



Assessment of coronary physiology in HOCM

Amir Lerman, MD

Barbara Woodward Lips Endowed Professor
Director Cardiovascular Research Center
Department of Cardiovascular Diseases
Mayo Clinic, Rochester, MN

DISCLOSURE

Relevant financial relationship(s) with industry

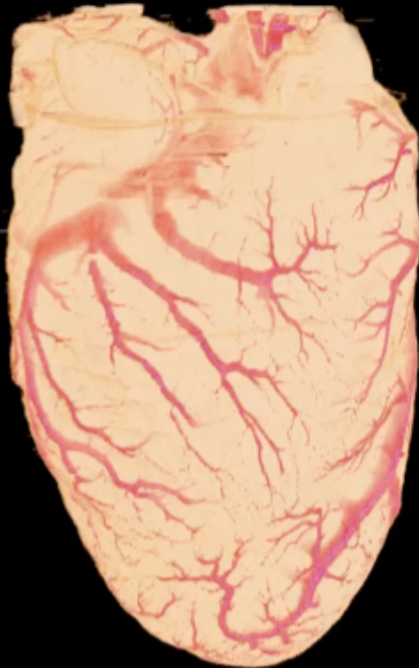
Itamar Medical: advisory board

Volcano/Philips consultant

69-year old female with HOCM and exertional chest pain

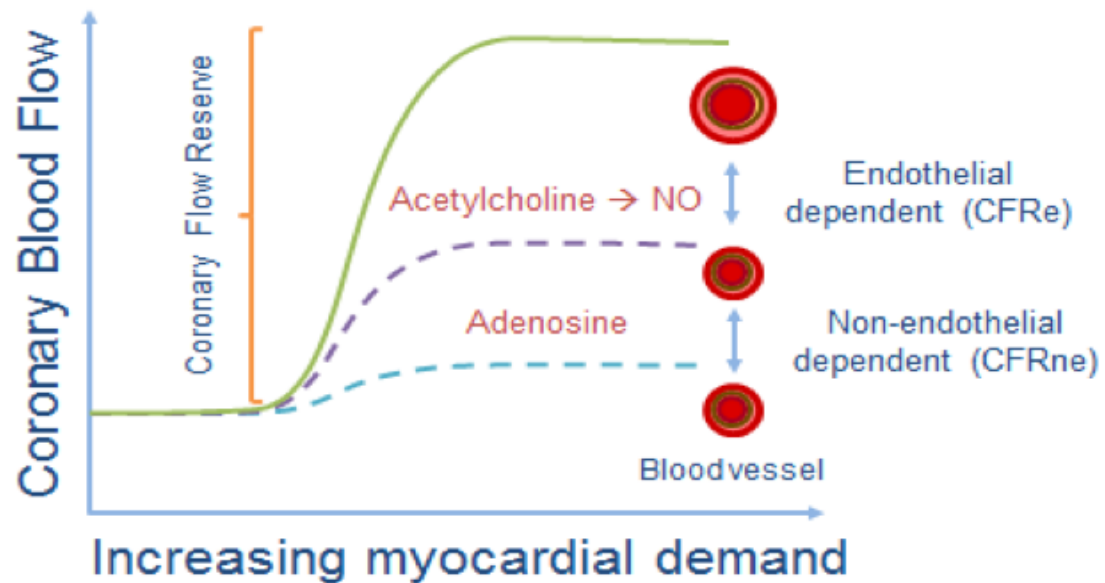
- Echo: LVH, EF 56%
- Asymmetric obstructive septal hypertrophy
- No SAM
- Mild mitral regurgitation

Coronary Microcirculation



High oxygen extraction 60-80% vs. 20-30% in skeletal muscle: coronary perfusion is flow dependent

Coronary Blood Flow Response to Increase Myocardial Demand

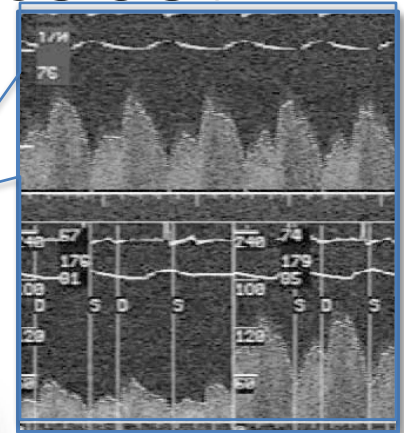


Functional Angiogram Protocol

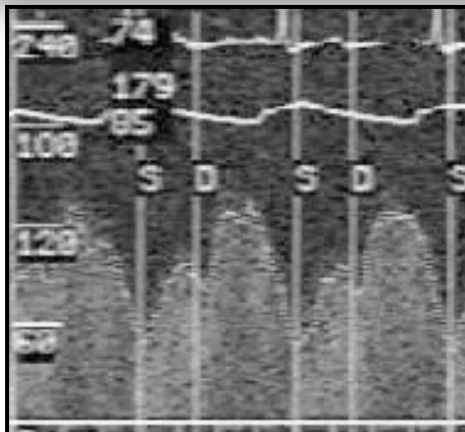
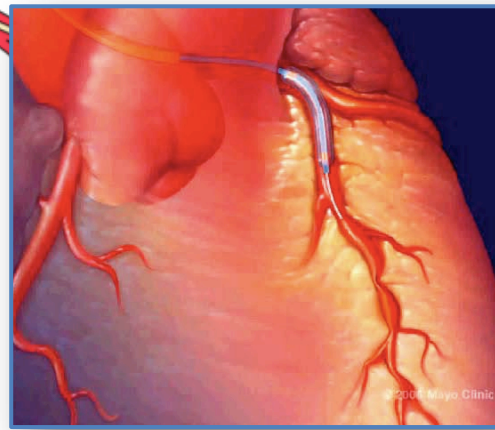
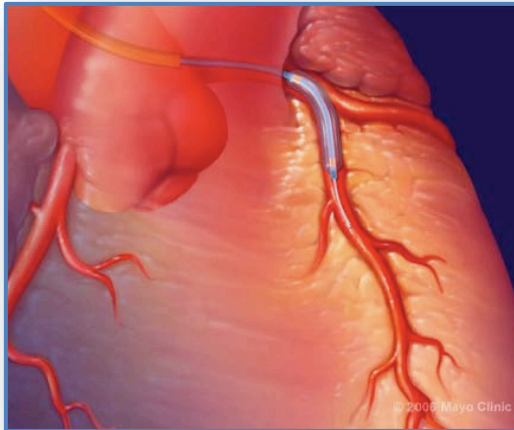
Diagnostic
angiography

