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ORIGINAL RESEARCH

Carotid ecodoppler and transesophageal echocardiography: complementary methods for evaluation of atherosclerosis?

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Abstract

Background: The purpose of this study was to assess the relationship between carotid ultrasonography (CU) and transesophageal echocardiography (TEE), regarding atherosclerotic disease findings, the presence of carotid plaques (CP), proximal aortic plaques (AP), carotid intima-media thickness (CIM), and the aortic intima-media thickness (AIM).

Methods: Sixty one patients (57.4% men, mean age 62.7 ± 14 years) were evaluated with CU and TEE with an interval inferior to one month. CIM was measured at the common carotid artery (CCA); CP was defined as a localizaed protrusion in the arterial lumen larger than 1.5 mm, in the CCA or the internal carotid, without uniform wall involvement. AIM was measured at the aortic arch; AP was defined as a hyperechogenic area with >2 mm of thickness.

Results: Thirty seven patients had CP and 19 had AP. Seventeen patients had plaques in both locations (p=0.002). There was a difference between the medians of AIM (1.4; IQR=0.5) and CIM (1.0; IQR=0.3) (p<0.001). There was a linear correlation between CIM and AIM (coef =0.378, p=0.003). The presence of CP was a predictor (OR 6.28, p=0.03) of AP. CIM (coef=0.52, p=0.05) and gender (coef=0.22, p=0.02) were predictors of AIMs.

Conclusion: The presence of CP was related to the presence of AP. There was a positive association between CIM and AIM. CU results can be used as surrogate markers of aortic atherosclerotic disease. Evaluation of thoracic aorta with TEE is important, since it provides additional information on the extent of atherosclerotic disease.

Keywords: Atherosclerosis, Transesophageal echocardiography, Carotid, Aorta, Intima-media, Plaque.

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Introduction

Atherosclerosis is a generalized process that may involve the entire vasculature. Although it mainly manifests in medium-sized vessels, it is also present in the great vessels, such as the thoracic or abdominal aorta and the carotid artery[1].

Some authors suggest that the carotid intima-media thickness (CIM), assessed by high resolution carotid ultrasound, can be considered an indicator of generalized atherosclerotic disease [2]. The presence of an atherosclerotic stenotic lesion in the carotid bulb or in the internal carotid artery (ICA) has been associated with an increased risk of stroke and it may account for up to 20% of all ischaemic strokes [3].

Atherosclerosis of the proximal aorta (ascending aorta and aortic arch), as evaluated by transesophageal echocardiography (TEE), also represents a potential source of emboli [4]. It has been established that stroke risk is associated with increasing thickness of the arch plaque, as well as with the extension of the atherosclerotic process to the brachio-cephalic arteries [5]. However, the precise relationship between the extension of asymptomatic atherosclerotic disease in the carotid artery and ascending aorta, is still not completely understood [2, 5]. We used carotid artery ultrasonography (CU) to study the predictive value of carotid atherosclerotic plaque and CIM thickening to determine the presence of aortic atherosclerotic plaques and AIM thickening.

Methods

Between July 2011 and July 2012, 120 consecutive patients were referred for TEE study at the echocardiography laboratory of our institution. All patients that did not meet the exclusion criteria were proposed to perform a CU within one month of the TEE.

The exclusion criteria were: prior history or clinical evidence of cerebrovascular disease, previous carotid endarterectomy or carotid angioplasty, and history of aortic dissection or aortic aneurysm. Furthermore patients with poor ultrasonographic recording quality with no clear delineation of the intima-media complex or incomplete examination of the proximal aorta were also excluded from the study.

A standard cardiac examination and aortic assessment was performed by TEE, using an ultrasonograph (General Electrics, ViVid 7) and a multiplane 5 MHz probe. The proximal aorta (aortic arch and ascending aorta) was imaged in short and long axis and the aortic intima media thickness (AIM) was measured in the aortic arch, in both views, in telediastole; the final value was obtained by averaging four measurements. Aortic plaque (AP) was defined as a hyperecogenic thickened area causing protrusion in the arterial lumen with more than 2 mm. Plaques were classified as small (<4 mm) or large (≥4mm) [6]. Recordings of all patients were reviewed in a work-station EchoPac 7 and measurements made offline by a single experienced cardiologist, blinded to the carotid ultrasound results.

