Carotid IMT: A Relevant Marker?

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Georgetown University Hospital
Professor of Medicine

Medstar Heart Institute
Medstar Heart Research Institute
ACC CV Risk Guideline

• Methods such as noncontrast CT for the assessment of coronary artery calcium, or carotid ultrasound for the assessment of intima media thickness and plaques improve the coronary heart disease risk assessment.

• In 2010, the American College of Cardiology:
  • CAC and CIMT granted a level 2A recommendation indicating these tests as reasonable to perform in the initial assessment of cardiovascular risk in order to refine the risk assessment.

  • “Measurement of carotid artery IMT is reasonable for cardiovascular risk assessment in asymptomatic adults at intermediate risk”.

• This recommendation is comparable to one from 2002 by the National Cholesterol Education Program noting CIMT could be “used to identify persons at higher risk than that revealed by the major risk factors alone”.
CIMT is relevant!

• Simple
• Highly accurate/reproducible
• Related to risk factors
• Predictive of outcomes

..... And, if you could get paid to do it, I bet you’d be even more enthusiastic!
B-Mode Image of the Carotid Artery Wall

plaque

intima

media

adventitia

Courtesy of W. Riley
CIMT Ultrasound

- Frequency: broadband
  - Newest device 13 MHz
  - Device cost: $40K +
- Specific advantages
  - Clinical
    - Noninvasive
    - No radiation exposure
    - No incidental findings
  - Research
    - Scalable
    - Low entry costs for multicenter investigations
    - Understood by clinicians
CIMT Ultrasound: Simple

• Far wall
  • Acoustic shadowing in near wall
• Which site?
  • CCA most reproducible
  • ICA/Bulb: more difficult
    • Plaque more common
    • Greater magnitude of change
• Measurement
  • ABD or manual, 1cm length
  • Easy- takes minutes
  • Accurate- .0x mm

Selection of end-diastolic images
Systolic expansion/IMT thinning
CIMT: Progressive improvement in image quality

13 MHz: 2005
<table>
<thead>
<tr>
<th>Requirements for training and certification of sonographers and readers</th>
<th>Sonographers</th>
<th>Readers</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ultrasound background</strong></td>
<td>Registered diagnostic cardiac sonographer, medical sonographer, or vascular technician</td>
<td>Appropriate credentials and institutional privileges to interpret cardiac and/or vascular ultrasound studies</td>
</tr>
<tr>
<td><strong>Content areas</strong> (minimum 8 h of didactic or online training)</td>
<td>Pathophysiology of atherosclerosis, histopathologic correlations between ultrasound and healthy and diseased arteries, carotid artery anatomy</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CVD risk assessment and rationale for noninvasive testing with carotid ultrasound</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Clinical use of carotid ultrasound to identify subclinical vascular injury and predict CVD risk, including evidence base from epidemiologic and clinical trials and advantages and limitations of testing</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Scanning technique, instrumentation, protocol selection, and imaging pitfalls, including limited hemodynamic evaluation of stenotic lesions, recognition of common cardiac arrhythmias, and blood pressure monitoring</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ultrasound principles and quality assurance</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Measurement and reporting</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Training standards for readers and sonographers</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Scanning (minimum 8 h, in-person)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-Protocol, image acquisition, best image</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-Demonstrate knowledge of content areas above</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reading (minimum 2 h, in-person)—demonstrate proficiency with reading program</td>
<td></td>
</tr>
<tr>
<td><strong>Initial hands-on, supervised training</strong></td>
<td>Submit at least 3 paired mock studies for review by an experienced sonographer</td>
<td>Scanning (minimum 2 h, in-person)</td>
</tr>
<tr>
<td></td>
<td>2 sets of images obtained at least 1 day apart, from 3 patient models</td>
<td>-Understand image generation and pitfalls</td>
</tr>
<tr>
<td></td>
<td>Demonstrate protocol adherence, image quality, and image reproducibility</td>
<td>-Familiarity with scanning protocol</td>
</tr>
<tr>
<td><strong>Follow-up of initial training</strong></td>
<td>Perform least 25 CIMT studies/y</td>
<td>Reading (minimum 2 h, in-person)—demonstrate proficiency with reading program</td>
</tr>
<tr>
<td></td>
<td>Annual retesting of repeatability*</td>
<td>Submit at least 10 measured scans to a core laboratory with published accuracy and reproducibility data</td>
</tr>
<tr>
<td></td>
<td>Quarterly detailed, objective feedback</td>
<td>-Mean Δ reader core laboratory &lt; 0.11 mm</td>
</tr>
<tr>
<td></td>
<td>If inactivity $&gt;2$ months, perform two mock studies to show continued competence</td>
<td>-95% of CIMT values within 0.11 mm of core laboratory87,88,95</td>
</tr>
<tr>
<td><strong>Maintenance of certification and quality assurance</strong></td>
<td>Read at least 25 CIMT studies/y</td>
<td>Annual testing of intraobserver and interobserver repeatability*</td>
</tr>
</tbody>
</table>
Correlation between the Framingham risk score and intima media thickness: The Paroi Artérielle et Risque Cardio-vasculaire (PARC) study

