

Validity of Wagner, SINBAB, PEDIS, and WIFI Scoring Systems to Assess Risk of Amputation in Patients with Diabetic Foot Ulcers

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ABSTRACT

Aim: This study aims to determine validity of the Wagner, SINBAD, PEDIS, and WIFI scoring systems in assessing the risk of amputation in patients with diabetic foot ulcers at Prof. dr. I.G.N.G. Ngoerah General Hospital, Denpasar. **Methods:** This research is an observational study of diagnostic tests with a cross-sectional design. The sample in this study was selected by consecutive sampling from 1 January 2022 to 31 December 2022 with total of 72 respondents. **Results:** Wagner score test obtained sensitivity 77.2%, specificity 80.0%, PPV 93.6%, NPV 48%, accuracy 77.7%, and RR 1.8. PEDIS score test results obtained sensitivity 82.5%, specificity 86.7%, PPV 95.9%, NPV 56.5%, accuracy 83.3%, and RR 2.2. The results of the SINBAD test score obtained sensitivity 78.9%, specificity 66.7%, PPV 90.0%, NPV 45.5%, accuracy 76.3%, and RR 1.6. WIFI score test obtained sensitivity 89.5%, specificity 66.7%, PPV 91.1%, NPV 62.5%, accuracy 84.7%, and RR 2.4. **Conclusion:** The WIFI score has better sensitivity and accuracy, compared to score Wagner, SINBAD, and PEDIS so it is recommended to use the WIFI score to assess the risk of amputation in diabetic foot ulcer patients.

Keywords: Wagner, PEDIS, SINBAD, WIFI, diabetic foot ulcer.

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INTRODUCTION

Diabetes mellitus is a group of metabolic diseases characterized by hyperglycemia. Indonesia itself is the country with the fourth highest number of people with DM in the world with a prevalence of 8.4 million people. Predictions from the International Diabetes Federation (IDF) also explain that in 2013-2017 there was an increase in the number of people with DM from 10.3 million to 16.7 million in 2045.^{1,2,3}

One example of a chronic complication is diabetic foot, the process of diabetic foot

begins with angiopathy, neuropathy, and infection. In the diabetic population, it is estimated that as many as 15% will experience complications in the form of diabetic foot ulcers. It is estimated that 15-25% of the DM population will develop diabetic foot ulcers with high morbidity rates, of which 40-80% of patients have a risk of infection and 10-20% of patients require amputation.^{4,5}

More than ten scoring systems have been developed since the 1970s to date. Scoring systems are intended for patient identification and subsequent therapy.

Scoring systems can also be used to predict the amputation that will be performed. Various scoring systems are used to provide a more thorough and organized data analysis, thereby improving diagnostic accuracy and the appropriateness of treatment.⁶

METHODS

This study is a diagnostic test observational study with a cross sectional design that will analyze the validity of the Wagner, SINBAD, PEDIS, and WIFI scoring systems in assessing the risk of amputation in patients with diabetic foot ulcers at Prof. Dr. I.G.N.G. Ngoerah Hospital from January 1, 2022 to December 31, 2022. The sampling technique used was consecutive sampling technique.

This study using secondary data was obtained from medical records. The dependent variables in this study are Wagner score, SINBAD score, PEDIS score, WIFI score. The independent variable in this study is the risk of amputation in diabetic foot ulcer patients within the next 12 months. Control variables in this study are age, gender, smoking history, alcohol history, diabetes duration, diabetes type, ulcer duration, revascularization history, debridement history, diabetes medication history, comorbidities.

The variables with nominal and ordinal data will be analyzed by demonstrating absolute numbers and percentages from each variable and cross-tabulation data. Determination of cut-off score with Receiver Operating Characteristic curve (ROC Curve) to assess the feasibility of scoring system with Area Under the Curve (AUC) value. Diagnostic tests were conducted to determine sensitivity and specificity values as well as analysis of positive and negative predictive values.

