Predicting Foot Salvageability in Diabetic Foot Lesion: Comparison of Benin Diabetic Foot Severity Score and Wagner System

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Abstract

Background: A diabetic foot lesion is a disabling and chronic complication of diabetes mellitus. An aid for making decision on choice, modality of treatment and prognostication is needful in the management of diabetic foot lesion. Such aid would be more purposeful if at the outset it can state which foot would be salvaged or not. The aim of this study was to compare the Wagner Diabetic Foot Severity Score (WDFSS) and Benin Diabetic Foot Severity Score (BDFSS) as predictors of foot salvageability in diabetic foot lesion.

Methodology: Sixty-five patients with diabetic foot lesions were recruited into the study. All the subjects were diagnosed diabetic using fasting blood sugar value of at least 7mmol/L or higher. Each patient's diabetic foot lesion was assessed and classified using the WDFSS and BDFSS prior to and during the course of treatment. Patients were treated with antibiotics based on bacteriological studies, blood sugar control and wound care using basic surgical principles. Treatment outcomes based on the stage or state of the foot lesion were documented. The data obtained was analyzed as both descriptive and inferential methods using SPSS version 20.0 statistical software. Logical argument and Receiver Operating Curve were also used.

Results:BDFSS had a greater AUC of 0.928 compared to WDFSS with an AUC of 0.78. BDFSS recorded a higher degree of 95% confidence interval of 85% to 99% as against WDFSS with 95% confidence interval of 66% to 90%. BDFSS had a higher sensitivity (95%) compared to WDFSS with sensitivity of 79%. Additionally, BDFSS had better Specificity (87%) compared to WDFSS with a Specificity of 73%. A bivariate logistic regression analysis was performed to assess which characteristic and clinical variables were independently associated with outcome using variables with P< 0.01 according to the univariate analysis.

Conclusion: This study demonstrated that the BDFSS has acceptable accuracy and capacity for predicting outcomes in patients with a diabetic foot lesion. BDFSS in this study was found to be comparable to the WDFSS thereby making it a useful tool in clinical practice and research for comparing patient subgroups.

Keywords: Diabetic foot, WDFSS, BDFSS, Diabetes mellitus, foot lesions

Introduction

Diabetes Mellitus (DM) is a rapidly growing global health problem that cuts across race, age and gender. It is projected that the number of diabetics worldwide, will rise from 382 million in 2013 to 592 million adults by 2035[1]. Fifteen per cent of these patients will develop a diabetic foot lesion in their life time[1,2]. The World Health Organization (WHO) defines a diabetic foot as the lower limb of a diabetic patient that has the potential risk of pathologic consequences, including infection, ulceration and destruction of deep tissues associated with neurological abnormalities and various degrees of peripheral vascular disease[3]. A diabetic foot is therefore a foot lesion occurring in a patient with DM[4]. A foot lesion refers to foot ulcers, infections and gangrene among others.

Diabetic Foot lesions cause a significant decrease in the quality of life among patients with DM and also places a huge burden on health care resources[5]. Diabetic foot lesions account for as much as 50% to 80% of non-traumatic amputations[6,7]. The huge economic burden imposed by diabetic foot lesions on individuals, families, and the society at large, especially in developing countries like Nigeria, creates an incentive to find ways to optimize healthcare resources. Thus, a multi-disciplinary approach in the management of the diabetic foot lesion is usually adopted from the onset in order to reduce these social and economic burdens.

Classification systems have been developed to aid the easy detection and efficient management of diabetic foot lesions. Among these are the Wagner Diabetic Foot Severity Score (WDFSS), the University of Texas (UT) systems and the SINBAD (Site, Ischaemia, Neuropathy, Bacterial Infection and Depth) classification system. Others are the Benin Diabetic Foot Severity Score (BDFSS), the Size (area, depth), Sepsis, Arteriopathy, Denervation system (S(AD)SAD) and the Perfusion, Extent(size), Depth/Tissue loss, Infection and Sensation (PEDIS) system. The WDFSS, developed in the United States, is widely accepted and has been in use for decades but the BDFSS is relatively new and has not enjoyed the same wide usage. The BDFSS was developed in 1998 at University of Benin Teaching Hospital, Benin City, Nigeria, by Prof Philip F.A. Umebese and Alfred O. Ogbemudia[8].