Pierre-Jean Touboul\textsuperscript{a,4}, Eric Vicaut\textsuperscript{b}, Julien Labreuche\textsuperscript{a}, Jean-Pierre Belliard\textsuperscript{c}, Serge Cohen\textsuperscript{d}, Serge Kownator\textsuperscript{e}, Jean-Jacques Portal\textsuperscript{f}, Isabelle Pithois-Merli\textsuperscript{f}, Pierre Amarenco\textsuperscript{a}, on behalf of PARC study participating physicians
Patient Selection

Invited Commentary

Appropriate use criteria for carotid intima media thickness testing

The Society of Atherosclerosis Imaging and Prevention, Developed in collaboration with the International Atherosclerosis Society

**ABSTRACT**

The Society of Atherosclerosis Imaging and Prevention, in collaboration with the International Atherosclerosis Society, conducted an appropriate use review of common clinical scenarios where carotid intima media thickness testing may be considered. The indications for this review were drawn from common applications or anticipated uses, as well as from current clinical practice guidelines. Thirty-three clinical scenarios were developed by a writing committee and scored by a separate technical panel on a scale of 1-9 to designate appropriate use, inappropriate use, or uncertain use. Clinical scenarios included the clinical application of CIMT for risk assessment in the absence of known coronary heart disease, risk assessment in patients with known CHD, and serial CIMT imaging for monitoring of CHD risk status. Appropriate indications were largely clustered within the detection of CHD risk among intermediate risk patients, metabolic syndrome, and older patients. There were no appropriate indications for serial testing. Inappropriate indications generally were seen among use of CIMT in low risk patients, and high risk patients. This document is intended to provide a practical guide to clinicians and promote optimal use of testing which includes both the avoidance of under and over testing. It is intended that these criteria will be updated as the evidence on CIMT imaging continues to evolve.

