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Assessment of Nutritional Status among Patients with Diabetic Foot Ulcer at the Time of Presentation and its Impact on Ulcer Healing Response

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ABSTRACT

Diabetes mellitus is increasing rapidly worldwide. A diabetic foot ulcer is the most common complication which leads to amputation and death. Diabetic foot ulcer (DFU) affects almost 15% of diabetics and it is considered as the major cause of lower limb amputation. Malnutrition is more prevalent in diabetic foot ulcer patients. Due to malnutrition, the incidence of severe infection is also high in DFU patients. The nutritional status of patients with diabetic foot ulcers affects the rate of wound healing.

The cross-sectional study was conducted to assess the nutritional status of patients with diabetic foot ulcer at the time of presentation and its impact on ulcer healing response. A total number of 100 patients diagnosed with diabetic foot ulcers were selected. All DFU patients were interviewed individually. Among these patients 84 were males and 16 were females. Nutritional status was assessed using body mass index, biochemical parameters, dietary recall and subjective global assessment. A questionnaire was designed to obtain information regarding demographics, biochemical tests, and treatment outcomes. Dietary data was collected through 24-hour dietary recall. The 24-hour dietary recall was performed at the time of presentation and after recovery. All patients were followed up until wound healing. We compared the actual intake of calories and macronutrients with the recommended intakes.

Results showed that, according to SGA, 58% of DFU patients were normally nourished, 36% were moderately malnourished and 6% were severely malnourished. As the Wagner grade of the ulcer increased, the BMI and serum albumin, the severity of infection and percentages of SGA grades B and C increased; and nutritional status deteriorated. A significant difference was seen in the recommended and actual intakes of calories and macronutrients (P-value ≤ 0.05). It is concluded that the actual intake of calories and macronutrients is not according to the recommended intake. The findings of the study will be useful for health care practitioners, endocrinologists, and clinical dietitians. They can plan interventions to improve the nutritional status of diabetic patients for better glycemic control as well as prevention and treatment of diabetic foot ulcers.

1. Introduction

Diabetes Mellitus (DM) is a metabolic disorder described by hyperglycemia due to defects in secretion and action of insulin or both. The complications of diabetes or hyperglycemia include dysfunction, long-term defects, and ultimately failure of the organs, especially kidneys, eyes, heart, nerves, and blood vessels (Association 2009). Diabetes Mellitus is a fast-growing problem in society. There are two major types of diabetes mellitus: Type 1 DM and type 2 DM. These are chronic problems that disturb the metabolism of glucose in the body and also impair the regulation of glucose. The liver serves as a major organ of metabolism in the body (Jiang *et al.* 2020).

Diabetic foot ulcer patients are at high risk of malnutrition. A study examined the dietary intake of diabetic foot ulcer patients, found that they were eating 55% of DRI for energy and eating 0.57 grams of protein/ kg body weight. The DRI of protein normally recommended is 0.8 gram/ kg weight. The study found that the protein intake is lower than the recommended intake (Basiri *et al.* 2020). Such patients also had considered a smaller number of micronutrients like vitamin B1, B2, B3, B6, vitamin E, sodium, magnesium, iron, potassium, and calcium. These vitamins are necessary for the rapid healing of the wound. The intake amount of protein in men and women is lower than the recommended amount of protein which lowers the process of the healing of the wound (Sajid *et al.* 2018).

Nutrition education has been hardly ever included in studies related to DFU and supplementation. The dietary intake of the patients can be increased by the DFU patients by enhancing their knowledge and awareness through educating them about the condition of the ulcer and sources of the essential nutrients. Adequate intake of the essential nutrients not only improves wound healing but also lessens the deteriorating delayed outcome associated with malnutrition (Huang *et al.* 2020). Our study focused on the assessment of the nutritional status of patients with diabetic foot ulcers and its impact on ulcer healing response. The other objective was to assess the daily nutritional intake and its correlation with poor dietary control and the development of its complications.

2. Materials and Methods

The study was conducted in the Diabetic Foot Care Clinic at the outpatient department of Mayo Hospital, Lahore, Pakistan. By using non-probability convenient sampling; a total number of 100 patients diagnosed with a diabetic foot ulcer were selected. Data related to assessment of nutritional status was collected from patients at the time of presentation in Diabetic Foot Care Clinic and then these patients were followed until the healing of the wound. The effect of nutritional status and nutritional intake on the rate of wound healing was assessed.

