



Coronary Artery Thermography



The 10th Anniversary, Interventional Vascular Therapeutics Angioplasty Summit 2005 TCT Asia Pacific



The 10th Anniversary, Interventional Vascular Therapeutics

Angioplasty
Summit2005
TCT Asia Pacific

Date Thursday, April 28 ~ Saturday, April 30, 2005

Venue The Convention Center of
Sheraton Walkerhill Hotel, Seoul, Korea

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Professor of Cardiology
Athens Medical School



In the search for vulnerable plaque What???



- Thin cap
- Lipid core
- Positive remodeling
- Reduction of smooth muscle cells
- Macrophages

Santorini Congress Conclusions
Eur Heart J 2004;25(12):1077-1082



Inflammation – Atheromatosis



THE WALL STREET JOURNAL. TUESDAY, JANUARY 28, 2004

New Heart Test Gets Major Backing

Heart Association and CDC Endorse Blood Screen For Inflammation; First Added Tool in 20 Years

By RON WINSLOW

FOR THE FIRST TIME in more than 20 years, two of the nation's leading health organizations are recommending a new tool for doctors and pa-

Taking the Test

The CRP test may help doctors decide whether to prescribe drugs for some patients.

What it is

Blood test to measure C-reactive protein levels, which indicate risk

Avoid it. (In general, insurance is likely to cover the cost, especially for uses of the test that are covered by the guidelines.) If additional studies, including a clinical trial just getting under way, provide further support for the value of the test, some cardiologists believe the test could one day be



Can we detect the vulnerable plaque?



NO IDEAL METHOD

Technique	Fibrous cap	Lipid core	Inflammation	Calcium	Thrombus	VV
IVUS	+	++	-	+++	+	-
Angioscopy	+	++	-	-	+++	-
OCT	+++	+++	+	+++	+	-
MRI	+	++	+	++	+	-
IVUS+contrast	+	++	+	++	+	+++?
Thermography	-	-	+++	-	-	-



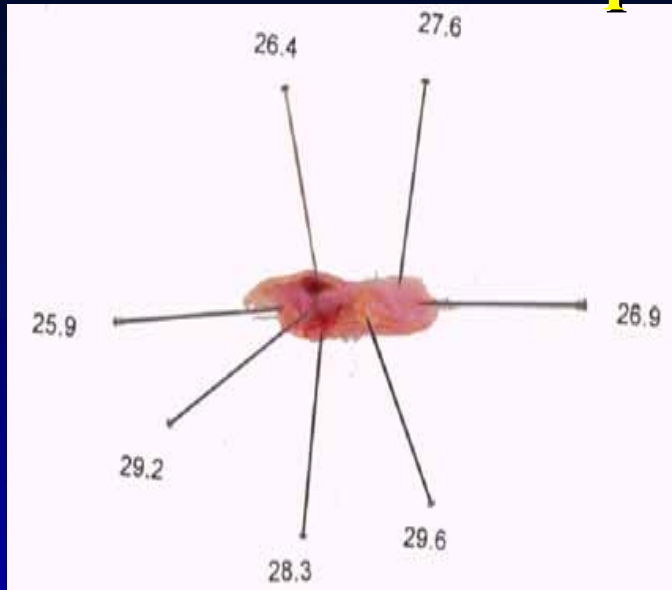
Thermography



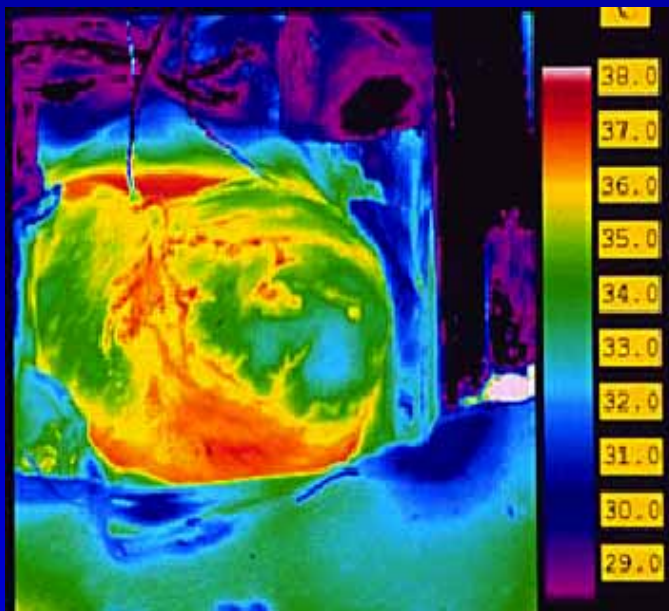
The Fire Within



Thermal Heterogeneity in Atherosclerotic Plaques



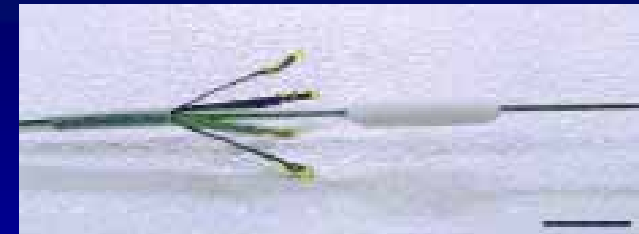
Casscells et al, Lancet 1996



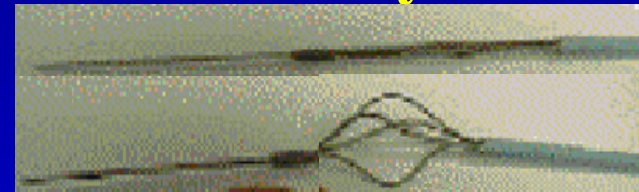
Medispes System



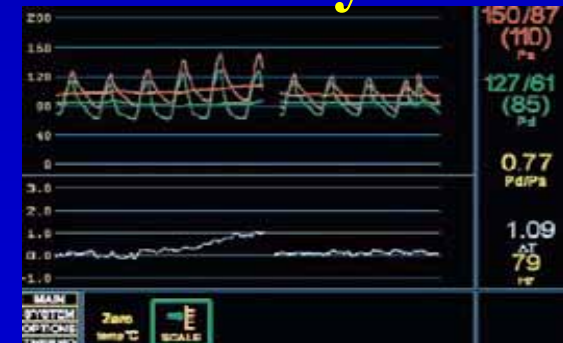
Thermocore System



Volcano System



RADI System



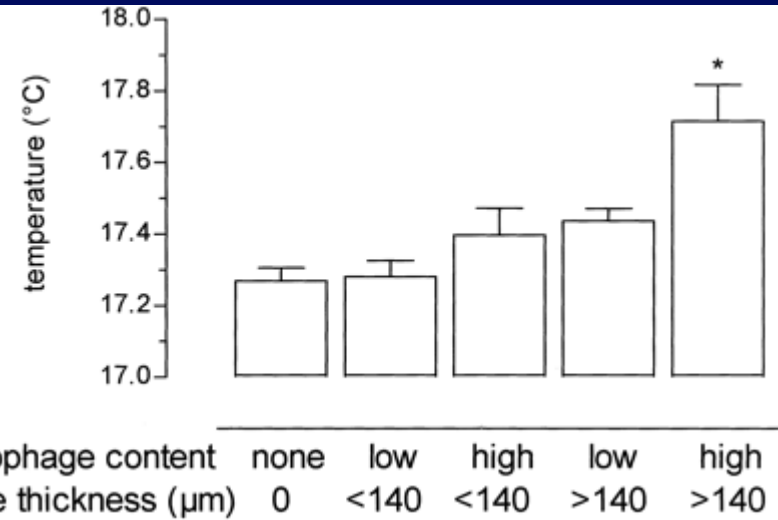
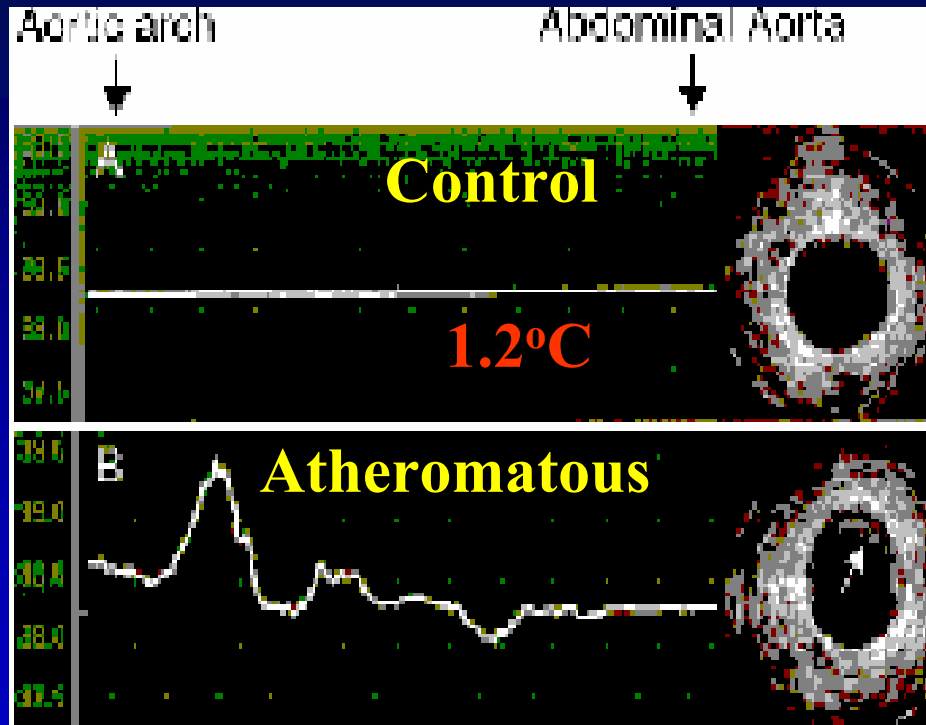