Carotid atherosclerosis was assessed by ultrasound Doppler, using a GE Vivid 4 ultrasonograph, with a 10 MHz Linear probe. The distal common carotid artery (CCA), and ICA were evaluated. CIM was measured in the far wall, 1 cm bellow the bifurcation of the CCA on a plaque free site. The final value was obtained by averaging two measurements of both right and left CCA. Carotid plaque (CP) was defined as a localized thickening of the CCA or ICA, making a protrusion in the arterial lumen greater than 1.5 mm, without uniform wall involvement, which resulted or not in an increased speed, as evaluated by pulsed Doppler.

The degree of stenosis at the ICA, was determined according to the criteria of the Society of Radiologists in Ultrasound consensus conference [7], and the patients categorized in the respective groups: no stenosis; less than 50% stenosis; ≥50% and <70%; ≥70% and less than near occlusion; near occlusion; and occlusion.

All CU examinations were performed by the same qualified vascular technician of the neurology department of our institution and reviewed offline by one independent senior echocardiographer who was blinded to patients demographics as well as to TEE data.

Regarding the vascular risk factors, hypercholesterolemia was defined as previous blood test with plasma LDL cholesterol >100 mg/dL or prior prescription of cholesterol lowering drugs. Hypertension was defined as blood pressure >140 mmHg (systolic) or >90mmHg (diastolic) measured twice in the hospital, or previous history of high blood pressure or prior prescription of pressure lowering drugs. Diabetes Mellitus was defined as previous history of the disease and taking glucose lowering drugs.

Statistical analysis

Descriptive statistics was performed and data is presented as mean values ± standard deviation for continuous variables with normal distribution, as median and interquartile range (IQR) for continuous variables with non-normal distribution and as proportions for categorical variables.

Differences between groups were assessed using the unpaired Student t-test or two-tailed Mann-Whitney test as required. Chi-square test was used to compare differences between proportions. To evaluate the strength of the linear correlation between variables the Spearman's coefficient was used.

In a second step, to identify independent variables related to the presence of AP and to the thickness of the AIM, the variables with a significant association in the univariate analysis were entered into a multivariate stepwise logistic or linear regression model. For all statistical analyses, a two-tailed p-value <0.05 was considered significant. The data was analyzed using IBM SPSS Statistics, version 20.

Results

Sixty one (61) patients met the inclusion criteria. The patients mean age was 62.7 ± 14 years and 35 (57.4%) patients were men. The motives for referral to TEE were: exclusion of intracardiac thrombus in 24 (39.3%) patients, evaluation of valvular heart disease in 23 (37.7%) patients, evaluation of endocarditis in 7 (11.5%) patients, and other motives in 7 (11.5%) patients.

The demographic and clinical characteristics, as well as reasons for the TEE of the entire study population, are presented in **Table 1**. Regarding vascular risk factors, 37 (60.7%) patients had hypertension, 21 (34.4%) dyslipidaemia, 10 (16.4%) diabetes mellitus, and 12 (19.7%) were current smokers (**Table 1**).

A summary of the carotid ultrasonography and transesophageal echocardiography data of the study population is presented in **Table 2**.

Carotid ultrasonography data

Carotid artery atherosclerotic plaques were present in 37 (60.7%) patients. 20 (32.8%) patients had bilateral plaques. In detail, 33 patients (54.1%) had plaques with stenosis <50%, 2 (3.3%) had plaques with stenosis ≥50% and <70%, 1 (1.6%) had a plaque with near occlusion and 1 (1.6%) patient had an occlusion of the carotid artery. The median value of the CIM was 1 mm (IQR = 0.3) (**Table 2**).

Transesophageal echocardiography data

Proximal AP was found in 19 (31.1%) patients. 17 (89.5%) of those had small plaques and 2 (10.5%) had large plaques. The median value of AP thickness was 2.5 mm (IQR = 1.2). The median value of AIM thickness was 1.4 mm (IQR = 0.5).

Comparing within the same patient, the measure of the AIM with the CIM, a significant difference was found, the first being significantly thicker (p<0.001), and with a positive linear correlation between them (Spearman's Rho = 0.378, p=0.003), as seen in **Figure 1**.

