ACC Guidelines for the Evaluation and Diagnosis of Chest Pain

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CHEST PAIN AND HEART DISEASE

- Heart disease is the **leading cause of death** for men & women.
- **One person dies every 34 seconds** from cardiovascular disease mainly for **Coronary heart disease**
- About **20.1 million adults** aged 20 and older have CAD (about 7.2%) and 2 in 10 deaths from CAD happen in adults less than 65 years old.

Centers for Disease Control and Prevention, National Center for Health Statistics. About Multiple Cause of Death, 1999–2020. CDC WONDER Online Database website. Atlanta, GA: Centers for Disease Control and Prevention; 2022. Accessed February 21, 2022.

Chest Pain

- Chest pain is one of the most common reasons for emergency department visits, accounting for over 7 million ED visits annually.
- It is one of the most challenging conditions to evaluate, which contributes to ED overcrowding, inefficient use of resources, and delays to diagnosis.
- A major challenge is to rapidly identify the small number of patients who have acute coronary syndrome or other life-threatening conditions among the large number who have more benign conditions, many of which are noncardiac.

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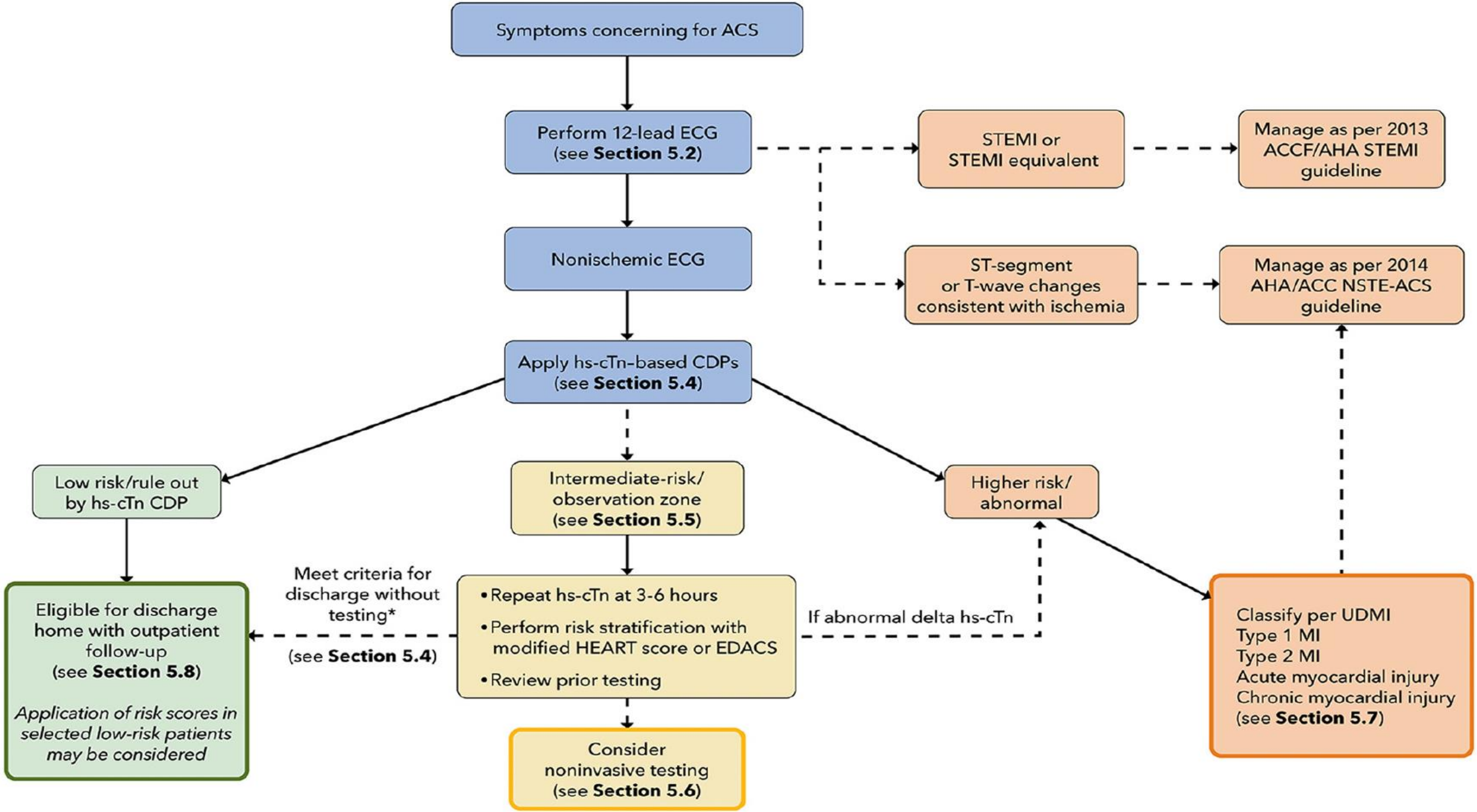
EXPERT CONSENSUS DECISION PATHWAY

2022 ACC Expert Consensus Decision Pathway on the Evaluation and Disposition of Acute Chest Pain in the Emergency Department

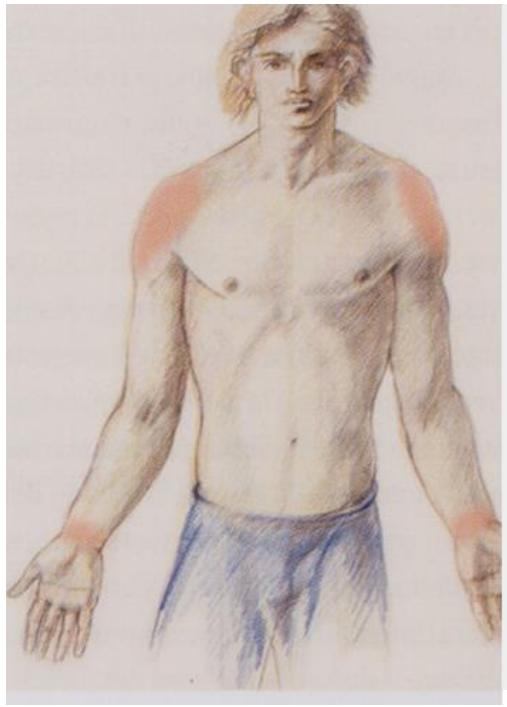

Symptoms concerning for ACS
Perform 12-lead ECG (see Section 5.2)
STEMI or STEMI equivalent
Manage as per 2013 ACCF/AHA STEMI guideline
Nonischemic ECG
ST-segment or T-wave changes consistent with ischemia
Manage as per 2014 AHA/ACC NSTE-ACS guideline
Apply hs-cTn–based CDPs (see Section 5.4)
Low risk/rule out by hs-cTn CDP
Intermediate-risk/ observation zone (see Section 5.5)
Higher risk/ abnormal
Eligible for discharge home with outpatient follow-up (see Section 5.8)
Application of risk scores in selected low-risk patients may be considered
Meet criteria for discharge without testing*
(see Section 5.4)
• Repeat hs-cTn at 3-6 hours
• Perform risk stratification with modified HEART score or EDACS
• Review prior testing
If abnormal delta hs-cTn
Classify per UDMI
Type 1 MI
Type 2 MI
Acute myocardial injury
Chronic myocardial injury
(see Section 5.7)
Consider noninvasive testing (see Section 5.6)

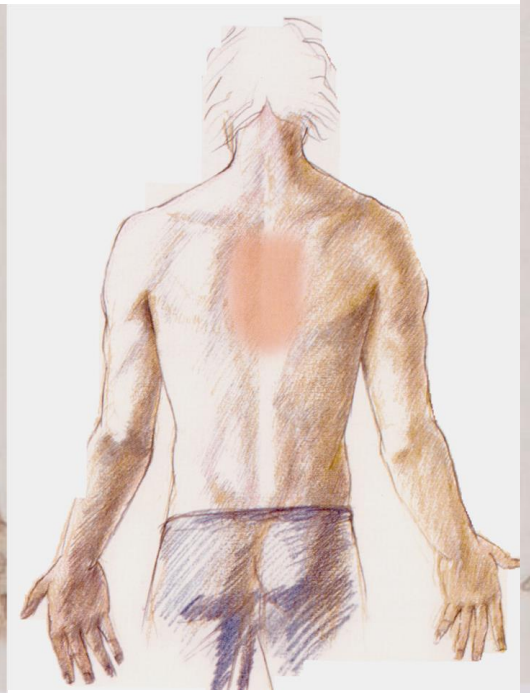
RULE # 1: SYMPTOM EVALUATION

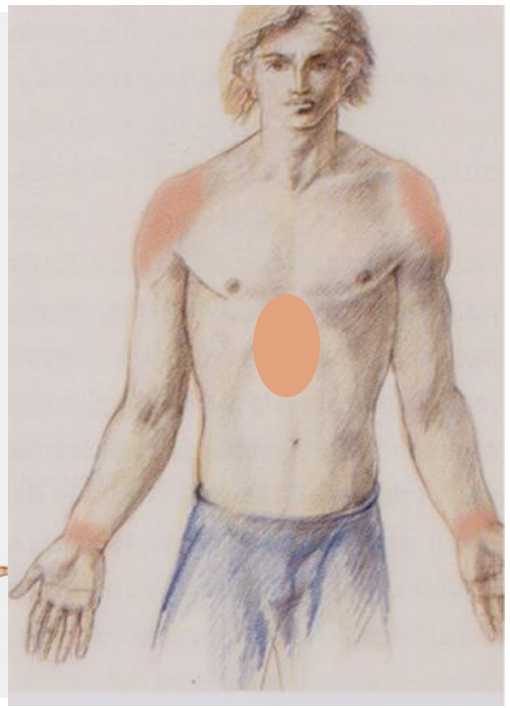
- CHEST PAIN IS CLASSIFIED AS:
  - CARDIAC.
  - POSSIBLE CARDIAC.
  - NON CARDIAC (AVOID ATYPICAL CHEST PAIN).

- *Clinical assessment should include the chest pain description and associated symptoms, onset, duration, location, radiation, and precipitating and relieving factors.*

Chest Pain Means More Than Pain in the Chest. Pain, pressure, tightness, or discomfort in the chest, shoulders, arms, neck, back, upper abdomen, or jaw, as well as shortness of breath and fatigue should all be considered anginal equivalents.

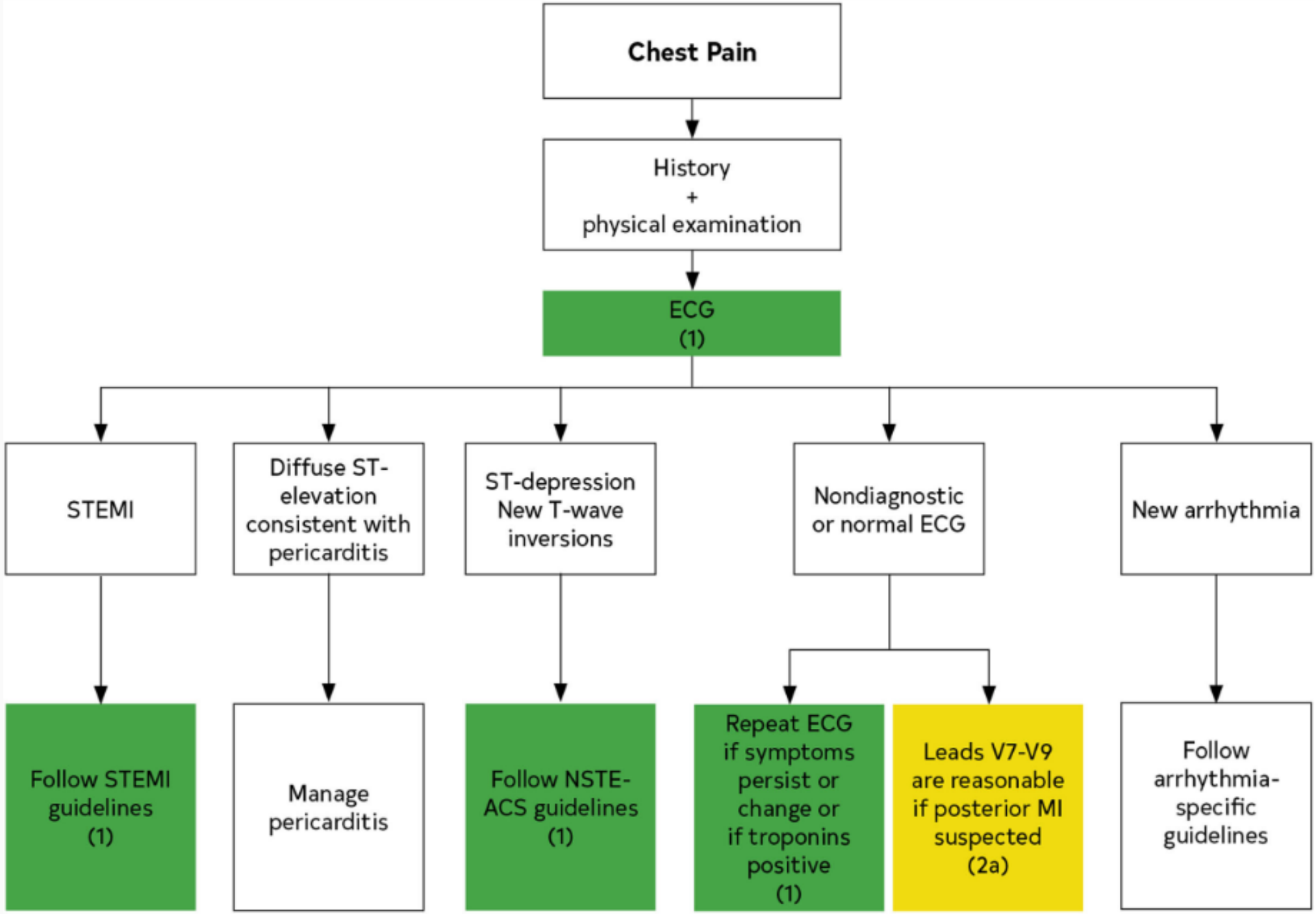




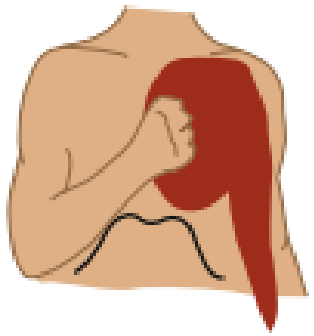


RULE # 2: Initial ECG Interpretation

- **The ECG is critical for the initial assessment and management of patients with potential ACS and therefore should be performed and interpreted within 10 minutes of arrival at the ED.**
- **The pre-hospital ECG is useful, because ischemic changes may have resolved before ED arrival.**
- **In the ED, the initial ECG should be examined for signs of ischemia, particularly for STEMI or a STEMI equivalent as this identifies patients who should undergo immediate reperfusion therapy.**


Chest Pain
History
+
physical examination
ECG
(1)
STEMI
Diffuse ST-elevation consistent with pericarditis
ST-depression New T-wave inversions
Nondiagnostic or normal ECG
New arrhythmia
Follow STEMI guidelines (1)
Manage pericarditis
Follow NSTE-ACS guidelines (1)
Repeat ECG if symptoms persist or change or if troponins positive (1)
Leads V7-V9 are reasonable if posterior MI suspected (2a)
Follow arrhythmia-specific guidelines

Early Care for Acute Symptoms. Patients with acute chest pain or chest pain equivalent symptoms should seek medical care immediately by calling 9-1-1. Although most patients will not have a cardiac cause, the evaluation of all patients should focus on the early identification or exclusion of life-threatening causes.