Plaque Thermography

- **What do we measure?**



Thermal Heterogeneity –Inflammatory In vivo experimental study

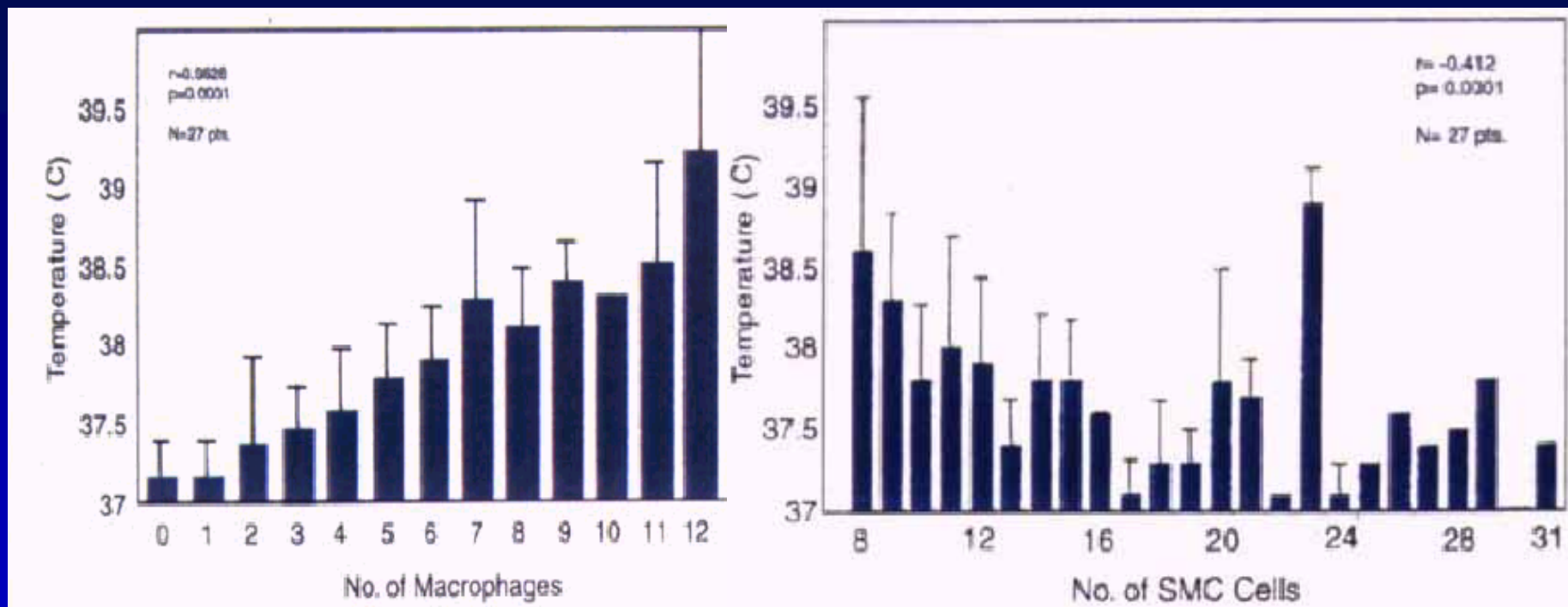


Ex vivo measurements

Verheye et al, Circulation 2002;105(13):1596-601



Correlation of Histology – Temperature Ex Vivo in Carotid Plaques

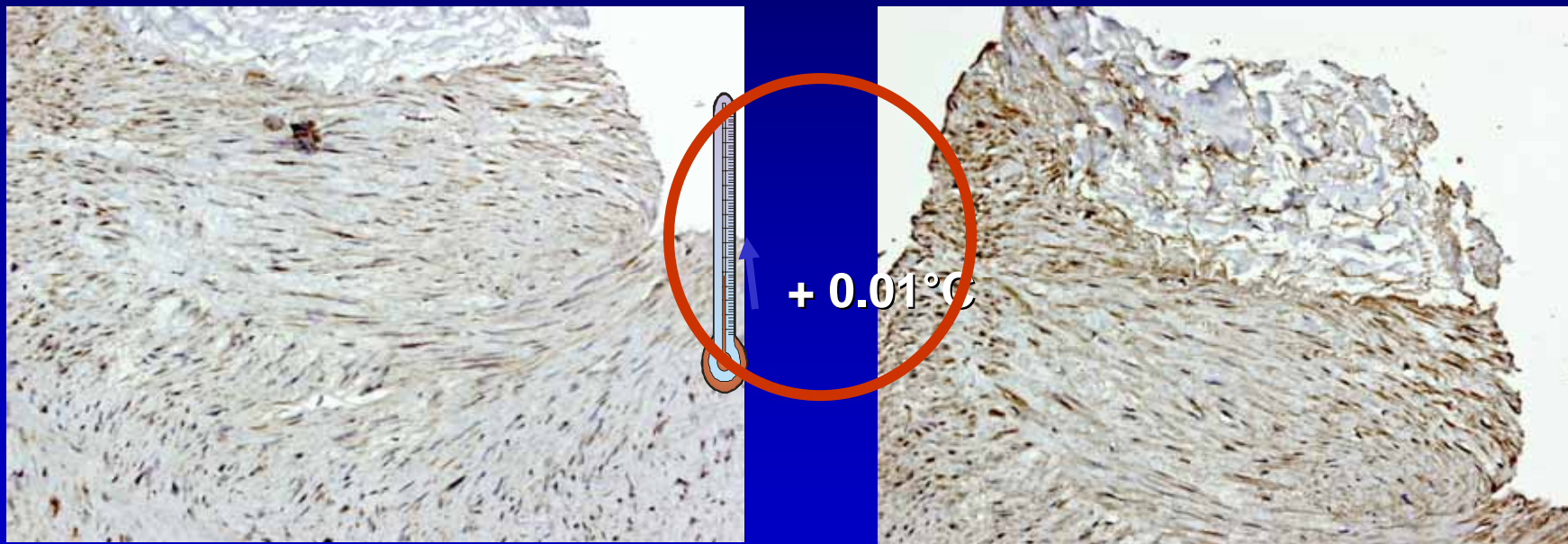


In 27 patients with carotid stenosis: In endarterectomy specimens histology was correlated with temperature measurements

Madjid M, Naghavi M, et al. Am J Cardiol 2002;90:36-39



Correlation of human coronary plaque temperature measurements with the presence of inflammatory markers in pathology examination



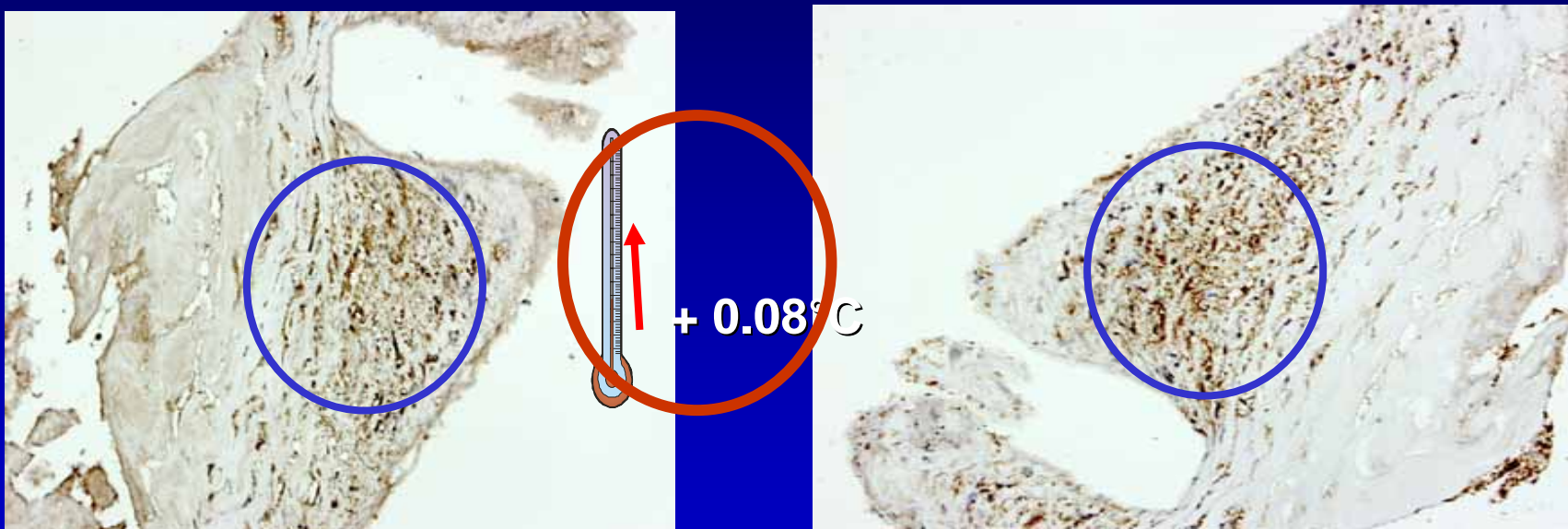
0% concentration of macrophage marker CD-68

Milan-Athens Experience



Correlation of human coronary plaque temperature measurements with the presence of inflammatory markers in pathology examination

Patient With Thermal Heterogeneity (TD: 0.08°C)

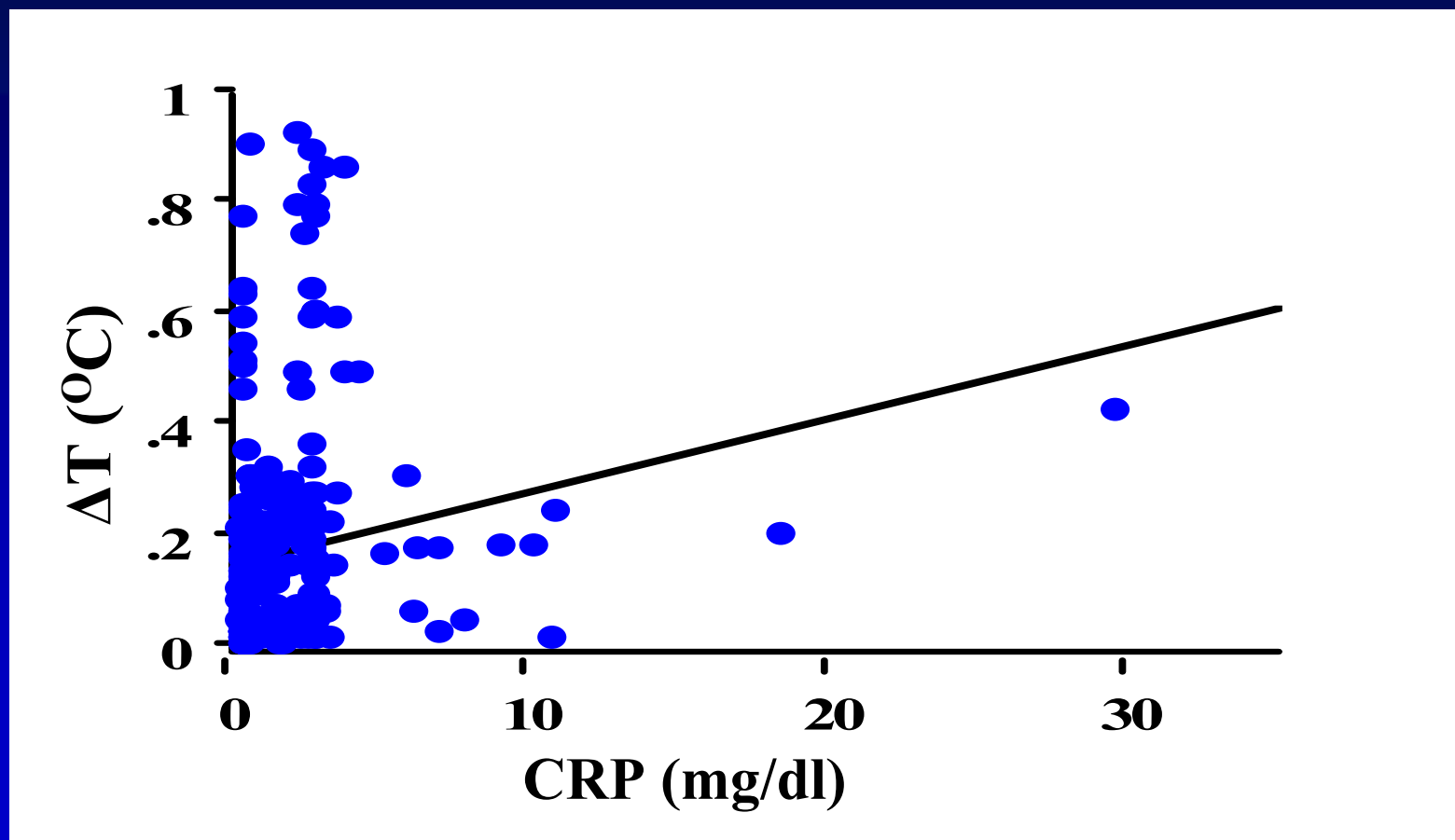


20% concentration of macrophage marker CD-68

Milan-Athens Experience



Correlation of human coronary plaque temperature measurements with systemic inflammatory markers





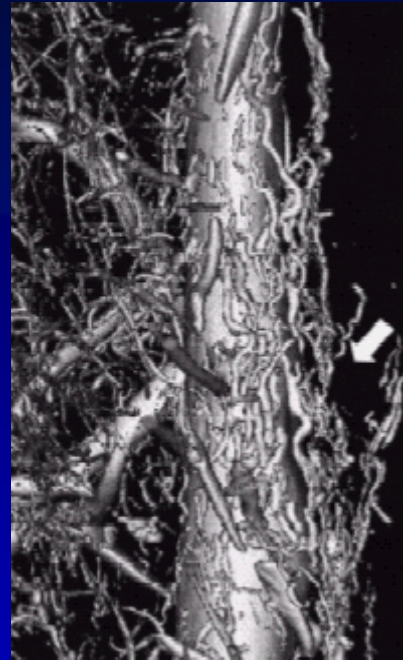
Vasa Vasorum



Angiogenesis in vasa vasorum

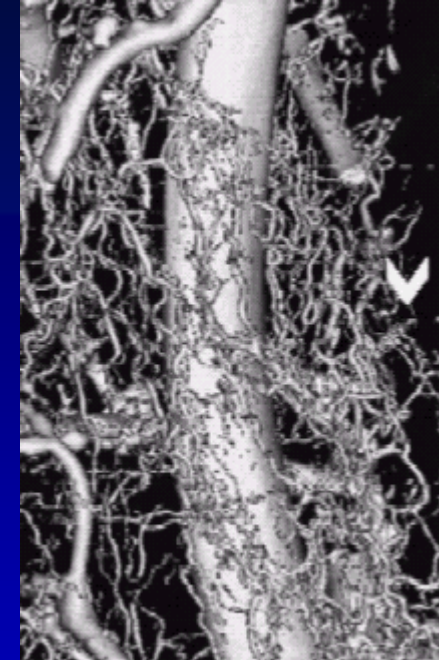


Control



2 weeks hyperlipidemic diet

No endothelial dysfunction



6 weeks

Endothelial dysfunction

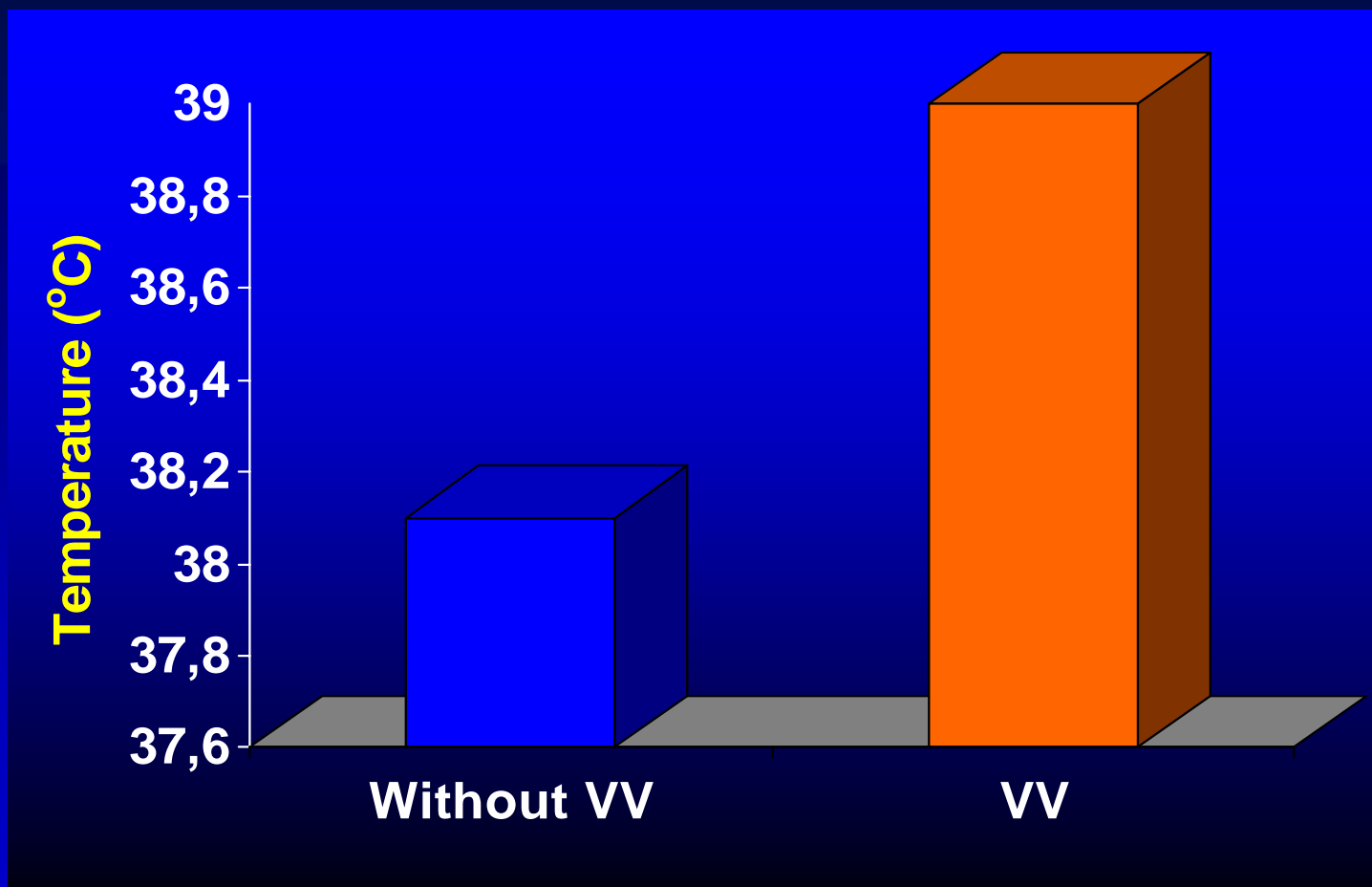
**Vasa vasorum development is observed prior to
endothelial dysfunction**

