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REVIEW

Carotid arteries ultrasound for predicting coronary artery disease

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Abstract

Ischemic heart disease and stroke are the leading causes of death in the world. Myocardial infarction or even death might be the initial presentation of ischemic heart disease. Myocardial infarction is the leading cause of long-term mortality in stroke surviving patients.

The aim of this paper is to present the possibilities of predicting coronary artery disease in stroke patients. Evaluating carotid arteries intima-media thickness (IMT), plaque morphology, and degree of stenosis can give us valuable additional information for predicting cardiovascular risk and silent coronary artery disease in otherwise asymptomatic patients. Measuring IMT and assessing carotid atherosclerotic plaque is justified in subjects with high vascular risk profile.

Keywords: Coronary artery disease, Carotid artery ultrasound, Intima-media thickness, Carotid stenosis.

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Introduction

Approximately 13 million deaths per year are caused by vascular diseases, ischemic heart disease and stroke account for 22.3% of the total yearly deaths in the world, of which 12.2% and 9.7% are due to ischemic heart disease and stroke, respectively [1]. Myocardial infarction is the leading cause of long-term mortality in stroke surviving patients [2], although stroke is the leading cause of disability in the world [3]. Atherosclerotic carotid artery disease is the cause of ischemic stroke in about 20% of cases [4]. The aim of this paper is to present the possibilities of predicting coronary artery disease in stroke patients.

The diagnosis of coronary artery disease (CAD) is often too late, because myocardial infarction or even death might be the first sign of CAD [5]. In contrary to carotid artery disease where severity of the stenosis is the main player, rupture-prone plaques in coronary artery disease cause acute myocardial infarctions and sudden cardiac deaths [6, 7]. About 68% of patients with acute myocardial infarction have a mild degree (<50%) of coronary artery stenosis [6]. Approximately 76% of sudden cardiac deaths are caused by the rupture-prone plaque and only 24% by severe stenosis [7].

Asymptomatic carotid bruit increases the risk of myocardial infarction and cerebrovascular death [8]. The non-invasive and reliable diagnostic tool for evaluating carotid artery atherosclerosis plaque or stenosis (CAS) is an ultrasound including measurement of intima-media thickness (IMT), which represents mainly medial layer hypertrophy [9-12]. IMT is usually measured in the common carotid artery and the internal carotid artery [13, 14]. In recent years, automated and semi-automated measurements of IMT were developed [15]. According to Mannheim consensus conference, measurement of IMT should be done on the far wall of the common carotid artery, with quality index greater than 0.5 [13, 14]. IMT, plaque, and stenosis should be regarded as distinct phenotypes, with distinct biological aspects and determinants [16].

Intima-media thickness and carotid plaque for predicting cardiovascular risk

Relationship between IMT and cerebral or cardiac vascular risk has been shown in several studies. The Carotid Atherosclerosis Progression Study (CAPS) included 5056 people with mean follow–up of 4.2 years [17]. The baseline measurements of IMT were taken at three sites and cerebrovascular risk factor and clinical events were monitored. The primary endpoints were myocardial infarction, stroke, and combined myocardial infarction, stroke, or death. The study showed that the incidence of myocardial infarction was 1.07% per year and the incidence of stroke 0.5% per year. Common carotid artery IMT (CCA-IMT) and bifurcation IMT were associated with risk of myocardial infarction and the combined endpoints, hazard rate ratio (HRR) per 1 SD CCA-IMT increase were 1.43 (95% CI, 1.35 to 1.51) for myocardial infarction, 1.47 (95% CI, 1.35 to 1.60) for stroke, and 1.45 (1.38 to 1.52) for myocardial infarction, stroke or death; all p<0.0001. This study showed that carotid IMT can independently predict future vascular events.

The Atherosclerosis Risk in Communities study (ARIC) has shown that the risk of CAD gradually increases with higher values of IMT [18]. Each increase of carotid IMT by 0.19mm raises the risk of CAD by 92% (95% CI, 50-90%) for women and 32% (95% CI, 23-51%) for men. The Rotterdam study included 7893 patients with mean follow-up 2.7 years [19]. The measurement of IMT was done bilaterally on near and far walls of the common carotid arteries. The odds ratio (OR) for stroke per SD increase (0.163mm) was 1.41 (95% CI, 1.25-1.82). After the adjustment of risk factors the OR was 1.34 (95% CI, 1.08-1.67) for stroke and 1.2 (95% CI, 0.98-1.58) for myocardial infarction.

French epidemiological Paroi Artérielle et Risque Cardiovasculaire (PARC) study evaluated the correlation between CCA-IMT and absolute cardiovascular risk measured by Framingham and PROCAM scores in 6416 patients [20]. This study has shown that The Framingham score and CCA-IMT values were significantly but non-linearly correlated [20]. In further sub-analysis of 5400 patients of the PARC study it was shown that subjects without risk factors had mean CCA-IMT 0.712 ± 0.122 mm in men and 0.682 ± 0.105 mm in women (p<0.0001) [21]. Each 10-year increment in age was associated with a sex-adjusted increase in mean CCA-IMT of 0.049 mm. In subjects with one risk factor, mean CCA-IMT was 0.765 ± 0.121 vs. subjects without risk factors (p<0.0001). Mean CCA-IMT increased continuously with increasing number of risk factors, irrespective of age groups. In multivariable analysis age, sex, and number of cardiovascular risk factors appeared independently associated with mean CCA-IMT [21]. These results suggest that CCA-IMT may help to identify the population with an intermediate cardiovascular risk [21] .

