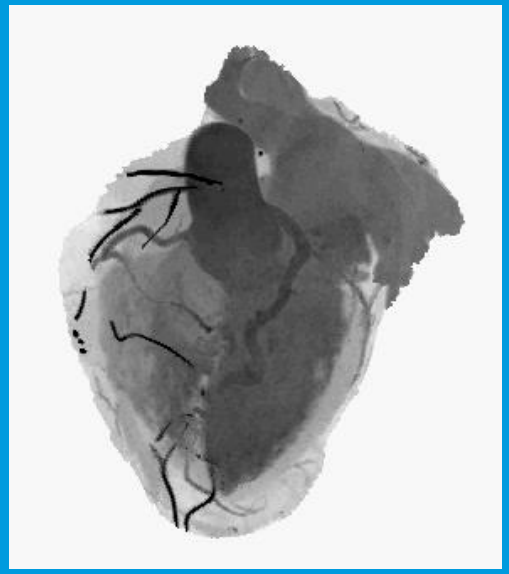


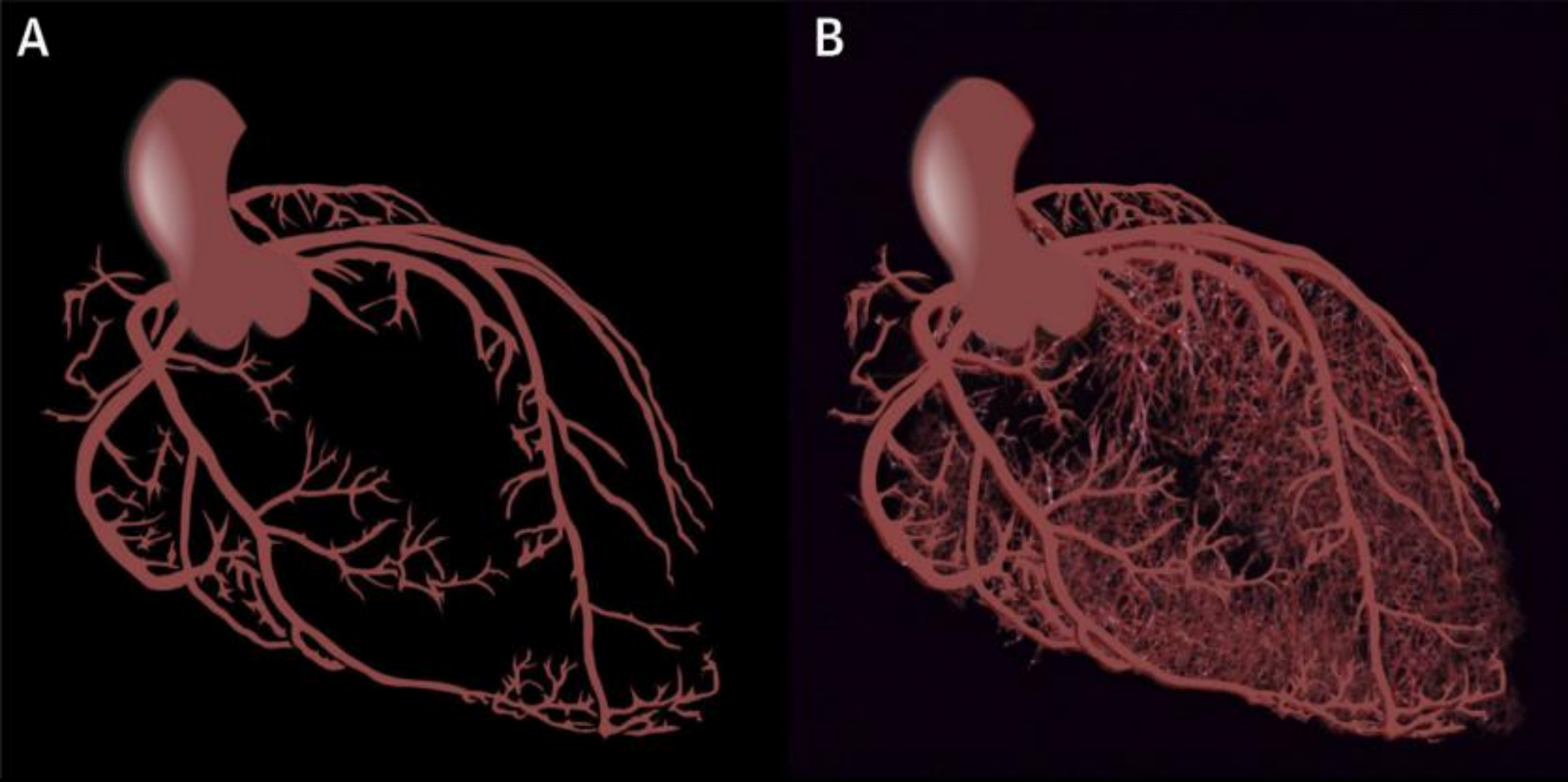
INOCA/ANOCA: THIS ISN'T GERD

Imaging and Diagnostics: Options for Making a Challenging Diagnosis

September 19, 2024

Shahryar G. Saba, MD
Director, Cardiac MRI & CT
Assistant Professor of Cardiology
North Shore University Hospital
Northwell Health

Northwell℠
Cardiovascular Institute


A
B

TERMS

Ischemia with Non-Obstructive Coronary Arteries (INOCA)

Angina with Non-Obstructive Coronary Arteries (ANOCA)

Myocardial Infarction with Non-Obstructive Coronary Arteries (MINOCA)

Open artery ischemia (OAI)

Coronary microvascular dysfunction (CMD)

CORONARY MICROVASCULAR DYSFUNCTION

"...spectrum of structural and functional alternations at the level of the coronary microcirculation, leading to an impaired coronary blood flow and ultimately resulting in myocardial ischemia."

Del Buono *et al*
Coronary Microvascular Dysfunction in Cardiovascular Diseases

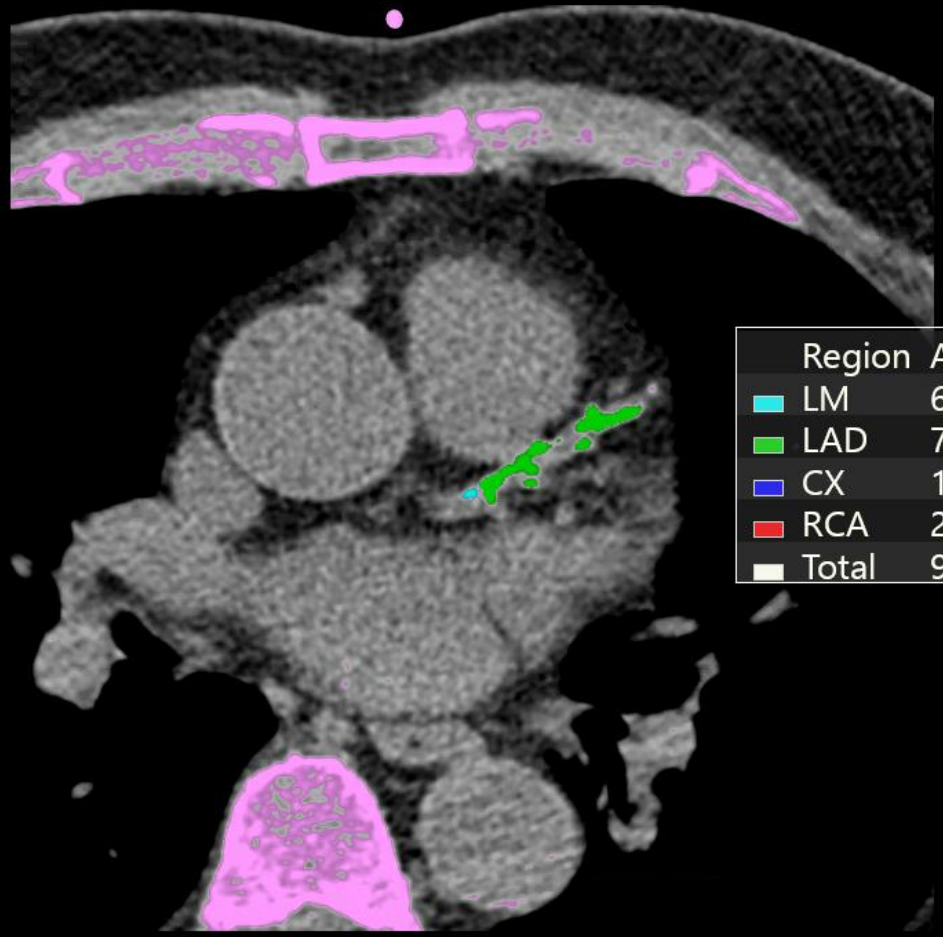
JACC VOL. 78, NO. 13, 2021
SEPTEMBER 28, 2021:1352–1371

73-YEAR-OLD WOMAN WITH DYSLIPIDEMIA (ATORVASTATIN 10), BP 130/86, HB A1C 6%, REPORTS EXERTIONAL CHEST PAIN

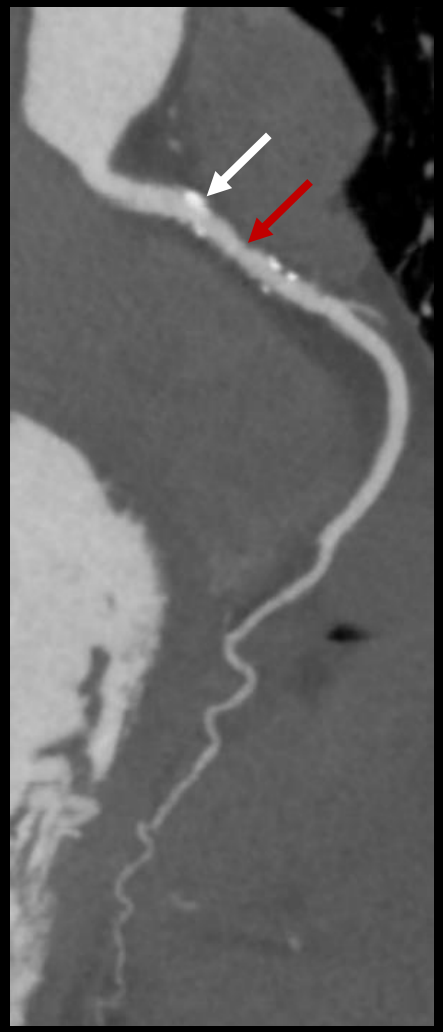
Conclusions:

