Treatment and imaging strategies in STEMI: what’s new in the ESC 2017 guidelines?

Ioannis Iakovou, MD, PhD

Associate Director

Catheterization Laboratory

Onassis Cardiac Surgery Center

Athens, Greece
### What is new in 2017 Guidelines on AMI-STEMI

<table>
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<tr>
<th>2012</th>
<th>CHANGE IN RECOMMENDATIONS</th>
<th>2017</th>
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What is new in 2017 Guidelines on AMI-STEMI (continued)

2017 NEW RECOMMENDATIONS

- Additional lipid lowering therapy if LDL >1.8 mmol/L (70 mg/dL) despite on maximum tolerated statins. **IMPROVE-IT, FOURIER**

- Complete revascularization during index primary PCI in STEMI patients in shock. **Expert opinion**

- Cangrelor if P2Y<sub>12</sub> inhibitors have not been given. **CHAMPION**

- Switch to potent P2Y<sub>12</sub> inhibitors 48 hours after fibrinolysis. **Expert opinion**

- Extend Ticagrelor up to 36 months in high-risk patients. **PEGASUS-TIMI 54**

- Use of polypill to increase adherence. **FOCUS**

- Routine use of deferred stenting. **DANAMI 3-DEFER**

## Procedural aspects of the primary percutaneous coronary intervention strategy

<table>
<thead>
<tr>
<th>Recommendations</th>
<th>Class</th>
<th>Level</th>
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<tbody>
<tr>
<td>IRA technique <em>(continued)</em></td>
<td></td>
<td></td>
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<tr>
<td>Routine use of thrombus aspiration is not recommended.</td>
<td>III</td>
<td>A</td>
</tr>
<tr>
<td>Routine use of deferred stenting is not recommended.</td>
<td>III</td>
<td>B</td>
</tr>
<tr>
<td>Non-IRA strategy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Routine revascularization of non-IRA lesions should be considered in STEMI patients with multivessel disease before hospital discharge.</td>
<td>IIA</td>
<td>A</td>
</tr>
<tr>
<td>Non-IRA PCI during the index procedure should be considered in patients with cardiogenic shock.</td>
<td>IIA</td>
<td>C</td>
</tr>
<tr>
<td>CABG should be considered in patients with ongoing ischaemia and large areas of jeopardized myocardium if PCI of the IRA cannot be performed.</td>
<td>IIA</td>
<td>C</td>
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ESC Guidelines for the management of acute coronary syndromes in patients presenting without persistent ST-segment elevation

The Task Force for the management of acute coronary syndromes (ACS) in patients presenting without persistent ST-segment elevation of the European Society of Cardiology (ESC)

Data from the Thrombolysis In Myocardial Infarction (TIMI)-3B\textsuperscript{42} and Fragmin during Instability in Coronary Artery Disease-2 (FRISC-2)\textsuperscript{43} studies show that 30–38\% of patients with unstable coronary syndromes have single-vessel disease and 44–59\% have multivessel disease (>50\% diameter stenosis). The incidence of left main narrowing varies from 4\% to 8\%. 
Complete revascularization