Activate EMS

Patient symptom onset of STEMI

EMS dispatch

EMS on scene
Encourage 12-lead ECGs
Consider prehospital fibrinolytic if capable and EMS-to-needle time ≤30 min

EMS triage plan

Hospital arrival

STEMI confirmed 12-lead ECG (≤10 min)

Hospital fibrinolysis: Door-to-needle time ≤30 min

Not PCI capable

Interhospital transfer

PCI capable

Goals

Patient	Dispatch	EMS on scene	EMS transport
5 min after symptom onset	1 min	≤8 min	EMS transport: EMS-device ≤90 min Patient self-transport: hospital door–to-device ≤90 min

Total ischemic time: <120 min

A

JAMA Cardiology | Brief Report

Multichannel Electrocardiograms Obtained by a Smartwatch for the Diagnosis of ST-Segment Changes

Carmen Anna Maria Spaccarotella, MD; Alberto Polimeni, MD, PhD; Serena Migliarino, MD; Elisa Principe, MD; Antonio Curcio, MD, PhD; Annalisa Mongiardo, MD; Sabato Sorrentino, MD, PhD; Salvatore De Rosa, MD, PhD; Ciro Indolfi, MD

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Supplemental content

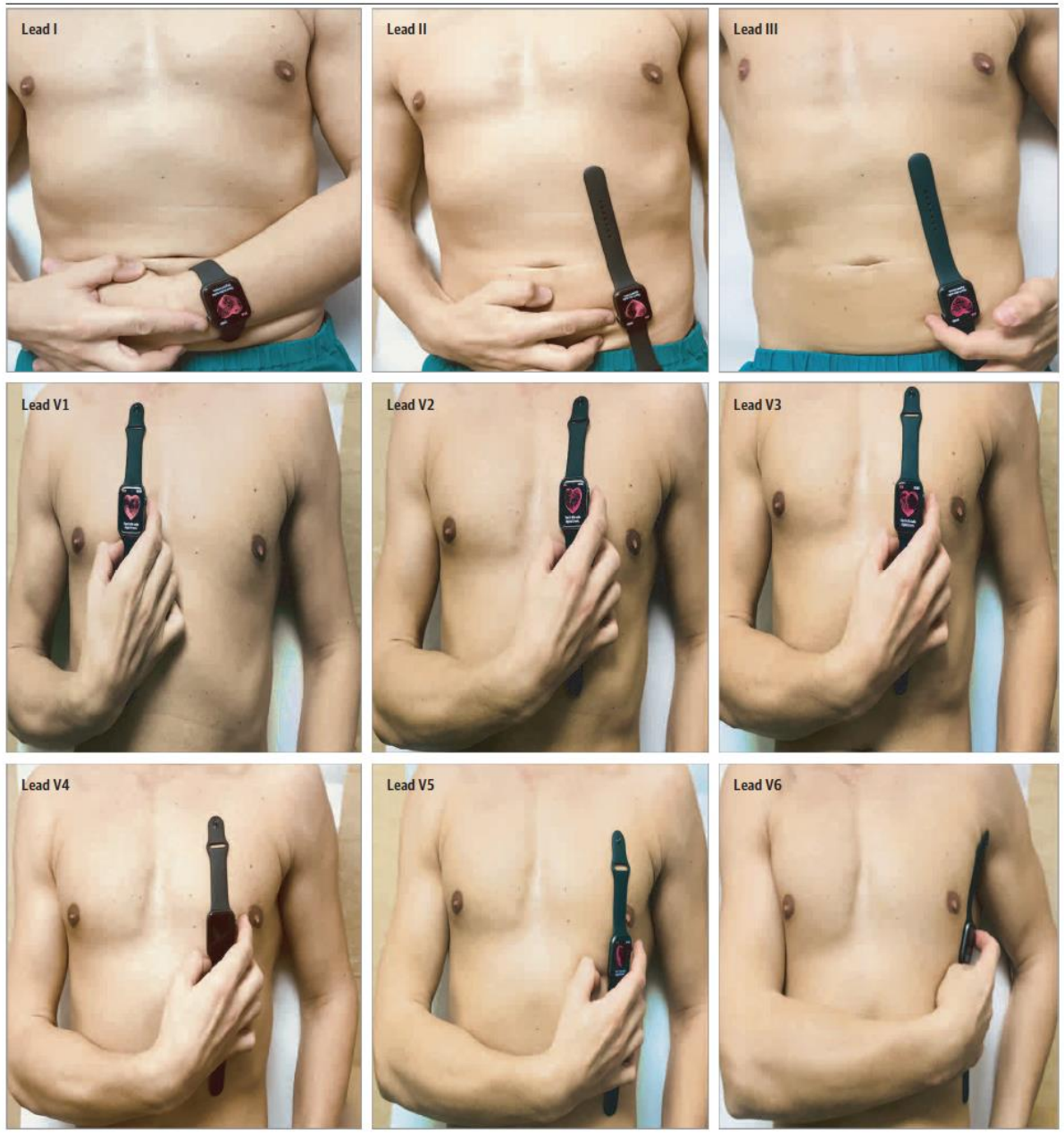
IMPORTANCE Acute coronary syndromes are the leading cause of death worldwide and the leading cause of disease burden in high-income countries. Quick and accurate diagnosis of acute coronary syndromes is essential to avoid fatal events, for timely intervention, and to improve the prognosis.

OBJECTIVE To prospectively investigate the feasibility and accuracy of a smartwatch in recording multiple electrocardiographic (ECG) leads and detecting ST-segment changes associated with acute coronary syndromes compared with a standard 12-lead ECG.

DESIGN, SETTING, AND PARTICIPANTS A commercially available smartwatch was used in 100 participants to obtain multiple-channel ECGs. The study was conducted from April 19, 2019, to January 23, 2020. Fifty-four patients with ST elevation myocardial infarction, 27 patients with non-ST elevation myocardial infarction, and 19 healthy individuals were included in the study. The watch was placed in different body positions to obtain 9 bipolar ECG tracings (corresponding to Einthoven leads I, II, and III and precordial leads V1-V6) that were compared with a simultaneous standard 12-lead ECG.

MAIN OUTCOMES AND MEASURES The concordance among the results of the smartwatch and standard ECG recordings was assessed using the Cohen κ coefficient and Bland-Altman analysis.

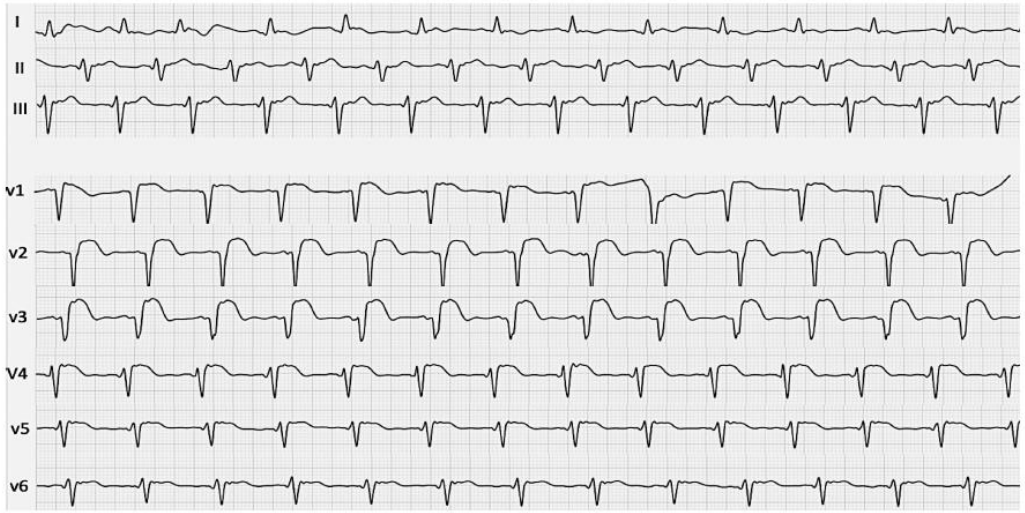
RESULTS Of the 100 participants in the study, 67 were men (67%); mean (SD) age was 61 (16) years. Agreement was found between the smartwatch and standard ECG for the identification of a normal ECG (Cohen κ coefficient, 0.90; 95% CI, 0.78-1.00), ST-segment elevation changes (Cohen κ coefficient, 0.88; 95% CI, 0.78-0.97), and non–ST-segment elevation changes (Cohen κ coefficient, 0.85; 95% CI, 0.74-0.96). In addition, the Bland-Altman analysis demonstrated agreement between the smartwatch and standard ECG to detect the amplitude of ST-segment changes (bias, −0.003; SD, 0.18; lower limit, −0.36; and upper limit, 0.36). Use of the smartwatch ECG for the diagnosis of normal ECG showed a sensitivity of 84% (95% CI, 60%-97%) and specificity of 100% (95% CI, 95%-100%); for ST elevation, sensitivity was 93% (95% CI, 82%-99%) and specificity was 95% (95% CI, 85%-99%); and for NSTE ECG alterations, sensitivity was 94% (95% CI, 81%-99%) and

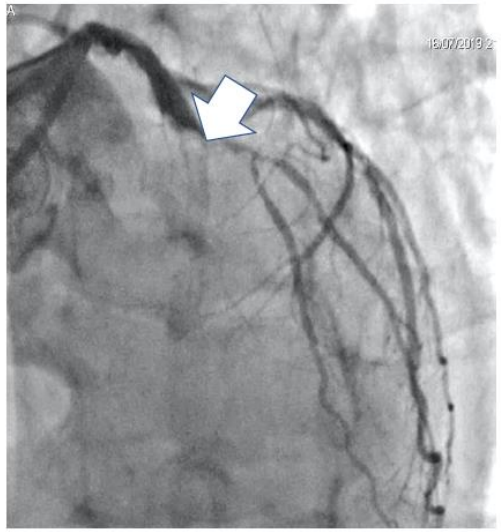


the ECG with smartwatch and standard ECG in STEMI

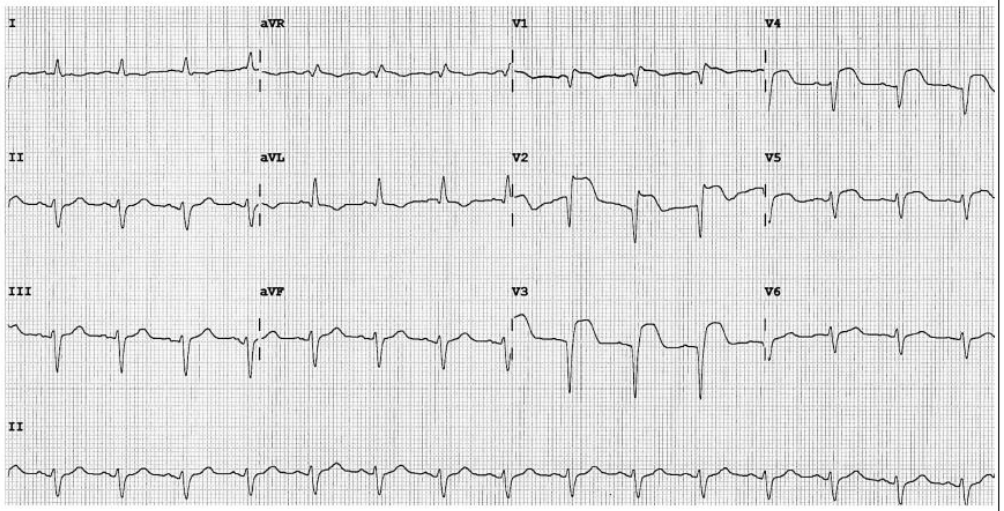
STEMI

SMARTWATCH ECG



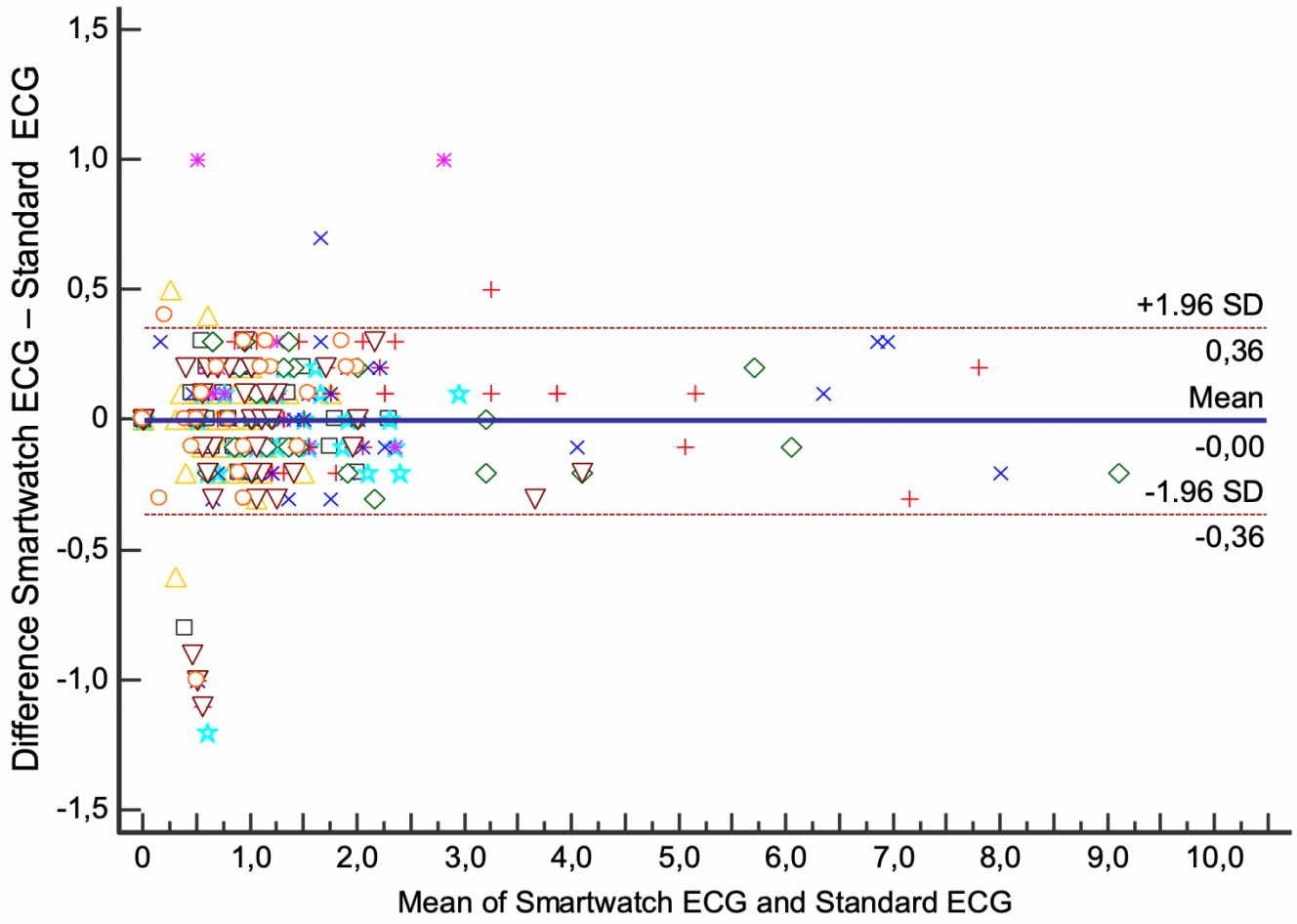


STANDARD 12-LEAD ECG



Spaccarotella, JAMA C, 2020

Comparison of the amplitude of ST-segment deviations between smartwatch and standard ECG.



