

Comprehensive Functional Coronary Assessment

John Beltrame

University of Adelaide

Central Adelaide Local Health Network



Expanding the Clinical Paradigm

Structural Coronary Artery Disease

- Obstructive ($\geq 50\%$) lesion
- Atherothrombotic processes

Expanding the Clinical Paradigm

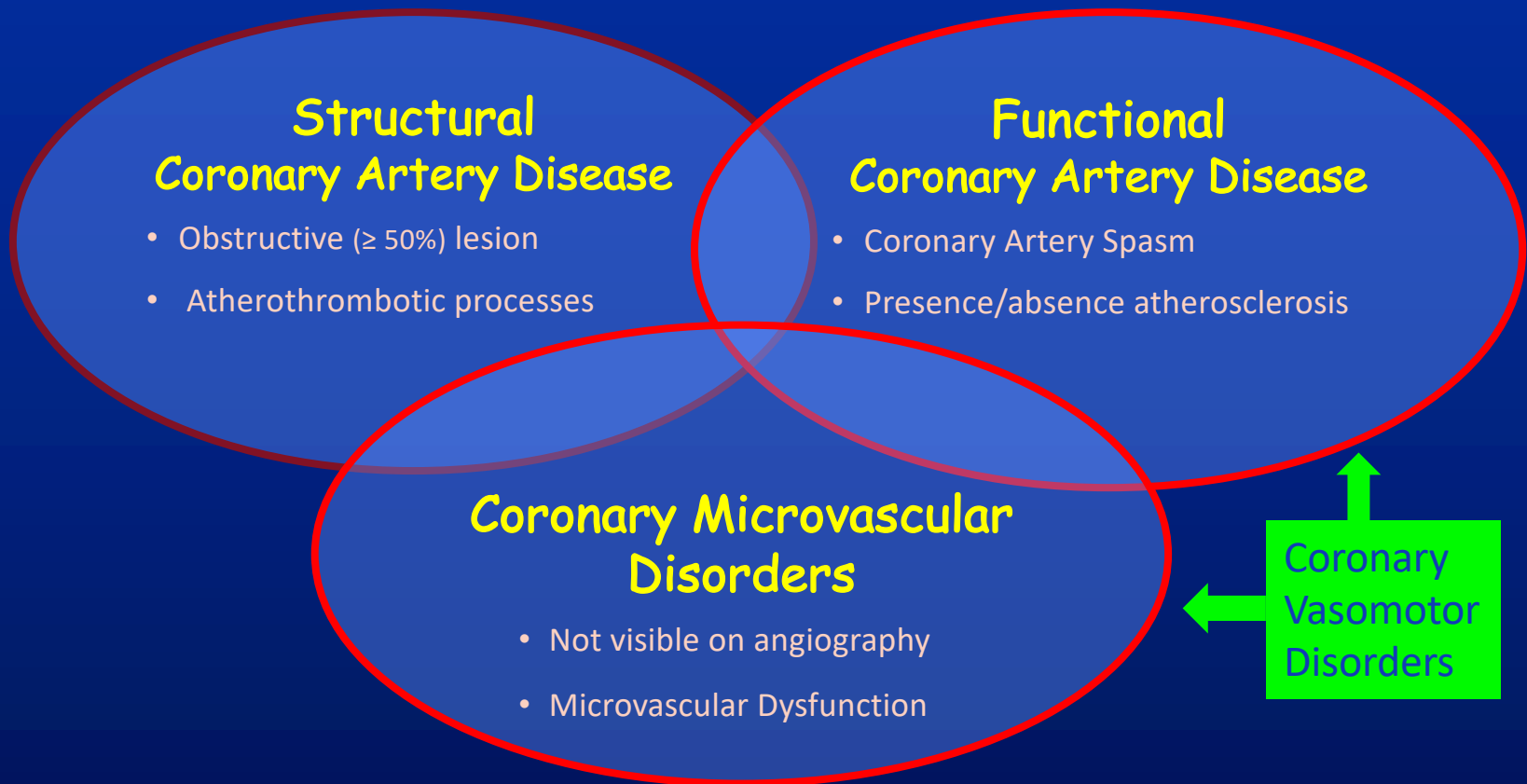
Structural Coronary Artery Disease

- Obstructive ($\geq 50\%$) lesion
- Atherothrombotic processes

Functional Coronary Artery Disease

- Coronary Artery Spasm
- Presence/absence atherosclerosis

Expanding the Clinical Paradigm



Beyond Structural Angiography

The Emergence of Functional Angiography

Comprehensive Coronary Evaluation of Suspected Cardiac Pain

Structural Coronary Angiography

Macrovascular
(Epicardial)
Dysfunction

- *Is there a tight stenosis?*
(check for late filling vessels - collaterals)
- *What are the lesion characteristics?*
(IVUS / OCT)
- *Is there a muscle bridge?*