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## Patient Selection

**CIMT clinical scenarios and appropriateness ratings.**

<table>
<thead>
<tr>
<th>Risk assessment in the absence of known coronary heart disease</th>
<th>Additional Patient Details</th>
<th>Median appropriateness ranking (category)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. CIMT for the initial detection of CHD risk</td>
<td>Low risk</td>
<td>3 (I)</td>
</tr>
<tr>
<td>2. CIMT for the initial detection of CHD risk in the setting of 2 or more NCEP risk factors</td>
<td>Intermediate risk</td>
<td>7 (A)</td>
</tr>
<tr>
<td>3. CIMT for the initial detection of CHD risk in patients with metabolic syndrome</td>
<td>High risk</td>
<td>5 (U)</td>
</tr>
<tr>
<td>4. CIMT for the initial detection of CHD risk in patients with diabetes mellitus</td>
<td>Low risk</td>
<td>5 (U)</td>
</tr>
<tr>
<td>5. CIMT for the detection of CHD risk in men &gt;45 years of age irrespective of CHD risk level</td>
<td>Intermediate risk</td>
<td>8 (A)</td>
</tr>
<tr>
<td>6. CIMT for the detection of CHD risk in women &gt;55 years of age irrespective of CHD risk level</td>
<td>&lt;30 years of age</td>
<td>4 (U)</td>
</tr>
<tr>
<td>7. CIMT for the detection of CHD risk in the setting of a family history of premature CHD</td>
<td>30–60 years of age</td>
<td>7 (A)</td>
</tr>
<tr>
<td>8. CIMT for the detection of CHD risk in patients with a known abnormal coronary calcium score (&gt;1.00 or above the 75th percentile for age and gender)</td>
<td>&gt;60 years of age</td>
<td>7 (A)</td>
</tr>
<tr>
<td>9. CIMT for the detection of CHD risk in patients with a known CAC score of zero</td>
<td>Without a history of CHD</td>
<td>7 (A)</td>
</tr>
<tr>
<td>10. CIMT for the detection of CHD risk in patients with known CHD</td>
<td>With known CHD</td>
<td>3 (I)</td>
</tr>
<tr>
<td>11. CIMT for the detection of CHD risk in patients with a known abnormal coronary calcium score (&gt;1.00 or above the 75th percentile for age and gender)</td>
<td>Low risk</td>
<td>6 (U)</td>
</tr>
<tr>
<td>12. CIMT for the detection of CHD risk in patients with a known abnormal coronary calcium score (&gt;1.00 or above the 75th percentile for age and gender)</td>
<td>Intermediate risk</td>
<td>8 (A)</td>
</tr>
<tr>
<td>13. CIMT for the detection of CHD risk in patients with a known abnormal coronary calcium score (&gt;1.00 or above the 75th percentile for age and gender)</td>
<td>PRS &lt;5%</td>
<td>3 (I)</td>
</tr>
<tr>
<td>14. CIMT for the detection of CHD risk in patients with a known abnormal coronary calcium score (&gt;1.00 or above the 75th percentile for age and gender)</td>
<td>PRS 5–10%</td>
<td>5 (U)</td>
</tr>
<tr>
<td>15. CIMT for the detection of CHD risk in patients with a known abnormal coronary calcium score (&gt;1.00 or above the 75th percentile for age and gender)</td>
<td>PRS 11–20%</td>
<td>7 (A)</td>
</tr>
<tr>
<td>16. CIMT for the detection of CHD risk in patients with a known abnormal coronary calcium score (&gt;1.00 or above the 75th percentile for age and gender)</td>
<td>Asymptomatic patient with focal carotid artery plaque on duplex carotid ultrasound</td>
<td>3 (I)</td>
</tr>
<tr>
<td>17. CIMT for the detection of CHD risk in patients with a known abnormal coronary calcium score (&gt;1.00 or above the 75th percentile for age and gender)</td>
<td>Asymptomatic patient with &gt;50% stenosis on carotid duplex ultrasound</td>
<td>3 (I)</td>
</tr>
</tbody>
</table>
ASE CONSENSUS STATEMENT
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*

James H. Stein, MD, FASE, Claudia E. Korcarz, DVM, RDMS, FASE, R. Todd Hurst, MD, Eva Lonn MD, MSc, FASE, Christopher B. Kendall, BS, RDMS, Emile R. Mohler, MD, Samer S. Najjar, MD, Christopher M. Rembold, MD, and Wendy S. Post, MD, MS, Madison, Wisconsin; Scottsdale, Arizona; Hamilton, Ontario, Canada; Philadelphia, Pennsylvania; Baltimore, Maryland; and Sheffield, Illinois.

Appendix 1 Common carotid artery carotid intima-media thickness values and percentiles from large North American cohort studies

A. Mean far wall common carotid artery carotid intima-media thickness values from the Atherosclerosis Risk in Communities Study

<table>
<thead>
<tr>
<th>Age, y/percentile</th>
<th>White male</th>
<th>White female</th>
<th>Black male</th>
<th>Black female</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>45</td>
<td>55</td>
<td>65</td>
<td>45</td>
</tr>
<tr>
<td>Right</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25th</td>
<td>0.496</td>
<td>0.572</td>
<td>0.648</td>
<td>0.476</td>
</tr>
<tr>
<td>50th</td>
<td>0.570</td>
<td>0.664</td>
<td>0.758</td>
<td>0.536</td>
</tr>
<tr>
<td>75th</td>
<td>0.654</td>
<td>0.774</td>
<td>0.894</td>
<td>0.610</td>
</tr>
<tr>
<td>Left</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25th</td>
<td>0.524</td>
<td>0.588</td>
<td>0.652</td>
<td>0.472</td>
</tr>
<tr>
<td>50th</td>
<td>0.598</td>
<td>0.684</td>
<td>0.770</td>
<td>0.538</td>
</tr>
<tr>
<td>75th</td>
<td>0.690</td>
<td>0.806</td>
<td>0.922</td>
<td>0.610</td>
</tr>
</tbody>
</table>
CIMT: Net reclassification of CHD Risk

- Net reclassification based upon CIMT findings in ARIC:
  - 1 in 8 reclassified to a lower risk group
  - 1 in 9 reclassified to a higher risk group

_Nambi and Ballantyne; JACC, 2010_

**Figure 1: Adjusted coronary heart disease incidence rate per 1,000 person year adjusted by C-IMT categories (<25th percentile, 25th-75th percentile and >75th percentile) with and without plaque**
Only meta-analysis that pooled individual, patient level data (versus study-level pooling) from 16 prospective cohort studies involving 36,984 patients encompassing 71% of the worldwide data on the topic.