Spaccarotella, JAMA C, 2020

RULE #3: Emergent Transthoracic Echocardiography

Emergent transthoracic echocardiography (TTE) for assessment of wall motion should be considered in patients with ECGs concerning for but not diagnostic of ischemia and infarction, particularly when borderline ST-segment elevation or left bundle branch block (LBBB) or equivocal signs of posterior MI are present.

RULE # 4: HS-Troponin as biomarker of MI

In all patients presenting to the ED with acute chest pain and suspected ACS, cTn should be measured as soon as possible after presentation

Recommendations for Biomarkers
Referenced studies that support the recommendations are summarized in Online Data Supplement 7.

COR	LOE	Recommendations
1	B-NR	1. In patients presenting with acute chest pain, serial cTn I or T levels are useful to identify abnormal values and a rising or falling pattern indicative of acute myocardial injury.[1-21]
1	B-NR	2. In patients presenting with acute chest pain, high-sensitivity cTn is the preferred biomarker because it enables more rapid detection or exclusion of myocardial injury and increases diagnostic accuracy.[17,21-25]
1	C-EO	3. Clinicians should be familiar with the analytical performance and the 99th percentile upper reference limit that defines myocardial injury for the cTn assay used at their institution.[23,26]
3: No benefit	B-NR	4. With availability of cTn, creatine kinase myocardial (CK-MB) isoenzyme and myoglobin are not useful for diagnosis of acute myocardial injury.[27-32]

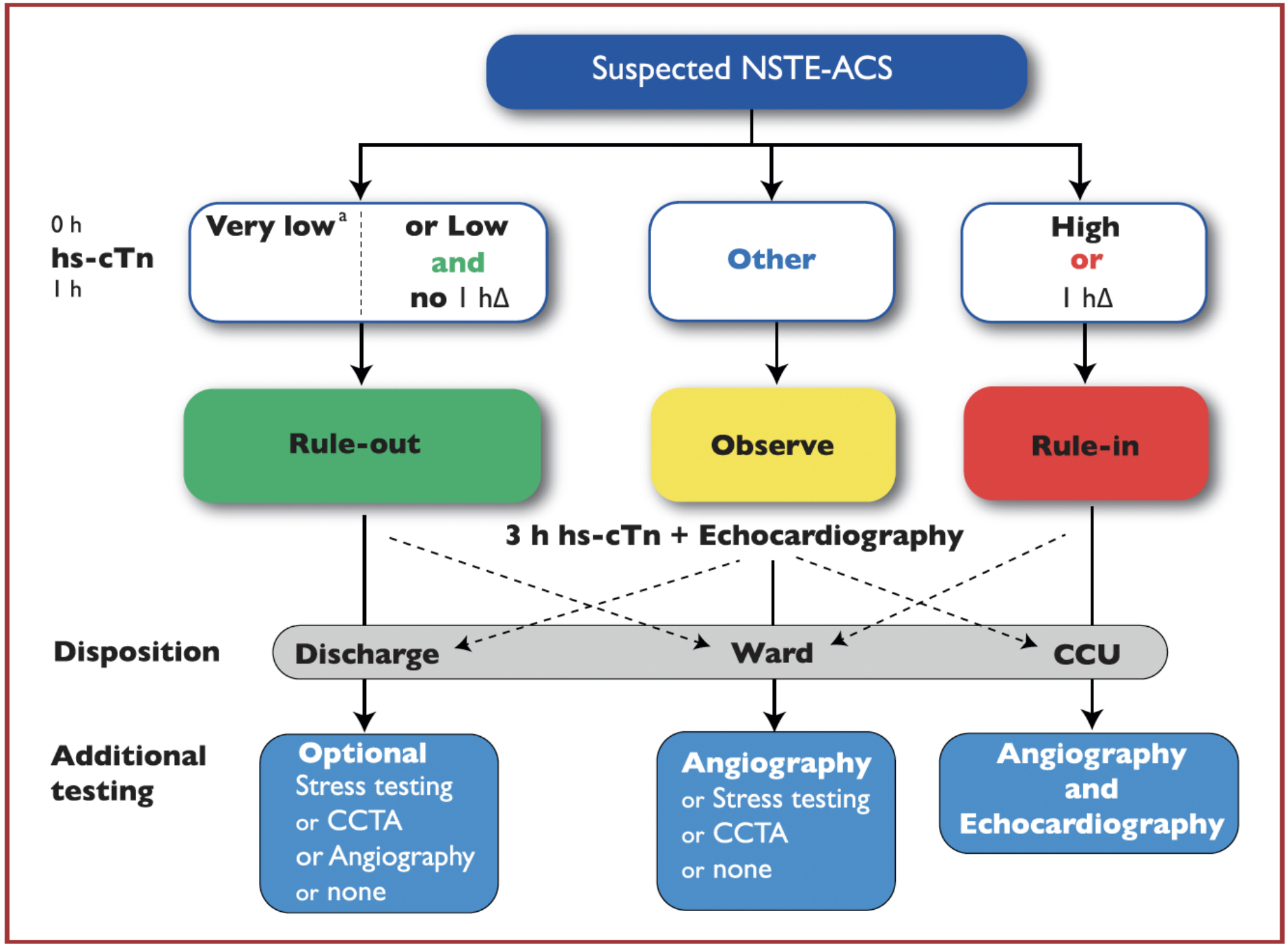
Defining Abnormal Hs-cTn Values

- Key questions for the management of patients with possible ACS in the ED are what constitutes an "**abnormal**" or an "**elevated**" hs-cTn value and how to rapidly and reliably differentiate between ACS and the multitude of other potential causes for cTn elevation.
- In the absence of an objective cTn threshold, the 99th percentile URL cTn value derived from a "normal reference population" has been endorsed.
- However, studies in large populations have shown that hs-cTn represents a continuum of risk, such that minor cTn elevations (detectable but below the 99th percentile URL) are associated with structural heart disease, worse cardiovascular outcomes, and increased mortality.
- Based on these findings, no detectable cTn level can be considered entirely "normal."

RELATIVE Vs ABSOLUTE CHANGES OF HS-cTNn

Relative change (Δ) in hs-cTn: the percentage change in hs-cTn across serial measurements. Relative changes ≥20% are considered significant and indicative of acute myocardial injury. However, at low troponin concentrations near the 99th percentile URL, absolute (rather than relative) change values provide greater specificity for acute myocardial injury.

Absolute change (Δ) in hs-cTn: The change in hs-cTn across serial measurements, reported as an absolute value in ng/L. At low hs-cTn concentrations near the 99th percentile URL, absolute rather than relative Δ should be used. Values are assay dependent. Recommended CDPs use absolute rather than relative Δ values.


Suspected NSTE-ACS
0 h
hs-cTn
1 h
Very low[a]
or Low
and
no 1 hΔ
Other
High
or
1 hΔ
Rule-out
Observe
Rule-in
3 h hs-cTn + Echocardiography
Disposition
Discharge
Ward
CCU
Additional testing
Optional
Stress testing
or CCTA
or Angiography
or none
Angiography
or Stress testing
or CCTA
or none
Angiography
and
Echocardiography

ESC 2020

ESC
European Society of Cardiology
European Heart Journal (2021) **42**, 1289–1367
doi:10.1093/eurheartj/ehaa575

ESC GUIDELINES

2020 ESC Guidelines for the management of acute coronary syndromes in patients presenting without persistent ST-segment elevation

ALGORITHM 0-1H

0H: HS-cTn

1H: HS-cTn

2.3 What is new?

Diagnosis

New key recommendations

As an alternative to the ESC 0 h/1 h algorithm, it is recommended to use the ESC 0 h/2 h algorithm with blood sampling at 0 h and 2 h, if an hs-cTn test with a validated 0 h/2 h algorithm is available.

For diagnostic purposes, it is not recommended to routinely measure additional biomarkers such as CK, CK-MB, h-FABP, or copeptin, in addition to hs-cTn.

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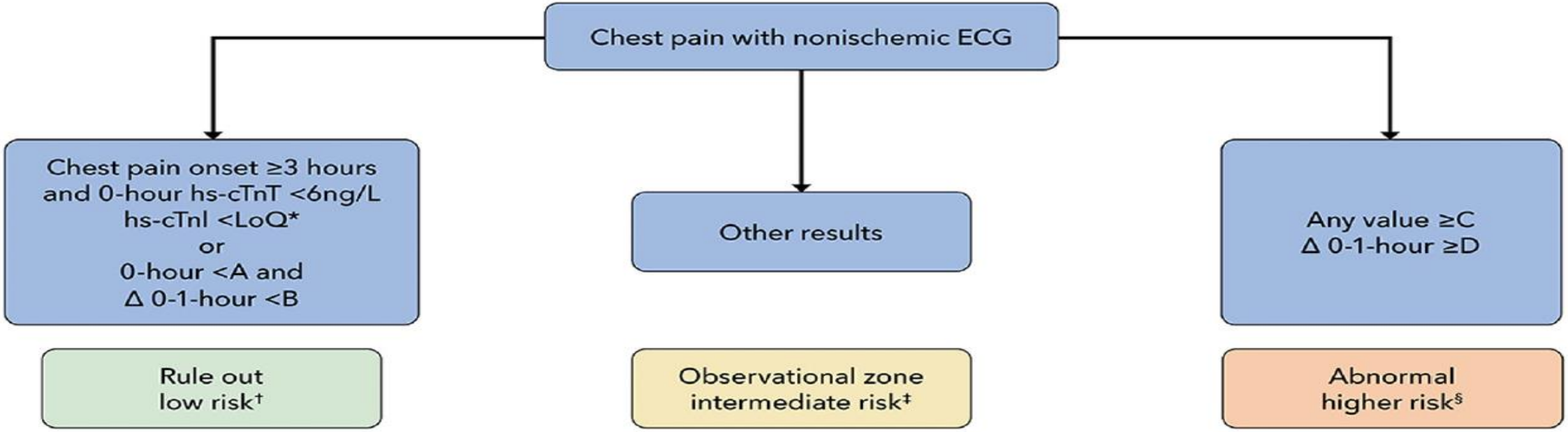
0-Hour HS-cTn Protocol

Ruling Out MI with a single Blood draw at the time of presentation (0-Hour Rule Out) provided symptoms started ≥ 3 hours before the hs-cTn measurement.

FIGURE 3 Modified European Society of Cardiology 0/1-Hour CDP for Ruling Out MI



Assay	LoQ	A	B	C	D
Roche Elecys hs-cTnT	6	12	3	52	5
Abbott Architect hs-cTnI	4	5	2	52	6
Beckman Coulter Access hs-cTnI	3	5	4	50	15
Siemens ADVIA Centaur hs-cTnI	3	6	3	120	12
Siemens Atellica hs-cTnI	3	6	3	120	12
Siemens Dimension Vista hs-cTnI	3	5	2	107	19

MODIFIED HEART AND EDACS SCORES

HEART Score Components Low risk: 0-3 points; non-low risk: ≥4 points
History
High suspicion
Moderate suspicion
Low suspicion
Electrocardiogram
ST-segment deviation
Paced, LBBB, RBBB, or LVH
Normal or nonspecific changes
Age, y
>65
45-65
<45
Cardiac risk factors
≥3 or known CAD
1-2
0

EDACS Components Low risk: 0-15 points; non-low risk: ≥16 points	
Age, y	
18-45	2
46-50	4
51-55	6
56-60	8
61-65	10
66-70	12
71-75	14
76-80	16
81-85	18
86+	20
Male sex	6
Age 18-15 and either ≥3 cardiac risk factors or known CAD	4
Diaphoresis	3
Pain radiating to arm or shoulder	5
Pain worsened with inspiration	−4
Pain reproduced by palpation	−6

Table 4 **Conditions other than acute type 1 myocardial infarction associated with cardiomyocyte injury (= cardiac troponin elevation)**

Tachyarrhythmias
Heart failure
Hypertensive emergencies
Critical illness (e.g. shock/sepsis/burns)
Myocarditis[a]
Takotsubo syndrome
Valvular heart disease (e.g. aortic stenosis)
Aortic dissection
Pulmonary embolism, pulmonary hypertension
Renal dysfunction and associated cardiac disease
Acute neurological event (e.g. stroke or subarachnoid haemorrhage)
Cardiac contusion or cardiac procedures (CABG, PCI, ablation, pacing, cardioversion, or endomyocardial biopsy)
Hypo- and hyperthyroidism
Infiltrative diseases (e.g. amyloidosis, haemochromatosis, sarcoidosis, scleroderma)
Myocardial drug toxicity or poisoning (e.g. doxorubicin, 5-fluorouracil, herceptin, snake venoms)
Extreme endurance efforts
Rhabdomyolysis

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TABLE 5 Myocardial Injury Differential

Myocardial Injury:
Defined as at Least 1 ng/L Above the 99th Percentile URL

Acute Myocardial Injury
(Rising and/or Falling Cardiac Troponin)

Cardiovascular Causes	Noncardiovascular Causes
Acute myocardial infarction (type 1-5 MI)	Sepsis
Hypertensive emergency/urgency	Acute renal failure
Acute heart failure	Noncardiac surgery
Pulmonary embolism	Critical illness
Acute aortic syndrome	Rhabdomyolysis
Cardiac surgery	Cardiotoxic medications
Cardiac intervention, including PCI, ablations, valve replacements, cardioversion/defibrillation, endomyocardial biopsy	Stroke
Acute valvular heart disease	Extreme exercise
Stress cardiomyopathy	False-positive result
Cardiac contusion	
Myocarditis/myopericarditis/endocarditis	
Arrythmias	

PCI = percutaneous coronary intervention; URL = upper reference limit

Chronic Myocardial Injury (Stable Elevation in Cardiac Troponin)	
Cardiovascular Causes	**Noncardiovascular Causes**
Stable coronary artery disease	Chronic renal failure
Chronic heart failure	Skeletal myopathies
Uncontrolled arrhythmias	Cardiotoxic medications
Hypertension	
Valvular heart disease	
Cardiomyopathies	
Pulmonary hypertension	
Left ventricular hypertrophy	

Testing Not Needed Routinely for Low-Risk Patients. For patients with acute or stable chest pain determined to be low risk, urgent diagnostic testing for suspected coronary artery disease is not needed.

Testing Not Needed Routinely for Low-Risk Patients

Recommendations from guideline Section 4.1.1. Low-Risk Patients With Acute Chest Pain		
COR	LOE	Recommendations
1	B-NR	1. Patients with acute chest pain and a 30-day risk of death or MACE <1% should be designated as low risk.