<table>
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<tr>
<th>Study ID</th>
<th>RR (95% CI)</th>
<th>% Weight</th>
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<tr>
<td>ARTS I CABG</td>
<td>0.57 (0.19, 1.72)</td>
<td>0.53</td>
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<tr>
<td>ARTS I PCI</td>
<td>0.49 (0.17, 1.43)</td>
<td>0.56</td>
</tr>
<tr>
<td>ARTS II PCI</td>
<td>0.63 (0.32, 1.24)</td>
<td>1.25</td>
</tr>
<tr>
<td>Asian Medical Center CABG cohort</td>
<td>1.39 (0.81, 2.39)</td>
<td>1.72</td>
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<tr>
<td>Asian Medical Center PCI cohort</td>
<td>0.69 (0.47, 1.02)</td>
<td>2.58</td>
</tr>
<tr>
<td>SYNTAX CABG</td>
<td>0.86 (0.52, 1.43)</td>
<td>1.86</td>
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<tr>
<td>SYNTAX PCI</td>
<td>0.74 (0.49, 1.14)</td>
<td>2.32</td>
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<tr>
<td>MASS II CABG</td>
<td>0.84 (0.51, 1.39)</td>
<td>1.89</td>
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<tr>
<td>MASS II PCI</td>
<td>0.66 (0.37, 1.17)</td>
<td>1.60</td>
</tr>
<tr>
<td>Jones et al.</td>
<td>0.56 (0.47, 0.68)</td>
<td>4.40</td>
</tr>
<tr>
<td>Scott et al.</td>
<td>0.64 (0.57, 0.71)</td>
<td>5.09</td>
</tr>
<tr>
<td>BARI</td>
<td>0.94 (0.62, 1.33)</td>
<td>3.29</td>
</tr>
<tr>
<td>Kleiisi et al.</td>
<td>0.37 (0.29, 0.48)</td>
<td>3.76</td>
</tr>
<tr>
<td>Rastan et al.</td>
<td>0.93 (0.81, 1.07)</td>
<td>4.84</td>
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<tr>
<td>Kozower et al.</td>
<td>0.81 (0.71, 0.93)</td>
<td>4.87</td>
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<tr>
<td>Caputo et al.</td>
<td>0.43 (0.27, 0.66)</td>
<td>2.23</td>
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<tr>
<td>Osswald et al.</td>
<td>0.60 (0.42, 0.85)</td>
<td>2.87</td>
</tr>
<tr>
<td>Mohammadi et al.</td>
<td>0.90 (0.67, 1.21)</td>
<td>3.37</td>
</tr>
<tr>
<td>BARI trial and registry</td>
<td>0.78 (0.54, 1.13)</td>
<td>2.73</td>
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<tr>
<td>BARI Bourassa et al.</td>
<td>0.77 (0.55, 1.08)</td>
<td>3.02</td>
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<td>Ijsseimuiden et al.</td>
<td>2.74 (0.75, 10.06)</td>
<td>0.40</td>
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<td>New York State registry</td>
<td>0.78 (0.71, 0.85)</td>
<td>5.25</td>
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<td>New York State registry II</td>
<td>0.67 (0.58, 0.79)</td>
<td>4.57</td>
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<td>Valenti et al.</td>
<td>0.37 (0.21, 0.64)</td>
<td>1.66</td>
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<tr>
<td>AQUITY Rosner et al.</td>
<td>0.70 (0.45, 1.11)</td>
<td>2.14</td>
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<tr>
<td>Nikolsky et al.</td>
<td>0.42 (0.21, 0.86)</td>
<td>1.15</td>
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<tr>
<td>Tamburino et al.</td>
<td>0.39 (0.15, 0.84)</td>
<td>0.81</td>
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<tr>
<td>Mariani et al.</td>
<td>0.64 (0.03, 13.11)</td>
<td>0.08</td>
</tr>
<tr>
<td>NHLBI dynamic registry</td>
<td>1.18 (0.66, 2.14)</td>
<td>1.50</td>
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<tr>
<td>Kloeter et al.</td>
<td>0.21 (0.01, 4.02)</td>
<td>0.08</td>
</tr>
<tr>
<td>CABRI</td>
<td>1.07 (0.38, 3.00)</td>
<td>0.61</td>
</tr>
<tr>
<td>Jones et al. II</td>
<td>0.80 (0.71, 0.89)</td>
<td>5.08</td>
</tr>
<tr>
<td>New York State registry III</td>
<td>0.89 (0.82, 0.98)</td>
<td>5.25</td>
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<td>Yang et al.</td>
<td>1.10 (0.29, 4.18)</td>
<td>0.38</td>
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<td>McNeer et al.</td>
<td>0.71 (0.56, 0.89)</td>
<td>3.99</td>
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<td>Norwa-Otto et al.</td>
<td>0.94 (0.69, 1.30)</td>
<td>3.16</td>
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<td>Appleby et al.</td>
<td>0.59 (0.53, 0.66)</td>
<td>5.10</td>
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<td>Tyras et al.</td>
<td>0.60 (0.44, 0.81)</td>
<td>3.26</td>
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<td>Deligonul et al.</td>
<td>0.93 (0.37, 2.35)</td>
<td>0.73</td>
</tr>
<tr>
<td>Overall (I-squared = 71.8%, p = 0.000)</td>
<td>0.71 (0.66, 0.78)</td>
<td>100.00</td>
</tr>
</tbody>
</table>

