International Surgery Journal
Sachor RK et al. Int Surg J. 2023 Sep;10(9):1461-1470
http://www.ijsurgery.com
pISSN 2349-3305 | eISSN 2349-2902

DOI: https://dx.doi.org/10.18203/2349-2902.isj20232637

Original Research Article

Correlation of glycated haemoglobin status with the foot ulcer

Rupali Kaur Sachar*, Hemashankar Rao, P. P. Sharma, M. P. Aggarwal, Sunita Yadav

Department of Surgery, Pacific Institute of Medical Sciences, Udaipur, Rajasthan, India

Received: 17 May 2023
Revised: 25 July 2023
Accepted: 02 August 2023

***Correspondence:**
Dr. Rupali Kaur Sachar,
E-mail: rupalijoy481@yahoo.co.in

ABSTRACT

Background: 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 were to determine the severity of diabetic foot ulcer at various level of HBA1C and determine the association.
Methods: A observational cross-sectional study with 160 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: The study included Sample size of 160 Patients. Here in the study mean age for group A was 41.2 years, for group B it was 29.6 years and for group C it was 25.8 years. Majority 40% patients in group A had T2DM. In group B we found that 51.7% patients had T2DM followed by 48.2% patients with T1DM. In group C we found that majority 67.01% patients had T2DM. We found that site of ulcer was improving with increasing duration of follow up. Initially we found 30% patients with infection at dorsum aspect of foot. After follow up day 9 we found improvement in ulcer infection
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. HbA1c has a linear relationship with the grades of Wagner classification of diabetic foot.

Key words: Glycated Hemoglobin, Foot ulcer, Diabetes

INTRODUCTION

Diabetes mellitus (DM) is considered to be a serious public health problem due to its high prevalence and related complications. Diabetic peripheral neuropathy (DPN) a disease often associated with neuropathic pain, foot ulceration and lower extremity amputation, which can significantly affect the quality of life of patients.[1,2] The most frequent type of neuropathy associated with diabetic foot complications is the distal symmetric sensorimotor polyneuropathy, and, along with peripheric vascular disease, it is a major contributing factor to the formation of foot ulcers. The control of the disease relies both on individual actions for self-care and on medical treatments and surveillance. A healthy, intact diabetic foot is indeed best maintained by a consistent and recurrent preventive treatment strategy accomplished through a multidisciplinary approach that encompasses instruction in Glucose assessment, insulin and other diabetes medication administration, Diet &Daily foot inspection and care; proper footwear and the necessity for prompt treatment of new lesions. Regarding medical surveillance, a common strategy to evaluate the effectiveness of DM treatment is the use of a biomarker. A biomarker is a "characteristic that is objectively measured and evaluated as an indicator

of normal biological processes, pathogenic processes or pharmacological responses to a therapeutic intervention".[3] Specifically, for the case of DM, the levels of glycated hemoglobin (HbA1c or hemoglobin A1c) are periodically measured, as glycemic variability has been recognized as the most important risk factor for DPN.

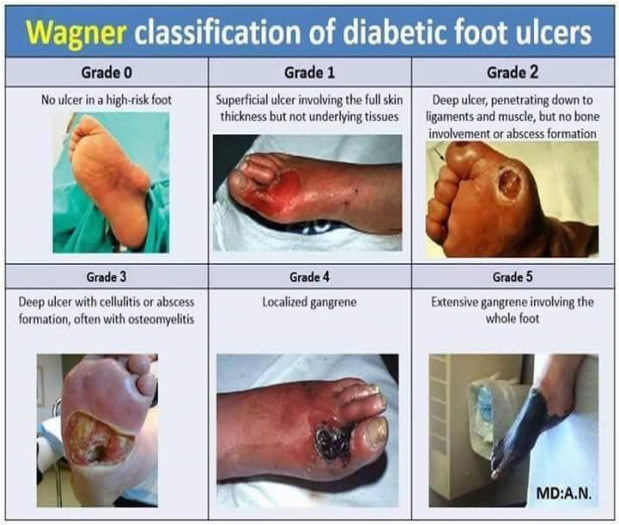

Figure 1: Wagnor classification of diabetic foot ulcers.[30]

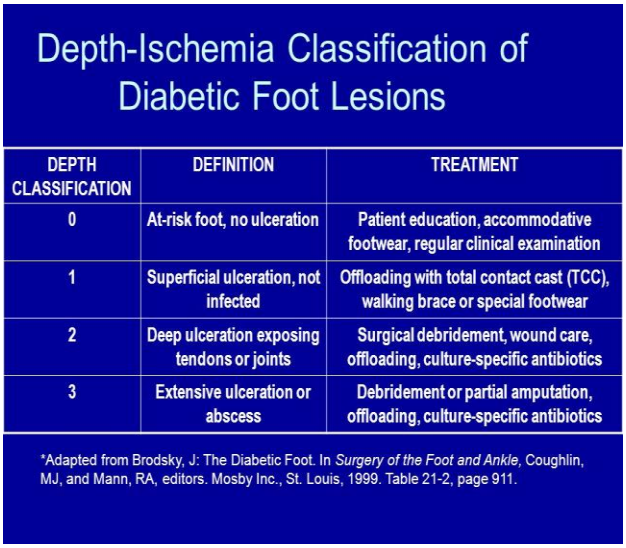

Figure 2: Depth-Ischemic classification.[31]

