复旦大学附属中山医院心内科
上海市心血管病研究所

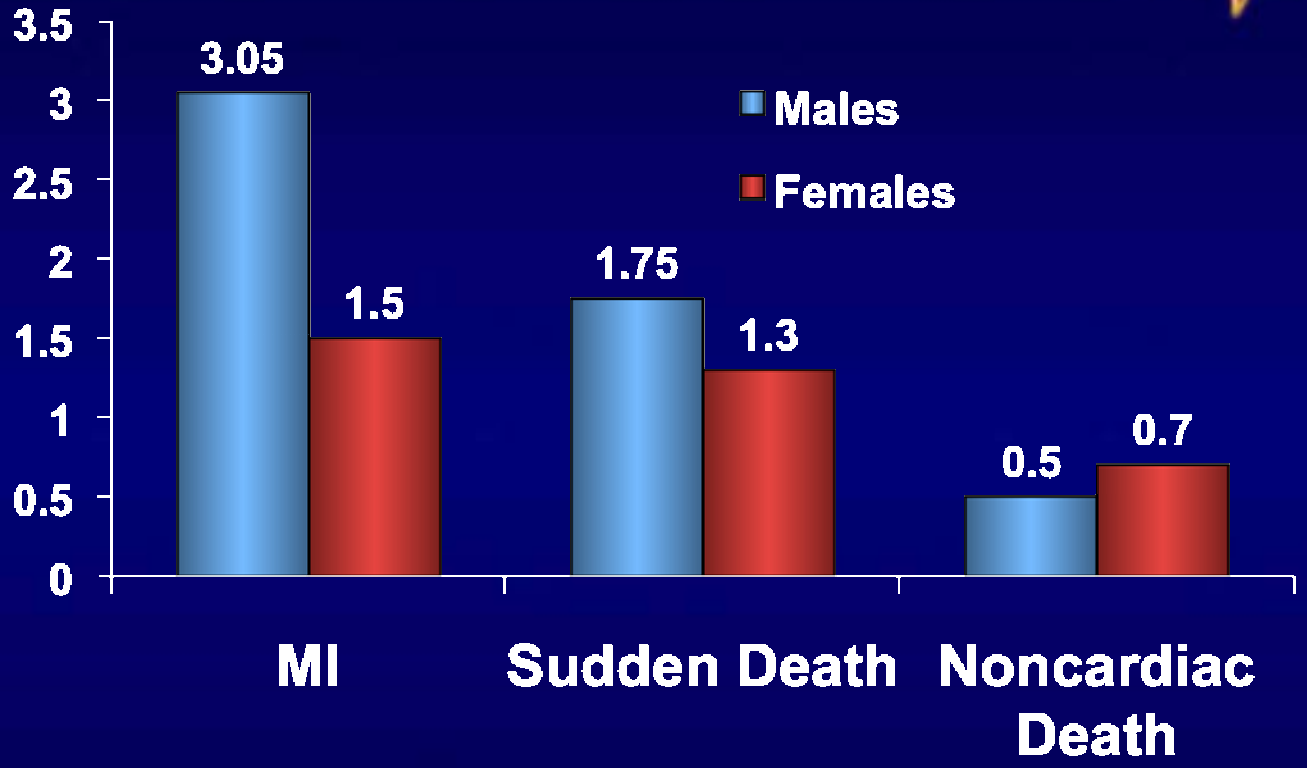
# Identification of Vulnerable Plaque by IVUS

Junbo Ge, MD, FACC, FESC, FSCAI
Professor of Medicine/Cardiology
Shanghai Institute of Cardiovascular Diseases
Zhongshan Hospital, Fudan University, China

# Case Report

- 82 yr old female
- Risk factors: Type 2 DM, Hyperglycemia
- LAD PCI because of NSTEMI
- Standard medical treatment
- Unstable Angina 3 months after LAD PCI
- ECG indicates inferior ischaemia

# Vulnerable Plaque



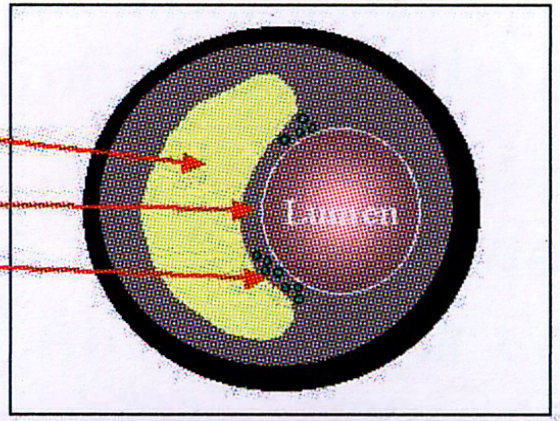

Number of thin-cap fibroatheromas in patients dying with MI, sudden death, or noncardiac causes and studied at necropsy using *cross-sectional analysis*

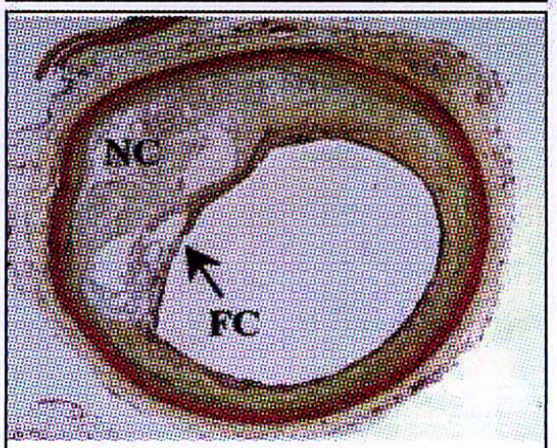
*(Burke et al. J Am Coll Cardiol 2003;41:1874-86-)*

# Vulnerable Plaque

## Vulnerable Plaque

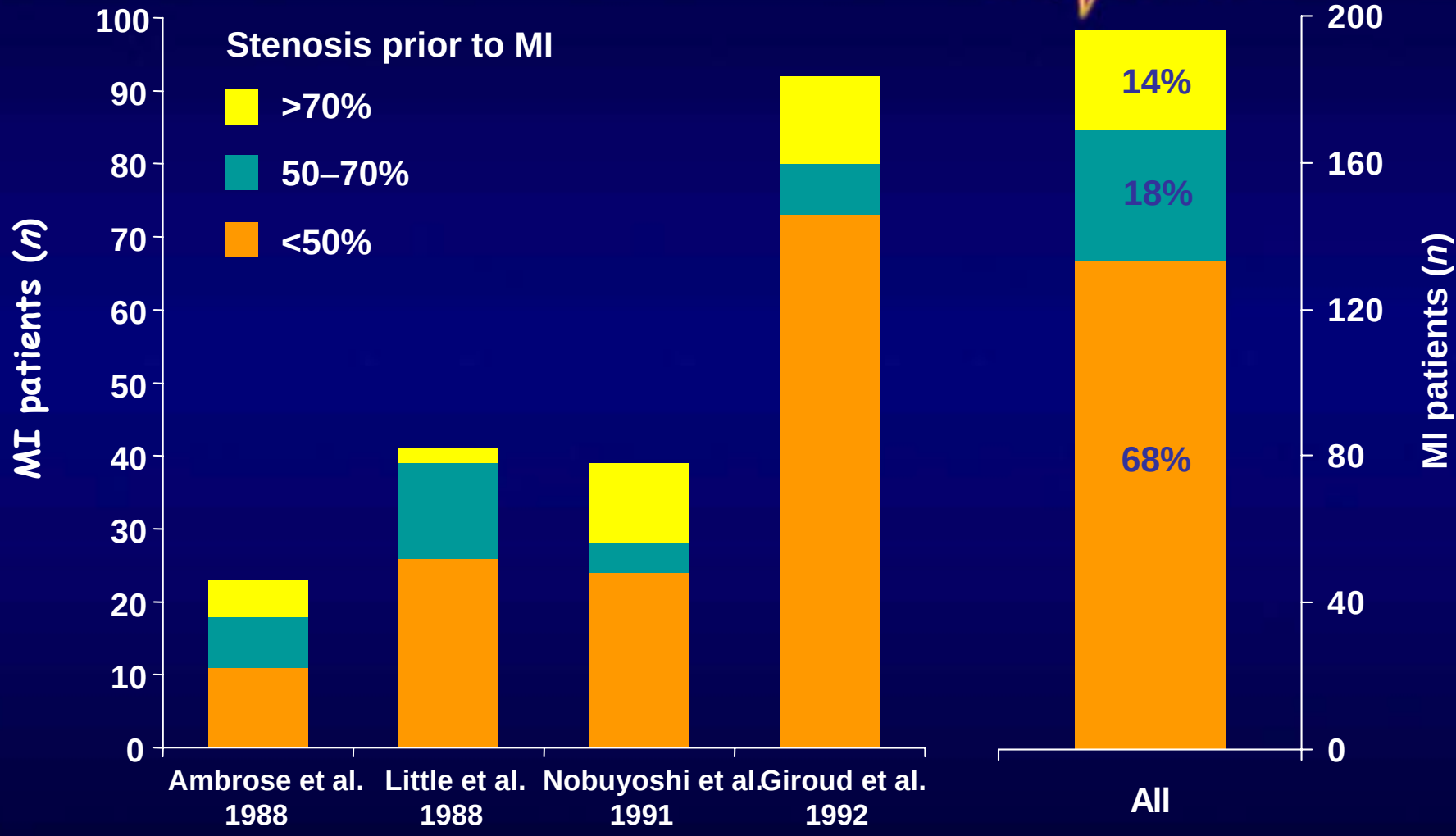
- Large necrotic lipid core
- Thin fibrous cap
- Dense Macrophage infiltration (metalloproteinases)
- Progressive matrix degeneration
- Paucity of SMCs
- Angiographically non-significant
- Positive remodelling
- Inflammation





