UNIVERSITY ABOUBEKR BELKAID

LABORATORY OF RESEARCH ON DIABETES

مخبر بحث سكري

« LAREDIAB »

Code ATRSS/DGRST N° W0417700

FACULTY OF MEDICINE BENAOUDA BENZERDJEB

https://laredlab.univ-tlemcen.dz

Mobile : 0770 218 100/ E-mail:ali.lounici@univ-tlemcen.dz

AMIWIT

جمعية الطب الداخلي لجامعي ولاية تلمسان

ACADEMIC HOSPITAL TIDJANI DAMERDJI

4th SÉMINARY OF LAREDIAB

10TH CONGRESS OF AMIWIT

Friday 10 & Saturday 11 June 2022

FACULTY OF SNV/STU - UNIVERSITY OF TLEMCEN

Use of Carotid Ultrasound to Identify Subclinical Vascular Disease and Evaluate Cardiovascular Disease Risk

Dr Esma Tabti

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

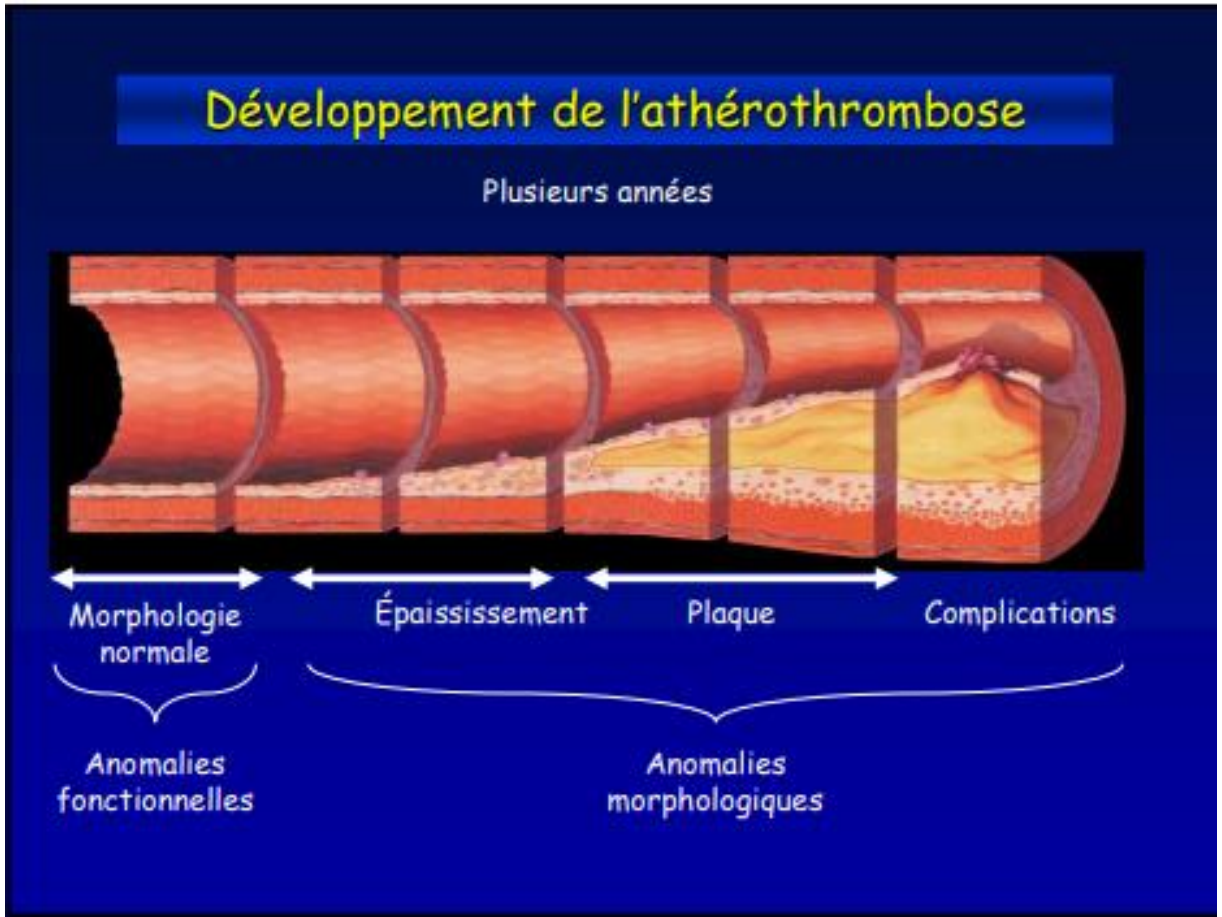
James H. Stein, MD, FASE, Claudia E. Korcarz, DVM, RDCS, FASE, R. Todd Hurst, MD, Eva Lonn MD, MSc, FASE, Christopher B. Kendall, BS, RDCS, Emile R. Mohler, MD, Samer S. Najjar, MD, Christopher M. Rembold, MD, and Wendy S. Post, MD, MS,

