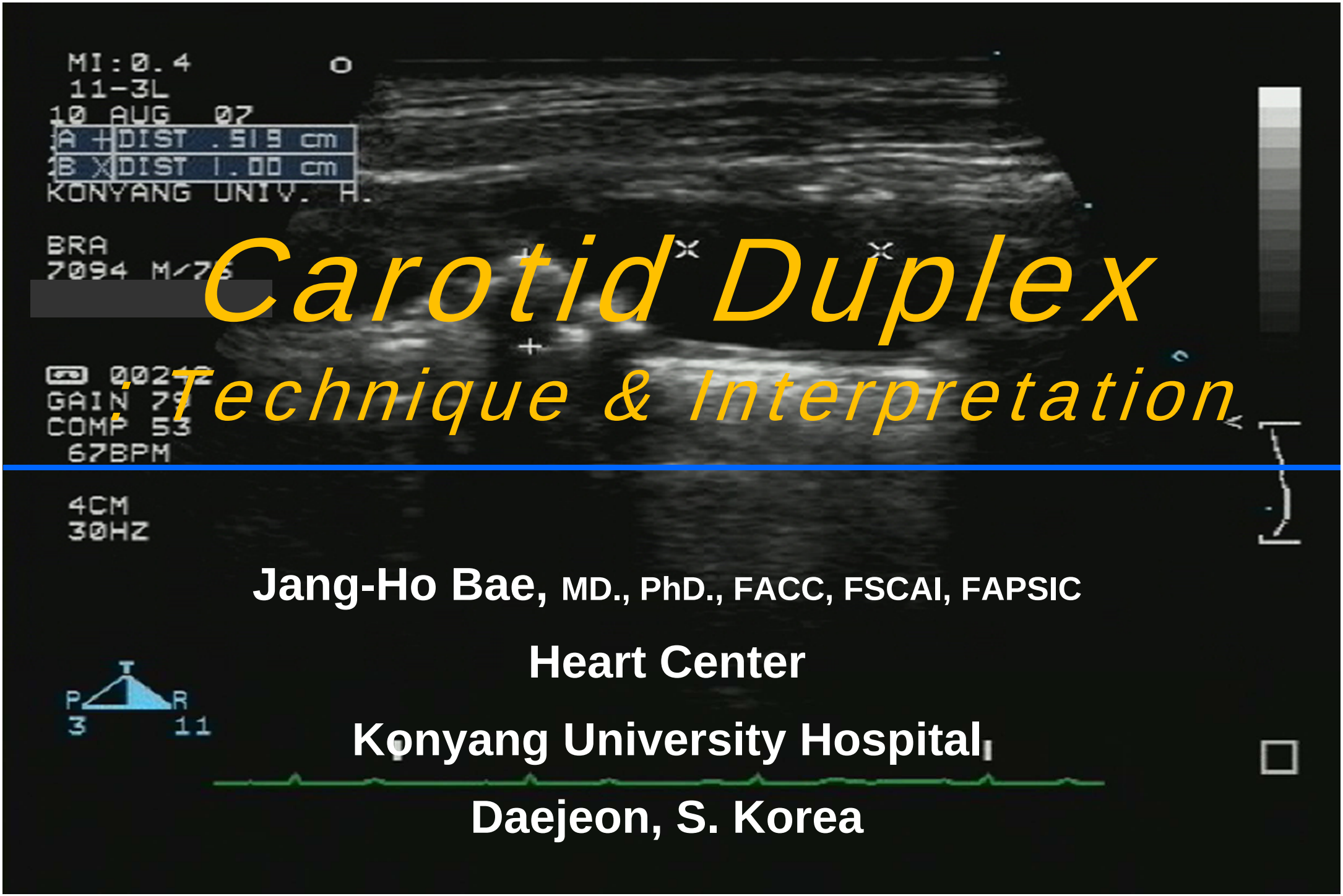


Carotid Duplex
; Technique & Interpretation

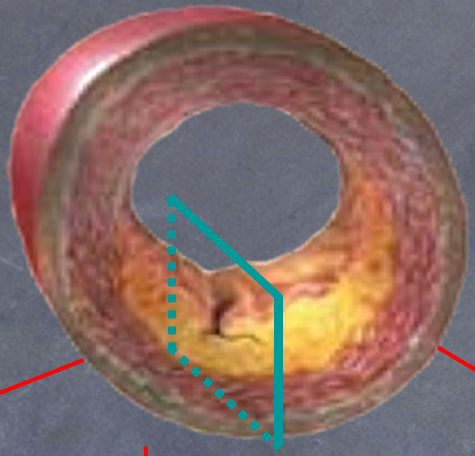
Jang-Ho Bae, MD., PhD., FACC, FSCAI, FAPSIC

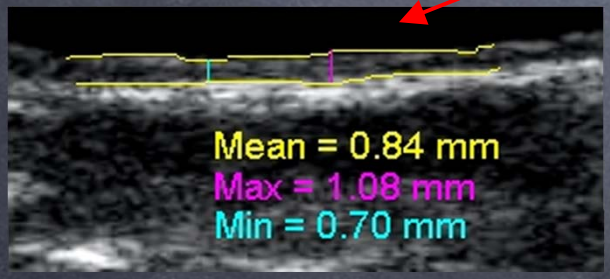
Heart Center

Konyang University Hospital

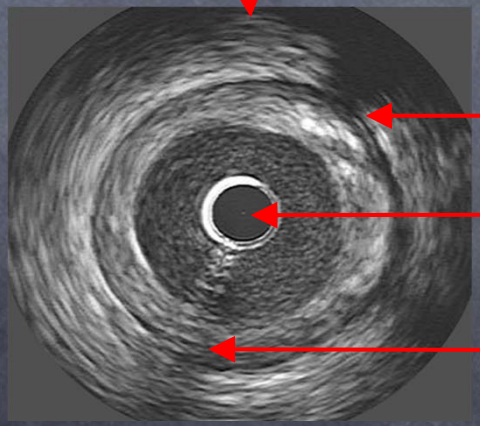
Daejeon, S. Korea

Why Duplex Ultrasound?

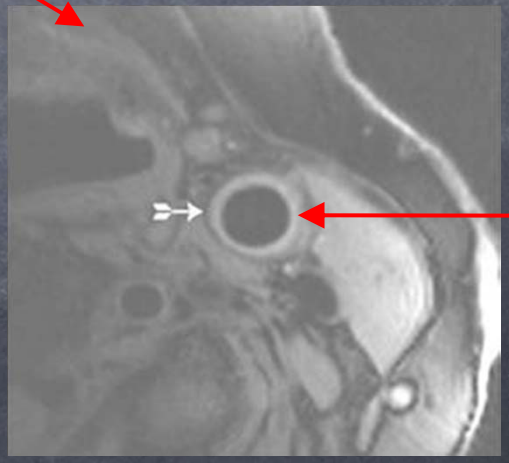




B-Mode Ultrasound of Carotid Intima-Media thickness (cIMT)



Intravascular Ultrasound (IVUS)



Magnetic Resonance Imaging (MRI)

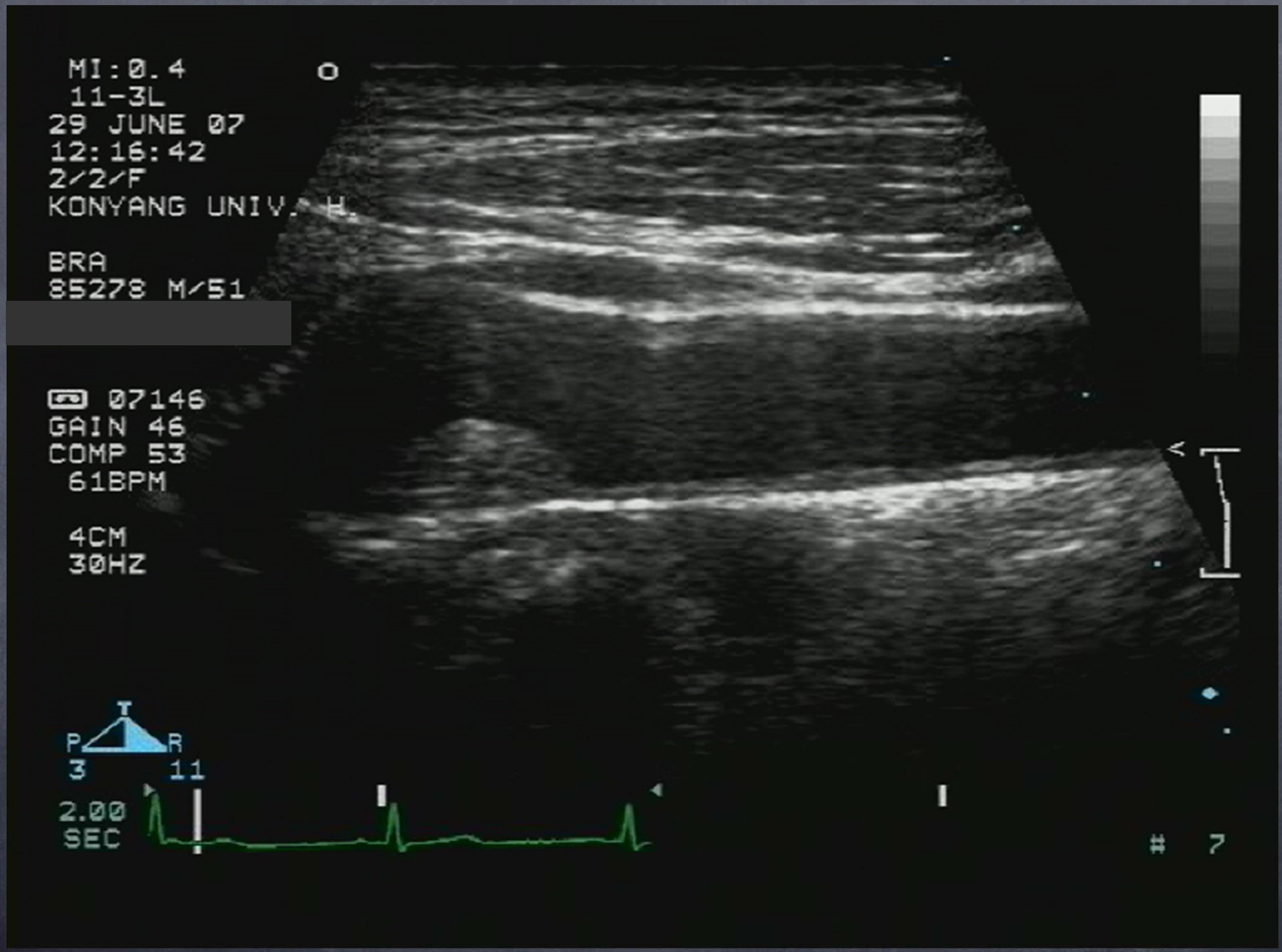
CIMT Consensus/Guidelines

Carotid Artery Evaluation

1. **AHA guideline – 2000**
2. **NHLBI/ACC – 2002**
3. **NCEP/ATP III guideline – 2002**
4. **ESC guideline – 2003**
5. **Mannheim CIMT consensus – 2006**
6. **SHAPE – 2006**
7. **ASE consensus – 2008** **(JASE 2008;21:93-111)**

Technique of Carotid Scanning

;very easy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GAIN 46
COMP 53
61BPM
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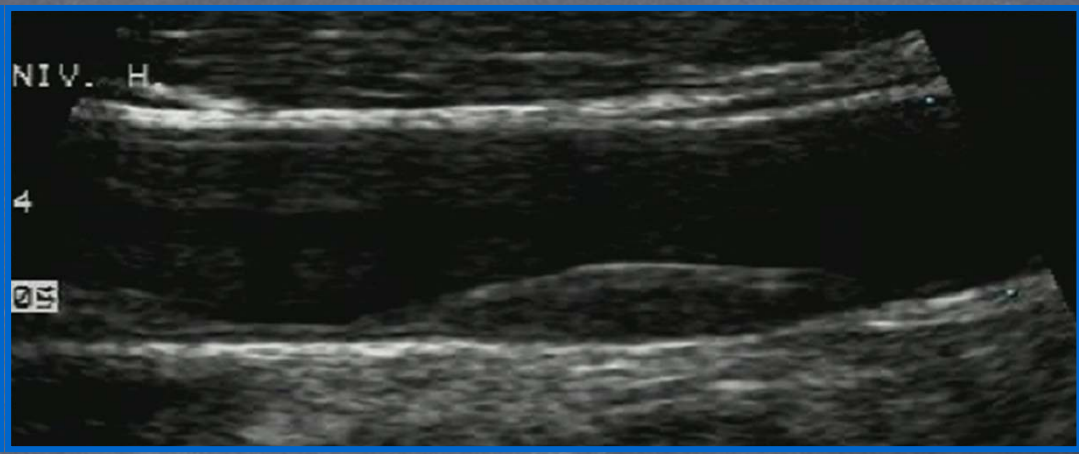
Why B-mode rather than M-mode?