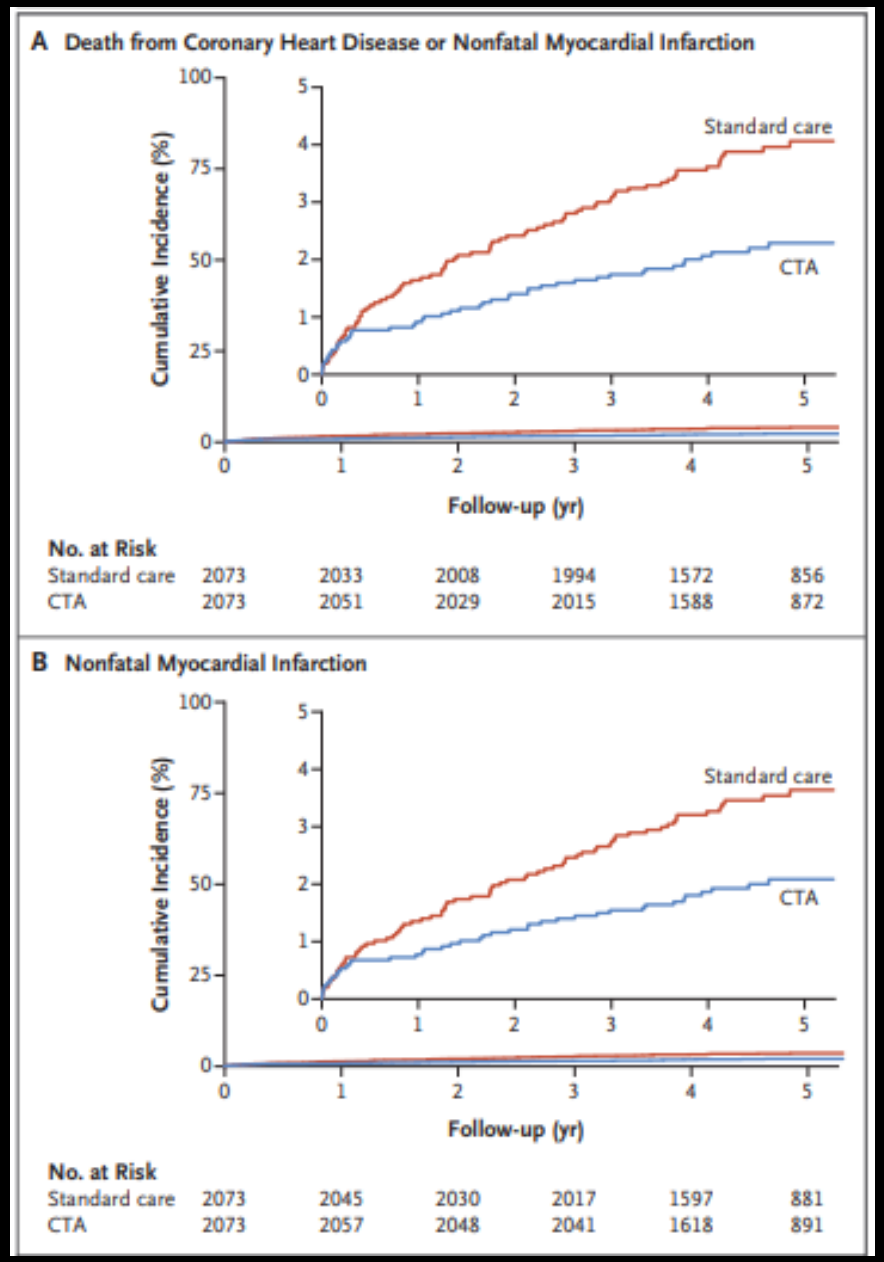
1. Exercise capacity is 7 METS, which is fair for age and gender.
2. Normal hemodynamic response.
3. Normal electrocardiographic response.
4. Normal augmentation in left ventricular systolic function.
5. Appropriate HR response.
6. Appropriate BP response.
7. Normal stress echocardiogram with no evidence of inducible ischemia.
8. Normal stress echo with fair exercise capacity

C C T A



Region	Agatston	Volume (mm3)
LM	6	10
LAD	750	601
CX	1	2
RCA	211	190
Total	968	803





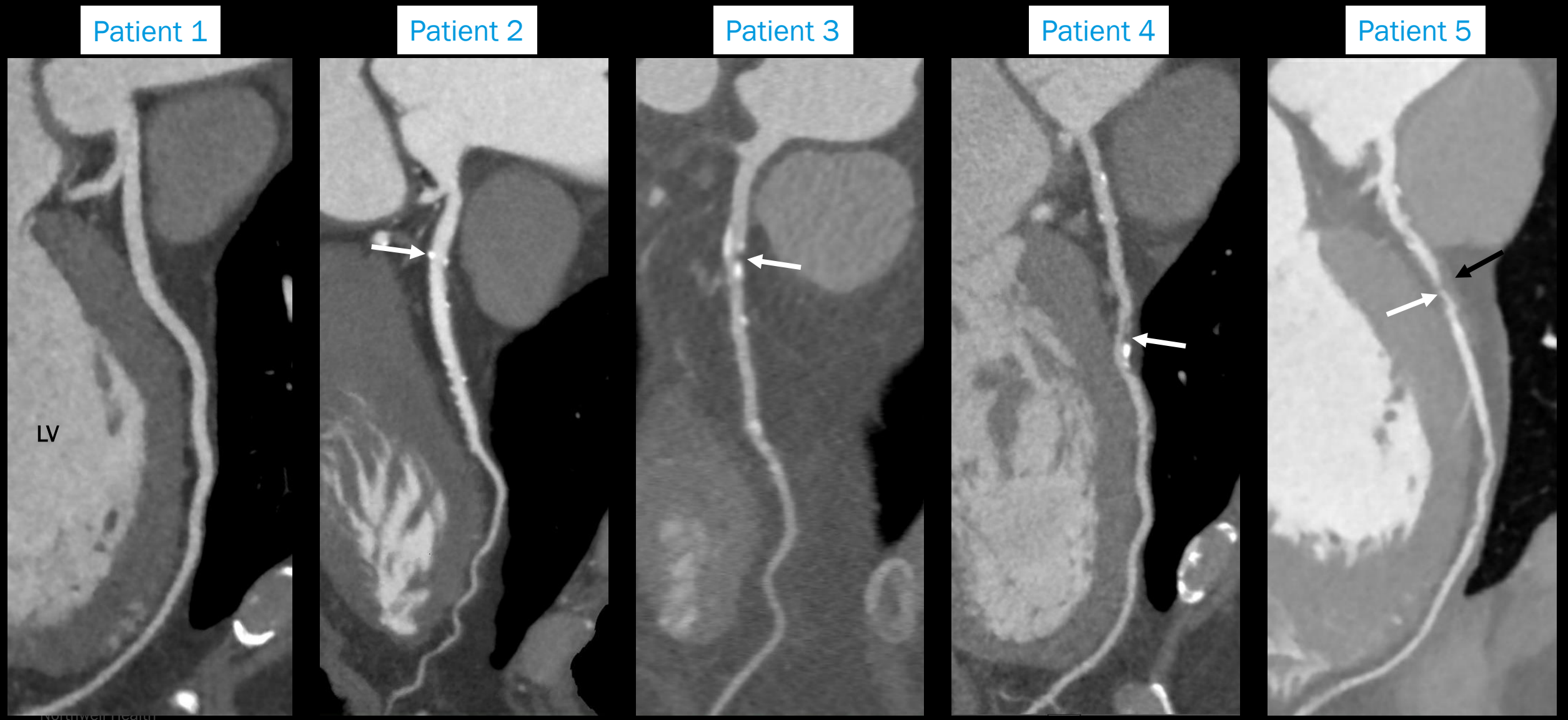
Coronary CT Angiography and 5-Year Risk of Myocardial Infarction

The SCOT-HEART Investigators*

CONCLUSIONS

In this trial, the use of CTA in addition to standard care in patients with stable chest pain resulted in a significantly lower rate of death from coronary heart disease or nonfatal myocardial infarction at 5 years than standard care alone, without resulting in a significantly higher rate of coronary angiography or coronary revascularization. (Funded by the Scottish Government Chief Scientist Office and others; SCOT-HEART ClinicalTrials.gov number, NCT01149590.)

CORONARY CT ANGIOGRAPHY



The Navier-Stokes Equations

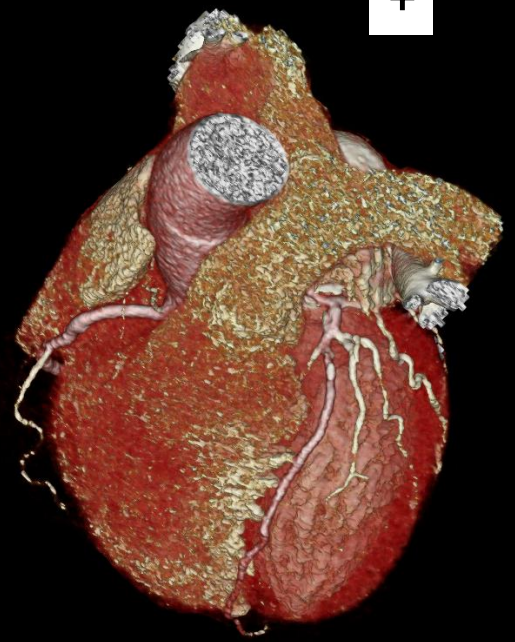
MASS ACCELERATION FORCE

$$\rho \cdot \left(\frac{\partial \vec{\mathbf{v}}}{\partial t} + (\vec{\mathbf{v}} \cdot \nabla)\vec{\mathbf{v}} \right) = \rho\vec{\mathbf{g}} - \nabla p + \mu \cdot \nabla^2 \vec{\mathbf{v}}$$

- ρ: Density of the Fluid
- $\frac{\partial \vec{\mathbf{v}}}{\partial t}$: Change in Velocity over Time
- $(\vec{\mathbf{v}} \cdot \nabla)\vec{\mathbf{v}}$: Speed and Direction of Fluid
- $\rho\vec{\mathbf{g}}$: External Forces such as Gravity
- ∇p: Pressure Gradient
- $\mu \cdot \nabla^2 \vec{\mathbf{v}}$: Internal Stress Forces (viscous effects)