The relevance or usefulness of each classification system lies in its ability to easily and correctly group or classify patients to different levels of care to optimize efficiency and effectiveness in the management of the patient with a diabetic foot lesion. It is important to have a scoring system that is an easy diagnostic tool for anticipating the probability that a diabetic foot lesion will heal with or without various degrees of surgical intervention. It is also very important for the scoring system to predict at the outset whether the foot can be salvaged or not. Accurate prediction of the foot that cannot be salvaged at the outset will indicate immediate below knee amputation thereby avoiding the time and economic resources that would have been expended in potentially lengthy periods involving repeated wound dressings and debridement. Foot salvageability implies maximal preservation of the foot and the avoidance of an amputation above the ankle[9]. For instance, gangrene involving only the toes may require disarticulation of the toe with the foot salvaged whereas gangrene involving the entire forefoot may require a below knee amputation with the foot not salvaged. The aim of this study was to compare the WDFSS and BDFSS as predictors of foot salvageability in patients with a diabetic foot lesion. In addition, we also sought to compare the sensitivity and specificity of the two classification systems, BDFSS and WDFSS, in predicting foot salvageability in the management of Diabetic Foot Lesions.

Methodology

This was a prospectively designed comparative study which was carried out at the University of Benin Teaching Hospital (UBTH), a tertiary health institution located in Benin City, Edo State, Nigeria. Ethical clearance to conduct this study was obtained from the Ethics and Research Committee of the UBTH prior to the start of the study. Each patient was evaluated at the onset using both scoring systems and at the end of 2 to 6 weeks of care. The study population was drawn from patients with diabetic foot lesion admitted into the medical or surgical wards of UBTH. All the patients were evaluated and scored using both classification schemes by the first author (CIB). Demographic data and clinical history were obtained from each patient. History about foot care, co-morbidities and social history were also collected from each patient. Each patient was evaluated clinically before the start of treatment, during the course of treatment, and at the completion of treatment. The grading and scores for each patient was awarded based on the WDFSS and BDFSS. The grading was done at the onset and repeated fort-nightly. To enable grading, the following was done:

- Grading of foot ulcer using adapted Wagner's grading system.
- Assessments of peripheral neuropathy considering response to light touch and pin prick.
- Assessment of ankle/foot vasculature by digital palpation of Dorsalis Pedis and Posterior Tibial pulsations.
- Assessment of the colour of the foot lesion compared to the adjacent normal skin colour. However, in situations of bilateral involvement, the foot lesion was compared with the skin of a normal part of the leg or thigh.
- Foot Plain Radiographs were obtained to assess the presence of osteomyelitis or calcification of peripheral vessels.

All the patients were treated based on basic surgical principles[10]. Wound care by basic surgical principles involved serial wound debridement and daily dressing, use of antibiotic based on bacteriological studies and surgical amputation when indicated. Each patient was treated till a time that the desirable outcome was achieved (foot salvaged) or such a time that the hope of achieving the expected desirable outcome was aborted (foot not salvaged). This time averages between 2 - 6 weeks. The desired treatment outcomes adopted for the purpose of this study were as follows[11].

The foot ulcer that has become clean and filled with healthy granulation tissue ready for skin coverage (foot salvaged). Secondly, the amputation stump that has healed or still harbor some clean and shallow residual ulcer[12] (foot not salvaged). The data collected were analyzed using the Statistical Package for Social Science (SPSS) version 20.0 statistical software. The categorical variables like were expressed as frequencies and percentages while the numerical variables were computed for, using descriptive methods such as mean and standard deviation. Receiver Operating Characteristic (ROC) curve was used to calculate the Sensitivity and Specificity of both scoring systems in order to generate a directly comparable data[10].

Results
The results showed that there were slightly more males (33) than females (32). The age range for both groups was 34 – 80years. The mean age was 58.3 years. 38.5% of participants had only primary education, 30.8% had secondary education 23.1% had tertiary education while 7.7% of them had no formal education. Majority of the patients (41.5%) had been diabetic for more than 10 years. 38.5% of patients had been diabetic for 1 – 5 years while 10.8% had been diabetic for 6 – 10 years. Most patients (72.3%) used oral medication only for blood sugar control. 15.4% used combination therapy, 9.2% used insulin injection only while 3.1% used herbal medications. 81.5% of the patients received care for the diabetes mellitus in the hospital prior to onset of foot ulcer. 7.7% received care at local pharmacy shops, 4.6% at local laboratories, 3.1% in traditional-medical homes before presentation to the hospital (UBTH) while 3.1% received care at home Table 1.