Herrmann et al. Cardiovasc Res 2001;51:762-6



Experimental Protocol

Effect of Vasa Vasorum on Plaque Temperature



Athens Medical School



Plaque Thermography

- **What do we measure?**
 - **Inflammation**
 - **Neovascularization**



Thermography

Coronary Artery

Coronary Sinus



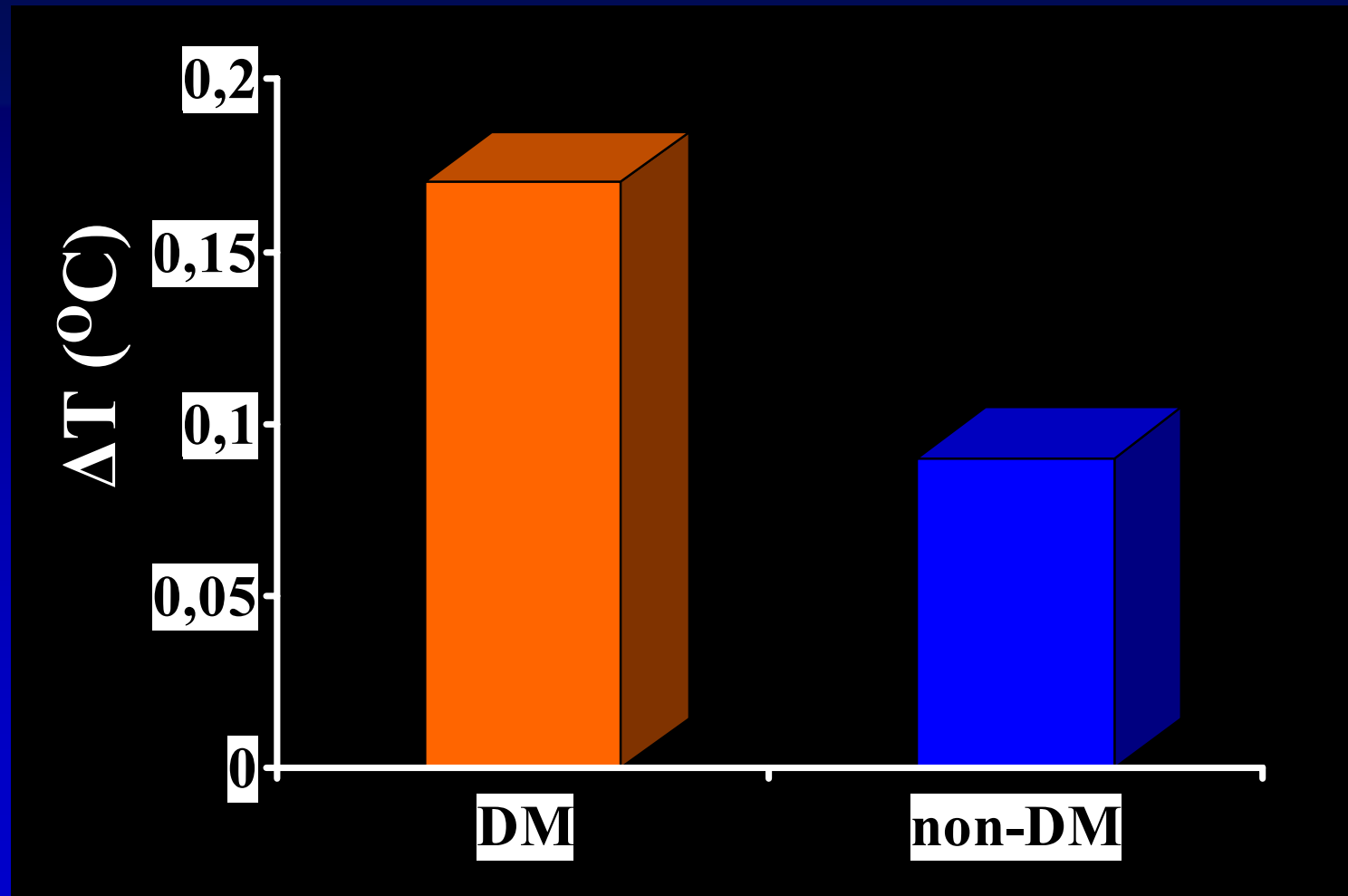
Clinical Studies

Thermal Heterogeneity and Diabetes Mellitus Type 2

**An Increased Inflammatory
Activation?**



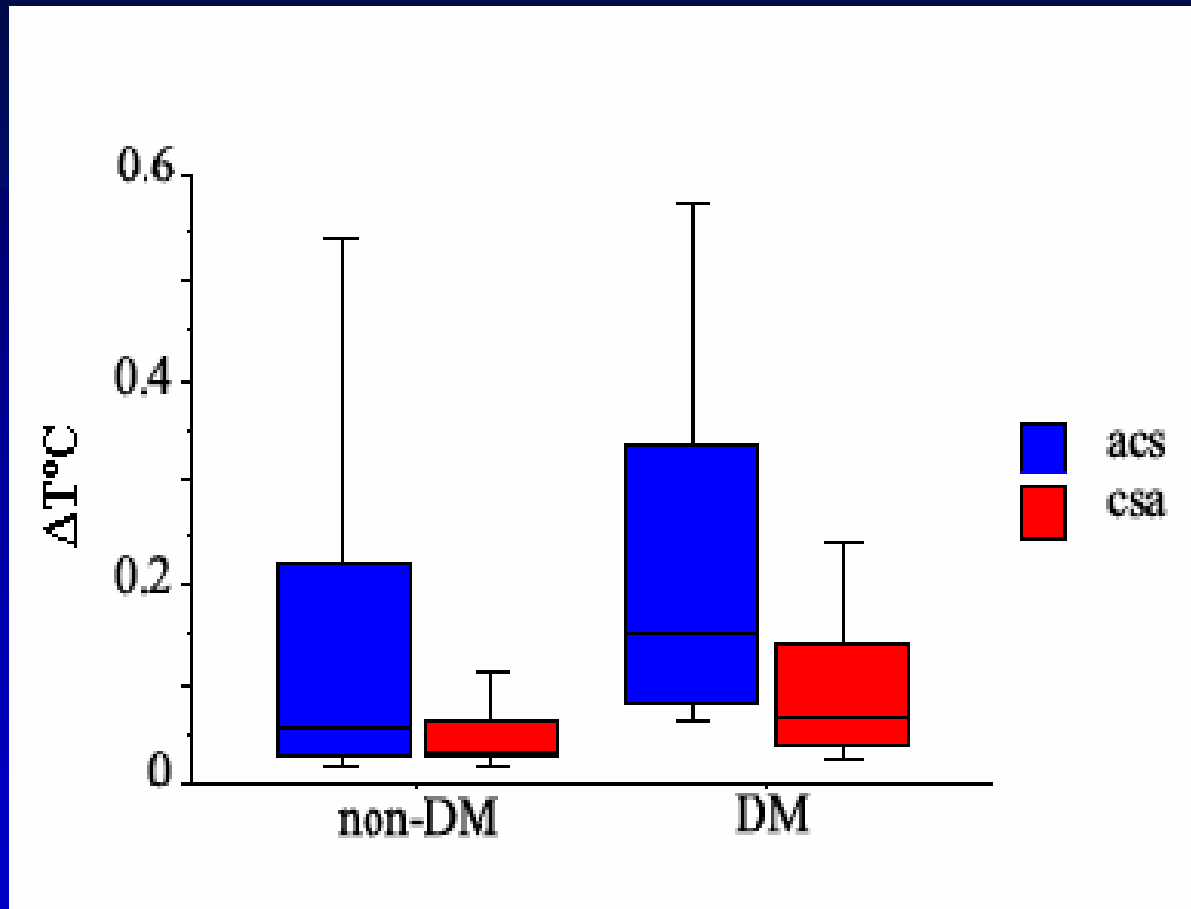
Diabetes Mellitus and Temperature Measurements



Toutouzas K, et al. Diabetes Care in press



Diabetes Mellitus and Temperature Measurements



Diabetic patients with ACS have higher thermal heterogeneity compared to non diabetic patients

Toutouzas K, et al. Diabetes Care in press



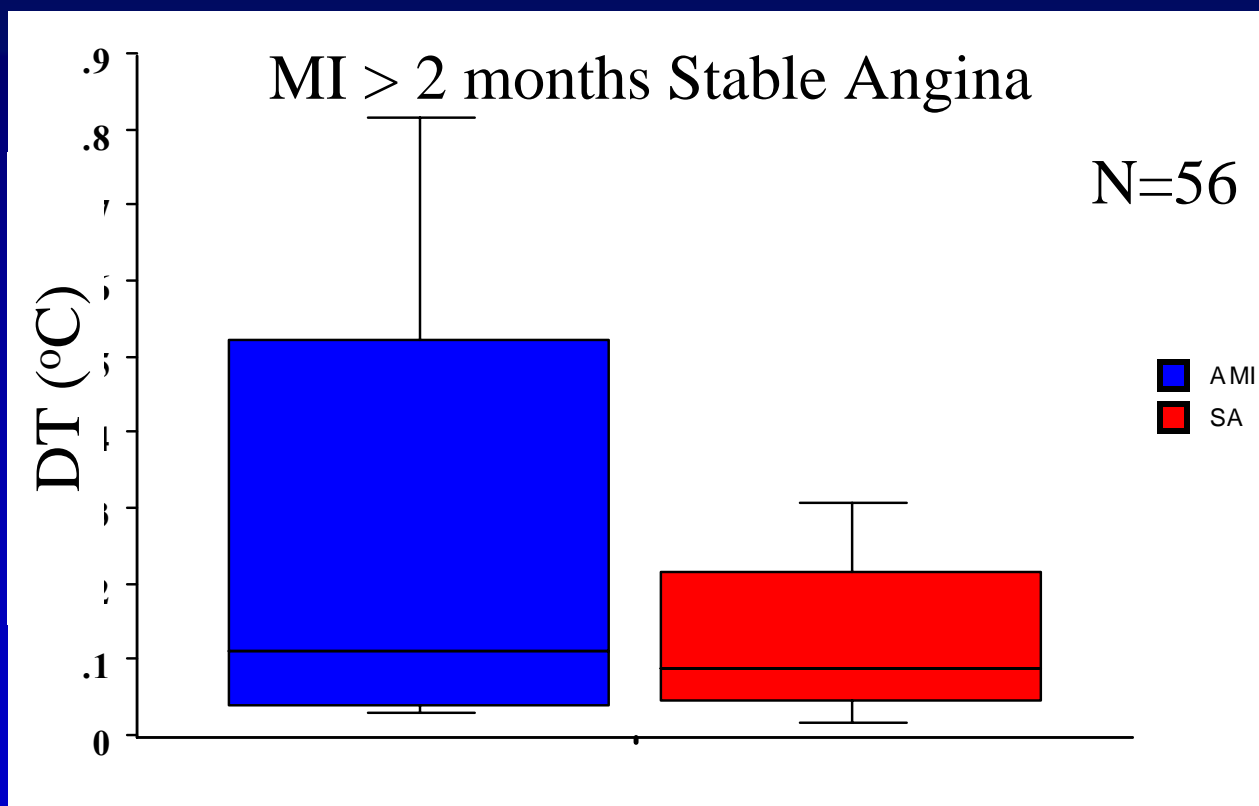
Prolonged Thermal Heterogeneity Post ACS

**A Prolonged Inflammatory
Activation?**



Prolonged inflammation

Prolonged thermal heterogeneity post MI



Toutouzas K et al, Am Heart J 2004



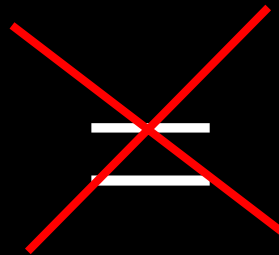
Prognostic implication of detection of vulnerable plaque