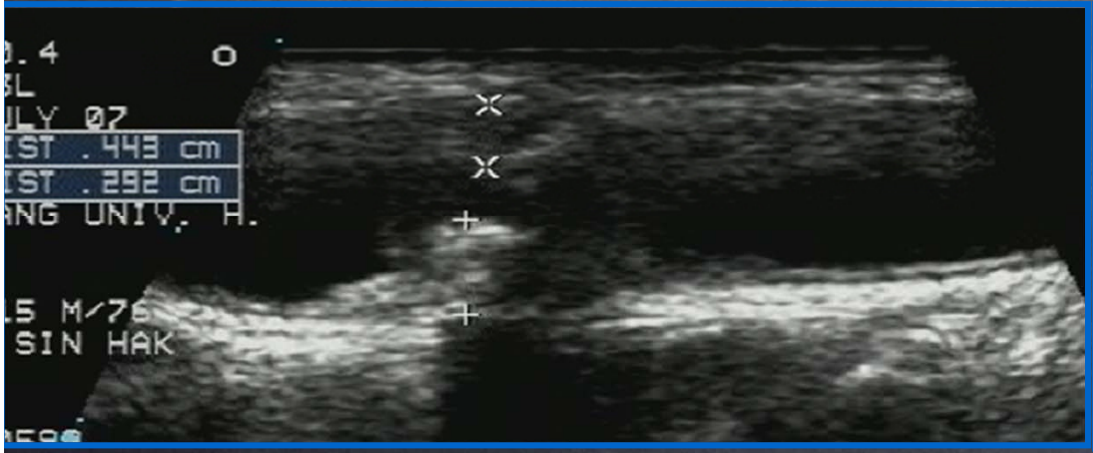
1. **Superior temporal resolution**

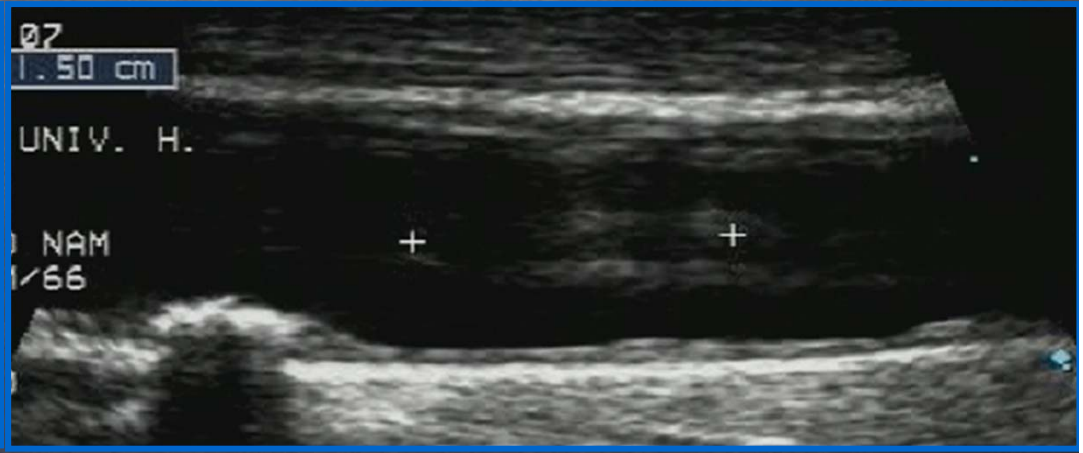
2. **Only a single point of thickness**

Stein JH et al. J Am Soc Echo. 2008;21:93-111

Near wall vs. Far wall

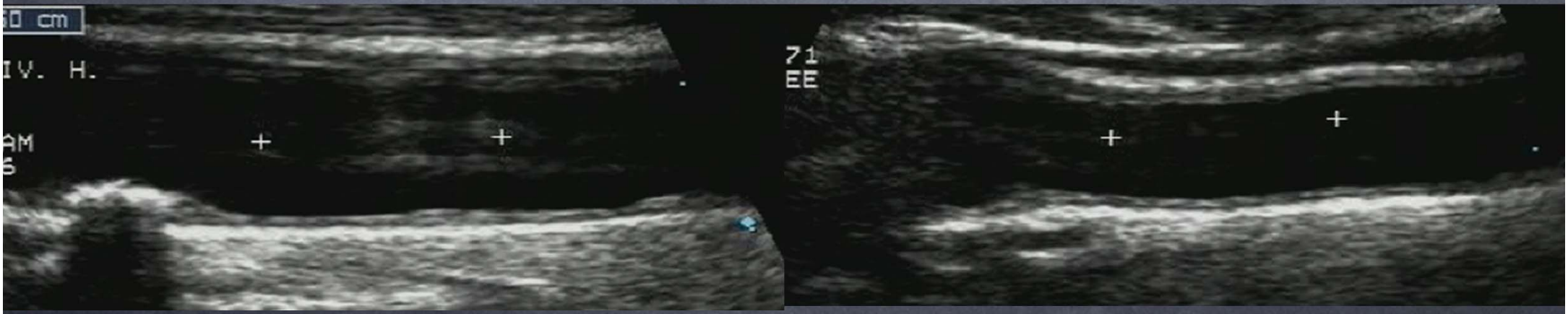




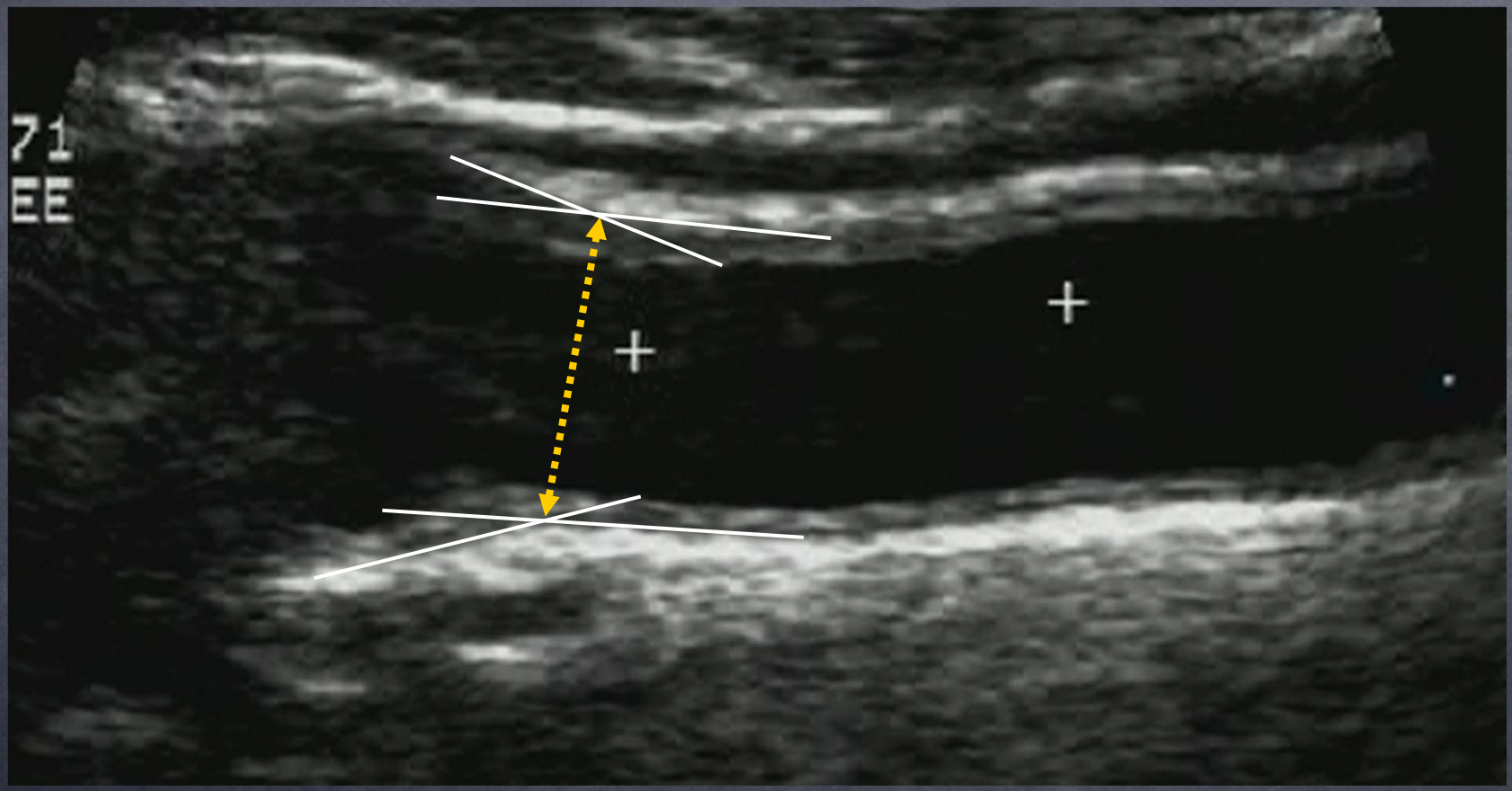


Where to Measure?

1. In a region free of plaque where the double-line pattern is observed
2. CCA, bulb, origin of the ICA



Where is bulb?



Right or Left?