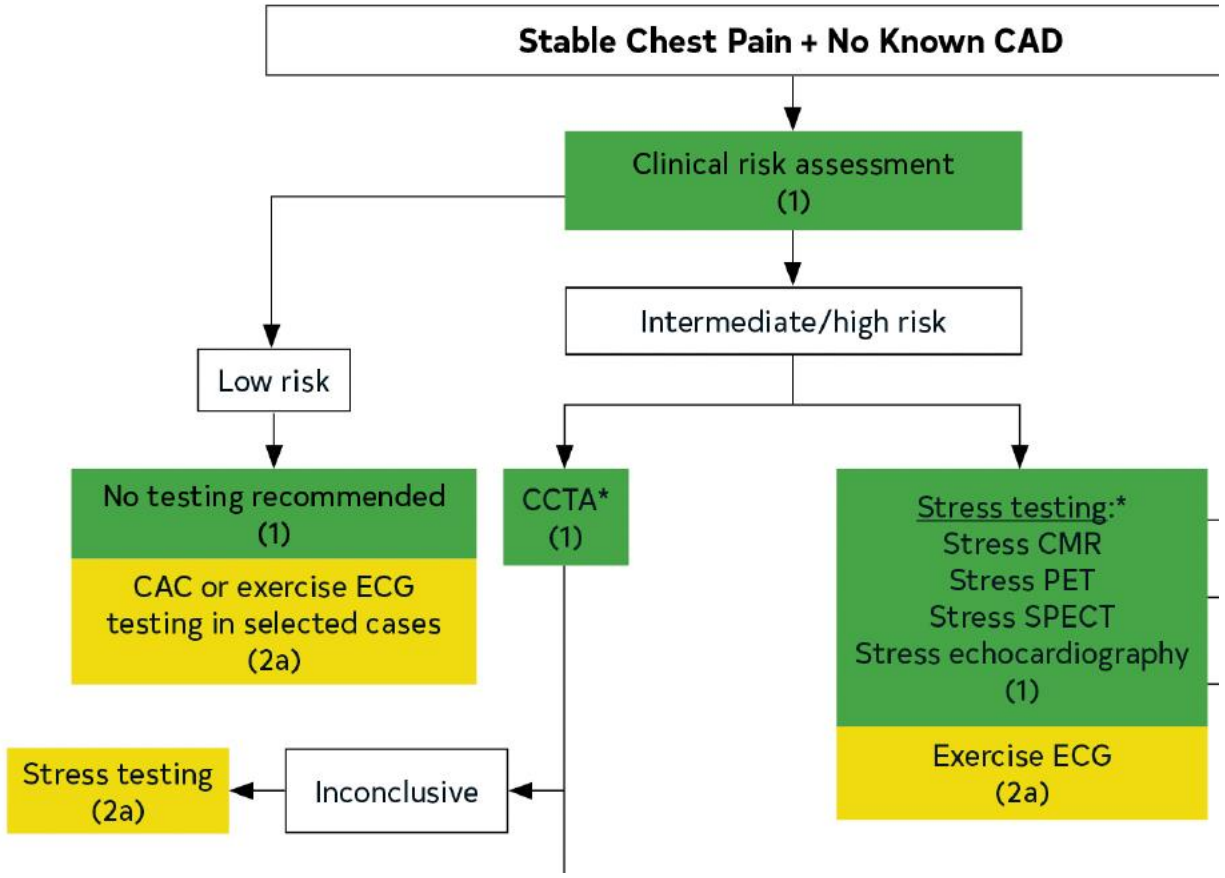
Table 8. Definition Used for Low-Risk Patients With Chest Pain

	Low Risk (<1% 30-d Risk for Death or MACE)
hs-cTn Based	
T-0	T-0 hs-cTn below the assay limit of detection or "very low" threshold if symptoms present for at least 3 h
T-0 and 1- or 2-h Delta	T-0 hs-cTn and 1- or 2-h delta are both below the assay "low" thresholds (>99% NPV for 30-d MACE)
Clinical Decision Pathway Based	
HEART Pathway (20)	HEART score <3, initial and serial cTn/hs-cTn < assay 99th percentile
EDACS (14)	EDACS score <16; initial and serial cTn/hs-cTn < assay 99th percentile
ADAPT (21)	TIMI score 0, initial and serial cTn/hs-cTn < assay 99th percentile
mADAPT	TIMI score 0/1, initial and serial cTn/hs-cTn < assay 99th percentile
NOTR (15)	0 factors

TABLE 4 Clinical Considerations for the Use of Noninvasive Testing for Coronary Artery Disease

Ischemia Test Modality	Strengths	Limitations	Patient Considerations Favoring Its Use
Exercise stress ECG	■ Low cost ■ Wide availability ■ Assessment of exercise symptoms, capacity ■ No ionizing radiation	■ Decreased accuracy compared with anatomical and stress-imaging tests ■ Requires interpretable ECG and ability to exercise sufficiently	■ Rarely recommended as a stand-alone test due to frequent known CAD, inability to exercise, or significant arrhythmias
Stress echocardiography	■ Wide availability ■ High diagnostic specificity ■ Assessment of ventricular and valvular function ■ No ionizing radiation	■ Decreased sensitivity compared with anatomical and other stress-imaging tests ■ Dependent on good image quality ■ Requires dobutamine in patients unable to exercise	■ Known good image quality and ability to exercise ■ Consider use of an ultrasound-enhancing agent to improve endocardial visualization ■ Known moderate or severe valvular disease
Stress/rest SPECT	■ Wide availability ■ Relatively high diagnostic sensitivity ■ Assessment of ventricular function	■ Increased artifacts resulting in nondiagnostic results and decreased diagnostic accuracy compared with stress/rest PET ■ Radiation exposure	■ Known CAD or high CAC burden on chest CT imaging ■ Preferred over stress echocardiography in patients who cannot exercise or who do not have significant bronchospastic disease
Stress/rest PET	■ High diagnostic accuracy ■ Lower radiation exposure than SPECT ■ Measures myocardial blood flow and flow reserve ■ Assessment of ventricular function	■ Limited availability ■ Relatively higher cost ■ Lack of exercise assessment	■ Known CAD or high CAC burden on chest CT imaging ■ Preferred over SPECT due to higher diagnostic accuracy and lower rate of nondiagnostic test results
Stress CMR	■ High diagnostic accuracy ■ Accurate assessment of chamber sizes, ventricular and valvular function ■ Diagnosis of prior infarction, scar, fibrosis ■ Measurement of myocardial blood flow and flow reserve is possible but not widely available currently ■ No ionizing radiation	■ Limited availability ■ Relatively higher cost ■ Lack of exercise assessment ■ Long scan acquisition times ■ Claustrophobia ■ Often not immediately available to patients with pacemakers or ICDs ■ Contraindicated in patients with significant renal dysfunction	■ Known CAD and/or cardiomyopathy ■ Elevated troponin not thought to be secondary to ACS ■ Known moderate or severe valvular disease ■ No significant renal dysfunction
CTA	■ High diagnostic accuracy ■ Does not require exercise ■ Identifies nonobstructive CAD	■ Radiation exposure ■ Lack of exercise assessment ■ Contraindicated in patients with significant renal dysfunction ■ Blooming artifacts when significant coronary calcification present ■ Atrial fibrillation or other arrhythmias ■ May require beta-blockade ■ Incidental noncardiac findings	■ No known CAD ■ Absence of severe coronary calcification ■ Prior normal, mildly abnormal, or inconclusive stress test results ■ No known iodinated contrast medium allergy or significant renal dysfunction ■ Low likelihood of high-quality stress testing or lack of timely access

Pathways. Clinical decision pathways for chest pain in the emergency department and outpatient settings should be used routinely.



Major changes in recommendations	
2015	**2020**
Diagnosis	
A rapid rule-out protocol at 0 h and 3 h is recommended if hs-cTn tests are available.	A rapid rule-out and rule-in protocol with blood sampling at 0 h and 3 h should be considered if an hs-cTn test with a validated 0 h/3 h algorithm is available.
MDCT coronary angiography should be considered as an alternative to invasive angiography to exclude ACS when there is a low-to-intermediate likelihood of CAD and when cardiac troponin and/or ECG are inconclusive.	CCTA is recommended as an alternative to invasive angiography to exclude ACS when there is a low-to-intermediate likelihood of CAD and when cardiac troponin and/or ECG are normal or inconclusive.
Rhythm monitoring up to 24 h or PCI (whichever comes first) should be considered in NSTEMI patients at low risk for cardiac arrhythmias.	Rhythm monitoring up to 24 h or to PCI (whichever comes first) is recommended in NSTEMI patients at low risk for cardiac arrhythmias.
Rhythm monitoring for >24 h should be considered in NSTEMI patients at intermediate-to-high risk for cardiac arrhythmias.	Rhythm monitoring for >24 h is recommended in NSTEMI patients at increased risk for cardiac arrhythmias.

PRE-TREATMENT WITH P2Y12-I IN NSTEMI BEFORE CORONARY ANGIOGRAPHY

Antiplatelet treatment		
Aspirin is recommended for all patients without contraindications at an initial oral LD of 150–300 mg (or 75–250 mg i.v.), and at a MD of 75–100 mg o.d. for long-term treatment.[179–181]	I	A
A $P2Y_{12}$ receptor inhibitor is recommended in addition to aspirin, and maintained over 12 months unless there are contraindications or an excessive risk of bleeding.[170,171,182] Options are:	I	A
• Prasugrel in $P2Y_{12}$ receptor inhibitor-naïve patients proceeding to PCI (60 mg LD, 10 mg/d as standard dose, 5 mg/d for patients aged ≥75 years or with a body weight <60 kg).[171]	I	B
• Ticagrelor irrespective of the planned treatment strategy (invasive or conservative) (180 mg LD, 90 mg b.i.d.).[170]	I	B
• Clopidogrel (300–600 mg LD, 75 mg daily dose), only when prasugrel or ticagrelor are not available, cannot be tolerated, or are contraindicated.[182,183]	I	C
Prasugrel should be considered in preference to ticagrelor for NSTE-ACS patients who proceed to PCI.[174]	IIa	B
GP IIb/IIIa antagonists should be considered for bail-out if there is evidence of no-reflow or a thrombotic complication.	IIa	C
Cangrelor may be considered in $P2Y_{12}$ receptor inhibitor-naïve patients undergoing PCI.[184–187]	IIb	A
Pre-treatment with a $P2Y_{12}$ receptor inhibitor may be considered in patients with NSTE-ACS who are not planned to undergo an early invasive strategy and do not have an HBR.	IIb	C
Treatment with GP IIb/IIIa antagonists in patients in whom coronary anatomy is not known is not recommended.[188,189]	III	A
It is not recommended to administer routine pre-treatment with a $P2Y_{12}$ receptor inhibitor in patients in whom coronary anatomy is not known and an early invasive management is planned.[174,177,178,190,191]	III	A

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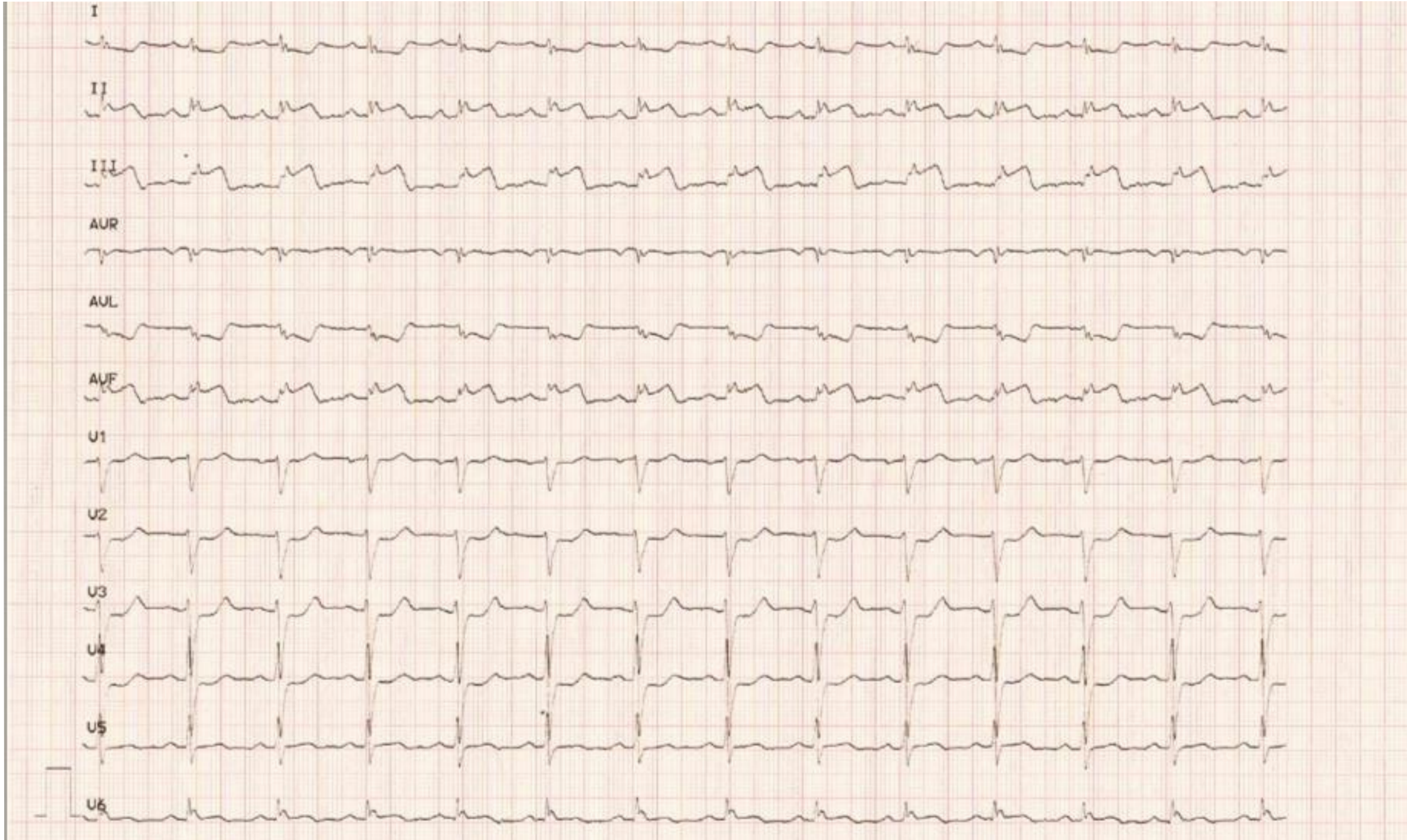
TIMING OF CORONARY ANGIOGRAPHY IN NSTEMI

Invasive treatment

An early invasive strategy within 24 h is recommended in patients with any of the following high-risk criteria:

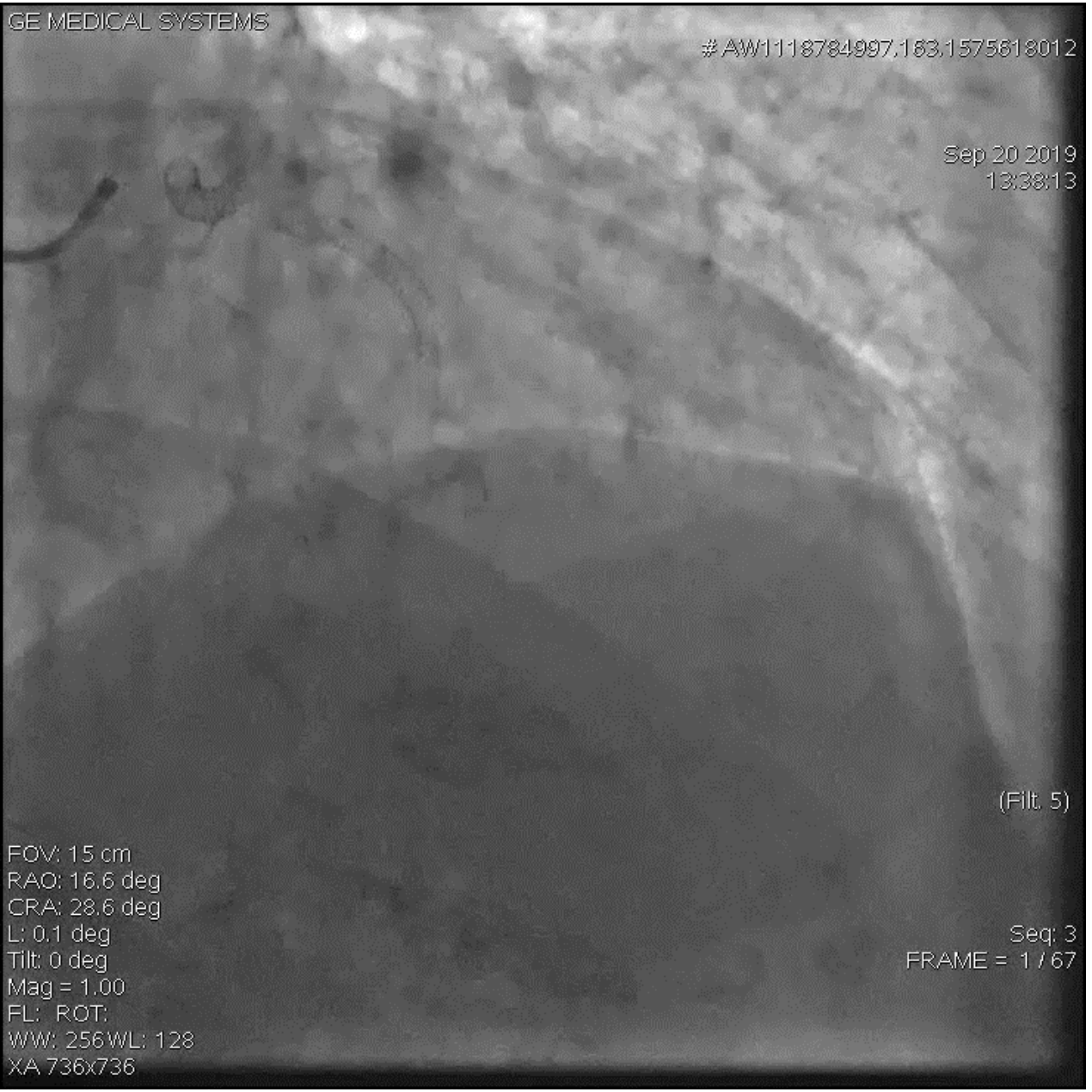
- Diagnosis of NSTEMI.
- Dynamic or presumably new contiguous ST/T-segment changes suggesting ongoing ischaemia.
- Transient ST-segment elevation.
- GRACE risk score >140.


