ORIGINAL ARTICLE

Toe Brachial Pressure Index as Alternative Method to Correlate Arteriosclerotic Disease in Type 2 Diabetes

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Abstract

Aim: To investigate the association between the ankle brachial pressure index and toe brachial pressure index with the findings of carotid Doppler ultrasonography in patients with diabetes and coronary ischaemic disease.

Methods and Results: We studied 81 type 2 diabetic patients, with established cardiovascular disease, consecutively admitted to our outpatient clinic in the Division of Diabetes of La Paz Hospital. We collected clinic and demographic data, ABI and TBI were measured and at the same time a carotid Doppler ultrasound was performed.

Multiple linear regression analysis was used to investigate the association of ABI and TBI with carotid disease.

We found a negative correlation between TBI and internal carotid artery peak systolic velocity (ICA PSV) (r = -0,300, p= 0,007), common carotid artery resistance index (CCA RI) (r = -0,232, p= 0,038) and intima-media thickness (IMT) (r -0,236, p=0,035). Toe blood pressure and ICA PSV showed an inverse association (r=-0,226, p=0,042). Adjusting for clinical and demographic characteristic, only low TBI index is associated with a higher ICA PSV.

Conclusions: Toe brachial pressure index and peak systolic velocity in internal carotid artery are the measurements that better correlate peripheral arterial disease with carotid arterial disease in patient with type 2 diabetes and ischaemic heart disease.

Introduction

Cardiovascular diseases are the main cause of death in patients with diabetes. Patients with diabetes have twice the risk of incident myocardial infarction and stroke as that of the general population.[1] Peripheral arterial disease (PAD) is a marker of vascular disease in other vascular beds, including coronary, cerebral or renal vessels, and implies a high risk of major cardiovascular events.[2]

Atherosclerosis is a dynamic and widespread disease that not affects in the same way all vascular beds.[3] Diabetes is an independent risk factor of arteriosclerosis. Years of silent arterial wall alterations precede vascular clinical events, which then reflect advanced atherosclerotic disease.[4]

There are different non-invasive methods to evaluate atherosclerotic disease that have also a prognosis value. Carotid Doppler ultrasonography (US) is the most common imaging examination performed in the diagnosis of carotid disease. It reports the degree of stenosis and evaluates the carotid intima-media thickness (IMT) that is usually increased in patients with diabetes.[5] Patients with diabetes have high prevalence of hemodynamic changes in the carotids arteries and this prevalence is higher when atherosclerotic disease is present in other vascular beds, for example intermittent claudication.[6] The intima-media thickness is the most evaluated parameter in carotid ultrasound. It is correlated with the heart ischemic disease, stroke, peripheral arterial disease and hypertension.[4, 7-10] Some studies have assessed the effect of different drugs in arteriosclerotic disease measuring the IMT.[11,12]

Ankle brachial pressure index (ABI), which is the ratio of ankle to brachial blood systolic pressure, is a non invasive, reproducible and simple method for diagnosis of PAD. Furthermore, several studies have shown that a low ABI is associated with increased risk of myocardial infarction and cardiovascular death.[13-15] However, medial arterial calcification and arterial stiffening may reduce the ability of ABI to detect PAD in people with diabetes.[2]

Toe brachial pressure index (TBI), which is the ratio of toe to brachial blood systolic pressure, has been traditionally used only as an alternative method to screen for PAD in patients with diabetes and medial arterial calcification.[16] However, some studies that compare both indices[17-19] suggest that TBI may be useful to predict the risk of vascular complication in patients with diabetes.[20-22]

Although many studies[7,10,23-26] have evaluated the association between the arteriosclerotic diseases in different territories, few had made it in exclusively diabetic population.[26]

Carotid intima-media thickness and ankle brachial pressure index are the main methods to evaluate and correlate arterial disease in the literature,[7,10,25] only one study[24] assessed flow velocity in the carotid arteries and toe brachial pressure index to relate the arteriosclerotic disease in different vascular beds. Measurements of ABI and IMT have some limitations in one subgroup of patients, so it is important have an alternative to use.

The aim of this study was to determine the relationship between ABI

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Table 1: Clinical characteristics

Diabetes duration (years)	81 (13, 4 ± 9, 2)
Retinopathy n (%)	15/81 (18,5)
Nephropathy n (%)	18/81 (22,2)
Hypertension n (%)	55/81 (67,9)
Dyslipidemia n (%)	68/81 (84)
Smoking n (%)	33/81 (61,7)
Polyneuropathy n (%)	11/81 (13,6)
Antiagreggation n (%)	73/81 (90,1)
Anticoagulation n (%)	11/81 (13,6)
Body mass index n (kg/m^2)	75 (30,9 ± 4,8)

Data are percent and mean ± SD

and TBI with parameters of the carotid ultrasound in patients with diabetes and ischaemic heart disease with the intention of having alternatives to the usual methods.