Adenosine IC
24-72 μg

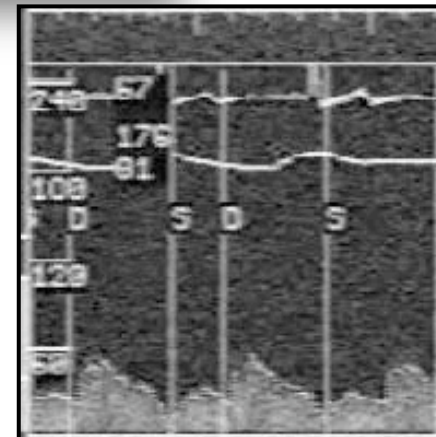
CFR: Non
endothelium
microcirculation



Acetylcholine
(endothelium
dependent
vasodilator)
Epicardial



Microcirculation

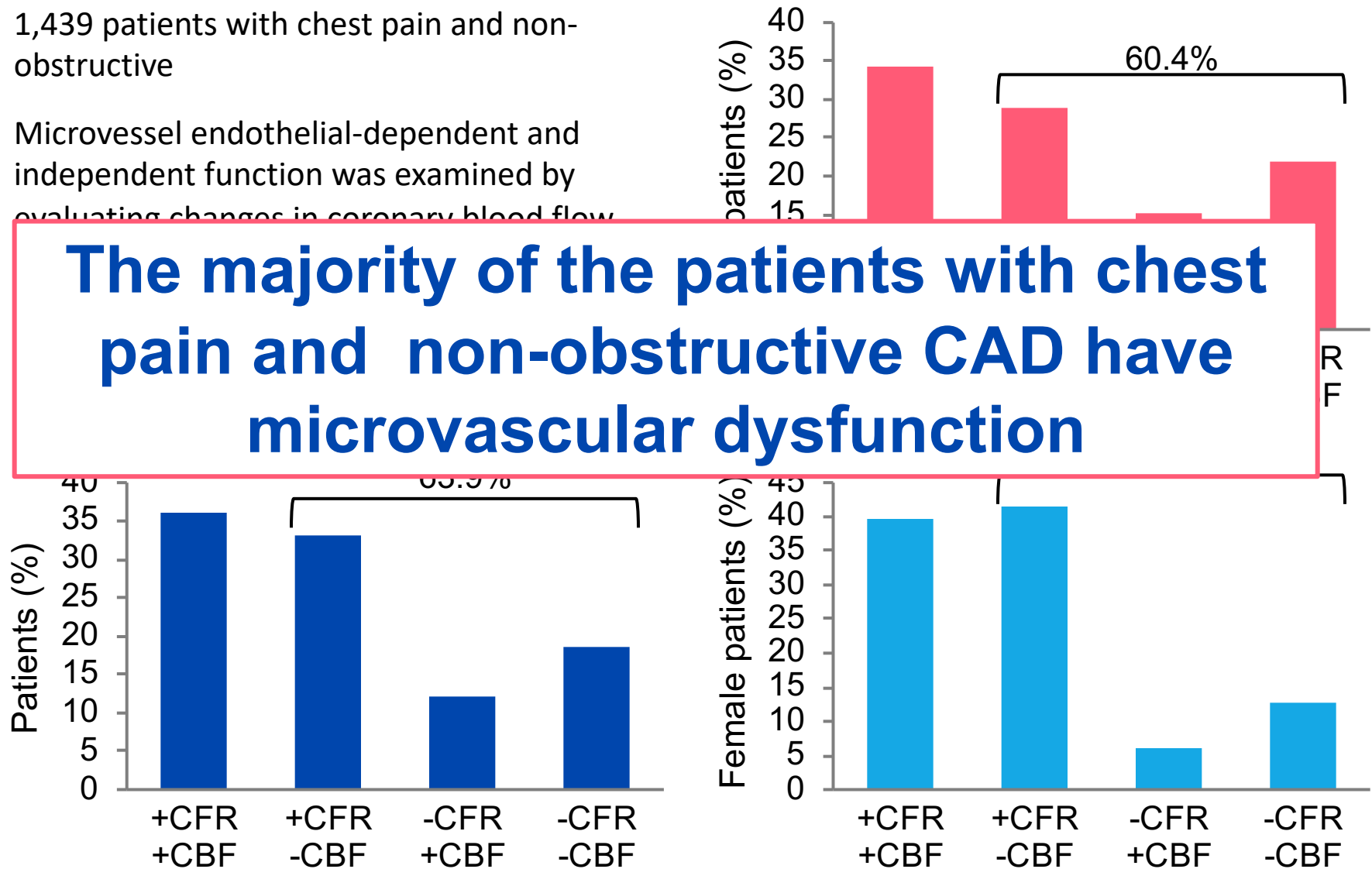


Prevalence of Microvascular Dysfunction in Patients With Non-Obstructive CAD

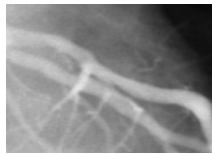
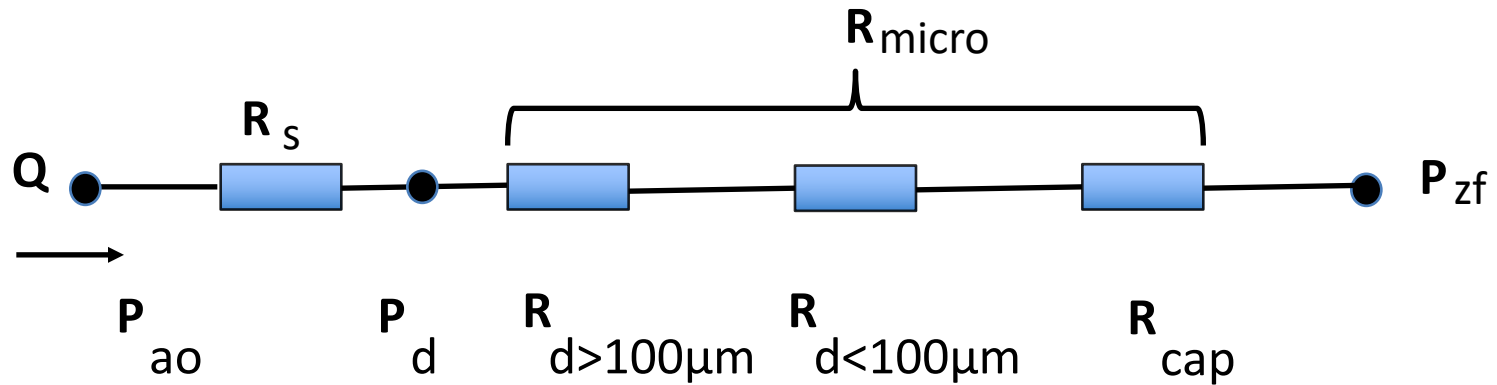
1,439 patients with chest pain and non-obstructive

Microvessel endothelial-dependent and independent function was examined by evaluating changes in coronary blood flow

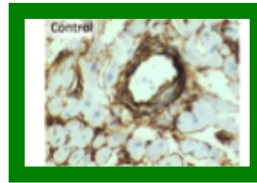
The majority of the patients with chest pain and non-obstructive CAD have microvascular dysfunction



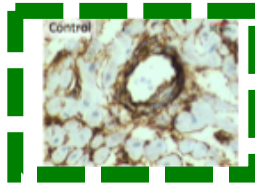
Physiological vasodilatory chain across different levels of coronary circulation



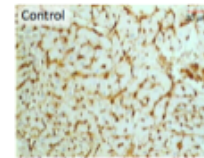
Endothelial
cell mediated
vasodilation



Endothelial
cell mediated
dilation



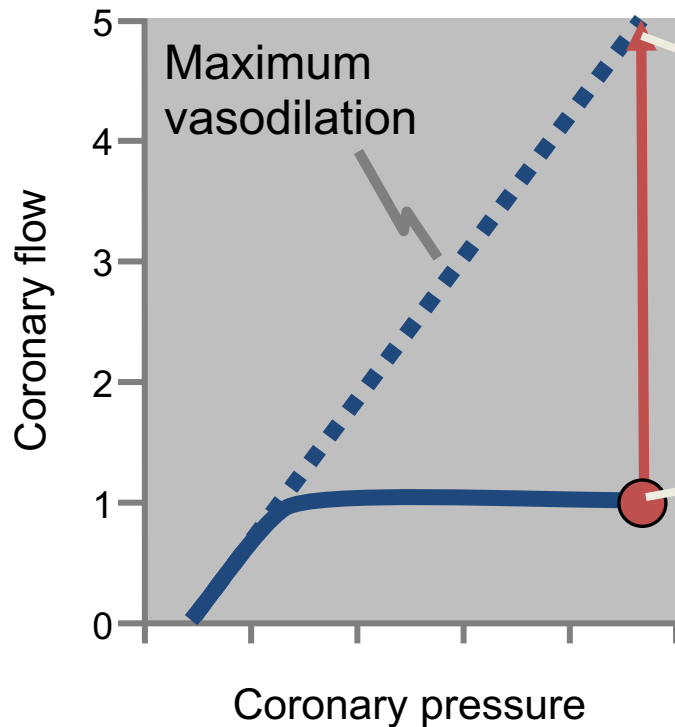
Metabolite
mediated
dilation



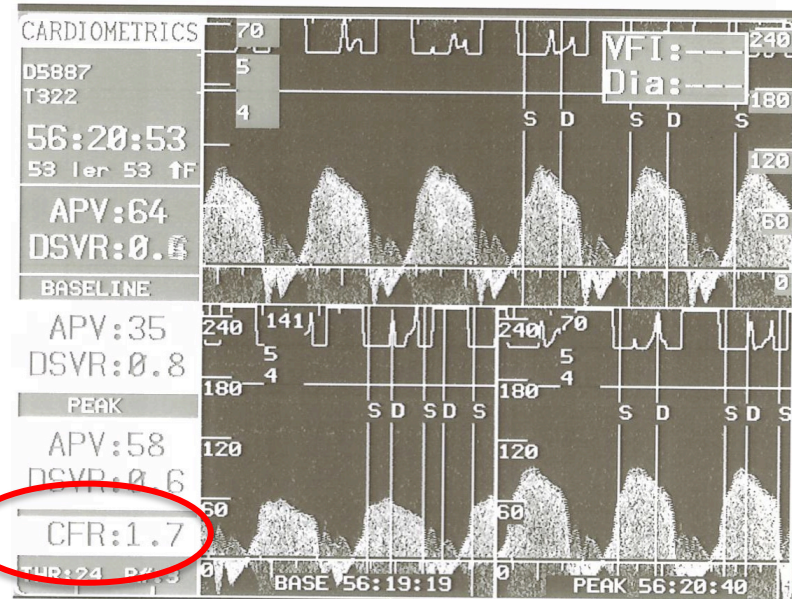
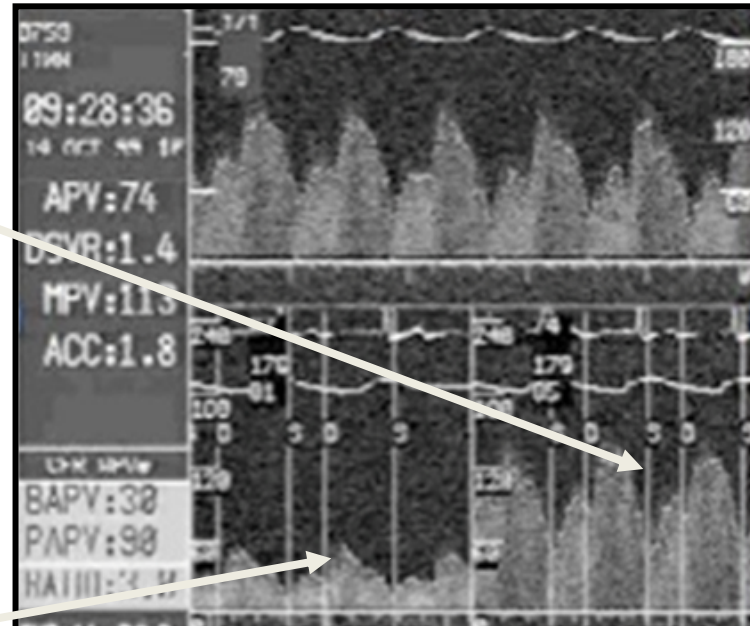
Capillary
recruitment

Coronary Flow Reserve

Response to Adenosine is Non-Endothelial Dependent



$$\text{Coronary reserve} = \frac{\text{Flow}_{\text{dilated}}}{\text{Flow}_{\text{initial}}}$$