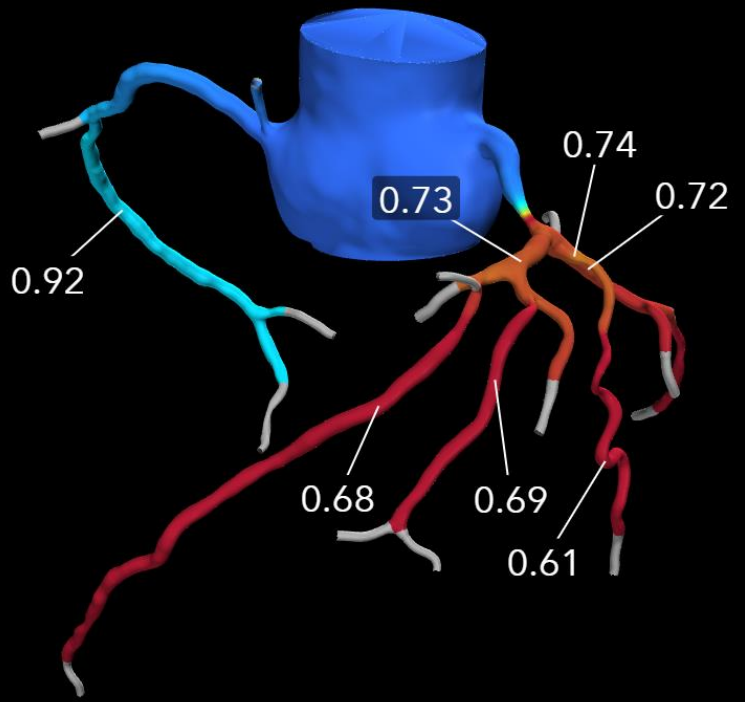
Newton's 2nd Law of Motion

+

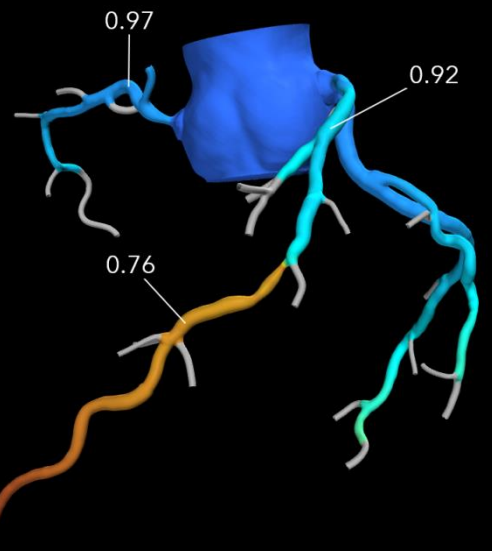


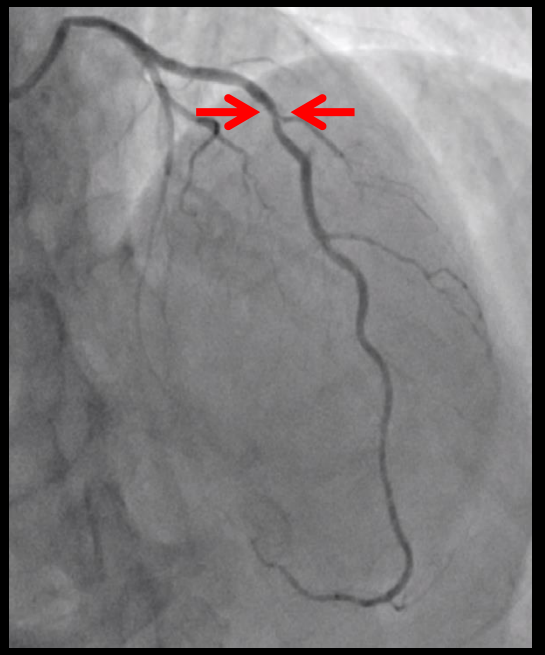
+

Mathematical derivation



FFR_{CT}-IFR CORRELATION





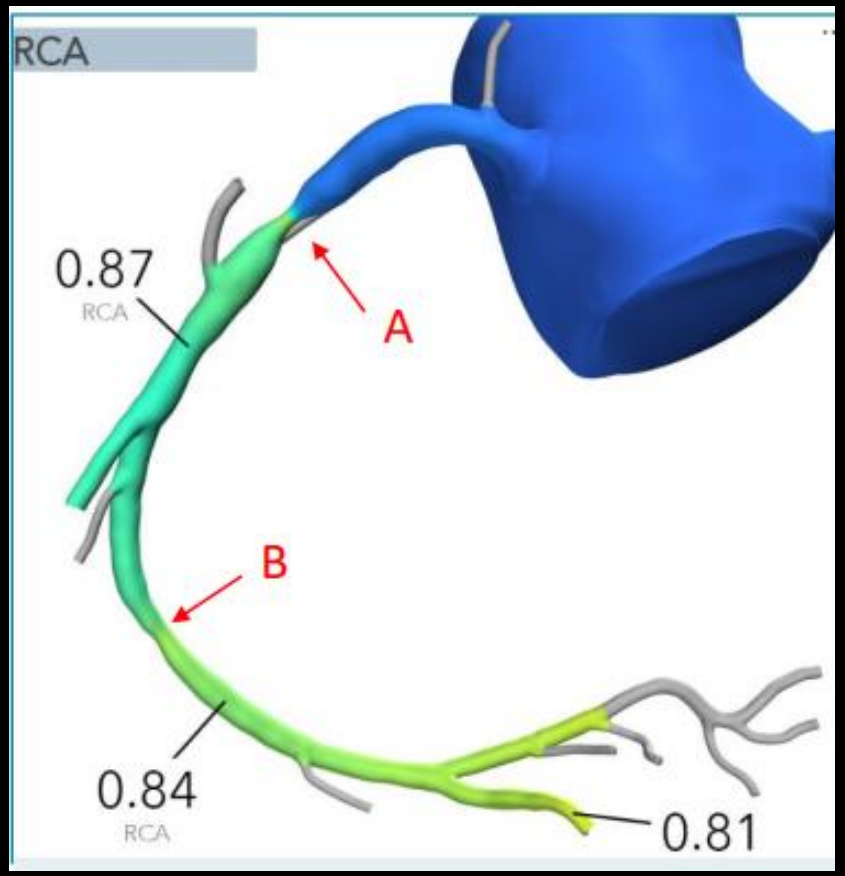

RCA
0.87
RCA
A
B
0.84
RCA
0.81

FIGURE 2 IVUS and OCT of LAD Myocardial Bridge

