

Non-invasive measurement of surrogate markers of atherosclerosis: Carotid intima-media thickness (c-IMT)

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Overview

Cardiovascular disease affects approximately 2 million people, with an estimated 1.2 million heart attacks and 750,000 strokes recorded annually. The use of non-invasive ultrasound imaging techniques continue to provide a major role in diagnosis and management of patients with cardiovascular disease. The early presence of atherosclerosis predates major clinical events such as myocardial infarction and stroke.

Over the last 17 years, the ultrasound-based measurement of carotid intima-media thickness, or c-IMT, has become a standard for assessing arteriosclerosis and is recommended by the American Heart Association for the non-invasive assessment of cardiovascular risk.^{1,2}

Definition: Carotid intima-media thickness (c-IMT)

Carotid intima-media thickness (c-IMT) is defined as the distance between the lumen-intima interface and the media-adventitia interface, which corresponds to the inner and outer echogenic lines seen on the B-mode ultrasound image. (Figure 1)^{1,3}

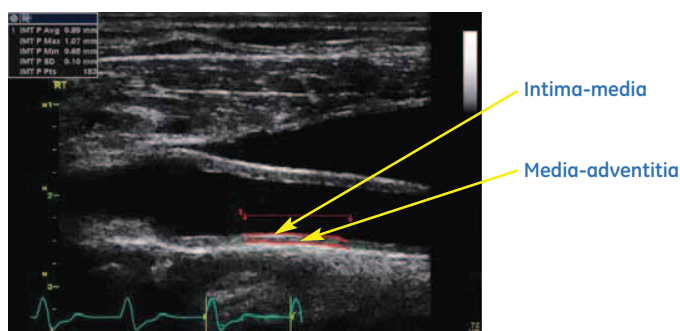


Figure 1: Intima-media wall thickness

Measurement of c-IMT is traditionally performed with the image of the carotid artery in the longitudinal axis, revealing the common carotid artery, the carotid bifurcation, and the internal and external carotid arteries. Although these measurements have been performed for years, significant variability exists when measuring the near wall due to technical and acoustic difficulties encountered when imaging the c-IMT of the near wall.⁴ Due to these technical limitations, clinical measurement of c-IMT using B-mode ultrasound is often applied to the far (posterior) wall of the common carotid artery.

With the development of non-invasive imaging technologies, ultrasound methods can be used to reliably measure intima-media thickness (IMT). This measurement serves a non-invasive marker of arterial wall atherosclerotic disease. Studies have been found that the intima-media thickness on average, based on gender and age, will increase 0.01-0.03mm per year. (See tables on page three regarding the historical clinical studies of c-IMT).

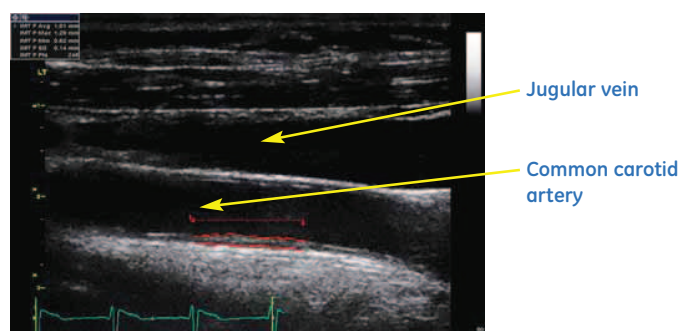
To perform these studies, the sonographers/clinicians use high frequency (7, 10 or 12) MHz linear array transducers with the Vivid™ 7 Dimension and the Vivid *i* to efficiently acquire multiple c-IMT measurements within seconds. The semi-automated measurement for intima-media wall is simple, easy and takes less than 4 steps. The physician receives immediate results which consists of these parameters: maximum, mean, average and number of data points examined.

Using the software application, the c-IMT measurement can be exported directly to a worksheet and report page, and subsequently placed in the patient's medical record.