Madison, Wisconsin; Scottsdale, Arizona; Hamilton, Ontario, Canada; Philadelphia, Pennsylvania; Baltimore, Maryland; and Charlottesville, Virginia

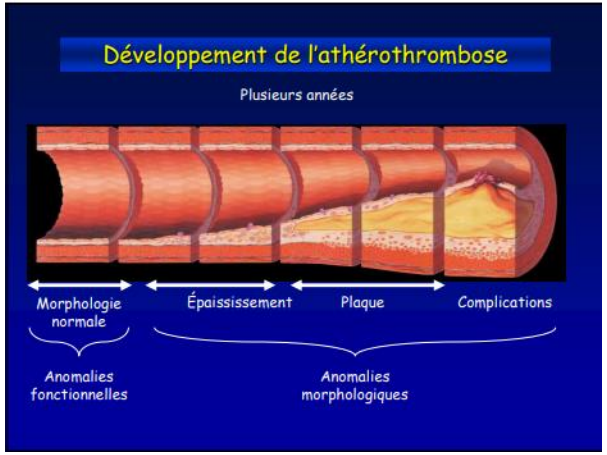
- Introduction:
- Rationale for using carotid ultrasound to identify subclinical vascular disease and evaluate CVD risk
- The relationship between CIMT and subclinical vascular disease
- Application of carotid ultrasound to CVD risk assessment
- Published experience of carotid ultrasound for cvd risk prediction in clinical practice
- Carotid ultrasound scanning technique
- Reporting carotid ultrasound study result
- Conclusion

INTRODUCTION:

- Atherosclerotic vascular disease begins in childhood and progresses over decades.
- Clinical cardiovascular disease (CVD) events generally occur when atherosclerosis progresses to flowlimiting disease that causes ischemia, or when a thrombus forms on an existing plaque as a result of rupture or erosion.



INTRODUCTION:



- To prevent death and morbidity from CVD, there is great interest in identifying asymptomatic patients at high risk who would be candidates for more intensive, evidence-based medical interventions that reduce CVD risk.
- Imaging of arteries to identify and quantify the presence of subclinical vascular disease has been suggested to further refine CVD risk assessment.
- Measurement of carotid intima-media thickness (CIMT) with B-mode ultrasound is a noninvasive, sensitive, and reproducible technique for identifying and quantifying atherosclerotic burden and CVD risk

RATIONALE FOR USING CAROTID ULTRASOUND TO IDENTIFY SUBCLINICAL VASCULAR DISEASE AND EVALUATE CVD RISK: EVIDENCE FROM CLINICAL RESEARCH STUDIES

RATIONALE

- Standard clinical carotid duplex ultrasound studies primarily are indicated to identify occlusive carotid plaques , a manifestation of advanced atherosclerosis.
- For assessment of CVD risk, the carotid artery wall, rather than the degree of luminal narrowig, is examined to identify areas of increased thickness and nonocclusive atherosclerotic plaque, which represent early stages of atherosclerosis.
- Ultrasound imaging of the far wall of the carotid artery produces two echogenic lines. In situ anatomic and in vitro histologic studies have validated these lines as the lumen-intima interface and the media-adventitia interface.
- The combined thickness of the intimal and medial layers of the arterial wall constitute the CIMT.