NOTE: Weights are from random effects analysis

Santiago Garcia et al. JACC 2013;62:1421-1431

Cardiovascular Imaging 2018, Athens May 19th
The SMILE trial

584 NSTEMI patients were randomly assigned in a 1:1 manner to 1S-PCI or MS-PCI

Usually we have no ischemia information at time of culprit PCI

Sardella et al, JACC 2016;67:264

Cardiovascular Imaging 2018, Athens May 19th
We’re not very good at guessing the physiology from the angiogram

213 patients with an angiographically equivocal left main coronary artery stenosis

Hamilos M et al. Circulation 2009;120:1505-1512
The Severity of Non-culprit Lesions at the Time of the Acute Event

Exaggeration of Nonculprit Stenosis Severity During Acute Myocardial Infarction: Implications for Immediate Multivessel Revascularization

Colm G. Hanratty, MD, MRCP,* Yutaka Koyama, MD,* Helge H. Rasmussen, FRACP, DMSc,*† Greg I. C. Nelson, FRACP,*† Peter S. Hansen, PhD, FRACP,*† Michael R. Ward, PhD, FRACP†

Sydney, Australia

548 patients with AMI (321 with multivessel disease), 112 had additional angiography; of these 48 had 59 lesions suitable for analysis

21% of patients had lesions >50% at AMI that were <50% at non-AMI angiography.

80 were randomised to early FFRguided PCI (invasive group), and 41 to medical treatment (conservative group).

• FFR negative in 40% of “significant” lesions (Euro Intervention 2010;5:968)
Physiology in STEMI

- Suboptimal setting for coronary physiology
- Available data suggest increase in resting flow and attenuation of hyperemic response
- iFR overestimates lesion severity
  - "treat to many lesions"
- FFR underestimates lesion severity
  - "miss significant lesions"

de Waard et al. JACCci 2016
Van der Hoeven et al. 2017 TCT
Limitations

Luminogram


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Limitations of Coronary Angiography

Coronary Cross-section

Angiogram Silhouette

75%

25%
Limitations of Coronary Angiography

Focal Disease

Diffuse Disease

Angiogram Silhouette

50% Lesion

50% Lesion
Intravascular Imaging Modalities

- **Intravascular Ultrasound**
  - IVUS grey scale
  - IVUS-VH or iMAP
  - Palpography
  - IVUS-Near-Infra Red Spectroscopy (Apollo catheter)
- **Angioscopy**
- **Optical Coherence Tomography**
  - 1st generation OCT systems (Time-domain OCT)
  - 2nd generation OCT system (Fourier-domain OCT)
## Comparison of Imaging Modalities

<table>
<thead>
<tr>
<th>Imaging Modality</th>
<th>Resolution</th>
<th>Fibrous Cap</th>
<th>Lipid Core</th>
<th>Calcium</th>
<th>Thrombus</th>
</tr>
</thead>
<tbody>
<tr>
<td>IVUS</td>
<td>100µm</td>
<td>+</td>
<td>++</td>
<td>+++</td>
<td>+</td>
</tr>
<tr>
<td>Angioscopy</td>
<td>Unknown</td>
<td>+</td>
<td>++</td>
<td>−</td>
<td>+++</td>
</tr>
<tr>
<td>OCT</td>
<td>10µm</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
<td>++</td>
</tr>
<tr>
<td>Spectroscopy</td>
<td>not applicable</td>
<td>+</td>
<td>++</td>
<td>++</td>
<td>−</td>
</tr>
</tbody>
</table>

+++ = Sensitivity > 90%; ++ = Sensitivity 80~90%; + = Sensitivity 50~80%; − = Sensitivity < 50%

Arterioscler Thromb Vasc Boil. 2003;23:1333-1342
Clinical questions in ACS and AMI

• Pre-intervention lesion assessment (ie., what is the culprit?)