Technical Tips: c-IMT measurements for the Vivid 7 Dimension/Vivid *i*

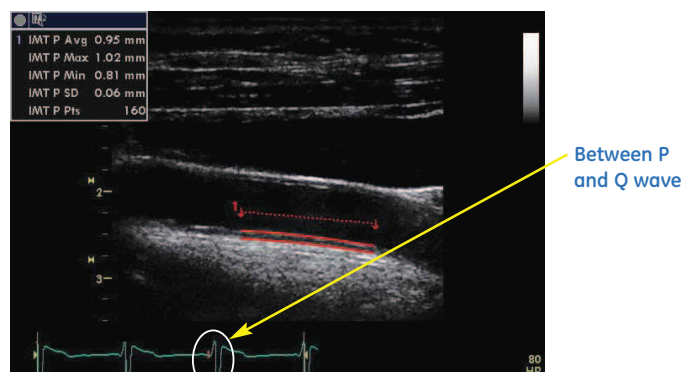
Imaging common carotid artery:

- Maximize the depth selection and optimize the gain settings to visualize the posterior intima-media wall of the common carotid artery.
- Attempt to capture the common carotid artery with the jugular vein to improve visualization of the anterior and posterior carotid walls.

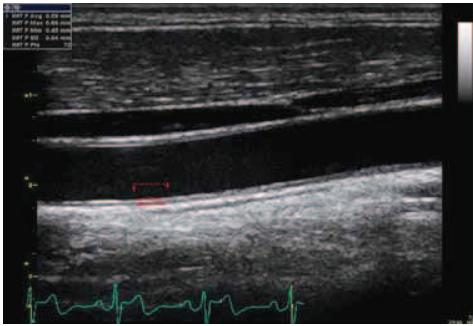


Measuring intima-medial wall thickness (c-IMT):

- Identify a single frame during the end-diastolic phase between the P and Q wave off the ECG trace.



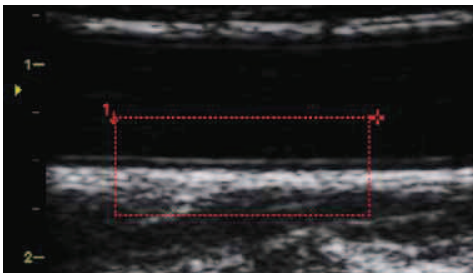
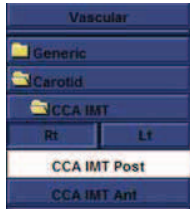
- Approximately 50-60 data points is an adequate sample when used to measure the intima-media thickness.



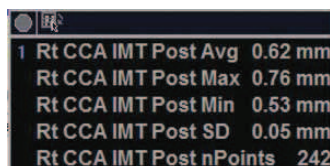
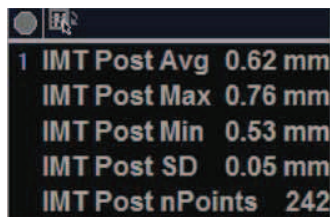
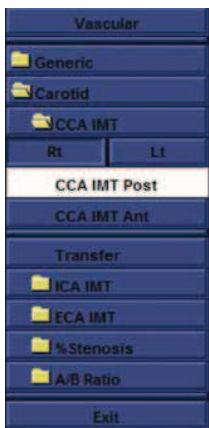
50-60 data points

Performing IMT measurement on the Vivid 7 and Vivid i:

- Select measurement key on the keyboard.
- Select from the measurement menu carotid folder, then CCA IMT, to identify either the right or left carotid artery, then CCA IMT Post, for posterior wall.
- Position the IMT cursor above the intima-media wall, then press select key to anchor the first cursor. Reposition the second cursor using the trackball then press select key to anchor the second cursor.



- If the IMT measurement result is acceptable, then select in the measurement Carotid folder: Transfer. The results will be displayed in the worksheet and in the final report.



There are several benefits in using the automated IMT package from Vivid 7/Vivid i

- The measurement procedure is not operator dependent and not as time intensive as compared to manual IMT measurements.
- The semi-automated technique simplifies the time taken to perform the measurement, as compared to manual measurement.
- The improved technology enhances c-IMT precision measurements and increases consistency and reliability of the results.
- The methodology is robust, reproducible and builds confidence among sonographers and physicians.

