

## Correlation of Spectral Doppler USG of Limb with PEDIS Score on Diabetic Foot Ulcers

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**Introduction:** Diabetic foot ulcer is one of the most severe complications in a patient with diabetes mellitus because it will lead to with amputation, which results in disability and death. Doppler ultrasound is an easily available and non-invasive modality for evaluating lower limb arteries and can detect the severity of blood flow disorders or peripheral arterial disease (PAD). WHO recommends the classification of perfusion, extent/size, depth/tissue loss, infection, and sensation (PEDIS) as a tool for establishing the diagnosis and helping determine the management of diabetic foot. This study aims to see the correlation of PEDIS scores in assessing impaired lower limb arterial flow with Doppler ultrasound in patients with diabetic foot ulcers.

**Method:** This was a cross-sectional study with subjects who has diabetic foot ulcer treated in the Division of Vascular and Endovascular Surgery, Cipto Mangunkusumo Hospital, Jakarta, Indonesia. The data of PEDIS scores and spectral ultrasound in the femoral artery, popliteal artery, dorsalis pedis artery, and posterior tibial artery were taken.

**Results:** As many as 81 subjects participated in this study, with 52 people (64%) were male, 29 people (36%) were female, and an average age of  $59.8 \pm 10.5$  years. Pedis cut-off scores were obtained using ROC (receiver operating characteristic) curves, with popliteal arteries scores of  $>10$ , dorsalis pedis arteries, and posterior tibial arteries scores of  $>8$  had the best values as diagnostic tools compared to USG as reference standards.

**Conclusion:** PEDIS score could be use as assessment for impaired lower limb arterial flow, compare to Doppler ultrasound.

**Keywords:** PEDIS score, Doppler ultrasound spectral, diabetic foot ulcer  
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### INTRODUCTION

Diabetic foot ulcers (DFU) is one of the most severe complications in patients with diabetes mellitus because it often ends in amputation, which results in disability and death. Various treatment methods have been developed, but until now, there is still limited satisfactory results. A diabetic foot ulcer is a disease that consumes many resources and can reduce the quality of life of patients.<sup>1-3</sup> On the other hand, research at Cipto Mangunkusumo Hospital showed that the prevalence of diabetic foot ulcers in Indonesia was 25% in outpatient care. This high prevalence is evidence that more efforts are needed in the management of diabetic foot ulcers in Indonesia.<sup>4,5-7,8,9</sup>

The WHO recommends the perfusion, extent/size, depth/tissue loss, infection, and sensation (PEDIS) classification system established by the International Working Group of the Diabetic Foot (IWGDF) as a tool for diagnosing and helping

determine the management of diabetic foot.<sup>5,6,10-13</sup> Another tools, Doppler ultrasound, is a non-invasive modality for evaluation of lower limb arteries and can detect the severity of blood flow disorders or peripheral arterial disease (PAD) with a sensitivity of 42.8% and a specificity of 97.5%. Doppler ultrasound examination can provide information on the severity of stenosis by giving the picture of waveforms of blood flow in the arteries. Most often, PAD occurs in DM patients involving blood vessels ranging from the popliteal arteries distally.<sup>8,14,15</sup> This study aims to determine the relationship of spectral findings of Doppler ultrasound with the severity of diabetic foot ulcers (PEDIS score).

### METHOD

This research was a cross-sectional study. The sample used was diabetic foot ulcer patients treated in the Division of Vascular and Endovascular Surgery, Cipto Mangunkusumo Hospital, Jakarta.



**Table 2.** Clinical characteristics of research subjects in each risk group PEDIS score.

Clinical characteristics	Risk groups based on PEDIS score (n=81)			
	Low <7 (n=8)		High ≥7 (n=73)	
	n	%	n	%
Male	3	3,7	49	60,5
Female	5	6,2	24	29,6
Age, mean (years)	56,4 ± 2,7		60,2±1,3	
Blood sugar level, mean (mg/dL)	295,5± 58,9		297,9 ± 11,6	
PEDIS score, median	6,0		9,0	
Hypertension	4	4,9	24	29,6

Inclusion criteria were diabetic foot ulcer patients, and the patient's condition allows for a vascular ultrasound examination. Patients with malignancy, coagulopathy, non-diabetic peripheral vascular disease, and had undergone amputation of the limb were excluded.