• What is the likelihood of embolization during stent implantation?

• Is this “other” lesion a vulnerable plaque that is at risk for future events?

• How do I optimize acute stent results (size, length, expansion, edge coverage)?

• Why did this stent thrombose or restenose?
Advantage:
- Reveals the morphology of the plaque
- Differs between soft (hypo-echoic) and Hard (hyper-echoic) plaques

Disadvantages:
- Doesn’t give information about plaque inflammation or thrombus
- Low spatial resolution (~ 200 μm)
Basic IVUS Measurements

- External elastic membrane CSA (equivalent to the total arterial CSA, measured by tracing the leading edge of the hyper echoic adventitia)
- Reference lumen CSA
- Final lumen (stent) CSA
- Cross-sectional narrowing (plaque burden or %plaque area) = \( \frac{P+M}{EEM} \) CSA, \([plaque+media (P+M) \text{ CSA} = EEM - \text{stent CSA}].\)
- Area Stenosis = (reference - lesion) lumen CSA / reference lumen CSA
- Arc of calcium

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IVUS Guided LM-Bifurcation PCI

Index procedure PPCI @ RCA

62 y, male, with ACS
IVUS Guided Bifurcation PCI
Case 3 provisional stenting

- IVUS (Atlantis pro 40 MHz) in both vessels
- Predilatation: Across HP 3.0 x 15 (16)
- Promus 4.0 x 24 (16)
- Post stenting IVUS → Postdilatation → Quantum 4.0 x 12 (16-18)
- FKBI
IVUS Guided Bifurcation PCI
Case 3
Final result

@1 y-FU pt is asymptomatic with neg EST
# Predictors of DES Thrombosis & Restenosis

<table>
<thead>
<tr>
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<th>DES Thrombosis</th>
<th>DES Restenosis</th>
</tr>
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<tbody>
<tr>
<td>(CSA &lt;5 mm²)</td>
<td>• Okabe et al., Am J Cardiol. 2007;100:615-20</td>
<td>• Hong et al. Eur Heart J 2006;27:1305-10</td>
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<td><strong>Edge pathology (5)</strong></td>
<td>• Fujii et al. J Am Coll Cardiol 2005;45:995-8)</td>
<td>• Liu et al, Am J Cardiol, in press</td>
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<td>(geographic miss,</td>
<td>• Okabe et al., Am J Cardiol. 2007;100:615-20</td>
<td>• Costa et al, Am J Cardiol, 2008;101:1704-</td>
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<td>secondary lesions,</td>
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<td>large plaque burden)</td>
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ADAPT DES
Relationship between IVUS Use and Definite or Probable ST within 1 Year

- 8,583 consecutive pts at 11 international centers, IVUS was used in 3,349
Gray Scale vs. Virtual Histology

Color Coding Scheme

Calcified  Fibrous  Fibro-Lipidic  Lipidic-Necrotic
Change in non-culprit lesion phenotype in 106 pts (201 lesions) with plaque burden >40% from the Global VH Registry with baseline and 8-month F/U

Pathological intimal thickening (PIT)  Thin-cap fibroatheroma (TCFA)  Thick-cap fibroatheroma (ThFA)  Fibrotic  Fibrocalcific

75% of TCFAs healed, 25% remained unchanged (mostly proximal in location), and 12 new TCFAs were noted.

Kubo et al. AHA 2008
Cardiovascular Imaging 2018, Athens May 19th
Near-infrared Spectroscopy for VP Detection

• NIR spectroscopy is a well-validated method frequently used to assess chemical composition.