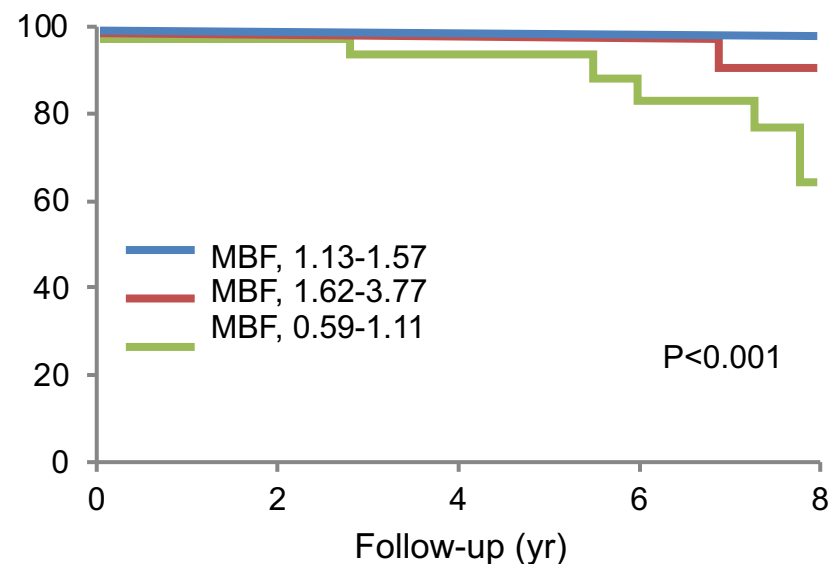
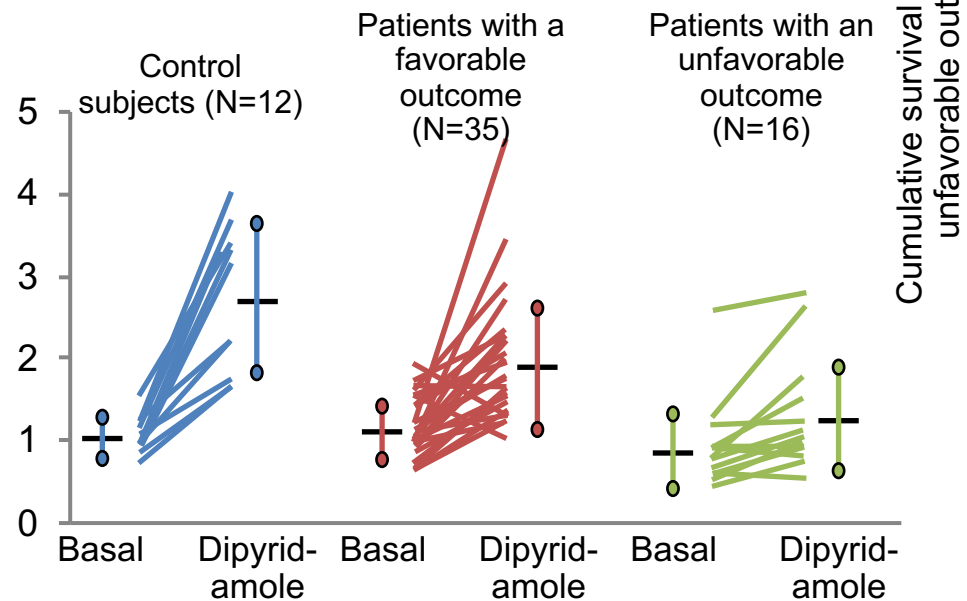
ORIGINAL ARTICLE

Coronary Microvascular Dysfunction and Prognosis in Hypertrophic Cardiomyopathy

Franco Cecchi, M.D., Iacopo Olivetto, M.D., Roberto Gistri, M.D.,
Roberto Lorenzoni, M.D., Giampaolo Chiriatti, M.D., and Paolo G. Camici, M.D.

Fifty-one patients (New York Heart Association Class I or II) were followed for a mean of 8.1 ± 2.1 years after PET

Myocardial Blood Flow (MBF) Values After Dipyridamole Infusion and Long-Term Prognosis

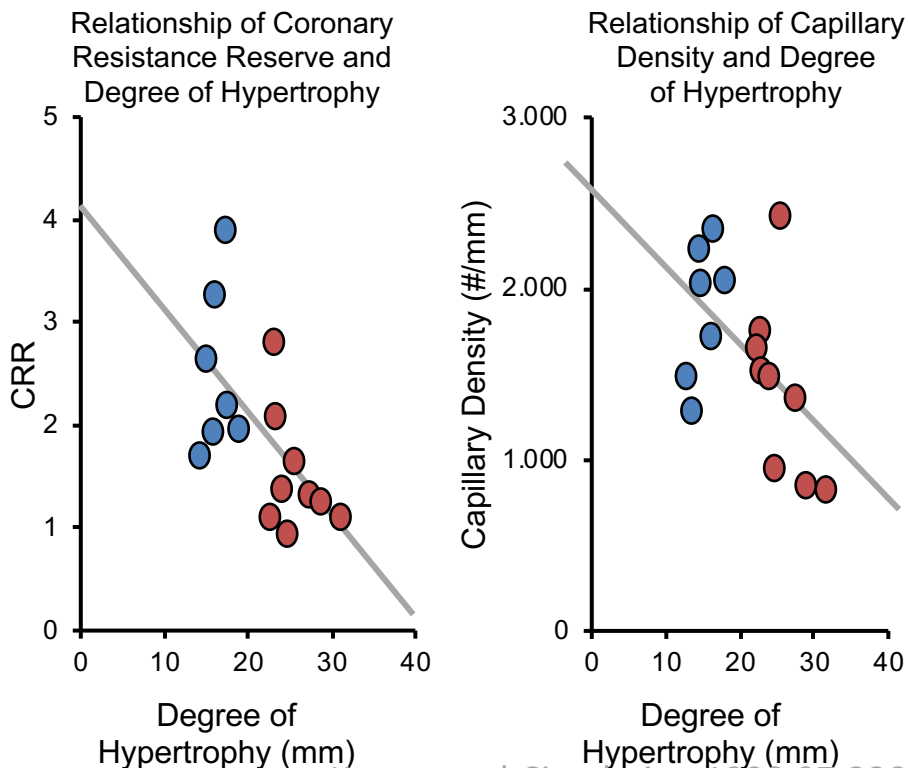


Brief Rapid Communications

Decreased Coronary Flow Reserve in Hypertrophic Cardiomyopathy Is Related to Remodeling of the Coronary Microcirculation

R. Krams, MD, PhD; M.J.M. Kofflard, MD; D.J. Duncker, MD, PhD; C. Von Birgelen, MD; S. Carlier, MD; M. Kliffen, MD, PhD; F.J. ten Cate, MD, PhD; P.W. Serruys, MD, PhD

This study evaluates the hypothesis that the occurrence of ischemia in HCM is related to remodeling of the coronary microcirculation



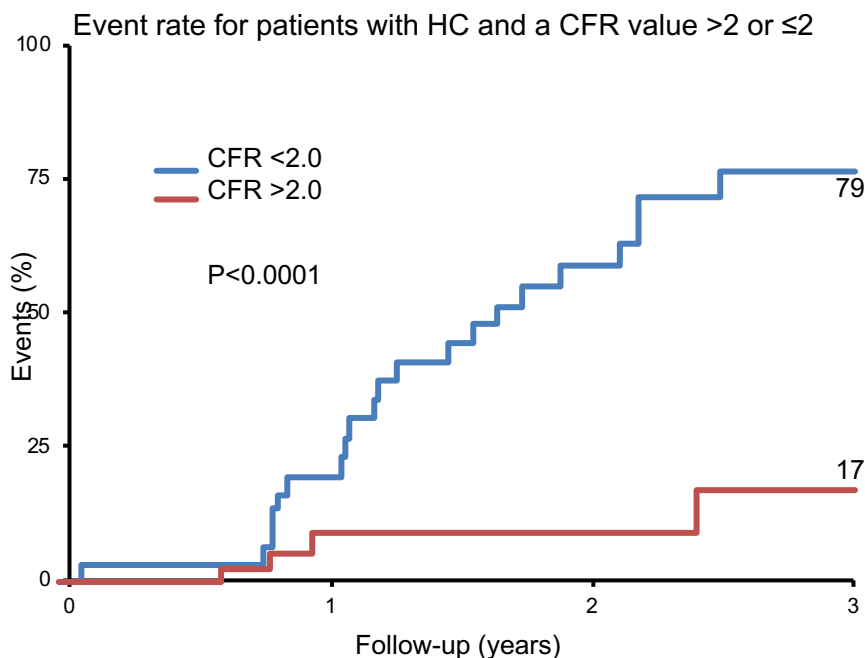
Krams et al: Circulation 1998;97:230

Prognostic Implications of Coronary Flow Reserve on Left Anterior Descending Coronary Artery in Hypertrophic Cardiomyopathy

Lauro Cortigiani, MD^{a,*}, Fausto Rigo, MD^b, Sonia Gherardi, MD^c, Maurizio Galderisi, MD^d, Rosa Sicari, MD, PhD^e, and Eugenio Picano, MD, PhD^e

The aim of the study was to prospectively evaluate a cohort of patients with hypertrophic cardiomyopathy (HC) after coronary flow reserve (CFR) assessment of the left anterior descending coronary artery.

Sixty-eight patients with HC underwent dipyridamole echocardiography with CFR evaluation of the left anterior descending coronary artery by Doppler.