Stenting in 'Hot' Plaques



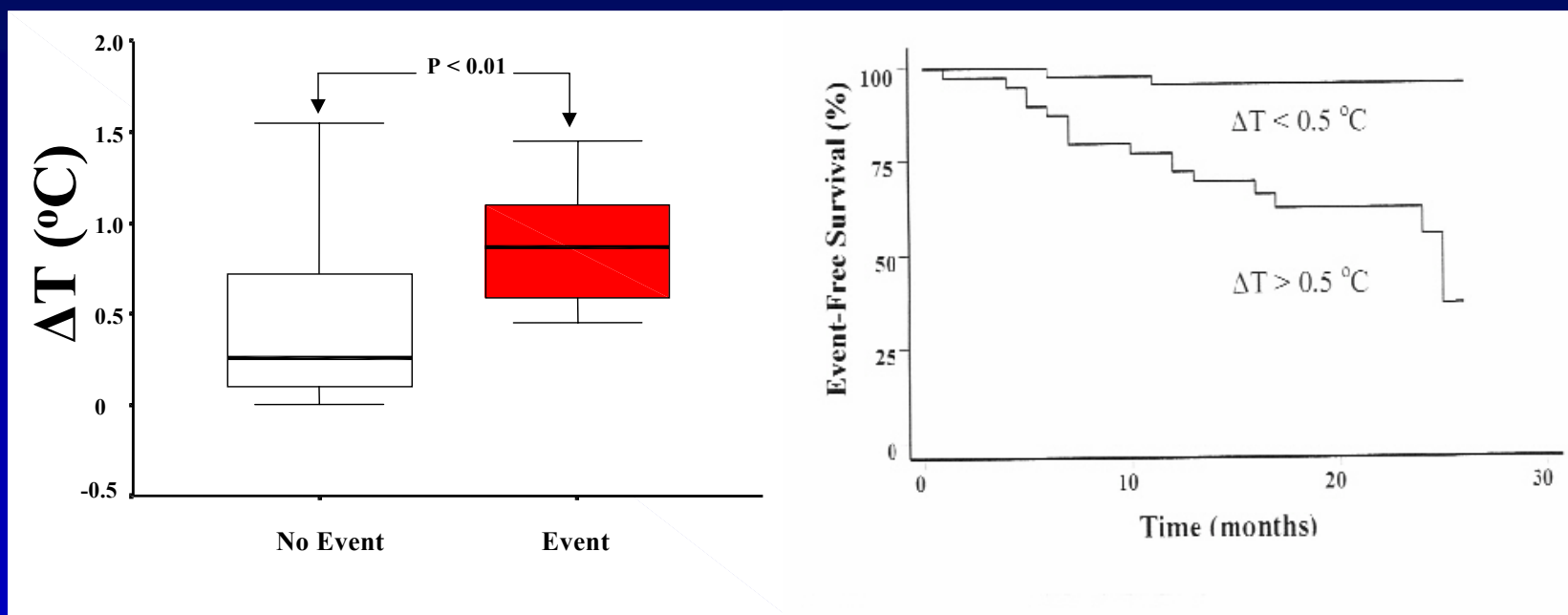
Cold plaque



Hot plaque



Temperature and Prognosis post PCI



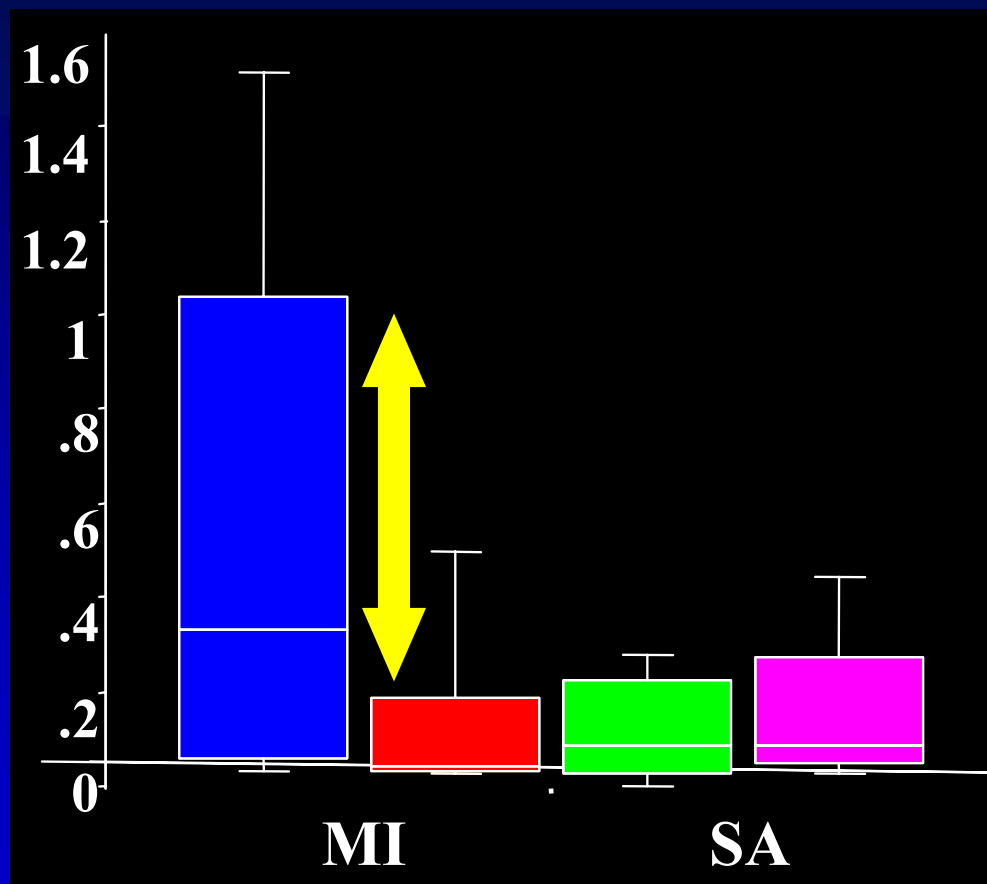
Stefanadis C et al, JACC 2001 April



Therapeutic implication of detection of vulnerable plaque



Statins and Temperature post AMI



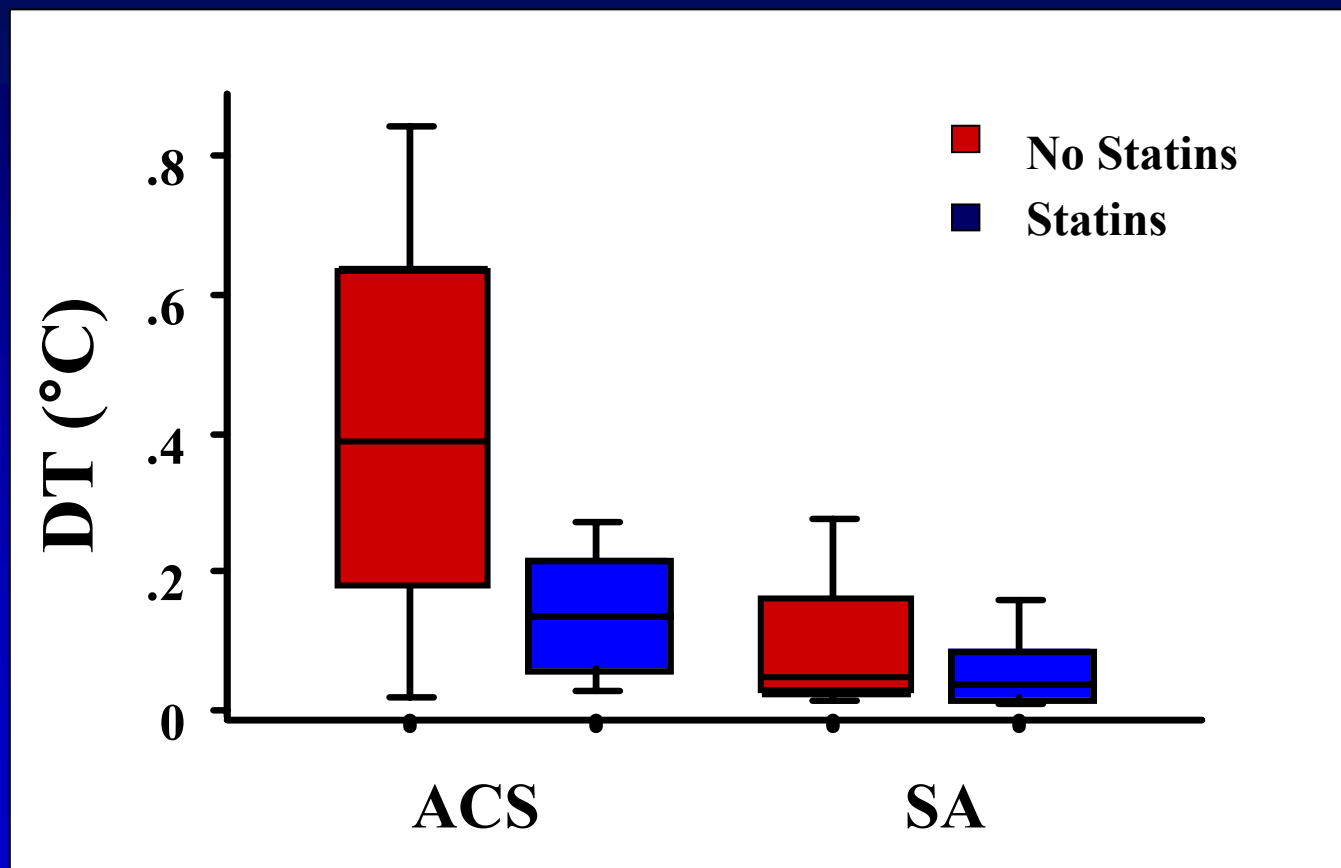
Toutouzas et al. Am Heart L 2004



Effect of Atorvastatin on Plaque Temperature



N=256 pts



Stefanadis et al, submitted



What influences local thermal heterogeneity of atheromatic lesions?



Prospective clinical study in 256 pts (136 under statins)

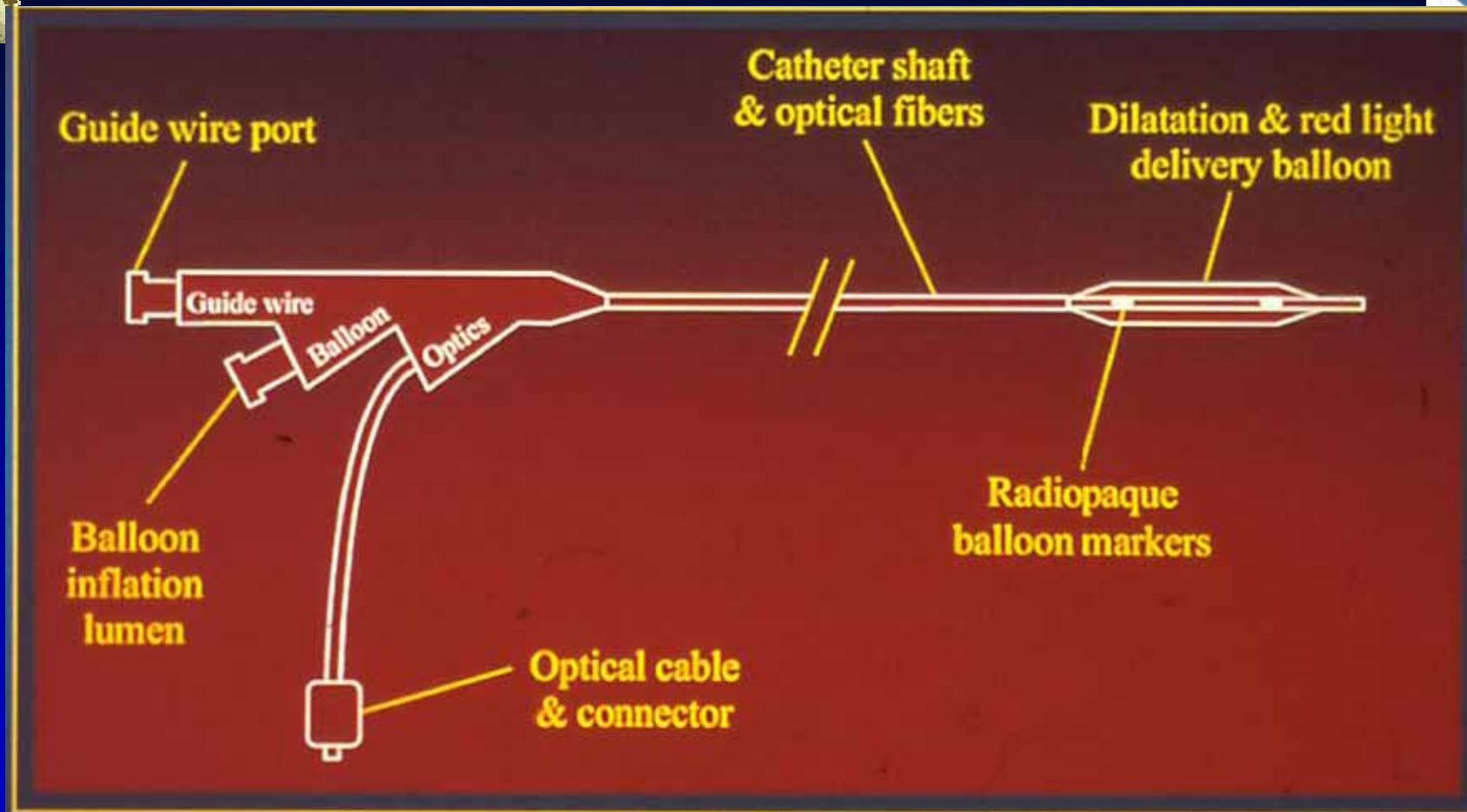
Multivariate Analysis

	b- coefficient	SEM	P-value
Atorvastatin	-0,13	0,02	< 0,001
Clinical Syndrome	-0,13	0,02	< 0,001