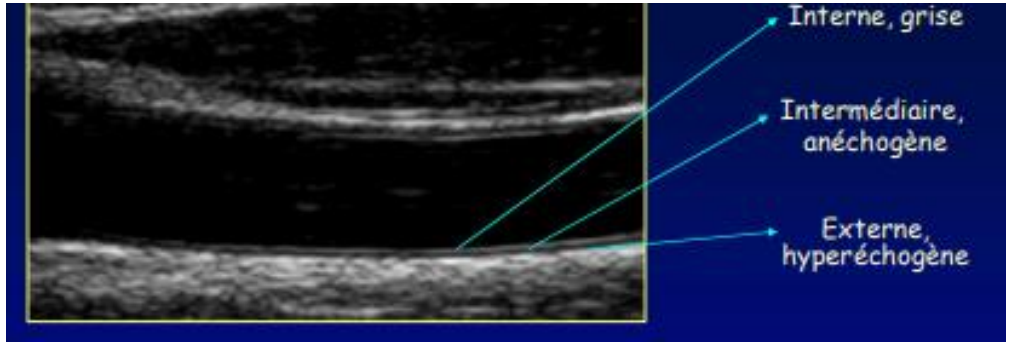
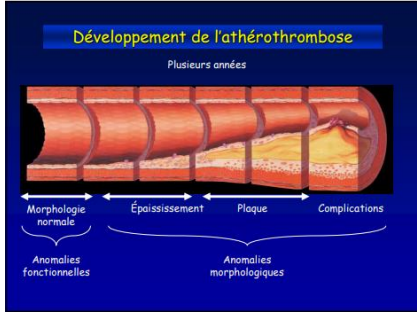


Table 1 Prospective studies of carotid intima-media thickness and risk for cardiovascular disease events in individuals without known cardiovascular disease (N >1000 participants each)

Study	N	Age (y); F	Follow-up (y)	Measurement; site	Event	ΔCIMT (mm); adjusted RR (95% CI)*	CIMT cut point; adjusted RR (95% CI)*†
ARIC[5]	12,841	45-64; 57%	5.2	Mean of mean; CCA/bulb/ICA	MI, CHD death	0.19; F: 1.38 (1.21-1.58) M: 1.17 (1.04-1.31)	Highest tertile; F: 2.53 (1.02-6.26) M: 2.02 (1.32-3.09)
				Mean; CCA	MI, CHD death	0.19; F: 1.46 (1.22-1.74) M: 1.08 (0.91-1.1.27)	—
ARIC[19]	14,214	45-64; 55%	7.2	Mean of mean; CCA/bulb/ICA	Stroke	0.19; F: 1.36 (1.16-1.59) M: 1.21 (1.05-1.39)	Highest tertile; F: 2.32 (1.09-4.94) M: 2.24 (1.26-4.00)
				Mean; CCA	Stroke	0.18; F: 1.32 (1.10-1.58) M: 1.38 (1.16-1.65)	Highest tertile; F: 1.65 (0.85-3.19) M: 2.69 (1.49-4.87)
CAPS[20]	5056	19-90; 50%	4.2	Mean; far wall CCA	MI	0.16; 1.16 (1.05-1.27)	Highest quartile 1.83 (0.97-3.45)
				Mean; far wall CCA	Stroke	0.16; 1.11 (0.97-1.28)	Highest quartile 1.82 (0.64-5.16)
				Mean; far wall CCA	MI, stroke, death	0.16; 1.17 (1.08-1.26)	Highest quartile 1.85 (1.09-3.15)
CHS[6]	4476	>65; 39%	6.2	Mean of maximum; near + far CCA/ICA	MI	1 SD; 1.36 (1.23-1.52)	Highest quintile; 3.61(2.13-6.11)
				Maximum; near + far CCA	MI	0.20; 1.24 (1.12-1.38)	Highest quintile; 2.46 (1.51-4.01)
				Mean of maximum; near + far CCA/ICA	Stroke	1 SD; 1.33 (1.20-1.47)	Highest quintile; 2.57 (1.64-4.02)
				Maximum; near + far CCA	Stroke	0.20; 1.28 (1.16-1.42)	Highest quintile; 2.13 (1.38-3.28)
KIHD[21]	1257	42-60; 0%	3	Maximum; far wall CCA	MI	0.11; 1.11 (1.06-1.16)	>1.0 mm; 2.1 (0.8-5.2)
Yao City[22]	1289	60-74; 0%	4.5	Mean of maximum; near + far CCA/ICA	Stroke	—	Highest quartile; 4.9 (1.9-12.0)
				Maximum; near + far CCA	Stroke	—	Highest quartile; 4.9 (1.9-12.0)
MDCS[23]	5163	46-68; 60%	7	Maximum; far wall CCA	MI, CHD death	0.15; 1.23 (1.07-1.41)	Highest tertile; 1.50 (0.81-2.59)
Rotterdam[24]	6389	>55; 62%	7-10	Maximum; near + far CCA	MI	0.21; 1.28 (1.14-1.44)	Highest quartile; 1.95 (1.19-3.19)