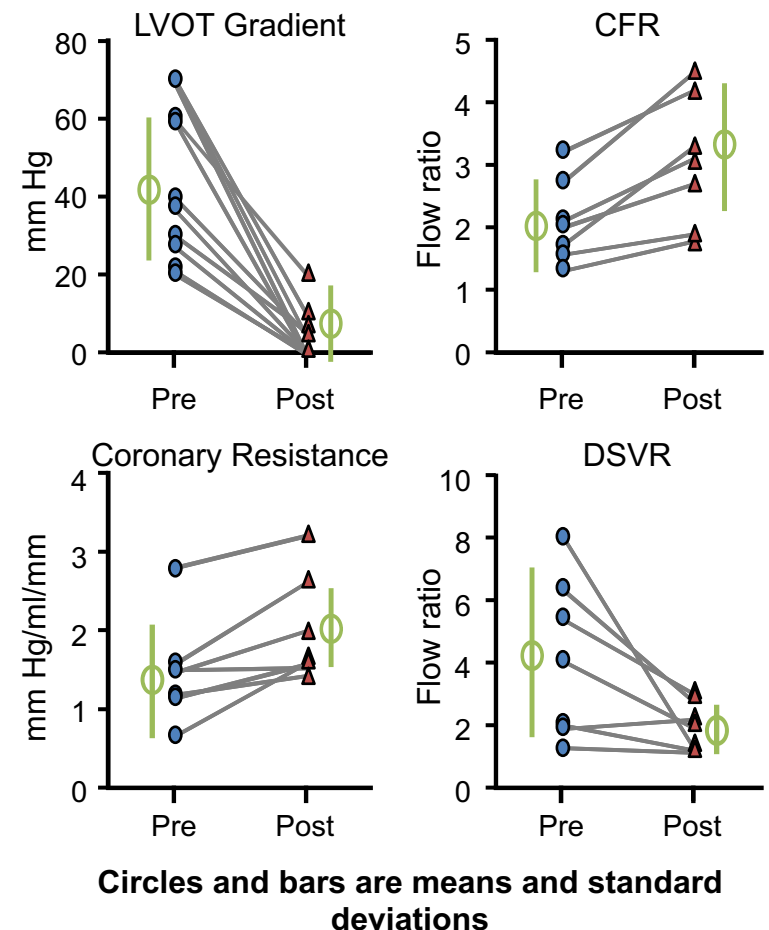
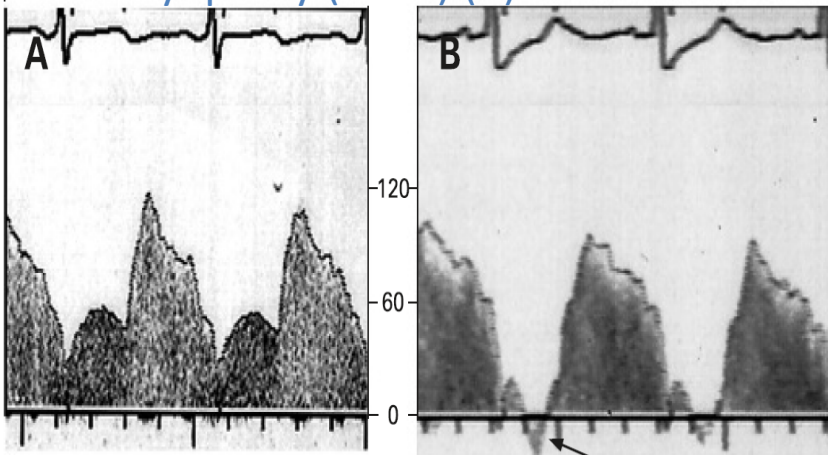
Cortigiani et al: Am J Cardiol 2008;102:1718

Immediate improvement in coronary flow reserve after alcohol septal ablation in patients with hypertrophic obstructive cardiomyopathy

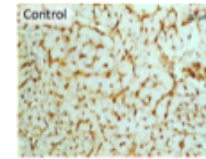
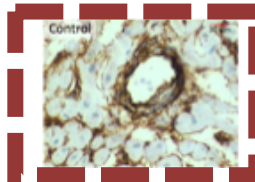
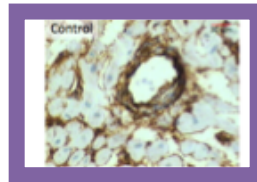
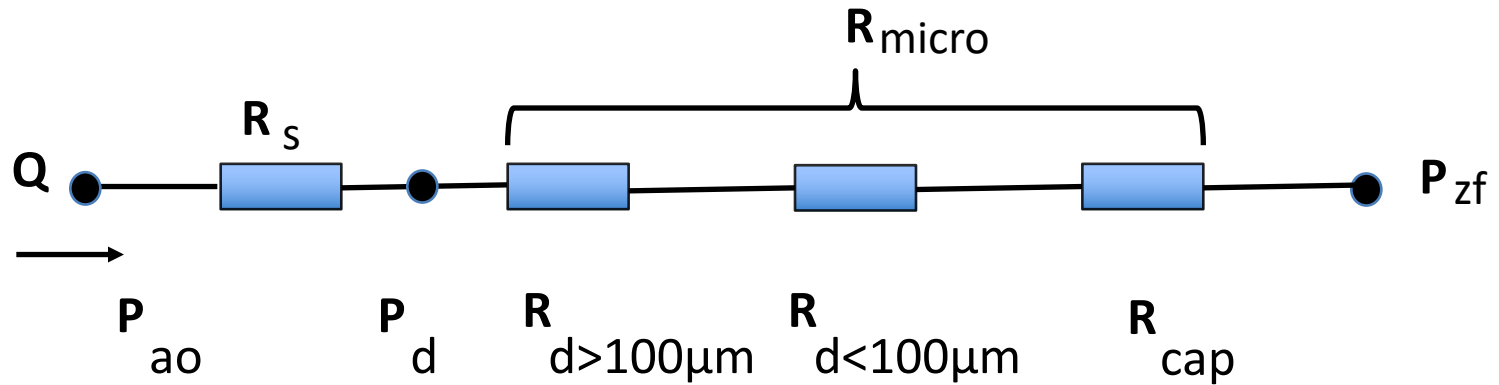
W A Jaber,¹ E H Yang,² R A Nishimura,¹ P Sorajja,¹ C S Rihal,¹ A Elesber,¹ E Eeckhout,³
A Lerman¹

Methods: CFR was measured immediately before and after septal ablation in patients with symptomatic obstructive HCM. CFR was also obtained in normal subjects (NL) for comparison.

Example of instantaneous intracoronary Doppler flow in a normal patient (A) and a patient with hypertrophic cardiomyopathy (HCM) (B)



Functional microcirculatory dysfunction in IHD



Adrenergic
drive also
causes constriction

Endothelial
cell mediated
dilation

Reversible
abnormal
mediated
dilation

19 year old male with Chest Pain

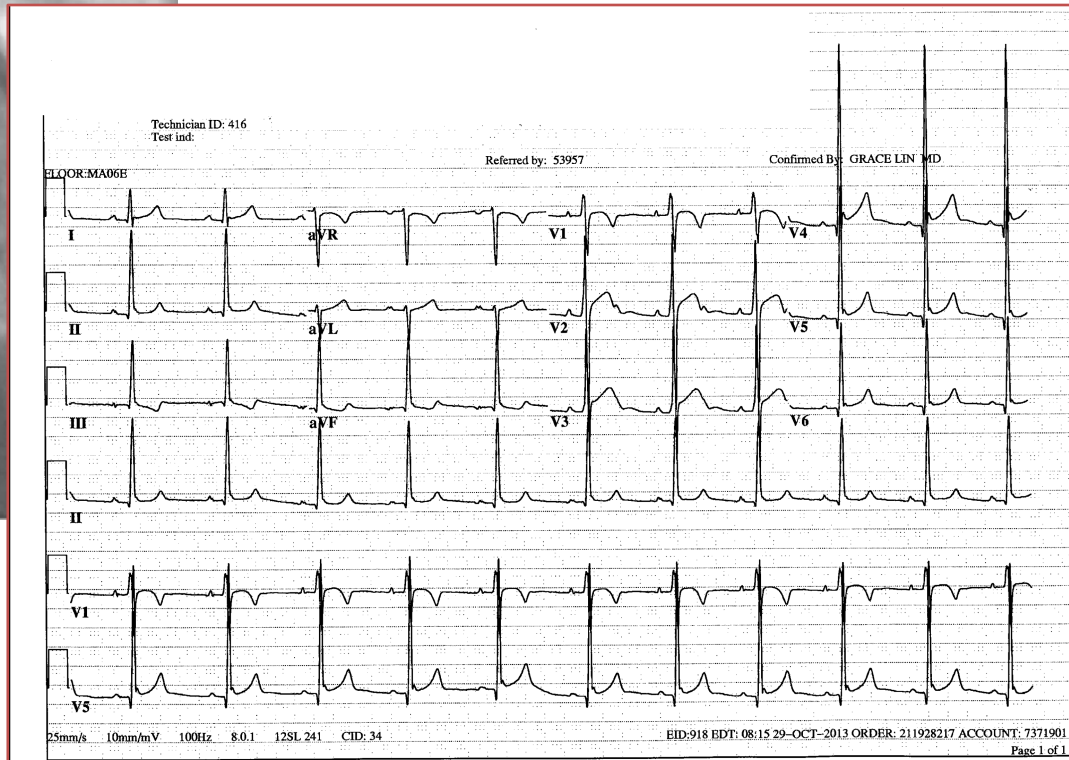
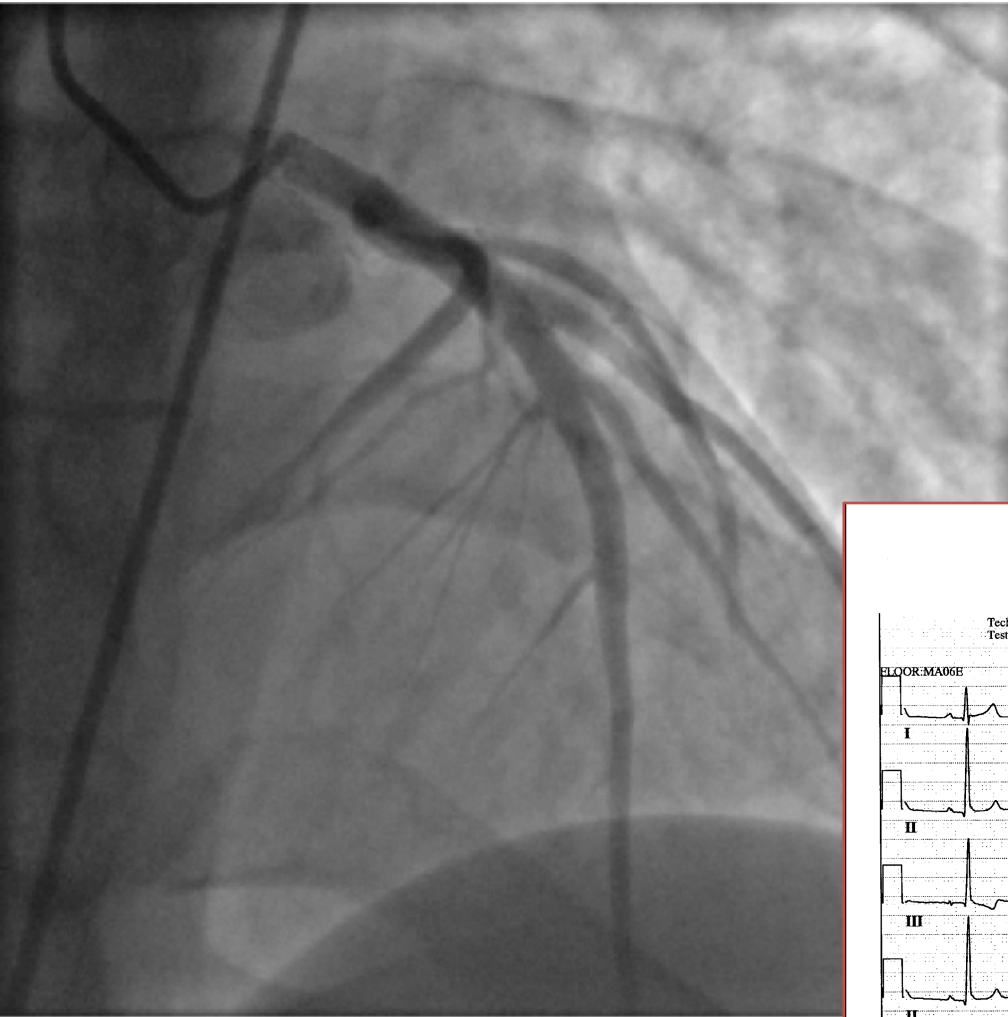
- A 19 college student a member of the rowing varsity team.
- Several episodes of severe chest pain during intense training.
- Admitted to the ER with ECG changes and Tn elevation
- No CAD risk factors.
- Loud positional systolic murmur on physical examination.

