

Microwave Radiometry: Potential for Non- invasive Detection of Carotid Artery Disease

MR is proposed as a safe, convenient, non-invasive method to detect natural electromagnetic radiation from internal tissues, indicating plaque inflammation with potential prognostic clinical implications.

A Q&A WITH PROFESSOR ELIAS SIORES

Increased thermal production in the carotid arteries as detected by non-invasive microwave radiometry (MR) may indicate atherosclerosis and higher risk of stroke, results of the first in vivo human study of the imaging technique suggests. Published in the *Journal of the American College of Cardiology*,¹ the study involved 34 consecutive patients scheduled to undergo carotid endarterectomy, based on ultrasound diagnosis of carotid artery disease. Prior to treatment, the patients underwent MR screening of the carotids, as did 15 healthy controls deemed not to have artery disease based on ultrasound. During ultrasound study, plaque texture, plaque surface, and plaque echogenicity were analyzed. Temperature difference (assigned as maximal minus minimum temperature) was associated with ultrasound and histological findings.

Analysis revealed that temperature difference was higher in atherosclerotic carotid arteries compared with the carotid arteries of controls ($p < 0.01$). Furthermore, higher temperature change was seen in fatty plaques, compared with mixed and calcified ($p < 0.01$) plaques. Plaques with ulcerated surface had higher temperature change compared with plaques with irregular and regular surface ($p < 0.01$), while hetero-



Dr. Siores demonstrates the non-invasive MR technique.

geneous plaques had higher change in temperature compared with homogenous ($p < 0.01$). Thin fibrous cap and intense expression of CD3, CD68, and vascular endothelial growth factor (VEGF) was associated with higher temperature change, compared with thick cap and low expression of CD3, CD68, and VEGF ($p < 0.01$).

Study co-author Professor Elias Siores, University of Bolton On Campus Provost and Director of Research, discussed the study and implications with *Practical Neurology*.

Your publication indicates the need for a prospective study. What would you hope to see in that study? What level of benefit is needed, in your view, to justify widespread clinical application of MR?

In this recent publication, microwave radiometry has been shown to provide temperature measurements of carotid plaques with intermediate lesions, reflecting the inflammatory activation within the plaque. Taking into consideration that inflammation is among other markers, a significant marker of plaque instability, a prospective follow-up study in patients with intermediate carotid plaque lesions and increased plaque temperature will provide important clinical information regarding the natural history of these lesions. Increased carotid plaque temperature at baseline may potentially be related to worse clinical outcome. Other prospective studies may be justified with a view to evaluate the value of microwave radiometry application for primary and secondary prevention. The potential beneficial impact of several drugs on plaque temperature and plaque progression may be also evaluated by serial microwave radiometry studies.

Could MR be used in conjunction with, or as an alternative to other modalities?

During the last decades there is a growing interest on imaging modalities aimed to reveal the biological activities of carotid atherosclerotic plaques with intermediate stenosis. Intermediate carotid atherosclerotic lesions have been shown to progress or rupture over time finally provoking cerebrovascular events. Microwave radiometry provides additive information to standard ultrasound since this method detects plaque inflammatory activation. Patients with carotid atherosclerotic plaques of intermediate stenosis may thus benefit from microwave radiometry and this method may serve as an additional tool for primary and secondary prevention.

Since microwave radiometry is safe and non-invasive, patients with carotid artery atherosclerosis or multiple cardiovascular risk factors may be another group that could potentially benefit from microwave radiometry measurements. However, future studies will elucidate the specific groups of patients that will finally benefit from microwave radiometry based on clinical outcome. The method currently evaluates only the functional characteristics of the plaque and does not provide information concerning the morphological characteristics. For this reason it should be used in conjunction with other imaging modalities.

What would be the implications of findings of temperature change in the clinical setting?

Increased carotid plaque temperature is an indirect indicator of increased inflammation and thus increased plaque vulnerability. Increased plaque temperature in coronary arteries has been related to worse clinical outcome in patients with coronary artery disease. Accordingly, increased temperature in carotid plaques may potentially have a negative predictive value for patients' clinical outcome. Still, both the clinical implication and the prognostic value of microwave radiometry application remain to be elucidated in a prospective follow-up study. The results of this study may further justify a more aggressive pharmaceutical or interventional management of patients with increased carotid plaque temperature, in terms of primary or secondary prevention.

What are the clinical and practical benefits of MR for high-risk patients? Are there any clinical or practical drawbacks?

Microwave radiometry detects accurately and non-invasively natural electromagnetic radiation from internal tissues at microwave frequencies. It ultimately allows the detection of plaque inflammation *in vivo*, providing thus information about the functional characteristics of the plaque with potential prognostic clinical implications. Most importantly, it is a safe and convenient method for the patients since the device serves as a sensor and not as a transmitter of radiation. However, since the current device does not provide information concerning the morphological plaque characteristics it still needs to be used in conjunction with other non-invasive imaging methods, such as ultrasound, serving as an additional tool for plaque evaluation.

What has been the response to your publication?

After the recent publication we had several interactive discussions with colleagues regarding the value of microwave radiometry in current clinical practice. Moreover we received several invitations with a scope to present in detail the technical characteristics of the device and the indications of application.

Several colleagues were interested in other potential clinical applications of microwave radiometry in cardiology. Indeed, since inflammation is implicated in several other aspects of cardiovascular disease, microwave radiometry may prove to be a promising device confined not only to vascular disease. Further technical improvement may offer a clinical role of microwave radiometry in coronary artery disease. ■

1. Toutouzias K, Grassos C, Drakopoulou M, Symetos A, Tsiamis E, Aggeli C, Stathogiannis K, Klettas D, Kavantzias N, Agrogiannis G, Patsouris E, Klonaris C, Liasis N, Tousoulis D, Siores E, Stefanadis C. First *in vivo* application of microwave radiometry in human carotids: a new noninvasive method for detection of local inflammatory activation. *J Am Coll Cardiol*. 2012 May 1;59(18):1645-53.