

A Clinical Study to Determine the Relation Between Hemoglobin A1c and Wound Healing in Diabetic Foot Wounds

Madhumitha V¹, N. Jeeva², P. Babu³, P. Kannan⁴, J. Karthick⁴

¹Post graduate, Department of General Surgery, Government Mohan Kumaramangalam Medical College Hospital, Salem, Tamilnadu, India

²Professor, Department of General Surgery, Government Mohan Kumaramangalam Medical College Hospital, Salem, Tamilnadu, India

³Assistant Professor, Department of General Surgery, Government Medical College and Hospital, Krishnagiri, Tamilnadu, India

⁴Assistant Professor, Department of General Surgery, Government Mohan Kumaramangalam Medical College Hospital, Salem, Tamilnadu, India

Abstract

Background: To test the hypothesis regarding the relation between HbA1c and diabetic foot wound healing, we conducted a prospective study of 200 diabetic foot ulcer patients treated at the Department of General Surgery, GMKMCH, Salem. **Material and Methods:** A prospective observational study analyzing clinical parameters, HbA1c levels, Wagner's grading, and surgical outcomes among 200 patients. **Results:** 72% were males and 28% females with ulcer duration >1 month. Neuropathic ulcers comprised 90% of cases, and amputation was performed in 41.5%. HbA1c > 6.5% was significantly associated with higher Wagner grades, BMI, retinopathy, nephropathy, hypertension, neuropathy, and smoking ($p < 0.01$). **Conclusion:** HbA1c demonstrates a strong linear relationship with Wagner's classification grades and predicts wound healing outcomes.

Keywords: Diabetic Foot Ulcer, Hemoglobin A1c, Wagner Grading, Wound Healing, Neuropathy, Amputation.

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INTRODUCTION

Diabetes mellitus is one of the important chronic metabolic diseases, which can impact a substantial number of population all around the globe. Indian government says it can be called a 'disease of complications' and an 'iceberg disease', as it hosts a huge burden with more than 33 million diabetic population with 8% prevalence in urban areas. Almost 1 in 5 hospitalizations for diabetics is for a foot condition.

Diabetes is expected to be greatly ramped-up worldwide with population ageing, urbanization, elevated obesity, and a lack of physical activity. Peripheral neuropathy and ischemia are the two most important factors in the development of DFUs. Neuropathy causes sensory loss, weak intrinsic muscle function and joint deformities that result in abnormal loading of the joints. These are further compromised by macrovascular and microvascular disease, which results in ischaemia.

Excessive hyperglycemia inhibits host defence mechanisms, affects neutrophil function and extracellular matrix remodeling. Hemoglobin A1c (HbA1c) is an indicator of blood sugar levels for the last 2-3 months. HbA1c testing along with other clinical factors offers valuable information for wound healing progression and surgical risk stratification for the DFU patient.

Aims and Objectives

The relationship between HbA1c and severity of DFI according to Wagner's classification was assessed.

To assess the effect of glycemic control on the time to healing and surgery results (e.g., amputation rates).

To study the relationship of diabetic microvascular and macrovascular complications to HbA1c.

MATERIALS AND METHODS

This clinical study was a prospective observational study which was carried out for the period of clinical study in the Department of General Surgery, Government Mohan Kumaramangalam Medical College and Hospital in Salem. There were 200 patients with DFI enrolled.

Inclusion Criteria

1. All diabetes patients with age > 18 years, presenting with DFUs.
2. Informed consent of patients with Type 1 or Type 2 diabetes mellitus.

Address for correspondence: Dr. Madhumitha.V,
Post graduate, Department of General Surgery, Government Mohan
Kumaramangalam Medical College Hospital, Salem, Tamilnadu, India.
E-mail: madhumithavelujo.mm@gmail.com

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Exclusion Criteria:

1. Non-diabetic ulcers (such as purely venous, post-traumatic or arterial ulcers in non-diabetics).
2. In patients with active malignant neoplasms, autoimmune diseases or immunosuppressive therapy.
3. Pregnant health care workers or those breastfeeding.

Methodology: Extensive clinical histories and examinations were conducted. Blood investigations performed in the laboratory were Fasting Blood Sugar (FBS), Postprandial Blood Sugar (PPBS) and HbA1c. The ulcers were classified using Wagner's classification system (Grades 0 to 5). The neuropathy was assessed by measuring with 10g Semmes-Weinstein monofilament, whereas the peripheral arterial disease (PAD) was screened by Ankle-Brachial Index (ABI).

RESULTS

A total of 200 patients were evaluated. The demographic, clinical, and biochemical parameters were summarized and analyzed statistically.