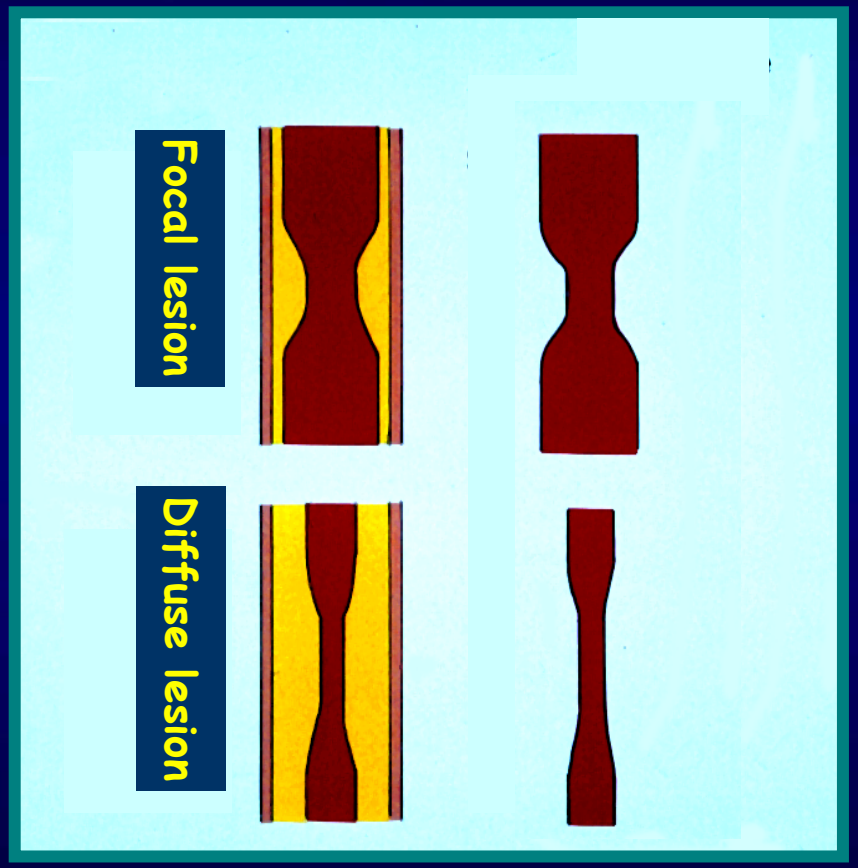

Virmani, et al: ATVB 2000; 20:1262

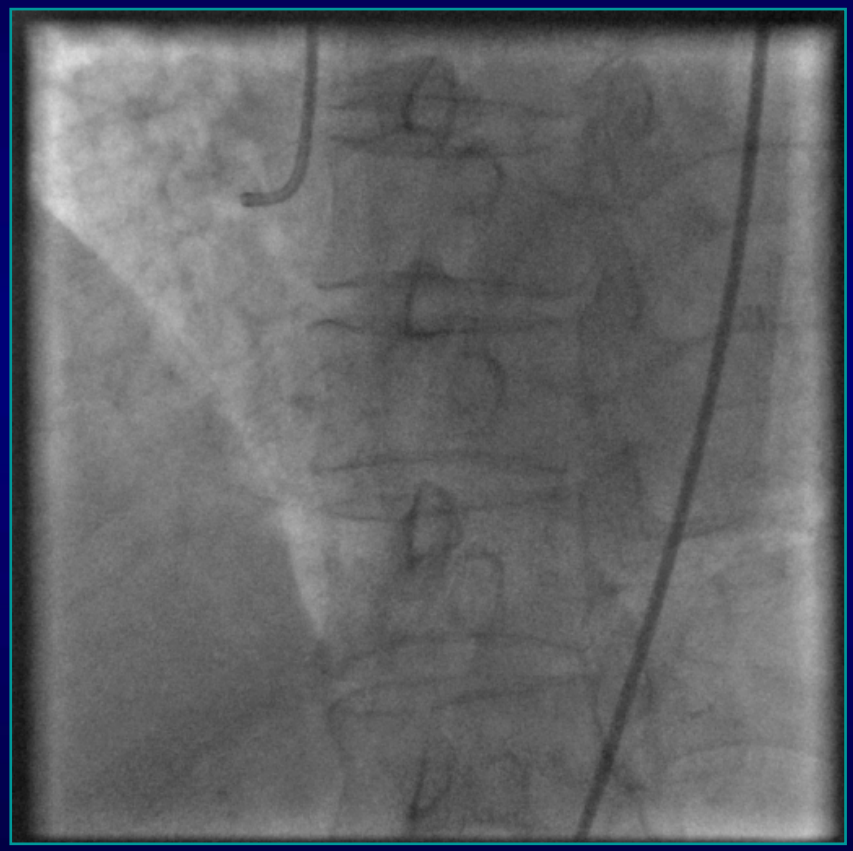
# 68%AMI occurred on the stenosis <50%



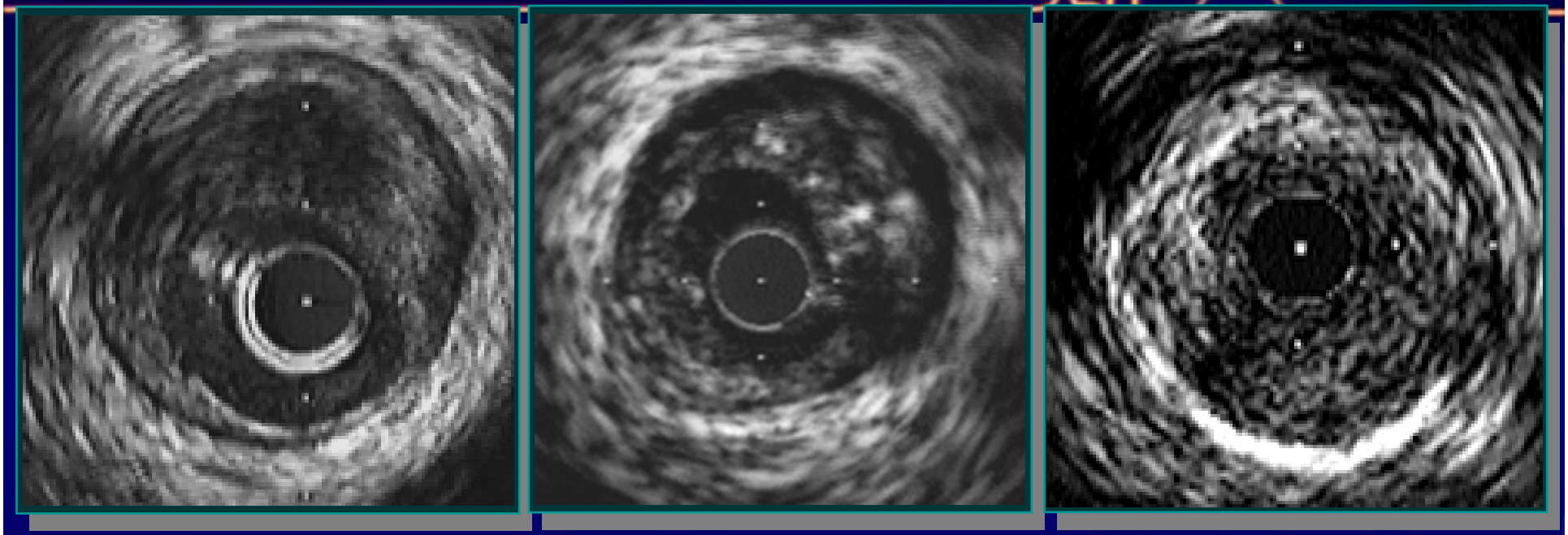

Falk E, et al. *Circulation.* 1995;92:657-671.