I
II
III
AUR
AUL
AUF
U1
U2
U3
U4
U5
U6

PRE-TREATMENT WITH P2Y12-I IN STEMI BEFORE CORONARY ANGIOGRAPHY

DAPT IN STEMI

Aspirin	Loading dose of 150-300 mg orally or of 75-250 mg i.v. if oral ingestion is not possible, followed by a maintenance dose of 75-100 mg/day.
Prasugrel	Loading dose of 60 mg orally, followed by a maintenance dose of 10 mg/day. In patients with body weight ≤60 kg, a maintenance dose of 5 mg/day is recommended. Prasugrel is contra-indicated in patients with previous stroke. In patients ≥75 years, prasugrel is generally not recommended, but a dose of 5 mg/day should be used if treatment is deemed necessary.
Ticagrelor	Loading dose of 180 mg orally, followed by a maintenance dose of 90 mg b.i.d.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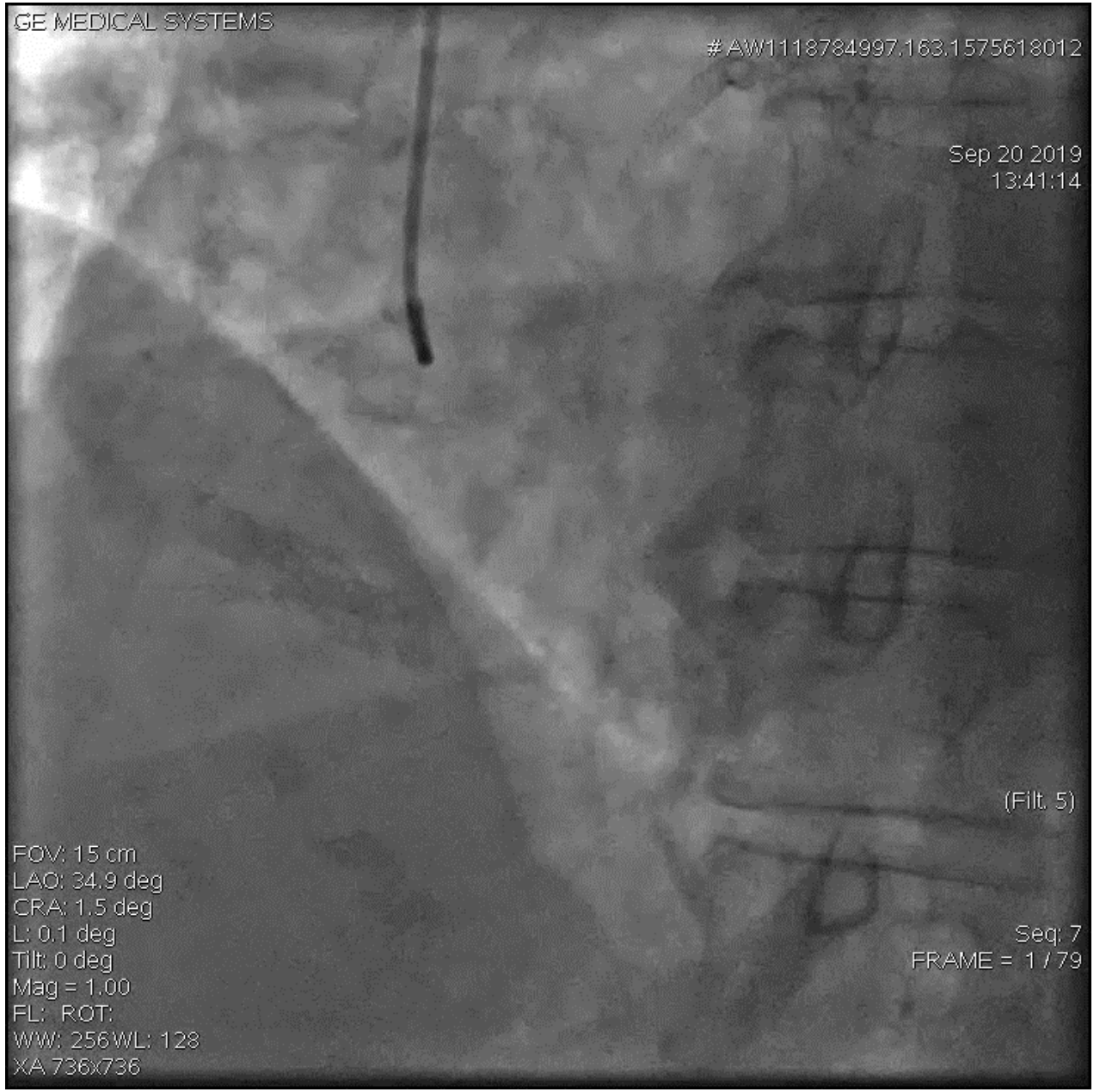
FRAME = 1 / 67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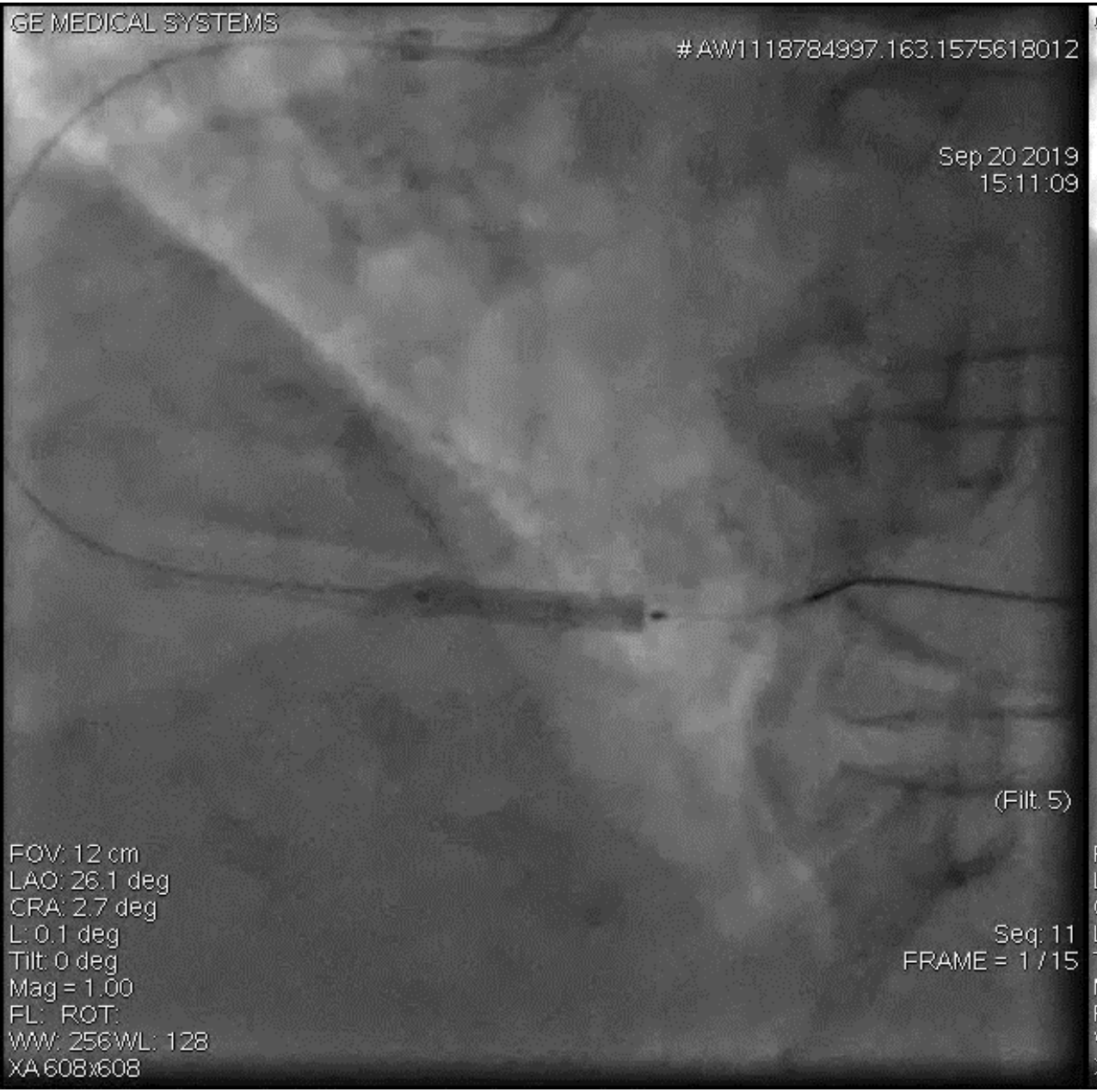
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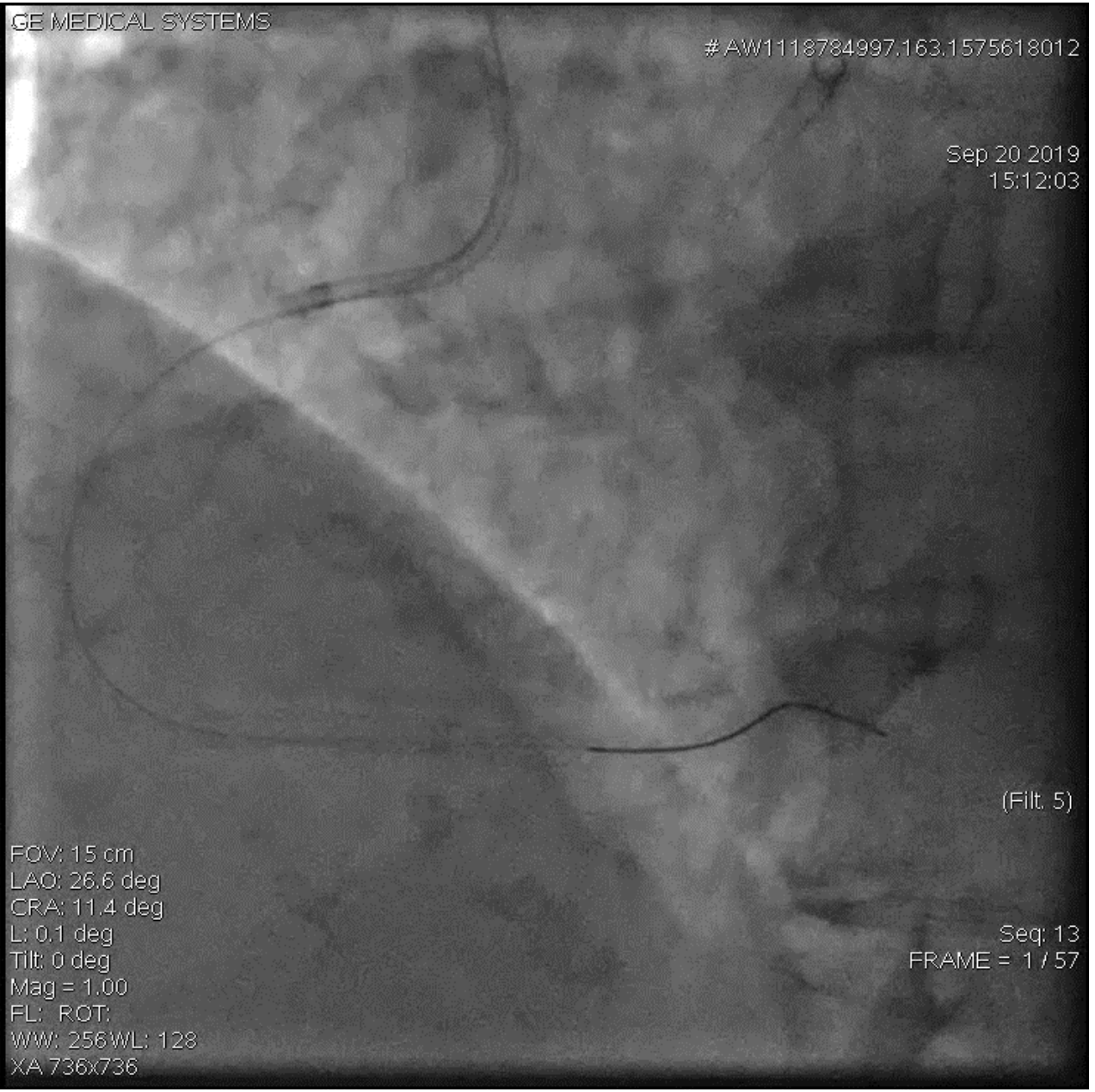
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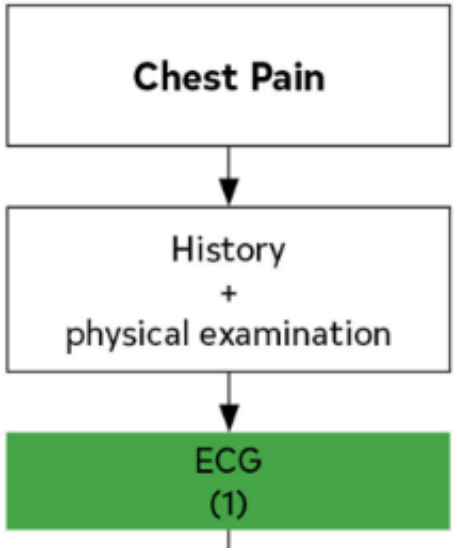
CRA: 11.4 deg
L: 0.1 deg
Tilt: 0 deg
Mag = 1.00
FL: ROT:
WW: 256WL: 128
XA 736x736
Seq: 13
FRAME = 1 / 57

CONCLUSIONS

- **A systematic approach is essential to achieve optimal outcomes for patients presenting with chest pain to the ED.**