It included 2028 events (MI, stroke, death).

Baseline CIMT predicted each of these outcomes with hazard ratios from 10-22% for each 0.1mm increase in CIMT.

- These data were after full adjustment for patient data on all cardiovascular risk factors, demographics, and socioeconomic adjusters.

Study-level pooling of 14 population-based cohort studies
- 45,828 individuals. The net reclassification improvement was 3.2% in men, 3.9% in women, a finding that the authors assessed as not clinically meaningful.

Weaknesses
- CIMT, not inclusive of plaque
- Less selective approach than the PROG IMT authors, pooling studies in this analysis that were heterogeneous, including those that used very different technical methods for CIMT over the past 2 decades
- They also included many short studies that used different methods of adjudicating events.
- The authors included studies that used CIMT as a method of pharmacologic evaluation (e.g., statin trials) leading to a source of bias in event rates.
The addition of common CIMT measurements to the Framingham Risk Score was associated with a small improvement in 10-year risk prediction of first-time myocardial infarction or stroke, but this improvement is unlikely to be of clinical importance.
Carotid intima-media thickness progression to predict cardiovascular events in the general population (the PROG-IMT collaborative project): a meta-analysis of individual participant data

Matthews W, Lorencz, Joseph P, Polak, Marjann Kauczok, Ebbes B Madsen, Henrik Wade, Toni-Pekka Toomainen, Dirk Sandor, Matthias Pillau, Alberto A Cipolli, Christine M Robertson, Stefan Kiechl, Tatjana Ruderer, Maria Desvignes, Lars Lund, Carole Schmid, Pranabesh Dasgupta, Lu Gao, Kathrin Ziegler-Birn, Michael J. Boys, Simon G. Thompson, on behalf of the PROG-IMT Study Group

Summary

Background Carotid intima-media thickness (cIMT) is related to the risk of cardiovascular events in the general population. An association between changes in cIMT and cardiovascular risk is frequently assumed but has rarely been reported. Our aim was to test this association.

Methods We identified general population studies that assessed cIMT at least twice and followed up participants for myocardial infarction, stroke, or death. Thirty-two studies contributed individual participant data to this meta-analysis. Excluding individuals with known myocardial infarction or stroke, we assessed the association between cIMT progression and the risk of cardiovascular events (myocardial infarction, stroke, vascular death, or a combination of these) for each study with Cox regression. The log hazard ratios (HRs) and 95% confidence intervals were pooled by random effects meta-analysis.

Findings Of 22 eligible studies, 16 with 30,964 participants were included. During a mean follow-up of 7.0 years, 1519 myocardial infarctions, 1339 strokes, and 2023 combined endpoints (myocardial infarction, stroke, or vascular death) occurred. Yearly cIMT progression was 0.03 mm/year (95% CI 0.03–0.03) and the HR of the combined endpoint was 1.1 (95% CI 1.08–1.11) per mm/year increase in cIMT. The overall HR of the combined endpoint was 0.97 (95% CI 0.94–1.00) when adjusted for age, sex, and mean common carotid artery intima-media thickness, and 0.98 (0.95–1.01) when also adjusted for vascular risk factors. Although we detected no associations with cIMT progression in sensitivity analyses, the mean cIMT of the two ultrasound scans was positively and robustly associated with cardiovascular risk (HR for the combined endpoint 1.16, 95% CI 1.10–1.22, adjusted for age, sex, mean common carotid artery intima-media thickness progression, and vascular risk factors). In three studies including 3349 participants who had ultrasound scans, cIMT progression did not correlate between occasions (reproducibility correlations between r = 0.06 and r = 0.02).

Interpretation The association between cIMT progression assessed from two ultrasound scans and cardiovascular risk in the general population remains unproven. No conclusion can be derived for the use of cIMT progression as a surrogate in clinical trials.
Studied 3703 subjects (3 RFs) using standardized carotid ultrasonographic evaluations with modern (10MHz) imaging technology.

Common carotid CIMT (each 1 standard deviation increase) was associated with a 31% increase in CV event risk.

Other carotid segments, and a composite assessment, were predictive of CV events, but not superior to common carotid IMT.