# Identificaton of Vulnerable Plaques



# Vulnerable Plaque



• Large eccentric plaque containing an ***echolucent area*** on grayscale IVUS can be at increased risk for future acute event

*Yamagishi M, et al. J Am Coll Cadiol 2000*

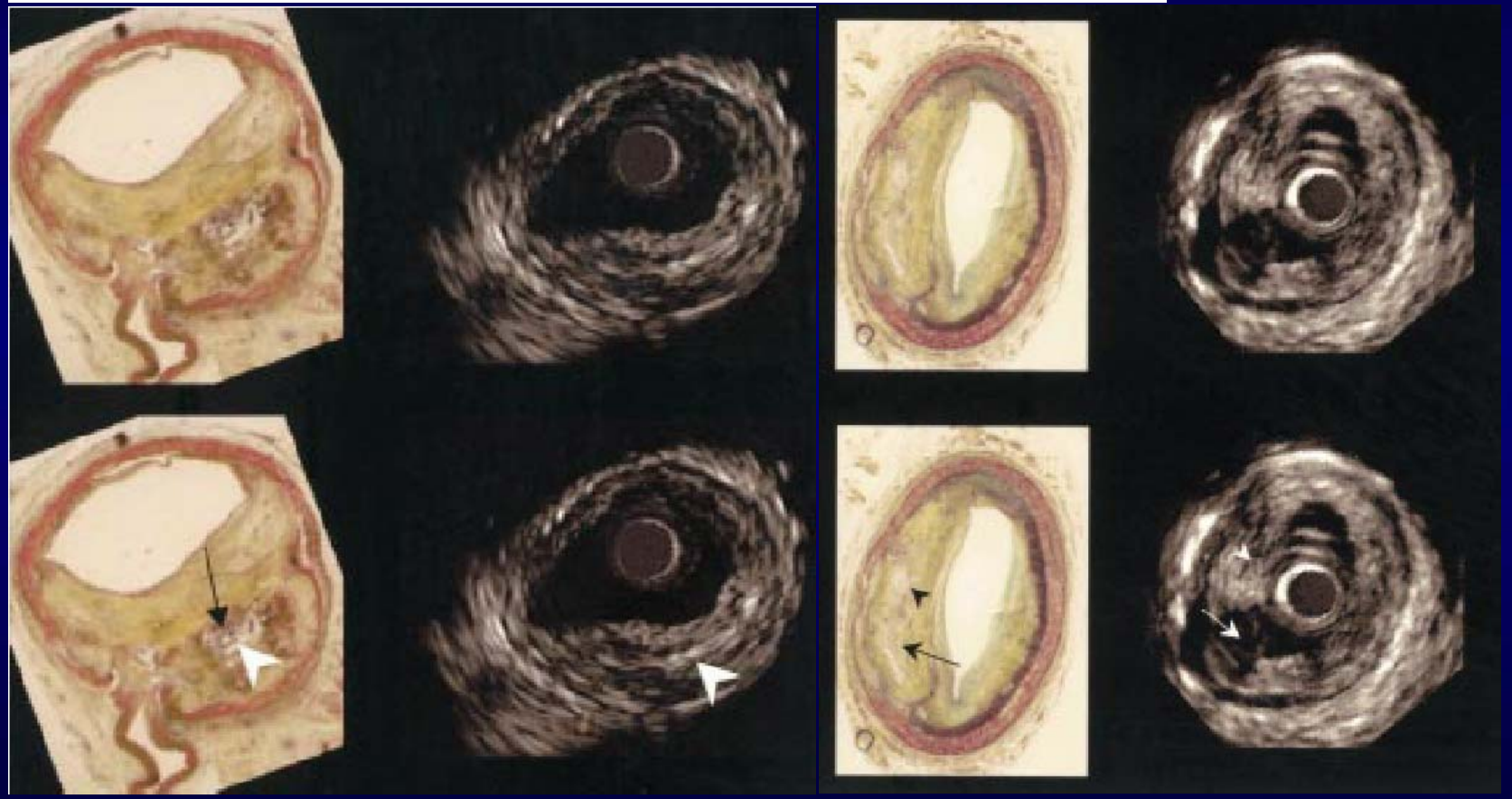
• The test of concordance for echolucent area visualization by 2 independent observers was 0.68

*Prati F, et al. Circulation 2003*

# Correlation between high frequency intravascular ultrasound and histomorphology in human coronary arteries

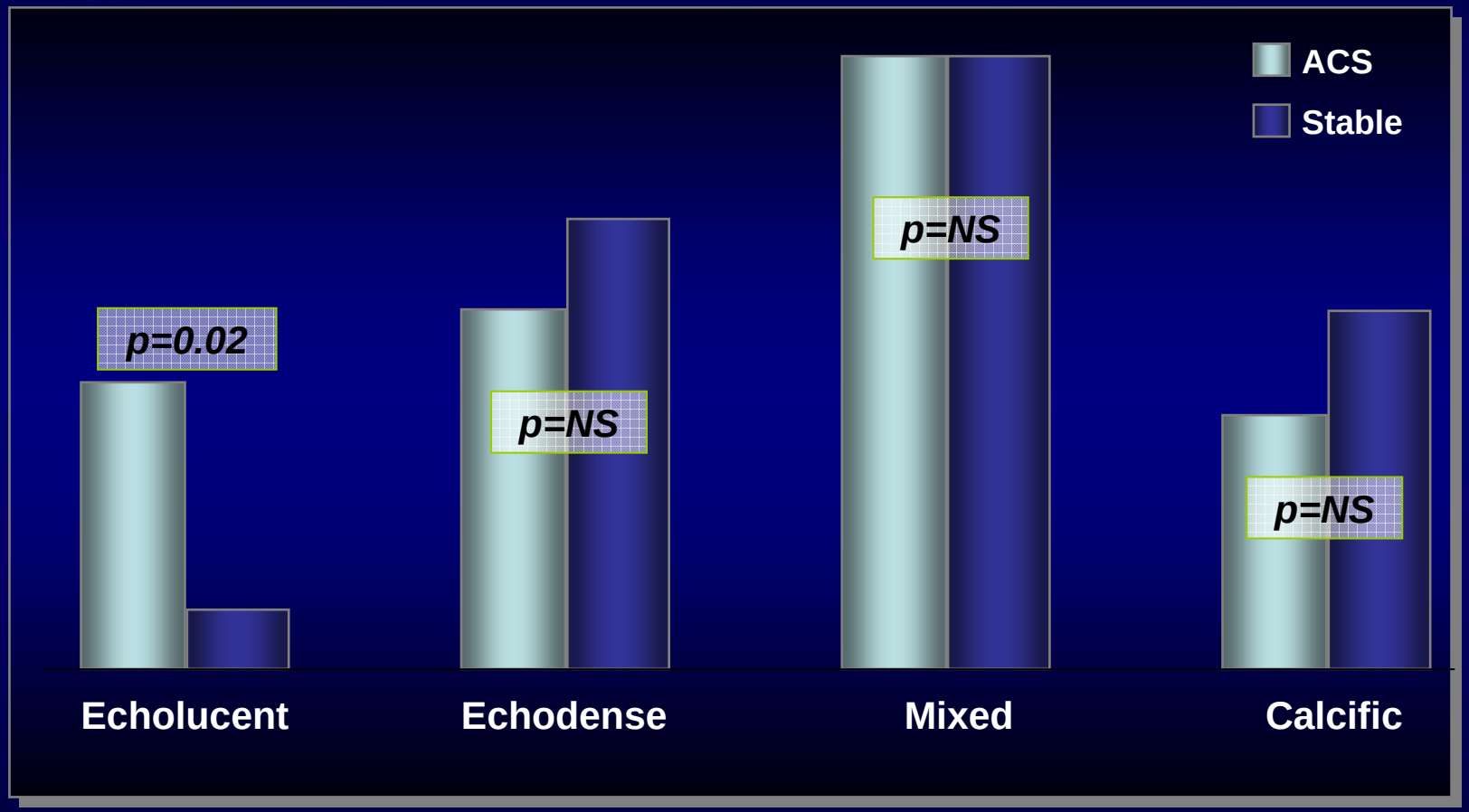
F Prati, E Arbustini, A Labellarte, B Dal Bello, L Sommariva, M T Mallus, A Pagano, A Boccanelli

Heart 2001;85:567-



In 122 cross-sections (12 arteries), lipid pools observed by histology in 30, revealed by IVUS in 19 (sensitivity 65% and specificity 95%)

