The diabetic foot

Value of vascular integrity indicators in the assessment of its severity

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Abstrak

Selama 5 tahun kami melakukan penelitian pada 312 penderita (88 laki-laki dan 224 wanita) dengan kaki diabetik yang ditangani pada 4 rumah sakit di Semarang. Umur penderita berkisar 24-76 (55.5±10.5) tahun. Selain umur dan jenis kelamin, indikator dari integritas vaskular (claudication intermiten, rest pain, hiperaemia reaktif, denyut arteri, tekanan ibu jari kaki, ankle pressure index (API) dan arteriografi) dinilai untuk menentukan berat-ringannya kaki diabetik. Analisa dengan model regresi menunjukkan korelasi yang kuat antara indikator-indikator integritas vaskular dan beratnya kaki diabetik (F=72.576, p=<0.01); 212 dari 312 penderita yang dilakukan pemeriksaan arteriografi menunjukkan gangguan integritas vaskular yang tidak ditemukan pada 100 penderita lainnya, sebaliknya, gejala dan tanda klinis menunjukkan gangguan integritas vaskular pada 214 dari 312 penderita yang diperiksa dengan 4 indikator integritas vaskular (claudication intermiten, denyut arteri, API dan tes jalan kaki). Analisa regresi menunjukkan korelasi yang kuat antara kombinasi keempat indikator vaskular tersebut dan berat-ringannya kaki diabetik (F=44.55; p<0.01), dengan sensitifitas of 86,79%, spesifisitas 43%, nilai ramal positif dan negatif berturut-turut 76,35% dan 65,56% pada prevalensi of 42%. Penelitian tersebut menunjukkan bahwa diagnosa berdasarkan pada kombinasi dari 4 indikator integritas vaskular yang telah disebutkan (claudication intermiten, denyut arteri, API dan tes jalan kaki) masih mempunyai nilai informatif yang cukup tinggi, khususnya pada keadaan dimana arteriografi tidak dapat dilakukan.

Abstract

During a five years period we conducted a study over 312 (88 males and 224 females) patients with diabetic foot treated at 4 hospitals in Semarang. The ages ranged from 24 to 76 (55.5 ± 0.5) years. Apart from age and sex, the indicators of vascular integrity (intermittent claudication, rest pain, reactive hyperaemia, arterial pulse, toe pressure, ankle pressure index [API] and arteriography) as well as the severity of diabetic foot were investigated. Analysis with a regression model revealed high correlation between vascular integrity indicators and the severity of the diabetic foot (F=72.576, p ≤ 0.01); 212 out of the 312 patients who underwent arteriographic investigation suggested disturbed vascular integrity, which was not found in the remaining 100; on the other hand, symptoms and signs suggesting disturbed vascular integrity were found in 214 of the 312 patients tested with a combination of four vascular integrity indicators (intermittent claudication, arterial pulse, API and walk test). Regression analysis demonstrated a high correlation between the combination of these 4 vascular integrity indicators and the severity of the diabetic foot (F=44.55; p < 0.01), with a sensitivity of 86,79%, specificity of 43%. The positive and negative predictive value being respectively 76,35% and 65,56% at the prevalence of 42%. The study demonstrates that diagnostic clues based on the combination of the mentioned 4 vascular integrity indicators are still highly informative, especially in situations where arteriography cannot be performed.

Keywords: *Vascular integrity indicators, diabetic foot, arteriography*

The role of vascular and nonvascular factors in the progression of the diabetic foot as well as on the predictive values of vascular integrity indicators in assessing its severity are still remains controversies.[1-3]

Several vascular integrity factors namely history, vascular physical examination and arteriography are fails to demonstrate sensitive and consistent correlation with the ocurrence and severity of the diabetic foot lesion. The existence of intermittent claudication denotes a good prognosis since only 5-10% of the cases progresing into gangrene while rest pain is related to a poorer prognosis.[4] The presence of popliteal pulse is not per se a guarantee of good distal vascularization since arterial occlusions seen in diabetic foot occurs mainly in the leg. Similarly, pulsation of the dorsalis pedis artery is often still palpable in patients with toe gangrene.[3,5] Another indicator of foot vascularization is the ankle pressure index (API), that is, the ratio of pressure of the dorsalis pedis or tibialis posterior to the brachial artery. This, again, is not allways a good

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indicator of the actual vascular state of the foot since high APIs are often found owing to diabetic intima calcification rendering the artery incompressible in the affected area.[6,7]

On the other hand, while arteriography is highly informative about the presence of occlusive or stenotic vascular lesions, it often fails to demonstrate actual vascular integrity and, being an invasive procedure not rarely related with complications, it is even an unreasonable test in a number of situations such as in cases of renal pathology.[2,8,9]

It seems from the above discussion that albeit the ample publication on the matter, the contribution of individual factors to the progression of the diabetic foot, with or without considering the vascular integrity disturbances, requires further investigation.

This work aims to assess the contribution of each of the vascular integrity indicators in the assessment of the gangrene severity and, on the other hand, taking the arteriographic findings as reference, to assess the reliability of the other indicators or their combination to assess the severity and degree of extension of the lesion in the diabetic foot.