Commonly used classification systems are; Wagner-Meggitt Classification: Most commonly and widely used. In this system foot lesions are divided into different grades starting from grade 0 to grade 5. Grade 0 includes high risk foot but no active lesion and grade 5 includes gangrene of entire foot. Only grade 3 addresses the problem of infection. This system does not mention about ischemia or neuropathy and that is the drawback of this system (Figure 1). Depth-Ischemic classification: It is a modification of Wagner-Meggit system. The purpose of this classification system is to make the classification more accurate, rational, easier to distinguish between wound and vascularity of foot, to elucidate the difference among the grades 2 and 3, and to improve the correlation of treatment to the grade (Figure 2). University of Texas classification: University of Texas San Antonio System incorporates lesion depth and ischemia. It is actually a modification of Wagner System and is somewhat superior. In this system each grade of Wagner System is further divided into stages according to the presence of infection or ischemia or combination of both (Figure 3).

University of Texas Diabetic Wound Classification System

Stage	Grade			
	0	I	II	III
A (no infection or ischemia)	Pre- or post-ulcerative lesion completely epithelialized	Superficial wound not involving tendon, capsule, or bone	Wound penetrating to tendon or capsule	Wound penetrating to bone or joint
B	Infection	Infection	Infection	Infection
C	Ischemia	Ischemia	Ischemia	Ischemia
D	Infection and ischemia	Infection and ischemia	Infection and ischemia	Infection and ischemia

Figure 3: University of Texas classification.[33]

Management of diabetic foot ulcers

The gold standard for diabetic foot ulcer management includes prevention, patient and caregiver education, glycemic control, debridement of the wound, management of any infection, revascularization procedures when indicated, off-loading of the ulcer and reconstructive surgery if needed. Other methods or addon therapies may be beneficial, such as hyperbaric oxygen therapy, use of advanced wound care products, and negative pressure wound therapy (NPWT/VAC).

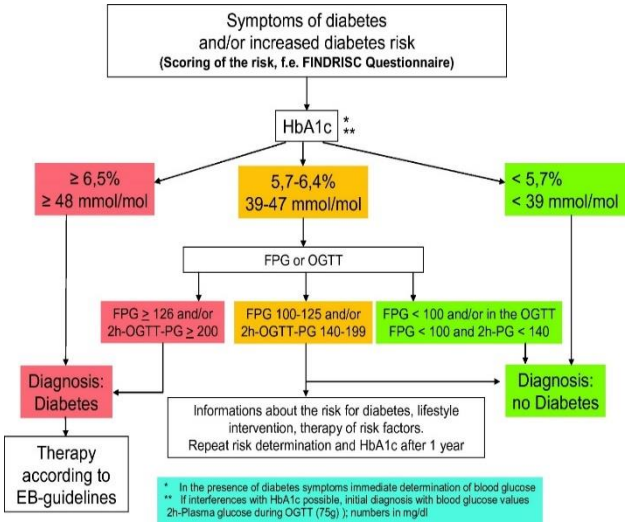

Figure 4: Glycated haemoglobin (hba1c) for the diagnosis of diabetes.[96]

Glycated haemoglobin (HbA1c) for the diagnosis of diabetes

HbA1c can be used as a diagnostic test for diabetes providing that stringent quality assurance tests are in place and assays are standardised to criteria aligned to the international reference values, and there are no conditions present which preclude its accurate measurement. An HbA1c of 6.5% is recommended as the cut point for diagnosing diabetes. A value of less than 6.5% does not exclude diabetes diagnosed using glucose tests.

Glycated haemoglobin (HbA1c) was initially identified as an "unusual" haemoglobin in patients with diabetes over 40 years ago. After that discovery, numerous small studies were conducted correlating it to glucose measurements resulting in the idea that HbA1c could be used as an objective measure of glycaemic control. The A1C-Derived Average Glucose (ADAG) study included 643 participants representing a range of A1C levels (Figure 4). It established a validated relationship between A1C and average glucose across a range of diabetes types and patient populations. HbA1c was introduced into clinical use in the 1980s and subsequently has become a cornerstone of clinical practice.[37] HbA1c reflects average plasma glucose over the previous eight to 12 weeks.[98] It can be performed at any time of the day and does not require any special preparation such as fasting. These properties have made it the preferred test for assessing glycaemic control in people with diabetes. More recently, there has been substantial interest in using it as a diagnostic test for diabetes and as a screening test for persons at high risk of diabetes.[39] Owing in large part to the inconvenience of measuring fasting plasma glucose levels or performing an OGTT, and day-to-day variability in glucose, an alternative to glucose measurements for the diagnosis of diabetes has long been sought. HbA1c has now been recommended by an International Committee and by the ADA as a means to diagnose diabetes.[39]

Although it gives equal or almost equal sensitivity and specificity to a fasting or post-load glucose measurement as a predictor of prevalent retinopathy, it is not available in many parts of the world. Also, many people identified as having diabetes based on HbA1c will not have diabetes by direct glucose measurementand vice versa. The relationship between HbA1c and prevalent retinopathy is similar to that of plasma glucose, whether glucose and HbA1c are plotted in deciles, in vigintiles or as continuous variables. This relationship was originally reported in the Pima Indians and has also been observed in several other populations including Egyptians, the NHANES study in the USA.[40,42,101]

In Japanese and more recently in the DETECT-2 analysis. Overall, the performance of HbA1c has been similar to that of fasting or 2-h plasma glucose. For all three measures of glycaemia, the value above which the prevalence of retinopathy begins to rise rapidly has differed to some extent between studies. However, HbA1c may be affected by a variety of genetic, haematologic and illness-related factors. The most common important factors worldwide affecting HbA1c levels are haemoglobinopathies (depending on the assay employed), certain anaemias, and disorders associated with accelerated red cell turnover such as malaria (16; 25).