19 year old male with Chest Pain

What should be the next step to allow him to go back to his team?

1. Exercise Sestamibi
2. Multi slice CT
3. Coronary angiography
4. Echocardiography: **HOCM non obstructive at rest**
5. The ECG and the Tn are secondary to intense exercise

Coronary angiography



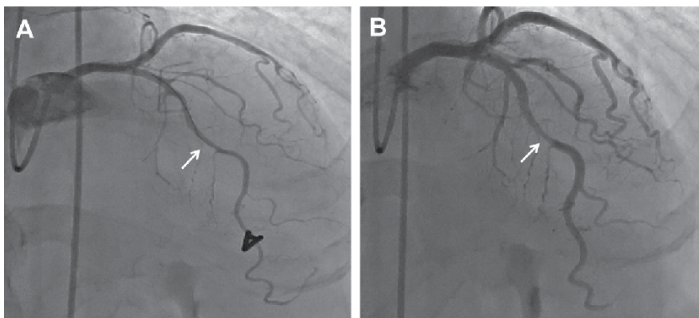
Myocardial Bridging

Contemporary Understanding of Pathophysiology With Implications for Diagnostic and Therapeutic Strategies

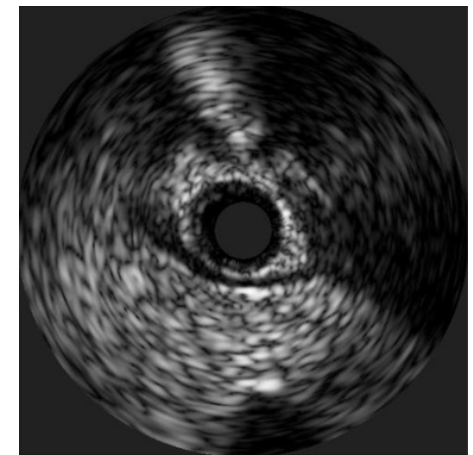
Michel T. Corban, MD,* Olivia Y. Hung, MD, PhD,* Parham Eshtehardi, MD,*
Emad Rasoul-Arzumly, MD,* Michael McDaniel, MD,* Girum Mekonnen, MD, MPH,*
Lucas H. Timmins, PhD,† Jerre Lutz, MD,* Robert A. Guyton, MD,‡ Habib Samady, MD*
Atlanta, Georgia

- Coronary arteries that tunnel through the myocardium are seen in as many as 40% to 80% of cases on autopsy; however, functional myocardial bridging is less commonly observed on angiography (0.5% to 16.0%) and can range from 4 to 80 mm in length
- 67% to 98% occur in the left anterior descending coronary artery (LAD)
- Autopsy and intravascular ultrasound studies have shown that the intramural and distal segments of bridged vessels remain free from atherosclerotic disease while the proximal segment of the vessel is prone to developing atherosclerosis

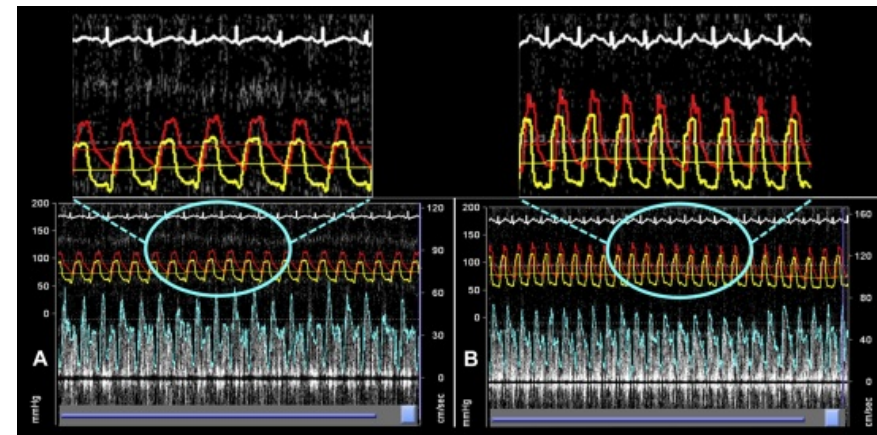
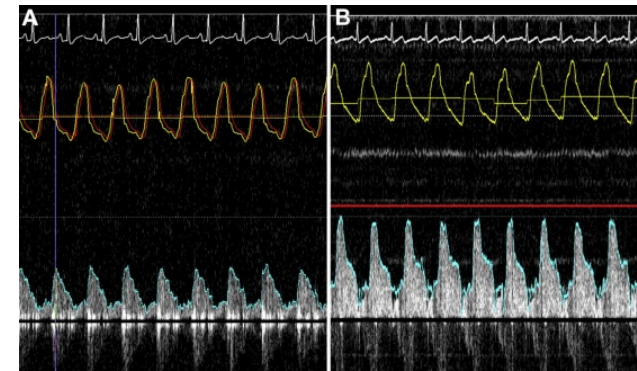
Systolic Narrowing at the Myocardial Bridge Accentuated by Intracoronary Nitroglycerin



Intravascular Ultrasound “Half-Moon” Sign



Fingertip Phenomenon During Intracoronary Doppler Measurements



Intracoronary Hemodynamics from a Patient with Myocardial Bridging

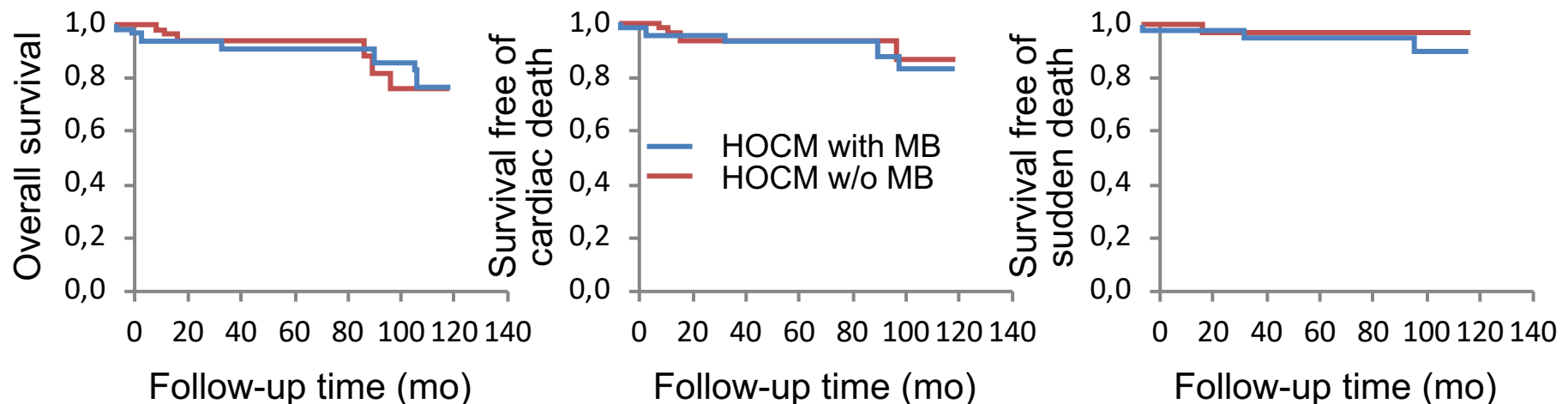
Myocardial Bridging in Adult Patients With Hypertrophic Cardiomyopathy

Paul Sorajja, MD, Steve R. Ommen, MD, Rick A. Nishimura, MD, Bernard J. Gersh, MB, CHB, DPHIL, A. Jamil Tajik, MD, David R. Holmes, Jr, MD

Rochester, Minnesota

The coronary angiograms of 425 patients with HCM were examined for the presence of myocardial bridging. Clinical follow-up was conducted to assess mortality. A total of 64 patients (15%) had myocardial bridging