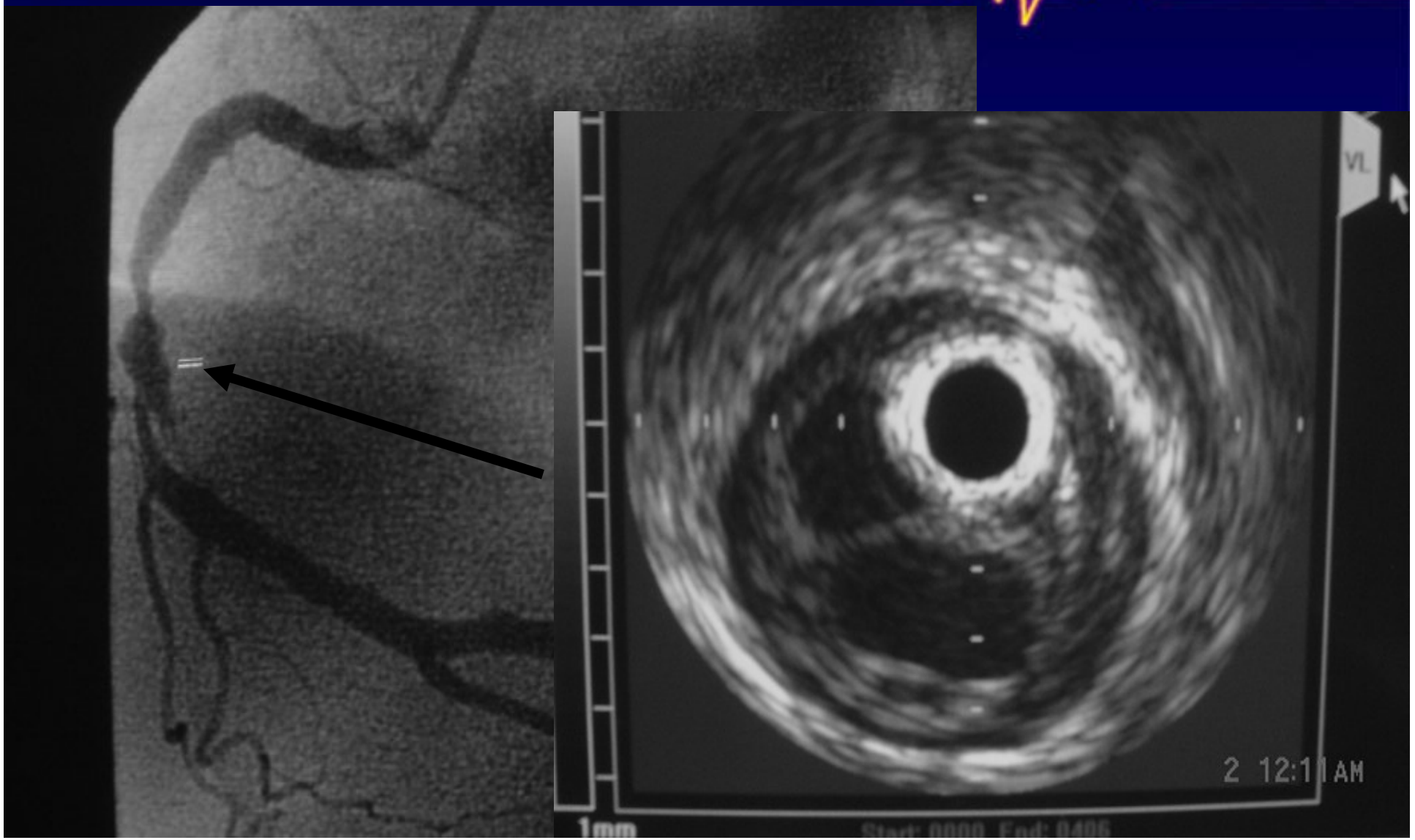
# Plaque Composition in Acute Coronary Syndromes




*Schoenhagen et al. Circulation 2000;101:598-603*

# Identificaton of Vulnerable Plaques

# Identificaton of Vulnerable Plaques



# Identificaton of Vulnerable Plaques

| | Group A | Group B |
|---|---|---|
| Pts (n) | 31 | 108 |
| Sex (male) | 87% | 85% |
| Age (yrs) | 55 | 58 |
| Hypertension | 61% | 45% |
| Diabetes | 23% | 23% |
| Smoking | 68% | 57% |
| Hyperlipidemia | 74% | 41%* |
| Family history | 35% | 41% |
| Obesity | 32% | 35% |
| Symptoms (unstable) | 74% | 18%* |

* p<0.01

*Ge et al, Heart 1999*

# Identificaton of Vulnerable Plaques

| | Group A | Group B |
|---|---|---|
| Thickness of the cap | 0.47 ±0.20 | 0.96 ±0.94* |
| Tear size | 0.83 ±0.29 | - |
| Eccentric | 94% | 64%* |
| Plaque size | 11.7 ± 7.0 | 13.4 ±6.3 |
| Lipid core size | 4.1 ±3.2 | 1.3 ±0.8* |
| Lipid/plaque ratio | 38.5 ±17.1% | 11.2 ±8.9%* |
| Percent stenosis | 56.2 ±16.5% | 67.9 ±13.4%* |
| Superfacial calcium | 52% | 51% |
| Deep calcium | 17% | 43%* |

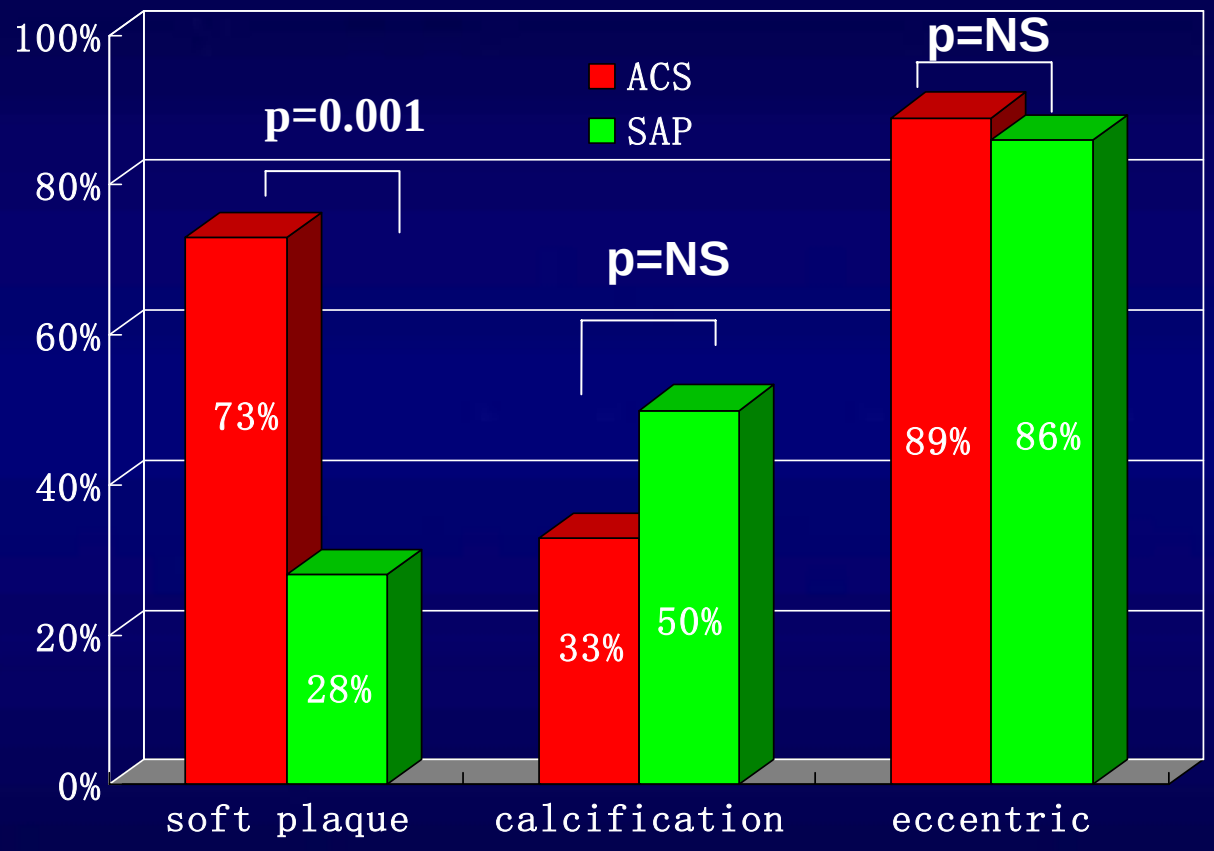
*=p<0.05

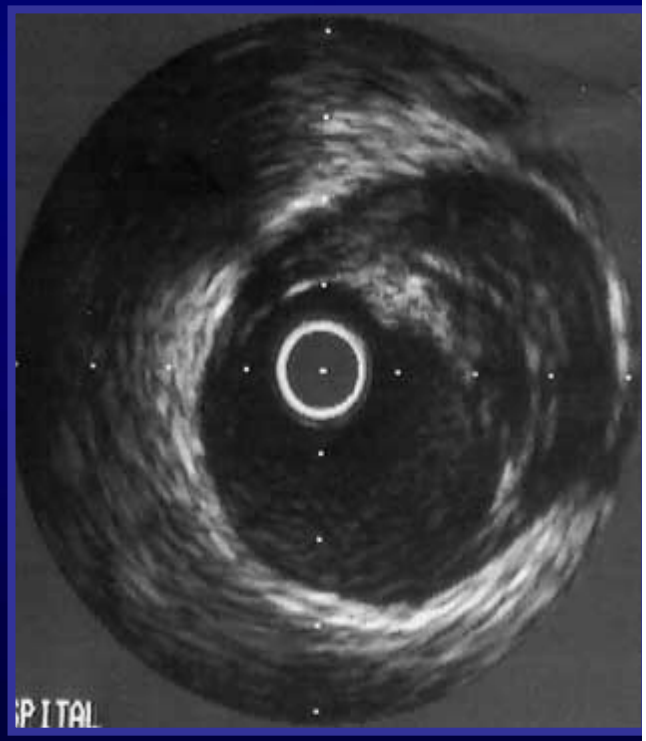
*Ge et al, Heart, 1999*

# Identificaton of Vulnerable Plaques

- IVUS is able to identify vulnerable plaques.
- The characteristics of vulnerable plaques include
  - Echolucent area>1mm$^2$ ;
  - Echolucent area/plaque ratio >20% ;
  - Thickness of fibrous cap<0.7mm。