Risk assessment

Multiple studies have shown that carotid intima-media thickness measurement is a valuable tool as a potential valid marker of early atherosclerotic disease that does appear to correlate with risk factors associated with coronary artery disease. With the identification of risk factors associated with development of atherosclerotic disease, the c-IMT tool does provide potential information in assessing the progression of the intima-media thickness to monitor atherosclerosis. In addition, there are ongoing research clinical studies utilizing the c-IMT measurement tool associated with drug therapy treatments that could potentially monitor changes in response to different drug therapy that includes lipid lowering drugs, antihypertensive agents, and hormone replacement therapy. The c-IMT measurement tool, upon further clinical validation, could be a surrogate marker of atherosclerosis and coronary heart disease risk. (Am J Cardiol. 2004 Jun 3;93(11A):32C-48C)

Men	Age	RT CCA IMT	LT CCA IMT
	<30	.39-.48	.42-.49
	31-40	.42-.50	.44-.57
	41-50	.46-.57	.50-.61
	>50	.46-.62	.53-.70
Women	Age	RT CCA IMT	LT CCA IMT
	<30	.39-.43	.30-.47
	31-40	.42-.49	.44-.51
	41-50	.44-.53	.46-.57
	>50	.50-.59	.52-.64

Clinical studies have found that the intima-media thickness on average, determined by gender and age, would increase approximately 0.01-0.03 mm per year. Based on multiple studies, the chart above provides normal IMT results, based on age and gender, done by Alain Simon, Jerome Gariapy at Centre de Médecine Préventive Cardiovasculaire, Hospital Broussais, Paris, in 2002 from the Journal of Hypertension. Another IMT study of normal values found similar results based on age and gender population.

In Figure 2: The normal IMT values are influenced by range of age, and gender.

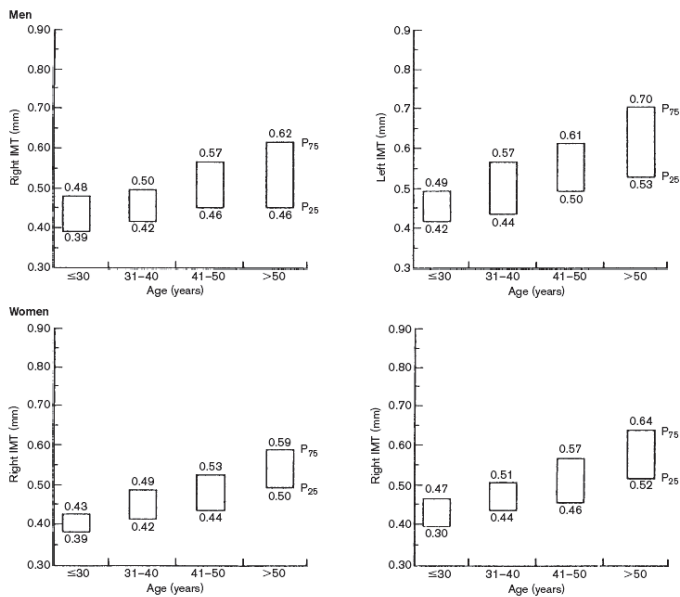
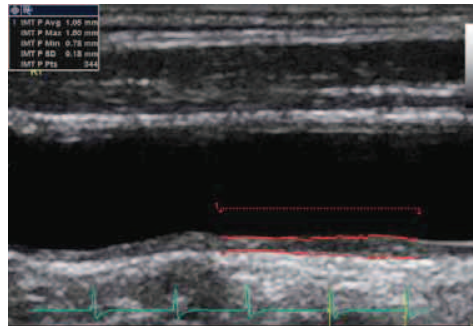


Figure 2
Distribution of "normal" values of common carotid artery far wall intima-media thickness (IMT) in a population of healthy men and women by age range: AXA Study. Upper and lower limits of bars are 75th upper and 25th lower percentiles of IMT distribution within the age range indicated in the x-axis. Abnormal increased IMT are values above the 75th percentile in each category of age.

The Vivid 7 Dimension and Vivid *i* provide an automated on-line IMT tool by acquiring multiple IMT data points in seconds. The automated IMT measurement tool is simple, easy and takes less than 4 steps. The physician receives immediate results that generate Maximum, Mean, Average, standard deviation, number of acquired IMT data points, distance. These can be incorporated into the worksheet and report as part of your carotid study examination and be placed in the patient's record files.

Case study

The case study demonstrates a patient with a history of CAD, stroke in 2001, hypertensive, and a carotid study was requested to rule out plaque. The following image demonstrates a calcified plaque located in the proximal ICA. The automated IMT measurement was used on the Vivid 7 Dimension, to assess the thickness of the intima-media of the far wall. The results showed that the average thickness of the IMT was 1.09 mm, considered as abnormal c-IMT based on gender and age of this patient.



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