- **A clinical decision pathway with cardiac Troponins and pre-test probability of CAD, symptoms, ECG, echocardiography and computed coronary tomography scan reduce ED “dwell” times and increase the proportion of patients with chest pain who can safely be discharged without additional testing.**

THANK YOU FOR ATTENTION

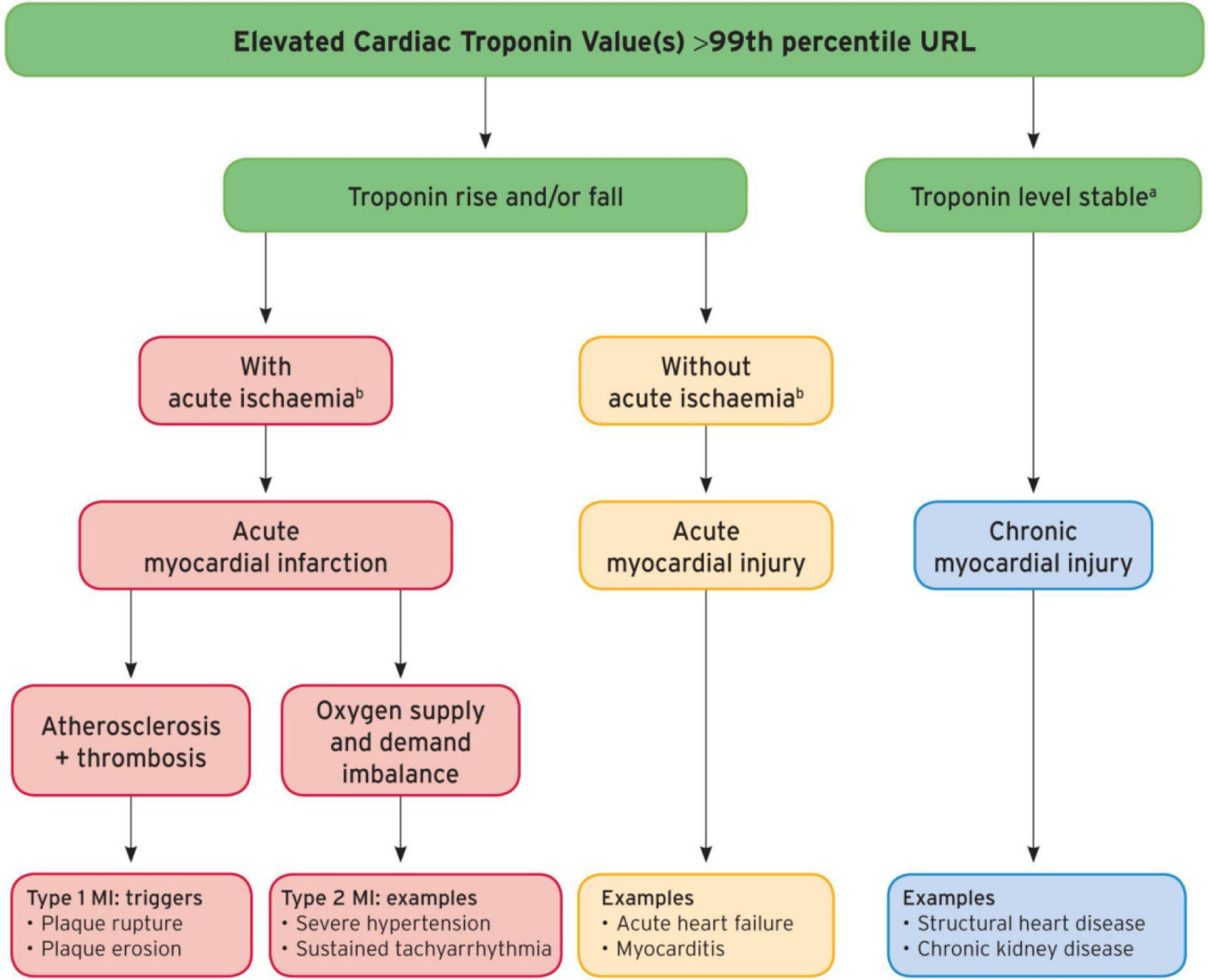


If initial ECG is nondiagnostic

In all patients presenting to the ED with acute chest pain and suspected ACS, cTn should be measured as soon as possible after presentation

Recommendations for Biomarkers
Referenced studies that support the recommendations are summarized in Online Data Supplement 7.

COR	LOE	Recommendations
1	B-NR	1. In patients presenting with acute chest pain, serial cTn I or T levels are useful to identify abnormal values and a rising or falling pattern indicative of acute myocardial injury.[1-21]
1	B-NR	2. In patients presenting with acute chest pain, high-sensitivity cTn is the preferred biomarker because it enables more rapid detection or exclusion of myocardial injury and increases diagnostic accuracy.[17,21-25]
1	C-EO	3. Clinicians should be familiar with the analytical performance and the 99th percentile upper reference limit that defines myocardial injury for the cTn assay used at their institution.[23,26]
3: No benefit	B-NR	4. With availability of cTn, creatine kinase myocardial (CK-MB) isoenzyme and myoglobin are not useful for diagnosis of acute myocardial injury.[27-32]



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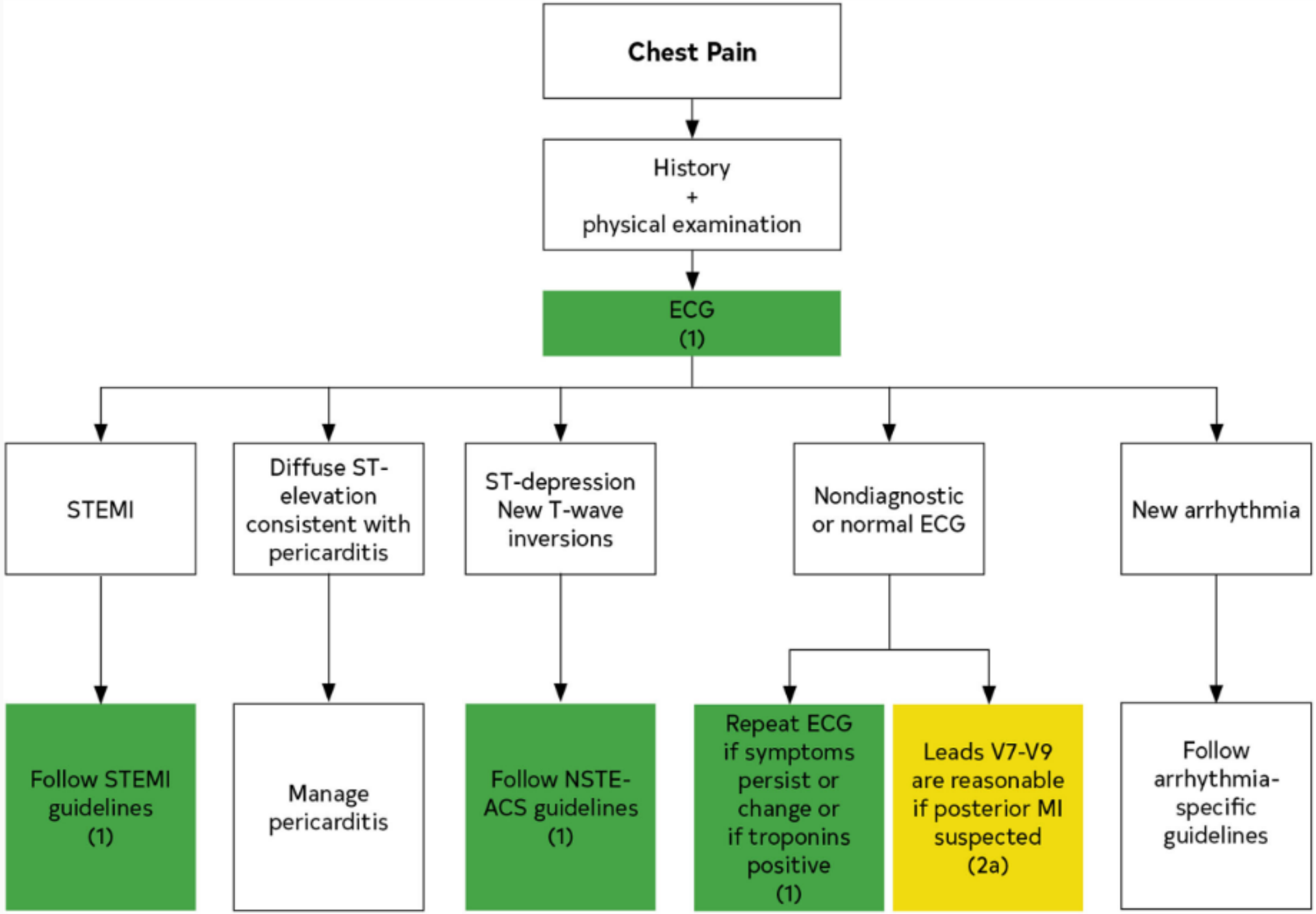
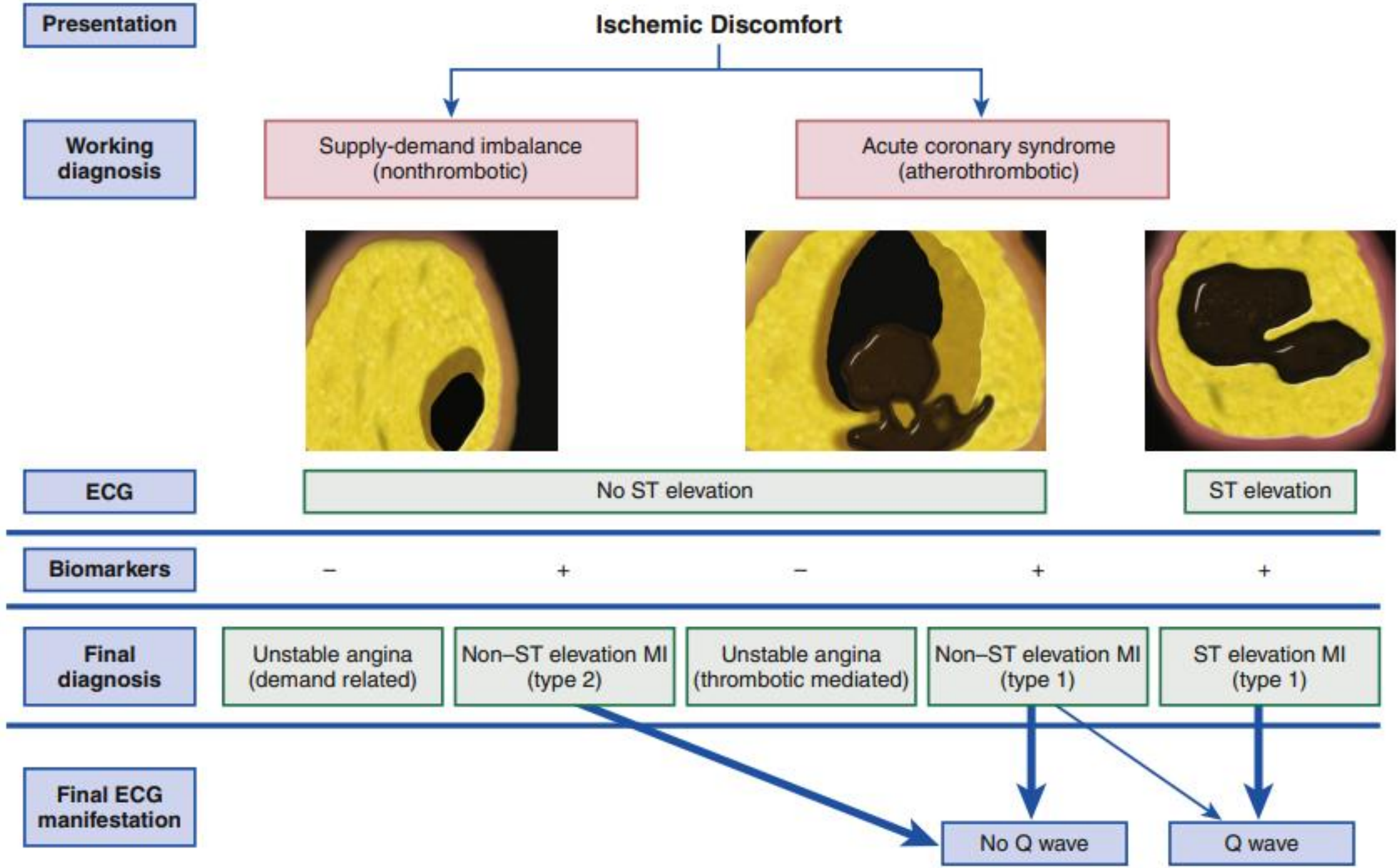
Rev Esp Cardiol. 2019;72:10–5

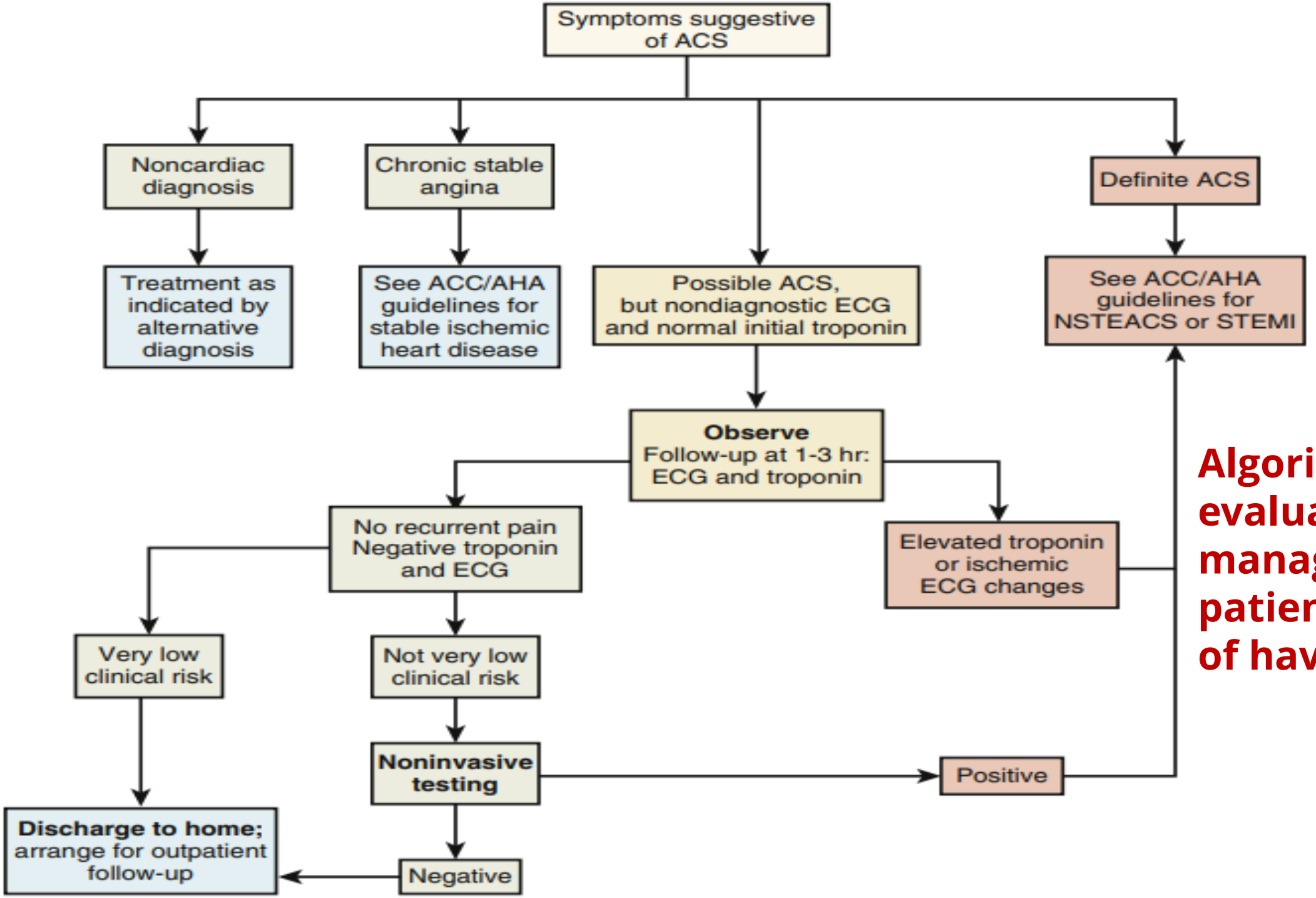
Universal definition of myocardial infarction

Detection of an increase and/or decrease of cardiac biomarker, preferably high sensitivity cardiac troponin (hs-cTn)T or I with at least one value above the 99th percentile of the upper reference limit and at least one of the following:

1.Symptoms of myocardial ischaemia.
2.New ischaemic ECG changes.
3.Development of pathological Q waves on ECG.
4.Imaging evidence of loss of viable myocardium or new regional wall motion abnormality in a pattern consistent with an ischaemic aetiology.
5. Intracoronary thrombus detected on angiography or autopsy.