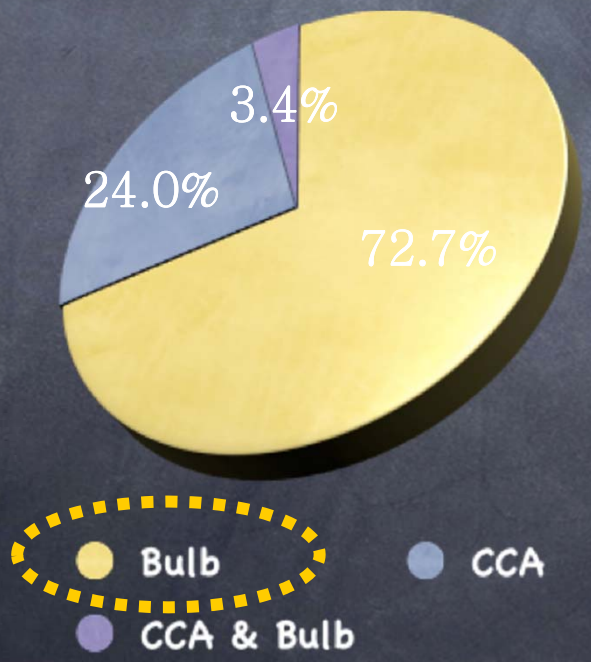
- **With IMT; not confirmed yet**
- **With plaque;**

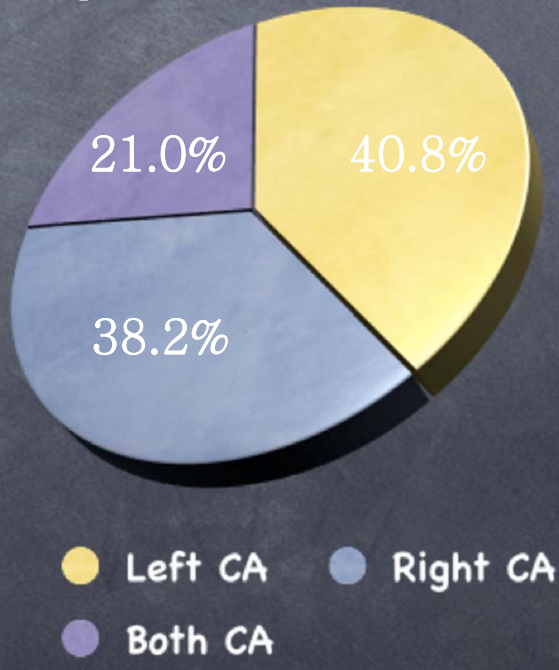
Prevalence & Location of Plaque

The prevalence of carotid plaques

30.3% (516/1705)

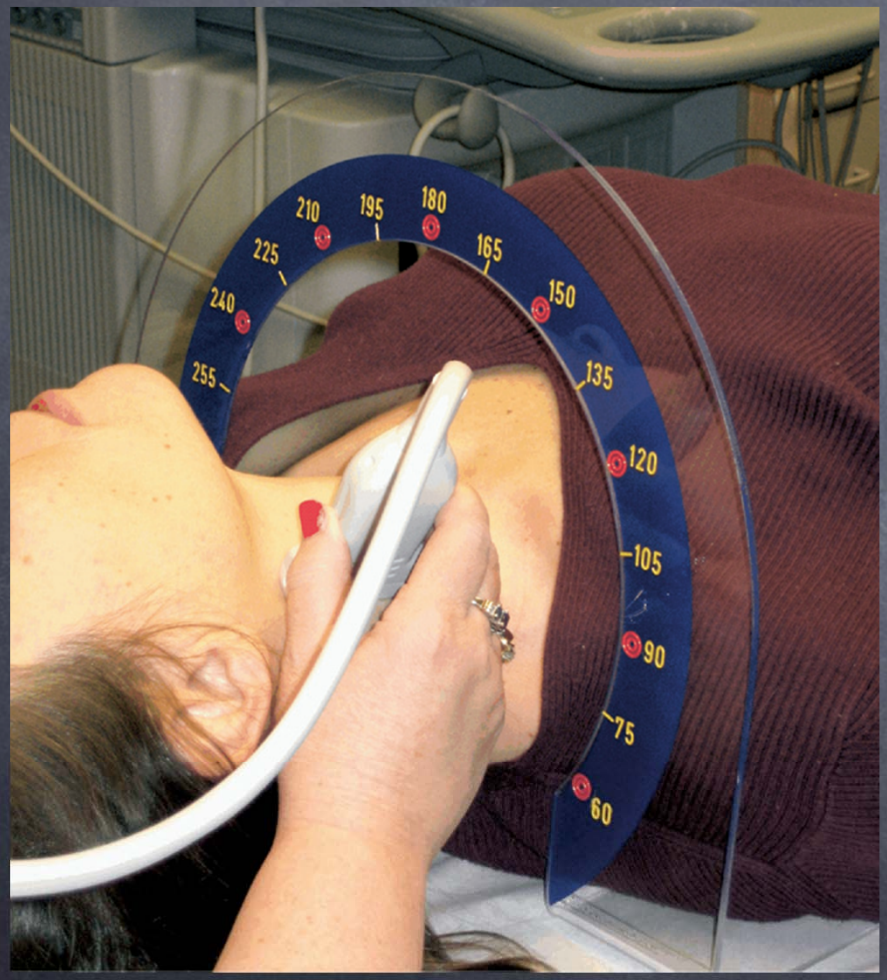
The location of carotid plaques

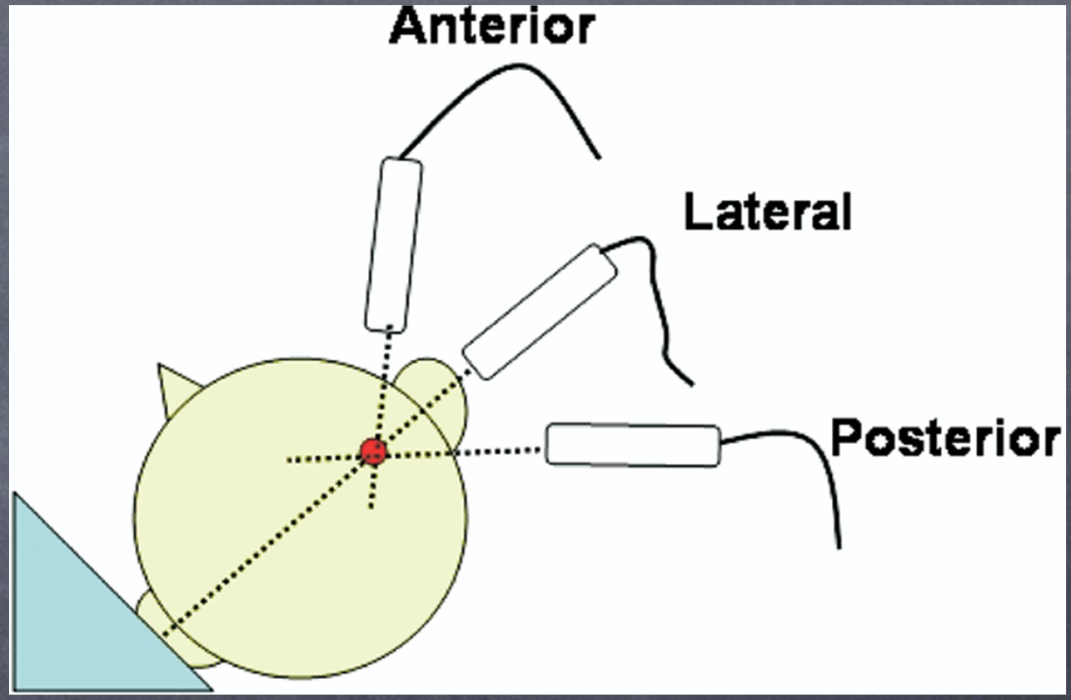




Bae JH et al. Korean J Circulation 2009

Angle of US beam

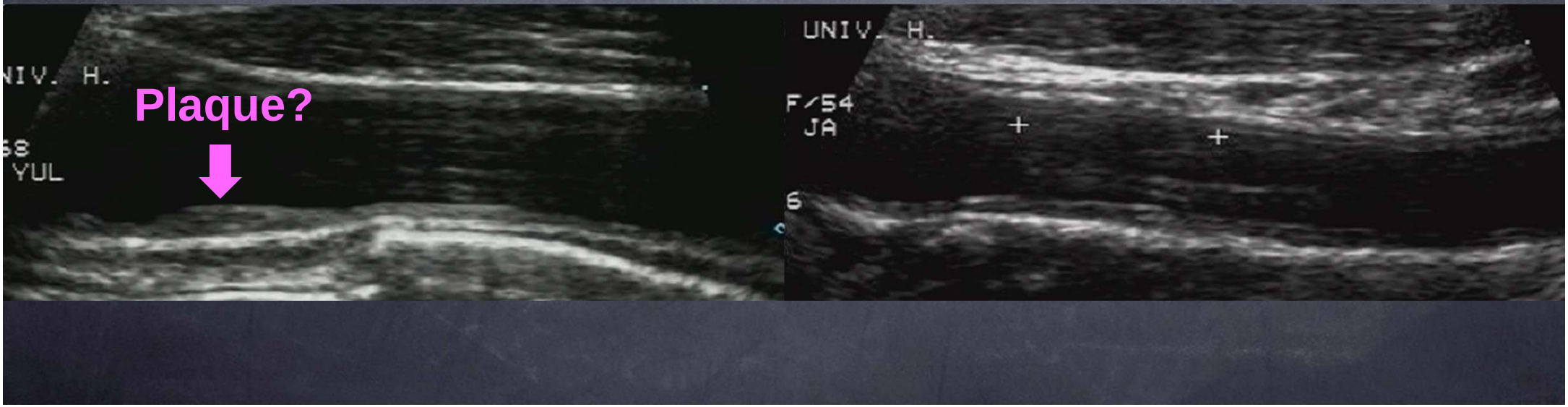




Stein JH et al. J Am Soc Echo. 2008;21:93-111

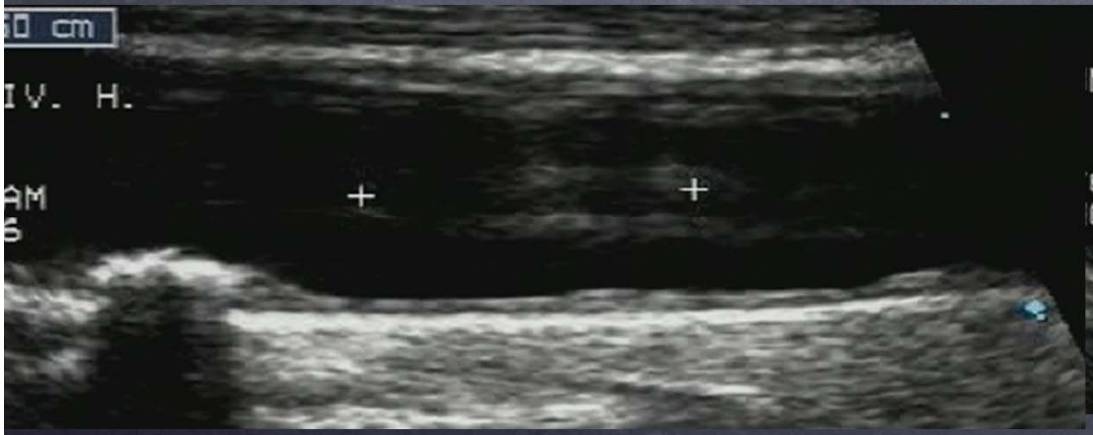
What is plaque?

Differentiation between early atherosclerotic plaque and thickened IMT



Definition of Plaque

1. Focal structure encroaching into the arterial lumen of at least 0.5mm or 50% of the surrounding IMT value
2. Or a thickness > 1.5mm as measured from the media-adventitia interface to the intima-lumen interface



Stein JH et al. J Am Soc Echo. 2008;21:93-111

What does carotid plaque mean?