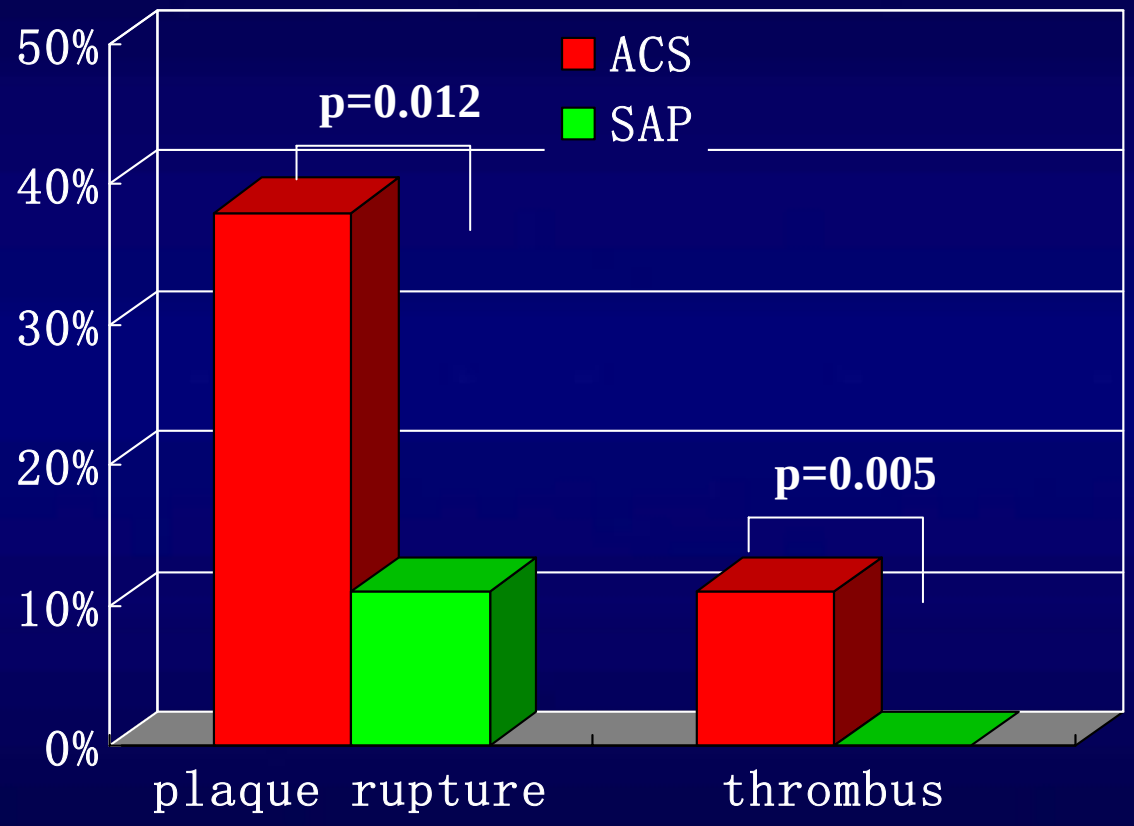
# Vulneralbe plaque: soft and eccentric

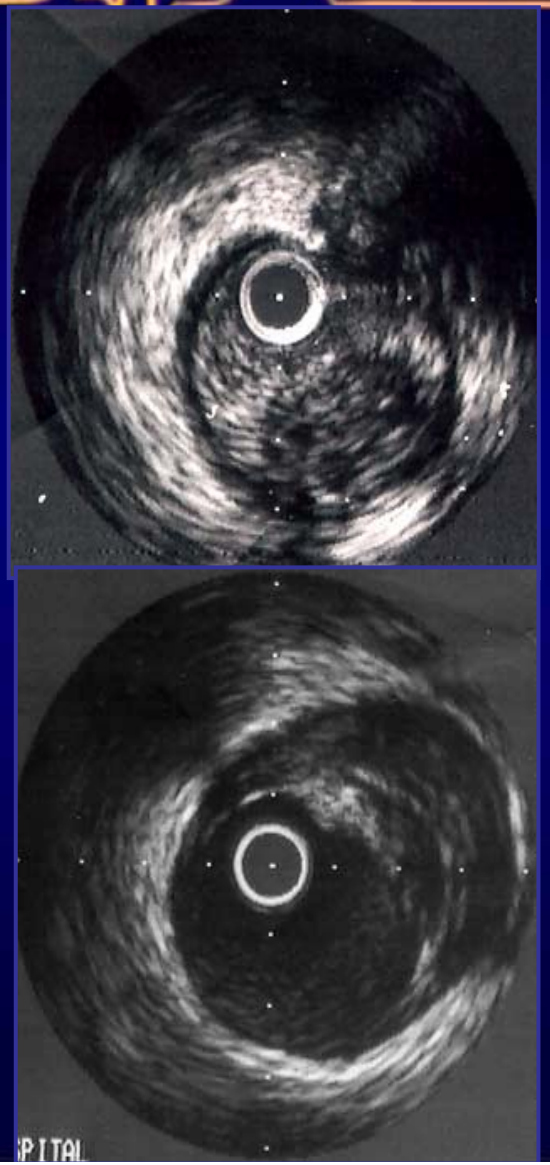


Wu HY, Chinese J Cardiol 2005; 33:894-898

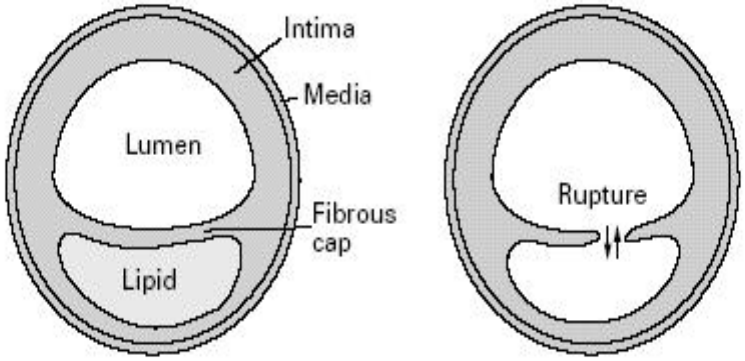
# Vulneralbe plaque: rupture and thrombogenesis