CCA, Common carotid artery; *CHD*, coronary heart disease; *CI*, confidence interval; *CIMT*, carotid intima-media thickness; *F*, female; *ICA*, internal carotid artery; *M*, male; *MI*, myocardial infarction; *RR*, relative risk. ARIC, Atherosclerosis Risk in Communities Study; CAPS, Carotid Atherosclerosis Progression Study; CHS, Cardiovascular Health Study; KIHD, Kuopio Ischemic Heart Disease Study; MDCS, Malmö Diet and Cancer Study.
*Adjusted for age, sex, and traditional risk factors.
†Highest tertile quartile or quintile compared with lowest.

RATIONALE



- CIMT values add additional information beyond traditional risk factors for classifying for predicting cardiovascular events.
- The relationship between increasing CIMT and incident CVD events has been established across a wide age range; however, the strongest data are for individuals between 42 and 74 years of age

THE RELATIONSHIP BETWEEN CIMT AND SUBCLINICAL VASCULAR DISEASE

CIMT AND SUBCLINICAL VASCULAR DISEASE

- CIMT is associated with **CVD risk factors**, prevalent CVD, incident CVD, and the degree of atherosclerosis in several different arterial beds.
- **Progression of CIMT** may be attenuated or reversed with risk factor interventions, in association with a reduced risk of future CVD events.
- CIMT measurements can be used as a surrogate **marker of atherosclerosis.**
- Increased CIMT may be related to intimal or medial hypertrophy or both
- It is well established that CIMT increases with advancing age, CIMT increases nearly 3-fold between the ages of 20 and 90 years.

CIMT AND SUBCLINICAL VASCULAR DISEASE

- Many factors have been implicated in the pathogenesis and progression of atherosclerotic plaques
- Endothelial dysfunction; increased endothelial cell adhesiveness and permeability; increases in procoagulant, vasoconstrictive, and inflammatory molecules; increases in cytokines and chemokines; increased oxidative stress; and proliferation and migration of smooth muscle cells.

APPLICATION OF CAROTID ULTRASOUND TO CVD RISK ASSESSMENT

CVD RISK ASSESSMENT

- The traditional approach to CVD risk assessment involves identifying and quantifying the presence or absence of CVD risk factors.
- The NCEP recommends estimating the 10-year risk for CHD death or myocardial infarction using the **Framingham risk score (FRS)** model
- Although the FRS accurately discriminates short-term CVD risk, it has some potential limitations.
- Because the FRS only predicts 10-year risk rather than lifetime risk and women tend to develop CVD at older ages, women with significant subclinical vascular disease can be misclassified as being at lower risk based on the 10-year FRS alone, and therefore, may not receive appropriate preventive measures.
- In addition, the FRS does not account for family history of premature CVD, and some risk factors such as smoking and diabetes mellitus are considered only as present or absent, although epidemiologic data support a continuous relationship between CVD risk and tobacco exposure and glucose levels, respectively.