Carotid Plaque & Mortality

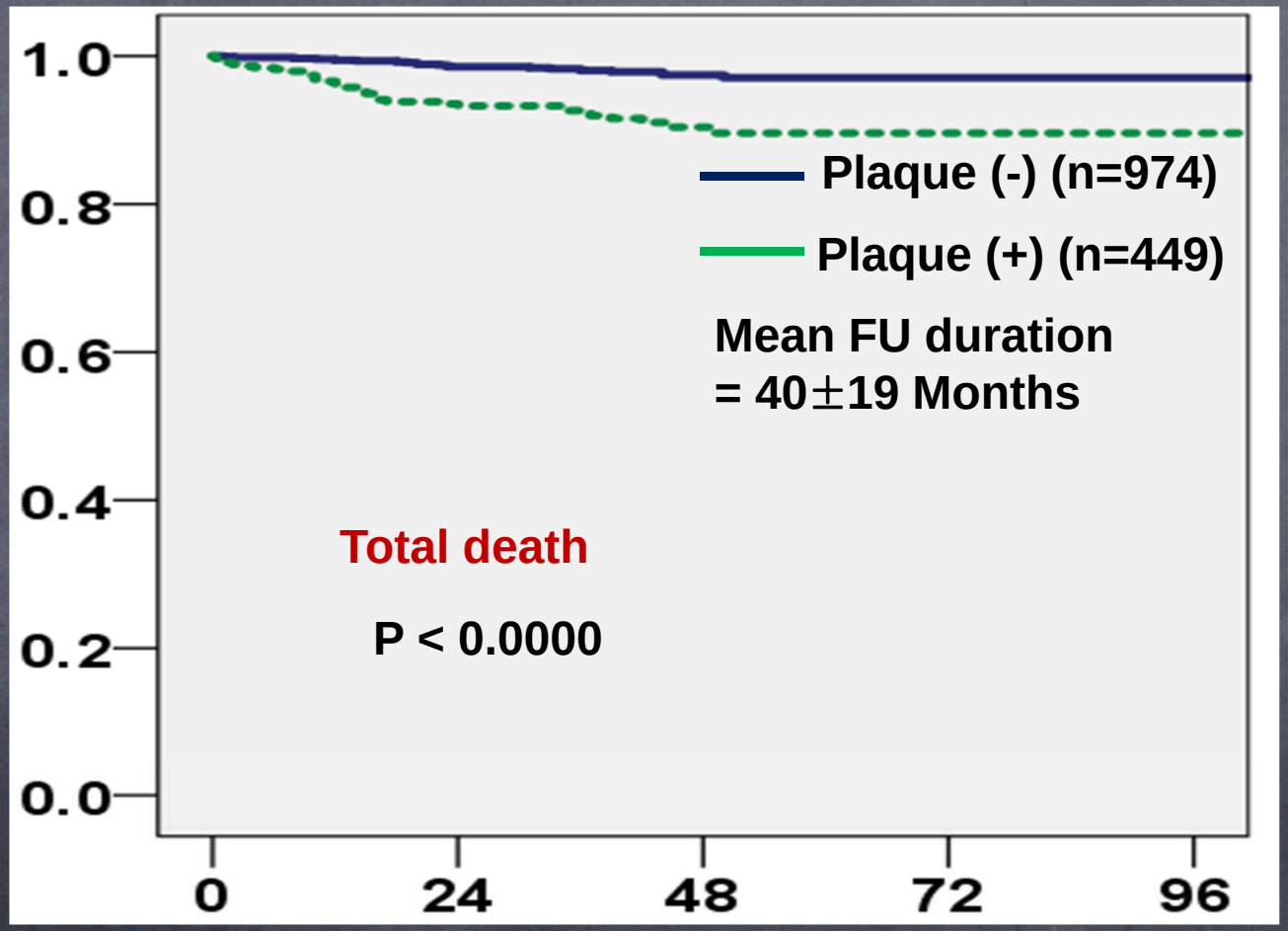
367 living men (mean 78yrs), 48-months FU, 70 deaths

	Subjects at risk, n	Events, n	HR (95% CI)
Total plaque score			
No plaque	60	4	1.00
1~2 plaques	98	16	2.89 (0.96-8.69)
3~4 plaques	90	16	2.91 (0.97-8.73)
5~6 plaques	75	23	4.89 (1.69-14.15)
7~12 plaques	42	11	4.53 (1.44-14.23)
≥1 plaque on both sides	220	52	2.00 (1.15-3.46)
Any plaque	307	66	3.48 (1.27-9.54)

Störk, et al. Circulation 2004;110:344-8

Total death-free survival rate

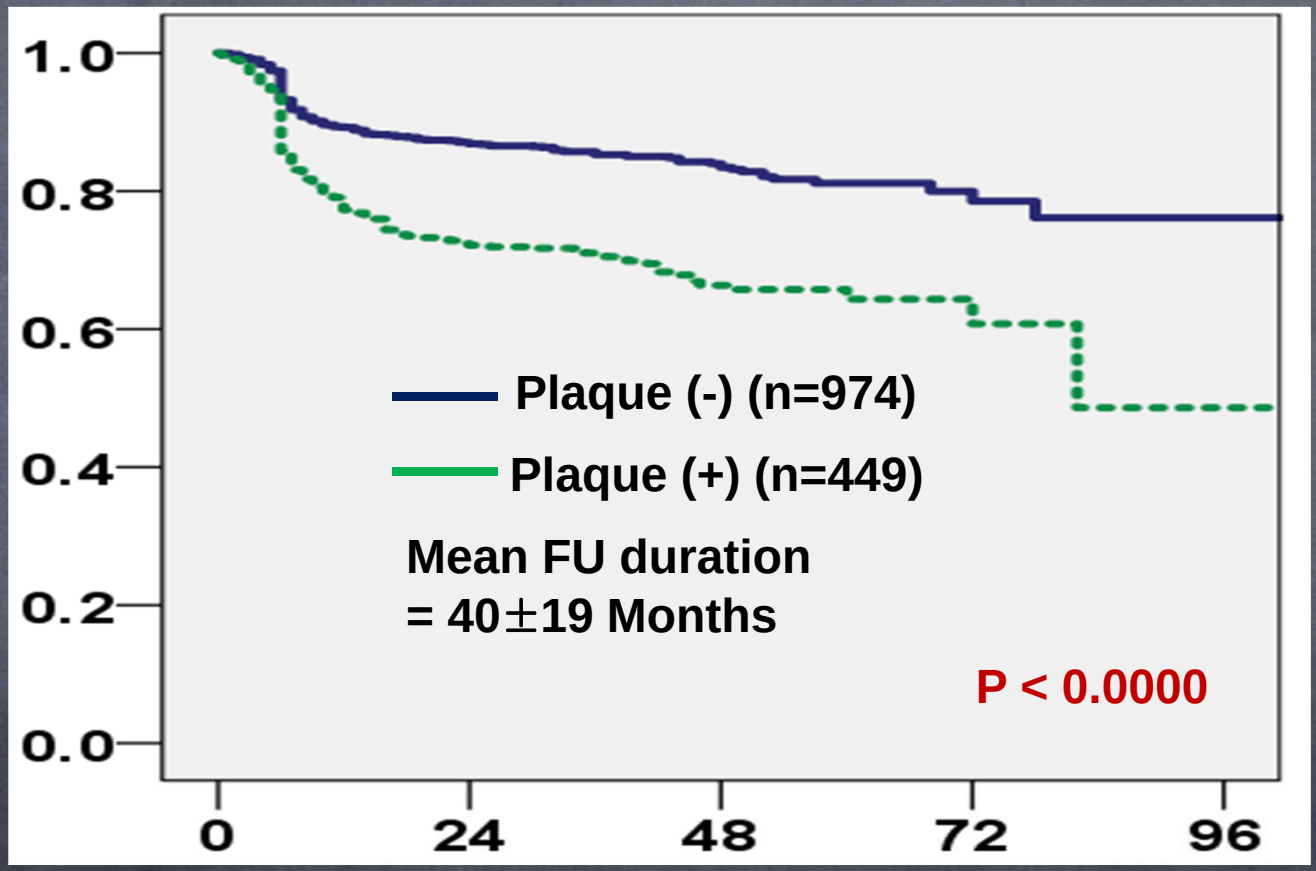
In patients with CAD



P value calculated by Log-rank test (FU duration, months)

Park HW, Bae JH et al. Korean Circ J 2010

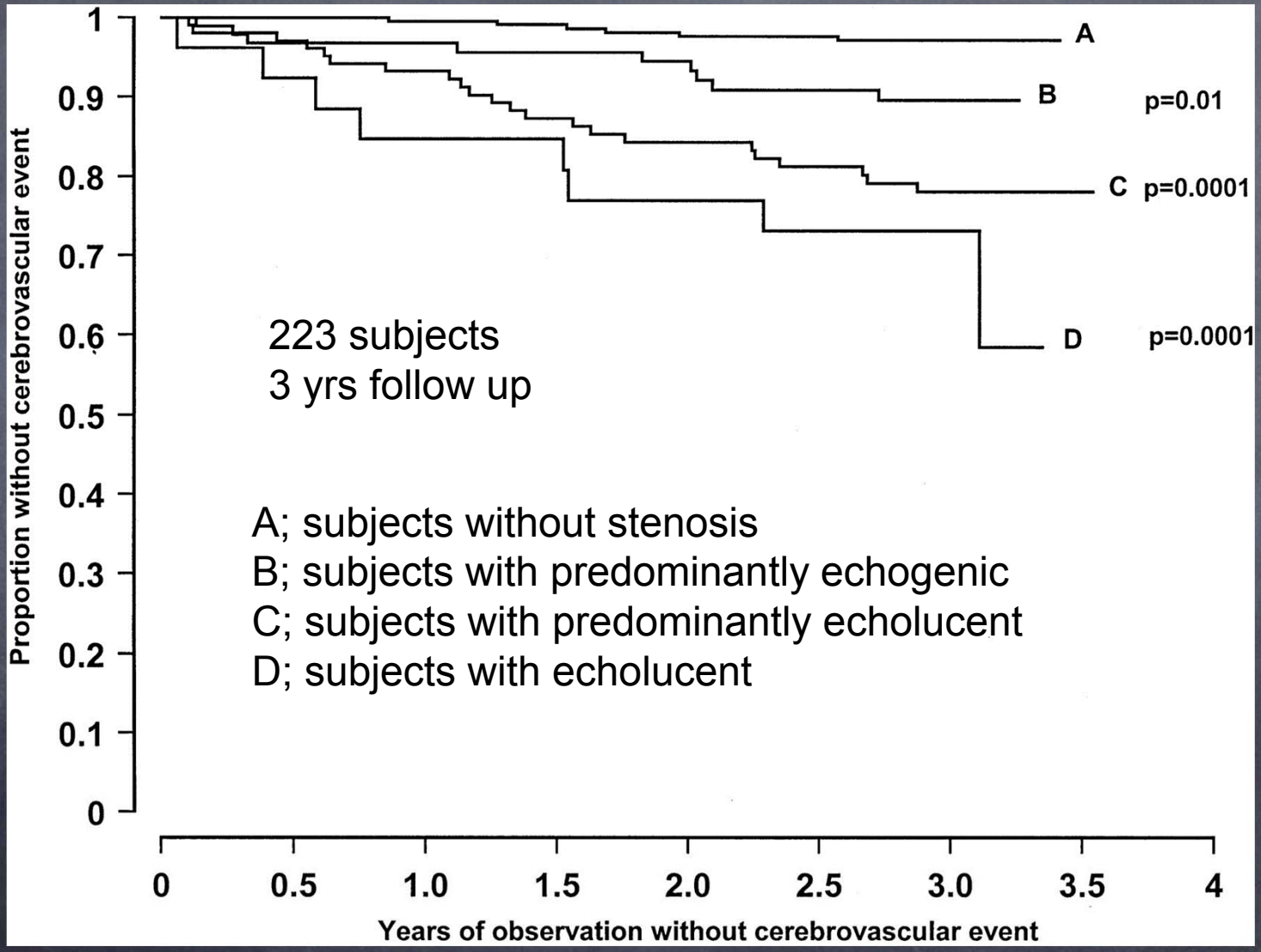
MACE -free survival rate



Events (Death, AMI, Stroke, PCI, CABG, Restenosis, TLR, CHF, PAOD)-free survival rate