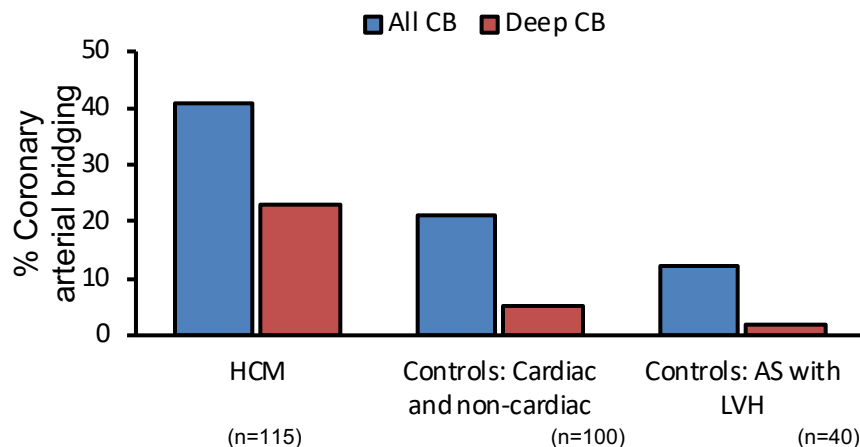
Survival Comparisons between Hypertrophic Cardiomyopathy (HCM) Patients with Myocardial Bridging



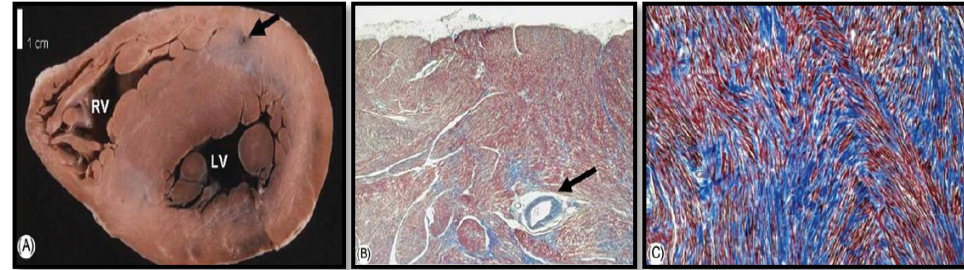
Myocardial bridging, a frequent component of the hypertrophic cardiomyopathy phenotype, lacks systematic association with sudden cardiac death

Cristina Basso¹, Gaetano Thiene^{1*}, Shannon Mackey-Bojack², Anna Chiara Frigo³, Domenico Corrado⁴, and Barry J. Maron⁵

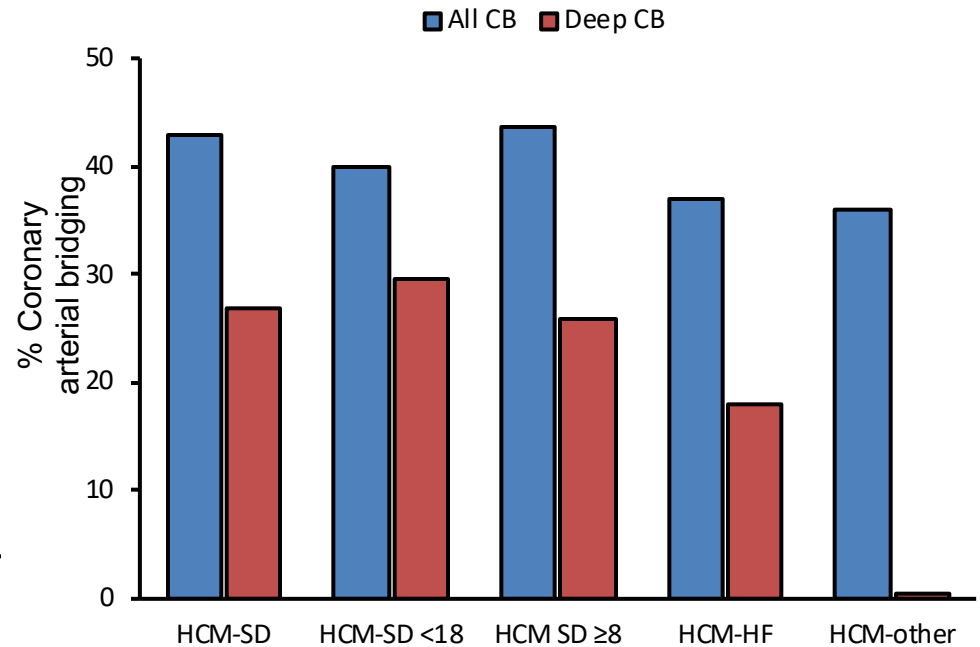
- Prevalence and depth of coronary artery bridges (CBs) were assessed in 255 hearts, including 115 with HCM and 140 controls
- Among the HCM hearts, CBs were present patients (43%) with sudden death
Comparison of the frequency with which CBs of the LAD occurred in HCM patients and controls



Deep CB in a 29-year-old woman with HCM and sudden death during jogging



Frequency of CBs with respect to mode of death in subsets of HCM patients: no statistically significant differences are visible when comparing both all CBs and deep CBs



HF, heart failure; SD, sudden death.

19 year old male with Chest Pain

What should be the next step?

1. FFR in response to IV adenosine
2. Drug eluting stent
3. IVUS or OCT to rule out plaque rupture
4. Conservative therapy
5. Other coronary physiology study

Myocardial bridging: FFR in response to IV dobutamine and IC Adenosine

FFR adenosine = 0.87

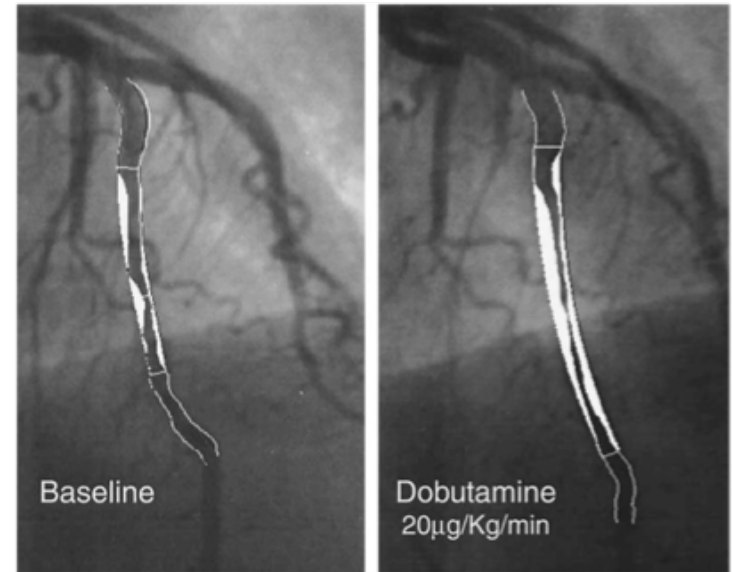
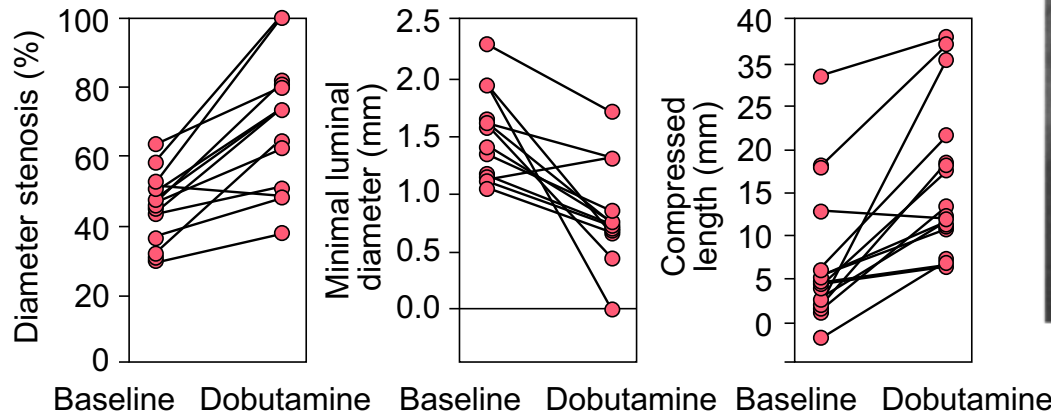
Dobutamine (40 µg/kg/min)



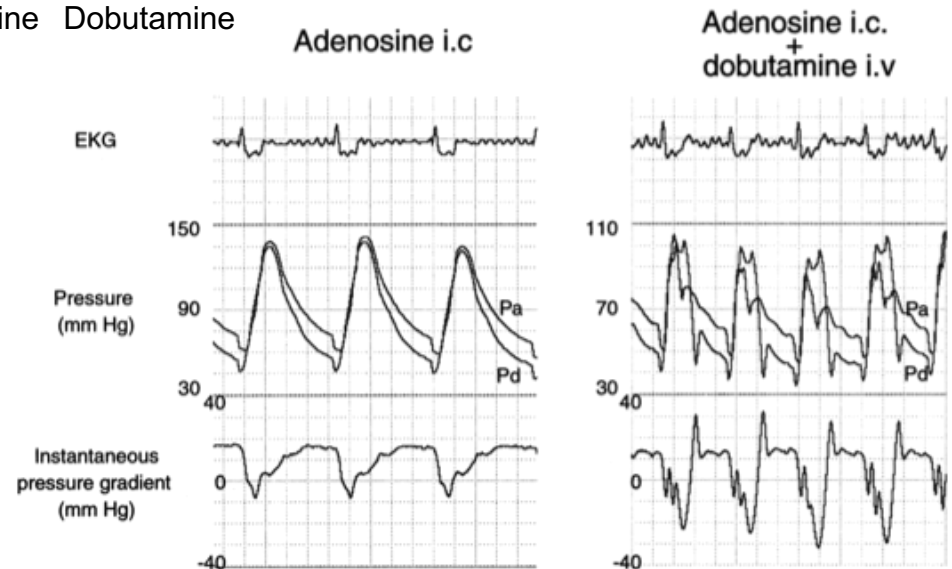
Importance of Diastolic Fractional Flow Reserve and Dobutamine Challenge in Physiologic Assessment of Myocardial Bridging