RESULTS

Based on the results of descriptive statistics on the research data, 72 patients who met the research criteria were obtained. 32 male patients (44.4%) and 40 female patients (55.6%), with an average age of 60.21 ± 13.97 years with a median age of 58 years. Based on the onset of ulcers, the average age was 3.9 ± 2.6 months, the average duration of diabetes was 6.81 ± 4.84 years, with a total of 57 (79.2%) patients amputated, with above knee amputation as many as 40 (70.1%) patients and below knee amputation as many as 17 (29.9%) patients. Smoking history was found to be 27 (37.5%) patients, alcohol history 16 (22.2%) patients, insulin treatment history 57 (79.2%) patients, previous debridement history 21 (29.2%) patients, hypertension history 25 (34.7%) patients, cardiac history 16 (22.2%) patients, obesity history 10 (13.9%) patients, renal history 14 (19.4%) patients. The mean Wagner score was 3.82 ± 0.95 with a median of 4.0. The mean PEDIS score was 7.44 ± 2.18 with a median of 7.5. The mean SINBAD score was 4.25 ± 1.33 with a median of 4.0. The average WIFI score shows 5.72 ± 1.7 with a median of 6.0 (**Table 1**).

Based on the comparison of Wagner score and amputation risk, the p-value is 0.000, the comparison of PEDIS score and amputation risk is 0.000, the comparison of SINBAD score and amputation risk is 0.000, the comparison of WIFI score and amputation risk is 0.000, therefore it can be concluded that the four scoring systems show a significant relationship with amputation risk (**Table 2**).

To determine the ability of Wagner score, PEDIS score, SINBAD score and WIFI score in predicting amputation risk in patients with diabetic foot ulcers using ROC (Receiver Operating Characteristic) curve. The ROC curve assessment based on the area under curve (AUC) stated that if $\geq 80\%$ is considered statistically significant. Cut off point of

Wagner score, PEDIS score, SINBAD score of point, diagnostic tests (sensitivity, and WIFI score is based on on youden index specificity, positive predictive value, negative obtained Wagner is 3.5 (YI=0.572), PEDIS is predictive value, accuracy) will be conducted. 6.5 (YI=0.691), SINBAD is 3.5 (YI=0.456) (Table 3) (Figure 1). and WIFI is 4.5 (YI=0.561). Based on the cutt

Table 1. Demographic characteristics of the study sample (n=72)

Variable	Mean ± SD	Median
Age	60.21 ± 13.97 years	58 years
Ulcer Onset	3.9 ± 2.6 months	3 months
Duration of Diabetes	6.81 ± 4.84 years	5 years
Wagner Score	3.82 ± 0.95	4.0
PEDIS Score	7.44 ± 2.18	7.5
SINBAD Score	4.25 ± 1.33	4.0
WIFI Score	5.72 ± 1.7	6.0
Variable	Yes	No
	27 (37.5%)	45 (62.5%)
Alcohol History	16 (22.2%)	56 (77.8%)
Medication History	57 (79.2%)	15 (20.8%)
Debridement History	21 (29.2%)	51 (70.8%)
Hypertension History	25 (34.7%)	47 (65.3%)
Cardiac History	16 (22.2%)	56 (77.8%)
Obesity History	10 (13.9%)	62 (86.1%)
Renal History	14 (19.4%)	58 (80.6%)
Amputation	57 (79.2%)	15 (20.8%)
Above Knee	40 (70.1%)	
Below Knee	17 (29.9%)	

Table 2. Cross Table of Four Scoring for Amputation (n=72)

Characteristics	Criteria		p-value
	Amputation	Non Amputation	
Scoring Wagner			
Wagner 1	0 (0.0%)	1 (6.7%)	0.000
Wagner 2	0 (0.0%)	5 (33.3%)	
Wagner 3	13 (22.8%)	6 (40.0%)	
Wagner 4	25 (43.9%)	3 (20.0%)	
Wagner 5	19 (33.3%)	0 (0.0%)	
Scoring PEDIS			
PEDIS 2	0 (0.0%)	1 (6.7%)	0.000
PEDIS 3	0 (0.0%)	2 (13.3%)	
PEDIS 4	1 (1.8%)	5 (33.3%)	
PEDIS 5	1 (1.8%)	2 (13.3%)	
PEDIS 6	8 (14.0%)	3 (20.0%)	
PEDIS 7	12 (21.1%)	1 (6.7%)	
PEDIS 8	10 (17.5%)	1 (6.7%)	
PEDIS 9	12 (21.1%)	0 (0.0%)	
PEDIS 10	8 (14.0%)	0 (0.0%)	
PEDIS 11	4 (7.0%)	0 (0.0%)	
PEDIS 12	1 (1.8%)	0 (0.0%)	
Scoring SINBAD			
SINBAD 1	0 (0.0%)	2 (13.3%)	0.000
SINBAD 2	1 (1.8%)	4 (26.7%)	
SINBAD 3	11 (19.3%)	4 (26.7%)	
SINBAD 4	13 (22.8%)	2 (13.3%)	
SINBAD 5	19 (33.3%)	2 (13.3%)	