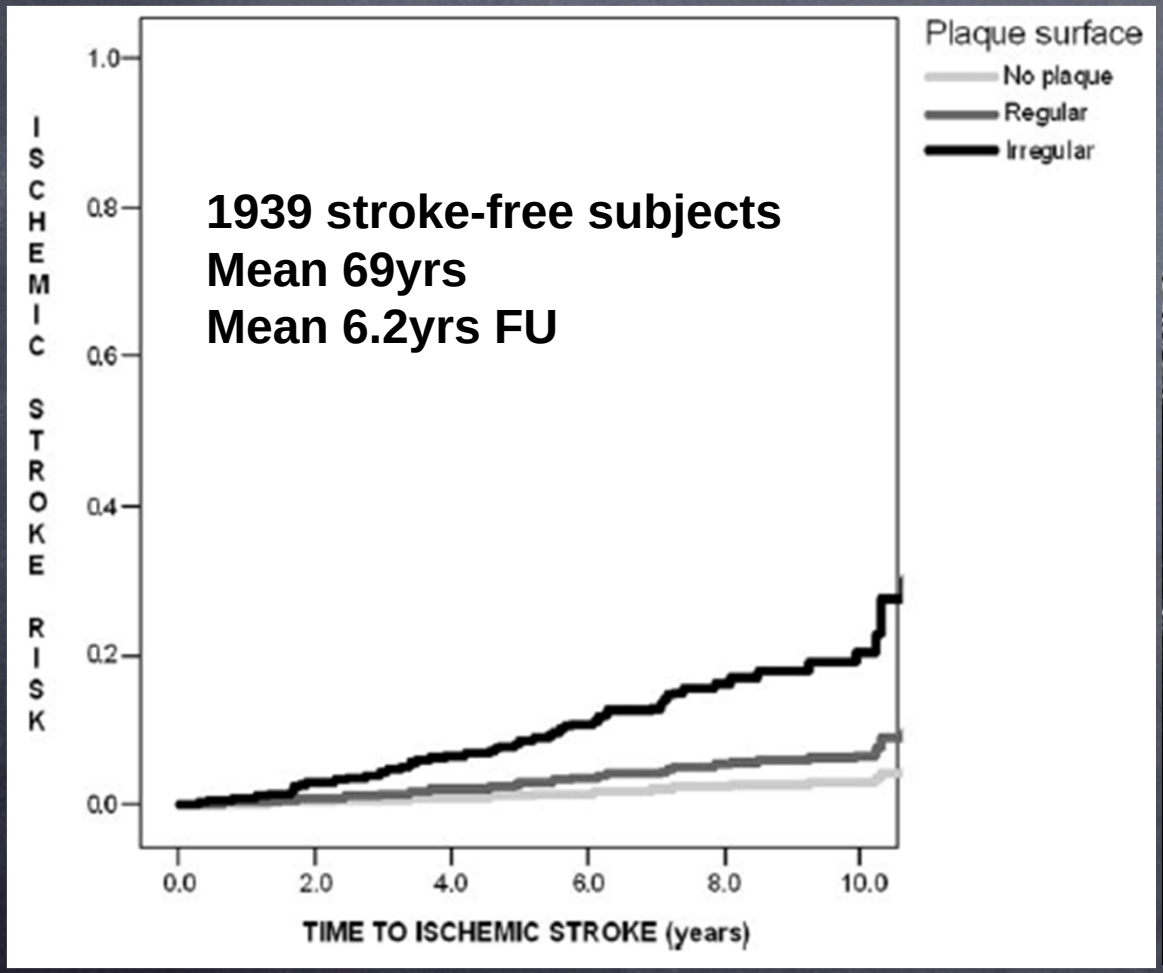
Park HW, Bae JH et al. Korean Circ J 2010

Plaque Echolucency & Risk of Stroke

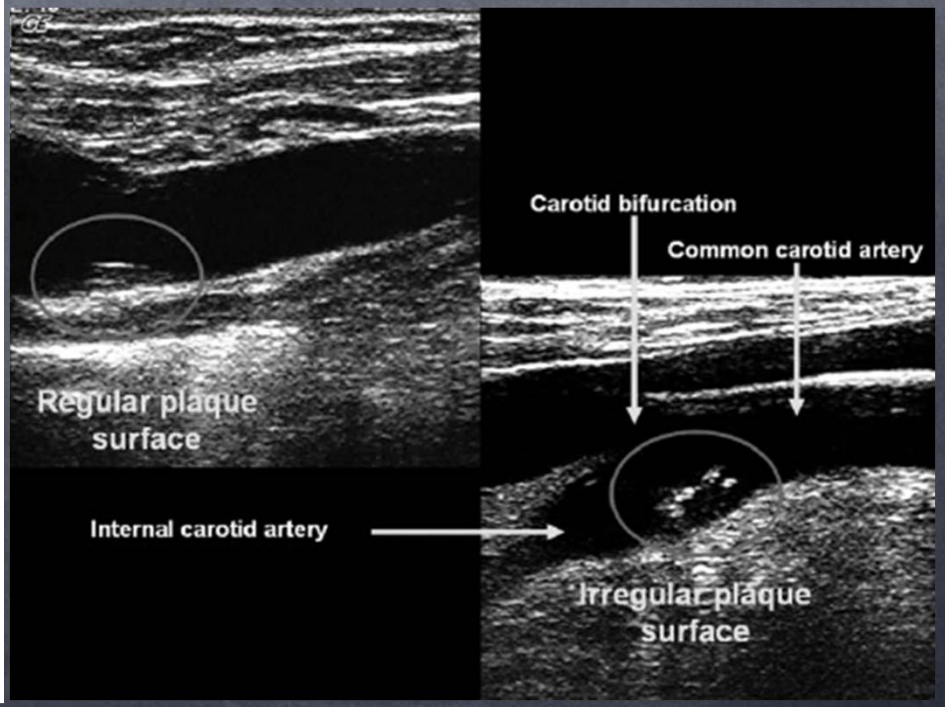


Mathiesen, E. B. et al. Circulation 2001;103:2171-2175

Plaque Surface Irregularity & Ischemic Stroke



- Plaque was seen in 56.3%
  (Irregular plaque; 5.5%)
- 5-yr risk of stroke; 1.3%, 3.0%, 8.5%
  (no, regular, irregular)

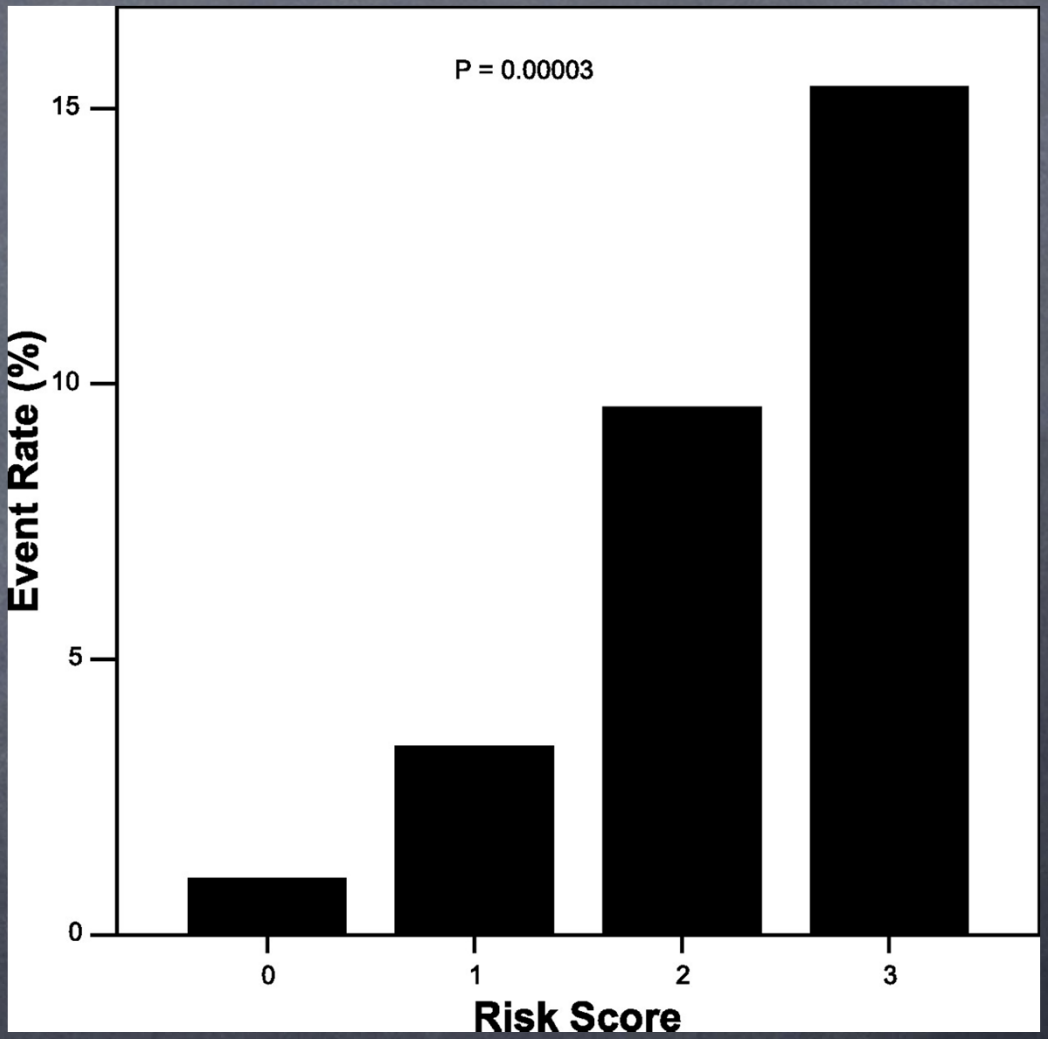


Prabhakaran S, et al. Stroke 2006;37:2696-701

Plaque Ulceration & MACE in CAS

606 patients
Stroke, MI, mortality within 30 days

Risk Score
1.Age ≥ 80 yrs
2.DM with inadequate control
3.Morphological features of ulceration
4.Contralateral stenosis ≥ 50%



Hofmann R, et al. Stroke 2006;37:2557-61

What does thickened CIMT mean?