In addition, the assessment of the PEDIS classification was carried out after debridement, and necrotomy had previously been done on diabetic foot ulcers. The Doppler ultrasound examination was done with the patient lying in a supine position and not wearing shoes, socks, or stockings. The Doppler ultrasound then examined the femoral artery, popliteal artery, posterior tibial artery, and dorsalis pedis artery, and then their spectral picture was recorded. The data was then analyzed using SPSS version 20 for Windows®.

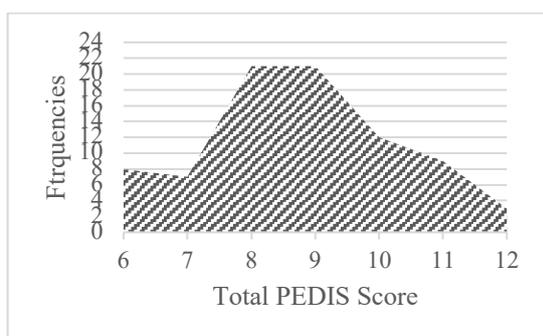
## RESULTS

From 81 of patients included in the study, obtained data on the characteristics of the study subjects in the form of gender, age, and blood sugar level at the time of the initial examination and other co-morbidities in the form of hypertension (Table 1).

**Table 1.** Clinical characteristics of research subjects.

Characteristics	Total (n=81)	
	n	%
Male	52	64,2
Age, mean (years)	59,8 ± 10,5	
Blood sugar level mean (mg/dL)	297,6± 21,8	
PEDIS score, median	9	
Hypertension	28	34,6

The total data of PEDIS score patients were then grouped based on the risk profile, which was a high risk (>7) and low risk (<7) group. A total of 8 patients had a low-risk PEDIS score (<7), and a total of 73 remaining had a high-risk PEDIS score (>7) [Figure 1]. The description of the characteristics of each risk group was then calculated (table 2).

**Figure 1.** Distribution of research subjects based on total PEDIS score.

The data from ultrasound examination results on the femoral artery, popliteal artery, dorsalis pedis artery, and posterior tibial artery were taken, which were the gold standard on examination of diabetic foot ulcers. Each ultrasound examination results were then grouped into normal (triphasic) and abnormal (biphasic, monophasic, and absent groups) [table 3].

**Table 3.** Results of abnormal Doppler ultrasound based on arterial position.

Artery	n	%
Femoralis		
Normal	79	97.5%
Abnormal	2	2.5%
Poplitea		
Normal	23	71.6%
Abnormal	58	28.4%
Dorsalis Pedis		
Normal	11	13.6%
Abnormal	70	86.4%
Tibialis Posterior		
Normal	11	13.6%
Abnormal	70	86.4%

PEDIS scores in each ultrasound group and the results of the ultrasound examination in each artery were then analyzed using the paired T-test. The results of data processing showed a significant relationship ( $p < 0.001$ ) between PEDIS scores and ultrasound spectrum in the popliteal artery, dorsalis pedis artery, and posterior tibial artery (table 4).

After knowing the relationship between the PEDIS score and the ultrasound examination, data analysis was continued by conducting a diagnostic test with the results of the ultrasound examination as a reference standard (table 5).

The sensitivity and specificity values above were then included in the ROC curve analysis. ROC curve analysis was performed to look for a description of the accuracy of PEDIS scores qualitatively and quantitatively (figure 3).

From the results of the ROC curve analysis, quantitative analysis was carried out to find the level of accuracy using the area under the curve (AUC) calculation of each of these values. An optimal cut-off was also obtained based on the best sensitivity and specificity values on the ROC curve (Table 6).

Further analysis was carried out by looking for the relationships between each component of the PEDIS score, which includes perfusion, extent, depth, infection, and sensory with each artery on ultrasound examination (table 7). Analysis of each component was carried out to find out which component had the most significant relationship with the results of the ultrasound examination.