Microvascular
Dysfunction

- *Is there impaired contrast flow?*
(TIMI-2 flow / TIMI Frame Count)

IVUS = Intravascular Ultrasound, OCT = Optical Coherence Tomography, iv = intravenous, ic = intracoronary, ACh = Acetylcholine

Beyond Structural Angiography

The Emergence of Functional Angiography

Comprehensive Coronary Evaluation of Suspected Cardiac Pain

	Structural Coronary Angiography	Functional Coronary Angiography
Macrovascular (Epicardial) Dysfunction	<ul style="list-style-type: none"> • <i>Is there a tight stenosis?</i> (check for late filling vessels - collaterals) • <i>What are the lesion characteristics?</i> (IVUS / OCT) • <i>Is there a muscle bridge?</i> 	<ul style="list-style-type: none"> • <i>Is the stenosis obstructive?</i> (Fractional Flow Reserve) • <i>Is the stenosis fixed or dynamic?</i> (lesion response to ic nitrates) • <i>Is there inducible spasm?</i> (>90% constriction to icACh bolus)
Microvascular Dysfunction	<ul style="list-style-type: none"> • <i>Is there impaired contrast flow?</i> (TIMI-2 flow / TIMI Frame Count) 	<ul style="list-style-type: none"> • <i>Is there appropriate microvascular hyperemia?</i> (iv adenosine – Coronary Flow Reserve, Microvascular Resist) • <i>Is there inappropriate microvascular constrictor?</i> (icACh bolus – ischemia in absence of epicardial spasm)

IVUS = Intravascular Ultrasound, OCT = Optical Coherence Tomography, iv = intravenous, ic = intracoronary, ACh = Acetylcholine

Functional Coronary Angiography Protocol

1. Coronary Angiogram Imaging

- *Structural:* Exclude obstructive CAD (no stenosis \geq 50%)
- *Dynamic:* Coronary Slow Flow, Myocardial Bridge

2. Coronary Hyperaemic Indices (Adenosine)

- *Large Vessel:* Intermediate Coronary Stenosis (FFR)
- *Microvessels:* Microvascular Angina (CFR, iMR, hMR)

3. Coronary Spasm Provocation (ACh bolus)

- *Inducible Coronary Spasm:* Vasospastic Angina
- *No inducible Coronary Spasm:* Microvascular Spasm

4. Coronary Endothelial Function (ACh infusion)

- *Mechanism:* Endothelial integrity
 - *Prognosis:* Endothelial function studies
-

Value of Functional Angiography

- **Diagnostic Value** – is there a cardiac abnormality?
- **Pathophysiological Value** – macro vs microvascular?
- **Prognostic Value** – guarded prognosis?
- **Therapeutic Value** – identify target?



Value of Functional Angiography

Diagnostic Guideline Recommendations

ESC Chronic Coronary Syndrome

• **Ia Recommendation**

- *Guidewire-base CFR or microcirculatory resistance* measurements should be considered in patients with persistent symptoms, but coronary arteries that are either angiographically normal or moderate stenoses with preserved FFR.
- *Intracoronary acetylcholine* with ECG monitoring may be considered during angiography, if coronary arteries are either angiographically normal or have moderate stenoses with preserved FFR, to assess microvascular vasospasm.