Table 1 – Clinical History of Diabetes Mellitus

Characteristics		Frequency	Percentage
Duration of diabetes mellitus	< 1 year	6	9.2%
	1 – 5 yeas	25	38.5%
	6 – 10 years	7	10.8%
	> 10 years	27	41.5%
Type of care and control of diabetes mellitus	Dieting alone	0	0.0%
	Herbal medication	2	3.1%
	Oral medication	47	72.3%
	Insulin injection	6	9.2%
	Combination	10	15.4%
Place where care was received	Home	2	3.1%
	Trado-medical	2	3.1%
	Local Laboratory	3	4.6%
	Chemist	5	7.7%
	Hospital	53	81.5%

Table 2 outlines the summary of clinical history of foot ulcer. 52.3% of the patients had ulcer between 1 – 3 months before presentation at the hospital whereas 43.1% had it less than 1 month before presentation at the hospital. On the other hand, 4.6% had it between 4 months – 1 year. 40% of the ulcer was caused by a traumatic event, 30.8% was caused by infection while 29.2% were spontaneous. All the patients recorded high blood sugar levels at the time of presentation while only 12.3% had previous foot ulcer. 50.8% of all the ulcers had the presence of gangrene at the time of presentation while 49.2% were malodorous and discharging purulent material.

Table 2: Summary on Clinical History of Foot Ulcer

Characteristics	Frequency	Percentage

Duration of ulcer		< 1 Month	28		43.1%
		1 – 3 Month	34		52.3%
		4 Month – 1 Year	3		4.6%
		> 1 Year	0		0.0%
Cause of Ulcer/Sore		Spontaneous	19		29.2%
		Infection	20		30.8%
		Trauma	26		40.0%
Blood Sugar at the time of admission		Euglycaemic	0		0.0%
		Hyperglycaemic	65		100%
Previous Foot Ulcer		Yes	8		12.3%
		No	57		87.7%
State of Ulcer at Presentation		Clean	0		0.0%
		Discharge/ smelling	32		49.2%
		Presence of gangrene	33		50.8%

At the onset of care, the severity of each patient's diabetic foot was assessed using both BDFSS and WDFSS. The scoring was repeated fortnightly until the final outcome was achieved. Table 3 and 4 shows the summary of the foot ulcer grading recorded at intervals for the BDFSS and WDFSS respectively. For the BDFSS, all the mild cases of foot lesion were salvaged while all the severe cases had below knee amputations. For the moderate cases, 85.3% had their foot salvaged while 14.7% had below knee amputation. A review of the WDFSS cases showed that no patient had grade I. 100% of those with grade II had their foot salvaged, 83.3% of those with grade III had their foot salvaged while grade IV had only 39.3% of the foot salvaged. Conversely, there was no grade V salvaged. All had below knee amputation.

Table 3: Showing Summary of Foot Ulcer Grading and Outcome of Care Using BDFSS

Characteristics	Frequency	Outcome		Result	Frequency	Percentage
< 11 (Severe)	20	Above ankle amputation	18	Foot not Salvaged	20	100%
		Died	2			
12 – 15 (Moderate)	34	Ulcer healed	5	Foot salvaged	29	85.3%
		Ulcer grafted or healthy granulation tissue ready for grafting	18			
		Limited amputation	6			
		Above ankle amputation	5	Foot not salvaged	5	14.7%
> 16 (Mild)	11	Healed ulcer		Foot salvaged	11	100%

Table 4: Showing Summary of Foot Ulcer Grading and Outcome of Care Using WDFSS.

Characteristics	Frequency	Outcome		Result	Frequency	Percentage
Stage I	Nil	-		-	-	-
Stage II	9	Ulcer healed	7	Foot salvaged	9	100%
		Ulcer filled with healthy granulation.	2			
Stage III	24	Ulcer healed	5	Foot salvaged	20	83.3%
		Ulcer filled with healthy granulation tissue or grafted	15			
		Below knee amputation	4	Foot not salvaged	4	16.7%

Stage IV	28	Limited amputation	11	Foot salvaged	11	39.3%
		Below knee amputation	17	Foot not salvaged	17	60.7%
State V	4	Below knee amputation	2	Foot not salvaged	4	100%
		Dead	2			

Comparison Of Wdfss And Bdfss Scores

To achieve the objectives of this study SPSS Version 20.0 was used to compute the different Receiver Operating Characteristic (ROC) curve from which the sensitivity and specificity were derived[10]. In this study, each patient was evaluated using both BDFSS and WDFSS classification systems and assigned a grade according to each system. To achieve this purpose for each scoring system, the grade versus outcome of each of the 65 patients was tabulated. The grade is represented by the classification score using the BDFSS or WDFSS system while the outcome is either 1 or 0. It is 1 when the foot is salvaged and 0 when the foot is not salvaged (above ankle amputation is carried out).

