Risk factor analysis for diabetic foot amputations

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Key words: Diabetic foot; foot ulcer; risk factors

Abstract

Objectives

To identify the risk factors of patients with diabetic foot ulcers who will require amputations, with special reference to Wagner's grading system.

Methodology

A total of 100 patients were included who were admitted with various grades of diabetic foot ulcers to the surgical units of Fauji Foundation Hospital. Risk factors such as Wagner's grade, family history of diabetes, compliance to treatment and HBA1c were compared with the final treatment outcome of limb salvage.

Results

Wagner's grade had a significant association with limb salvage (p=0.000). Other risk factors had no statistical significance.

Conclusions

Wagner's grading system should be more often used in the clinical assessment of patients with diabetic foot to predict limb salvage.

Introduction

Diabetes is one of the most commonly occurring chronic diseases in our country. Its' prevalence is about 10% ranging from 5.3% to 16.2% in various studies [1]. Diabetes causes complications based on its principle of micro and macro-angiopathy. It is associated with a wide array of complications but one complication which is very serious, for both the patient and physician alike, is diabetic foot.

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Diabetic foot, amongst diabetics, is also very common in our setup as well as around the world. 15% to 20% of diabetic patients end up having diabetic foot ulcers at some point in their lifetime [2,3]. It is associated with increased morbidity and mortality of the patients. Patients with diabetic foot ulcers have a 2-fold death rate as compared to ones with no ulcers [4]. Patients with diabetic foot during their lifetime are subjected to depression and have very a poor quality of life. This phenomenon only gets worse with patients who end up with amputations [5,6]. Amongst all the complications of diabetes, diabetic foot should be considered a subject of importance due to the seriousness of its effects on patients' lives and more so, when its rate is increasing faster than any other diabetic complication [7].

Development of diabetic foot in a diabetic patient is dependent on many factors such as neuropathy, deformity of the foot and ultimately trauma [8]. Amongst all these problems, the start of diabetic foot disease is marked by polyneuropathy. It renders a foot with both sensory and proprioceptive deficit. This leads to inappropriate weight distribution on the foot leading to trauma [9]. Autonomic neuropathy causes increased blood pooling in limbs while motor neuropathy causes atrophic changes in musculature leading to foot deformity. A foot with sensory neuropathy lacks its protective response to injury leading to the development of ulcers. Polyneuropathy is reported to be present in 10% of cases at the time of diagnosis, but is present in 50% of diabetic patients with a longstanding history of diabetes [10].

Risk factors for development of diabetic foot ulcers, which ultimately lead to amputations in large proportions, have been discussed in detail by Edward J. et all [11]. Key factors associated with development of foot ulcers were BMI, glycaemic control (HBAIC), ESR, serum creatinine, old history of foot ulcers or amputations. Factors not associated with diabetic foot

ulcers were age, race and cigarette smoking. Overall, neuropathy and peripheral vascular disease have been identified as factors of key importance for both the development of foot ulcers and subsequent amputations [12].

Development of infection in a diabetic foot ulcer predisposes it to more serious outcome. Soft tissue infections occur more commonly as compared to osteomyelitis. Infected foot ulcers result in 55.7 times greater hospital admissions with 154.5 times greater risk of amputation [13]. Risk factors for developing an infection in ulcers are depth and duration of wound, recurrences, association with trauma and peripheral vascular disease [13]. The increased chance of infection may be explained by a decreased inflammatory response in diabetics [14] as there is a decrease in leukocyte function [15].

1% to 3% diabetic patients end up with lower limb amputations [16,17]. The patients who have to undergo major amputations have a 5 year survival rate of less than 50% [18]. The overall rate of amputations have been seen to rise to 30% in recent years [19]. This makes it a matter of great concern for the physician. Multiple factors have been reported which increase the risk of a patient to a potential amputation, but infected and non-infected foot ulcers have shown a high association with amputations. Infected and gangrenous ulcers are present in 66% to 85% of patients who are predisposed to amputations [20, 21, 22]. Other reported associations include reamputation [23], contralateral limb amputation [24], depth and stage of wound [25] and the additional presence of peripheral vascular disease and neuropathy [26].

In our study we have taken some of the factors which promise a good predictive value to detect possible future amputations and analysed their association with amputations.

Materials and methods

Our study is a uni-centric study where a total of 100 patients were enrolled. These patients were admitted with a diagnosis of diabetic foot disease to all units of the surgical department of Fauji Foundation Hospital, Rawalpindi, during the period of February 2013 to January 2014. The demographical distribution of these patients ranged from Kashmir to mid Punjab up to the Jhelum region. This covers a large area of the northern part of Pakistan.