A total number of one hundred men and non-pregnant, non-lactating women, specifically diagnosed with type 1 or type 2 diabetes mellitus, undergoing treatment for wound healing, and at least one-foot ulcer were included in the study. Individuals with a history of radiation used for ulcer treatment, use of bioengineered tissue, having Human Immunodeficiency Virus (HIV) or Acquired Immunodeficiency Syndrome(AIDS), Chronic Kidney Disease (CKD), Liver damage or Cirrhosis, active malignancy, excessive alcohol consumption, or any other mental or physical issue that can cause problem to follow nutrition education and nutritional intake were excluded from the study.

Nutritional status was comprehensively assessed through Subjective Global Assessment (SGA) and a self-designed questionnaire. SGA, a clinical tool used to assess the nutritional status of individuals based on their physical examination and medical history. Different parameters were included in SGA such as dietary intake, weight changes, gastrointestinal symptoms, functional capacity, metabolic stress, muscle wasting, sacral edema, and loss of subcutaneous fat. Body mass index (BMI) was calculated by dividing the weight of an individual by the square of body height

(Jager-Wittenaar *et al.* 2020).

The self-designed questionnaire consisted of information regarding demographics like age, sex, location of living, marital status, and occupation status. Other parameters were also included in the questionnaire such as duration of diabetes and diabetic foot ulcer, treatment outcome, ulcer healing response, insulin usage, and use of oral hypoglycemic drugs. Random blood glucose (RBG), fasting blood glucose (FBG), white blood cells (WBCs), serum albumin level, and blood pressure was included in biochemical data. Different complications and comorbidities such as hypertension, ischemic heart disease, peripheral vascular disease, neuropathy, retinopathy, smoking, callosities, ulcer history, infection, were included in medical history (Zhang *et al.* 2013). Data was collected using a questionnaire of self-care awareness in DFU patients. The questionnaire about self-care awareness included three parts to assess awareness about the disease, physical activity, and diet. A 24-hour dietary recall is a tool that is used to assess the intake of foods and beverages which are consumed by the individual in the past 24 hours. A three-day 24-hour dietary recall was recorded at the time of presentation and also at the end of the study to assess the consumption of different food groups.

Data of different parameters were collected. The study was analyzed by using multiple regression analysis. Statistical analysis was performed by using SPSS software. The significance was observed at 5% probability ($p < 0.05$) (Zhang *et al.* 2013).

3. Results

The present study was conducted in the foot care clinic in Mayo hospital. It was a cross-sectional study on the assessment of nutritional status among patients with diabetic foot ulcers at the time of presentation and its impact on ulcer healing response. The DFU patients were interviewed individually, and data was collected. The results will be presented in various sections.

For the 100 patients in the Wagner grade 1-5 groups, the mean age, and duration of DM was (Mean 58 ± 5.49) and (Mean 12.84 ± 5.52) years, respectively. Most of these patients had poor blood glucose control, Random Blood Glucose (RBG) (Mean 317.30 ± 72.30) and Fasting Blood Glucose (FBG) (Mean 230.40 ± 62.73). Indicators of nutritional status (BMI, albumin) were lower in higher grades than those in patients with Wagner grade 0 ulcers. Most of the patients 58% were well nourished (Among them 48% were males and 10% were females). The number of moderately malnourished and severely malnourished patients was 36% and 6% respectively. Among them, 30% of males and 6% of females were moderately malnourished. Only 6% of males were severely malnourished.

Most patients 50% were normal (Among them 44% were males and 6% were females). Almost 31% of DFU patients (Among them 24% were males and 7% were females) were overweight and 19% of DFU patients (Among them 16% were males and 3% were females) were underweight. Most of the patients (67%) had hypertension while a few patients (7%) had ischemic heart disease. Almost (34%) patients used to smoke.

The comparison between the actual intake and recommended amount of calories and macronutrients (Carbohydrates, Proteins, and Fats) showed that the actual intakes increased after recovery but were still lower than the recommended amounts. The prevalence of different complications and comorbidities were assessed. The data showed most of the patients (67%) had hypertension while few patients (7%) had ischemic heart disease. The majority of the patients (68%) had peripheral vascular disease. Most patients (60%) had neuropathy and callus was present in almost 70% of patients. Almost 34% of patients were smoking or had a history of smoking. Almost 78% of patients were infected and only 2% of DFU patients were not using insulin. The awareness data showed that 57% of patients were unaware of the disease diabetes, 52% of patients did not know about their diet and 39% of patients were unaware of which type of physical activity was suitable for

them.

The mean duration of diabetes was 12.84 ± 5.52 years. The average duration of the diabetic foot ulcer was 13.79 ± 5.11 days and the mean duration of wound healing was 72.01 ± 10.06 days. Most of the patients 58% were well nourished (Among them 48% were males and 10% were females). The number of moderately malnourished and severely malnourished patients was 36% and 6% respectively. Treatment outcomes showed that 62% of patients were healed and 34% of patients were not healed. Only 4% of patients were amputated.