Methods

Study population

We studied 81 patients (21 women and 60 men) aged 41-86 years that were recruited from an outpatient diabetes and ischemic heart disease unit at the Hospital Universitario La Paz, Madrid, Spain, from 2003-2011. A cross-sectional study was conducted during 2011-2012, at this time were performed different tests. Ethical approval for this research was provided by the Hospital Ethical Committee and all participants gave their informed consent. The inclusion criteria were: patients with known type 2 diabetes who presented with an acute coronary syndrome.

Data collection and definitions

We collected demographic and anthropometric data, use of medications, presence of cardiovascular risk factors (smoking, dyslipidaemia and hypertension), microvascular complications (retinopathy, nephropathy, and neuropathy) and history of prior cardiovascular disease. In all patients were measured ankle brachial pressure index and toe brachial pressure index and a carotid Doppler ultrasound was performed.

Hypertension was defined as systolic blood pressure >140 mmHg and/or diastolic blood pressure > 90 mmHg and/or treatment with antihypertensive agents. Dyslipidaemia was defined as total cholesterol ≥ 200 mg/dl and/or treatment with lipid-lowering drugs. Retinopathy was assessed by a comprehensive dilated eye examination by an ophthalmologist. Nephropathy was defined as urinary albumin excretion ≥ 30 mg/24h in at least three successive measurements in absence of others reasons for proteinuria.

Table 2: ABI and TBI and carotid doppler ultrasound measurements

	n	
ABI	81	1,00 ± 0,25
TBI	81	0,60 ± 0,20
Toe blood pressure (mmHg)	81	76,4 ± 27,7
ICA PSV (cm/s)	81	78,63 ± 28,68
ICA EDV (cm/s)	81	24,51 ± 7,82
CCA PSV (cm/s)	81	73,81 ± 28,68
CCA EDV (cm/s)	81	18,61 ± 4,54
ICA RI	81	0,71 ± 0,06
CCA RI	81	0,77 ± 0,05
ICA/ CCA ratio	81	1,09 ± 0,42
IMT (mm)	81	0,94 ± 0,13

Data are mean ± SD. I ABI: Ankle brachial pressure Index. TBI: Toe brachial pressure index. CA: Internal carotid artery. CCA: Common carotid artery. PSV: Peak systolic velocity. EDV: End diastolic velocity. RI: resistance index

Measurements of ABI and TBI

Standardized methodology was used to assess ABI and TBI in all subjects. All measurements were performed in a room at a temperature of 23º C, with the subject in a supine position. The systolic blood pressure (SBP) of the brachial artery, the posterior tibial artery and dorsalis pedis artery were measured in both arms and legs using a blood pressure standard cuff and an 8 MHz frequency Doppler. Systolic blood pressure in both digital toe arteries was measured using a blood pressure 10 cm cuff. ABI was calculated by dividing the higher of the ankle SBP by the higher of the brachial systolic blood pressure. TBI was calculated by dividing the higher of the toe SBP by the higher of the brachial SBP. The lowest ABI and TBI value for each limb were registered. Mean ABI and TBI of the two limbs were used for analysis.

Carotid Doppler ultrasonography

The ultrasonographic examination was carried out by experienced ultrasonographers of the Radiology Department, according to a standardized technique. All Carotid arteries ultrasounds were performed by a Philips iU22 Ultrasound system with a 3-9 MHz frequency Doppler. Measurements were obtained with the patient lying in supine position and with the neck rotated to the opposite side of examination.

Peak flow systolic velocities (PSV), end diastolic velocities (EDV), resistance index (RI) were measured in the common carotid artery and in the internal carotid artery and the mean value of the internal carotid artery / common carotid artery ratio (ICA/CCA) was registered. The carotid intima-media thickness was measured as the distance between the intima-lumen interface and the media-adventitia interface on the B-mode image (4). Carotid arteries were examined bilaterally at the levels of the common carotid arteries, the bifurcation and the internal carotid arteries. We registered the mean value of the IMT and a value ≤ 0, 90 cm was considered normal.

Statistical analysis

Statistical analyses were performed using SPSS version 11.0 statistical software (SPSS Inc., Chicago, IL, USA). Data are expressed as the mean ± SD or the median. Pearson correlation coefficients were used to examine the associations between carotid and peripheral arterial measurements. Multiple linear regression analysis was conducted to determine the independent contribution of each variable. A *p* value 0, 05 was considered as statistically significant.

Results

The mean age of the study population was 65, 3 years (range 56,2- 74,4), with the majority of patients being male (74, 1 %). Mean HbA1c when patients were recruited was 8, 3 ± 1, 7% (67 ± 5 mmol/mol). When the arterial tests were performed mean HbA1c was 6, 9 ± 0, 9 % (52 ± 14 mmol/mol) All patients had a history of ischemic heart disease, 3, 7% of cerebrovascular disease and 8, 6% of peripheral arterial disease.

The clinical characteristics of the study subjects are presented in Table 1. The mean and standard desviations of ABI, TBI and measurements of carotid Doppler ultrasound are listed in Table 2.