Stefanadis et al, submitted



Red Light Catheter

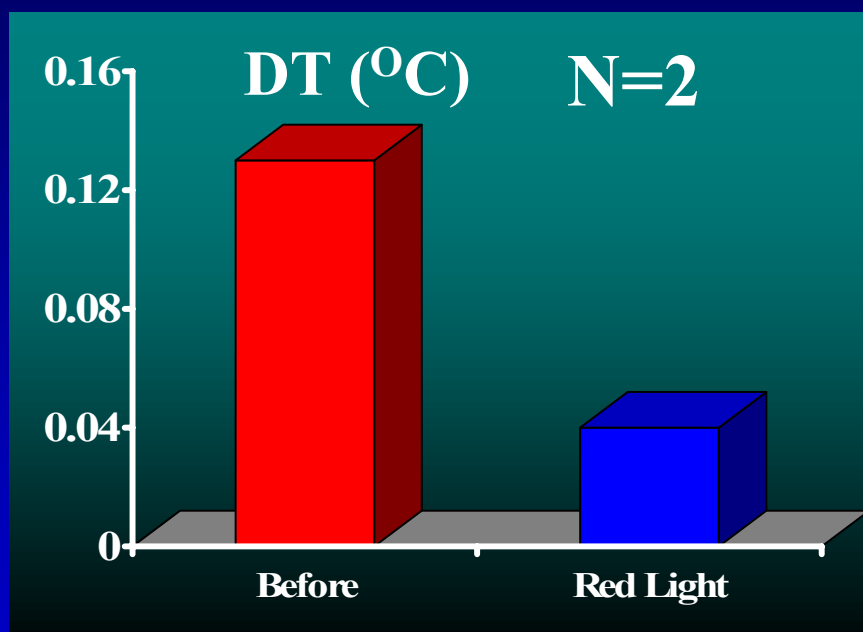


- The possible mechanism includes increased NO synthesis
- Several previous studies have demonstrated light induced vasorelaxation in vivo and in vitro

Kipshidze et al. J Am Coll Cardiol. 1998



Red Light Catheter and Vulnerable Plaque

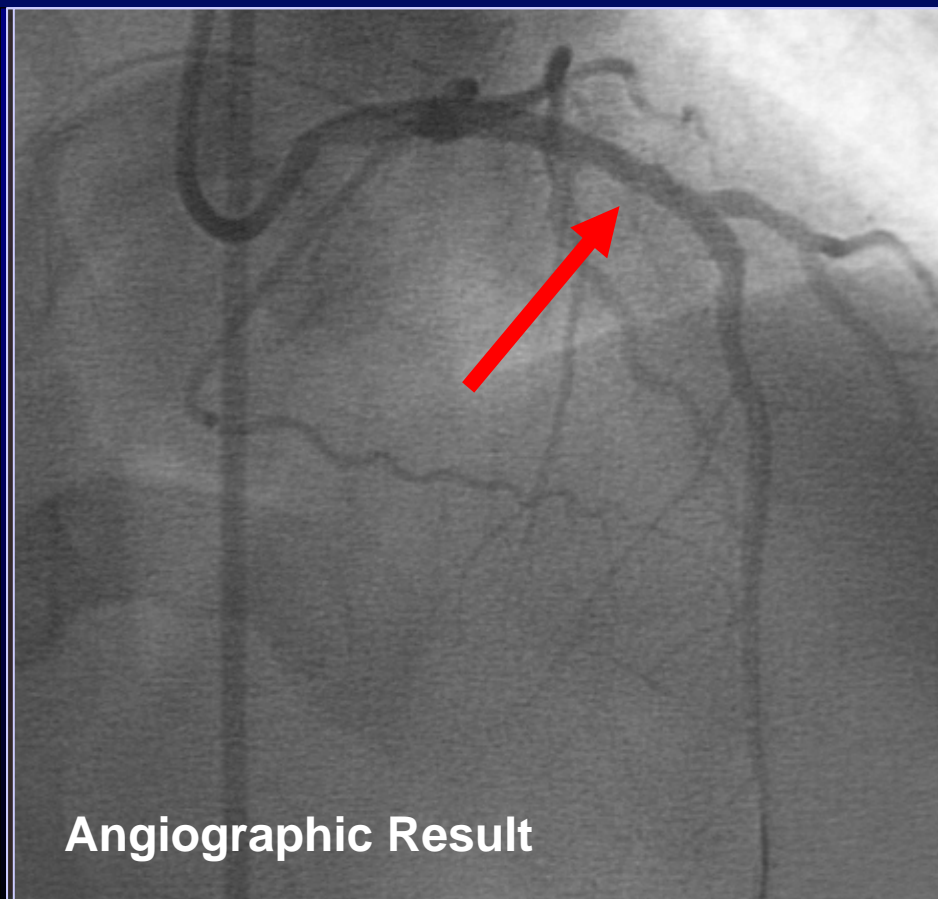
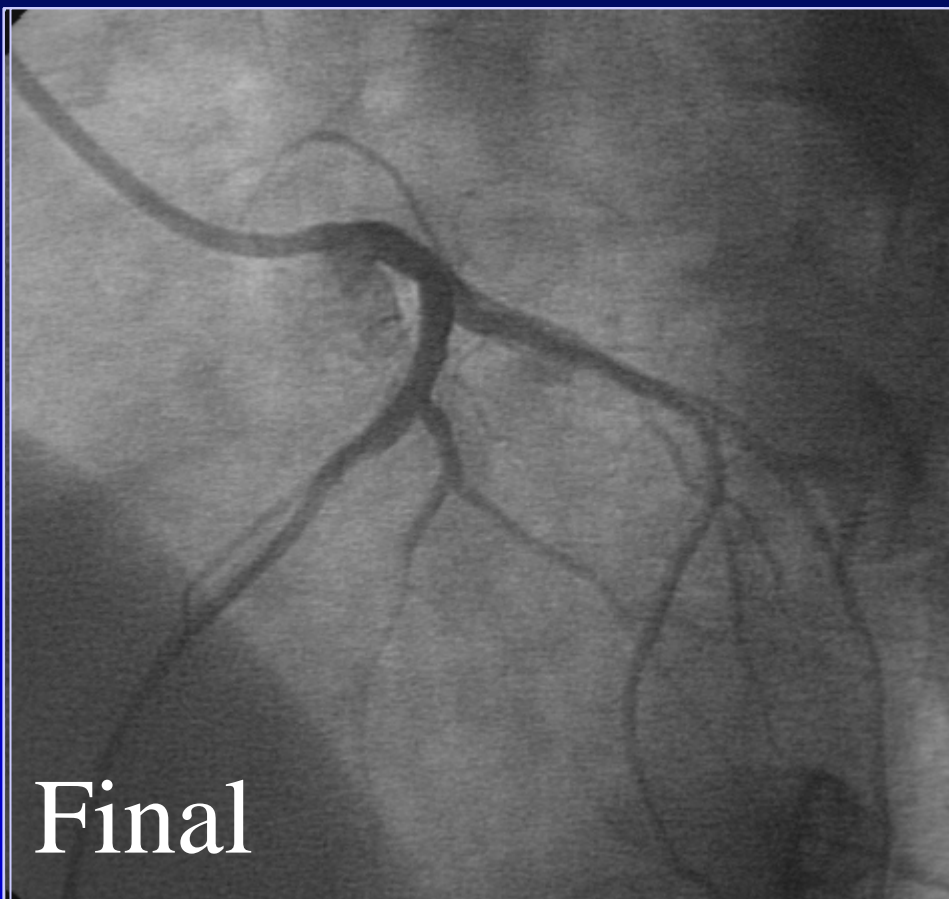


We applied red light in 3 intermediate lesions. Temperature was immediately decreased.

Kipshidze N, Toutouzas K, Stefanadis C



Red Light Laser Case



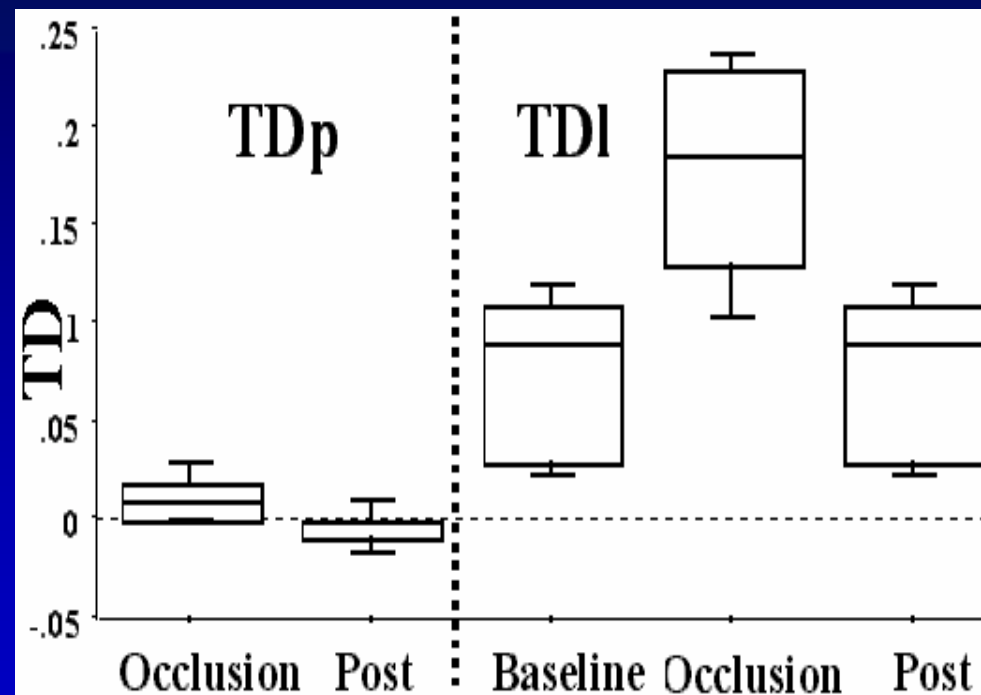
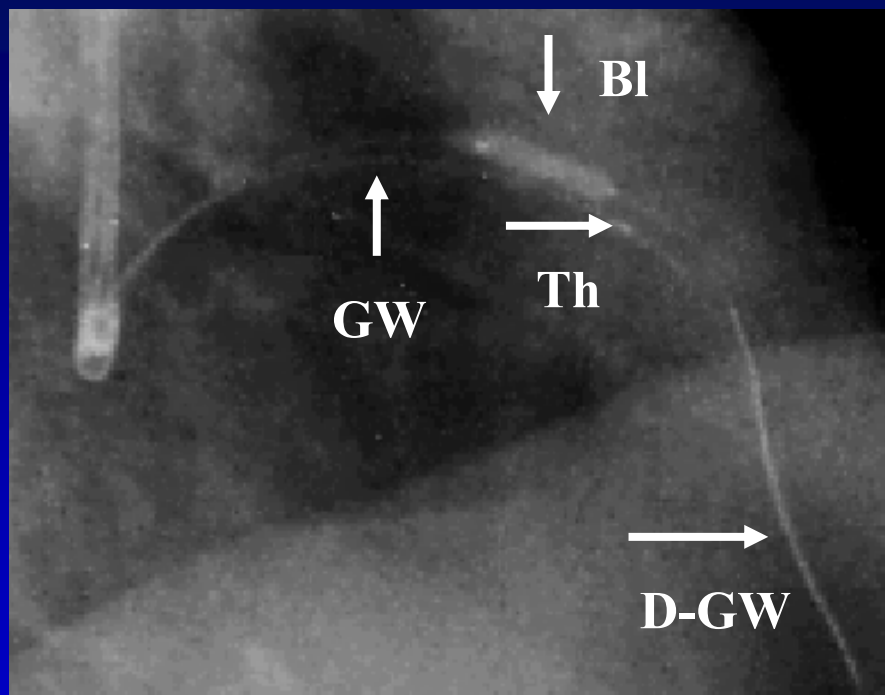


Coronary Thermography Limitation

- **Effect of Flow**



The “Cooling Effect of Blood Flow”



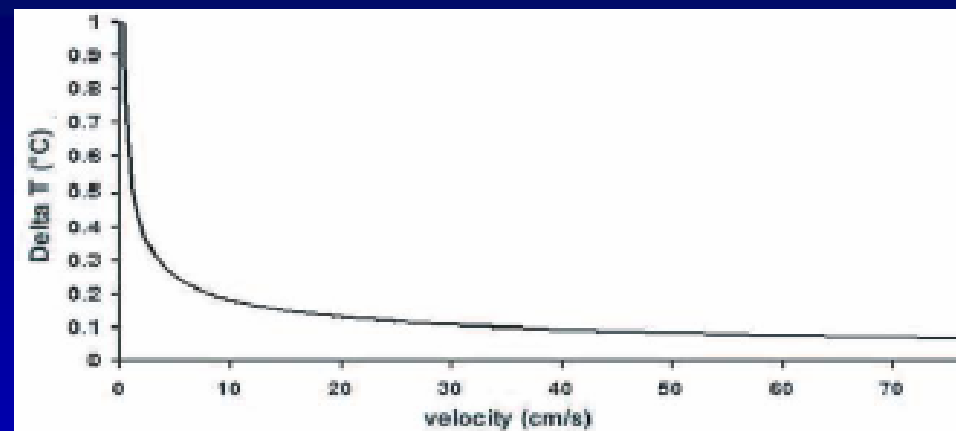
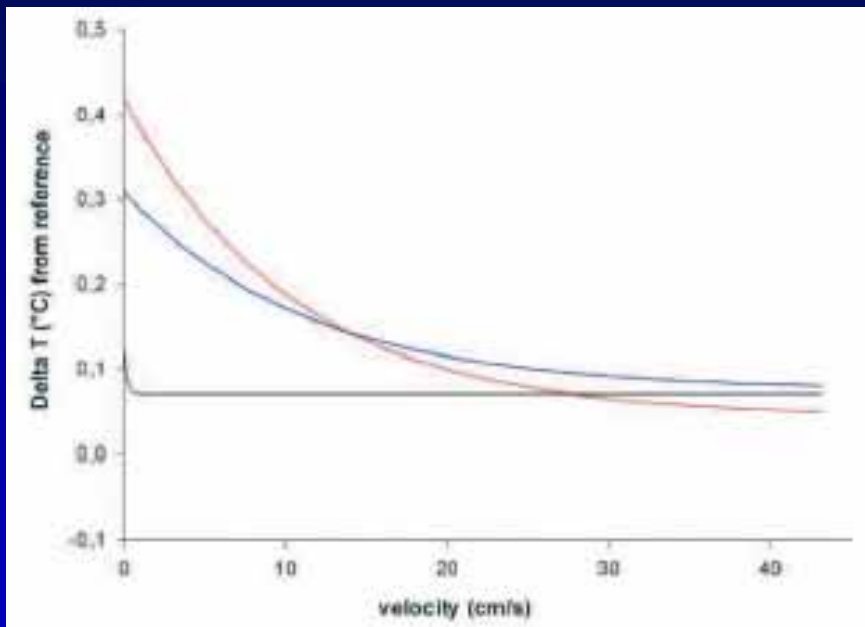
Stefanadis C, et al. J Am Coll Cardiol 2003; Febr.