Patients included were over the age of 18 with diagnosed diabetic foot disease. Patients who had any other cause of neuropathy or no palpable dorsalis pedis & posterior tibial pulses were excluded from the study. Although manual palpation of pulses is not a reliable indicator of blood flow in arteries, this method was not expected to bias our study results as the method was only used to exclude subjects from the study. If we had intended to include the study subjects on the basis of distal arterial blood flow, the use of more sophisticated methods would have been appropriate.

Measurement of ankle pressure was difficult to perform for us in the wards or in out-patients because of equipment constraints. Transcutaneous measurement of oxygen pressure (TcPO2) is not an accurate representation of blood supply to the foot because the pressure in the skin may be better than the deeper tissues. The university of Texas grading system was not adopted by us because it requires accurate assessment of ischaemic status of the foot in order to stage the wound but does not classify the grade of ischaemia itself. There is no provision in classification grades of what impact minor, moderate or critical ischaemia would have on different stages.

Patients were graded according to Wagner's classification system [27] at the time of presenting with diabetic foot disease. This system of classification is based on the severity of disease, extent of tissue involvement and necrosis [28]. Details of this classification system are given in (Table 1). The decision of involvement of bone (osteomyelitis) was made on plain x-ray [29].

The final outcome of each patient was recorded alongside its Wagner's grade. Other factors which were the subject of analysis were recorded for each of these patients. These factors were family history of diabetes, regularity of treatment, HBAIC levels and socio-economic status of the patient. Family history was defined as diabetes diagnosed in any parent or sibling of the patient. Siblings of parents or cousins of the patient were not included. Treatment was considered regular when the patient was followed up on physician-determined intervals. Treatment was considered to be irregular if the gap in follow up visits exceeded four

months.

Treatment outcome of the patients was divided into three distinct groups according to the aggressiveness of the treatment: conservative management, minor amputations and major amputations. Conservative management included non-surgical management and incision and drainage. Non-surgical management included intravenous or oral moxifloxacin if the wound was infected; saline dressings; and topical negative pressure therapy in selected cases. Minor amputations included toe amputation, mid-foot amputation, ray amputation or Syme's amputation. Major amputations included below-knee or above-knee amputations. Amputations were considered in patients with gangrene or gross osteomyelitis.

Values of HbAIC were divided to good control (< 6.5mmol/l), fair control (6.5 - 9.0mmol/l) and poor control (> 9.0mmol/l).

Patients were followed up until healing or for eight months. All of the data was recorded and analysed using SPSS version 18. All the qualitative variables were analysed using chi-square test and its p-value recorded for drawing further inference. Recorded p-value were 2-tailed and value of 0.05 or less was considered statistically significant.

Table 1: Wagner's classification

Grades	Clinical Details
Grade 0	No ulcer
Grade 1	Superficial ulcer
Grade 2	Deep ulcer, no bony involvement
Grade 3	bony involvement (as shown by X-ray)
Grade 4	Localized gangrene
Grade 5	Extensive gangrene involving the whole foot
Note: Grade 1–3 (non-gangrenous ulcers) and Grade 4 and 5 (gangrenous ulcers)	

Table 1. Wagner's Classification

Results

A total of 100 patients, who were enrolled in the study, were all type 2 diabetics with the exception of only 2 patients who were type 1. Out of all these patients, 84 were females and 16 were males with a mean age of 59.5 (±9.3) years. Complete distribution of patients into various categories of family history, treatment compliance, Wagner's grading and treatment outcome are given in (Table 2). 11 patients who were in Wagner's grade 0 and 1 had to undergo minor or major amputation as their status changed over time. All of them belonged to the group with poor glycaemic control as determined by their HbA1C levels.

Groups		No. of Patients
Male		16
Female		84
Family History of Diabetes	Yes	55
	No	45
Treatment Compliance	Yes	69
	No	31
HbA_1C Levels	Good control	16
	Fair control	44
	Poor control	40
Socio-Economic Status	Low	47
	Middle	43
	High	10
Treatment Outcomes	Conservative	37
	Minor Amputations	34
	Major Amputations	29
Wagner's Grading	Grade 0	3
	Grade 1	34
	Grade 2	9
	Grade 3	16
	Grade 4	28
	Grade 5	10

Table 2: Patient numbers in different groups (n=100)

Most of the factors which were analysed in our study for any relation with the treatment outcome of the patient proved insignificant. Family history of diabetes (p= 0.173), treatment compliance (p=0.510), long term control of blood sugar (p=0.285) and socioeconomic status of the patient (p=0.676) all proved to be statistically insignificant as related to the treatment outcome.