SINBAD 6	13 (22.8%)	1 (6.7%)	
Scoring WIFI			
WIFI 2	0 (0.0%)	4 (26.7%)	
WIFI 3	0 (0.0%)	3 (20.0%)	
WIFI 4	6 (10.5%)	3 (20.0%)	
WIFI 5	12 (21.1%)	2 (13.3%)	0.000
WIFI 6	16 (28.1%)	2 (13.3%)	
WIFI 7	13 (22.8%)	1 (6.7%)	
WIFI 8	7 (12.3%)	0 (0.0%)	
WIFI 9	3 (5.3%)	0 (0.0%)	

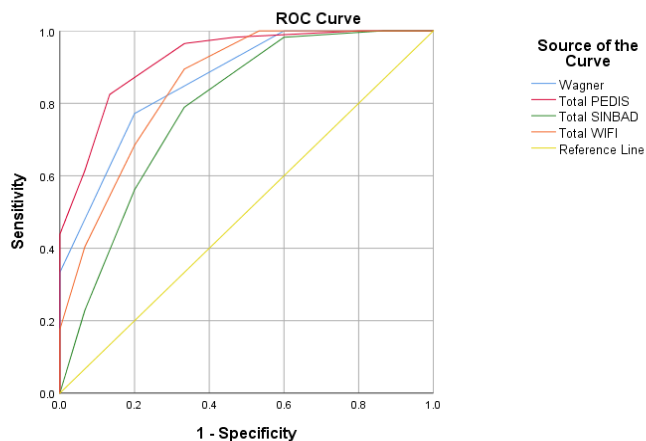


Figure 1. ROC curves of Wagner, PEDIS, SINBAD, and WIFI.

Table 3. Area Under Curve

Scoring	AUC value	IC 95%	p-value
Wagner	86.5%	0.764-0.966	0.000
PEDIS	92.2%	0.848-0.997	0.000
SINBAD	78.4%	0.638-0.931	0.001
WIFI	85.3%	0.735-0.971	0.000

Table 4. Validity Test of Wagner Score System, PEDIS Score, SINBAD Score, and WIFI Score on Amputation

Variable	Criteria		SN	SP	PPV	NPV	ACC	RR	p
	Amputation	Amputation							
Wagner									
≥3.5	44	3	77.2%	80%	93.6%	48%	77.7%	1.8	0.000
<3.5	12	12							
PEDIS									
≥6.5	47	2	82.5%	86.7%	95.9%	56.5%	83.3%	2.2	0.000
<6.5	10	13							
SINBAD									
≥3.5	45	5	78.9%	66.7%	90.0%	45.5%	76.3%	1.6	0.001
<3.5	12	10							
WIFI									
≥4.5	51	5	89.5%	66.7%	91.1%	62.5%	84.7%	2.4	0.000
<4.5	6	10							

Validity Test of Wagner Score System, PEDIS Score, SINBAD Score, and WIFI Score, based on the crossing table of cut off values with amputation incidence, the sensitivity, specificity, positive predictive value, negative predictive value, accuracy were obtained. The highest sensitivity is WIFI score (89.5%), the highest specificity is PEDIS score (86.7%), the highest positive predictive value is PEDIS score (95.9%), the highest negative predictive value is WIFI score (62.5%), the highest accuracy is WIFI score (84.7%), and the highest RR is WIFI score (2.2) (**Table 4**).