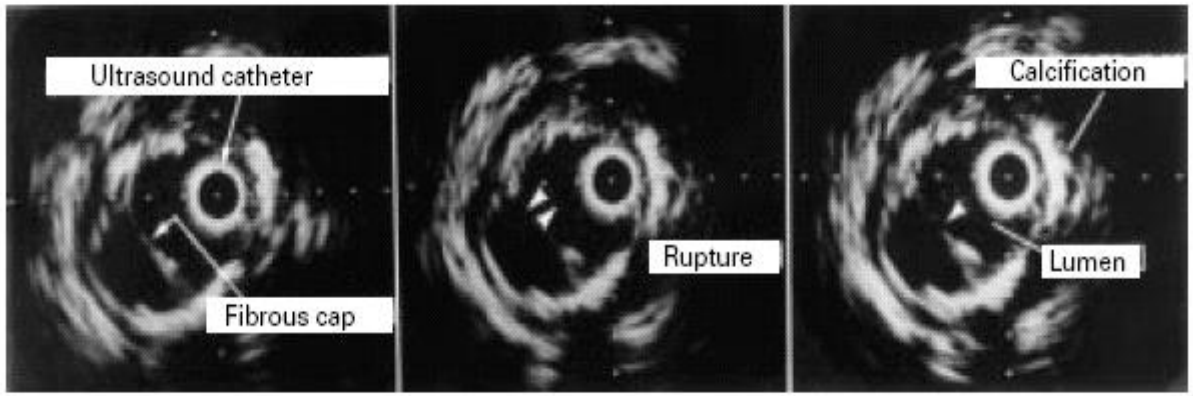


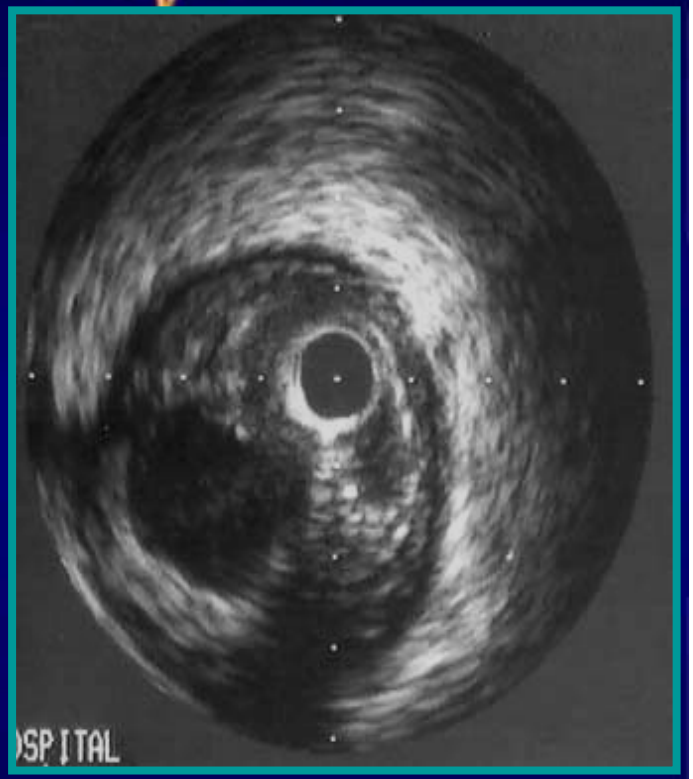



Wu HY, Chinese J Cardiol 2005; 33:894-898

# Identificaton of Vulnerable Plaques (Summary)

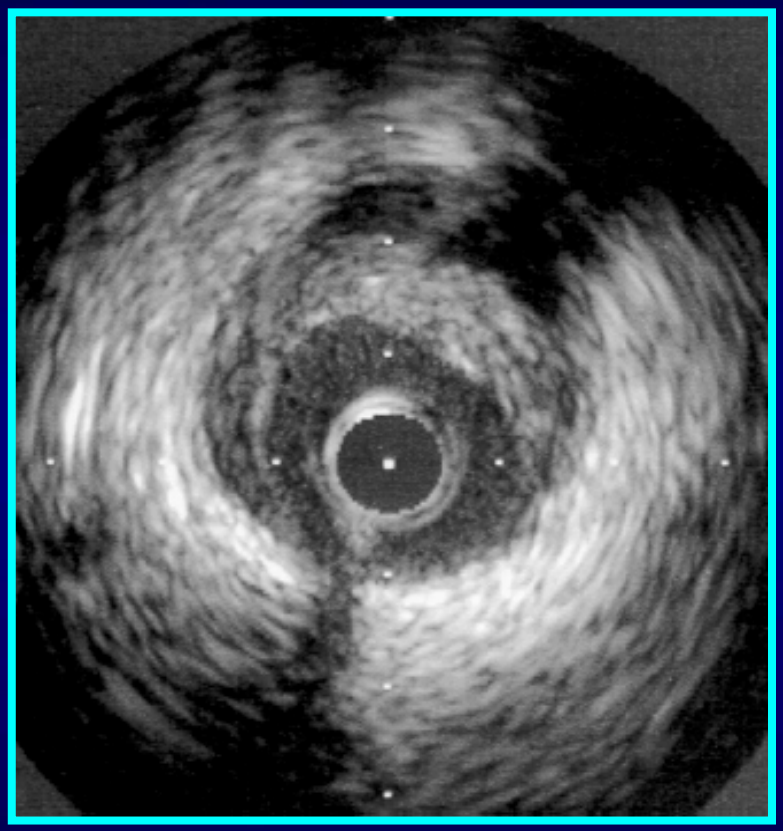


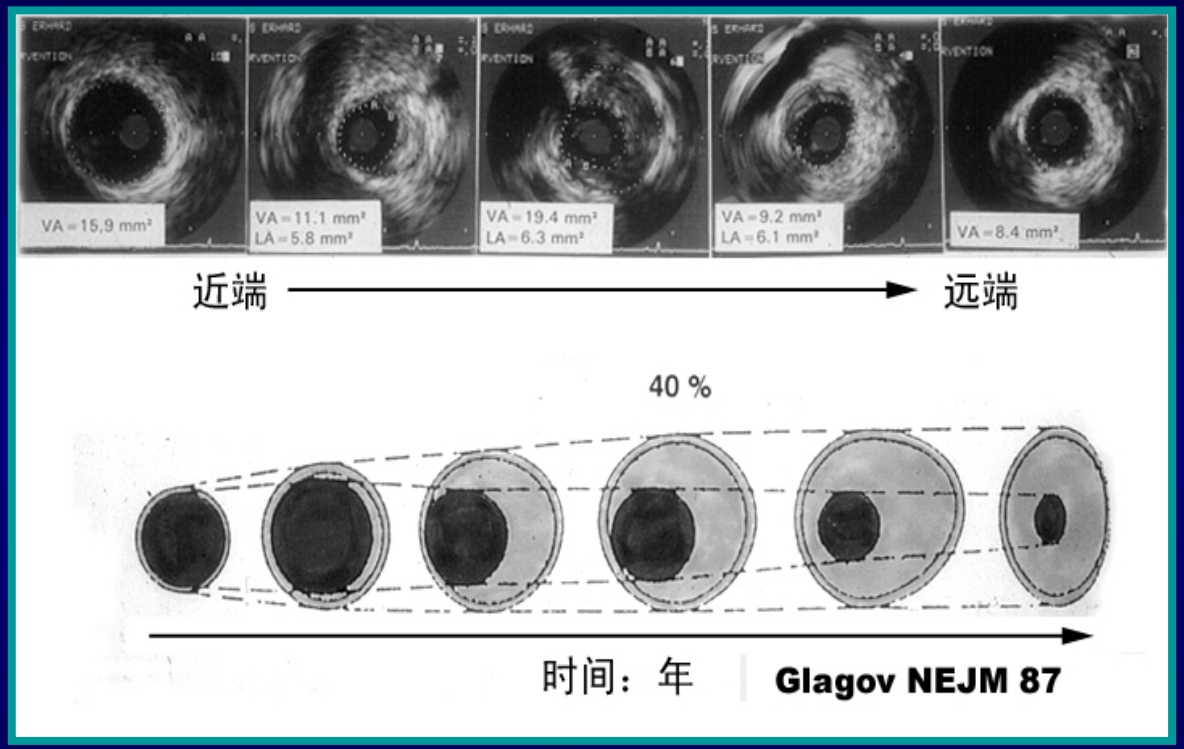
- Ge J, et al. ***Herz 1999;24:32***
- Ge J, et al. ***Heart 1999;81:621***
- Wu H, Ge J. ***Chin J Cardiol2005;33:894***

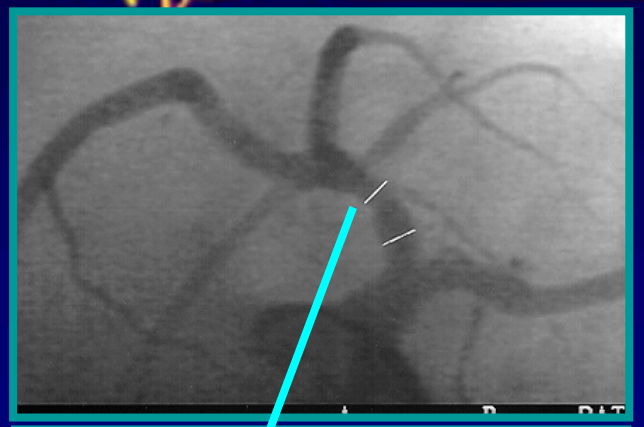
# IVUS- What is Unproven

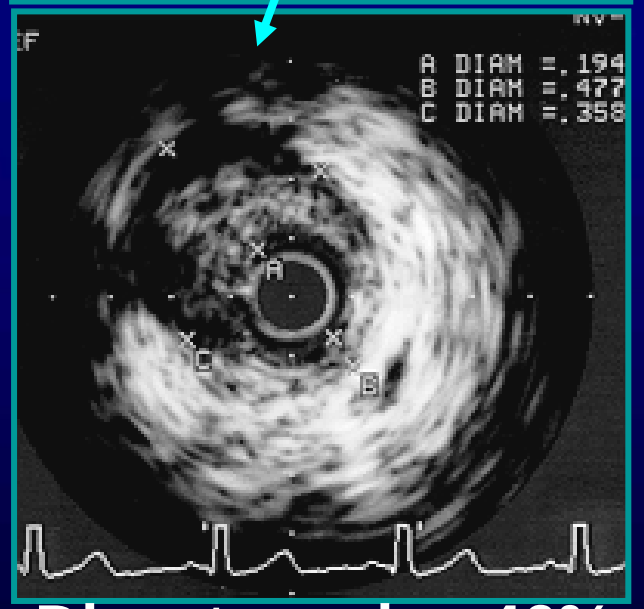


- Will this morphologic characteric plaque rupture?
- When will it rupture?
- What is the cnsequence after rupture?