CVD RISK ASSESSMENT

- Measuring CIMT and identifying carotid plaque by ultrasound are most useful for refining CVD risk assessment in patients at intermediate CVD risk (FRS 6%-20% without established CHD, peripheral arterial disease, cerebrovascular disease, diabetes mellitus, or abdominal aortic aneurysm). **Patients with the following clinical circumstances also might be considered for CIMT measurement and carotid plaque detection: (1) family history of premature CVD in a firstdegree relative (men < 55 years old, women < 65 years old); (2) individuals younger than 60 years old with severe abnormalities in a single risk factor (eg, genetic dyslipidemia) who otherwise would not be candidates for pharmacotherapy; or (3) women younger than 60 years old with at least two CVD risk factors.**
- Imaging should not be performed in patients with established atherosclerotic vascular disease or if the results would not be expected to alter therapy.

Coronary artery calcium/ Carotid Intima media thickness

- **Fast computed tomography** to measure coronary artery calcium evaluates subclinical vascular disease; however, carotid ultrasound has some potential advantages compared with this test.
- Carotid ultrasound does not involve exposure to ionizing radiation
- In addition, CIMT has the advantage of being a continuous measure that could be used to stratify risk in women and younger men, and in African American individuals, where coronary artery calcium scoring may have limited discriminatory power because of a high prevalence of a zero calcium score

PUBLISHED EXPERIENCE OF CAROTID ULTRASOUND FOR CVD RISK PREDICTION IN CLINICAL PRACTICE

PUBLISHED EXPERIENCE

- In clinical practice, CIMT values can help reclassify patients at intermediate risk, and predict major adverse cardiovascular events
- the ability of a management strategy that includes CIMT or plaque screening tests to improve CVD outcomes are limited to changes in patient or physician behavior that would be expected to lead to reduced CVD risk.
- In a small (N 50) interventional study, physicians were more likely to prescribe aspirin and lipid-lowering therapy to patients who were found to have carotid plaque during an office screening examination.
- In a small (n 74) randomized study, smokers shown images of their carotid plaques were more likely to stop smoking at 6 months.
- In a study of 210 individuals described in a review article, patients were more likely to adhere to recommendations regarding diet, exercise, and smoking cessation 12 months after seeing pictures of their CIMT examination.
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PUBLISHED EXPERIENCE

- The Measuring Effects on Intima-Media Thickness: An Evaluation of Rosuvastatin (METEOR) Study demonstrated that middle-aged adults at apparently low to intermediate CVD risk but with increased CIMT (N 984) benefited from statin therapy that they otherwise would not have qualified for based on current treatment guidelines.
- In this prospective, randomized multicenter clinical trial, the magnitude of the difference in CIMT progression rates (– 0.145 mm/y) was similar to that observed in secondary prevention trials that were associated with a reduction in cardiovascular events
- this study suggests that using CIMT to modify preventive treatment strategies is feasible and associated with a delay in the progression of vascular injury.

CAROTID ULTRASOUND SCANNING TECHNIQUE

Patient and Sonographer Preparation:

Both the sonographer and patient should be positioned properly to facilitate high-quality, reproducible images.

ınd study.

Table 3 Study setup

Sonographer	Patient
Position at head of patient, with enough space to rest elbow on bed Adjust height and location of ultrasound system keyboard and monitor, examination bed, and chair to avoid ergonomic injuries	Position supine on scan bed with head resting comfortably Slightly hyperextend and rotate neck in direction opposite to probe Use 45-degree angle wedge pillow to help standardize lateral rotation During scan, sonographer may adjust neck position to optimize images, especially in anterior scanning planes Use rolled towels under neck and pillows under legs for comfort Use external landmarks such as the Meijer arc (Figure 1)[91] or similar devices can help standardize transducer angle

Instrumentation and Image Display

- The carotid arteries should be interrogated using a state-ofthe-art ultrasound system with a linear-array transducer operating
- At a fundamental frequency of at least **7 MHz.** Use of nonfundamental frequencies can increase wall thickness.
- At a standard **depth of 4 cm**, however, increased depth may be necessary in some patients with larger necks or deeper vessels.
- Use of the zoom function is discouraged because most studies relating CIMT to CVD events did not use zoomed images.