Table I indicates the association between characteristic variables of DFU patients and Wagner's Grades. Poor glucose levels showed a highly significant association with Wagner's grades ($P < 0.05$). More uncontrolled glucose levels lead to higher Wagner's grade. There is a highly significant association among duration of disease ($P = 0.002$), duration of diabetic foot ulcer ($P = 0.04$), WBC ($P = 0.000$), albumin ($P = 0.006$), infection ($P = 0.000$), and Wagner's grade.

Table I: association between characteristic variables of DFU patients and Wagner's Grades

Variables	W0	W1	W2	W3	W4	P-Value
Total	21	35	27	13	4	
Age	57.71 ± 5.03	58.11 ± 5.97	57.18 ± 5.04	58.30 ± 5.97	62.75 ± 4.57	0.456
Duration of diabetes(Yr)	11.09 ± 2.70	13.25 ± 6.86	12.77 ± 3.57	13.69 ± 7.71	16.00 ± 6.16	0.002
Duration of DFU (days)	14.00 ± 4.42	12.20 ± 4.90	15.29 ± 4.77	12.38 ± 5.07	21.00 ± 5.71	0.04
Duration of healing(days)	73.00 ± 9.01	70.54 ± 11.42	71.03 ± 9.84	73.76 ± 8.38	80.50 ± 7.00	0.004
RBG level	310.95 ± 60.07	333.42 ± 82.60	282.59 ± 64.96	338.46 ± 57.42	375.00 ± 28.86	0.000
FBG level	230.00 ± 55.40	242.57 ± 67.79	198.14 ± 56.16	249.23 ± 52.03	282.50 ± 53.77	0.000
WBCs	13.69 ± 2.83	14.25 ± 4.12	11.99 ± 1.97	15.53 ± 2.14	18.00 ± 3.16	0.000
Albumin	3.60 ± 0.54	3.50 ± 0.73	3.79 ± 0.60	3.45 ± 0.65	3.00 ± 0.58	0.006
Infection	66%	74%	77%	100%	100%	0.000

Table II indicates the association between characteristic variables of DFU patients and SGA classification. The SGA results were significantly associated ($P < 0.05$) with the duration of diabetes ($P = 0.007$), diabetic foot ulcer ($P = 0.012$), wound healing ($P = 0.000$), and biochemical parameters (RBG, FBG, WBC, Albumin) ($P < 0.05$). As the SGA score increased, the prevalence of complications and comorbidities (ischemic heart disease $P = 0.001$, peripheral vascular disease $P = 0.041$, callus formation $P = 0.002$) also increased ($P < 0.05$).

Table II: Association between characteristic variables of DFU patients and SGA classification

Variables	SGA-A	SGA-B	SGA-C	P-Value
Total	58	36	6	
Age	57.05 ± 5.33	58.66 ± 4.75	63.00 ± 8.43	0.025
Duration of diabetes(Yrs)	11.55 ± 4.24	14.11 ± 6.63	17.66 ± 5.75	0.007
Duration of DFU	12.55 ± 5.03	15.75 ± 4.54	14.00 ± 6.26	0.012

(days)				
Duration of healing(days)	67.18±8.66	79.33±7.84	74.66±7.22	0.000
RBG level	283.44±58.44	349.72±56.79	450.00±0.00	0.000
FBG level	204.65±51.95	251.94±52.03	350.00±0.00	0.000
WBCs	12.30±2.14	15.07±3.09	21.33±1.03	0.000
Albumin	3.90±0.52	3.25±0.48	2.40±0.38	0.000
Ischemic heart disease	0%	14%	50%	0.001
Peripheral vascular disease	81%	97%	100%	0.041
Callus formation	56%	86%	100%	0.002
Family History	58%	86%	66%	0.019

Table III indicates the association between characteristic variables of DFU patients and treatment outcomes. The treatment outcomes were significantly associated ($P<0.05$) with the duration of diabetes ($P=0.000$), diabetic foot ulcer ($P=0.029$), wound healing ($P=0.000$), and biochemical parameters (RBG, FBG, WBC, Albumin) ($P<0.05$). As the SGA score increased, the prevalence of complications (callus formation $P=0.040$, infection $P=0.006$) also increased ($P<0.05$).