• Laser, fiber-optic, and chemometric technologies make intra-coronary use feasible.

• 3.2Fr IVUS-like rapid-exchange coronary catheter

• Can scan artery through blood

• 5 msec spectra acquisition

• Identifies chemical composition of vessel wall
  – TCFA sensitivity and specificity > 85% in autopsy specimens
  – In 2006 lipid spectra detected in an MI patient and in HC Swine studyaria
Angioscopy

• Perhaps the best technique for assessing thrombus
• Also useful for assessing stent neointimal coverage

(Kubo et al. J Am Coll Cardiol 2007;50:933-9)
(Kubo et al. J Am Coll Cardiol 2007;50:933-9)
Optical Coherence Tomography (OCT) is a high-resolution imaging technology that employs near-infrared light to probe micrometer-scale structures inside biological tissues.
Optical Coherence Tomography (OCT)

**Advantage:**
- Very high-resolution

**Disadvantages:**
- Limited penetration
OCT
- Indications in ACS treatment

- **Stent evaluation:**
  - **Immediate:** malapposition, dissections / ruptures, thrombus, protrusion...
  - Mid-long term: thrombus, endothelization, intimal hyperplasia
OCT IVUS-like guidance Bifurcation PCI

Proximal dissection

Taxus 3.5/20 mm

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OCT in ACS pts treated with 2nd gen DES

Prospective Registry

13 pts treated with 19 stents for ACS with MV disease

Xience V
N=11

Biomatrix
N=3

Nobori
N=2

Endeavor
Resolute
N=3

Primary end-point: proportion of stent struts uncovered and/or malapposed in OCT at 110 (48-343) days (staged procedure)

QCA @ baseline, and OCT @ staged procedure by 2 independent readers (AA & KI)

* All patients in dual antiplatelet therapy

Cardiovascular Imaging 2018, Athens May 19th  Iakovou et al EuropCR 2013
1841 struts were included in the analysis after exclusion of struts overlying side branches (n=45). A total of **1278 struts (69.4%) were covered** with neointima whereas **563 struts (30.6%) were uncovered**. There were **1755 struts (95.3%) with complete apposition** and **86 struts (4.7%) with incomplete apposition**.
Characteristics of Spasm Sites as Assessed by OCT in Patients With Vasospastic Angina

Fibrous Cap Disruption: Fibrous cap discontinuity with or without a cavity formed inside the plaque

OCT-defined Erosion: Underlying visualized plaque with intact fibrous cap, lumen irregularity and thrombus

Luminal irregularity

No luminal irregularity or thrombus

Eun-Seok Shin et al. JIMG 2015;8:1059-1067
80-year-old female patient with hypertension and hypercholesterolemia who presented with a NSTEMI.

Hannah Sinclair et al. JIMG 2015;8:198-209
Relationship of Fibrous Cap Thickness to Macrophage Infiltration

Renu Virmani et al. Circ
OCT for Vulnerable Plaque Detection

*Intimal Rupture*
OCT for Vulnerable Plaque Detection

Vulnerable Plaque

Thrombus

Thin cap

Necrotic Core

Cardiovascular Imaging 2018, Athens May 19th
The resolution of OCT is 10 times higher than that of IVUS.

OCT is capable of providing accurate coronary measurements.

OCT is more accurate than IVUS in detecting subtle stent morphologies including malapposition, residual thrombus, plaque prolapse, and residual dissections.

Further studies are needed to define the clinical value of OCT.

_Eur Heart J. 2014;35:2541-2619_
Normal vessel 2018

High resolution imaging allows clear delineation of healthy vessel layers

Chan et al JACC Intervn 2016

Cardiovascular Imaging 2018, Athens May 19th
Conclusions

• New AMI guidelines call for complete revasc.
• Intravascular imaging has become an integral part of interventional cardiology and is used frequently in ACS and AMI
• Choice of imaging modality is dependent upon the lesion and the question to be answered
• Comprehensive lesion assessment requires multimodality imaging
In clinical medicine when faced with a diagnostic or therapeutic decision, we must always choose the right tool for the right job. Invasive imaging is no different. None of the available tools is a single, all-in-one solution. All of them are important in specific situations. Physicians must learn to interpret and use these techniques correctly. The issues with IVUS – time, cost, expertise, etc – apply to all of the new modalities.
Thank you!!!