Instrumentation and Image Display

- B-mode imaging is preferred
- Multiple measurements of several extended segment lengths permit expression of CIMT values with higher precision (subpixelar level)

- **All reported observational studies relating CIMT values to cardiovascular events used B-mode measurements, usually averaged over at least a 1-cm segment.**

Imaging Protocol

- **Carotid ultrasound imaging should follow a scanning protocol from a large epidemiologic study (ARIC Study: Atherosclerosis Risk in Communitie).**
- the task force recommends that ultrasound images of the distal 1 cm of the far wall of each CCA should be obtained
- Multiple measurements of several extended segment lengths permit expression of CIMT values with higher precision
- the far wall of the CCA provides a **convenient window** to study arterial structure using B-mode ultrasound.

IMAGING PROTOCOL

- It should be supplemented by a thorough **scan of the extracranial carotid arteries** for the presence of carotid plaques, to increase sensitivity for identifying subclinical vascular disease.
- **Carotid Plaque Screening**: a circumferential scan ranging from anterior to posterior angles, and imaging the near or far walls of the CCA, bulb, and internal carotid artery segments is required

OVERVIEW AND TIPS FOR CIMT IMAGING

- The region to be measured includes the far wall of the distal 1 cm of the CCA. The distal CCA should be perfectly horizontal on the screen with simultaneous double lines in the near and far walls of the CCA ("double-line" sign)
- This is accomplished by a combination of small adjustments in transducer tilt, rotation, and differential pressure of proximal-to-distal end of the probe (heel-toe movement)