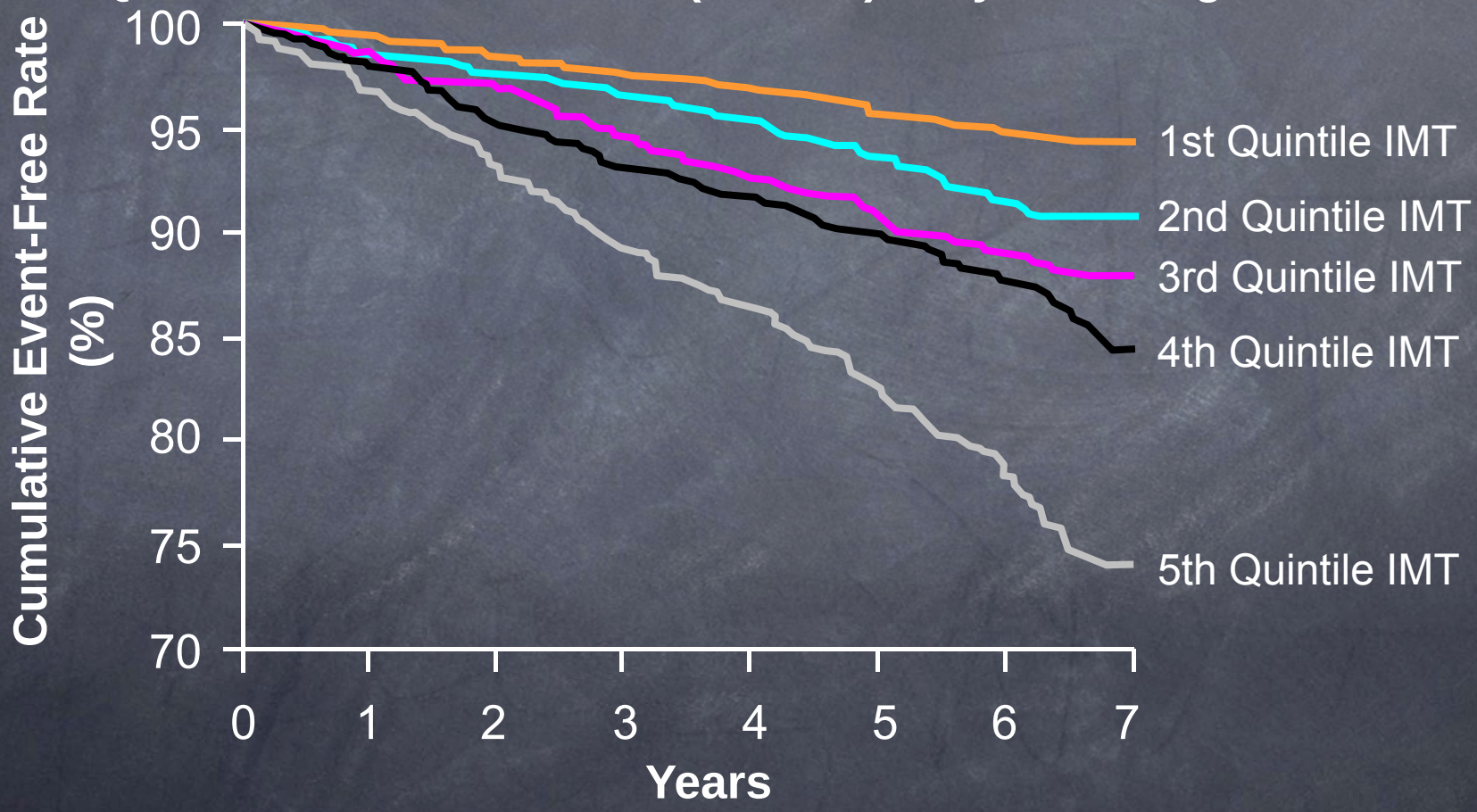
The Atherosclerosis Risk in Communities (ARIC) Study

- 12841 subjects aged 45-64 years.
- 4-7 years of follow-up for coronary heart disease
- Extreme mean carotid IMT (≥1mm) had higher HR (1.85) in men and HR (5.07) in women.

Chambless LE et al. Am J Epidemiol. 1997;146:483-94.

Systemic Atherosclerosis: Carotid Disease as a Marker of CV Risk

Cumulative Event-Free Rates for MI or Stroke, According to Quintile of Combined IMT (n=4476), 65 years of age or older.



O'Leary et al. *N Engl J Med*. 1999;340:14-22.

The Rotterdam Study

- 6389 subjects aged 55 years or more.
- Carotid IMT; quartiles (cutoff points; 0.88, 0.99, 1.12mm)

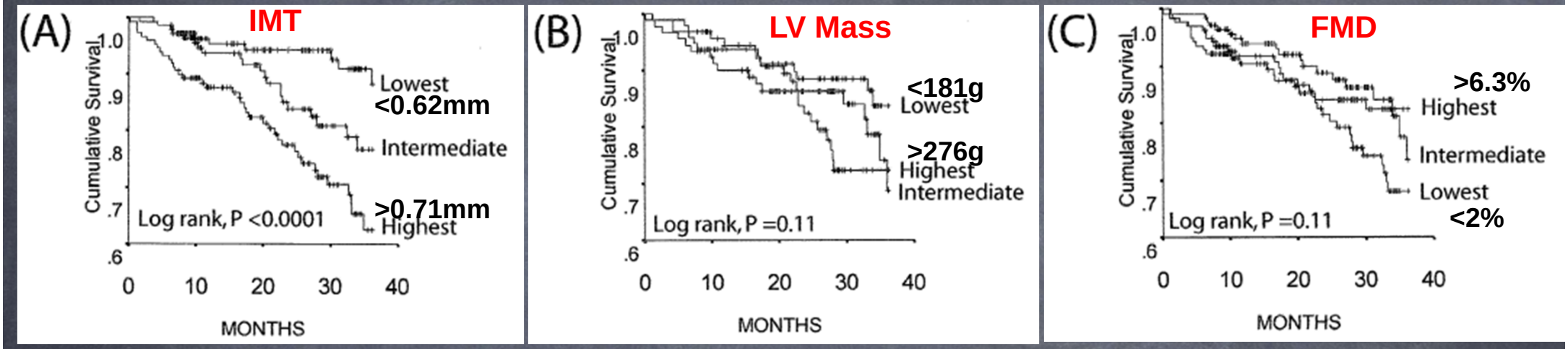
TABLE 2. Hazard Ratios for Incident Myocardial Infarction Associated With Carotid Measures of Atherosclerosis

	Severity of Atherosclerosis			
	No	Mild	Moderate	Severe
Carotid intima-media thickness				
Model 1	1.0	1.68 (1.03–2.75)	2.05 (1.26–3.32)	2.91 (1.80–4.70)
Model 2	1.0	1.56 (0.95–2.54)	1.63 (1.00–2.65)	1.95 (1.19–3.19)
+ Carotid plaques	1.0	1.56 (0.94–2.57)	1.49 (0.90–2.46)	1.70 (1.01–2.85)
+ Aortic atherosclerosis	1.0	1.53 (0.92–2.57)	1.52 (0.91–2.55)	1.79 (1.06–3.01)
+ Lower-extremity atherosclerosis	1.0	1.64 (1.00–2.70)	1.59 (0.96–2.64)	1.94 (1.17–3.23)

Van der Meer IM et al. Circulation. 2004;109:1089-94.

The Relative Importance of Vascular Structure and Function in Predicting Cardiovascular Events

Kaplan-Meier curves for event-free survival



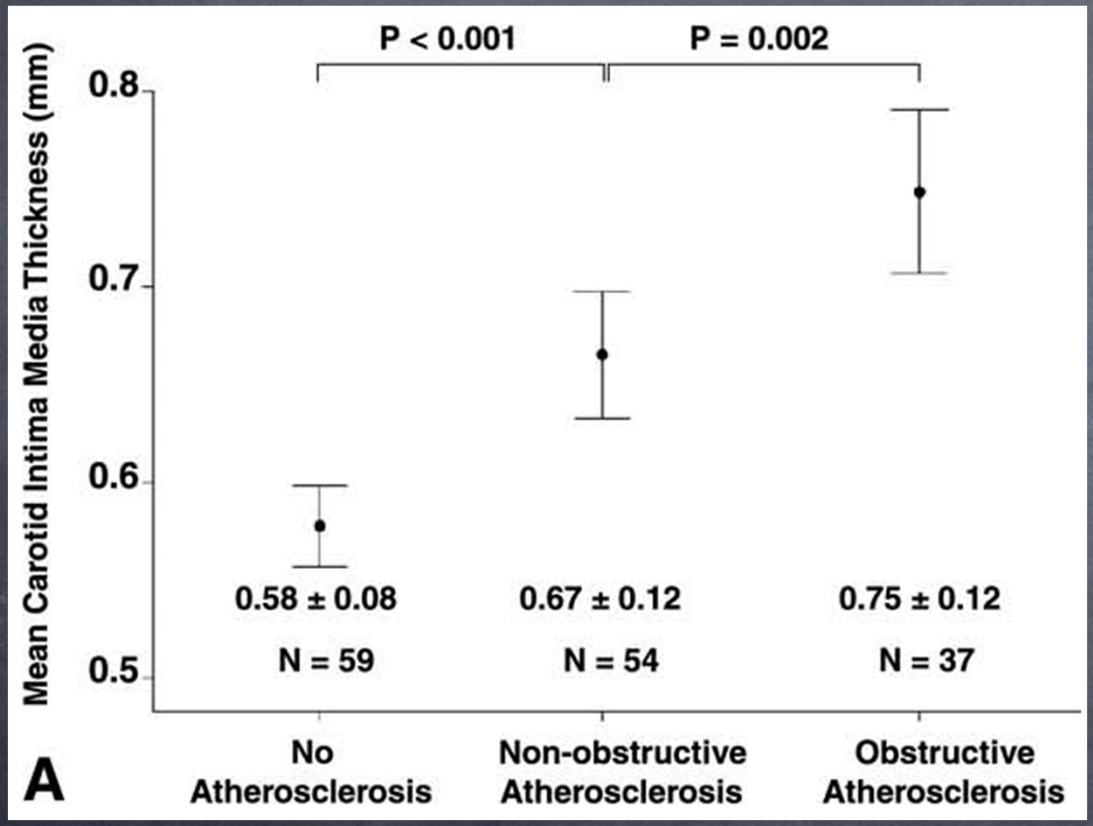
CV events; death, MI, admission with ACS, stroke, revascularization
444 patients with CAD, dialysis, or multiple risk factors
Follow-up; 24 months

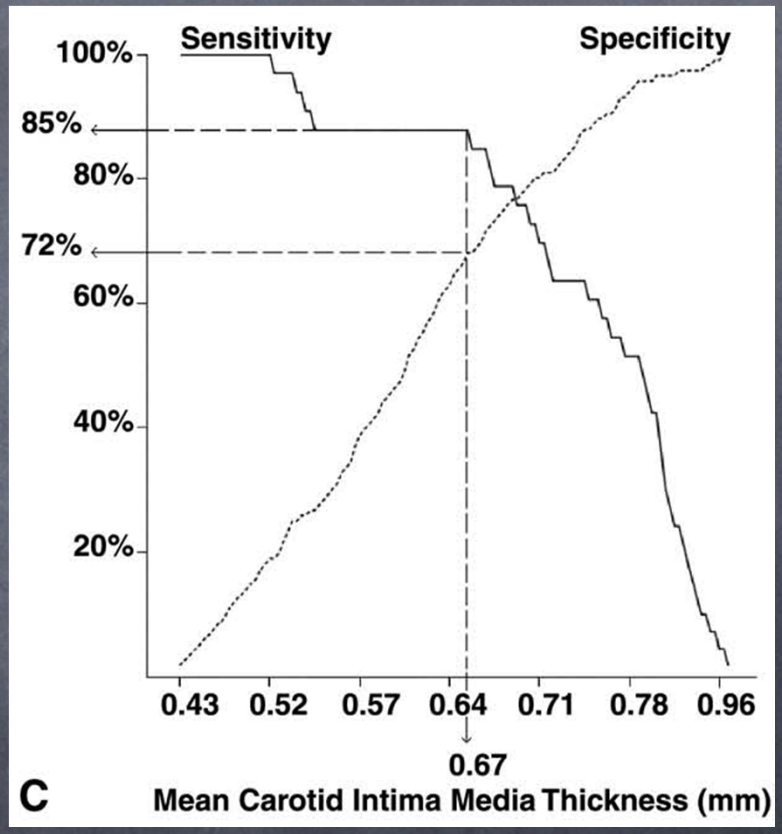
IMT was the independent vascular factor for mortality, even in the subgroup with no CAD and low risk.