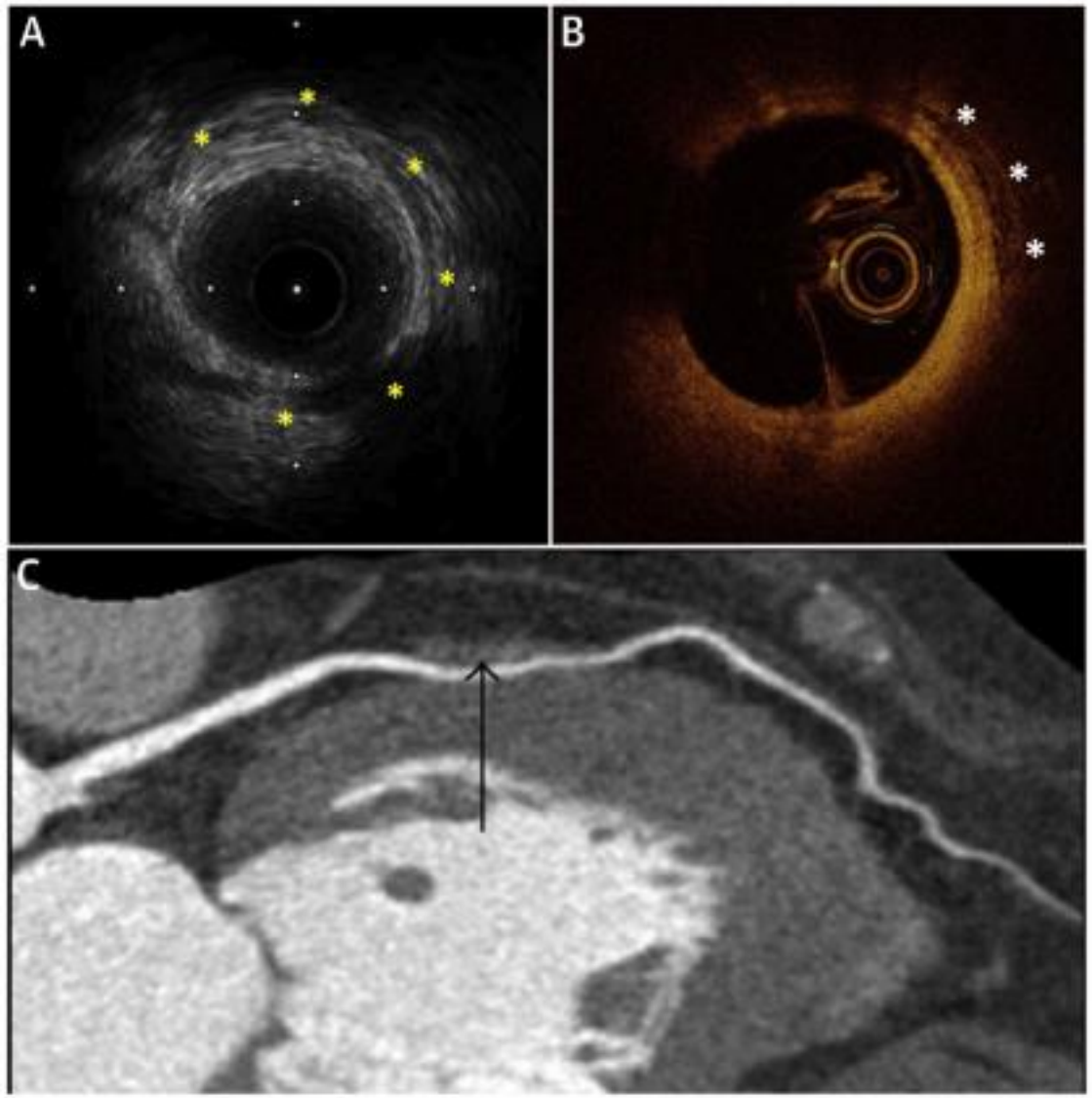
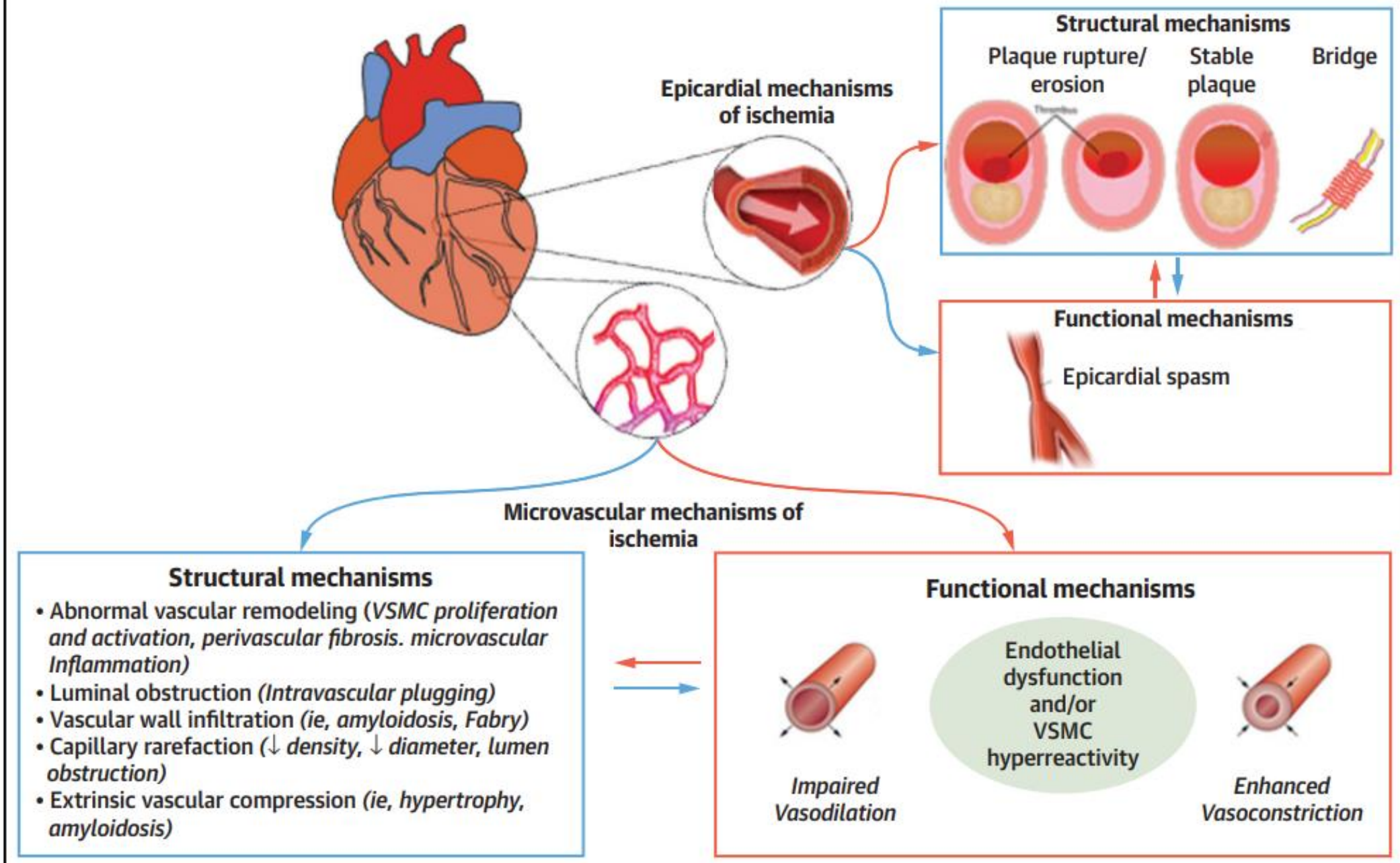
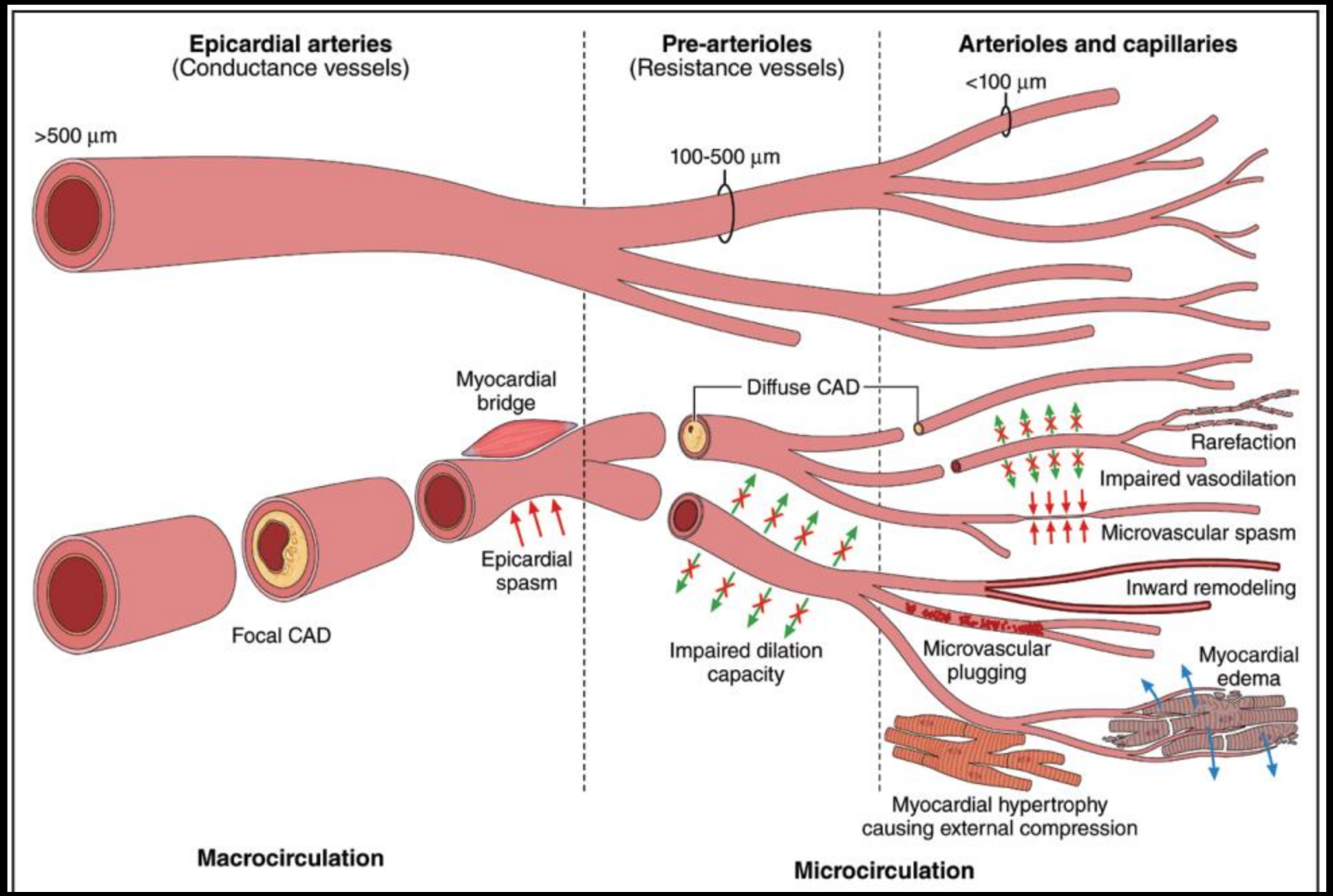


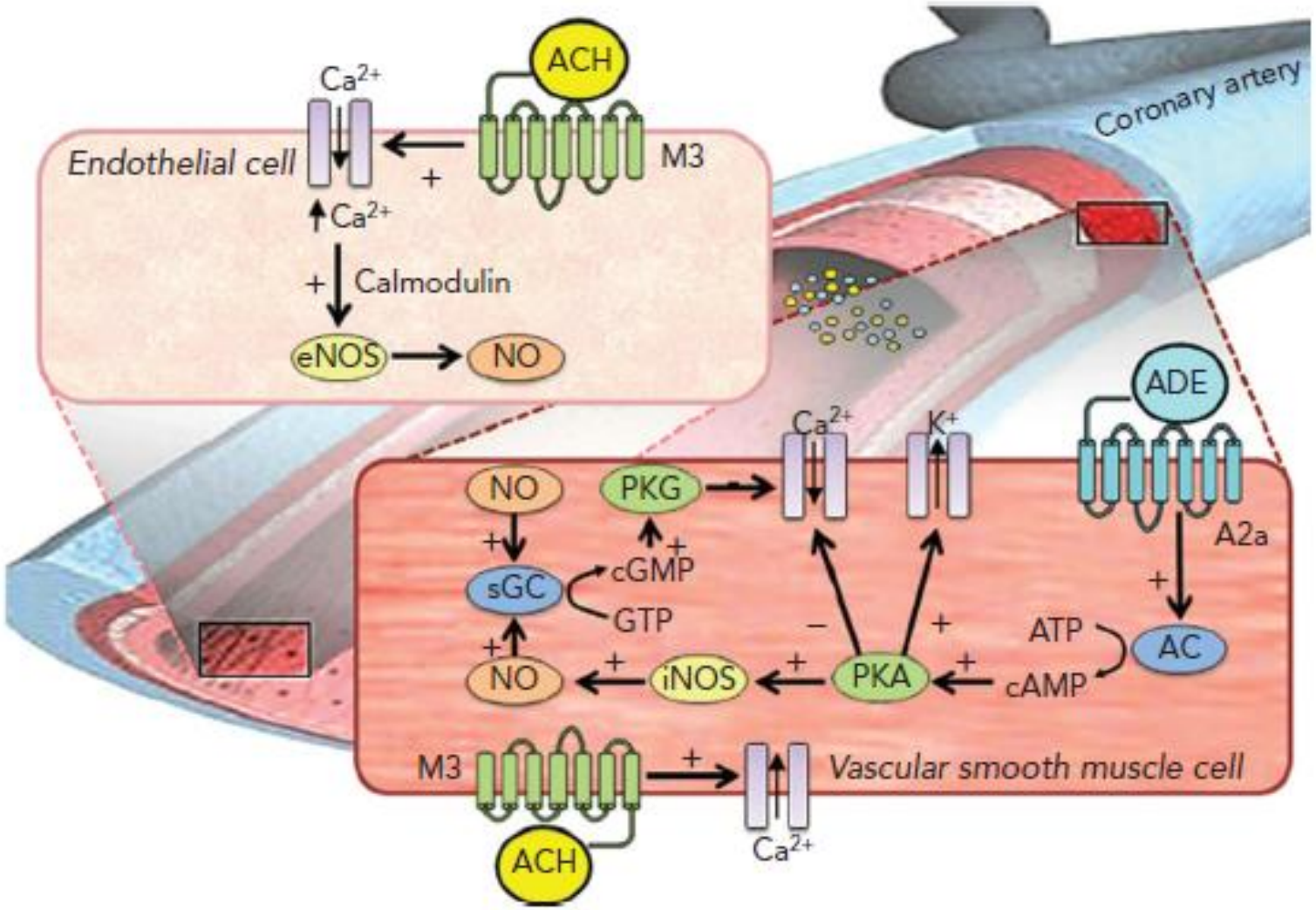
FIGURE 2 Role of CMD in Determining Ischemia





Circ Cardiovasc Interv. 2023;16:e012568. DOI: 10.1161/CIRCINTERVENTIONS.122.012568