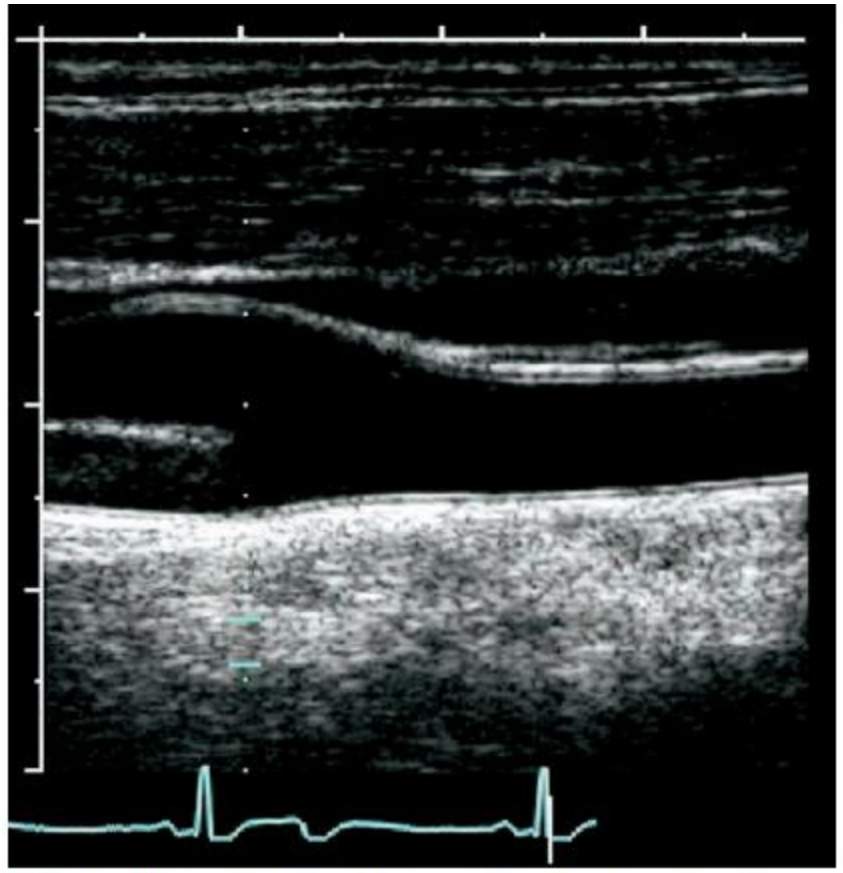
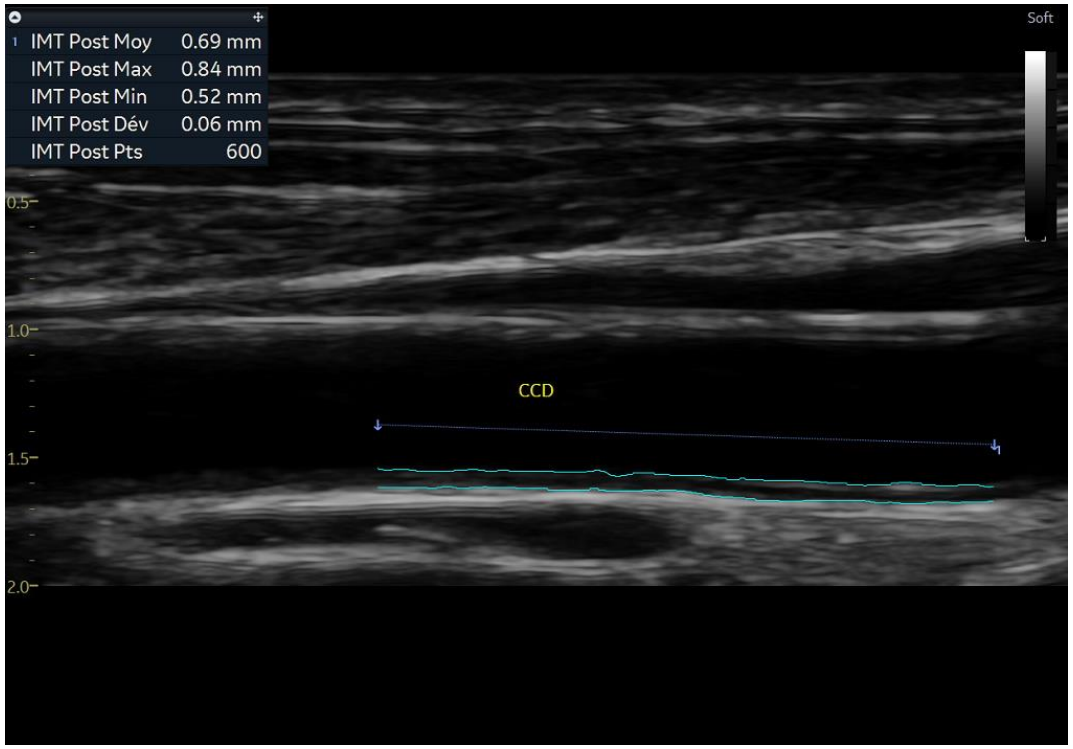
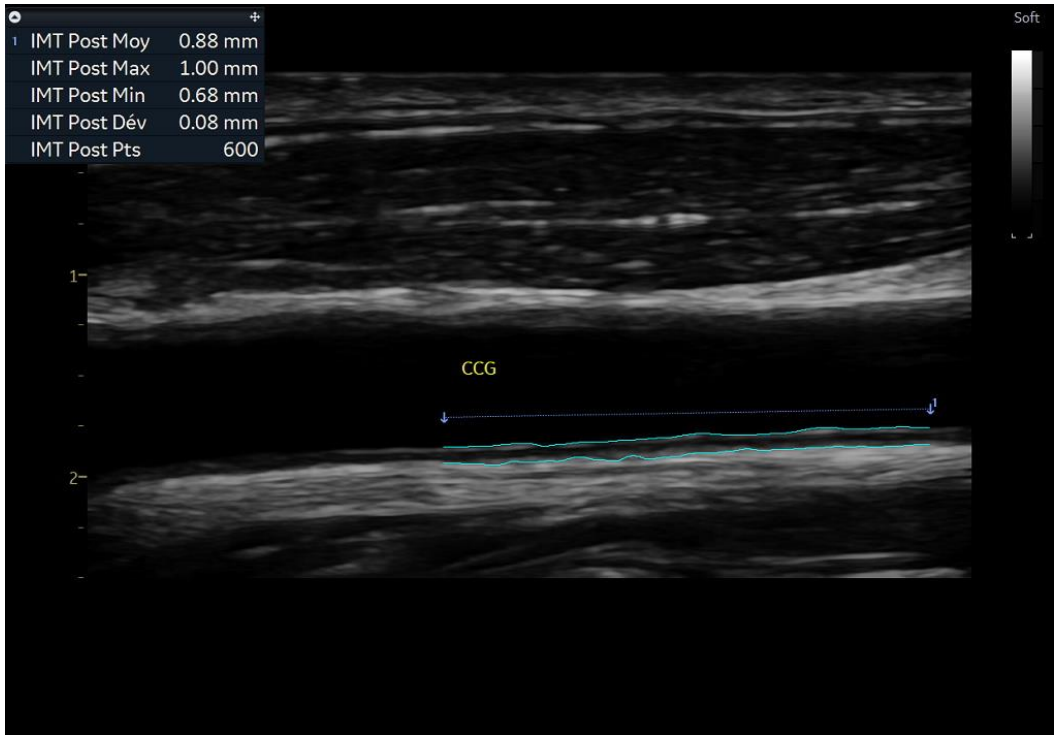


