

## Carotid Intima Media Thickness (CIMT) as a biomarker in the detection of atherosclerosis by ultrasonography

Atherosclerosis is a major cause of cardiovascular events worldwide and has a number of means of diagnosis. A widely used method is the determination of Carotid Intima Media Thickness (CIMT) of the Common Carotid Artery (CCA) via ultrasonography. A number of healthcare organizations involved in prevention, diagnosis and treatment of cardiovascular diseases strongly advocate the use of CIMT in the quantification of atherosclerosis and risk assessment of coronary artery disease. This paper aims to provide an overview on the purpose of measurement of CIMT and its relevance to atherosclerosis, highlighting the important guidelines and publications in this area.

CIMT is a universally used marker for the identification of generalized atherosclerosis. It is defined as the distance that can be easily observed between the lumen of the blood vessel and the interface of the tunica media and the tunica adventitia. On the other hand, carotid plaque formation signals an increase in the adjacent CIMT by about 50% and an increase in thickness of 1.5 mm (Bauer et al., 2012). On an ultrasound image, it is seen as a double line on both the external and internal walls of the carotid artery (Bartels et al., 2012).

The main purpose of CIMT measurement is to identify the atherosclerotic burden in the CCA. The CCA on the right side originates from the truncus brachiocephalicus and the one on the left side has its origins in the aortic arch. Each of the two CCAs is made up of three layers – the tunica intima which is the innermost layer comprising of a single layer of endothelial cells, the tunica media or the middle layer which is made up of smooth muscle cells, and tunica externa or tunica adventitia which is the outermost layer and lies embedded in the circumjacent tissue (Bauer et al., 2012).

Atherosclerosis is a chronic systemic inflammatory disorder, which is the most common cause of cardiovascular-related deaths in the world. The main cause of atherosclerosis is the passage of LDL-cholesterol through the endothelium, deposition of the LDL in tunica intima, and formation of complexes due to various enzymatic and oxidative processes. Hence, the condition of the tunica intima of the CCA is an important marker of the extent of atherosclerosis in a patient. The CCA usually shows an increased thickness at the intima media in early stages of atherosclerosis, whereas carotid plaques are commonly observed during the later stages at the bifurcation of the carotid arteries and the internal carotid artery. An increased CIMT is also indicative of a strong risk of hypertension and stroke (Bauer et al., 2012).

Other markers which are commonly used for the diagnosis and/or risk prediction of atherosclerosis include traditional risk factors such as diabetes, high blood pressure, obesity, stress, smoking and metabolic syndrome, and other less traditional factors such as high LDL, low HDL, homocysteine and LDL particle size. Imaging modalities can also give useful information about the structure and function of arteries. Although ultrasound measurements of CIMT and carotid plaques are most widely used, other measures such as aortic and carotid plaque assessment by MRI and coronary calcium score measurement by electron beam CT (EBCT) are also some of the commonly used techniques. Other less widely used markers include ultrasound measurement of brachial vasoreactivity, measurement of vascular compliance by radial tonometry and measurement of microvascular reactivity by fingertip tonometry (Bartels et al., 2012). Coronary intravascular ultrasound is a common variation used to visualize the dimensions of the vessels and the characteristics of the arterial walls. In addition to the diameter of the lumen, the area of the plaques and the thickness of the arterial walls is also measured (Amato et al., 2007).

According to the guidelines detailed by the American Heart Association, there are two main noninvasive approaches for the quantification of atherosclerosis in the carotid artery – CIMT and plaque formation (Belibou et al., 2012). The measurement of CIMT is usually done by B-mode sonography and it is a relatively safe, cheap and quick procedure. It is noninvasive and allows the visualization of the walls of the carotid artery and the measurement of CIMT (Bauer et al., 2012). Studies such as the Atherosclerosis Risk in Communities (ARIC) study, the Cardiovascular Health Study (CHS), and the Rotterdam study have shown a strong correlation between CIMT measurements and the risk of cardiovascular problems in patients. Clinical trials have also demonstrated a reduction in the risk of cardiovascular events with therapies that lower lipids in the body (Bartels et al., 2012).