The only variable that shows a statistically significant association with the treatment outcome of the patient was Wagner's grade (p=0.000). Most patients with a

higher Wagner's grade ended up with amputations whilst those with lower grades healed with conservative treatment (Table 3).

Table 3: Wagner's Classification vs. Treatment blocks cross-tabulation

Wagner's classification		Treatment blocks			Total (n)
		Conservative	Minor amputation	Major amputation	
Grade 0	Intact Skin	2	0	1	3
Grade 1	Superficial ulcer of skin/ subcutaneous tissue	24	7	3	34
Grade 2	Ulcer extends into tendon, bone and capsule	6	2	1	9
Grade 3	Deep ulcer with osteomyelitis, or abscess	3	11	2	16
Grade 4	Gangrene of toes or forefoot	2	14	12	28
Grade 5	Midfoot or hindfoot gangrene	0	0	10	10
Total Patients (n)		38	33	29	100
***p-Value (0.000)**					

Table 3. Wagner's Classification vs. Treatment blocks cross-tabulation

Discussion

Diabetic foot disease is a debilitating disease which frequently requires admission to a hospital. This leads to loss of earning capacity and significant anxiety to the patient. In addition, diabetic foot predisposes the patient to increased risk of amputation and may even be fatal. Furthermore, it is documented that a number of diabetic patients require re-amputation. Identification of the risk factors that lead to amputations is easy and can help in identifying patients at potential risk [30].

Another important aspect of this issue is cost of hospitalization and utilization of resources. Diabetic foot needs to be dealt with on a multi-disciplinary basis which involves utilization of a lot of resources. Diabetic foot has shown to increase the risk of hospitalization [31, 32]. This further consolidates the factual need for reliable predictors for potential high risk patients who are at risk of failure of conservative treatment. Therefore, it is desirable to identify factors which predispose a diabetic patient to an increased risk of a major amputation. This would allow an early amputation and hence, reduced number of admissions, reduced morbidity and a better quality of life.

In our study, the only variable that had a significant association with outcome was Wagner's grade (p=0.000), thus making it a good predictor for clinical use. This trend is in conformity with available literature [33, 34]**.** There are other factors including C-reactive protein, white blood cell counts and serum creatinine levels that have been considered in clinical practice. Amongst these, serum creatinine has shown more promise of being another factor with a reliable predictive value regarding treatment outcome [35].

Our aim was to identify one factor that may assist physicians with regard to treatment of patients with diabetic foot on an in-patient or out-patient basis. Wagner's grade is an excellent way to make such decisions in an outpatient setting as it relies on clinical assessment alone. No sophisticated gadgets or laboratory investigations are required to reach a conclusion. This is one reason why the university of Texas classification of diabetic foot was not adopted by us for the purpose of this study. Like the International Working Group grading, it requires measurement of the ischaemic status of the foot for every patient in order to determine the stage [36, 37]. This can be done either by transcutaneous measurement of oxygen pressure which may not depict the accurate status of deeper tissues [38]. Ankle-brachial index may be used for this purpose, but this classification grading does not specify the utility of various grades of ischaemia [39]. Instead we assumed that all patients with diabetic foot have some degree of ischaemia due to inherent vasculopathy, and excluded those who had critical limb ischaemia, detected clinically by absent distal pulses.

It is desirable to use a hand-held Doppler, if readily available, to measure ankle pressure or the flow in distal arteries. Those with severe or critical ischaemia should be investigated more elaborately by Doppler studies or CT angiography and managed in a vascular surgery unit. Our subjects, excluded from the study due to absent distal pulses, were nevertheless investigated more thoroughly and managed by a vascular surgeon.

The strength of this study is that it has been carried out in Pakistani patients with their particular circumstances. Another advantage is that this study has come up with a predictive tool that relies exclusively on clinical examination. This makes it an important contribution for healthcare systems with resource constraints that are

catering to large populations of diabetic patients **[40]**. The weakness of the study is that it included patients from a particular region in Pakistan and may not be representative of the whole country.

Conclusion

Wagner's grading system is an effective tool in assessing patients' severity of disease and the possible future outcome patient will have. This tool should be used more often while assessing patients with diabetic foot disease. This will help a clinician to distribute the hospital resources more efficiently and to the most deserving of the patients. Better prediction of a patient at potential risk of amputation can be managed aggressively and with a better devised multi-disciplinary approach. This ultimately saves the health care system a lot of time and resources, and delivers better treatment to the patients.

All authors disclose no conflict of interest. The study was conducted in accordance with the ethical standards of the relevant institutional or national ethics committee and the Helsinki Declaration of 1975, as revised in 2000.

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