Figure 3 True longitudinal plane simultaneously demonstrating double lines on the near and far walls of the common carotid artery ("double-line" sign).

INTERPRETATION OF CAROTID ULTRASOUND STUDIES FOR CVD RISK ASSESSMENT

- Evaluating for the presence or absence of plaque in conjunction with measuring CCA CIMT offers a better representation of subclinical vascular disease and CVD risk than only measuring CIMT.
- Carotid plaque is defined as the presence of focal wall thickening that is at least 50% greater than that of the surrounding vessel wall or as a focal region with CIMT greater than 1.5 mm that protrudes into the lumen that is distinct from the adjacent boundary
- The task force recommends use of a semiautomated border detection program with validated accuracy.
- Mean CIMT values from the far walls of the right and left CCAs (mean-mean) should be reported.





Male 60 ans
CVF: tabac
CIMT Max left = 0,88 mm , Max Right: 0,69 mm
Mean=0,78

REPORTING CAROTID ULTRASOUND STUDY RESULT

- Communication of CIMT results is facilitated by qualitatively describing broad ranges of percentiles.
- This avoids the appearance of greater precision than is achievable when mapping CIMT values to a reference population
- CIMT values greater than or equal to **75th percentile** are considered high and indicative of increased CVD risk.
- Values in the **25th to 75th** percentile are considered average and indicative of unchanged CVD risk.
- Values less than or equal to **25th** percentile are considered lower CVD risk,

B. Mean far wall common carotid artery carotid intima-media thickness values from the Carotid Atherosclerosis Progression Study (Matthias W. Lorenz, MD, personal communication, December 6)[20]

Age, y/percentile	Male							Female						
	25	35	45	55	65	75	85	25	35	45	55	65	75	85
25th	0.515	0.585	0.634	0.68	0.745	0.814	0.83	0.524	0.575	0.619	0.665	0.718	0.771	0.807
50th	0.567	0.633	0.686	0.746	0.83	0.914	0.937	0.567	0.615	0.665	0.719	0.778	0.837	0.880
75th	0.633	0.682	0.756	0.837	0.921	1.028	1.208	0.612	0.66	0.713	0.776	0.852	0.921	0.935

C. Maximum* far wall common carotid artery carotid intima-media thickness values from the Edinburgh Artery Study (F. Gerald R. Fowkes, MBChB, PhD, personal communication, November 2006)[81]

Age, y/percentile	Male					Female				
	60-64	65-69	70-74	75-79	>80	60-64	65-69	70-74	75-79	>80
25th	0.60	0.70	0.70	0.70	0.80	0.60	0.60	0.70	0.70	0.72
50th	0.80	0.80	0.80	0.90	1.00	0.70	0.80	0.80	0.90	0.90
75th	0.90	1.00	1.00	1.20	1.20	0.80	0.90	0.90	1.00	1.40

Y, years. All values are in mm.

*Maximum of right or left common carotid artery.

CONCLUSIONS

- Ultrasonic detection of carotid plaque and CIMT measurements can be useful for refining CVD risk assessment in some asymptomatic patients.
- This noninvasive approach can detect subclinical vascular disease and help identify patients at increased risk of CVD.
- Strict attention to quality control in image acquisition, measurement, interpretation, and reporting are necessary for implementation of this technique in clinical practice

Thank you for your attention

Take care of your arteries