Aim and objectives

Aim was to study the correlation between glycated haemoglobin and the foot ulcer. Objectives were to determine the Glycated Hb levels in patients with the foot ulcer and to study the changes in the foot ulcer in relation with glycated hemoglobin with time.

METHODS

The study was conducted on patients in OPD/IPD of department of surgery in Pacific institute of medical sciences from January 2021 to January 2023 for a period of 18 months on 160 patients

Sample size calculation

Sample size was calculated using the formula:

$$n = z2x\ pq/l2$$

Where n is sample size, p is prevalence, q is 1-p and l is confidence interval.

Inclusion criteria

The inclusion criteria were: association between HBA1c, DPN and diabetic foot complications, HBA1c levels between groups with and without DPN and diabeticfoot complications and age of the patient.

Exclusion criteria

Exclusion criteria were; juvenile diabetes, patients with inflammatory or infectious diseases, autoimmune and rheumatic diseases, cancer, hematological diseases and those who were under treatment with anti-inflammatory drugs, pregnant and lactating female were excluded. Patient with recent venous thromboembolism.

Procedure

All the patients having diabetes with foot ulceration in the department of surgery at PIMS Hospital were taken into the research study. This is the crossectional study. 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. All patients gave informed consent to take part in this study. Foot ulcer was defined as a full-thickness skin defect that required Then Clinical Examination was

done with focus on General, Regional and Local Examination of the ulcersite. The laboratory investigations include testing for random blood glucose for diabetic patients.

Differential diagnosis was established and patients were categorized into diabetic and non-diabetic patients. Study design was observational cross sectional study and study variables includes age, gender, HbA1c, CBC, serum glucose, electrolytes. Urea and creatinine level, gram stain, culture and sensitivity, type of ulcer, length of hospital stay and mortality.Clinical assessment for signs of infection (swelling, exudates, surrounding cellulitis, odour, tissuenecrosis, crepitation, pyrexia).

Ulcer size was determined by multiplying longest and widest diameters and expressed in centimetres square. Wound was graded and staged at time of hospitalization according to University of Texas Wound classification system as grade 1 (superficial wound not involving tendon, capsule or bone), grade 2 (wound penetrating to tendon or capsule) and grade 3 (wound penetrating bone or joint).three groups of patients were made: Group A with HBA1c upto 6, Group B with HbA1c upto 7, Group C with HBA1c more than 7. Diabetic peripheral neuropathy was seen for the symptoms whether it is sensory motor or autonomous.

General examination

General examination includes assessing the general condition of the patient which includes general appearance of the patient, lymph nodes, checking vital signs such as pulse, blood pressure, respiration rate. Systemic examination includes examining cardio-vascular system, respiratory system, digestive system, excretory system and nervous system.

Local examination

Examination of abdomen was done to rule out any lump, any free fluid or organomegaly. Co Morbidity was looked for Diabetes Mellitus which can be controlled or uncontrolled, nephrotic syndrome, transplanted patient, obesity on immune suppression and on corticosteroid. Local examination of the ulcer: Wound colour, Type of ulcer, Local edema, Discharge colour, Discharge amount, Smell and Content.

RESULTS

It was observed that mean age for group A was 41.2 years, for group B it was 29.6 years and for group C it was 25.8 years.

Table 1: Distribution of patients according to age.

Age (years)	Group A (HbA1C <7)		Group B (HbA1C (7-8)		Group C (HbA1C >8)	
	N	%	N	%	N	%
25-40	2	40.00	18	31.03	17	17.53
41-55	3	60.00	22	37.93	29	29.90
>55	0	0.00	18	31.03	51	52.58
Total	5	100.00	58	100.00	97	100.00
Mean±SD	41.2±12.04		29.6±0.5		25.8±1.09	
P value	<0.0001					

Table 2: Distribution of patients according to BMI.

BMI	Group A (HbA1C <7)		Group B (HbA1C (7-8)		Group C (HbA1C >8)	
	N	%	N	%	N	%
Overweight	5	100.00	9	15.52	19	19.59
Obese	0	0.00	24	41.38	31	31.96
Normal	0	0.00	25	43.10	47	48.45
Total	5	100.00	58	100.00	97	100.00
P value	0.13					

Table 3: Distribution of patients according to smoking.

Smoking	Group A (HbA1C <7)		Group B (HbA1C (7-8)		Group C (HbA1C >8)	
	N	%	N	%	N	%
Current	3	60.00	17	29.31	20	20.62
Former	2	40.00	22	37.93	42	43.30
Never	0	0.00	19	32.76	35	36.08
Total	5	100.00	58	100.00	97	100.00
P value	0.3					

Table 4: Distribution of patients according to duration of diabetes mellitus.