A recent analysis of the ARIC study showed that coronary heart disease (CHD) risk prediction could be improved by adding all carotid artery segments IMT (A-C IMT) or common carotid artery IMT (CCA-IMT) with plaque information to traditional risk factors. The evaluation of carotid artery for plaque presence and CCA-IMT measurement provides a good alternative to measuring A-C IMT for CHD risk prediction [22]. Also, increased CCA-IMT is associated with brain infarction, and this may help in selecting patients with a high risk for brain infarction [23].

In spite of the above mentioned studies, several studies have shown that the carotid plaque is more closely related to CAD than measuring of the IMT [24-28]. Recently published meta-analysis of 11 population-based studies has shown that the ultrasound assessment of carotid plaque has a significantly higher accuracy for predicting

future myocardial infarction or CAD events compared with carotid IMT assessment [28]. The analysis of 27 diagnostic cohort studies in detecting CAD has shown that the ultrasound assessment of carotid plaque has a higher accuracy for predicting CAD, but the results weren't statistically significant. This meta-analysis is also important because it pointed out two types of IMT, with and without plaque thickness [28]. IMT without plaque is not atherosclerotic and it might have a different phenotype, representing mainly hypertensive medial hypertrophy [11]. The authors suggest that IMT with plaque can be called plaque thickness [11].

Although, the plaque measurement might be superior to IMT in predicting risk for CAD, it can be used for treatment evaluation [29]. The plaque measurement is more sensitive to the effects of therapy [29].

Stroke and coronary artery disease

Autopsy study on 341 patients with fatal stroke has shown that coronary plaques, coronary stenosis, and myocardial infarction were present in 72.4%, 37.5%, and 40.8% respectively, which was statistically significant compared to autopsies of 462 patients with other neurological diseases [2]. Two-thirds of myocardial infarction cases were clinically silent and found only on autopsy. The prevalence of coronary plaques, coronary stenosis, and myocardial infarction was 79.0%, 42.9%, and 46%, respectively, when plaque was present in any segment of the extracranial or intracranial brain arteries, which was significantly more prevalent in comparison with patients without extracranial or intracranial plaques. The frequency of coronary atherosclerosis and myocardial infarction was similar between stroke subtypes and the presence of carotid plaque was as closely associated to coronary atherosclerosis or myocardial infarction as the presence of carotid stenosis or occlusion. It is to note that stroke patients even without atherosclerotic plaque in any segment of the cerebral arteries had a high prevalence of coronary plaques and stenosis, 51% and 18% respectively.

The Asymptomatic Myocardial Ischemia in Stroke and Atherosclerotic Disease (AMISTAD) study [30] that analyzed 315 acute ischemic stroke without known CAD who underwent coronary angiography has shown that coronary plaques were present in 61.9% and the coronary stenosis (>50%) was present in 25.4% of patients. The presence of plaques in carotid or femoral arteries was associated with higher prevalence of CAD. Marked increase in the prevalence of coronary plaque, especially in those with arterial lumen reduction of 50%, was associated with the increasing severity of carotid atherosclerosis. Silent coronary stenosis (>50%) was more frequent in patients with carotid occlusion or high degree of carotid artery stenosis.

The Tel Aviv Prospective Angio Survey (TAPAS) study [31] that evaluated 1405 consecutive patients who were undergoing coronary angiography for the presence of asymptomatic carotid artery CAS has shown that the degree of internal carotid artery (ICA) stenosis was related to the extent of CAD. Independent predictors of severe CAS defined by Peak Systolic Velocity (PSV) on Doppler were the presence of left-main or three-vessel CAD, older age, a history of stroke, smoking status, and diabetes mellitus. The prevalence of significant ICA stenosis is lower in specific CAD subsets than previously reported, most probably because different methods for classification of carotid stenosis were used, and because recently there is better adherence to optimal medical treatment and statins use in contrast to the studies of 1999 and 2005 [32, 33].

Conclusion

Atherosclerosis is the common pathophysiological cause for development of coronary and carotid artery disease. The degree of carotid stenosis plays a more important role in pathophysiology of embolic stroke. Evaluating carotid arteries for IMT, plaque morphology, and degree of stenosis can give us valuable additional information for predicting cardiovascular risk and silent CAD in otherwise asymptomatic patients. Therefore measuring IMT and assessing carotid atherosclerotic plaque is justified in subjects with high vascular risk profile.

Abbreviations

CAD: Coronary artery disease; CAS: Carotid artery stenosis; CCA-IMT: Common carotid artery intima-media thickness; CHD: Coronary heart disease; ICA: Internal carotid artery; IMT: Intima-media thickness; OR: Odds ratio; PSV: Peak systolic velocity

Competing interests

The authors declare no conflict of interest.

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