Fathi R et al. J Am Coll Cardiol 2004;43:616-23

CIMT and Screening for CAD in DM

150 asymptomatic DM patients underwenting cardiac CT angiography

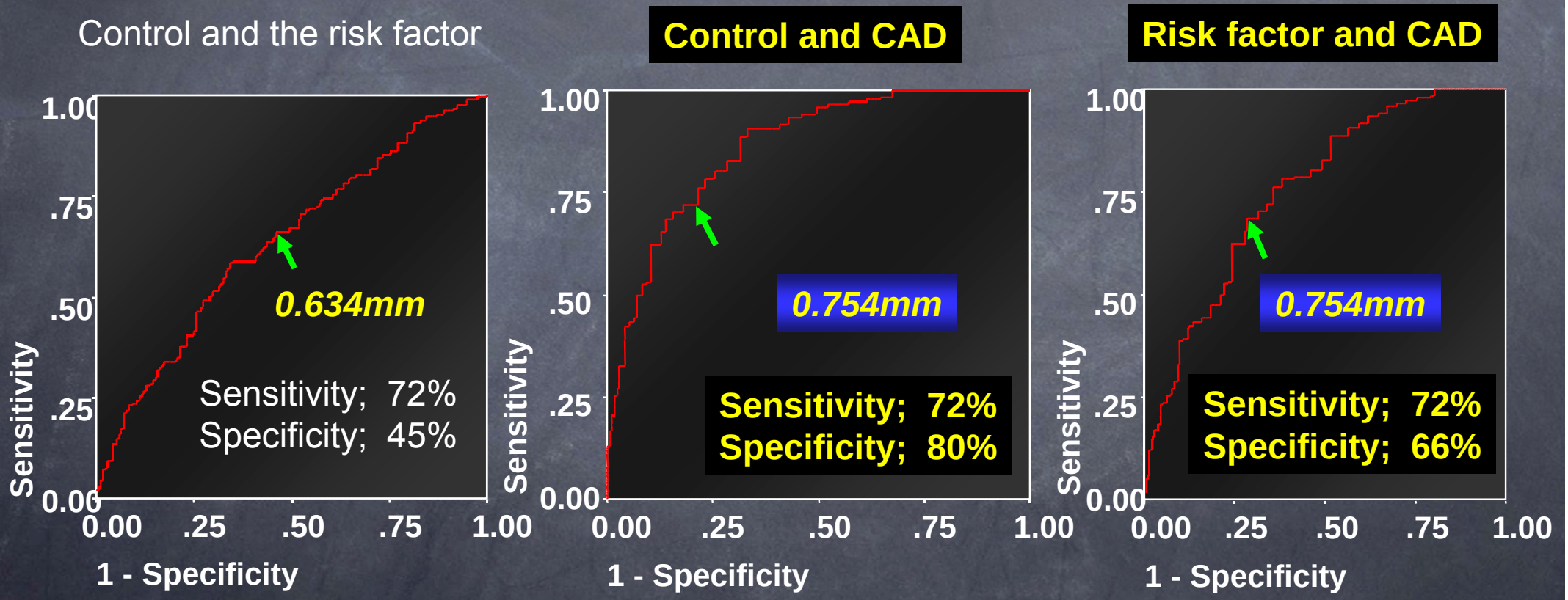




CIMT cut-off value of 0.67 mm for prediction of obstructive coronary atherosclerosis.

Djaberi R et al. AJC. 2009;104:1041-6

Carotid IMT ; as a Screening Test for CAD

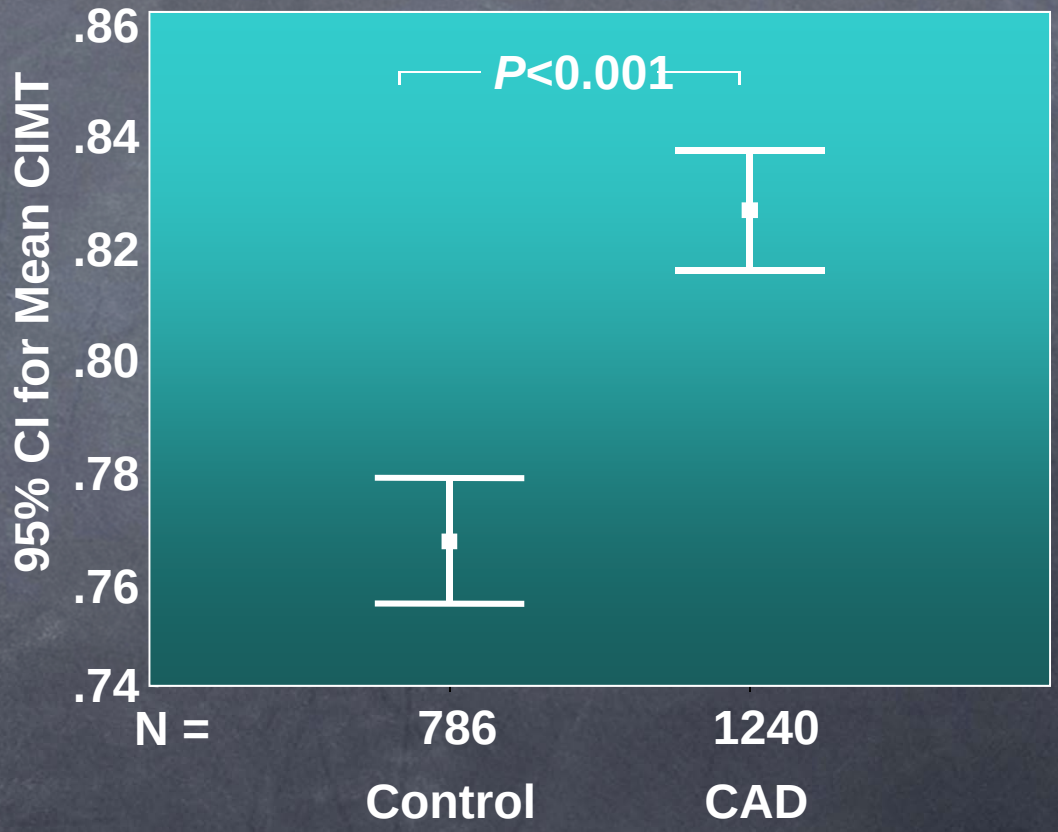


Control; 173, Risk factor; 207, CAD; 229 (number, all age- and sex-matched)

Jeong IB, Bae JH et al. *Korean Circulation J.* 2004;35:460-6.

2026 Pts underwent CAG

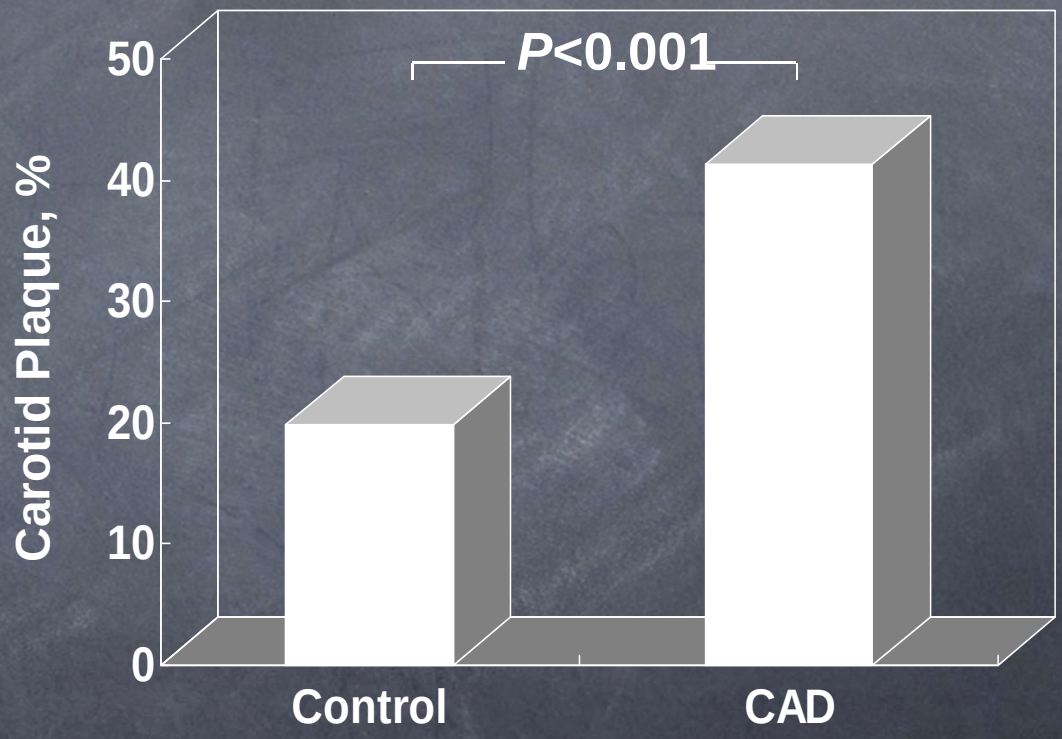
- Prediction of significant CAD
- CIMT 0.755mm
- Sensitivity 58.9%
- Specificity 53.1%