Figure 2: Acetylcholine and Adenosine Coronary Vascular Effects

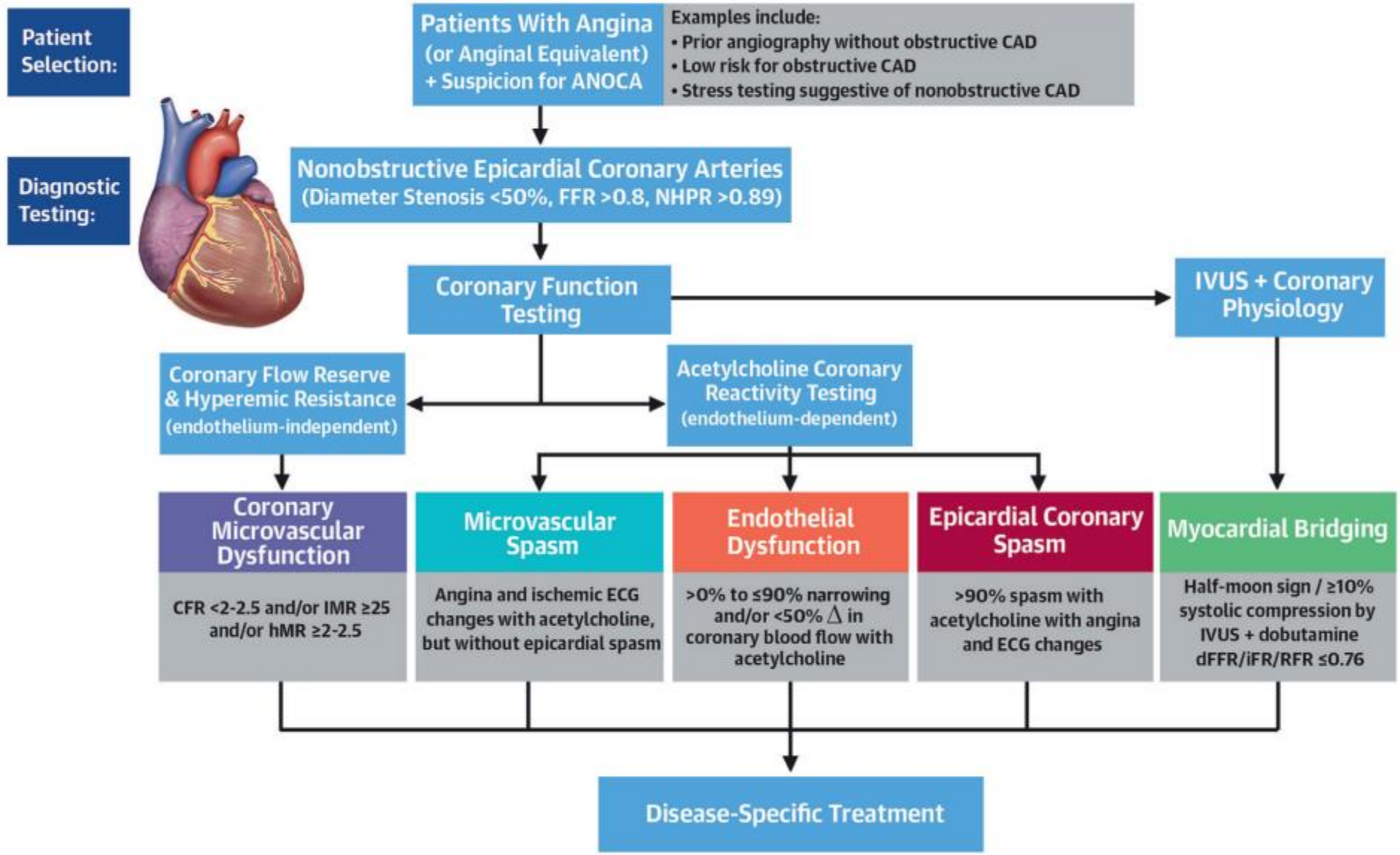


US Cardiology Review 2018;12(1):41–5.

ENDOTHELIAL-DEPENDENT VERSUS ENDOTHELIAL-INDEPENDENT (ENDOTYPES)

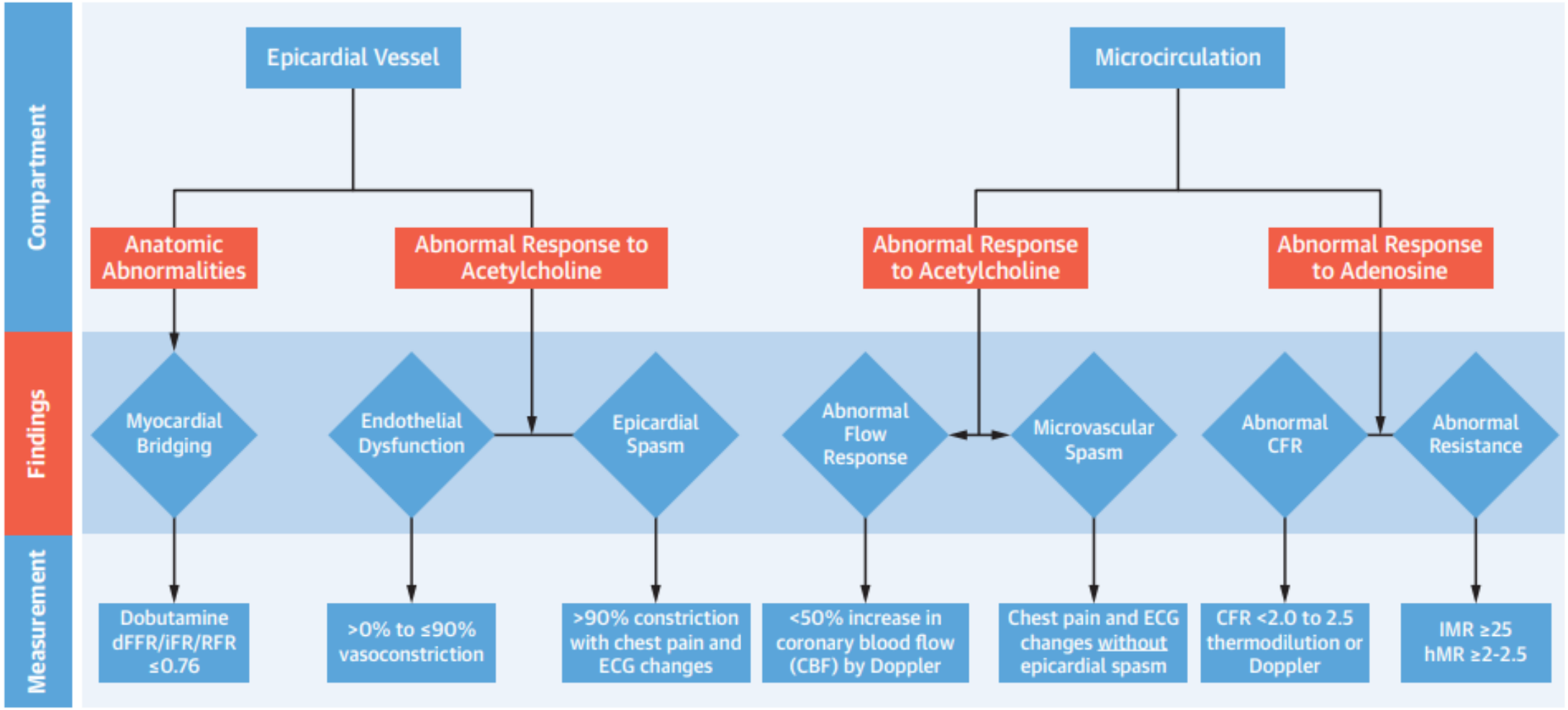
Endothelial-dependent	Endothelial-independent
Functional abnormality (decreased NO)	Structural abnormality (intimal thickening)
Endothelial cell	Vascular smooth muscle cell
Vasoconstriction/vasospasm	Decreased coronary flow reserve
Acetylcholine	Adenosine
Invasive approach	Non-invasive/invasive approach
CCB	Beta-blocker/ACE/ARB

CENTRAL ILLUSTRATION Invasive Diagnostic Pathway for Patients With ANOCA



Samuels BA, et al. J Am Coll Cardiol. 2023;82(12):1245-1263.

FIGURE 1 Underlying Causes of Angina With Nonobstructive Coronary Arteries



Samuels BA, et al. J Am Coll Cardiol. 2023;82(12):1245-1263.

TABLE 1 Strengths and Limitations of Select Diagnostic Techniques for the Evaluation of CMD

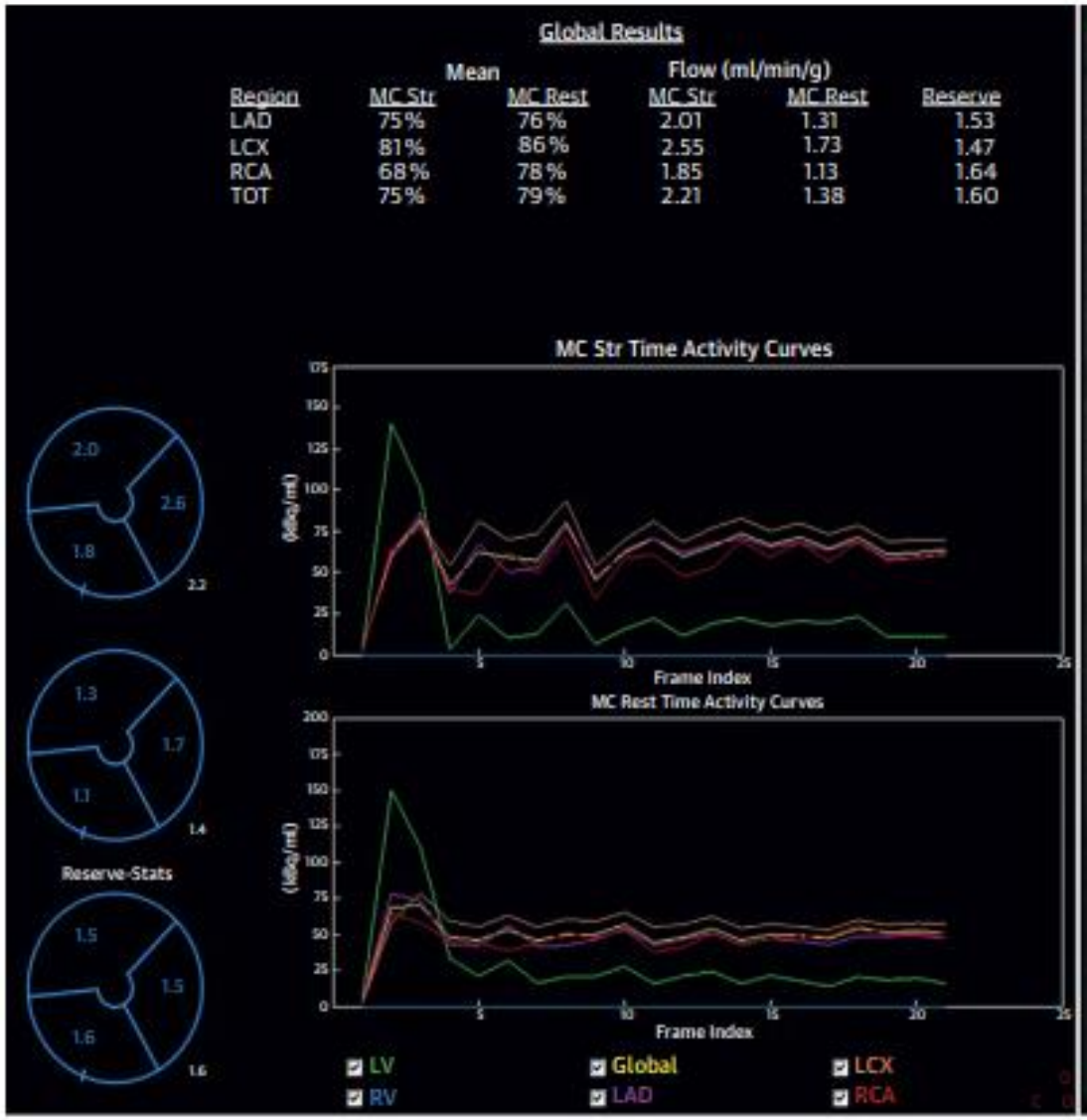
	Accuracy	Reproducibility	Diagnostic Threshold	Prognostic Validation	Availability	Cost
Noninvasive*						
PET	++++	++++	CFR <2	++++	++	$$$
CMR	+++	+++	MPRI <2	++	++	$$$
Doppler echocardiography	++	+++	CFVR <2	+++	++++	$
Invasive*						
CFR	++++	++++	<2.3	+++	++++	$$$$
IMR	++++	+++	>25 U	++	++	$$$$