Email: ioannis.iakovou@gmail.com
Pyramid of Diagnostic Accuracy

- **FFR** 95%
- Contrast FFR 85%
- Resting Physiology (Pd/Pa, IFR) 80%
- Coronary Angiography 65%
- Coin Flip 50%

Increasing Accuracy (%) and Hyperemia

Johnson et al, J Am Coll Cardiol Intv 2016;9:757
Cardiovascular Imaging 2018, Athens May 19th
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Source: European Society of Cardiology

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- Complete revascularization during index primary PCI in STEMI patients in shock. Expert opinion

- Cangrelor if P2Y₁₂ inhibitors have not been given. **CHAMPION**
- Switch to potent P2Y₁₂ inhibitors 48 hours after fibrinolysis. Expert opinion
- Extend Ticagrelor up to 36 months in high-risk patients. **PEGASUS-TIMI 54**
- Use of polypill to increase adherence. **FOCUS**
- Routine use of deferred stenting. **DANAMI 3-DEFER**
Diagnostic test flow chart in MINOCA

SUSPECTED STEMI
ACUTE INVESTIGATION

Coronary stenosis ≥50%

Urgent angiography

No Coronary stenosis ≥50% + Fulfillment universal AMI criteria

Treat as STEMI

MINOCA

Acute LV wall motion assessment (angiogram/echo)

SUSPECTED DIAGNOSIS AND FURTHER DIAGNOSTIC TESTS

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<th>Invasive</th>
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<tr>
<td><strong>Myocarditis</strong></td>
<td><strong>Endomyocardial biopsy</strong> (myocarditis)</td>
</tr>
<tr>
<td>TTE Echo (Pericardial effusion)</td>
<td></td>
</tr>
<tr>
<td>CMR (Myocarditis, pericarditis)</td>
<td></td>
</tr>
<tr>
<td><strong>Coronary (epicardial)/microvascular</strong></td>
<td><strong>IVUS/OCT</strong> (Plaque disruption/dissection)</td>
</tr>
<tr>
<td>TTE Echo (Regional wall motion abnormalities, embolic source)</td>
<td>Ergonovine/Ach test (Spasm)</td>
</tr>
<tr>
<td>CMR (Small infarction)</td>
<td>Pressure/Doppler wire (Microvascular dysfunction)</td>
</tr>
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<td></td>
</tr>
<tr>
<td><strong>Myocardial disease</strong></td>
<td>****</td>
</tr>
<tr>
<td>TTE Echo</td>
<td></td>
</tr>
<tr>
<td>CMR (Takotsubo, others)</td>
<td></td>
</tr>
<tr>
<td><strong>Pulmonary Embolism</strong></td>
<td><strong>Blood test, Extracardiac investigation</strong></td>
</tr>
<tr>
<td>D-dimer (Pulmonary embolism)</td>
<td></td>
</tr>
<tr>
<td>CT scan (Pulmonary embolism)</td>
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</tr>
<tr>
<td>Thrombophilia screen</td>
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</tr>
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Oxygen supply/demand imbalance-Type 2 MI


Cardiovascular Imaging 2018, Athens May 19th
## Diagnostic test flow chart in MINOCA (continued)

### SUSPECTED DIAGNOSIS AND FURTHER DIAGNOSTIC TESTS

<table>
<thead>
<tr>
<th>Suspected Diagnosis</th>
<th>Non-invasive</th>
<th>Invasive</th>
</tr>
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<tr>
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<td>Endomyocardial biopsy (myocarditis)</td>
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## Diagnostic test flow chart in MINOCA (continued)

### SUSPECTED DIAGNOSIS AND FURTHER DIAGNOSTIC TESTS

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