The Mannheim Carotid Intima Media Thickness and Plaque Consensus published in 2012 focus on characterization of CIMT and plaques on ultrasound, physical and structural bases of the examination, image acquisition standards, settings of the ultrasound device, examination procedure, and methodology standards (Touboul et al., 2012). The ACC/AHA guideline on the initial detection of cardiovascular risk has placed CIMT measurement as a class IIA diagnostic measure, meaning that it is reasonably safe to perform on patients with risk of coronary heart disease (Greenland et al., 2012). According to the National Cholesterol Education Program Adult Treatment Panel III, CIMT measurement is an important marker for subclinical atherosclerosis and it helps in the decision of lipid management (NCEP, 2002). The ESH/ESC European guidelines mandated in Spain uses CIMT to identify organ damage due to high blood pressure (Sierra et al., 2009). Criteria for CIMT measurement are given in detail by the American Society of Echocardiography (Stein et al., 2008) and the Society of Atherosclerosis Imaging and Prevention (Society of Atherosclerosis Imaging and Prevention, 2011).

In conclusion, CIMT is an important biomarker for the identification and quantification of atherosclerosis. Although there are a number of other imaging modalities that give information about the stage of atherosclerosis and the thickness of the carotid intima media, this technique is widely recommended and most commonly followed in clinics all over the world. This has also been subjected to a number of modifications to improve its diagnostic ability, accuracy and precision. However, its painless, inexpensive and quick methodology has made it the gold standard in the field of cardiovascular diseases.

## References

- Amato, M., Montorsi, P., Ravani, A., Oldani, E., Galli, S., Ravagnani, P. M., Tremoli, E., & Baldassarre, D. (2007). Carotid intima-media thickness by B-mode ultrasound as surrogate of coronary atherosclerosis: correlation with quantitative coronary angiography and coronary intravascular ultrasound findings. *European Heart Journal*, *28*, 2094-2101.
- Bartels, S., Franco, A. R., & Rundek, T. (2012). Carotid intima-media thickness (cIMT) and plaque from risk assessment and clinical use to genetic discoveries. *Perspectives in Medicine*, *1*(1-12), 139-145.
- Bauer, M., Caviezel, S., Teynor, A., Erbel, R., Mahabadi, A. A., & Schmidt-Trucksass, A. (2012). Carotid intima-media thickness as a biomarker of subclinical atherosclerosis. *Swiss Medical Weekly*, *142*, w13705.
- Belibou, C., Ancuta, C., Ancuta, E., Filos, C., & Chirieac, R. (2012). Carotid intima-media thickness and plaque as surrogate biomarkers of atherosclerosis among consecutive women with systemic lupus erythematosus. *Romanian Journal of Morphology & Embryology*, *53*(1), 29-34.
- Greenland, P., Alpert, J. S., & Beller, G. A. (2010). ACCF/AHA guideline for assessment of cardiovascular risk in asymptomatic adults: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines. *Journal of the American College of Cardiology Foundation*, *56*, e50-e103.
- National Cholesterol Education Program (NCEP) Expert Panel (ATP III): Third report of the National Cholesterol Education Program (NCEP) Expert Panel on detection, evaluation and treatment of high blood cholesterol in adults (Adult Treatment Panel III) final report. *Circulation*, *106*, 143-421.

Sierra, A., Zamorano, J. L., & Ruilope, L. M. (2009). Application of hypertension guidelines in clinical practice: implementation of the 2007 ESH/ESC European Practice Guidelines in Spain. *Journal of Hypertension Supplement*, 27, S27-S32.

Society of Atherosclerosis Imaging and Prevention, developed in collaboration with the International Atherosclerosis Society: Appropriate use criteria for carotid intima thickness testing. *Atherosclerosis*, 214, 43-46.

Stein, J. H., Korcarz, C. E., & Hurst, R. T. (2008). Use of carotid ultrasound to identify subclinical vascular disease and evaluate cardiovascular disease risk: a consensus statement from the American Society of Echocardiography Carotid Intima-Media Thickness Task Force. Endorsed by the Society for Vascular Medicine. American Society of Echocardiography Carotid Intima-Media Thickness Task Force. *Journal of American Society of Echocardiography*, 21, 93-111.

Touboul, P. J., Hennerici, M. G., Mears, S., Adams, H., Amarenco, P., Bornstein, N., Csiba, L., Desvarieux, M., Ebrahim, S., Hernandez, R. H., Jaff, M., Kownator, S., Naqvi, T., Prati, P., Rundek, T., Sitzer, M., Schminke, U., Tardif, J. C., Taylor, A., Vicaut, E., & Woo, K. S. (2012). Mannheim carotid intima-media thickness and plaque consensus (2004-2006-2011). *Cerebrovascular Diseases*, 34, 290-296.