Figure 1: a view of diabetic gangrene of second to fourth toe with poor glycemic control



Figure 2: grade 4 wagners grading with good glycemic control.

Table 1: Demographic and Clinical Profile

Parameter	Category / Group	Percentage / Value
Age Distribution	31 - 40 yrs	7.5%
	41 - 50 yrs	15.0%
	51 - 60 yrs	33.5%
	61 - 70 yrs	39.0%
	71 - 80 yrs	5.0%
Gender	Male	72.0% (n=144)
	Female	28.0% (n=56)
Duration of DM	< 5 years	24.5%
	5 - 10 years	33.0%
	> 10 years	42.5%
Smoking	Yes	52.0%
	No	48.0%
BMI Category	< 18.5 (Underweight)	8.5%
	18.5 - 24.9 (Normal)	44.5%
	25.0 - 29.9 (Overweight)	27.0%
	≥ 30.0 (Obese)	20.0%

Table 2: Comorbidities, Complications, and Ulcer Characteristics

Parameter	Variable / Category	Prevalence (%)
Comorbidities	Hypertension / CAD	46.0%
	Hyperlipidemia	35.0%
	None	19.0%
Diabetic Complications	Neuropathy	90.5%
	Nephropathy	27.0%
	Retinopathy	38.0%
	Peripheral Vascular Disease	20.0%
Ulcer Size	< 4 cm	28.0%
	≥ 4 cm	72.0%
Infection / Surgical Outcome	Deep Ulcer	38.5%
	Ulcer with Abscess	20.0%
	Amputation Required	41.5%

Table 3: Cross-tabulation of HbA1c Levels vs. Wagner's Ulcer Grade

Wagner Grade	HbA1c 7 - 9%	HbA1c 9 - 11%	HbA1c ≥ 11%	Total Count
Grade 1	31.0%	20.0%	5.0%	31
Grade 2	23.5%	18.0%	8.0%	47
Grade 3	35.0%	17.0%	12.0%	64
Grade 4 & 5	10.5%	45.0%	75.0%	58
Chi-Square Test	Chi-square = 160.849, df = 6, p < 0.001 (Highly Significant)			200

Table 4: Descriptive Laboratory Statistics

Parameter	Minimum	Maximum	Mean $\pm$ SD
Fasting Blood Sugar (FBS)	70.5 mg/dL	336.9 mg/dL	182.4 $\pm$ 45.2 mg/dL
Postprandial Blood Sugar (PPBS)	120.0 mg/dL	512.0 mg/dL	238.1 $\pm$ 62.8 mg/dL
HbA1c (%)	6.2%	14.8%	9.85 $\pm$ 2.2%
Duration of Healing (Days)	14 days	120 days	42.5 $\pm$ 18.3 days



Figure 3: shows below knee amputation with good glycemic control

DISCUSSION

DFUs are a significant clinical problem. HbA1c is an important biomarker for predicting the progression of wound healing and the risk of amputation. Our study of 200 patients showed an increase in male patients (72%) which is similar to the results of the literature study by Delbridge et al and Vijay et al who also revealed that male diabetic patients were more susceptible to develop diabetic foot complications.^[1-3] There was a significant association between high HbA1c ($> 8.5\%$) and high Wagner grade (Chi-square = 160.849, $p < 0.001$), with a large percentage of the patients presenting with both high HbA1c and high Wagner. Extended hyperglycemia elevates levels of Advanced Glycation End-products (AGEs) which leads to collagen cross linking, thickening of the capillary basement membrane and poor tissue perfusion.^[4-6] In addition, the vast majority of individuals (90.5%) had neuropathy, indicating that sensory loss is the most common cause of unseen trauma. 41.5% of patients required surgical intervention with minor amputation (35.5%) and major amputation (6.0%). Surgical intervention (minor or major amputation) was required in 41.5% (mainly patients with higher HbA1C ($95.0\% \geq 11\%$)). With glycemic control (HbA1c $< 7.0\%$) it is crucial to speed up wound healing and lower the risk of limb loss.^[7,8]

CONCLUSION

1. HbA1c levels are directly and linearly associated with the severity of diabetic foot ulcers (DFU) graded by Wagner's classification.
2. Uncontrolled glycemic status (HbA1c $>8.5\%$) is undoubtedly linked with long healing time of wound and increased amputation rate.
3. The most common secondary complication of the patients with DFU (90.5%) was neuropathy.
4. Diabetic foot disease has to be treated with strict glycemic control and multidisciplinary foot care to minimize bad consequences.

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Conflicts of interest

There are no conflicts of interest.

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