Table III: Association between characteristic variables of DFU patients and treatment outcomes

Variables	Healing	Deferment	Amputation	P-Value
Total	62	34	4	
Age	57.03±5.16	59.32±5.80	61.50±5.06	0.062
Duration of diabetes(Yr)	11.32±4.21	14.55±6.22	21.75±5.85	0.000
Duration of DFU (days)	12.98±5.20	14.61±4.67	19.25±3.50	0.029
Duration of healing(days)	66.46±7.86	81.94±5.03	73.50±7.00	0.000
RBG level	283.38±59.55	369.41±55.09	400.00±57.73	0.000
FBG level	205.80±53.33	268.23±55.40	290.00±69.28	0.000
WBCs	12.61±2.82	15.41±3.08	19.50±2.88	0.000
Albumin	3.83±0.56	3.21±0.57	2.70±0.40	0.000
Callus formation	61%	82%	100%	0.040
Infection	67%	94%	100%	0.006

4. Discussion

Previous studies identified different diabetic foot ulcer classification systems as a predictor of the clinical outcome of the ulcer treatment. The present study not only assessed the ulcer classification system but also used it to assess the nutritional status of diabetic foot ulcer patients as a predictor of clinical outcome of ulcer treatment along with the prevailing complications among DFU patients. The present study showed the rate of amputation lowered at 4% after the early introduction of ulcer treatment. A higher rate of amputation especially in males as compared to the females is like in other studies (Holstein *et al.* 2000). This study showed a 4% amputation rate depending on the severity of the ulcer at the time of presentation.

The risk of amputation in DFU patients varies as the severity of diabetic ulcer at the time of

presentation as assessed by the grading system as in the present study Wagner's grading system was used. The DFU patients presenting at low Wagner's grades usually have mild foot issues, therefore, the amputation rate was lower in those patients with a good prognosis. However, the DFU patients presenting at high Wagner's grades were at a high amputation risk with a poor prognosis. Amputation is considered not only the marker of disease but also the management of disease (Krittayawong *et al.* 2014). The decrease in amputation rate is likely to be multifactorial. Lavery *et al.* showed in a study by implementing a lower extremity disease management program consisting of assessment and treatment protocols for DFU patients managed care environment lower the risk of amputation by 47.4% (Lavery *et al.* 2005). We analyzed the dietary intake of energy, protein, carbohydrates, and fats during the study. Adequate energy and protein intake are required for maintaining energy balance and supporting a positive nitrogen balance. Protein is also required for optimum wound healing and is essential for the synthesis of enzymes, which are involved in healing, cell proliferation, and collagen synthesis (Stechmiller 2010).

The results of this study showed that dietary intake of energy, protein, carbohydrates, and fats for wound healing was significantly lower in patients with DFU even when they were compared with the recommendations for a healthy population (Aranceta and Pérez-Rodrigo 2012). These findings are consistent with other studies that reported significantly low dietary intake of energy, protein, carbohydrates, and fats in this population (Maier *et al.* 2017). Various studies have also reported the average age of patients with DFU as between 40–55 years. (Moeini *et al.* 2017). There is no significant reason for DFU incidence in middle-aged persons but this can be due to the higher prevalence of diabetes in the middle-age than in other age groups. Furthermore, in recent studies, the duration of diabetes in patients with DFU has been noted as 11–16 years (Wukich *et al.* 2016). The present study represents the average duration of diabetes in DFU patients as 12.84 ± 5.52 but in the Jae-Seung Yun *et al.* study this time has been reported as 6.1 years. This time is important to learn about diabetes and foot care (Yun *et al.* 2016).

5. Conclusion

The current research aimed to assess the nutritional status among patients with diabetic foot ulcers (DFU) at the time of presentation and its impact on ulcer healing response. It was assumed that the poor nutritional status of the DFU patients leads to delayed healing responses. According to this study deteriorated nutritional status leads to poor healing of the foot wound. The findings showed that the actual intake of Kcals and macronutrients (Carbohydrates, Proteins, and Fats) was lower than the recommended intake of Kcals and macronutrients (Carbohydrates, Proteins, and Fats). Poor nutritional status enhanced the severity of wounds and infection. Poor glycemic and plasma glucose control further disturbs the healing response. So, urgent attention should be given to maintaining glycemic control among DFU patients. This requires future investment in educating DFU patients and society as well as performing more investigations.

6. Recommendations

The growing burden of diabetes mellitus and its complications especially diabetic foot ulcers in Pakistan are a serious concern that needs to be addressed with insight. The favorable point to work over diabetic foot ulcers is that screening should be started of diabetic patients because it is a fundamental step to prevent our population from complications of diabetes through its timely diagnosis and treatment. In Pakistan, a proper framework for nutrition education of diabetic foot ulcer patients is lacking. Therefore, health care networks should focus on the arrangements of nutrition education and awareness programs.

In Pakistan, media can play an important role with the health care sector in promoting education and awareness by running public campaigns about diabetes and diabetic foot ulcer.

Effective and timely prevention from the complications of diabetes can be achieved through lifestyle and dietary modifications and also glycemic control. Therefore, diabetic patients should be provided education and awareness about dietary choices.

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