We calculated by the Pearson´s coefficient the correlation between ABI, TBI and toe blood pressure and the measurements of the Doppler Carotid Ultrasound: ICA PSV, ICA EDV, CCA PSV, CCA EDV, ICA RI, CCA RI, ICA/ CCA ratio and IMT. We found a significant linear negative correlation only between toe brachial pressure index and ICA PSV (r = -0,300, p= 0,007), CCA RI (r = -0,232, p= 0,038) and IMT (r -0,236, p=0,035). Toe blood pressure and ICA PSV also showed an inverse association (r=-0,226, p=0,042) (Figure 1). No correlation were founded

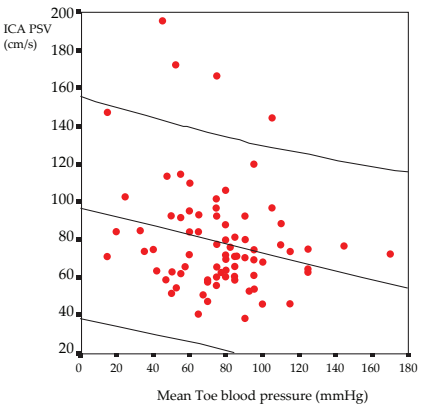

Fig. 1: Correlation between toe blood pressure and peak flow systolic velocity in internal carotid artery. ICA PSV: Internal carotid artery peak systolic velocity; r= -0,226; p= 0,042

between ABI and any Doppler Carotid US parameters.

Significant variables were analyzed by a lineal regression model and only the association between toe brachial pressure index with peak systolic velocity in internal carotid arteries remained statistically significant event after adjustment for gender, age, duration of diabetes, smoking status, A1c and BMI (r adjusted = - 0,241; p 0,040).,

Discussion

The role of ankle brachial index and carotid ultrasound in the diagnosis of cardiovascular risk has been reviewed in many studies.[7-10,13-15] The intima-media thickness is the most common parameter of carotid US used to evaluate the cardiovascular risk in general population and in patients with diabetes.[27,28]

Few studies have compared the usefulness of carotid US and ABI in patients with diabetes[23-26] and rarely used TBI, although in patients with diabetes its´ utility has been documented.[21,22] In addition there are few studies that compare the arteriosclerotic diseases in different vascular beds.

In our study, as well as IMT, we have analyzed other parameters of carotid ultrasound, and we found that IMT, resistive index and peak systolic velocity in internal carotid artery are inversely correlated with TBI but not with ABI. In addition peak systolic velocity was correlated with the toe blood pressure. After adjusting for clinical and demographic characteristics, only the association between PSV and TBI remained statistically significant although this relation is weak.

Our results suggest that more distal arterial ischaemia in lower limbs and stenosis in internal carotid artery have a parallel course in patients with diabetes and established cardiovascular disease.

The relation between ABI and IMT has been demonstrated in some studies, The Rancho Bernardo Study,[25] with 6% of the population having diabetes, showed an inverse association between ITM and ABI. McDermott et al[23] showed that in patients with no history of cardiovascular disease, low ABI was associated with arteriosclerotic carotid and coronary disease evaluated with coronary calcium and IMT. These results were confirmed in type 2 diabetes patients in the study of Hayashi et al.[26] They concluded that a low ABI and an increased IMT were related with major prevalence of cardiovascular disease, but this association was stronger if both test were altered. Our results, in terms of number of patients, may not be comparable with previous studies, nor with the study population since all of our patients had advanced cardiovascular disease, some with a history of several major cardiovascular events. We recruited this profile of patients because there is a well characterized and strict monitoring population in our clinics.

The study by Long et al[24] is the only one study that is methodologically similar to ours. They assessed flow velocity to evaluate carotid arteries and ABI and TBI to evaluate the peripheral arterial disease, but they included patients with no history of diabetes or cardiovascular disease. They compared the severity of the carotid disease with the affectation in lower limbs and, as in our study, they found a correlation between both vascular territories. These results are in agreement with the fact that the arteriosclerosis is a widespread disease that can affect simultaneously different arterial vascular beds.

We analyzed the severity of vascular disease in two territories with non-invasive test and as would be expected the association is weaker than if we analyzed prevalence of vascular disease or used invasive methods to evaluate the arterial disease.

Our measurements confirmed that arteriosclerotic disease is a dynamic process and the degree of damage is different from one vascular bed to another.

In our study, only peak flow velocity in internal carotid artery is useful to correlate carotid disease with others vascular beds. Although our correlation is weak it is consistent that the fact that peak flow velocity may be used to establish the degree of stenosis[29] and is the best measure to reflect the flow alteration.

Therefore, we may assume that, in patients with diabetes and established cardiovascular disease, it is more relevant to evaluate carotid disease with PSV than with IMT, at least in relation to different arterial vascular territories.

On other hand, the relation between carotid US and TBI shows that a more distal peripheral arterial disease is best correlated with the carotid affectation. Probably, TBI is a better method than ABI to evaluate arterial disease, in patients with diabetes and established coronary disease.[20-22,30] Further studies would be needed to establish TBI as the advisable parameter to correlate peripheral arterial disease with other vascular bed involvement in patients with type 2 diabetes and established cardiovascular disease.

Duality of Interest. No potential conflicts of interest relevant to this article were reported.

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