KYUH Data, unpublished

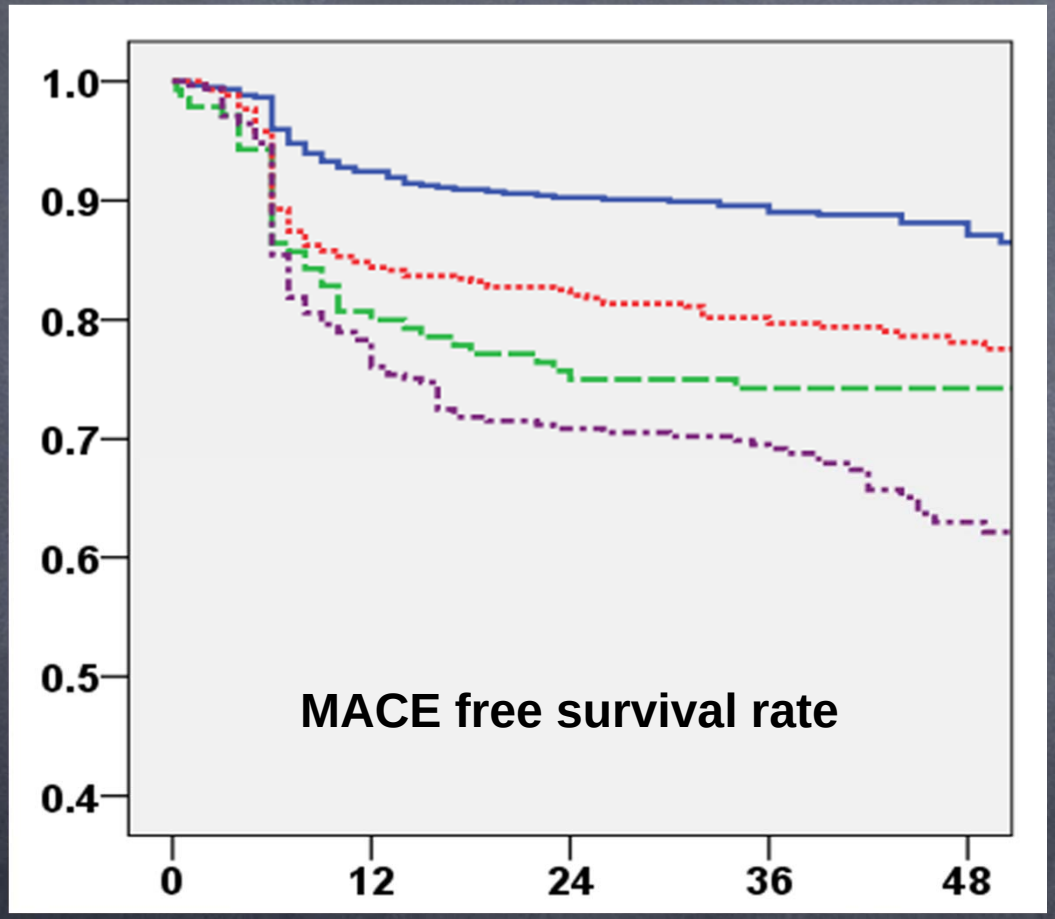
2026 Pts underwent CAG

- Prediction of significant CAD
- Plaque (+)
- Sensitivity 76.6%
- Specificity 46.4%



KYUH Data, unpublished

Carotid plaque or thickened CIMT?



KYUH Data, unpublished

When do we need to evaluate carotid artery?

ACC, 2002

1. Carotid plaque is more related with a risk for CAD than carotid IMT

2. CIMT is recommend in middle aged patients

The 1st S.H.A.P.E. Guideline

Towards the National Screening for Heart Attack Prevention and Education (SHAPE) Program

Apparently Healthy Population Men>45y Women>55y[1]

Step 1

Very Low Risk[3] ← Exit | Exit → All >75y receive unconditional treatment[2]

Atherosclerosis Test

- Coronary Artery Calcium Score (CACS) or
- Carotid IMT (CIMT) & Carotid Plaque[4]

Step 2

Negative Test

- CACS =0
- CIMT <50th percentile

No Risk Factors[5] | + Risk Factors

Positive Test

- CACS ≥1
- CIMT ≥50th percentile or Carotid Plaque

• CACS <100 & <75th% • CIMT <1mm & <75th% & no Carotid Plaque	• CACS 100-399 or >75th% • CIMT ≥1mm or >75th% or <50% Stenotic Plaque	• CACS >100 & >90th% or CACS ≥400 • ≥50% Stenotic Plaque[6]

Step 3

Lower Risk | **Moderate Risk** | **Moderately High Risk** | ABI<0.9 CRP>4mg → Optional | **High Risk** | **Very High Risk**

LDL Target	**<160 mg/dl**	**<130 mg/dl**	**<130 mg/dl** <100 Optional	**<100 mg/dl** <70 Optional	**<70 mg/dl**
Re-test Interval	5-10 years	5-10 years	Individualized	Individualized	Individualized

Myocardial Ischemia Test → Yes → Angiography → Follow Existing Guidelines

Myocardial Ischemia Test → No

Noghavi, Falk, Hecht et al. AJC 2006

CIMT & Plaque Evaluation

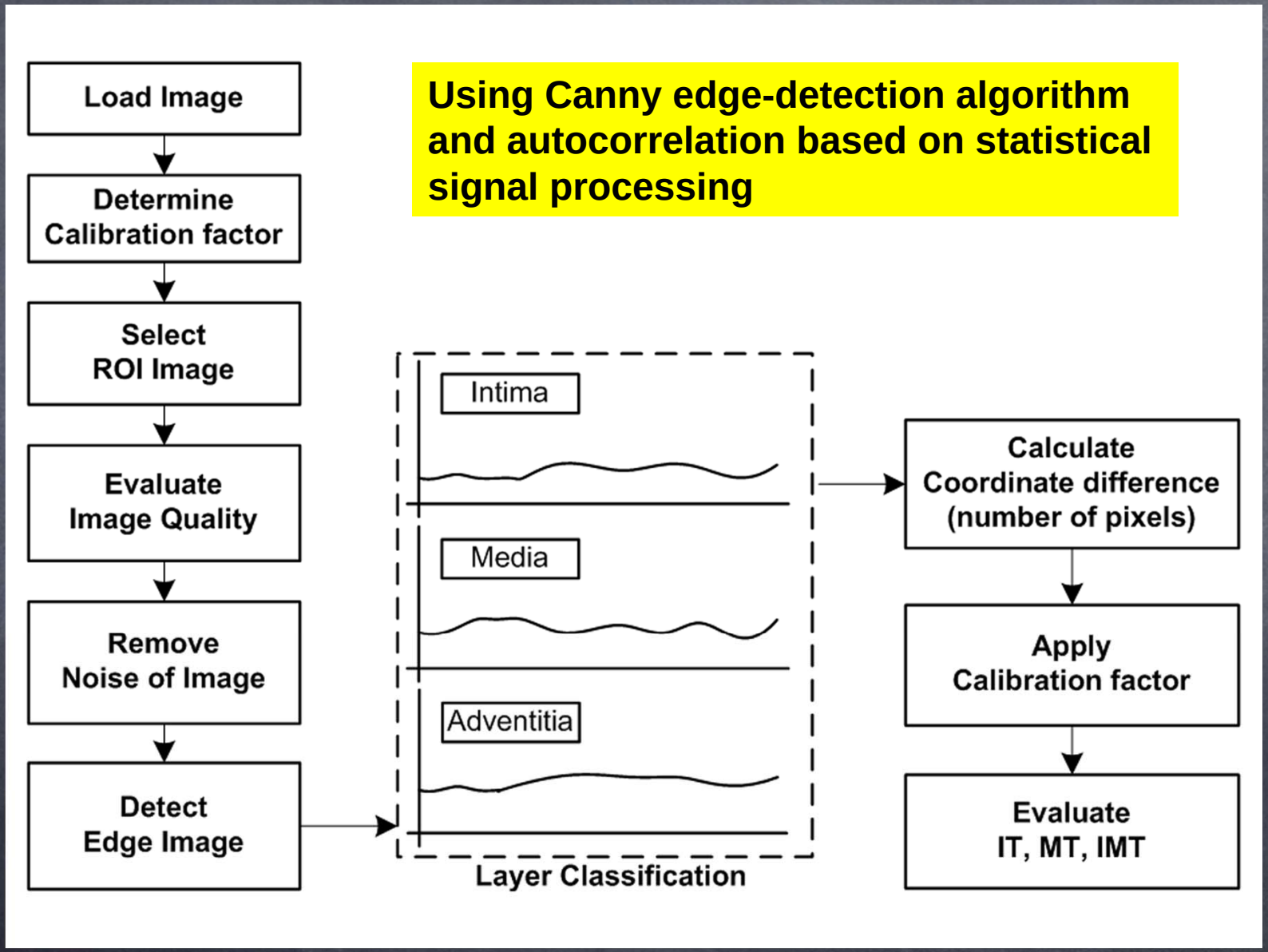
Should not be performed in

1. **Pts with established atherosclerotic vascular disease**
2. **If the results would not be expected to alter therapy**
3. **Serial studies of CIMT to address progression/regression are not recommended for use in clinical practice**

JASE 2008;21:93-111

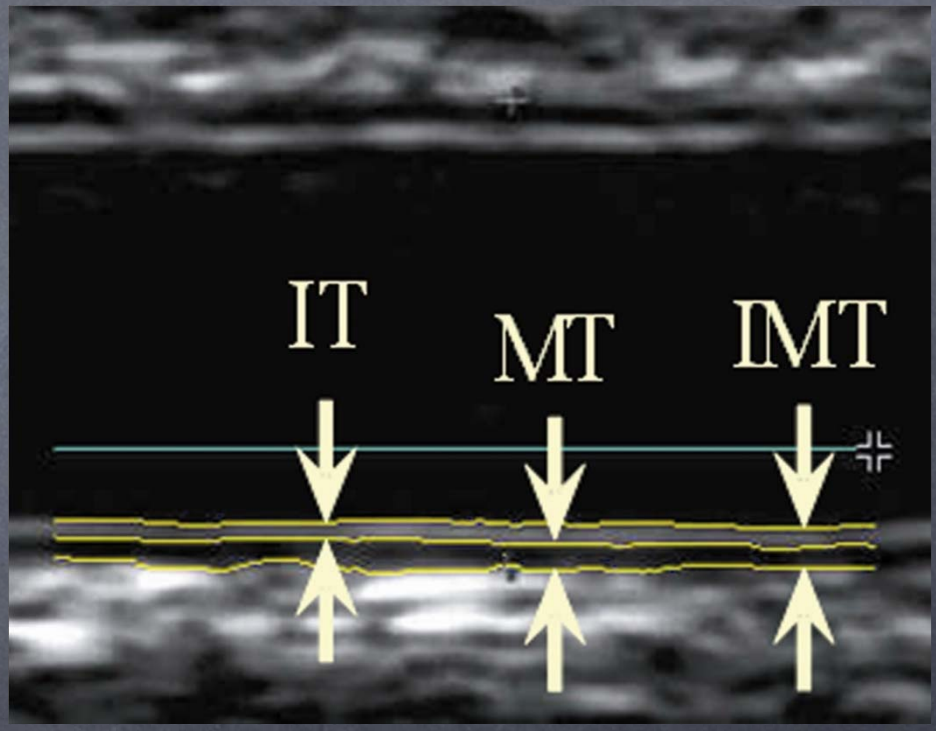
Differential Measurement of carotid wall

Individual Carotid Arterial Wall measurement



Bae JH et al. Arterioscler Thromb Vasc Biol. 2006;26:2380-5.

Individual Carotid Arterial Wall measurement



Future subjects; evaluation of plaque

Bae JH et al. Arterioscler Thromb Vasc Biol. 2006;26:2380-5.

Thank You For your Attention

High CIMT value?

1. ≥ 75th percentile – high CIMT, increased CVD risk
2. 25th to 75th percentile – average, unchanged CVD risk
3. ≤25th percentile – lower CVD risk, not known whether or not they justify less aggressive preventive therapy

Stein JH et al. J Am Soc Echo. 2008;21:93-111

50th % & 75th % of CIMT in Korean

CIMT	*Healthy*	*Risk factor*	*CAD*
50th %	*0.62*	*0.67*	*0.78*
75th %	*0.70*	*0.77*	*0.89*

From Korean IMT study data out of PARC-AALA study

How to Analyze?

1. high resolution B-mode system with linear transducers at frequencies above 7MHz (7-10MHz)
2. appropriate depth of focus (30-40mm)
3. frame rate > 15Hz
4. adequate gain setting (minimal intraluminal artifacts)

Stein JH et al. J Am Soc Echo. 2008;21:93-111

How to Analyze?

1. in a longitudinal view
2. on the far wall
3. minimum of 10mm length : for serial reproducible measurement
4. Edge detection system
5. Diameter measurement
6. Mean, max, right, left; no answer
7. Periodical Quality Control

Stein JH et al. J Am Soc Echo. 2008;21:93-111