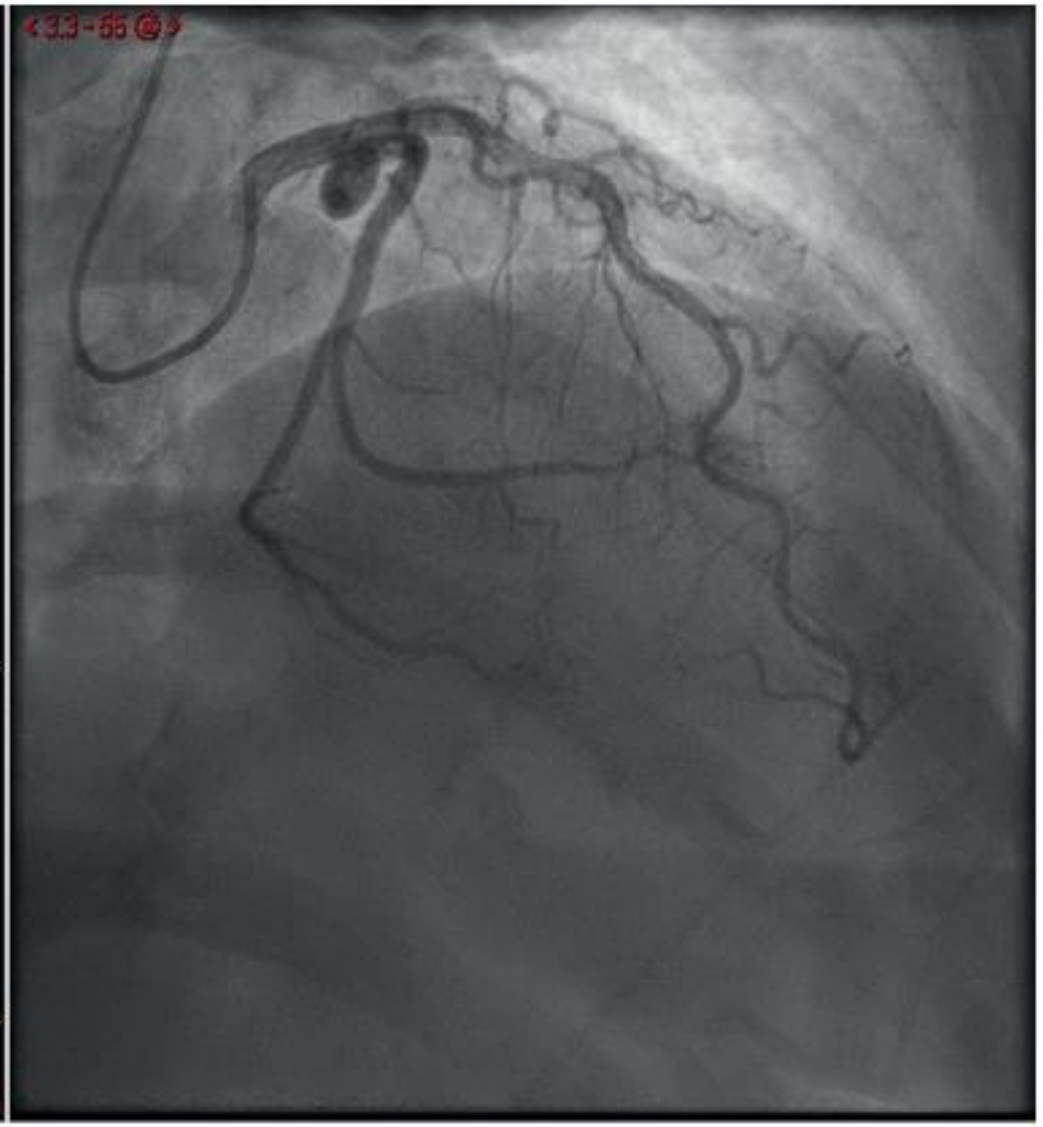
*Assumes exclusion of obstructive coronary artery disease.

CFR = coronary flow reserve; CFVR = coronary flow velocity reserve; CMD = coronary microvascular disease; CMR = cardiac magnetic resonance; CT = computed tomography; IMR = index of microvascular resistance; MPRI = myocardial perfusion reserve index; PET = positron emission tomography.

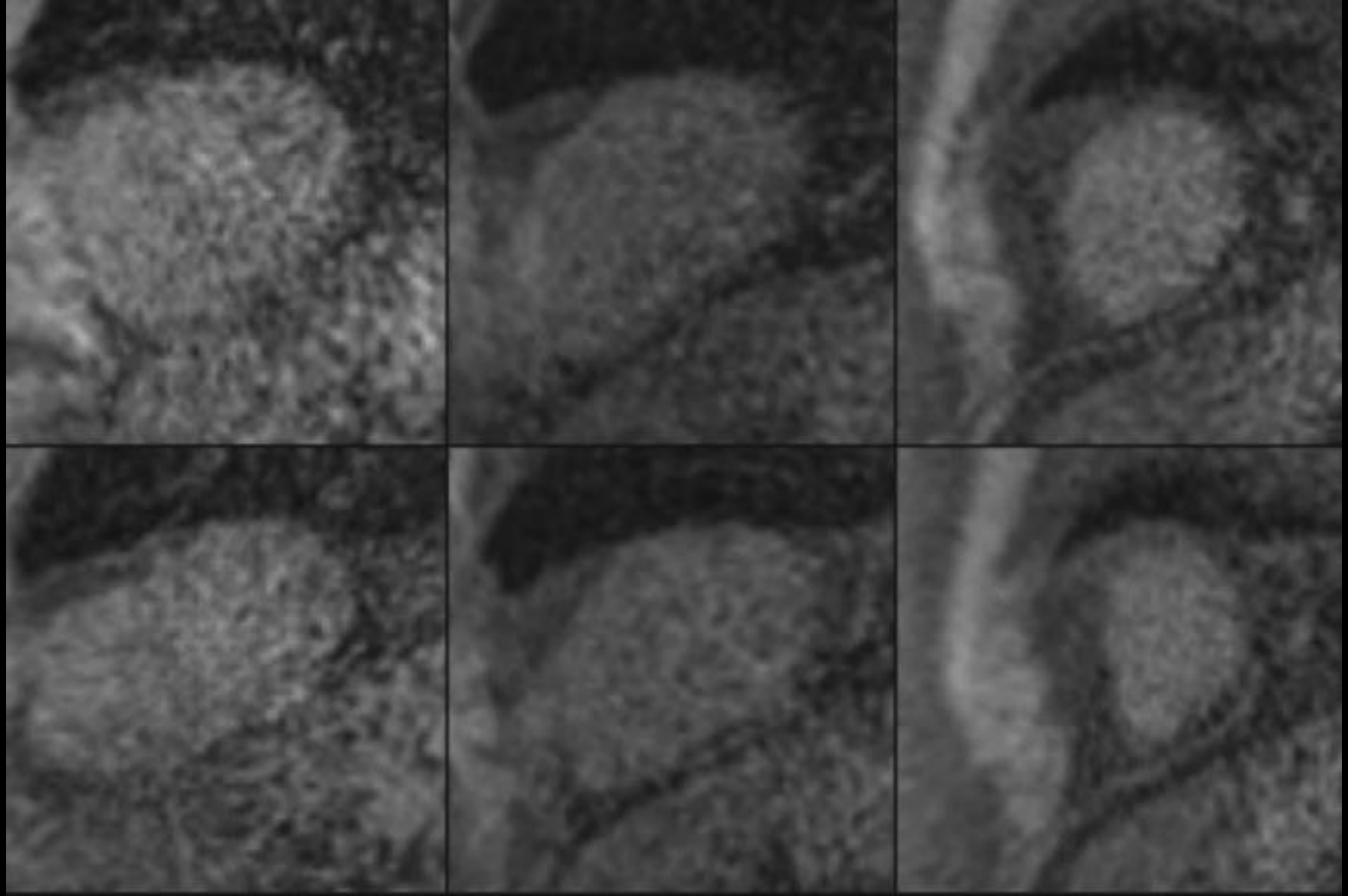
CENTRAL ILLUSTRATION Abnormal Myocardial Perfusion Reserve in Nonobstructive Coronary Artery Disease