Table 1. Baseline characteristics of the study population and transoesophageal echocardiography indications.

	Study population (*n* = 61)
Baseline characteristics	
Age (years)	62.7±14
Men, n (%)	35 (57.4)
Hypertension, n (%)	37 (60.7)
Diabetes, n (%)	10 (16.4)
Dyslipidemia, n (%)	21 (34.4)
Smokers, n (%)	12 (19.7)
TEE indications	
Exclusion of thrombus, n (%)	24 (39.3)
Evaluation of valve, n (%)	23 (37.7)
Evaluation of endocarditis, n (%)	7 (11.5)
Other, n (%)	7 (11.5)

TEE = Transesophageal echocardiography; n = Number of patients

Table 2. Carotid ultrasonography and transesophageal echocardiography data of the study population.

	Study population (*n* = 61)
Characterization of carotid plaques	
Patients with plaques, n (%)	37 (60.7)
Bilateral plaques, n (%)	20 (54.0)
Plaques without hemodynamic repercussion, n (%)	28 (75.7)
Plaques < 50% stenosis, n (%)	5 (13.5)
Plaques 50%-70% stenosis, n (%)	2 (5.4)
Plaques 70% stenosis to near occlusion, n (%)	0 (0)
Near occlusion, n (%)	1 (2.7)
Occlusion, n (%)	1 (2.7)
Characterization of aortic plaques	
Patients with plaques, n (%)	19 (31.1)
Plaques 2-4 mm, n (%)	17 (89.5)
Plaques ≥ 4 mm, n (%)	2 (10.5)
Dimension of plaques (mm), median (IQR)	2.5 (1.2)
Intima-media thickness	
CIM (mm), median (IQR)	1.0 (0.3)
AIM (mm), median (IQR)	1.4 (0.5)

n = number; mm = millimetres; IQR = Interquartile range; CIM = Carotid intima media thickness; AIM = Aortic intima media thickness

Table 3 shows the baseline characteristics of the study population according to CP presence. Compared with the patients without plaques, patients with carotid atherosclerotic plaques were older (p = 0.001) and had a higher prevalence of AP (p = 0.002). Both CIM and AIM were thicker in patients with CP (p = 0.02).

Association between carotid and aortic atherosclerosis

Table 4 shows the variables associated with AP in the logistic univariate and multivariate analysis. Age (p = 0.01), male gender (p = 0.03), and CP (p = 0.006) were related to the presence of AP. In logistic multivariate analysis the presence of CP was related (OR 6.28, 95% CI [1.16 to 34.1]) (p = 0.03) with the presence of AP, when adjusted for age, male gender, and CIM, with a square R = 0.327.

To evaluate the predictors of the AIM thickness, univariate and multivariate linear regression were performed; the results are shown in **Table 5**. CIM (p<0.001), age (p<0.001), gender (p = 0.002) and CP (p = 0.03), were univariate predictors of increasing AIM thickness. In the multivariate linear regression model CIM (coefficient = 0.52, 95% CI [0.001 to 1.03]) (p = 0.05) and gender (coefficient = 0.22, 95% CI [0.027 to 0.4]) (p = 0.02) were found as predictors of AIM, when adjusted for age and hypertension, with a square R = 0.31.

Discussion

In the present study we evaluated the relationship of atherosclerotic disease (plaque and intima-media thickness (IMT)) in the carotid arteries and proximal aorta, in patients without clinical evidence of atherosclerotic vascu-