# IVUS- What is Unproven



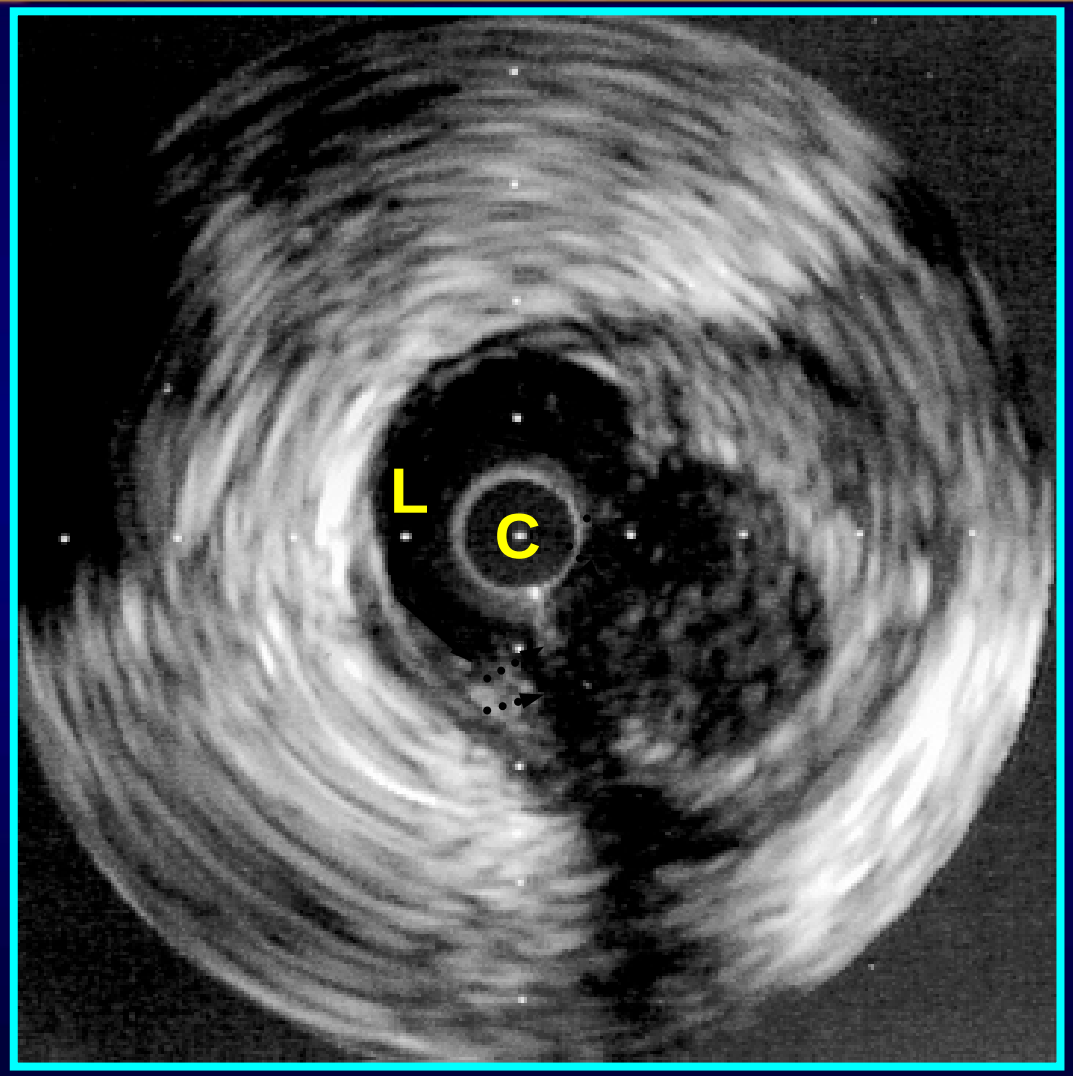



**Angiography: Dia. stenosis 14%**
**Area stenosis 26%**

Ge J, et al. *J Am Coll Cardiol 1993；21:455*
Ge J, et al. *Coron Artery Dis. 1993; 4(11):981*