AHA/ACC Chest Pain Evaluation

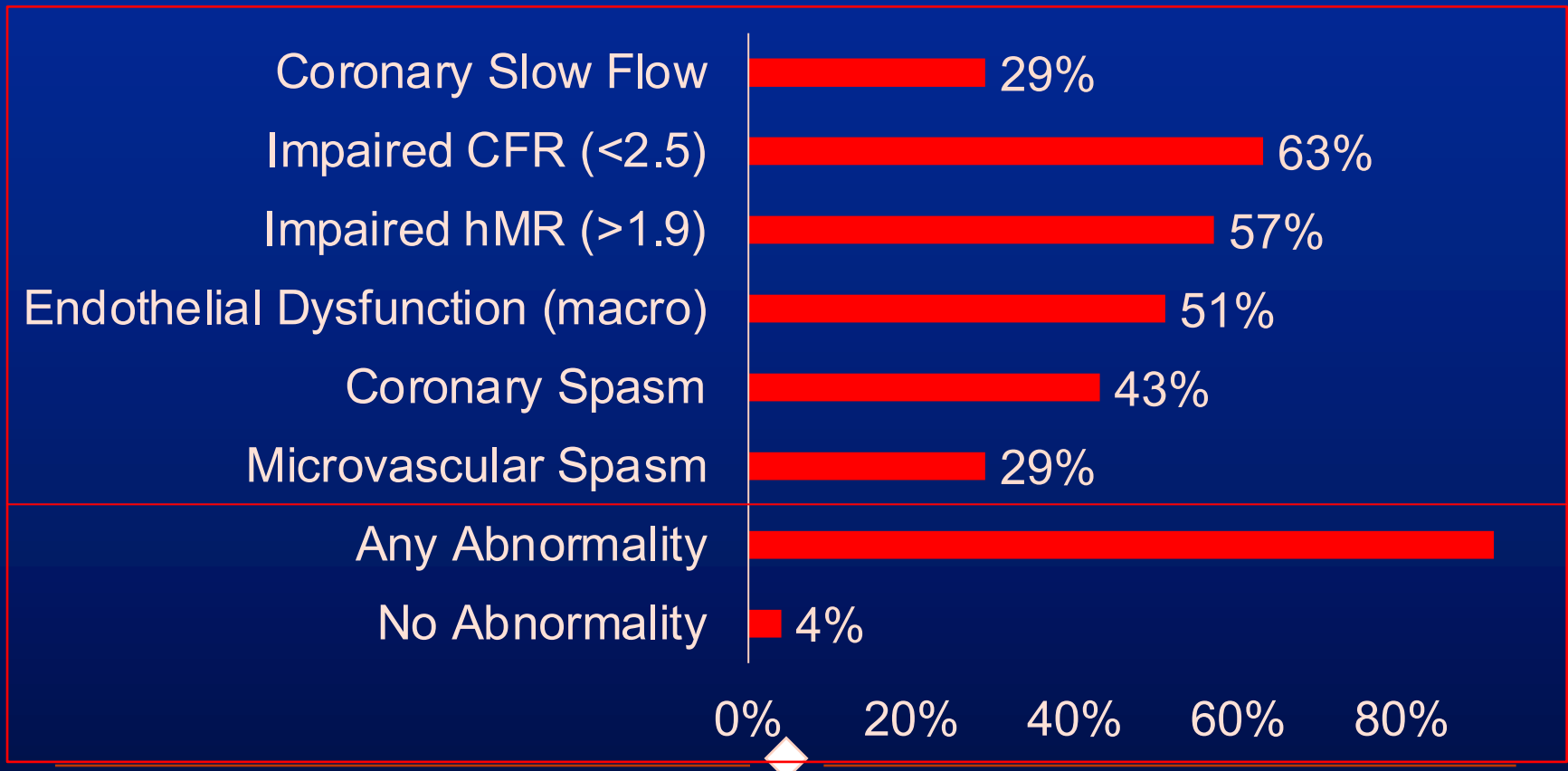
• **Ia Recommendation** (Evidence-B)

- For patients with persistent stable chest pain and nonobstructive CAD and at least mild myocardial ischemia on imaging, it is reasonable to consider *invasive coronary function testing* to improve the diagnosis of coronary microvascular dysfunction and to enhance risk stratification.