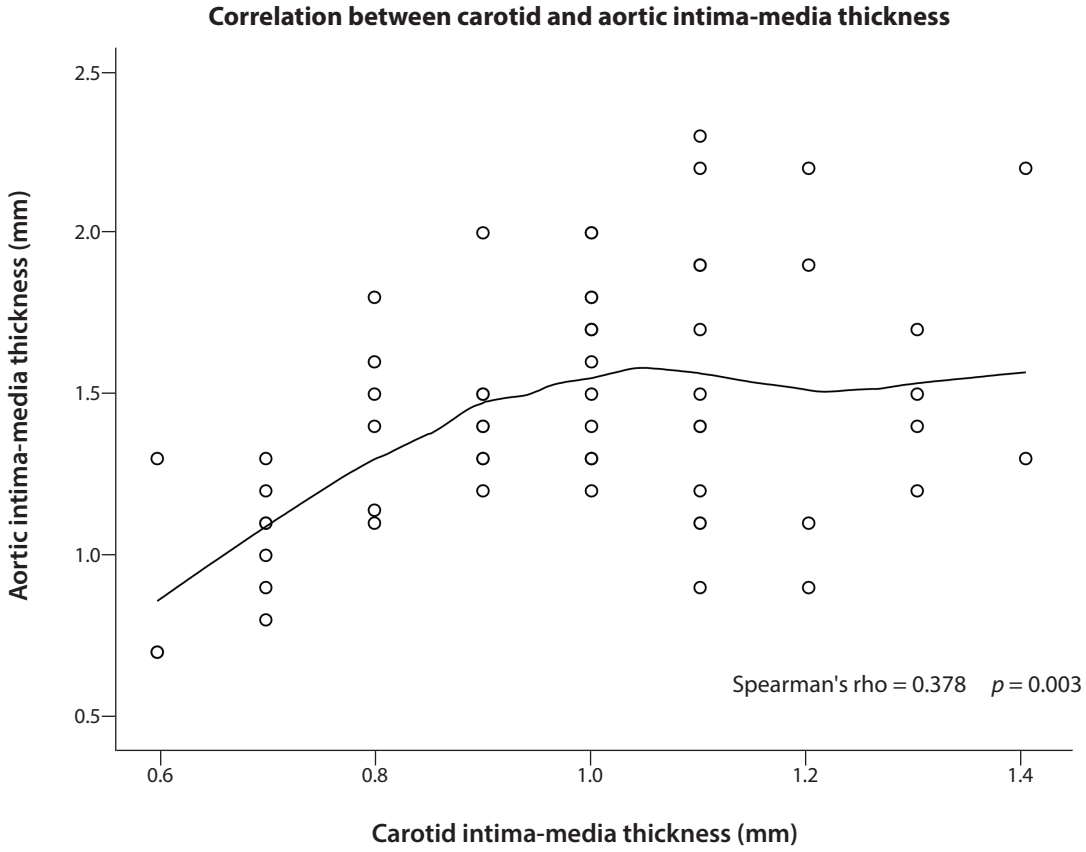

Figure 1. Measurements of intima-media thickness. Relationship between carotid intima-media thickness and aortic intima-media thickness, as measured by carotid ultrasound and transesophageal echocardiography, respectively.

lar disease, referred for evaluation by TEE.

In our study population, we found that the presence of asymptomatic carotid atherosclerotic plaques could indicate the presence of aortic atherosclerotic plaques, whereas the absence of carotid plaques may not reflect the absence of aortic plaques.

When comparing the group of patients with and without carotid plaques, we found that the patients with carotid plaques had more often, plaques in the proximal aorta (p = 0.002), and higher values of CIM (p = 0.02) and of AIM (p = 0.02). The patients with plaques in the carotid artery were also significantly older (p < 0.001).

In the multivariate analysis we found that the presence of plaques in the carotid artery, was related to the presence of plaques in the proximal aorta, these results are in agreement with previous studies [2, 8, 9].

The awareness of the association between carotid and aortic atherosclerosis may have preventive, therapeutic and prognostic implications, because aortic arch plaques are a risk factor for stroke [5]. Unnoticed proximal aortic plaques are related to stroke in patients undergoing cardiac surgery or invasive procedures that involve the proximal segment of the aorta, like a coronary angiogram [5].

TEE is one of the exams of choice for evaluating the aorta and although it is not considered an invasive exam, it can cause anxiety and discomfort in some patients, and it is not without risk for the patients [10]. So it is desirable to find another way to diagnose aortic atherosclerotic disease, using a non-invasive and easily available test, like the carotid ultrasonography Doppler [11]. According to the results of our study there is an association between the presence of carotid plaques, diagnosed by carotid ultrasonography and the presence of proximal aortic plaques. Therefore, we suggest that it is possible to use the findings of the carotid ultrasonography as a surrogate marker for the presence of plaques in the proximal aorta.

Table 3. Characteristics of the study population according to the presence of carotid plaque.