Parameter	Group A (HbA1C <7)		Group B (HbA1C (7-8)		Group C (HbA1C >8)	
	Mean	SD	Mean	SD	Mean	SD
Duration of diabetes mellitus	15	0	14.2	5.4	15.04	4.8
P value	0.04					

Table 5: Distribution of patients according to grades.

Grades	Group A (HbA1C <7)		Group B (HbA1C (7-8)		Group C (HbA1C >8)	
	N	%	N	%	N	%
One	0	0.00	3	5.17	3	3.09
Two	0	0.00	6	10.34	8	8.25
Three	0	0.00	14	24.14	34	35.05
Four	5	100.00	22	37.93	26	26.80
Five	0	0.00	13	22.41	26	26.80
Total	5	100.00	58	100.00	97	100.00
P value	0.47					

Table 6: Distribution of patients according to neuropathy.

Neuropathy	Group A (HbA1C <7)		Group B (HbA1C (7-8)		Group C (HbA1C >8)	
	N	%	N	%	N	%
Motor neuropathy	5	100.00	11	18.97	31	31.96
No neuropathy	0	0.00	16	27.59	21	21.65
Sensory neuropathy	0	0.00	31	53.45	45	46.39
Total	5	100.00	58	100.00	97	100.00
P value	0.2					

Table 7: Distribution of patients according to vasculopathy.

Vasculopathy	Group A (HbA1C <7)		Group B (HbA1C (7-8)		Group C (HbA1C >8)	
	N	%	N	%	N	%
Ant tibial art vasculopathy	0	0.00	15	25.86	21	21.65
Post tibial art vasculopathy	2	40.00	35	60.34	49	50.52
No vasculopathy	3	60.00	8	13.79	27	27.84
Total	5	100.00	58	100.00	97	100.00
P value	0.05					

Table 8: Distribution of patients according to chronic kidney disease.

Chronic kidney disease	Group A (HbA1C <7)		Group B (HbA1C (7-8)		Group C (HbA1C >8)	
	N	%	N	%	N	%
Yes	3	60.00	36	62.07	52	53.61
No	2	40.00	22	37.93	45	46.39
Total	5	100.00	58	100.00	97	100.00
P value	0.04					

Table 9: Distribution of patients according to wound infection.

Wound infection	Group A (HbA1C <7)		Group B (HbA1C (7-8)		Group C (HbA1C >8)	
	N	%	N	%	N	%
Mild	3	60.00	12	20.69	21	21.65
Moderate	2	40.00	27	46.55	63	64.95
Severe	0	0.00	19	32.76	13	13.40
Total	5	100.00	58	100.00	97	100.00
P value	0.04					

Table 10: Distribution of patients according to presence of gangrene.

Presence of gangrene	Group A (HbA1C <7)		Group B (HbA1C (7-8)		Group C (HbA1C >8)	
	N	%	N	%	N	%
Yes	5	100.00	34	58.62	56	57.73
No	0	0.00	24	41.38	41	42.27
Total	5	100.00	58	100.00	97	100.00
P value	0.61					

There was significant difference found between these groups as p value was <0.05. It was observed that all the patients in group A were overweight. In group B majority 43.1% patients normal followed by 41.38% obese patients and 15.5% overweight patient. In group C we found that majority 48.4% patients were normal followed by 31.96% obese patients.

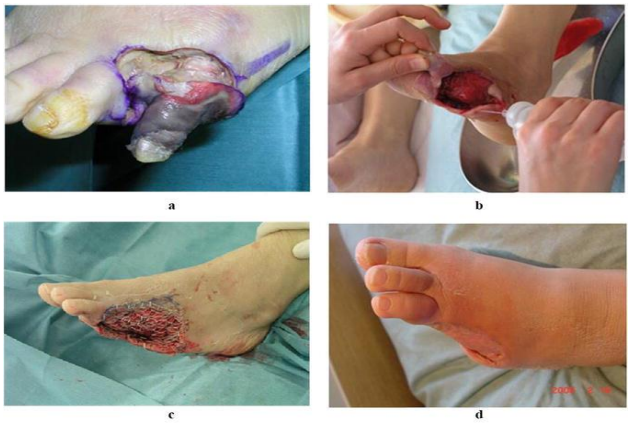

Figure 5: A view of diabetic foot gangrene with a) osteomyelitis of the fifth toe, b) After fourth and fifth toe amputation, cleansing was performed for 2 weeks, c) Intraoperative view showing free skin grafting on the wound, d) A view of the foot 1 month after surgery showing favorable coverage of the wound.

It was observed that in group A majority 60% patients were current smoker followed by 40% former smoker patients. In group B we found that majority 37.93% patients were former smoker followed by 29.3% patients with current smoker. In group C we found that majority 43.3% were former smoker. It was observed that mean duration of diabetes mellitus for group A, group B and group C was 15 years, 14.2 years and 15.04years. There was significant difference found between these group as p value was <0.05. It was observed that majority 100% patients in group A were of grade 4. In group B we found that majority 37.9% patients were of grade 4 followed by 24.14% patients with grade 3. In group C we found that majority 35.05% patients were of grade 3 followed by 26.8% of grade 4 and 5 each. It was observed that majority 100% patients in group A were of motor neuropathy. In group B we found that 53.4% patients were of sensory neuropathy followed by 18.97% patients with motor neuropathy. In group C we found that majority 46.3% patients had sensory neuropathy followed by 31.96% patients with motor neuropathy.