The WDFSS recorded an AUC of 0.783 and 95% confidence interval of 66% to 90% while BDFSS recorded AUC of 0.928 and 95% confidence interval of 85% to 99%. Also, the value of the ROC had a sensitivity and specificity of 79% and 73% respectively for WDFSS while the value of the ROC had sensitivity and specificity of 95% and 86.5% respectively for BDFSS.

Discussion

There has been some controversy over male/female preponderance as a risk factor in diabetic foot ulcer. Some researchers have demonstrated male preponderance as a risk factor in diabetic foot lesion while other studies have shown no difference. This study has shown no difference in gender effect as a risk factor unlike Umebese et al that demonstrated male preponderance with a male/female ratio of 3:1[8]. The mean age was found to be 58.3years with 66.2% of the patients falling within the age range 50 – 59 years. Most of the patients (82.3%) had some level of education ranging from primary to tertiary. The people with primary level were highest in number with tertiary level the lowest. The reason for this finding could be the that none of the states within the environment being studied is among the educationally disadvantaged states in Nigeria. This finding probably explained why majority of the patients received initial care from hospitals rather than traditional set ups. Conversely, in a similar study, Ngim et al found 86% of the respondents in his study to be without any formal education[13]. This disparity could be a problem with location and environment around the study centre. Majority of the patients (41.5%) had diabetes mellitus for more than 10 years before developing diabetic foot. This is in keeping with the findings of Nwadiaro et al that demonstrated a mean DM duration of 10.6 years[14]. From the findings of this study, there was no reason provided why those with diabetes mellitus between 1 – 5 years were more than those that had it between 6 – 10 years. 81.5% of the patients sought and received care from a hospital for their DM control prior to the onset of developing a diabetic foot ulcer. Again, 96.9% of them used oral medication, insulin injection or a combination of both. Despite this, all the patients had elevated blood sugar at the time of presentation with a diabetic foot lesion. This could be an indication of poor blood sugar control prior to the development of the ulcer, though most of them reported a history of poor compliance to medication.

Trauma was the most common precipitating cause of diabetic foot lesion in this study. This finding agrees with the results obtained by Ngim et al, who also found trauma to be the most common precipitating factor in 58% of patients in that study[13]. In contrast, Nwadiaro et al found that majority of the ulcers developed spontaneously[14]. Only 12.3% of the patients had previous ulcers. None of the ulcers were clean at the time of presentation in the hospital. 50.9% had the presence of gangrene while 49.2% had a malodorous discharge from the ulcer. Since the average age of the patients was 58.3 years, it becomes difficult to conclude that the observed co-morbidities are due to long standing diabetes mellitus. Some of the observed co-morbidities include hypertension, renal disease, peptic ulcer disease and previous amputation.

On comparison of the BDFSS and WDFSS, the ROC curve was done in order to generate a comparable data. BDFSS had an AUC of 0.928, with a sensitivity of 95% and a specificity of 87% while WDFSS had an AUC of 0.86, sensitivity of 79% and specificity of 73%. The AUC represents the percentage of foot

salvaged by each scoring system in graphical terms as well as the capacity to predict foot salvageability. Additionally, BDFSS recorded a higher degree of 95% confidence interval of 85% to 99% as against WDFSS with 95% confidence interval of 66% to 90% $p < 0.01$.

This study had several limitations. The BDFSS has some subjectivity and can thus easily lead to bias. For instance, it could be difficult to assess the dorsalis pedis and Posterior tibialis pulsations especially when there is cellulitis and swelling. The use of a hand-held pulse ultra sound machine can remove this bias. Secondly, use of electronic device to assess the sensation will make the BDFSS grading more reliable. We did not carry out any inter- or intra observer reliability testing. Some of the criteria for BDFSS grading such as colour of the foot are subjective and could easily lead to bias.

Conclusion

The study demonstrated that the BDFSS has acceptable accuracy and capacity for predicting the salvageability of diabetic lesion outcome. Consequently, in this study the BDFSS was found to be significantly comparable to the WDFSS and so could be said to be useful in clinical practice and research, both for the anticipation of health care cost and for comparing patient subgroups. BDFSS could also be a very good aid for communication between health professionals.

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