**Table 4.** Patient pedis scores based on artery location.

Artery		N	Mean	Std. Deviation	p
Popliteal	Normal	58	8.12	±1.201	0,001
	Abnormal	23	10.35	±1.112	
Dorsalis pedis	Normal	11	6.45	±0.688	0,001
	Abnormal	70	9.11	±1.314	
Tibialis posterior	Normal	11	6.27	±0.467	0,001
	Abnormal	70	9.14	±1.266	

**Table 5.** Results of diagnostic tests with PEDIS scores with a cut-off of 7 using USG result as reference standard.

	Popliteal		Dorsalis pedis		Posterior tibial	
	Estimate	95% CI	Estimate	95% CI	Estimate	95% CI
Sensitivity	25.86%	(16.35-38.38)	66.67%	(41.71-84.82)	100%	(74.12-100)
Specificity	100%	(85.69-100)	98.48%	(91.9-99.73)	94.29%	(86.21-97.76)
PPV	100%	(79.61-100)	90.91%	(62.26-98.38)	73.33%	(48.05-89.1)
NPV	34.85%	(24.48-46.89)	92.86%	(84.34-96.91)	100%	(94.5-100)
Accuracy	46.91%	(36.43-57.67)	92.59%	(84.77-96.56)	95.06%	(87.98-98.06)

**Table 6.** Analysis of ROC relationship between PEDIS score and Doppler ultrasound.

Artery	Area Under The Curve (AUC)	P	95% CI AUC		Cut-off point PEDIS score
			Lower	Upper	
Popliteal	0.918	0.045	0.850	0.985	>10.000
Dorsalis pedis	0.763	0.000	0.657	0.869	>8.000
Tibialis posterior	0.829	0.000	0.740	0.919	>8.000

**Table 7.** Correlation of each pedis score component compared with the results of the USG examination

		Femoral	Popliteal	Dorsalis pedis	Tibialis posterior
		P	r	-0.266	-0.573
	p	0.017	0.001	0.001	0.000
E	r	-0.139	-0.246	-0.443	-0.244
	p	0.216	0.027	0.001	0.028
D	r	-0.049	-.204	-0.149	-0.294
	p	0.665	0.067	0.185	0.008
I	r	0.037	-0.400	-0.417	-0.496
	p	0.744	0.001	0.001	0.000
S	r	0.109	-0.172	-0.100	-0.361
	p	0.331	0.126	0.375	0.001