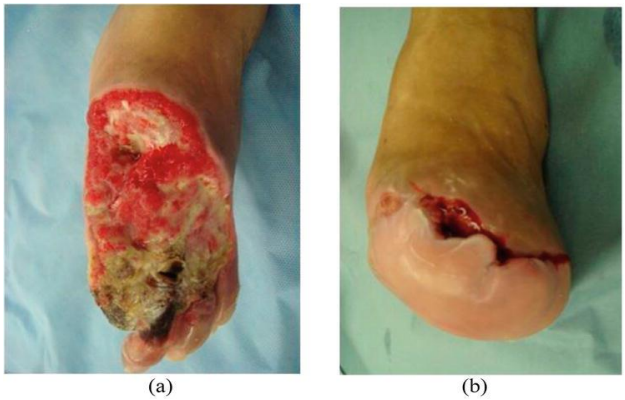

Figure 6: A view of diabetic gangrene extending the first and second metatarsal bones, a) After removal of the necrotic bone, the navicular was exposed, b) Intraoperative view of Chopart amputation followed by resurfacing with a local flap of the sole.

It was observed that majority 60% patients in group A had no vasculopathy followed by 40% patients with post tibial art vasculopathy. In group B we found that 60.3% patients had post tibial art vasculopathy followed by 25.8% patients with ant tibial art vasculopathy. In group C we found that majority 50.5% patients had post tibial art vasculopathy. It was observed that 60% patients in group A, 62.07% patients in group B and 53.6% patients in group C had chronic kidney disease.

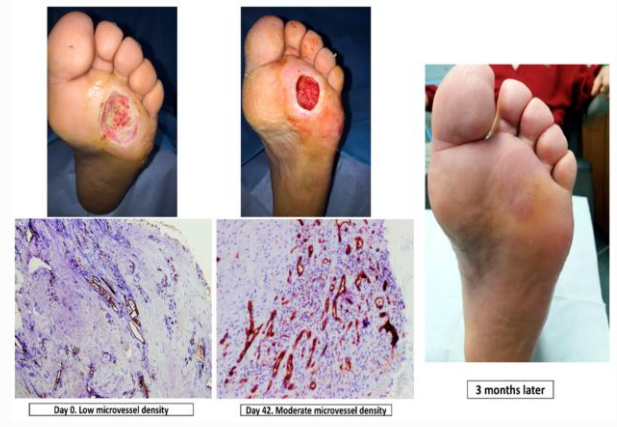

Figure 7: Group B showing good glycaemic control with healing of ulcer.

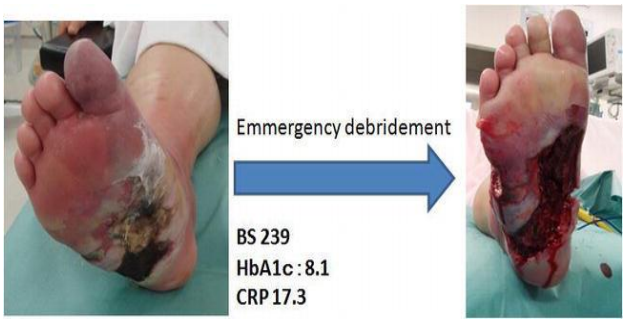

Figure 8: Group C with poor glycaemic control and host immune status for which radical debridement was done.

There was significant difference found between these group as p value was <0.05. It was observed that in group A 40% patients had moderate type wound infection followed by 60% mild infection. In group B we found that majority 46.5% patients in group B had moderate infection followed by 32.7% patients had severe infection. In group C we found that majority 64.9% patients were of moderate infection followed by 21.6% patients of mild infection. There was significant difference found between these group as p value was <0.05. It was observed that majority 100% patients in group A had gangrene. In group B we found that 58.6% patients had gangrene. In group C we had seen gangrene in 57.7% patients (Figure 5-6).

DISCUSSION

Diabetes has become one of the greatest global health problems of this century, and the burden of the disease is projected to double between 2000 and 2030.[19] Diabetic foot ulcers affect 1 out of seven people with diabetes. Additionally, dysfunction of the peripheral nerves is often associated with peripheral arterial disease and can lead to inadequate blood supply to the extremities, a condition known as diabetic angiopathy, leading to diabetic foot. Yes, it is possible to have neuropathy, nerve ischemia, or ischemia in just the foot of a diabetic (Figure 7).[28]