Javier Escaned, MD, PhD, Jorge Cortés, MD, Alex Flores, MD, PhD, Javier Goicolea, MD, PhD, Fernando Alfonso, MD, PhD, Rosana Hernández, MD, PhD, Antonio Fernández-Ortiz, MD, PhD, Manel Sabaté, MD, PhD, Camino Bañuelos, MD, Carlos Macaya, MD, PhD

Madrid, Spain



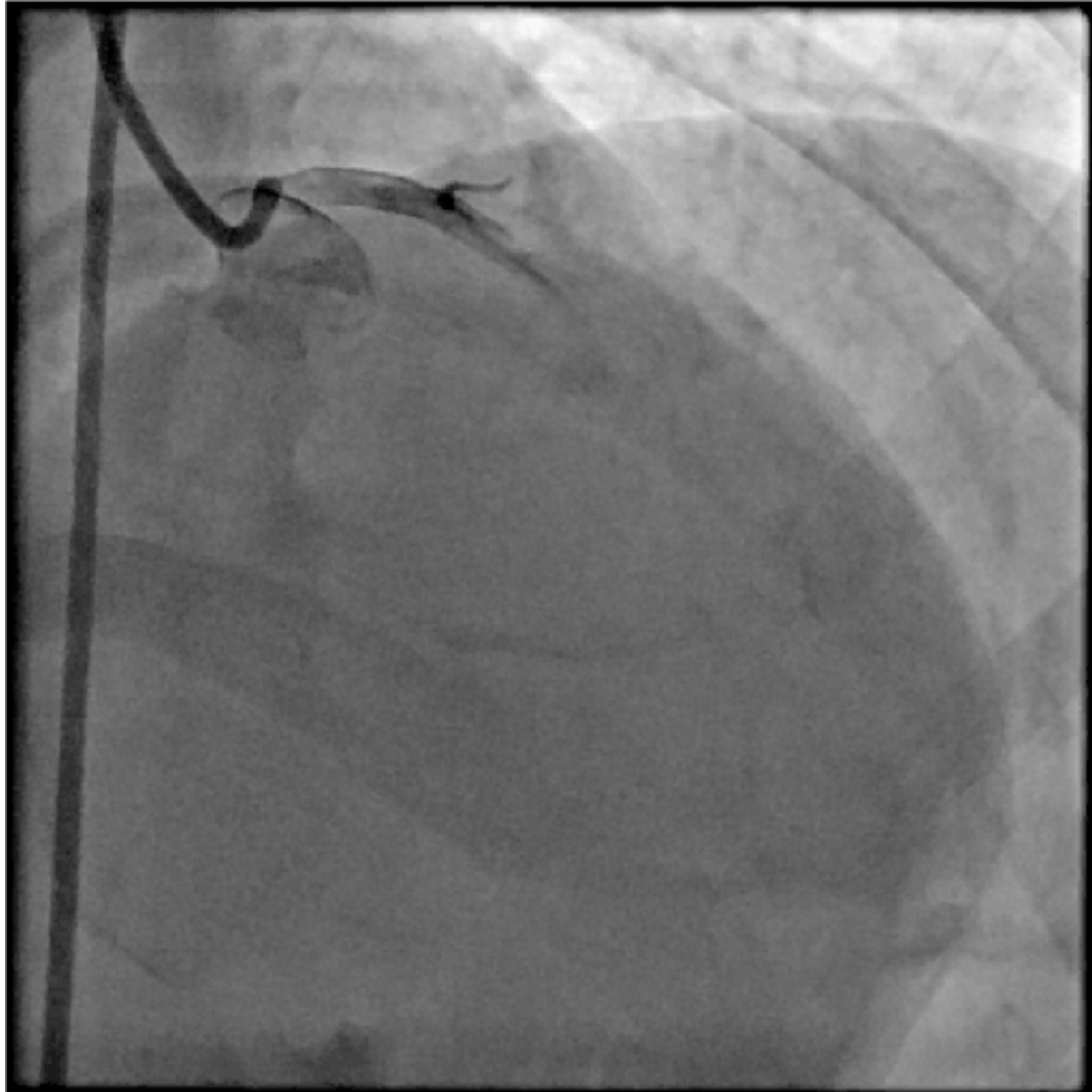
Conclusions: Physiologic assessment of MB should include dobutamine challenge. Diastolic FFR appears to be the technique of choice for MB assessment, where as mean FFR should be used with caution. (J



59 year old female with HOCM and Chest Pain

- Progressive exertional chest pain in the past several months.
- CAD risk factors: post menopausal, hypertension, hyperlipidemia.
- physical examination: 2/6 systolic murmur
- Echo: Apical HOCM, no SAM

Myocardial bridging



FFR to IC

adenosine : 0.90

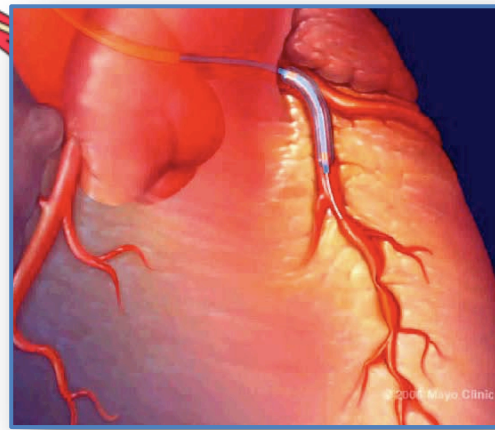
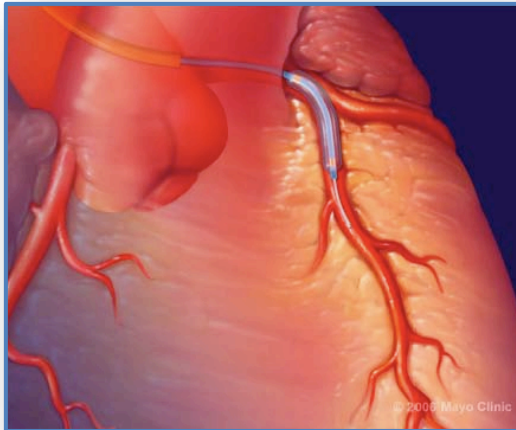
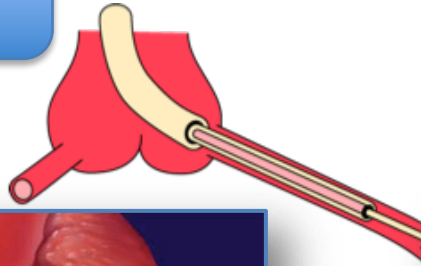
FFR to IV

dobutamine with IC

adenosine: 0.87

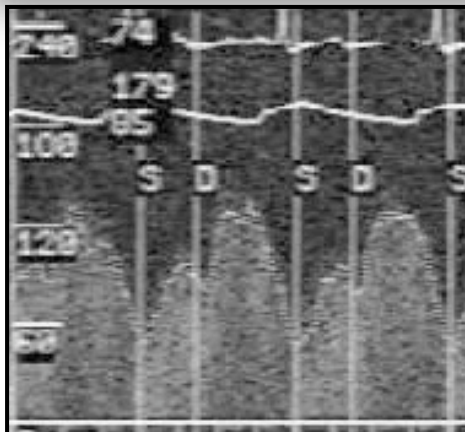
Coronary Endothelial Function Protocol

Diagnostic
angiography

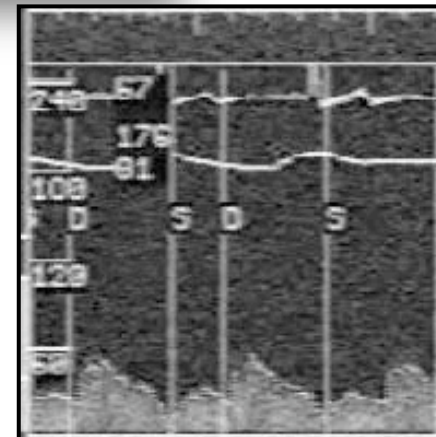


Acetylcholine
(endothelium
dependent
vasodilator)

