Carotid Ultrasonography in General Health Screening: Non-Invasive Assessment of Early Atherosclerosis

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As carotid ultrasonography is an easy, immediate, and non-invasive diagnosing modality that does not involve radiation exposure, it has gained considerable recognition for use in the screening of carotid atherosclerosis even in asymptomatic subjects. Carotid plaque may be defined when the maximum of the IMT measured at the several arterial segments surpasses a certain cut-off value, and, although not always, has a focal protrusion. The size, number, surface morphology, and echogenicity of such carotid plaque may provide useful information for estimating the likelihood of future ischemic cerebrovascular events. Although significant luminal narrowing (≥70% stenosis) of carotid arteries that may increase the incidence of stroke will rarely be encountered in the presence of Ningen Dock, the presence of carotid atherosclerosis may also indicate an increased likelihood of the presence of coronary artery stenosis or future cardiac events. In addition, visualization of the presence of plaque may also increase the subjects' motivation for making lifestyle modifications, such as smoking cessation. Due to its non-invasive nature, carotid ultrasonography has become a reasonable and feasible modality for the diagnosis of early atherosclerosis in the setting of general health screening or Ningen Dock. (Ningen Dock 2007; 21: 47–49)

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Duplex carotid ultrasonography, which enables the observation of both B mode ultrasonography and Doppler mode ultrasonography, has gained considerable recognition for use in the screening of carotid atherosclerosis. Because of its non-invasive nature, this method is appropriate for use on asymptomatic subjects, such as those who undergo general health screening or Ningen Dock. Although the exact screening region of the carotid artery that is screened may differ according to the institute, it usually includes the common carotid artery and bilateral internal carotid artery. We can also get images of vertebral arteries by ultrasonography, although some of these arteries may be obscured by vertebral bones. Ultrasonography can observe three layer structure, and the first high echoic layer and the second low echoic layer are collectively considered to represent the intima-media complex (Fig. 1). Carotid IMT increases with age and is larger in men than in women1.

Diagnosis of Carotid Atherosclerosis

Carotid atherosclerosis may be diagnosed when there is a plaque or a thickening of the intima-media complex within the internal carotid arteries, bifurcations, and common carotid arteries2. When the thickness of the intima-media complex, commonly referred to as the IMT, is greater than a certain cut-off point, the subject is said to have intima-media thickening. The cut-off value for diagnosing intima-media thickening may vary slightly across different studies.

Plaque may be defined when the maximum of the IMT measured at the several arterial segments surpasses a certain cut-off value, and, although not always, has a focal protrusion. Here again, cut-off values may differ slightly according to the study3-9. In Japan, guidelines for diagnosing carotid plaque have been advocated by several committees and study groups, including the Joint Committee on Guidelines for Management Stroke, the Japan Academy of Neurosonology (http://wwwsoc.nii.ac.jp/jan/index.html), and the Society for the Study of Early Atherosclerosis (http://www.imtca.com/).

In addition to the plaque size, the number of plaques, surface morphology, and echogenicity may provide useful information for estimating the likelihood of future ischemic cerebrovascular events10. Surface morphology may be classified as smooth, irregular or ulcerated. Heterogeneous plaque is considered to be at higher risk of rupture than homogenous plaque. Plaque may be categorized according to its density (hypodense, isodense, hyperdense, or calcified)5-11. Calcification within the plaque will make an acoustic shadow.

Screening for High-Grade Carotid Stenosis

Although significant luminal narrowing (≥70% stenosis) of carotid arteries increases the incidence of stroke, such high-grade carotid stenosis, which may require surgical or catheter intervention, will rarely be encountered in the setting of general health screening. Even when moderate-grade carotid stenosis is found in...
asymptomatic subjects, the indication for carotid artery endarterectomy should be carefully assessed because peri-operative mortality and/or morbidity following this procedure may not be negligible. Some investigators argue that carotid ultrasonography may not be cost-effective as a method of screening for significant carotid stenosis in the asymptomatic population12, whereas other investigators have proposed that ultrasonographic screening for carotid artery screening may be more cost effective especially in the senior population, if a new and more rapid protocol of carotid artery screening protocol is adopted13.