Diabetic foot syndrome includes multiple diabetic foot lesions such as infections, neuropathic osteoarthritis, and diabetic foot ulcers. Diabetic foot, which accounts for about 15% of these and is projected to grow up to 25%, is the most dangerous condition that can lead to amputation (Figure 8).[12] HbA1c has received particular attention from researchers and has been extensively studied in association with diabetic foot ulcers, gangrene, and limb amputation. HbA1c reflects glycemic control over the past 2-3 months, and its role in diabetes management is well established.[121] In the advance study, setting HbA1c to 6.5 was associated with macrovascular and microvascular complications. It has seen a dramatic reduction in symptoms. Although previous studies have suggested that lower baseline HbA1c level correlates with advanced wound healing, most studies noted that baseline HbA1c level was not associated with lower extremity wound healing in patients with diabetes.[19] When baseline HbA1c was divided into < 6.5%, 6.5-8.0%, > 8.0%, as described by Fesseha et al initial blood glucose level displayed no relationship with wound healing, based on the analysis using different adjusted models.[9] A similar outcome was obtained in our investigation. By baseline HbA1c data analysis, not grouped, another study showed that HbA1c at study inclusion did not predict the risk of delayed healing among a pooled analysis of 586 subjects with neuropathic DFU.[20]

DFU was characterized by poor healing outcome and hyperglycemia was identified as the culprit of impaired wound healing. Pre-existing diabetic angiopathy and neuropathy resulting from previous exposure to hyperglycemia have been recognized as the major causes of delayed wound healing. Besides, current exposure to hyperglycemia is also linked to impaired wound healing processes. Plenty of evidence showed that hyperglycemia-related advanced glycation end-products play a crucial role in disturbing the normal wound healing process, with underlying mechanisms like raised oxidative stress, altered cellular proliferation and apoptosis, and altered interaction between cell and extracellular matrix.[5,21] The existence of foot ulcers attracts more attention to hyperglycemia. However, ideal blood glucose targets could not be easily achieved, considering many uncontrolled factors like infection, other concomitant diseases, etc. These may be found in the baseline characteristics of study patients in our study or the studies referred to above. After work by multidisciplinary team, modifiable factors like infection and organ dysfunctions were managed. Blood glucose should be controlled at a reasonable level, not only for the wound healing but also for the whole body.

Only a few studies focused on the benefit of blood glucose control to wound healing during the DFU treatment. Research by Fesseha et al showed that increase of HbA1c during the treatment compared to admission was associated with a hazard ratio (HR) of nearly 2 for wound healing in DFU patients with baseline HbA1c < 7.5%, while no associated benefit was observed for DFU patients with baseline HbA1c over 7.5%. For the purpose of wound healing, this demands that blood glucose be controlled at higher levels if the initial HbA1c value is less than 7.5%. In our study, HbA1c controlled within 7.0-8.0% during DFU treatment is beneficial for wound healing; this advantage was even more evident in DFU patients with baseline HbA1c less than 8.0%.

Additionally, in contrast to those with HbA1c controlled at less than 7%, the wound healing rate was almost the same or slightly better in DFU patients with HbA1c higher than 8.0% during DFU treatment. Tight blood glucose control characterized by lower HbA1c level often leads to more frequent episodes of hypoglycemia as some large clinical trials demonstrated.[22-28] For elderly diabetic patients with long diabetes duration, such as patients with DFU, fluctuation of blood glucose is relatively more prevalent.[24] In general, mortality rate increases as the glycemic level

elevates for patients with diabetes. However, the mortality pattern was different in various disease statuses of diabetes.

For older patients with diabetes, mortality risk was significantly higher in those with an HbA1c > 8.0% compared with those with an HbA1c < 6.5%.[24] For patients with diabetes and chronic kidney disease, a U-shaped relationship between HbA1c and mortality was observed; HbA1c < 6.0% and ≥ 9.0% were associated with higher risk of death.[26,29-33] Patients suffering from DFU, which is believed to be the advanced stage of diabetes, are clearly different from ordinary diabetic patients. The association between HbA1c and mortality may be unique in patients with DFU. There was still no relevant study focused on the association of blood glucose level and mortality in the population with DFU. According to our results of 1-year follow-up, mortality was not associate significantly with glycemic control level.[34-40]

CONCLUSION

The high-risk diabetic patients for diabetic foot are those with older age, male gender, longer duration of DM, raised HbA1c, and pre-existing foot abnormalities. Since HbA1c is linearly related to the Wagner grade of diabetic foot, HbA1c can be used as a screening tool to predict its occurrence in the above diabetic patients at high risk of diabetic foot. This is important to prevent diabetic foot and its associated complications such as amputation, infection, disability and death through enhanced HbA1c control and awareness of proper foot care, as tight glycemic control reduces neuropathy and vascular complications of diabetes. Helps to reduce the incidence of disease. However, more large-scale studies are needed to find the true relationship between HbA1c and Wagner classification.

Limitations

Several limitations of our study should not be neglected. First, this is a single-center observational study; all participants were enrolled from one hospital, leading to inevitable selection bias. Second, subjects enrolled in this study were hospitalized patients with relatively worse conditions. Clinical patients with minor wounds and better general conditions were not included; thus, the results cannot be extended to the general population with diabetic foot ulcers. Third, the follow-up period was not long enough, so that it is impossible to observe more long-term outcomes. In spite of these shortcomings, our study still reflects the relationship of glycemic control and outcomes in such a specific population with severe DFU and poor general condition. Therefore, the importance of this study should not be negated.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