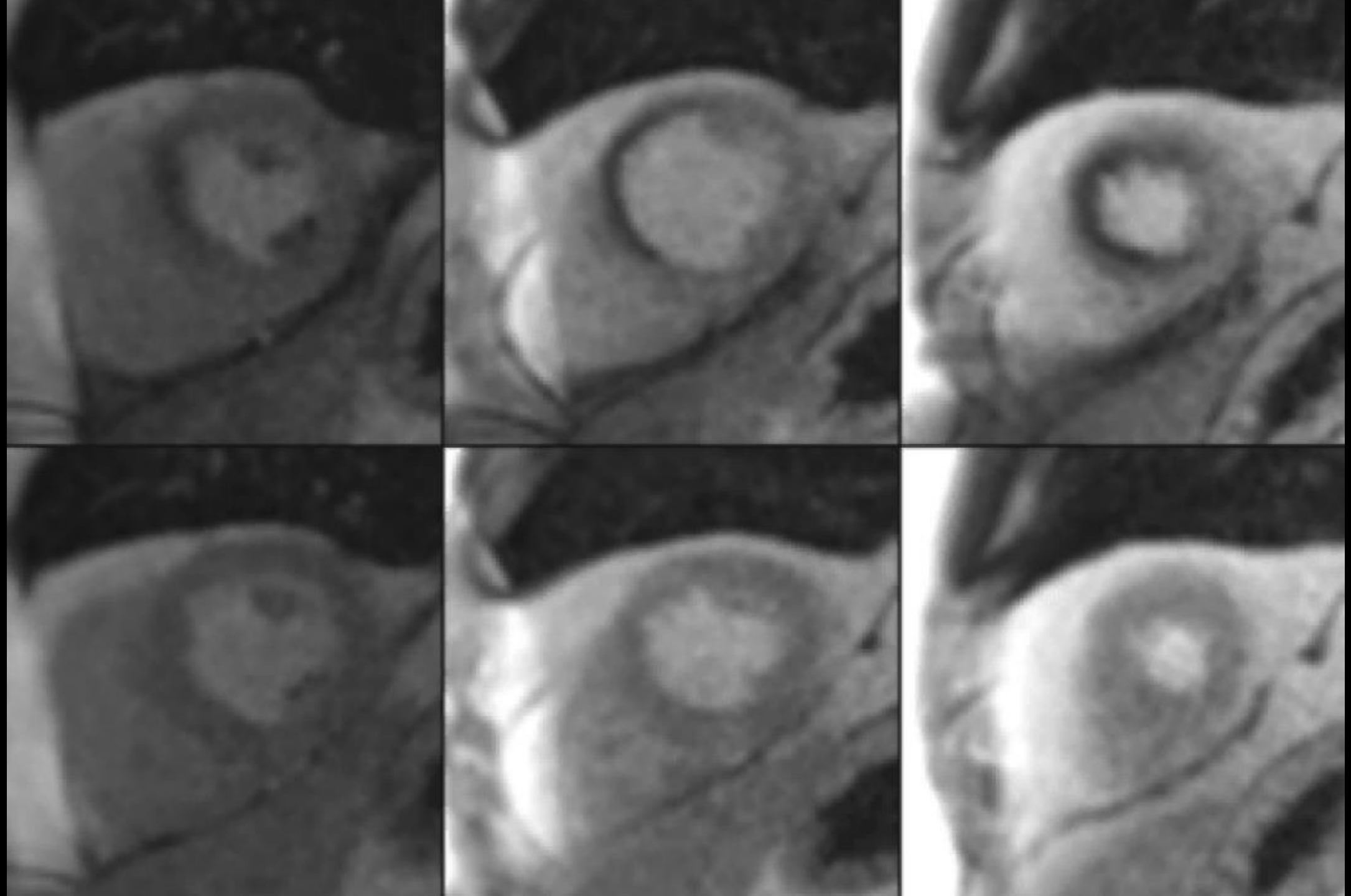
A



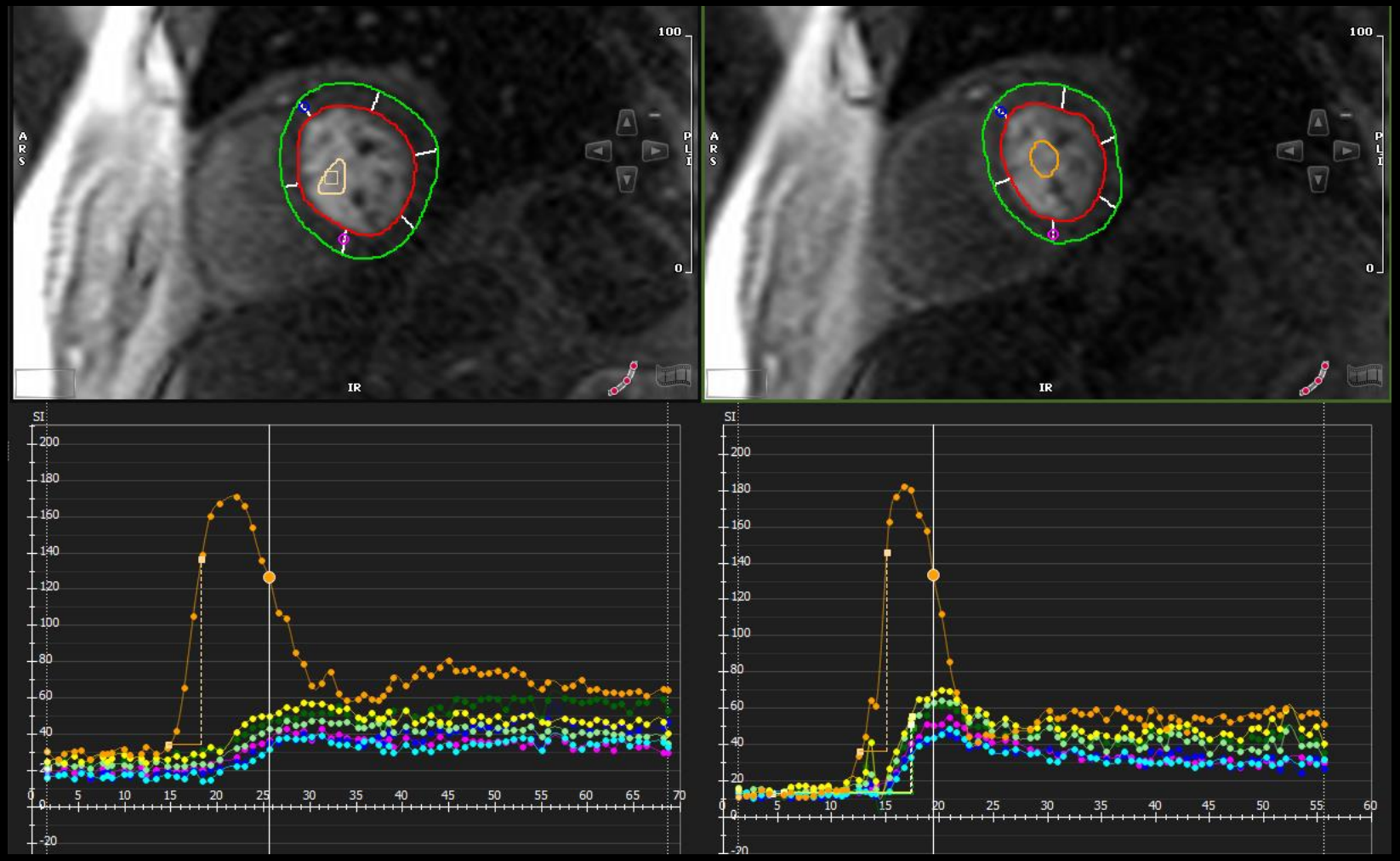


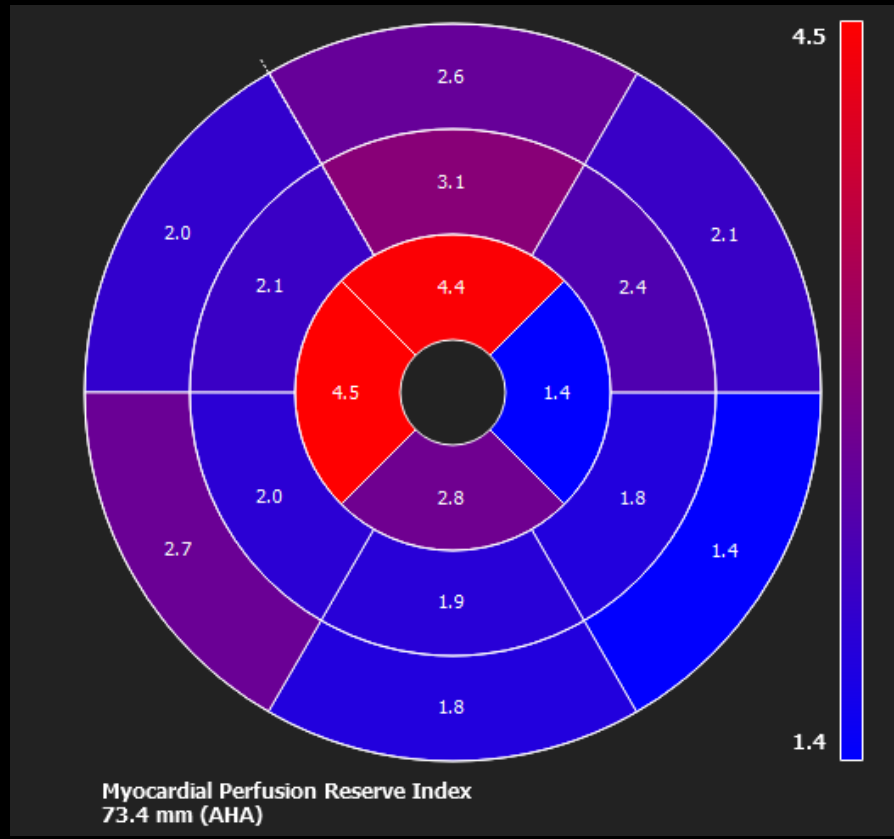
JACC: CARDIOVASCULAR IMAGING, VOL. 13, NO. 7, 2020
JULY 2020:1577–90