Characteristic	No carotid plaque (n =24)	Carotid plaque (n= 37)	*p*
Age, (years)	54.5±2.9	68±1.8	0.001
Men, n (%)	11 (45.8)	24 (64.9)	0.18
Hypertension, n (%)	12 (50)	25 (67.6)	0.19
Diabetes, n (%)	2 (8.3)	8 (21.6)	0.29
Dyslipidaemia, n (%)	5 (20.8)	16 (43.2)	0.10
Smokers, n (%)	6 (25)	6 (16.2)	0.30
Aortic plaques, n (%)	2 (8.3)	17 (45.9)	0.002
CIM (mm), (IQR)	0.8 (0.4)	1.0 (0.2)	0.02
AIM (mm), (IQR)	1.25 (0.5)	1.5 (0.5)	0.02

n = Number; CIM = Carotid intima media thickness; AIM = Aorta intima media thickness; IQR = Interquartile range

Table 4. Univariate and multivariate predictors of aortic plaque presence.

Characteristic	Odds ratio	95% CI	*p*
Univariate predictors of aortic plaque presence			
Age	1.06	1.01 - 1.120	0.01
Men	4.13	1.17 - 14.52	0.03
Hypertension	1.16	0.38 - 3.60	0.78
Diabetes	2.64	0.66 - 10.54	0.17
Dyslipidemia	0.58	0.17 - 1.91	0.37
Smokers	1.40	0.35 - 5.62	0.62
CIM	8.90	0.49 - 161.90	0.14
Carotid plaques	9.35	1.91 - 45.60	0.006
Multivariate predictors of aortic plaques presence			
Age	1.03	0.97 - 1.10	0.25
Men	3.05	0.77 - 12.13	0.12
CIM	0.99	0.016 - 62.7	0.99
Carotid plaques (yes)	6.28	1.16 - 34.1	0.03

CIM = Carotid intima media thickness

The IMT is a validated marker of atherosclerotic disease, as well as a known marker of coronary atherosclerotic disease [12]. The most frequent location to measure the IMT is at the CCA, because it is more reproducible and has a capability to predict ischemic events comparable to the invasive methods [13]. The CIM value is a continuum and according to the Manheim consensus [14], the values considered normal for the age group in our study population are between 0.75 and 0.85 mm. The majority of our patients had an increased CIM (median 1.0 mm). This could be explained in part because we examined a population of patients referred for the study of cardiac disease.

Table 5. Univariate and multivariate analysis of predictors of aorta intima media thickness.

Characteristic	Coefficient	95% CI	*p*
Univariate predictors of aortic intima media thickness			
CIM	0.83	0.38 - 1.29	0.001
Age	0.01	0.005 - 0.018	0.001
Gender	2.99	0.11 - 0.48	0.002
Hypertension	0.18	0.15 - 0.38	0.07
Diabetes	0.07	0.19 - 0.34	0.59
Dyslipidaemia	0.01	0.19 - 0.22	0.89
Smokers	- 0.03	0.17 - 0.11	0.66
Carotid plaque	0.21	0.02 - 0.41	0.03
Multivariate predictors of aortic intima media thickness			
CIM	0.52	0.001 - 1.03	0.05
Age	0.003	0.004 - 0.011	0.39
Gender	0.22	0.027 - 0.40	0.02
Hypertension	0.12	0.06 - 0.29	0.21

CIM = Carotid intima media thickness

In our study population we found a positive linear correlation between the CIM and the AIM, measured in the same patient. In multivariate analysis both CIM and gender were independently related to AIM.

Here, the classical vascular risk factors weren't predictors of the presence of proximal aortic plaques or of increased AIM.

In view of our results, when evaluating the presence and/or extension of atherosclerotic disease, one should consider carotid ultrasonography as surrogate for proximal aorta atherosclerosis. Carotid ultrasonography is a non-invasive, easy, and reliable method for the diagnosis of atherosclerotic disease, directly in the carotid artery territory and indirectly, as a predictor, of the proximal aorta artery atherosclerosis.

Limitations of the study

There were several limitations to our study. First, the study population was small, which limited the power of the statistical analysis.

The population was composed of patients referred to TEE to study some form of heart disease, whether it was detection of thrombus or valve disease, which limits the use of these findings in the general population.