Value of Functional Angiography

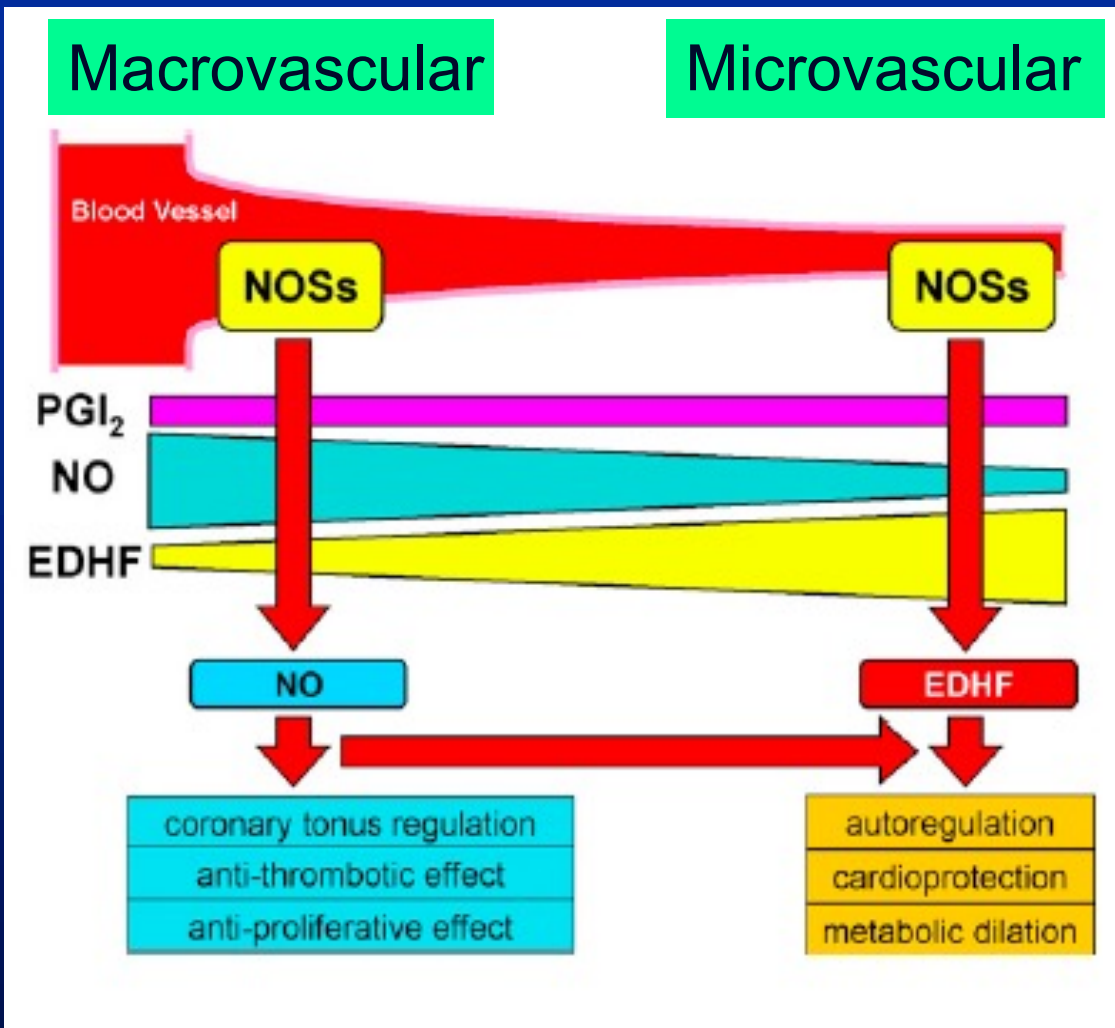
Diagnostic Value

- 49 pts with angina and non-obstructive CAD
- Angio, pressure-Doppler sensor guidewire, ACh test



Value of Functional Angiography

Pathophysiological Value



Pathophysiological Insights

• Vascular Site:

- Macrovascular
- Microvascular
- Both

• Nature of Dysfunction:

- Hyperconstriction
- Impaired Dilation
- Both

Value of Functional Angiography

Prognostic Value

Japanese Coronary Spasm Association Risk Score

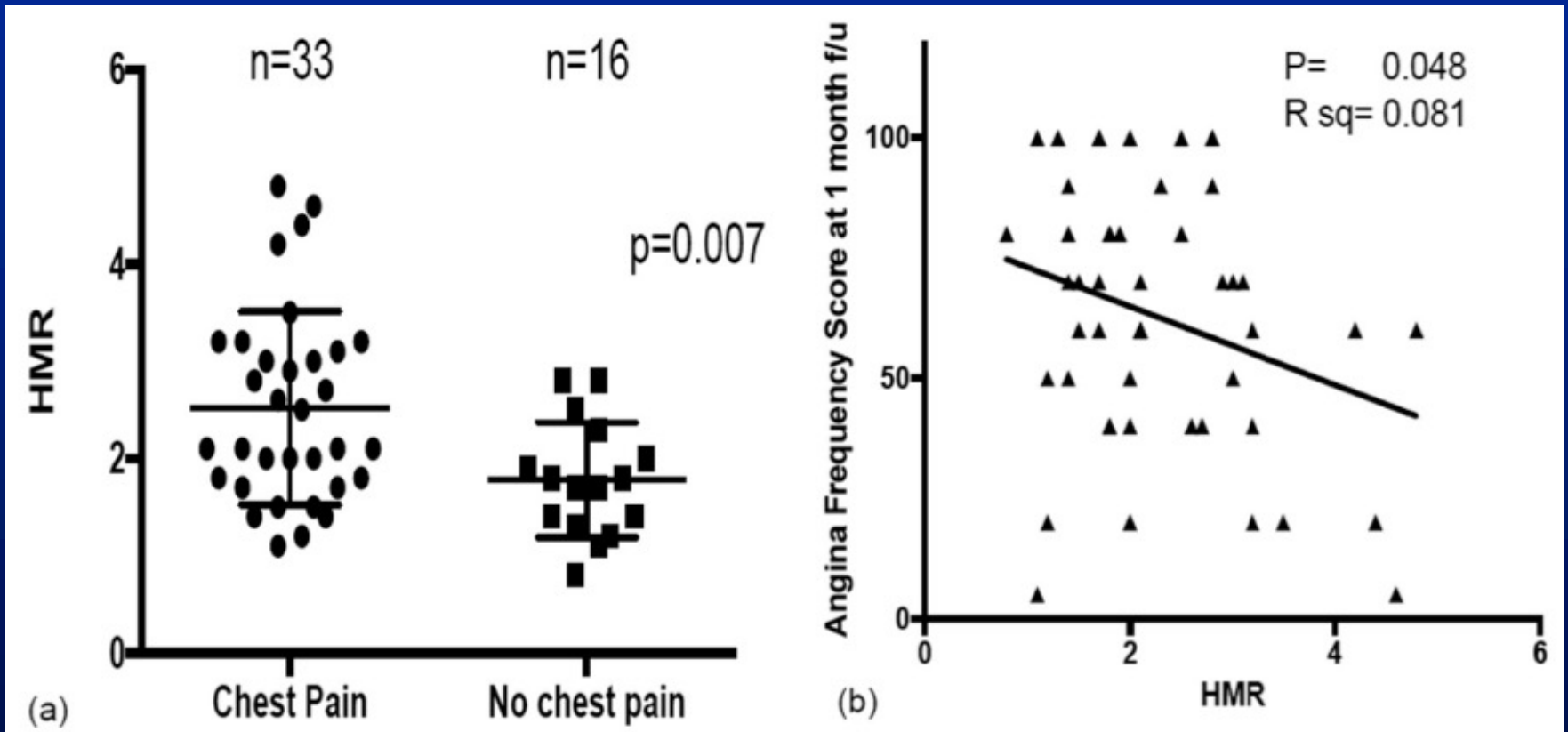
- 1,429 vasospastic angina pts followed for median period of 32mths
- MACE Predictors (cardiac death, non-fatal MI, appropriate ICD shock)
 - Low Risk (0-2): 0.5% MACE/5yrs
 - Intermediate Risk (3-5): 0.8% MACE/5yrs
 - High Risk 6-9): 3.1% MACE/5yrs