Chest Pain
History
+
physical examination
ECG
(1)
STEMI
Diffuse ST-elevation consistent with pericarditis
ST-depression New T-wave inversions
Nondiagnostic or normal ECG
New arrhythmia
Follow STEMI guidelines (1)
Manage pericarditis
Follow NSTE-ACS guidelines (1)
Repeat ECG if symptoms persist or change or if troponins positive (1)
Leads V7-V9 are reasonable if posterior MI suspected (2a)
Follow arrhythmia-specific guidelines


Presentation
Ischemic Discomfort
Working diagnosis
Supply-demand imbalance (nonthrombotic)
Acute coronary syndrome (atherothrombotic)
ECG
No ST elevation
ST elevation
Biomarkers
–
+
–
+
+
Final diagnosis
Unstable angina (demand related)
Non–ST elevation MI (type 2)
Unstable angina (thrombotic mediated)
Non–ST elevation MI (type 1)
ST elevation MI (type 1)
Final ECG manifestation
No Q wave
Q wave



Algorithm for the evaluation and management of patients suspected of having ACS.

ESC
European Society of Cardiology
European Heart Journal (2021) **42**, 1289–1367
doi:10.1093/eurheartj/ehaa575

ESC GUIDELINES

2020 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 in patients presenting without persistent ST-segment elevation of the European Society of Cardiology (ESC)

2.3 What is new?

New key recommendations

Diagnosis

As an alternative to the ESC 0 h/1 h algorithm, it is recommended to use the ESC 0 h/2 h algorithm with blood sampling at 0 h and 2 h, if an hs-cTn test with a validated 0 h/2 h algorithm is available.

For diagnostic purposes, it is not recommended to routinely measure additional biomarkers such as CK, CK-MB, h-FABP, or copeptin, in addition to hs-cTn.

Major changes in recommendations

2015	2020
Diagnosis	
A rapid rule-out protocol at 0 h and 3 h is recommended if hs-cTn tests are available.	A rapid rule-out and rule-in protocol with blood sampling at 0 h and 3 h should be considered if an hs-cTn test with a validated 0 h/3 h algorithm is available.
MDCT coronary angiography should be considered as an alternative to invasive angiography to exclude ACS when there is a low-to-intermediate likelihood of CAD and when cardiac troponin and/or ECG are inconclusive.	CCTA is recommended as an alternative to invasive angiography to exclude ACS when there is a low-to-intermediate likelihood of CAD and when cardiac troponin and/or ECG are normal or inconclusive.
Rhythm monitoring up to 24 h or PCI (whichever comes first) should be considered in NSTEMI patients at low risk for cardiac arrhythmias.	Rhythm monitoring up to 24 h or to PCI (whichever comes first) is recommended in NSTEMI patients at low risk for cardiac arrhythmias.
Rhythm monitoring for >24 h should be considered in NSTEMI patients at intermediate-to-high risk for cardiac arrhythmias.	Rhythm monitoring for >24 h is recommended in NSTEMI patients at increased risk for cardiac arrhythmias.

0 h/1 h rule-out and rule-in algorithm using high-sensitivity cardiac troponin assays in haemodynamically stable patients

0 h and 1 h refer to the time from first blood test.

Ruled out. NSTEMI can be ruled out at presentation if the hs-cTn concentration is very low. NSTEMI can also be ruled out by the combination of low baseline levels and the lack of a relevant increase within 1 h (no 1hΔ).

Ruled in. Patients have a high likelihood of NSTEMI if the hs-cTn concentration at presentation is at least moderately elevated or hs-cTn concentrations show a clear rise within the first hour (1hΔ). Cut-offs are assay specific and derived to meet predefined criteria for sensitivity and specificity for NSTEMI.

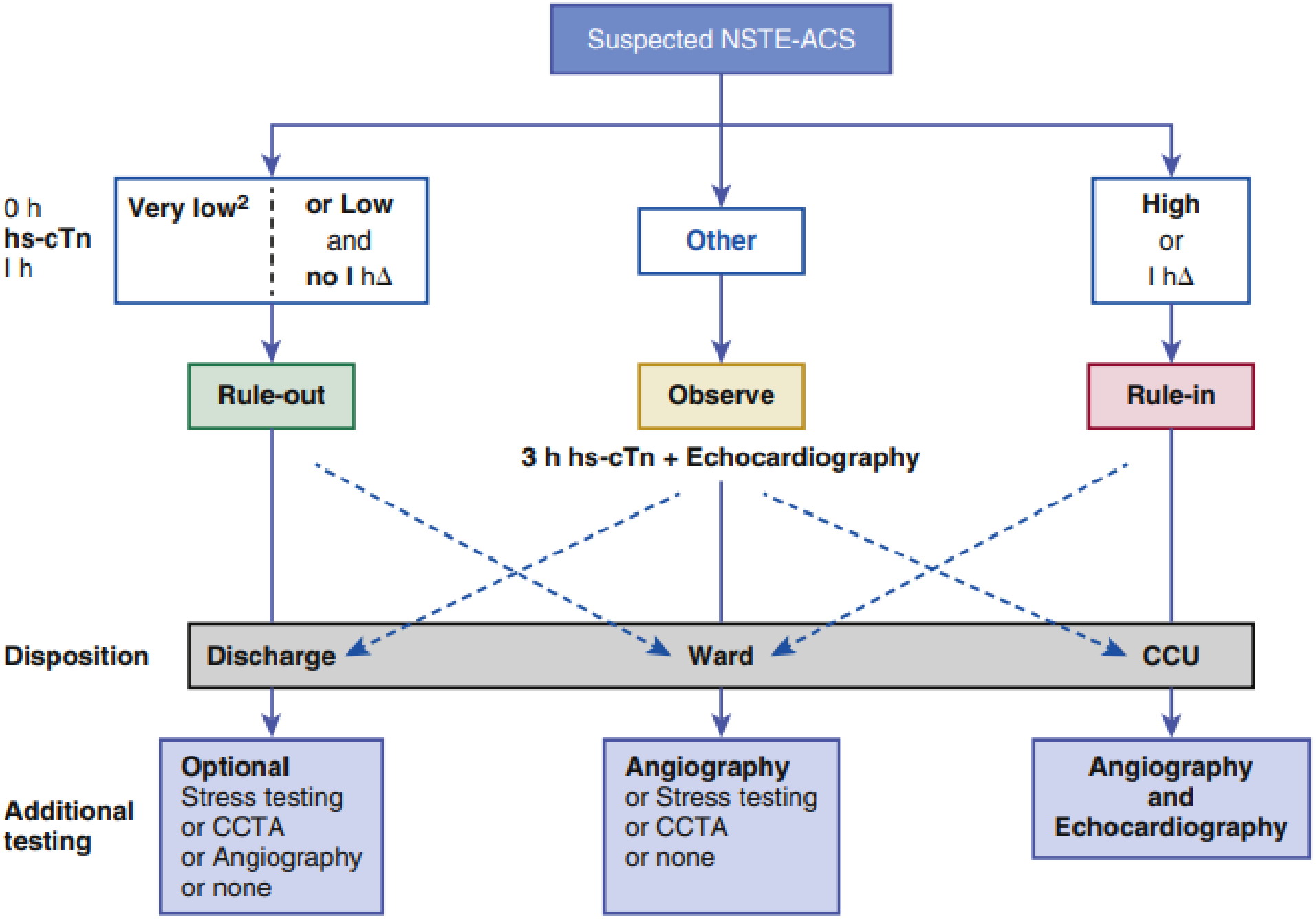
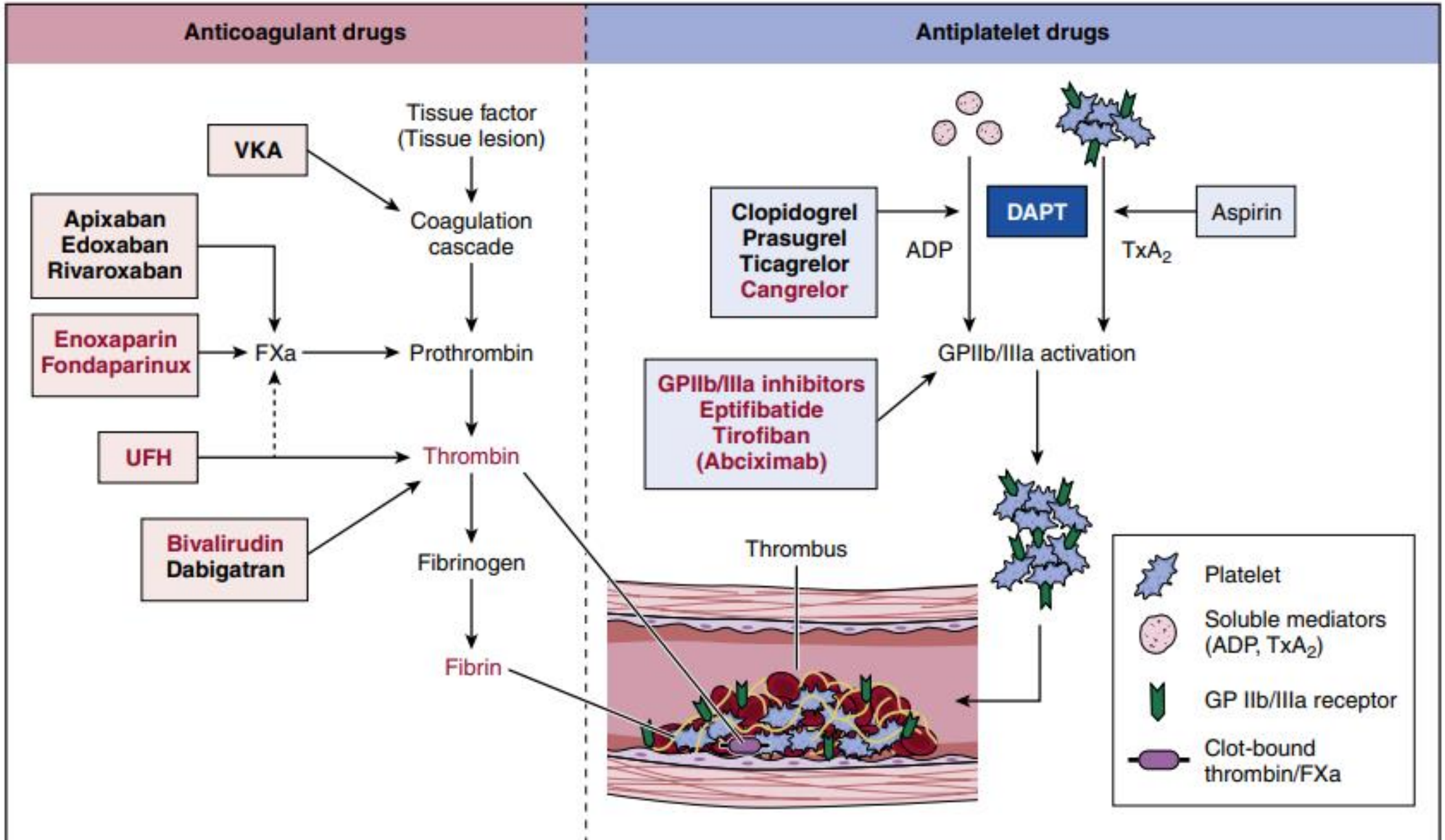


Figure 3 (1)

0 h/1 h rule-out and rule-in algorithm using high-sensitivity cardiac troponin assays in haemodynamically stable patients presenting with suspected non-ST-segment elevation acute coronary syndrome to the emergency department.

ANTITHROMBOTIC TREATMENTS



1. Aspirin: All patients should immediately receive aspirin (150 to 300 mg) oral loading dose (or 75 to 150 mg intravenously).
2. Parenteral anticoagulation before PCI:
   - UFH or enoxaparin preferred. Bivalirudin may be considered. Avoid fondaparinux.
   - Patients on VKA: Uninterrupted anticoagulation with VKA therapy is preferred, as interruption of VKA with use of bridging parenteral anticoagulation is associated with increased bleeding.
   - Patients on NOAC: Stop NOAC and start parenteral anticoagulation with UFH or LMWH, regardless of the timing of the last NOAC dose.
3. Anticoagulation during PCI:
   - If immediate PCI (<2 h from symptom onset), use low-dose intravenous anticoagulation, regardless of the last dose of oral anticoagulant. Options include UFH 60 IU/kg or enoxaparin 0.5 mg/kg intravenously.
   - For PCI >2 h from symptom onset:
     - Patients on VKA: Perform PCI without interruption of VKA if the INR is >2.5 without additional parenteral anticoagulation. Low-dose (if INR 2.0-2.5) or standard dose UFH or enoxaparin (if INR <2.0) may be used otherwise.
     - Patients on NOAC: Use additional intraprocedural low-dose parenteral anticoagulation, irrespective of timing of last dose of NOAC.
4. $P2Y_{12}$ inhibitors: To reduce the risk of bleeding, consider:
   - Postpone administration of $P2Y_{12}$ inhibitors until the coronary anatomy is known, and PCI is planned.
   - Use clopidogrel instead of ticagrelor or prasugrel.
5. GP IIb/IIIa inhibitors: avoid use unless for bail-out.
6. Stent selection: Do not use bioabsorbable vascular scaffolds due to a higher thrombotic risk and need for longer DAPT duration.

Prasugrel should be considered in preference to ticagrelor for NSTE-ACS patients who proceed to PCI.