Effect of Flow on Thermography



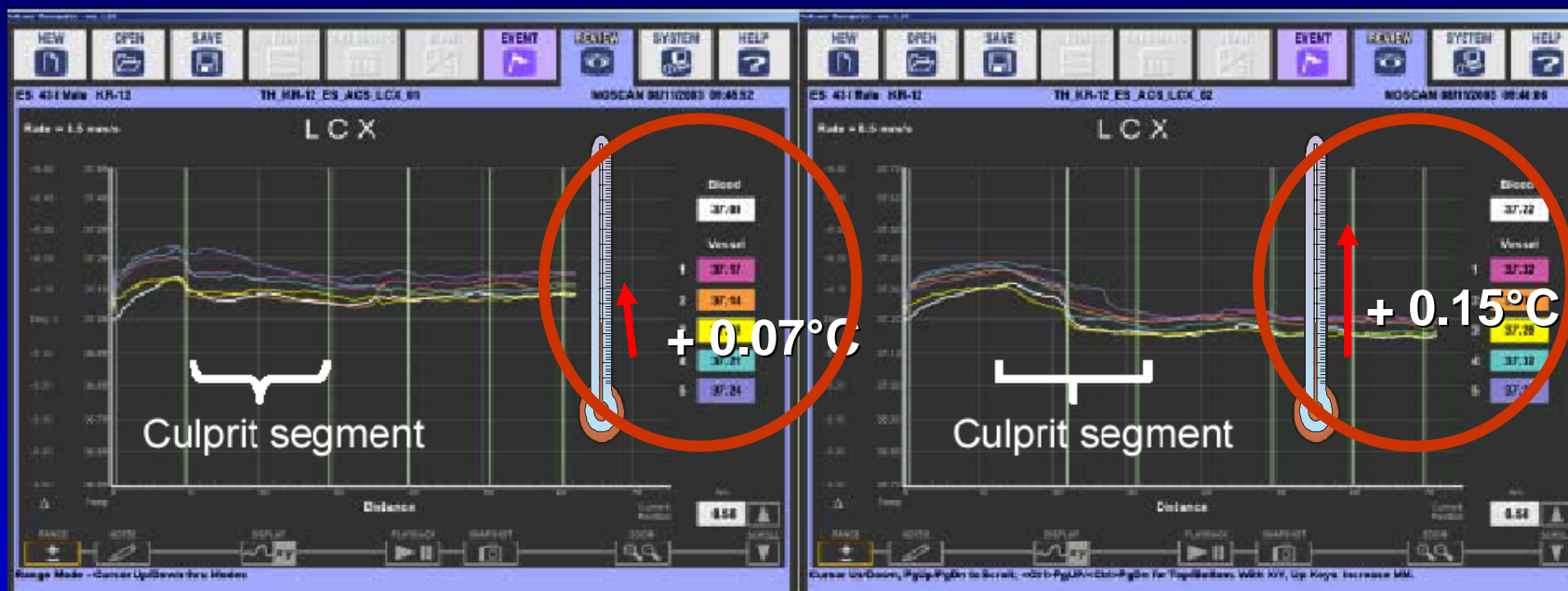
Thermocore System



Verheye S, ... Serruys P. Eur Heart J 2004;Jan:158-65



Thermography in vivo - Volcano



With flow

Without Flow

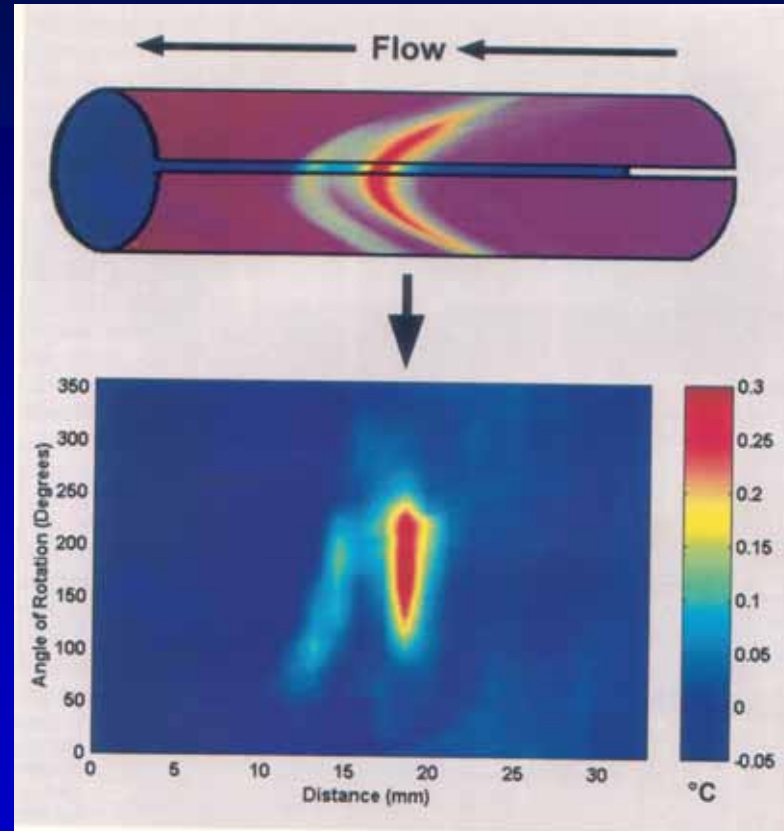
Dudek et al. TCT 2004



Coronary Thermography



In vitro model for studying the effect of Flow on heat

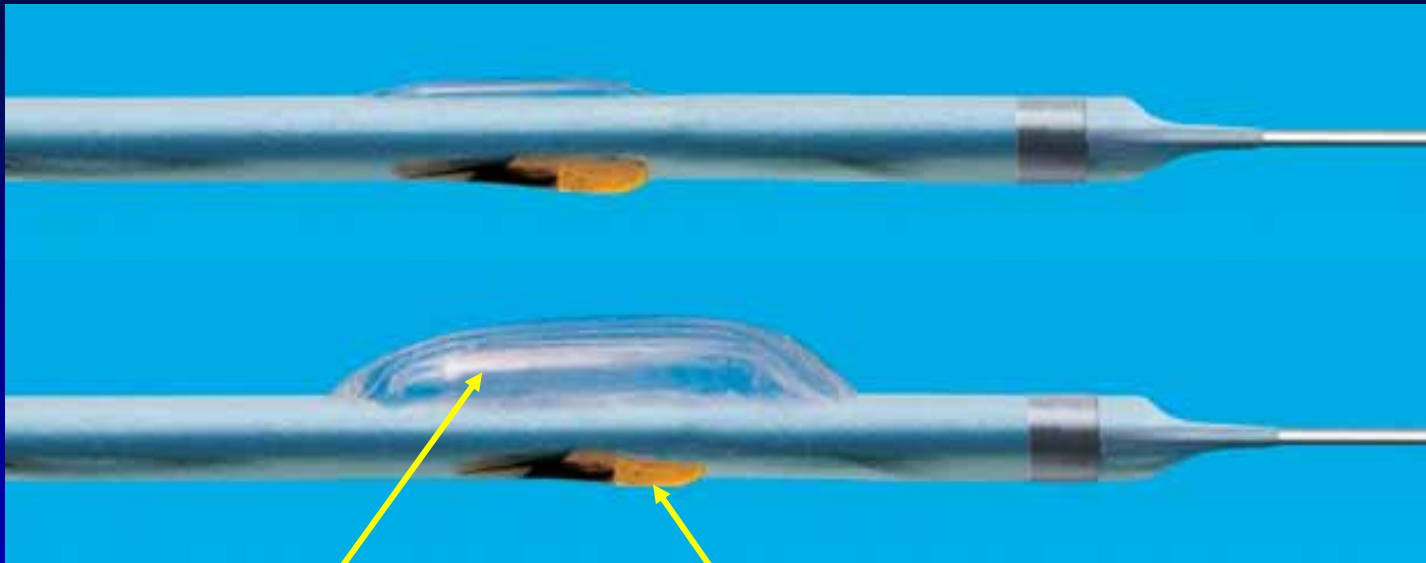


Heat is transmitted in the direction of coronary flow

Weiltz, ..., Fitzgerald. Cathet Cardiovasc Interv 2004;27:256-61



Balloon-Occluded Thermography Catheter



**Low pressure
balloon**

Thermistor

One thermistor

Impairment of flow

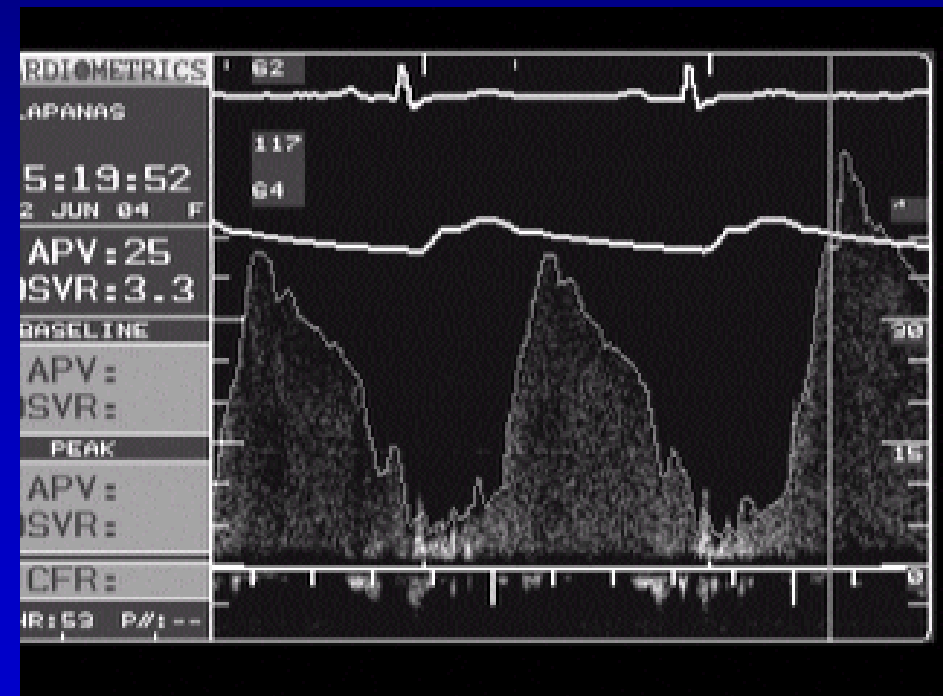
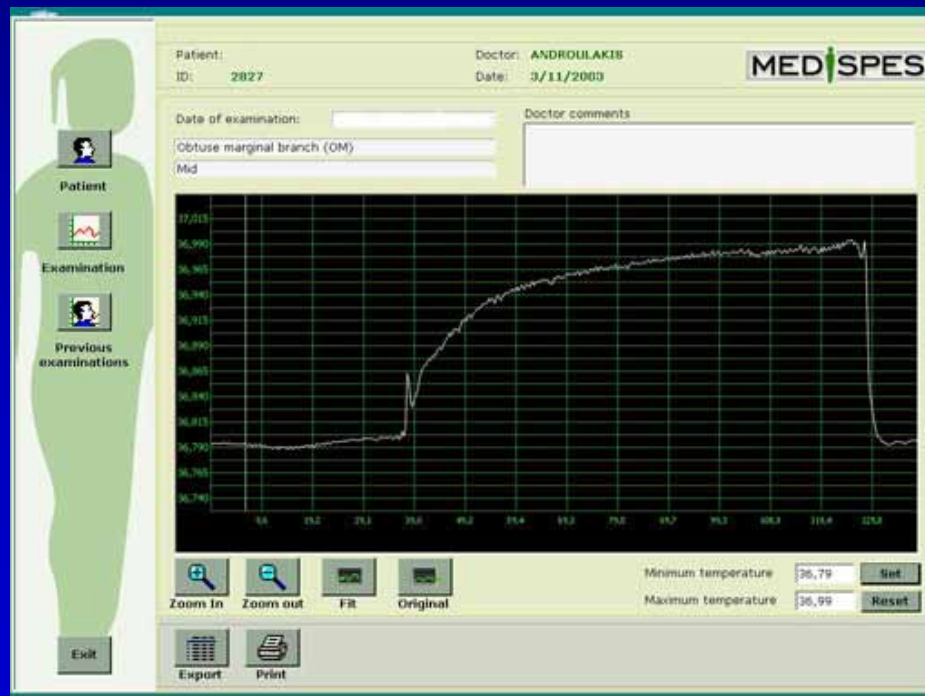
Measurements in non-significant lesions