Table 3. Coronary Spasm Association Risk Score

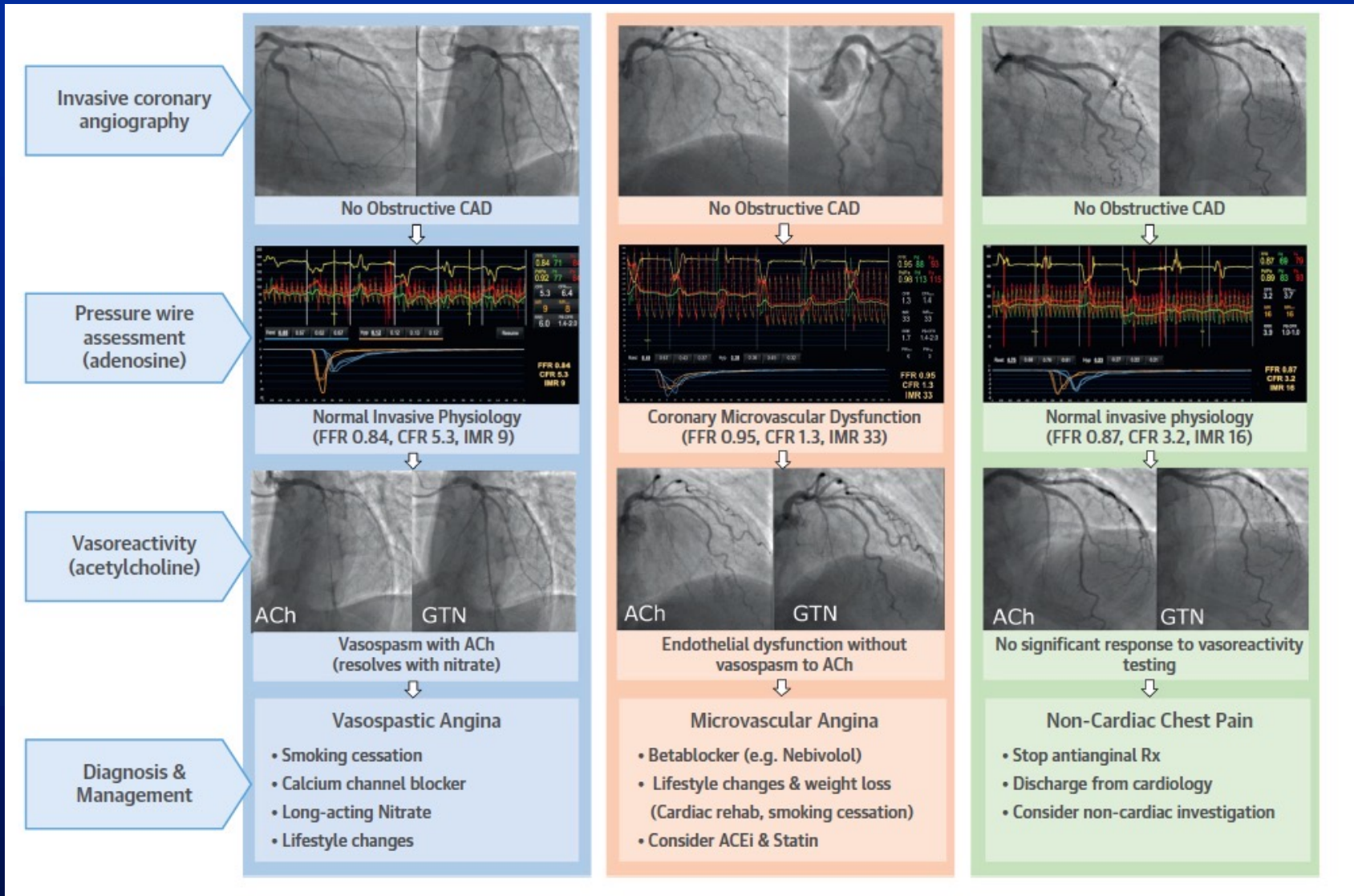
Clinical determinant	Hazard ratio (95% CI)	Assigned score
Out-of-hospital cardiac arrest	3.79 (1.61–8.94)	4
Significant organic stenosis	2.24 (1.33–3.78)	2
Rest angina alone	1.71 (1.08–2.72)	2
Smoking	1.71 (1.04–2.79)	2
Multivessel spasm	1.69 (1.03–2.78)	2
ST elevation during angina attack	1.54 (0.95–2.50)	1
Use of β -blockers	2.00 (0.88–4.54)	1

Value of Functional Angiography Prognostic Value

- Functional coronary angiography for chest pain (n=49)
- Predictors of chest pain at 30-days: Previous unstable angina
hMR



Value of Functional Angiography Therapeutic Value



Interventional Cardiologist Role

- Unique diagnostic role (not provided by other subspecialties)
- Beyond Structural Angiography → Functional Angiography
- Comprehensive coronary evaluation of chest pain mechanism:
 - INOCA
 - MINOCA
 - Secondary Coronary Vasomotor Dysfunction
 - Obstructive CAD
 - Cardiomyopathies
 - Other
- Improve Patient Outcome:
 - Confirm Diagnosis
 - Prognostic Implications
 - Guide therapy