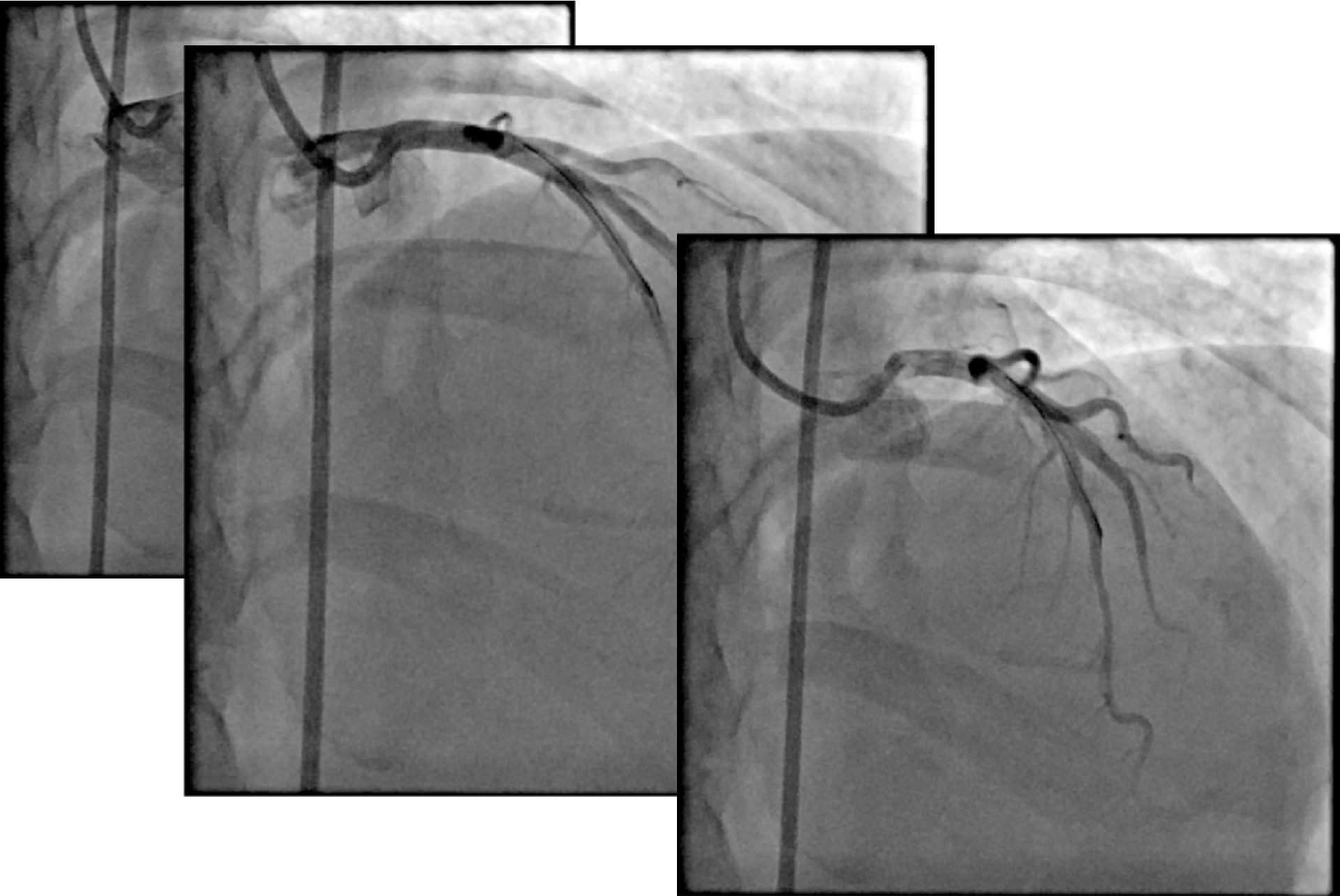
Epicardial



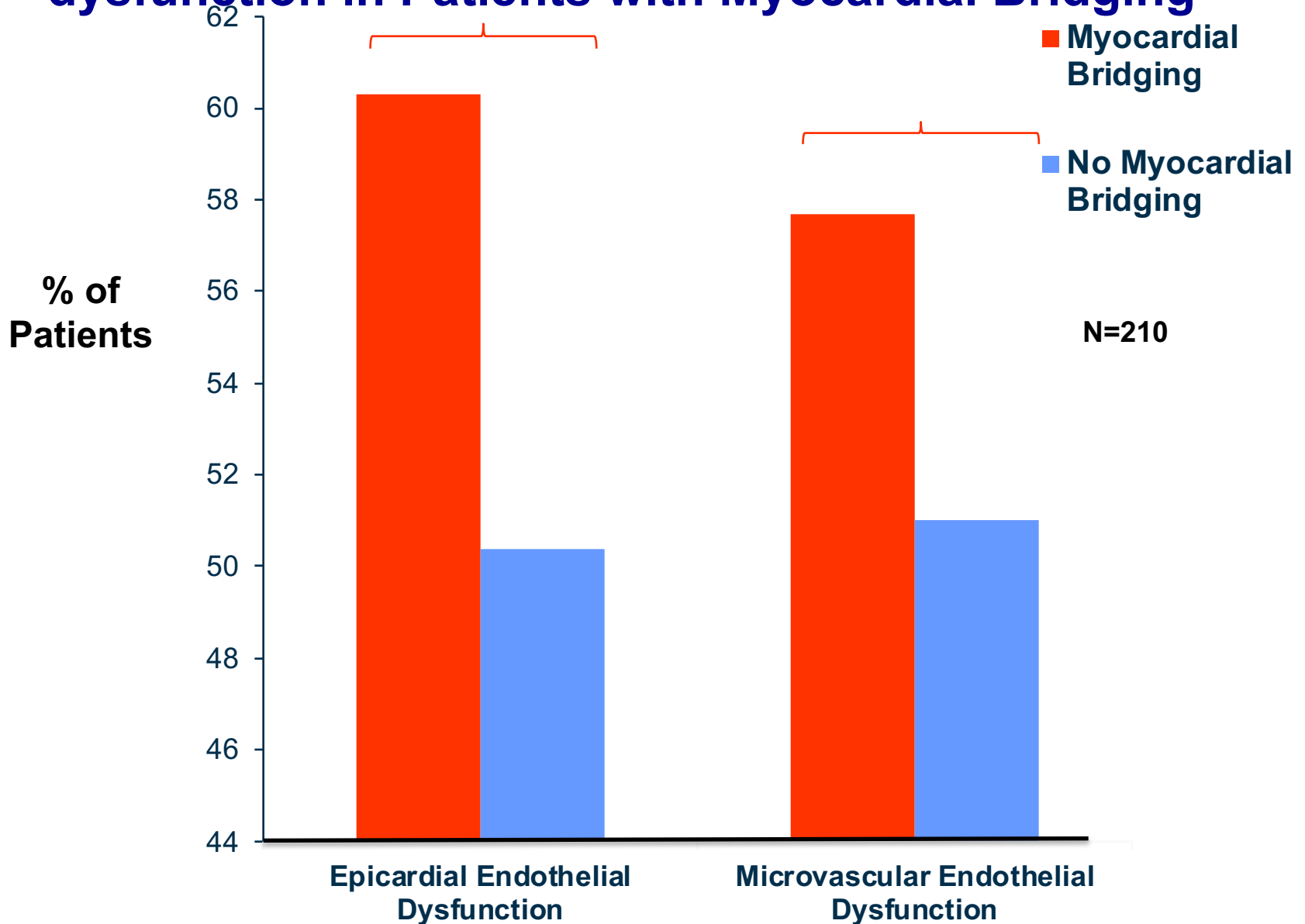
Microcirculation



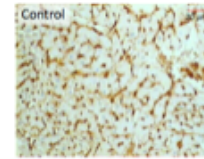
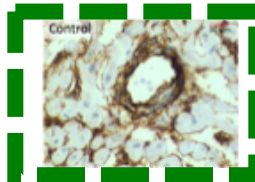
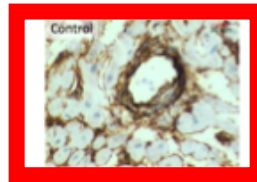
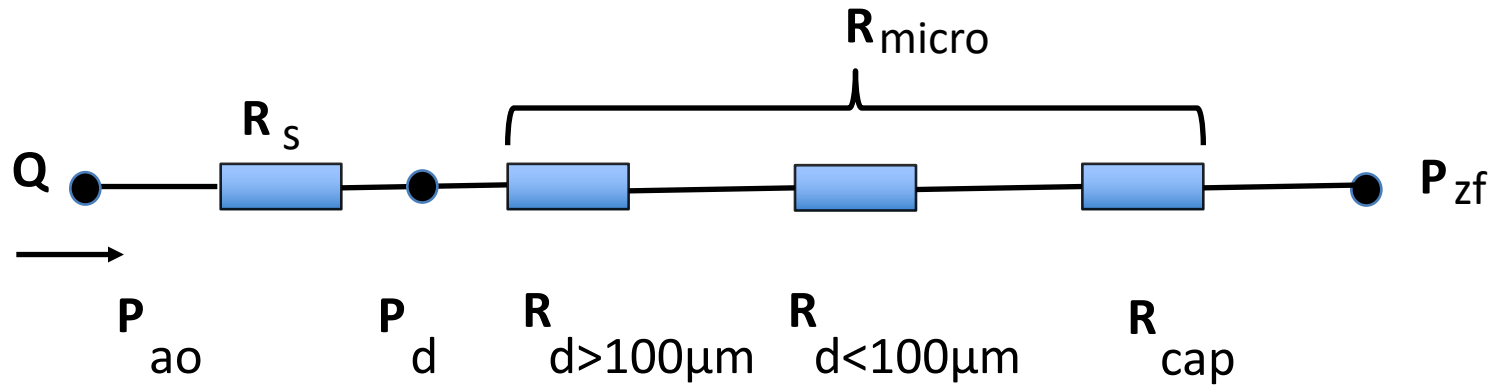
Myocardial bridging and endothelial function



Prevalence of Epicardial and Microvascular Endothelial dysfunction in Patients with Myocardial Bridging



Functional microcirculatory dysfunction in IHD



Adrenergic drive also causes constriction

Endothelial cell mediated constriction

Metabolite mediated dilation

59 year old female with Chest Pain

What should be the next step?

1. Drug eluting stent
2. IVUS or OCT to rule out plaque rupture
3. Conservative therapy: CCB
4. NTG and beta blockers
5. Surgical intervention

Myocardial bridging: Surgical experience at Mayo

- 63 patients 1996 to 2017 mean age of 48 years
- Unroofing was complicated by entry into the RV in three patients. Mean stay in the hospital 5 days
- No hospital mortality and no CV mortality on 30 days
- During follow-up (median 31 months, 95% CI 18-52 months), there were no cardiac-related deaths and 75% reported no chest pain.

Lerman et al

Outcome of Repair of Myocardial Bridging at the Time of Septal Myectomy

Meghana R. Kunkala, MD, Hartzell V. Schaff, MD, Harold Burkhardt, MD, Gurpreet S. Sandhu, MD, PhD, Daniel B. Spoon, MD, Steve R. Ommen, MD, Paul Sorajja, MD, and Joseph A. Dearani, MD

Divisions of Cardiovascular Surgery and Cardiovascular Diseases, Mayo Clinic, Rochester, Minnesota

A case-controlled study of 36 patients with hypertrophic cardiomyopathy and myocardial bridging

No adverse events

Coronary pathophysiology in HOCM