REFERENCES

1. Hussain A, Ali I, Ijaz M. Correlation between hemoglobin A1c and serum lipid profile in Afghani patients with type 2 diabetes: hemoglobin A1c prognosticates dyslipidemia. Ther Adv Endocrinol Metab. 2017;8:51-7.
2. Diabetes Available at: http://www.diabetesatlas. org/. Accessed on 8 August 2019.
3. Anjana RM, Pradeepa R, Deepa M, Datta M, Sudha V. India diabetes study: methodological details. J Diabetes Sci Technol. 2011;5(4):906-14.
4. Reiber GE. Epidemiology of foot ulcers and amputations in the diabetic foot. In: Bowker JH, Pfeifer MA (eds). St. Louis: Mosby; 13-32.
5. Laing P. The development and complications of diabetic foot ulcers. Am J Surg. 1998;176(2):11-19.
6. Dyck PJ, Kratz KM, Karnes JL, Litchy WJ, Klein R, Pach JM, Wilson DM, O'Brien PC, Melton LJ 3rd, Service FJ. The prevalence by staged severity of various types of diabetic neuropathy, retinopathy, and nephropathy in a population-based cohort: the Rochester Diabetic Neuropathy Study. Neurology. 1993;43(4):817-24.
7. Callaghan BC, Cheng HT, Stables CL, Smith AL, Feldman EL. Diabetic neuropathy: clinical manifestations and current treatments. Lancet Neurol. 2012;11(6):521-34.
8. Biomarkers Definitions Working Group. Biomarkers and surrogate endpoints: Preferred definitions and conceptual framework. Clin Pharmacol Ther. 2001;69: 89-95.
9. Boulton AJ. Management of Diabetic Peripheral Neuropathy. Clin Diab. 2005;23:9-15.
10. Oyibo SO, Prasad YD, Jackson NJ, Jude EB, Boulton AJ. The relationship between blood glucose excursions and painful diabetic peripheral neuropathy: a pilot study. Diabet Med. 2002;19(10):870-3.
11. Katoulis EC, Ebdon-Parry M, Lanshammar H, Vileikyte L, Kulkarni J, Boulton AJ. Gait abnormalities in diabetic neuropathy. Diabetes Care. 1997;20(12):1904-7.
12. Boulton AJM, Kirsner RS, Vileikyte L. Neuropathic Diabetic Foot Ulcers. N Engl J Med. 2004;351:48-55.
13. Abbott CA, Carrington AL, Ashe H, Bath S, Every LC, Griffiths J, et al. The North-West Diabetes Foot Care Study: incidence of, and risk factors for, new diabetic foot ulceration in a community-based patient cohort. Diabet Med. 2002;19(5):377-84.
14. Moghtaderi A, Bakhshipour A, Rashidi H. Validation of Michigan neuropathy screening instrument for diabetic peripheral neuropathy. Clin Neurol Neurosurg. 2006;108(5):477-81.
15. Shahzad M, Al Robaee A, Al Shobaili HA, Alzolibani AA, Al Marshood AA, Al Moteri B. Skin manifestations in diabetic patients attending a diabetic clinic in the Qassim region, Saudi Arabia. Med Princ Pract. 2011;20(2):137-41.
16. Carrington AL, Shaw JE, Van SCH. Can Motor Nerve Conduction Velocity Predict Foot Problems in