Stefanadis et al. Cathet and Cardiovasc Interv 2003;March



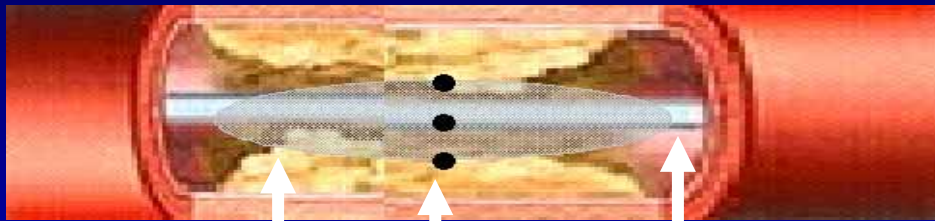
Coronary Thermography

- Effect of Flow in Vivo





In Vivo Thermography



B

Th

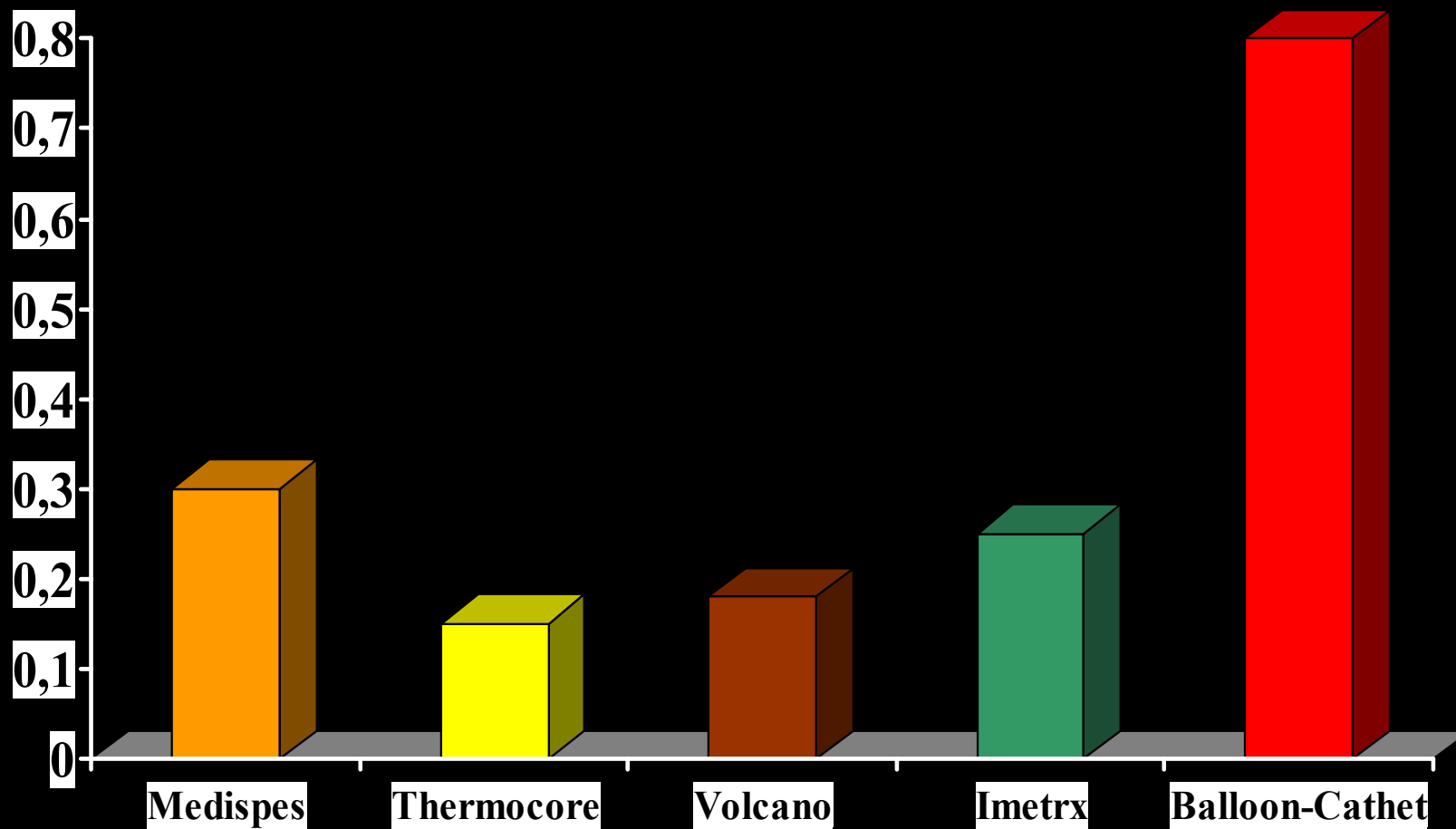
C

0.3-2.2°C

Belardi J and O'Neil W, TCT 2004



In Vivo Thermography





Future Protocols for Detection of Thermal Energy

By measurement of thermal energy in a diseased 'segment':

- **Accurate information regarding 'regional' vulnerability**
- **Elimination of 'cooling effect'**
- **Estimation of 'vulnerable arteries' rather than local plaque temperature**

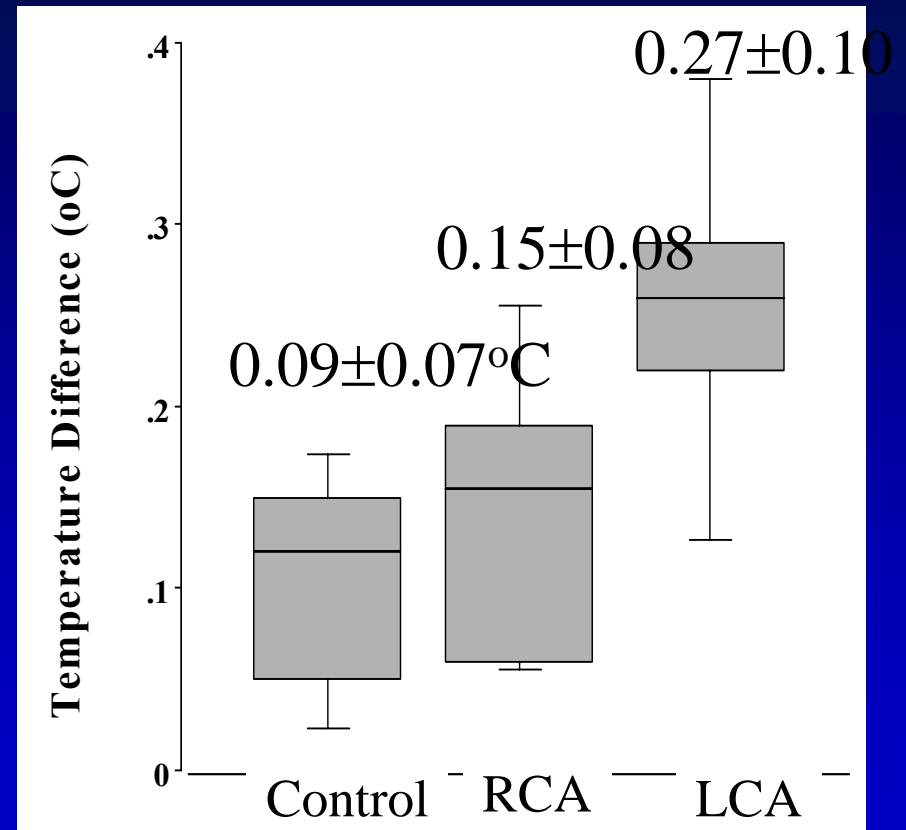
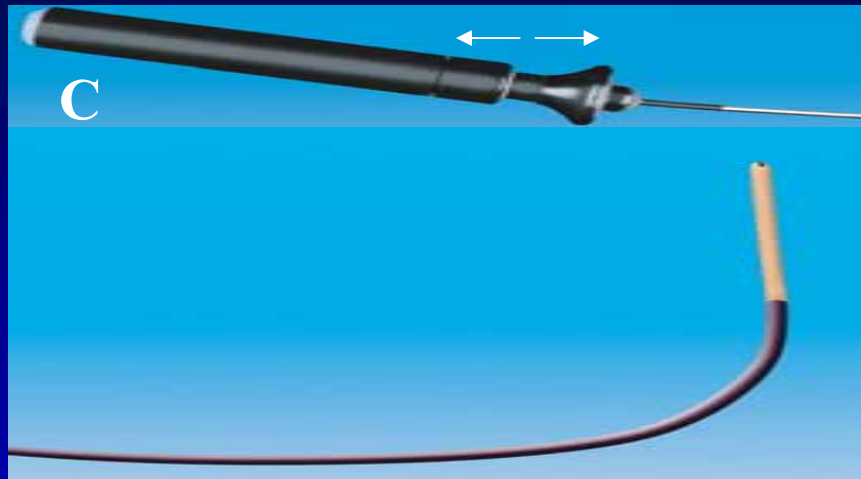


Plaque Thermography

- Coronary artery
- Coronary sinus



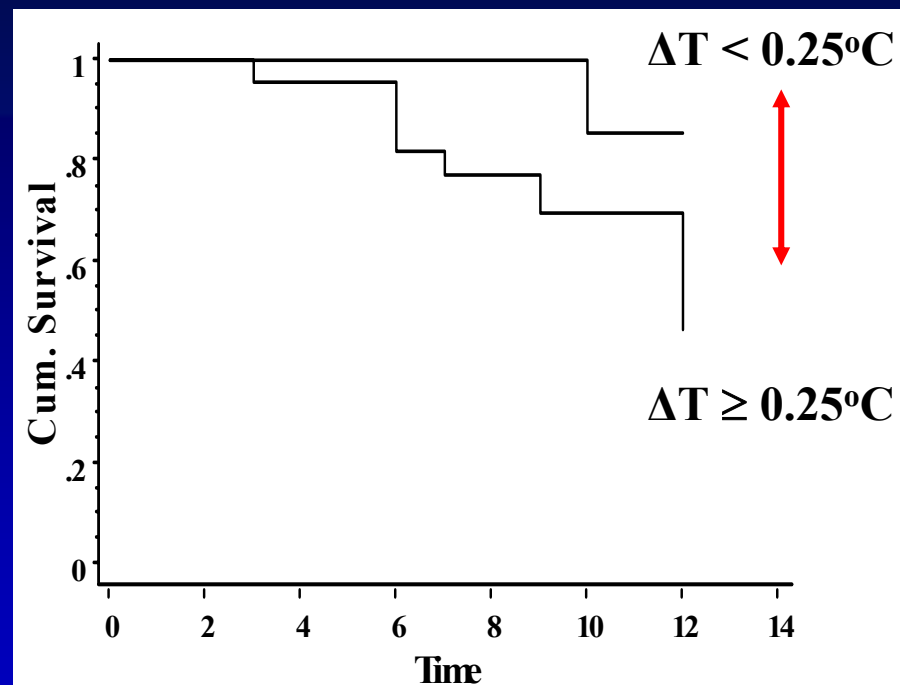
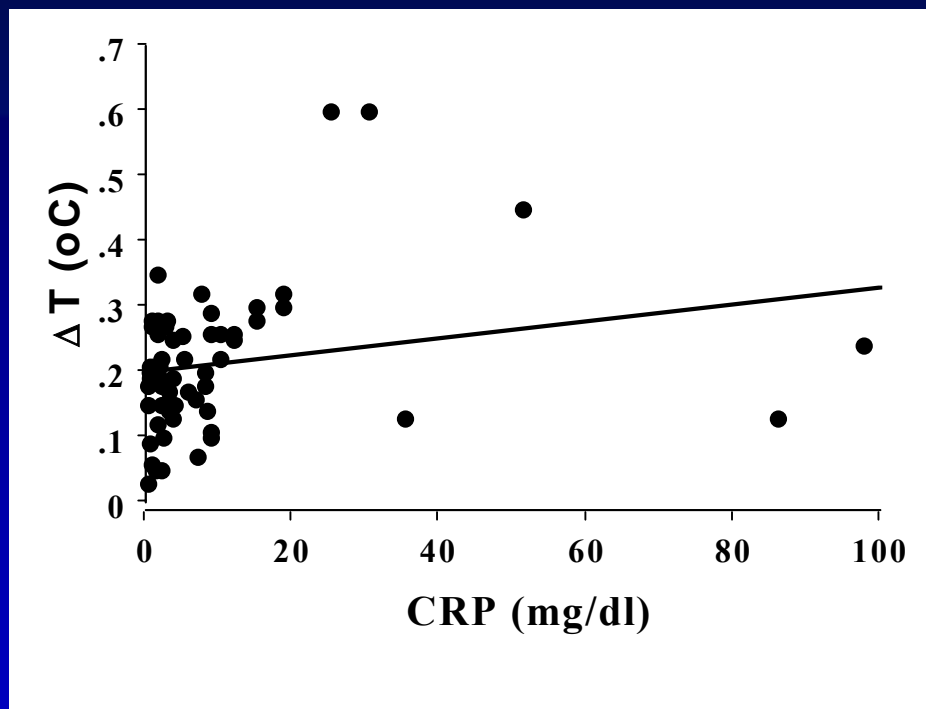
Coronary Sinus Temperature