Although we may need to be aware of the cost-effectiveness of the ultrasonographic screening of extracranial carotid artery in asymptomatic individuals, cost-effectiveness may not be the chief concern of those undergoing general health screening in our country. As the presence of carotid plaque is a risk factor for ischemic stroke and coronary heart disease7,14,24, anti-platelet and/or vasodilating agents might be recommended for a subset of subjects with such low-grade carotid stenosis. We may be able to identify the subjects at higher risk for ischemic stroke and/or coronary artery disease by plaque morphology combined with other diagnostic tests, such as a treadmill exercise test. At present, however, there is no standard therapeutic protocol is present for the treatment of subjects with such low-grade carotid stenosis.

**Risk Factor Properties of Carotid Atherosclerosis**

Atherosclerosis can develop simultaneously in different vascular beds. In this sense, it is reasonable to assume that the presence of carotid atherosclerosis may indicate an increased likelihood of the presence of coronary artery stenosis or future cardiac events. Indeed, much evidence shows that the presence of carotid intima-media thickening15-17 and carotid plaque18,19 are predictors for future cardio- and cerebrovascular events, and thus represent a subclinical atherosclerosis. A recent study showed that in elderly community-dwelling Japanese people, a 0.3 mm increase in the left and the right, respectively, carotid IMT was associated with a relative risk of 1.7 and 3.3 for all cause mortality, and that of 2.4 and 2.9 for cardiovascular mortality20.

Craven et al. have reported that in individuals older than 50 years old, the B-mode score was associated with coronary stenosis, which was independent of other traditional coronary risk factors, and that considering the results of the B mode score, in addition to conventional risk factors, may increase the sensitivity and specificity for determining coronary artery disease status in such a population21. Simon et al. reported that the presence of carotid atherosclerosis in asymptomatic subjects was associated with a coronary heart disease with an incidence of 1.2% to 3.3% per year, which was, surprisingly, greater than the incidence associated with major risk factors, such as hypertension, diabetes, and smoking22. Importantly, they found that an absence of intima-media thickening was associated with a yearly incidence of coronary heart disease of 0.1% to 0.8%. Collectively, these studies indicate that the findings of carotid ultrasonography can provide useful information as an aid to the diagnosis of coronary heart disease.

**Comparison with Other Non-Invasive Diagnostic Modalities**

In addition to carotid ultrasonography, several non-invasive or least-invasive diagnostic modalities for atherosclerotic diseases have become available with recent advances in technology, including computed tomography (CT) and magnetic resonance (MR) angiography. In a recent meta-analysis, Wardlaw et al. compared the power and accuracy of several diagnostic tools for the diagnosis of carotid stenosis. They found that both the sensitivity and specificity of carotid ultrasonography are comparable to those of MR and CT angiography when 70-99% stenosis is present. On the other hand, the sensitivity of carotid ultrasonography and MR angiography for carotid stenosis may not be satisfactory for detecting carotid stenosis when there is an angiographically-proven level of 50-69% stenosis23.

**Carotid Ultrasonography in General Health Screening**

In the setting of general health screening or Ningen Dock, many other hemodynamic and metabolic data can be obtained from the health screening participants at the time of carotid artery screening; therefore, such data may enable us to analyze the possible association between early atherosclerosis and various non-traditional putative risk factors such as metabolic syndrome, microalbuminuria, CRP, and circulating WBC count (Fig. 2).

Carotid ultrasonography is an easy, immediate, and non-invasive diagnosing modality that does not involve radiation exposure. Visualization of the presence of plaque may help to assess the extent of atherosclerosis in the subjects, and may also increase the subjects’ motivation for making lifestyle modifications, such as smoking cessation25. Considering that the presence of carotid plaque and intima-media thickening not only increases the risk of stroke, but also increases the like-
Fig. 2. Increased WBC count is a risk factor for carotid plaque in men. Odds ratios were calculated after adjusting for age, BMI, systolic BP, total and HDL cholesterol, TG, and fasting glucose.

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References