DISCUSSION

Characteristics of respondents based on gender obtained male patients amounted to 44.4% and women amounted to 55.6%. Different research results were obtained in a study conducted by Vanherwegen (2019) they found that men had a higher risk of amputation than women. Studies show that men tend to have lower levels of adherence to diabetes management. Studies have also identified social and psychological factors that contribute to the risk of amputation in diabetic foot ulcers. Some studies have shown that men tend to have higher levels of depression and lower social support, which can affect diabetes management and wound care. Based on age, the mean age was 60.21 ± 13.97 years with a median age of 58 years. In Yusuf's (2016) study, he observed a population of veterans with diabetes in Indonesia and found that the risk of amputation increased significantly with age, especially at ages above 60 years. Based on ulcer onset in this study, the mean age was 3.9 ± 2.6 months, with an average diabetes duration of 6.81 ± 4.84 years. Al-Rubeaan (2015) conducted a study showing that longer diabetes duration (>10 years) increases the

risk of amputation in patients with diabetic foot ulcers.^{7,8,9}

Characteristics of respondents based on smoking history obtained (37.5%) patients, history of alcohol (22.2%) patients, history of insulin treatment (79.2%) patients, history of hypertension (34.7%) patients, history of heart (22.2%) patients, history of obesity (13.9%) patients, history of kidney disease (19.4%) patients. In a study by Kim et al. (2018) found that smoking and alcohol can worsen wound healing in patients with diabetic foot ulcers and increase the risk of amputation. Smoking and alcohol damage blood vessels and worsen peripheral circulation in diabetic patients. Zheng's (2018) study found that poor blood sugar control, as measured by high HbA1c, was an independent risk factor for amputation in patients with diabetic foot ulcers. Shin's (2017) study showed that a comorbid history of other diseases such as hypertension, heart disease, and kidney disease, significantly increased the risk of amputation in diabetic foot ulcer patients. However, dyslipidemia, obesity, retinopathy, and neuropathy showed no statistically significant difference.^{10,11}

Different sensitivity and specificity rates of Wagner scoring systems have been reported. Similar results were also obtained in a study by Jeon (2017) comparing several scoring systems at Cheonan Hospital in Korea in 137 patients with the results of Wagner's score with 75% sensitivity, 66% specificity, 50% positive predictive value, 66% negative predictive value with 85% accuracy. The Wagner scoring system showed the most predictive results in the study, the Wagner scoring system has the advantage of being the simplest scoring compared to other scoring systems, but has the disadvantage of not specifically assessing matters related to infection, vascularization, and neuropathy of diabetic foot ulcers.⁶

In Chuan's research (2015) in Chongqing Hospital China showed a similar thing, namely a score ≥ 7 indicates the risk of amputation in the next 6 months to 1 year. In the study, the sensitivity value was 93%, specificity 82%, positive predictive value 80%, negative predictive value 61% with accuracy 87.5%. The study, which compared several scoring systems, showed that the PEDIS scoring system had the best capacity to predict amputation risk compared to other scoring systems especially in Asian populations.¹²

In a study by Jeon (2017) comparing several scoring systems, the results obtained were 63% sensitivity, 91% specificity, 88% positive predictive value, 72% negative predictive value with 77% accuracy. Similar results were obtained in a study that showed the SINBAD scoring system showed the lowest accuracy compared to other scoring systems. The study showed that the SINBAD score was originally created in Western populations so it is less suitable when applied to Aia and Middle Eastern ethnicities. Other studies have also shown that ethnic differences affect the accuracy of SINBAD scores.⁶

In Jeremy's research (2017) which conducted a diagnostic test of the WIFI score as a predictor of major amputation in patients with diabetic foot ulcers at Beth Israel Deaconess Medical Center in the United States in 1336 diabetic foot ulcer patients, it was found that the sensitivity was 82.3%, specificity 80%, positive predictive value 90.29%, negative predictive value 66.6% with accuracy 93.3%. In this study, high accuracy was obtained as a predictor of major amputation in the next 1 year. The study has limitations because it is a retrospective study so that it can allow data bias. The data presented came from one institution so that the results of the study were influenced by patient preferences and the experience of surgeons at that institution.¹³

CONCLUSION

The WIFI score has better sensitivity and accuracy than the Wagner, PEDIS, and SINBAD scores so it is recommended to use this WIFI score to assess the risk of amputation in patients with diabetic foot ulcers. It is hoped that it can improve the quality of surgical services better through the use of a scoring system to assess the risk of amputation in patients with diabetic foot ulcers, so that faster and holistic treatment can be carried out.

DECLARATIONS

All the writers have no conflict of interest in this study publication

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