**IVUS: Dia. stenosis: 46%**
**Area stenosis: 74%**

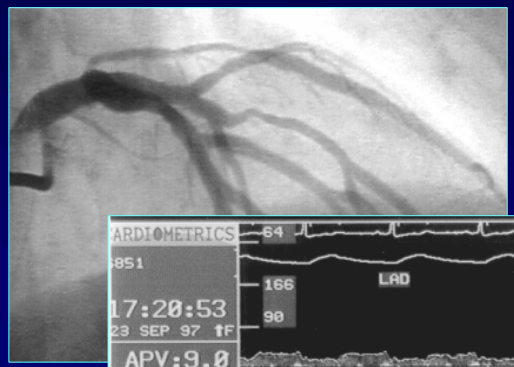
# IVUS- What is Unproven

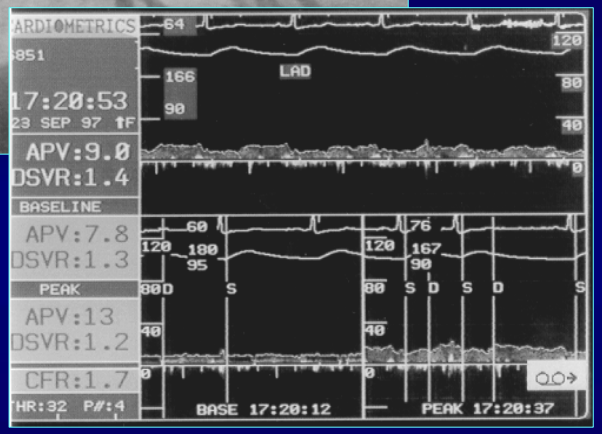



❖Silent healing of spontaneous rupture, an IVUS follow-up

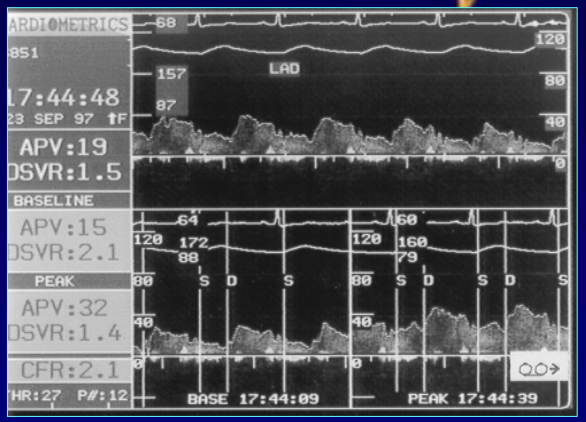
---Ge J, et al.
Eur Heart J 1994

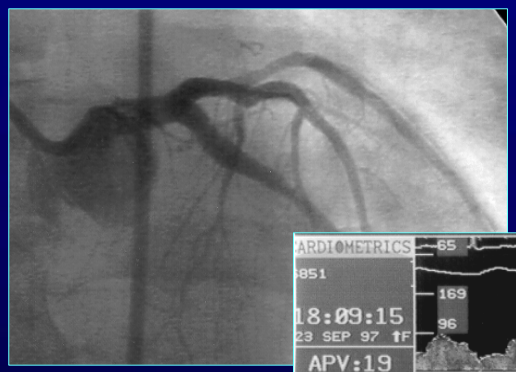
# IVUS- What is Unproven



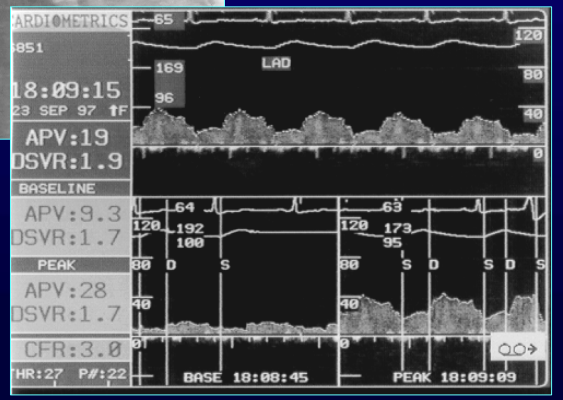



Pre-intervention
CFVR=1.7



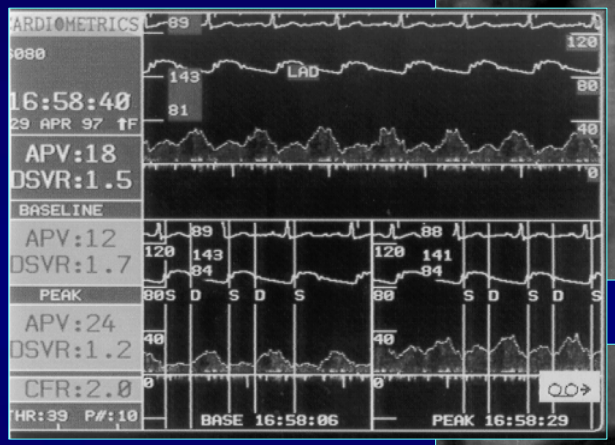



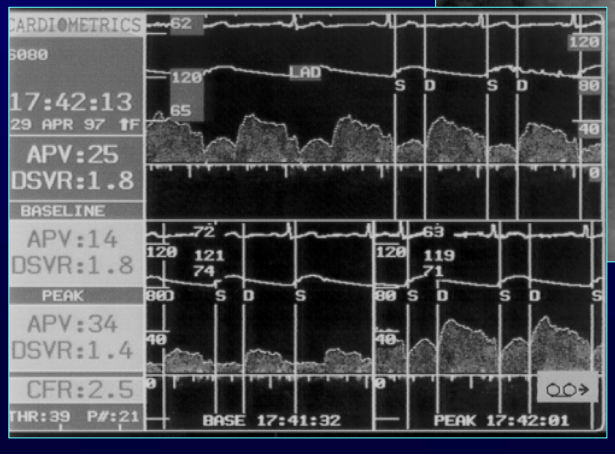
After stenting
CFVR=3.0

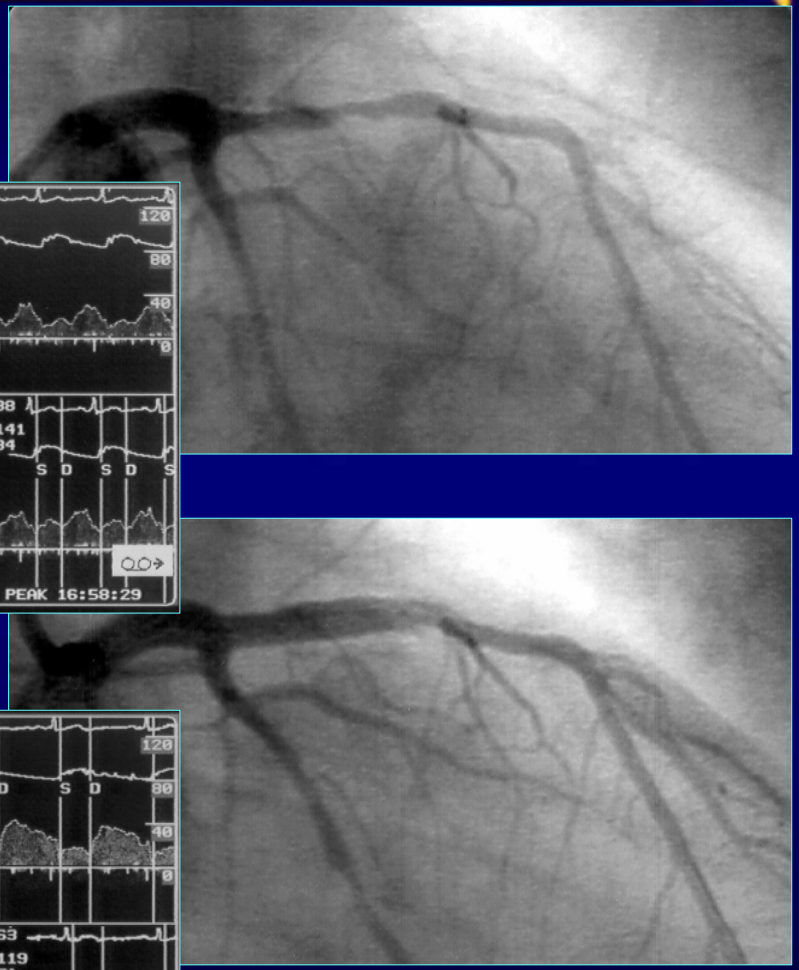



55 yr old male
SAP

# IVUS- What is Unproven



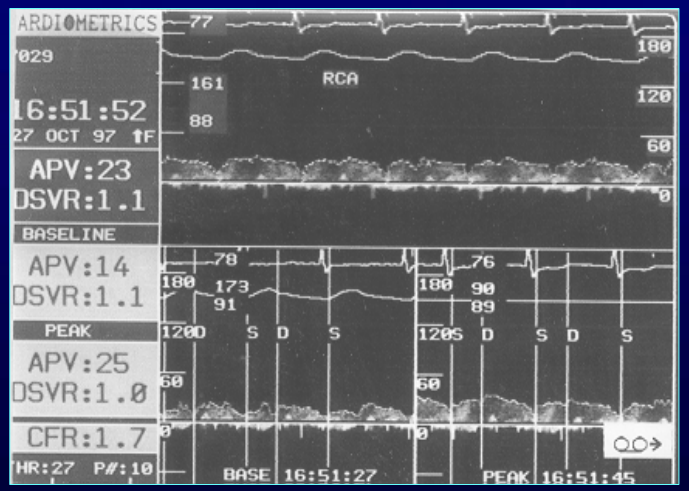
48 yr old male
UAP

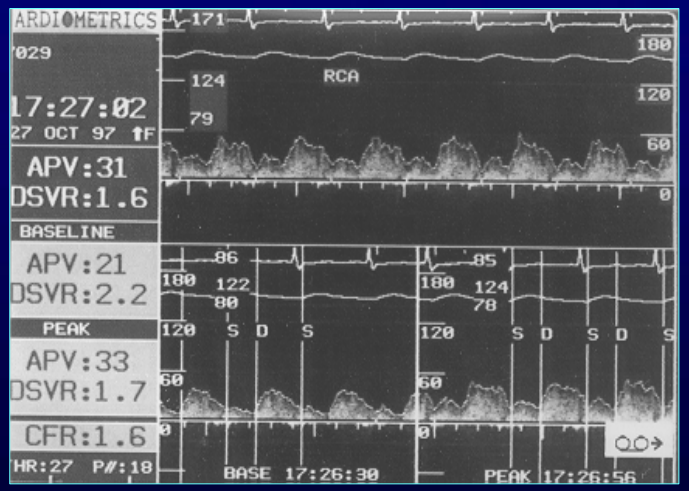
Pre-
intervention
CFVR=2.0

After
stenting
CFVR=2.5

# IVUS- What is Unproven

58 yr old
female, UAP



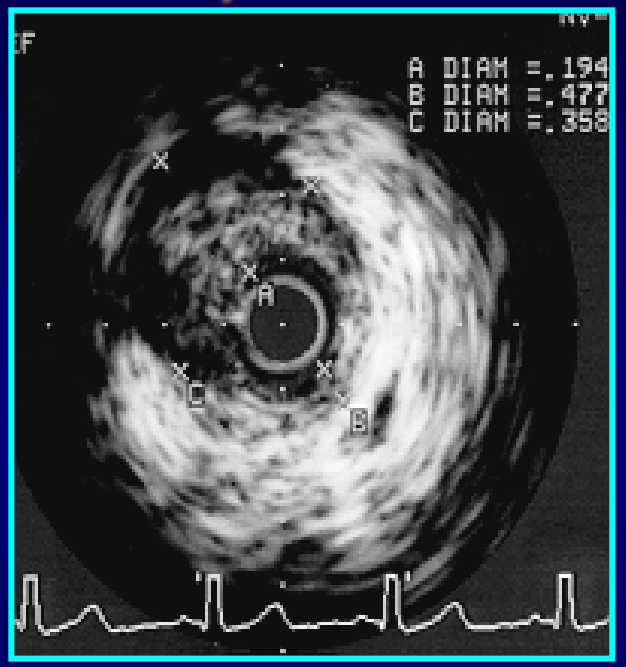




Pre-intervention, CFVR=1.7

After stenting, CFVR=1.6

# IVUS- What is Unproven

Angiography: Dia. stenosis: 14%
Area stenosis: 26%

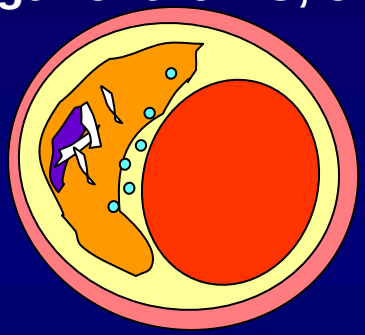


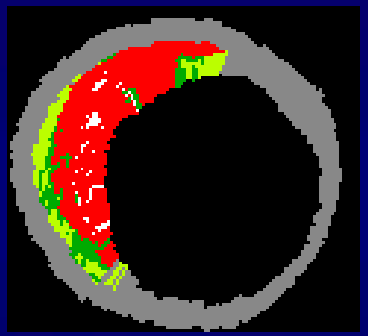

IVUS: Dia. stenosis: 46%
Area stenosis: 74%

„Plaque at risk“ to rupture

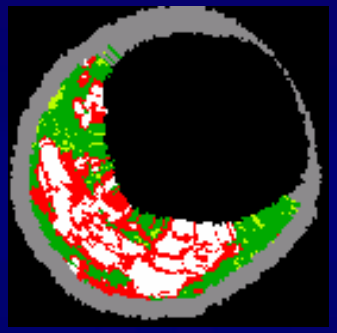
# Virtual Histology (VH)-Thin Cap Fibroatheroma

**"Thin Cap Fibro-Atheroma (TCFA)" or "Vulnerable Plaque" -- Confluent Necrotic Core >10% of total plaque, >33% of lesion circumference at the lumen surface, and present in 3 consecutive frames. Based on the presence or absence of Ca, the length of the NC, or signs of previous ruptures, TCFA can be further sub-classified**

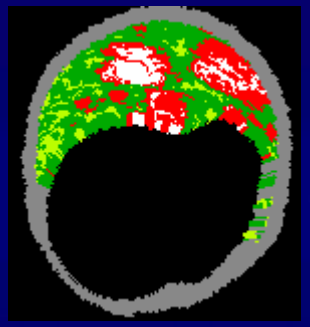




**<10% calcium**



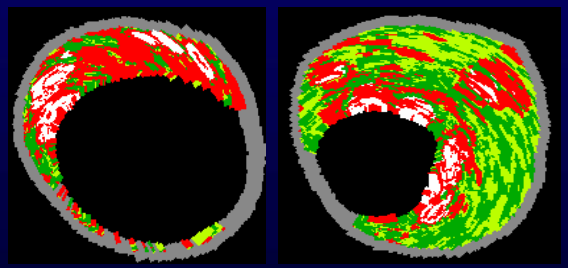
**>10% calcium**



**multiple layers**

***Still further sub-classification can be based on presence of luminal narrowing.***

**"TCFA without significant narrowing" - plaque burden <50% on IVUS and/or less than 25% narrowing on angiogram. (Pathologic data suggests that TCFA without significant plaque burden are less "vulnerable")**



**"Highest Risk TCFA"**

a. **Confluent NC>20%**
b. **No evidence of fibrotic cap**
c. **Calcium >5%**
d. **Remodeling index >1.05**
e. **>50% plaque burden by IVUS**

**(Pathologic data suggests that TCFA with significant plaque burden are the most vulnerable)**