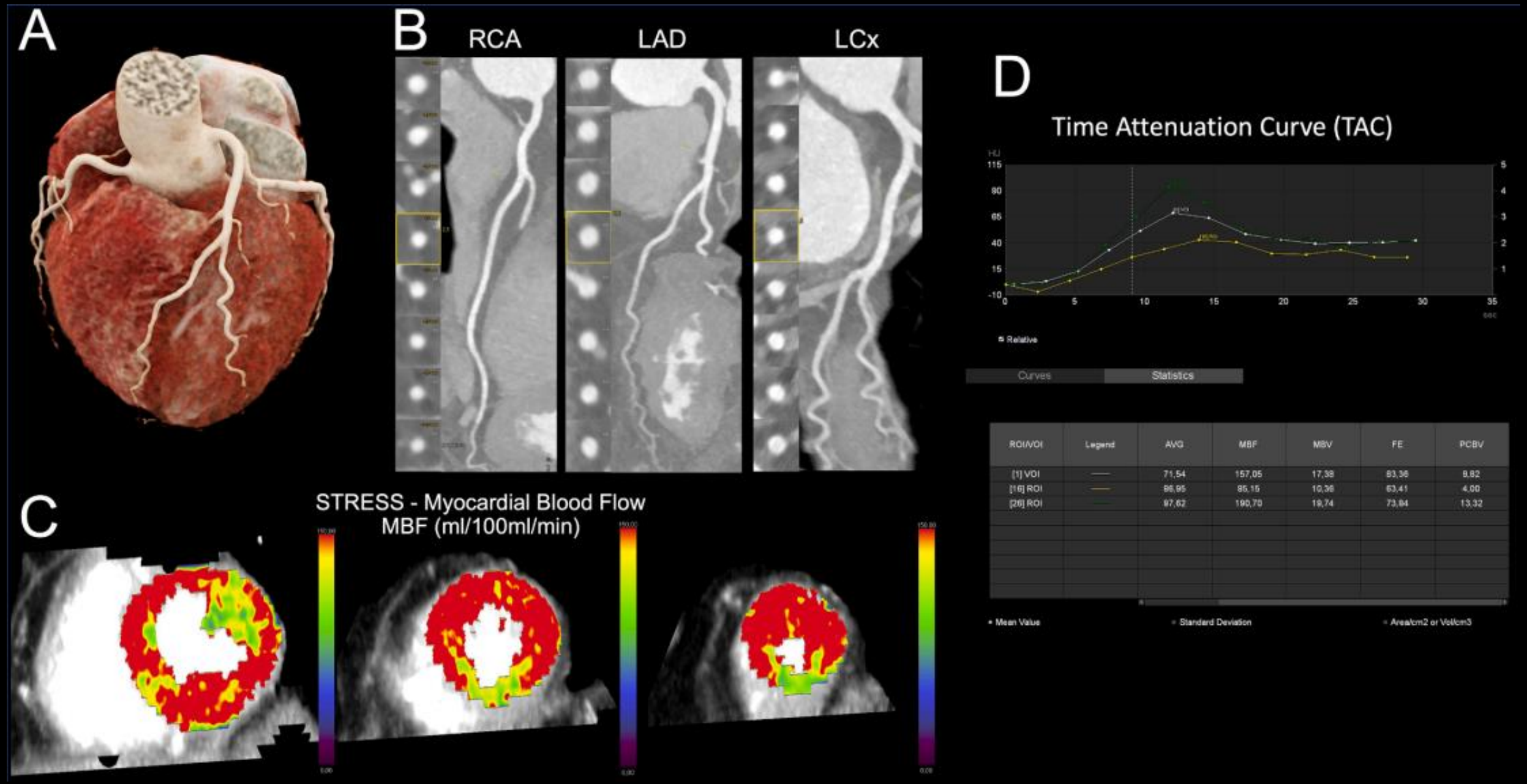




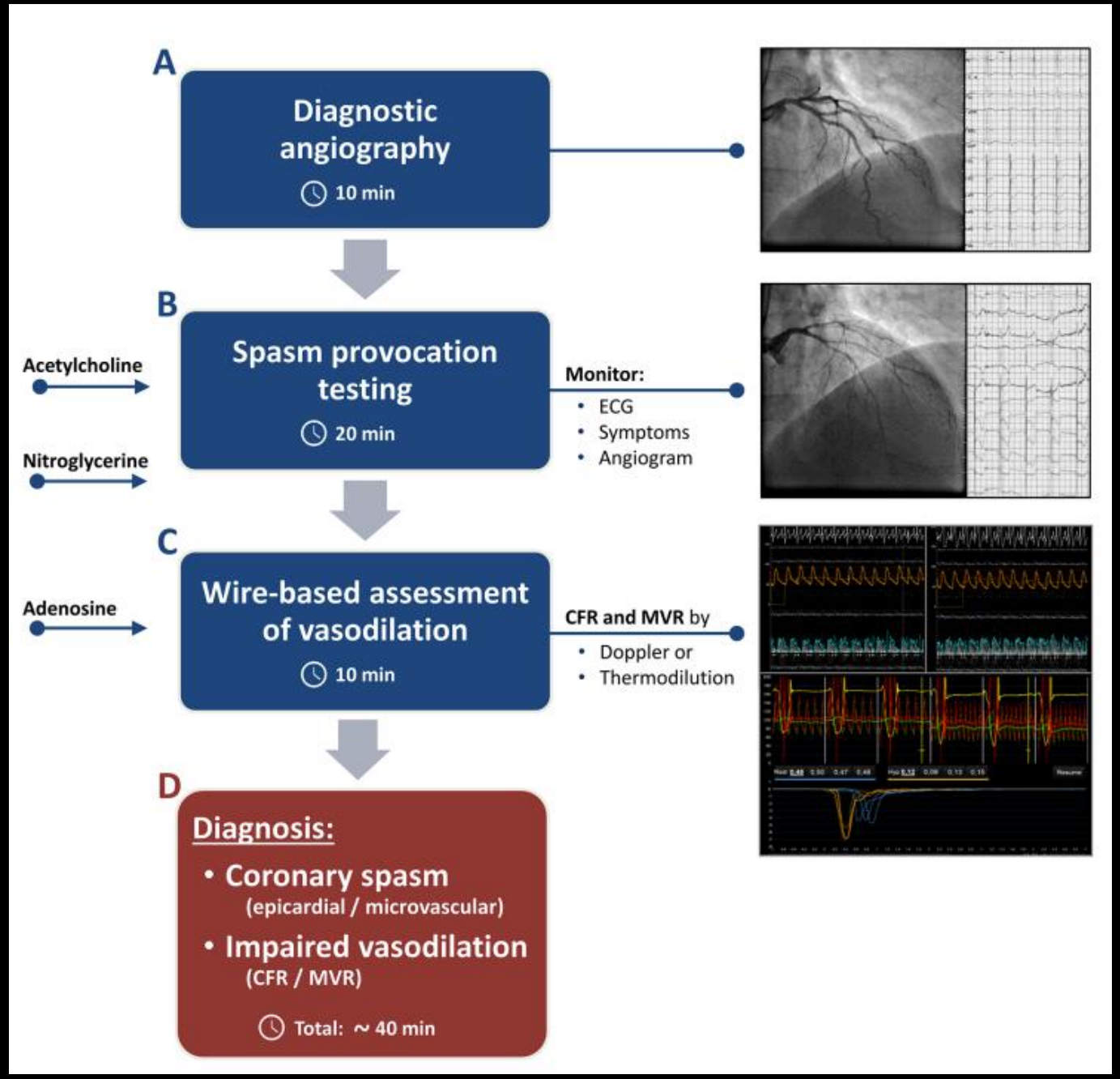
SEMI-QUANTITATIVE PERFUSION AND MPR INDEX



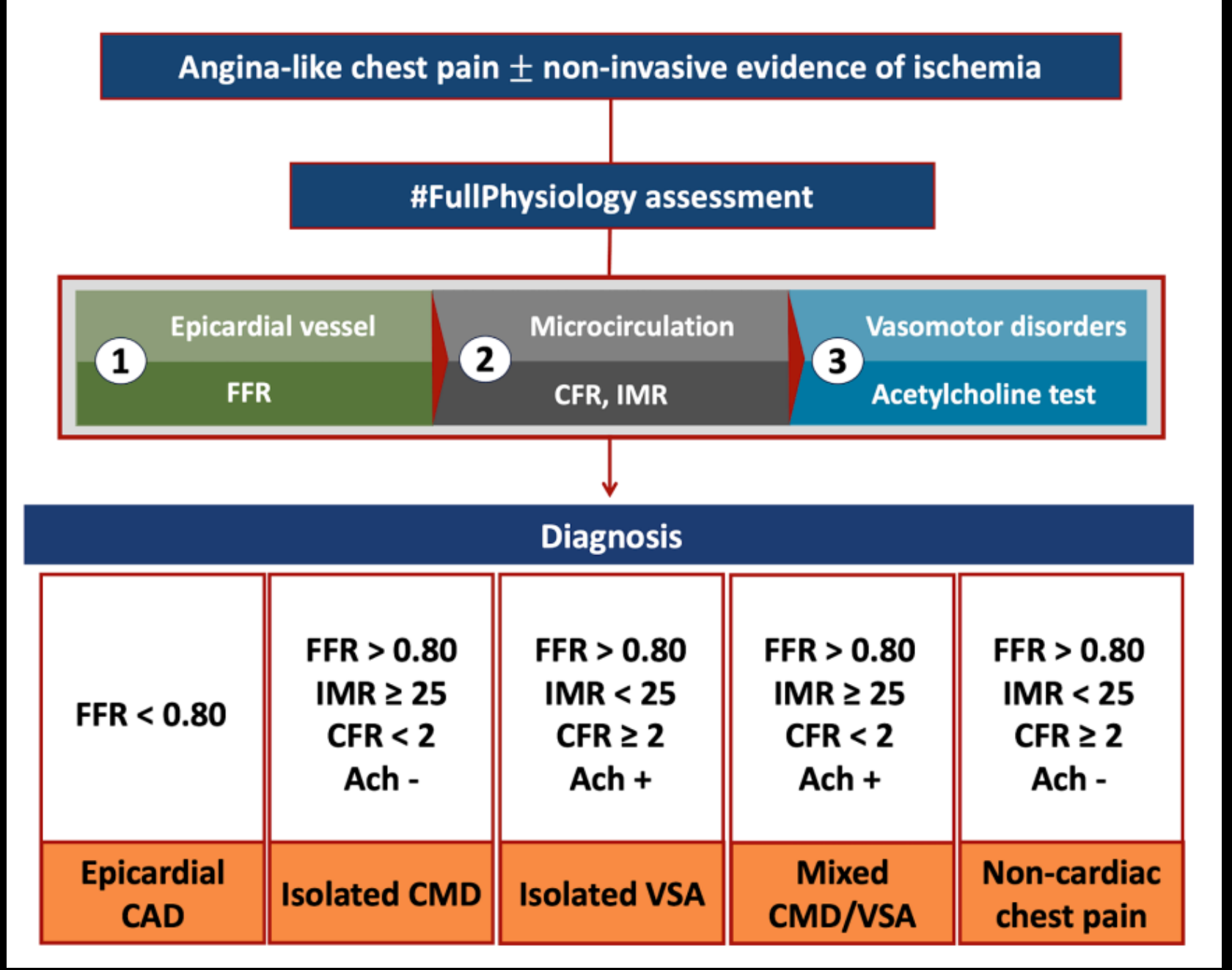




S. Benenati et al. European Journal of Internal Medicine 127 (2024) 15–24



Peter Ong. ACC 12.18.2020.



S. Benenati et al. European Journal of Internal Medicine 127 (2024) 15–24

CONCLUSIONS

ANOCA/INOCA represent a diagnostic starting point to establish underlying pathophysiology

Consider CCTA to assess for obstructive CAD (and myocardial bridge)

PET and CMR may be considered to evaluate for CMD (endothelium-independent)

Invasive approach may be considered to evaluate for coronary/microvascular vasospasm/vasoconstriction (endothelium-dependent)

THANK YOU

Northwell[SM]
Cardiovascular Institute