PATIENTS AND METHODS

The study was performed at four hospitals in Semarang, namely Dr Kariadi Hospital, St Elizabeth Hospital, Telogorejo Hospital and Sultan Agung Hospital. A total of 312 patients attending the vascular department of those hospitals with symptoms of diabetic foot during five consecutive years were retrospectively investigated. The age and sex of each patient were recorded, as well as symptoms and signs considered indicators of vascular integrity (intermittent claudication, rest pain, walk test, arterial pulsation, toe pressure, ankle pressure index [API] and arteriography) and the severity of the lesion.

For convenience of the study the age was limited to 20 to 80 years. Intermittent claudication was defined as pain on the foot, leg or hip, felt on walking but resumed on rest (Table 1). Rest pain was defined as pain felt on the foot, leg or thigh worsened by walking (Table 2). Arterial pulsation was recorded by palpating the dorsalis pedis and the tibial artery after 10 minutes of rest (Table 3). API was obtained after measurement of the arterial pressure of the arm and the leg, being it the ratio of the leg arterial pressure to the brachial pressure. It was recorded as being higher, equal or less than 1.

Walk test was performed by having the patient walking on the treadmill, after which (ie on rest) the systolic pressure of the dorsalis pedis or posterior tibial artery was being recorded. The test was performed during 5 minutes or until pain ensues. Arterial pressure measurements were taken prior to the test and in the following 12 minutes. The return of the arterial pressure to its basal value was recorded and graded (Tabel 4). The Toe Pressure Index (TPI) was obtained in the simillar way as the API with the difference of using the toe arterial pressure instead that of the leg. Arteriographic findings were graded 1 to 6 (Tabel 6). The criteria for diabetic foot severity was graded after Wagner,[10] wich ranged from 0 to 5.

Clinical and arteriographic findings were analysed using a regression model aimed to determine the vascular integrity indicator related to the severity of the lesion, the value of the correlation and the diagnostic

Table 1. Gradings of intermittent claudication

1. No complaint
2. Pain on walking but subsides on rest
3. Severe pain interfering with normal daily activities

Table 2. Gradings of rest pain

1. No complaint
2. Pain persists at rest
3. Severe, awakes patient from sleep

Table 3. Gradings of arterial pressure

1. Present
2. Weak
3. Absent

Table 4. Grading of walk test

1. Less than 2 minutes
2. 2-6 minutes
3. 6-12 minutes
4. more than 12 minutes
5. the time required to the reverse of the arterial pressure to its normal (basal) value

Table 5. Gradings of TPI

1. Sytolic pressure of the toe is ≥ 80% of the pressure measured at the leg
2. Sytolic pressure of the toe is 60-80% of the pressure measured at the leg
3. Sytolic pressure of the toe is 15-60% of the pressure measured at theleg
4. Sytolic pressure of the toe is les than 15% of the pressure measured at the leg

Tabel 6. Gradings of arteriography findings

1. normal arteriographic appearance
2. occlusive appearance of less than 50% in a single artery
3. less than 50% occlusion in 2-3 arteries of the leg
4. more than 50% occlusion in a single artery
5. occlusion of more than 50% in or 3 arteries of the leg
6. more than 50% occlusion in 2 or 3 arteries of the leg, as sociated
7. with poor foot vascularization denoted by the abscence of branches of the dorsalis pedis and tibialis posterior arteries

contribution of the combination of four vascular integrity indicators (intermittent claudication, rest pain, arterial pulsation, toe pressure and API) in terms on sensitivity, specificity, predictive values and efficiency.

Vascular integrity as indicated by the combination of those 7 parameters was scored 7 (good) to 26 (poor). With the scores 9 and 10 as limits, standing respectively for good and disturbed vascular integrity.

RESULTS

Eighty eight male and 224 female diabetic foot patients were included in this study. The mean age was 55.5 ± 10.5 (24-76) years. Most of the 188 patients (102 vs 86) who complained intermittent claudication had a grade 1 lesion. Rest pain was complained by 166 patients, mainly (60%) were grade 1. The pulsation of the dorsalis pedis or tibialis posterior artery was good in 180 patients, weak in 50 and abscent in 82. Walk test performance was normal in 188 patients; the disturbances noted in the remaining patients were, respectively, grade 1 in 34 patients, grade 2 in 38 and grade 4 in 52. The mean to pressure was 94 ± 34 (30-200) mmHg while the TPI was 80% in 129 patients, in the range of 60-80% in 69 and 15-59% in 114; there was no patient with a TPI of less than 15%. API higher than 1 was found in 134 patients, equal to 1 in 22, and less than 1 in 150 patients. Arteriographic findings consisted of 100 patients with a grade 2 anomaly, while grades 3 to 5 consisted of 93, 44 and 24 patients respectively.

It was found that 240 (76,9%) patients had disturbed vascular integrity ranging from grade 1 (light) to grade 3 (severe).