Diabetic Subjects Over a 6-Year Outcome Period?. Diabetes Care. 2002;25:2010-5.
17. Xu F, Zhao LH, Su JB, Chen T, Wang XQ, Chen JF, Wu G, Jin Y, Wang XH. The relationship between glycemic variability and diabetic peripheral neuropathy in type 2 diabetes with well-controlled HbA1c. Diabetol Metab Syndr. 2014;6(1):139.
18. Kiernan MC, Bostock H. Effects of membrane polarization and ischaemia on the excitability properties of human motor axons. Brain. 2000; 123(12):2542-51.
19. American Diabetes Association. Standards of Medical Care in Diabetes 2017 Abridged for Primary Care Providers. Clin Diab. 2016;35:5-26.
20. Saudek CD, Herman WH, Sacks DB, Bergenstal RM, Edelman D, et al. A new look at screening and diagnosing diabetes mellitus. J Clin Endocrinol Metab. 2008;93:2447-53.
21. Boulton AJM. The global burden of diabetic. Lancet. 2005;366:1719-24.
22. Li X, Xiao T, Wang Y, Gu H, Liu Z, Jiang Y, Liu Y, Lu Z, Yang X, Lan Y, Xu Z. Incidence, risk factors for amputation among patients with diabetic foot ulcer in a Chinese tertiary hospital. Diabetes Res Clin Pract. 2011;93(1):26-30.
23. Stettler C, Allemann S, Juni P. Glycemic control and macrovascular disease in types 1 and 2 diabetes mellitus: meta-analysis of randomized trials. Am Heart J. 2006;152:27-38.
24. Levin ME. Preventing amputation in the patient with diabetes. Diabetes Care. 1995;18:1383-94.
25. Apelqvist J, Larsson J, Agardh CD. The influence of external precipitating factors and peripheral neuropathy on the development and outcome of diabetic foot ulcers. J Diabet Complicat. 2009;4:21-5.
26. Aamir AH, Nasir A, Jadoon MZ, Mehmood K, Ali SS. Diabetic foot infections and their management in a tertiary care hospital. J Ayub Med Coll Abottabad. 2011;23:58-62.
27. Hasan F, Rana HN, Ali M, Tahir M, Saleem R. Diabetic foot - assessment and management of 100 cases. Pak J Med Health Sci. 2011;5:677-81.
28. Ashraf MN, Rehman K, Malik KI, Iqbal GS. Epidemiology and outcome in patients of diabetic foot. J Ayub Med Coll Abottabad. 2011;23:122-4.
29. Falanga V. Wound healing and its impairment in the diabetic foot. Lancet. 2005;366(9498):1736-43.
30. Fesseha BK, Abularrage CJ, Hines KF. Association of hemoglobin A1c and wound healing in diabetic foot ulcers. Diab Care. 2018;41(7):1478-85.
31. Vinod R, Gyawali P, Raut PP, Regmi P, Singh KP, Pandeya DR, et al. Association between glycaemic control and serum lipid profile in type 2 diabetic patients: Glycated haemoglobin as a dual biomarker. Biomedical Res. 2011;22(3):32-9.
32. Mostafa S, Coleman R, Agbaje O, Gray A, Holman R, Bethel M. Modelling incremental benefits on complications rates when targeting lower HbA1c levels in people with Type 2 diabetes and cardiovascular disease. Diab Med. 2018;35(1):72-7.
33. Christman AL, Selvin E, Margolis DJ, Lazarus GS, Garza LA. Hemoglobin A1c predicts healing rate in diabetic wounds. J Invest Dermatol. 2011;131(10): 2121-7.
34. Ahmed AA. Epidemiology of diabetes mellitus and diabetic foot problems in Saudi Arabia. Avan Diab. 2010;29:29-35.
35. Jeffcoate WJ, Harding KG. Diabetic foot ulcers. Lancet. 2003;361:1545-51.
36. Monteiro-Soares M, Ribas R, Pereira da Silva C, Bral T, Mota A, Pinheiro Torres S, et al. Diabetic foot ulcer development risk classifications' validation: A multicentre prospective cohort study. Diab Res Clin Pract. 2017;127:105-14.
37. Joshi SR, Parikh RM. India-diabetes capital of the world: now heading towards hypertension. J Assoc Physicians India. 2007;55:323-4.
38. Wild S, Roglic G, Green A, Sicree R, King H. Global prevalence of diabetes-estimates for the year 2000 and projections for 2030. Diab Care. 2004;27(3):1047-53.
39. Whiting Dr, Guariguata L, Weil C, Shawj. IDF Diabetes atlas: Global estimates of the prevalence of diabetes for 2011 and 2030. Diab Res Clin Pract. 2011;94:311-21.
40. Anjana RM, Ali MK, Pradeepa R, Deepa M, Datta M, Unnikrishnan R, Rema M, Mohan V. The need for obtaining accurate nationwide estimates of diabetes prevalence in India - rationale for a national study on diabetes. Indian J Med Res. 2011;133:369-80.
41. Zargar AH, Khan AK, Masoodi SR, Laway BA, Wani AI, Bashir MI, Dar FA. Prevalence of type 2 diabetes mellitus and impaired glucose tolerance in the Kashmir Valley of the Indian subcontinent. Diab Res Clin Pract. 2000;47(2):135-46.
42. Ramachandran A, Snehalatha C, Kapur A, Vijay V, Mohan V, Das AK, Rao PV, Yajnik CS, Prasanna Kumar KM, Nair JD; Diabetes Epidemiology Study Group in India (DESI). High prevalence of diabetes and impaired glucose tolerance in India: National Urban Diabetes Survey. Diabetologia. 2001;44(9): 1094-101.
43. Diabetes Foot Ulcer. Available at: https://els-jbs-prod-cdn.jbs.cms/attachment/9b1b5ad3-cc86-4eea-bca4-c224fd53daa7/gr6_lrg.jpg. Accessed on 20 February 2022.
44. Bramley D, Hebert P, Jackson R, Chassin M. Indigenous disparities in disease-specific mortality, a cross-country comparison: New Zealand, Australia, Canada, and the United States. Nz Med J. 2004; 117(1207):U1215.
45. Khalil H, George J. Diabetes management in Australian rural aged care facilities: A cross-sectional audit. Australas Med J. 2012;5(11):575-80.
46. Rao CR, Kamath VG, Shetty A, Kamath A. A crosssectional analysis of obesity among a rural population in coastal southern Karnataka, India. Australas Med J. 2011;4(1):53-7.
47. Misra A, Khurana L. Obesity-related non-communicable diseases: South Asians vs White Caucasians. Int J Obes. 2011;35(2):167-87.

48. Mohan V, Shah S, Saboo B. Current glycemic status and diabetes related complications among type 2 diabetes patients in India: data from the A1chieve study. JAPI. 2013;61:12-15.
49. Rema M, Premkumar S, Anitha B, Deepa R, Pradeepa R, Mohan V. Prevalence of diabetic retinopathy in urban India: The Chennai urban rural Epidemiology Study (CurES) Eye Study. Invest Ophthalmol Vis Sci. 2005;46:2328-33.
50. Iyer SN, Drake AJ, West RL, Tanenberg RJ. Diabetic muscle infarction: a rare complication of long-standing and poorly controlled diabetes mellitus. Case Rep Med. 2011;2011:407921.

Cite this article as: Sachar RK, Rao H, Sharma PP, Aggarwal MP, Yadav S. Correlation of glycated haemoglobin status with the foot ulcer. Int Surg J 2023;10:1461-70.