabetes Control and Complications Trial (DCCT) and United Kingdom Prospective Diabetes Study (UKPDS) [14].

Similar results have been replicated in other studies as well like the one in Rajiv Gandhi Center for Diabetes and Endocrinology, in which diabetic patients who had a raised HBA1c (>6.5%) showed a high risk of development of diabetic foot ulcer along with correlation with variables like ulcer duration, hypertension, smoking and retinopathy [15]. our study has similar finding of progressive increase in severity of ulcers with progressive rise in A1c. Grade 4 and grade 5 ulcers were more common at higher A1c levels and no grade 1 or 2 ulcers and the opposite was true for lower A1c. Another research on the effects of HBA1C was conducted by Sarinnapakorn *et al.*, in which he found no significant correlation between prevalent Diabetic Foot Ulcer in relation to Fasting Blood Glucose and HBA1C but he also stated that a majority of these patients were in high-risk groups of diabetic foot ulcer contrary to our findings [16]. Christman *et al.*, in their work on HBA1C and Diabetic foot ulcers found that among many variables including cholesterol, BMI, BP, Pulse, Temperature, TGL and Peripheral Neuropathy. HbA1c was the only factor having a statistical impact on the wound healing rate of ulcers with a decrease of healing rate by 0.028 for every 1% increase in HBA1C (p=0.027) [17]. As our study was cross sectional, so in this study, we couldn't assess this but it seems to be the case if followed longitudinally. In a retrospective study by Wu *et al.*, involving 296 diabetic patients in a tertiary care hospital in which he underlined risk factors for diabetic foot and reinforced our speculations through establishing trends in risk factors associated in diabetic patients including diabetes duration, diabetes control along with other factors [18]. This emphasize our current study factor, diabetes control, too important in preventing diabetic foot ulcer formation. Our study establishes a clear link and supplements previous literature on the association of HBA1C with diabetic ulcers, thus efforts should be directed at primary and secondary protection of diabetic foot ulcers. Patients should be educated on a Diabetes friendly diet, foot care and regular checkups so any inevitable morbidity is caught in its tracks and the damage is minimized [19, 20].

CONCLUSIONS

Diabetes is a prevailing condition plaguing the public and it is becoming worse in modern times. Diabetic foot ulcer has become one of the most feared complications for both patients and physicians with impending consequences like osteomyelitis, sepsis and amputation of various body parts. This research showed that HBA1C and its control

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plays a vital role in limiting complications specially the severity and progression of a diabetic foot ulcer.

Conflicts of Interest

The authors declare no conflict of interest

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