Data collection was only done in the proximal portion of the aortic artery (ascending aorta and aortic arch). The descending aorta was not studied, which may underestimate the number of patients with atherosclerosis of the aorta. Moreover, in 31 patients (25.8%) no quality ultrasound reading was obtained from the proximal aorta, which further confirms the technical limitations in the assessment of AIM. Also, the authors could not find standardized values for the thickness of aorta intima-media

Conclusions

In our study population, the presence of carotid artery plaques was related to the presence of proximal aortic plaques. We found a positive association between CIM and AIM. In view of these results, when evaluating the presence and/or extension of atherosclerotic disease, one should consider that the information of carotid ultrasonography Doppler can be a surrogate marker of proximal aorta atherosclerosis.

Evaluation of the thoracic aorta with TEE is important when performing echocardiography, because it provides additional information of the extension of atherosclerotic disease.

Abbreviations

AIM: Aortic intima media; AP: Aortic plaque; CCA: Common carotid artery; CIM: Carotid intima-media; CP: Carotid plaque; CU: Carotid artery ultrasonography; ICA: Internal carotid artery; IMT: intima-media thickness; IQR: Interquartile range; TEE: Transesophageal echocardiography

Competing interests

The authors declare no conflict of interest.

References

1. Fuster V, Weinberger J, Kohler T, et al. Pathology: clinical correlation of carotid, aortic and peripheral vascular disease. In: Fuster V, ed. Syndromes of Atherosclerosis. New York, NY: Futura Publishing Co; 1996.
2. Kallikazaros I, Tsioufis C, Stefanadis C, et al. Closed relation between carotid and ascending aortic atherosclerosis in cardiac patients. Circulation 2000; 102:Iii-263-Iii-268.
3. Lovrencic-Huzjan A, Rundek T, Katsnelson, M. Review Article - Recommendations for Management of Patients with Carotid Stenosis. Stroke Research and Treatment 2012; 2012:175869.
4. Kronzon I, Tunik P, Aortic atherosclerotic disease and stroke, Circulation 2006; 114:63-75.
5. American Heart Association/American Stroke Association: Guidelines for the Primary Prevention of Stroke. Circulation 2006; 113:e409-e449.
6. Tessitore E, Rundek T, Zhezhen, J. Association Between carotid intima-media thickness and aortic arch plaques. J Am Soc Echocardiogr 2010; 23(7): 772-777.
7. Grant EG, Benson CB, Moneta GL, et al. Society of Radiologists in Ultrasound. Carotid artery stenosis: grayscale and Doppler ultrasound diagnosis—Society of Radiologists in Ultra Ultrasound consensus conference. Ultrasound Q. 2003; 19(4):190-8.
8. Harloff, A, Handke, M, Geibel, A, et al. Do stroke patients with normal carotid arteries require TEE for exclusion of relevant aortic plaques?.J Neurol Neurosurg Psychiatry 2005; 76:1654–1658.
9. Fasseas P, Brilakis ES, Leybishkis B, et al. Association of carotid artery intima-media thickness with complex aortic atherosclerosis in patients with recent stroke. Angiology 2002; 53:185–189.
10. Daniel W, Erbel R, Kasper w, et al. Safety of transesophageal echocardiography. A multicenter survey of 10,419. Circulation 1991; 83:817-821.
11. Russo, C, Zhezhen, J, Rundek, T, et al; Atherosclerotic disease of the proximal aorta and the risk of vascular events in a population-based cohort: the aortic plaques and risk of isquemic stroke (APRIS) study. Stroke 2009; 40:2313-2318.
12. Ibáñez, B, Pinero, A, Orejas, M, et al. Novel imaging techniques for quantifying overall atherosclerosis burden. Rev Esp Cardiol 2007; 60(3):299-309.
13. Lorenz M, Markus H, Bots M, et al. Prediction of Clinical Cardiovascular Events With Carotid Intima-Media Thickness: A Systematic Review and Meta-Analysis. Circulation 2007;115:459-467.
14. Touboul P, Hennerici M, Meairs S. Mannheim Carotid Intima-Media Thickness Consensus (2004–2006). Cerebrovascular Disease 2007; 23:75–80.