## DISCUSSION

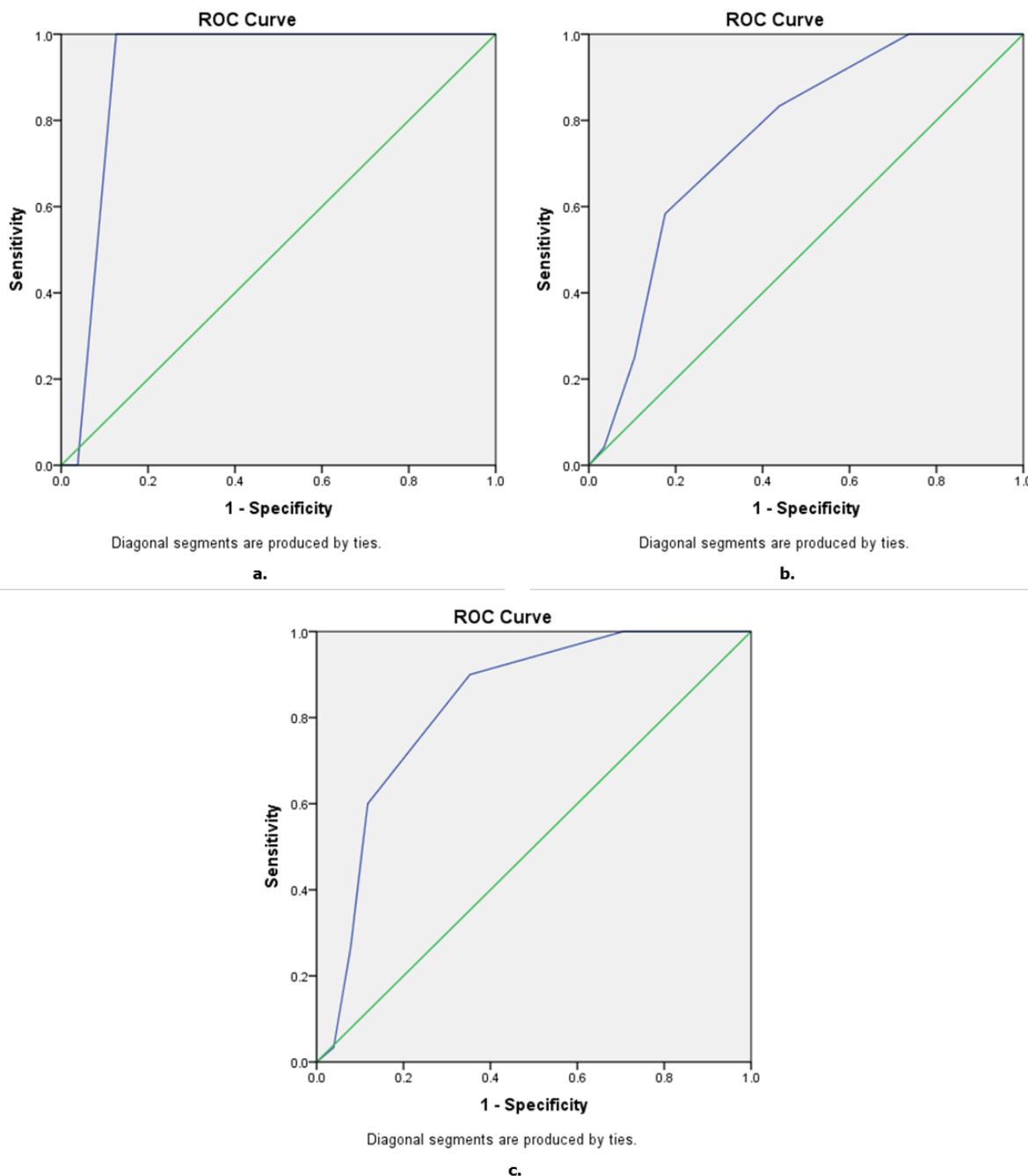
In this study found 81 subjects with 52 people (64%) were male, and 29 people (36%) were female. Several epidemiological studies of other diabetic foot ulcers in Romania (2008), Sydney (2011), and Egypt (2012) showed that the incidence of diabetic foot ulcers was highest in males, with a ratio of 2:1.<sup>16-18</sup>

In this study, the average age was 59.8 ± 10.5 years. Research by Zaine et al.,<sup>17</sup> and Nwabudike et al.,<sup>19</sup> showed that the highest incidence of diabetic foot ulcers was in the 6<sup>th</sup> decade of life. Research in America also reports that the percentage of the diabetic foot was highest at the age of 45-64 years. As we know, the elderly usually have limited mobility, poor vision, and other disease problems. Diabetic foot related to old age disease is very high because, at this age,

physiological function decreases. In the elderly with DM, mostly, they do not seek treatment regularly so that complications of DM itself such as diabetic foot ulcers occur faster than it should if blood sugar levels are always well controlled.

The results of the analysis showed that PEDIS scores were significantly different between normal and abnormal Doppler ultrasound in the location of the popliteal, dorsal, and tibial arteries. All abnormalities showed a higher PEDIS score. Normal Doppler spectral images in all lower extremity arteries are more likely to heal, whereas abnormal Doppler spectral images tend to be difficult to heal.

When conducting diagnostic tests to determine the cut-off pedis score using the receiver operating characteristic (ROC) curve, a popliteal artery cut-off score of >10 was obtained, while the dorsalis pedis artery and the posterior tibial artery



**Figure 2.** ROC curves for relationship between PEDIS Score and ultrasound examination results on (a) popliteal arteries, (b) dorsalis pedis arteries, and (c) posterior tibial arteries.

score was >8. From the analysis of the ROC curve between the PEDIS score and the findings of the ultrasound, it was found the value of the area under the curve (AUC) in the popliteal artery, dorsalis pedis artery, and posterior tibialis artery were 0.918, 0.783, and 0.829 respectively.

**CONCLUSION**

There was a correlation between PEDIS scores with Doppler ultrasound spectral images. The higher the PEDIS score, the worse the Doppler ultrasound spectral picture. It was found in the popliteal artery, the dorsalis pedis artery, and the posterior tibial artery, but not in the femoral artery. Further research using cohort and larger sample research methods is recommended.

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