Stefanadis et al, Am J Cardiol 2004 Jan



Coronary Sinus – Inflammation - Prognosis



Stefanadis et al, Am J Cardiol 2004;Jan



Prospective Multicenter Studies with Thermography



Current Multicenter Studies for Evaluation of Vulnerable PLaques

- Parachute
- IBIS
- PROSPECT
- THERMO CAD



PARACHUTE TRIAL

PARACHUTE and Tempo Clinical Trials - Joint U.S. and European initiative -

- 1) 2) ~1000 patient natural history trial
 - Patients with acute coronary syndromes
 - Prospectively correlate temperature elevation with non target lesion events to develop predictive models (regulatory approval)
 - Assess temporal changes in plaque temperature

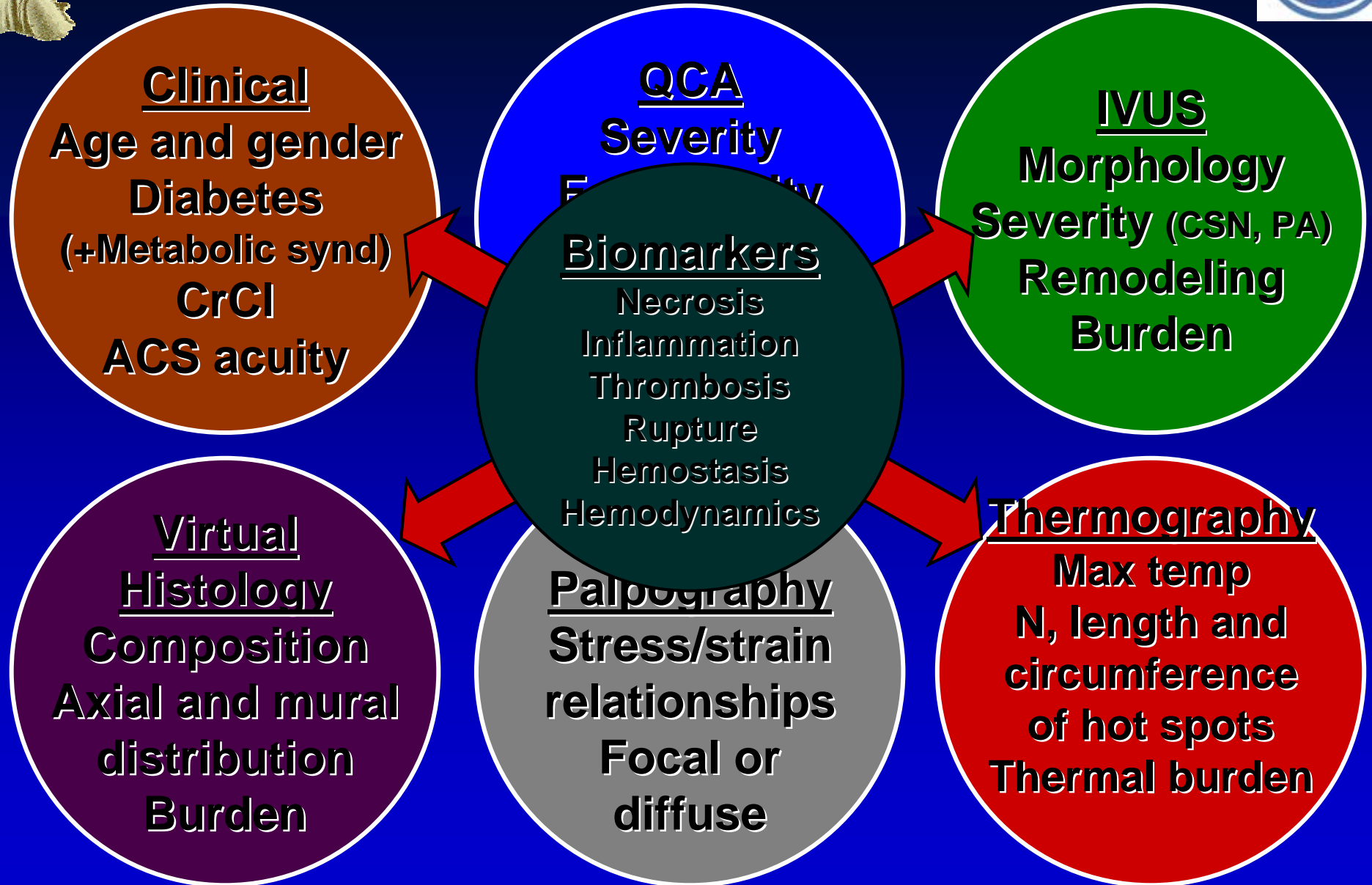


IBIS TRIAL

- Thorax Center, Rotterdam
- 90 patients
- Evaluation of intermediate lesions by:
 - Angiography
 - IVUS
 - Elastography
 - Virtual histology
 - OCT
 - Thermography



PROSPECT: Analysis domains





Thermo CAD Study

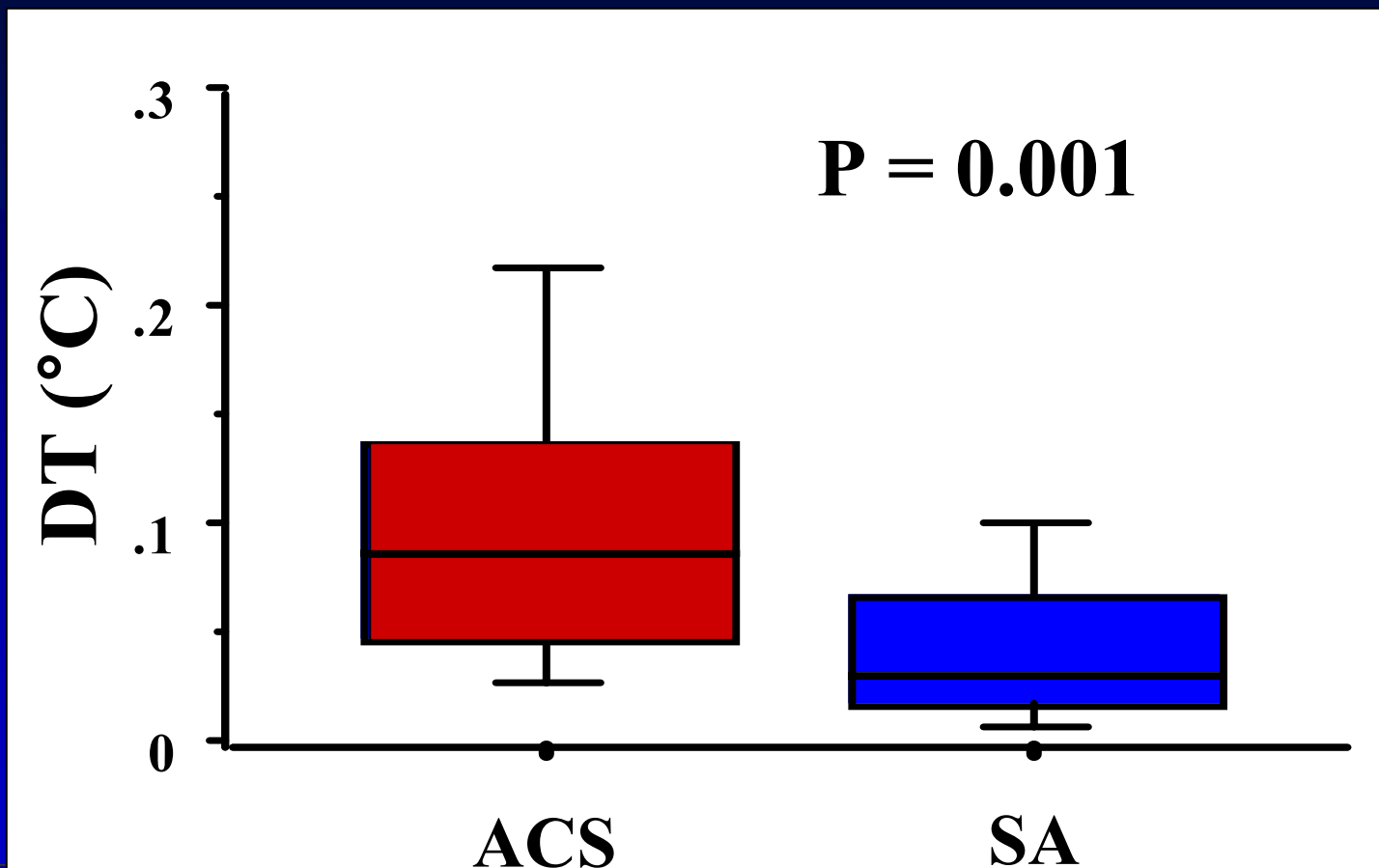
- Thermography in two vessels (culprit and non-culprit)
- Multicenter study
- Preliminary results in 92 lesions and 46 patients from:
 - *Hippokration Hospital, Athens*
 - *Onnaseion Hospital, Piraeus*
 - *Patra University Hospital, Patra*



Thermo CAD study: Preliminary Results



Widespread thermal heterogeneity



In patients with ACS culprit and non-culprit lesions have increased thermal heterogeneity compared to patients with CSA

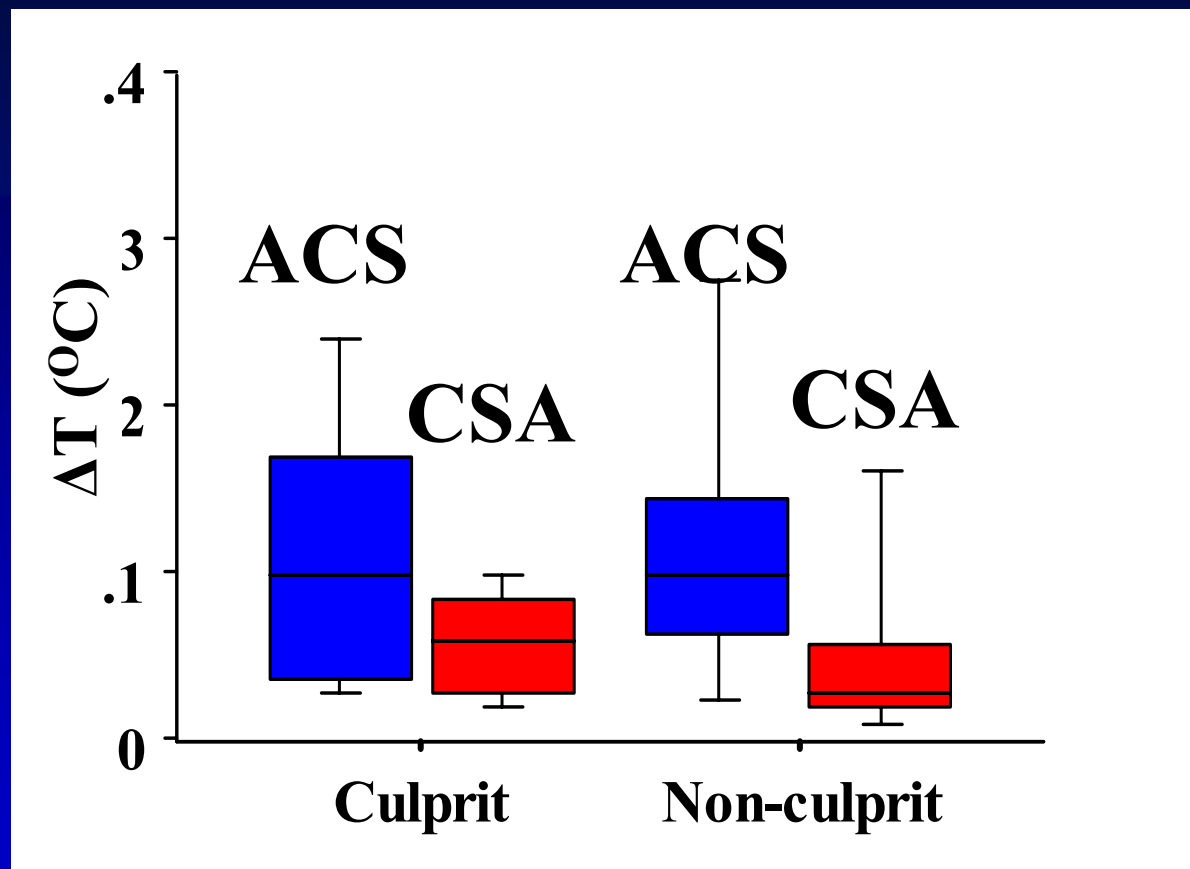


Thermo CAD study: Preliminary Results



Widespread thermal heterogeneity

N = 92 lesions
46 patients



In patients with ACS and CSA culprit and non-culprit lesions have similar thermal heterogeneity.



Temperature and Coronary Artery Disease

1995-6

1997-9

2000-2

2003-



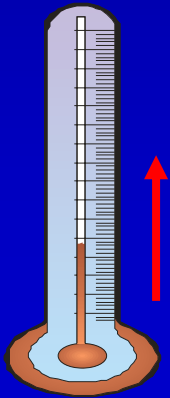
Ex vivo

In vivo

First clinical studies

Cooling Effect of flow
Pathophysiology

- Correlation with morphology
 - Prognosis
 - Treatment



New Technologies

Clinical Use?



Conclusions

- Coronary thermography reflects the inflammatory activation in atherosclerotic plaques. Neovascularization may play an additive role.
- Coronary thermography provides significant clinical information, but still the limitations need to be obviated.
- Coronary sinus temperature measurement may provide information regarding the vulnerable patient.
- The ideal scenario would be the combination of thermography and imaging techniques for the identification of the vulnerable plaque.