The net reclassification improvement for combined CIMT and plaque, over risk factors alone, was 13%.
Notable Points

• Technique misunderstood and misrepresented
  • Must be done well

• Other imaging techniques accomplish the same aims (e.g., CAC)

• Limited data on qualitative characteristics other than plaque

• No data linking CIMT measurement to improved processes of care or cardiovascular outcomes

• Not reimbursed
Criteria for development and evaluation of CPT Category I and Category III Codes

In developing new and revised Category I codes the CPT Advisory Committee and the CPT Editorial Panel require:

• that the service/procedure has received approval from the Food and Drug Administration (FDA) for the specific use of devices or drugs;

• that the suggested procedure/service is a distinct service performed by many physicians/practitioners across the United States;

• that the clinical efficacy of the service/procedure is well established and documented in U.S. peer review literature;

• that the suggested service/procedure is neither a fragmentation of an existing procedure/service nor currently reportable by one or more existing codes; and

• that the suggested service/procedure is not requested as a means to report extraordinary circumstances related to the performance of a procedure/service already having a specific CPT code.
Criteria for development and evaluation of CPT Category I and Category III Codes

- Current codes
  - 0126T- Level 3 code
  - 93880 Duplex scan of extracranial arteries; complete bilateral study
  - 93882 unilateral or limited study

- According to the latest CPT code book, 93880 and 93882 should not be used for a carotid IMT study (currently code 0126T), which is “for evaluation of atherosclerosis burden or CHD risk assessment.”

- Parity with calcium scoring:
  - 75771 Computed tomography, heart, without contrast material, with quantitative evaluation of coronary calcium
## Current Usage of Limited Carotid Ultrasound

<table>
<thead>
<tr>
<th>Site of Care: 93882</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outpatient Facilities</td>
<td>15,760</td>
<td>15,448</td>
<td>15,283</td>
</tr>
<tr>
<td>Freestanding</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Physician Office</td>
<td>157,192</td>
<td>163,984</td>
<td>163,863</td>
</tr>
<tr>
<td>Emergency</td>
<td>664</td>
<td>660</td>
<td>905</td>
</tr>
<tr>
<td>Total Outpatient Episodes</td>
<td>173,616</td>
<td>180,092</td>
<td>180,051</td>
</tr>
</tbody>
</table>

Source: Thomson-Reuters (Aileron)

## IMT Scans As Per AAPP (0126T, 93882)

<table>
<thead>
<tr>
<th>Site of Care</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012**</th>
<th>2017**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concierge Cash Pay Practices (40 scans a month)</td>
<td>140,000</td>
<td>160,000</td>
<td>200,000</td>
<td>220,000</td>
<td>480,000</td>
</tr>
</tbody>
</table>
Unique Work in CIMT

- Pre-service Work:
  - Prior to CIMT/plaque survey testing, a clinical assessment of cardiovascular risk should be performed, including standard cardiovascular risk factors, and evaluation of family history for coronary heart disease.
  - Review medical record and any applicable prior imaging studies.
  - Review indication for study and appropriateness.
Unique Work in CIMT

- **Intra-service work**
  - Educate the patient on the study procedure and its use in medical decision making, and obtain informed consent where applicable.
  - Review protocol for examination with technologists and other clinical staff.
  - Ensure adequacy, quality, and completeness of images prior to analysis/quantitation.
  - Quantitate CIMT using dedicated software that determines the mean and maximum CIMT for both the right and left carotid arteries.
  - Interpret images for the presence or absence of **focal atherosclerotic plaque**.
  - Interpreting physician archives images detailing quantitative assessment and annotations.
  - Compare the CIMT for each individual patient to databases of population stratified by age, gender, and ethnicity, in addition to ensuring comparability of imaging methods used in the assessment.
  - Determine the revised cardiovascular risk assessment for the patient by using computer-based risk calculators such as those provided by the Atherosclerosis Risk in Communities study. Data required include quantitative cardiovascular risk variables, CIMT, and the presence or absence of atherosclerotic plaque.
  - Finally, create the report for the medical record including details of the cardiovascular risk assessment. Maintain responsibility for HIPAA standards.
Unique Work in CIMT

- **Post-service work**
  - Review and sign the final report for the medical record.
  - Communicate results, clinical implications, and therapeutic modifications to referring physician and the patient.
  - Provide availability and support to the referring physician for questions in test interpretation and implementation of results.
CPT proposal:

Imaging of the carotid artery for subclinical atherosclerosis with the assessment of both arterial wall thickness (intima-media thickness) and a survey for focal atherosclerosis.
CIMT is a marker whose time has come

• Simple
  • CIMT plus plaque screen
• Highly accurate/reproducible
• Related to risk factors
• Incrementally predictive of outcomes
  • NRI of approximately 10%
• Time for a level 1 CPT code