Lesion extension and severity as found in the toes, on the foot (plantar and dorsal surfaces), on the arms and legs was represented in a combined score ranging from 1 to 17; a score of ≤ 6 was considered light, 7-12 mild and ≥ 13 severe. Light lesion was found in 225, mild in 57 and severe in 30 patients.

Table 7. The role of the vascular integrity indicators on the progression of the diabetic foot lesion

Variable	Correlation (r)	Relative contribution (%)	Effective contribution (%)
Arteriography	0.769	65.909	41.235
Toe pressure	0.537	10.324	6.459
API	0.433	6.177	3.864
Arterial pulsation	0.543	6.056	3.789
Intermittent claudication	0.512	5.229	3.271
Walk test	0.429	5.165	3.231
Rest Pain	0.380	1.141	0.741

Regression analysis showed a high correlation ($F=72.576$, $p < 0.01$) between those 7 indicators and the severity of the lesion as the dependent variable, where arteriographic was found to have the highest correlation (Table 7).

Varied degrees of disturbed vascular integrity was found in 121 out of the 312 patients who underwent arteriographic examination; in the remaining 100 no disturbance was found. On the other hand, a combination of four vascular integrity indicators (intermittent claudication, rest pain, arterial pulsation, toe pressure, and API) demonstrated presence of vascular disturbance in 214 out of the 312 patients (Table 2). Diagnostic tests on that combination showed a sensitivity of 86.79%, specificity of 43%, and within the prevalence of 43%, the positive and negative predictive values were respectively 76.35% and 60.56%.

Table 8. Parallel diagnostic test of 4 vascular integrity indicators against arteriography

		Arteriography		
		Vascular integrity		
		Disturbed	Good	Total
4 vascular Integrity Indicators	≥ 11	184	57	241
	≤ 11	28	43	71
	Total	212	100	312

Regression analysis showed a high correlation ($F=44.55$, $p < 0.01$) between the combination of the named four indicators and the severity of the lesion (Table 8).

DISCUSSION

Although a few technical limitations (possibility of hemorrhage, infection and lack of information concerning the actual hemodynamic statue) merit some considerations,[8,11,13] arteriography still remains the gold standard examination. Since most of the clinical vascular examinations depends on the state of the popliteal, collateral of the tibial and peroneal arteries and the extent of resistance of the arteries of the foot, arteriography is the generally recomended routine procedure in diabetic foot cases.[14] Furthermore, it is supported by the fact that arteriography yealds not only information concerning the presence or abscence of occlusive or stenotic vascular lesions, but also its extent and the existence or abscence of collaterals.

In this study arteriography was found to be higly correlated with the severity of the lesion in diabetic foot, and discloses information on the existence and extension of occlusive and stenotic lesions as well as the existence or abscence of collaterals. On the other hand, given the limitations related to equipment and technical requirements as well as the possibility of complications related to the nature of the arteriographic investigation, other simple but still reliable tests must be looked for.

The limited diagnostic information yielded by single tests can be overcomed by a combination of a number of tests performed in parallel or as a battery.

Arterial pulsation is, among all of the vascular integrity indicators, the most simple test. Although some investigators have some doubts concerning its reliability[8] since it can still be felt on the presence of a distal grangene and also gives no information about the vascular state of the toes, of the arterial pulsation is still a realiable examination especially to predict the healing process; in 265 diabetic gangrene patients with a palpable arterial pulsation Sizer and Weelcock[15] found that only 2,5% of the amputation wounds did not heal, while in 11% of 227 patients with no palpable arterial pulsation the amputation wound did not heal.

API is an examination that is allways suggested in cases of vascular disturbances, either diabetic or not. Furthermore, because its results are almost allways stable, it is often used as a mean to evaluate treatment. Thomas et al.,[16] demonstrated the importance of API in limb salvage and evaluation of vascular reconstruction.

Between intermittent claudication and rest pain which are anamnestic informations, intermittent claudication proved to be more reliable. Thus, with a good information gathering, the very characteristic complaint of intermittent claudication can be elicited in order to trace the location and severity of the existent vascular disturbance. On the other hand, rest pain seems to be a weak vascular integrity indicator; as demonstrated by several investigators[16,17], this can be explained on the basis of diabetic neuropathy which often raises pain not related to any existing vascular disturbance.

The results showed that a combination of four vascular integrity indicators (intermittent claudication, rest pain, arterial pulsation, toe pressure, and API) yielded a quite high sensitivity (86,79%) although the specivity (43%) is quite low. On the other hand, they are examinations with a certain degree of acuracy, safety and can be performed with lesser expenses than arteriography.

With a specivicity of 43% it means that the combination of theses four parameters shows anomalies in a great number of patients with still good vascular integrity; however, with a sensitivity of 86,75% it means that only a few number of patients with vascular disturbance fail to be detected by the combination of these tests. In that view, these tests can pe performed in any primary health center (Puskesmas) as a screening procedure prior to referral a more equiped centers of care.

CONCLUSIONS

This study demonstrates that among the vascular integrity indicators, intermittent claudication, walk test, arterial pulsation and API are the simplest and cheapest non invasive tests with a reliable accuracy.

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