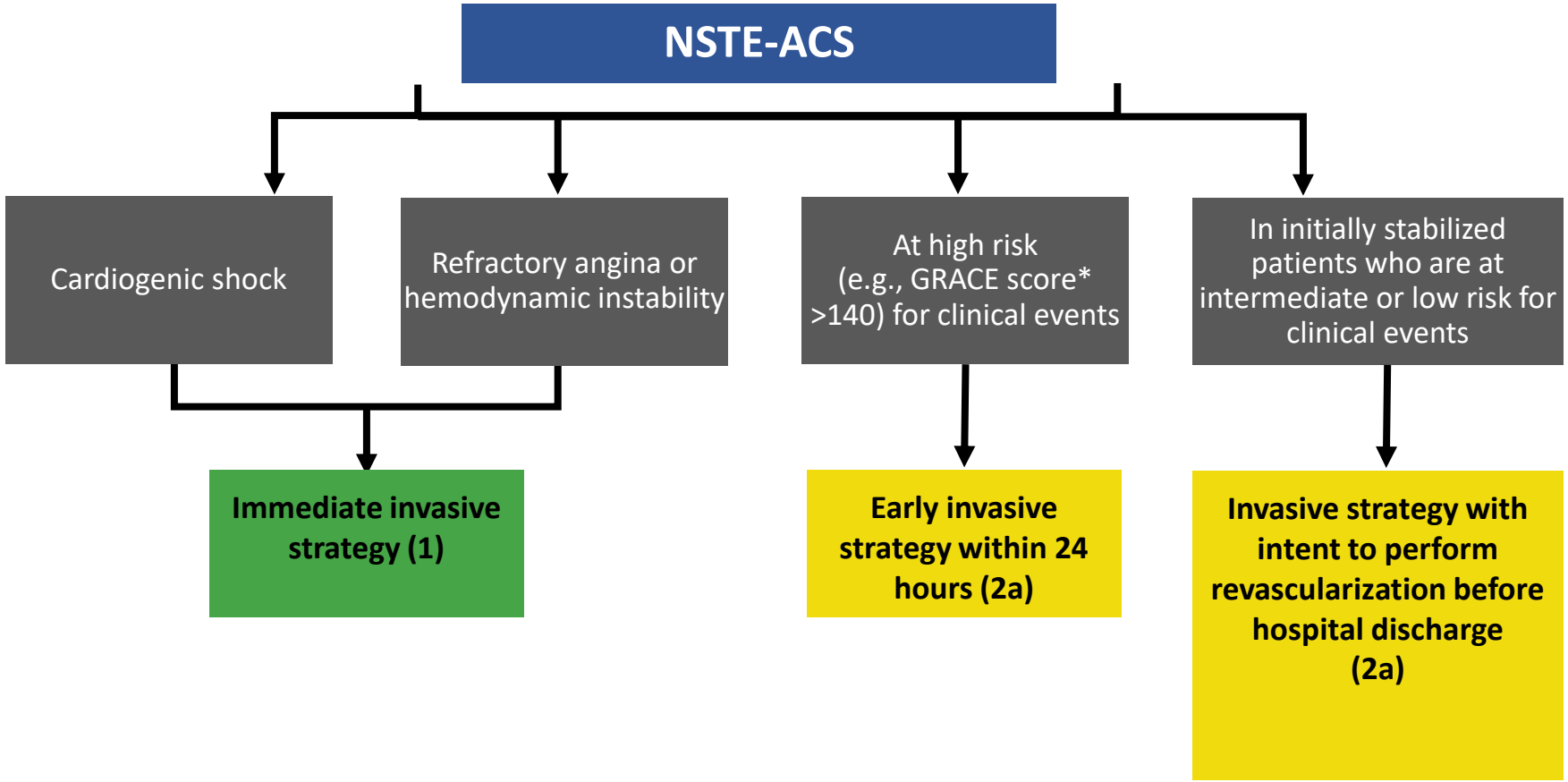
It is not recommended to administer routine pre-treatment with a $P2Y_{12}$ receptor inhibitor to patients in whom the coronary anatomy is not known and early invasive management is planned.

In patients with NSTE-ACS who cannot undergo an early invasive strategy, pre-treatment with a $P2Y_{12}$ receptor inhibitor may be considered depending on bleeding risk.

De-escalation of $P2Y_{12}$ inhibitor treatment (e.g. with a switch from prasugrel or ticagrelor to clopidogrel) may be considered as an alternative DAPT strategy, especially for ACS patients deemed unsuitable for potent platelet inhibition. De-escalation may be done unguided based on clinical judgment, or guided by platelet function testing, or CYP2C19 genotyping depending on the patient's risk profile and availability of respective assays.

Antiplatelet treatment		
Aspirin is recommended for all patients without contraindications at an initial oral LD of 150–300 mg (or 75–250 mg i.v.), and at a MD of 75–100 mg o.d. for long-term treatment.[179–181]	I	A
A $P2Y_{12}$ receptor inhibitor is recommended in addition to aspirin, and maintained over 12 months unless there are contraindications or an excessive risk of bleeding.[170,171,182] Options are:	I	A
• Prasugrel in $P2Y_{12}$ receptor inhibitor-naïve patients proceeding to PCI (60 mg LD, 10 mg/d as standard dose, 5 mg/d for patients aged ≥75 years or with a body weight <60 kg).[171]	I	B
• Ticagrelor irrespective of the planned treatment strategy (invasive or conservative) (180 mg LD, 90 mg b.i.d.).[170]	I	B
• Clopidogrel (300–600 mg LD, 75 mg daily dose), only when prasugrel or ticagrelor are not available, cannot be tolerated, or are contraindicated.[182,183]	I	C
Prasugrel should be considered in preference to ticagrelor for NSTE-ACS patients who proceed to PCI.[174]	IIa	B
GP IIb/IIIa antagonists should be considered for bail-out if there is evidence of no-reflow or a thrombotic complication.	IIa	C
Cangrelor may be considered in $P2Y_{12}$ receptor inhibitor-naïve patients undergoing PCI.[184–187]	IIb	A
Pre-treatment with a $P2Y_{12}$ receptor inhibitor may be considered in patients with NSTE-ACS who are not planned to undergo an early invasive strategy and do not have an HBR.	IIb	C
Treatment with GP IIb/IIIa antagonists in patients in whom coronary anatomy is not known is not recommended.[188,189]	III	A
It is not recommended to administer routine pre-treatment with a $P2Y_{12}$ receptor inhibitor in patients in whom coronary anatomy is not known and an early invasive management is planned.[174,177,178,190,191]	III	A

Recommendations Timing of Invasive Strategy in NSTE-ACS



Guiding Principle:
Revascularization in the context of NSTE-ACS should consider clinical stability, risk of recurrent event(s), coronary anatomy, and degree of myocardium at risk.

Recommendations	Class	Level
In the absence of ST-segment elevation, a *primary PCI strategy* is indicated in patients with suspected ongoing ischaemic symptoms suggestive of myocardial infarction and at least one of the following criteria present: – haemodynamic instability or cardiogenic shock, – recurrent or ongoing chest pain refractory to medical treatment, – life-threatening arrhythmias or cardiac arrest, – mechanical complications of myocardial infarction, – acute heart failure, – recurrent dynamic ST-segment or T-wave changes, particularly with intermittent ST-segment elevation.	I	C

Invasive treatment

An early invasive strategy within 24 h is recommended in patients with any of the following high-risk criteria:

- Diagnosis of NSTEMI.
- Dynamic or presumably new contiguous ST/T-segment changes suggesting ongoing ischaemia.
- Transient ST-segment elevation.
- GRACE risk score >140.

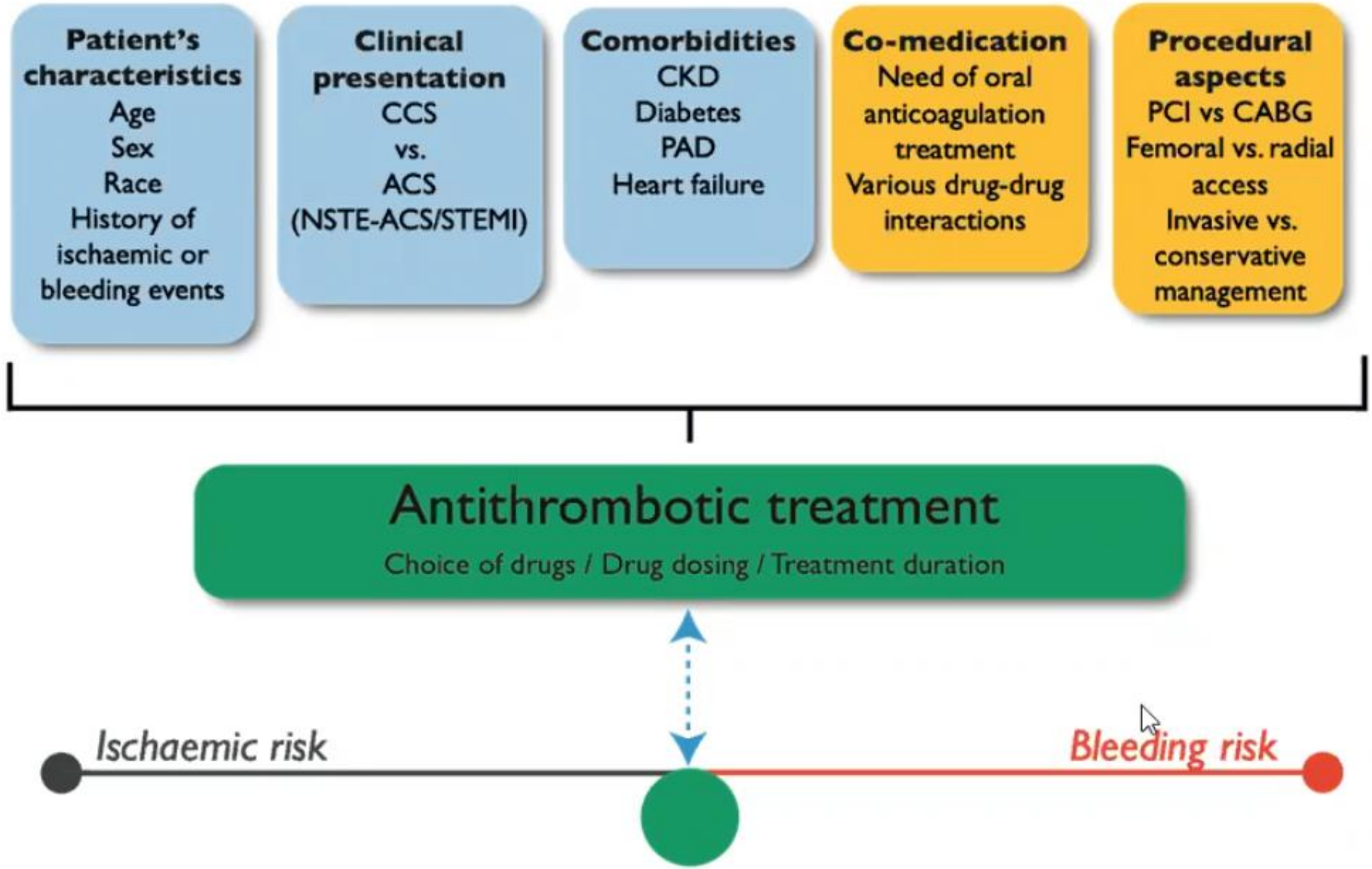
A selective invasive strategy after appropriate ischaemia testing or detection of obstructive CAD by CCTA is recommended in patients considered at low risk.

Delayed, as opposed to immediate, angiography should be considered in haemodynamically stable patients without ST-segment elevation successfully resuscitated after an out-of-hospital cardiac arrest.

Complete revascularization should be considered in NSTE-ACS patients without cardiogenic shock and with multivessel CAD.

Complete revascularization during index PCI may be considered in NSTE-ACS patients with multivessel disease.

FFR-guided revascularization of non-culprit NSTE-ACS lesions may be used during index PCI.


Patient's characteristics
Age
Sex
Race
History of ischaemic or bleeding events
Clinical presentation
CCS
vs.
ACS
(NSTE-ACS/STEMI)
Comorbidities
CKD
Diabetes
PAD
Heart failure
Co-medication
Need of oral anticoagulation treatment
Various drug-drug interactions
Procedural aspects
PCI vs CABG
Femoral vs. radial access
Invasive vs. conservative management
Antithrombotic treatment
Choice of drugs / Drug dosing / Treatment duration
Ischaemic risk
Bleeding risk

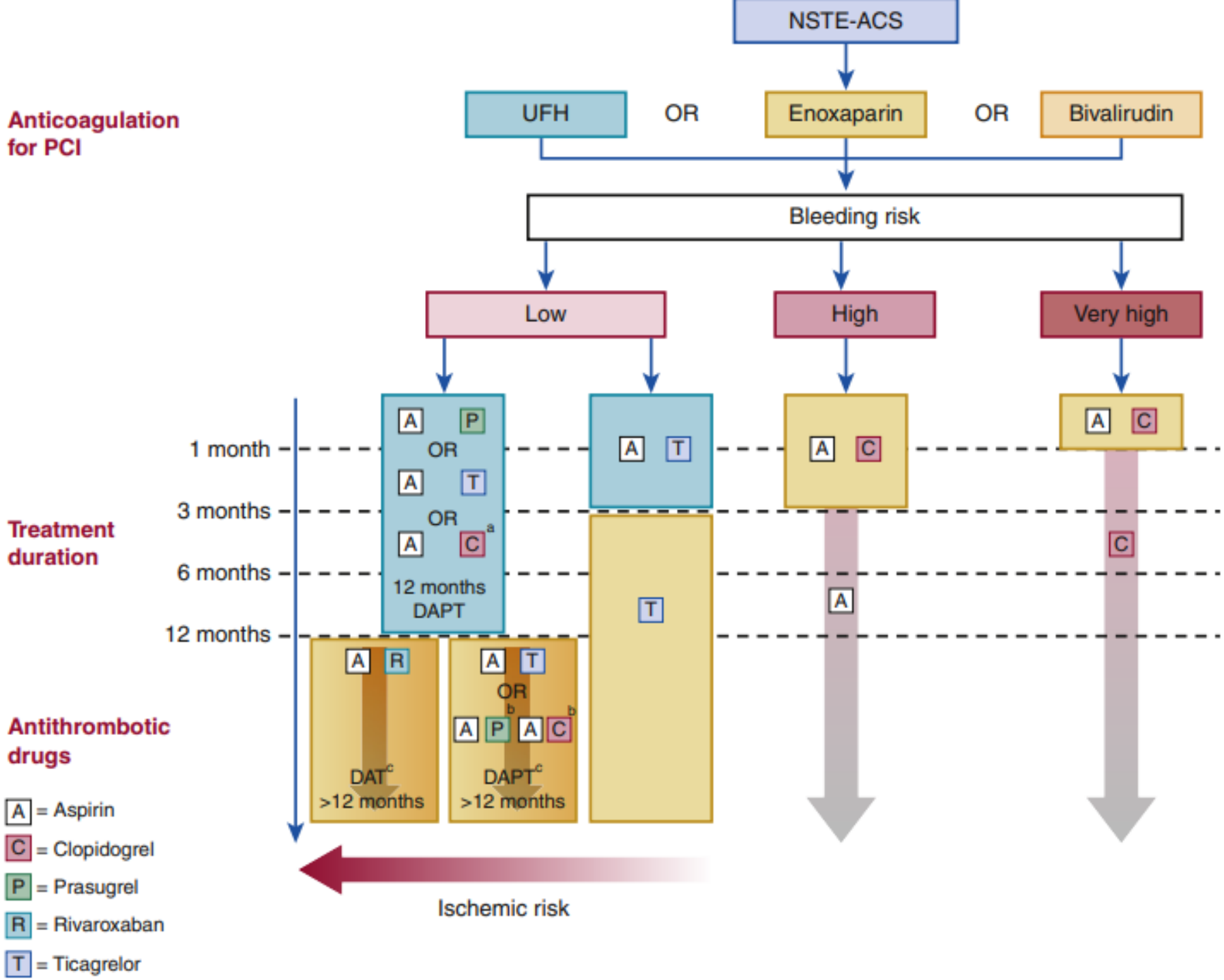


Figure 7 (1)

Algorithm for antithrombotic therapy in non-ST-segment elevation acute coronary syndrome patients without atrial fibrillation undergoing percutaneous coronary intervention.

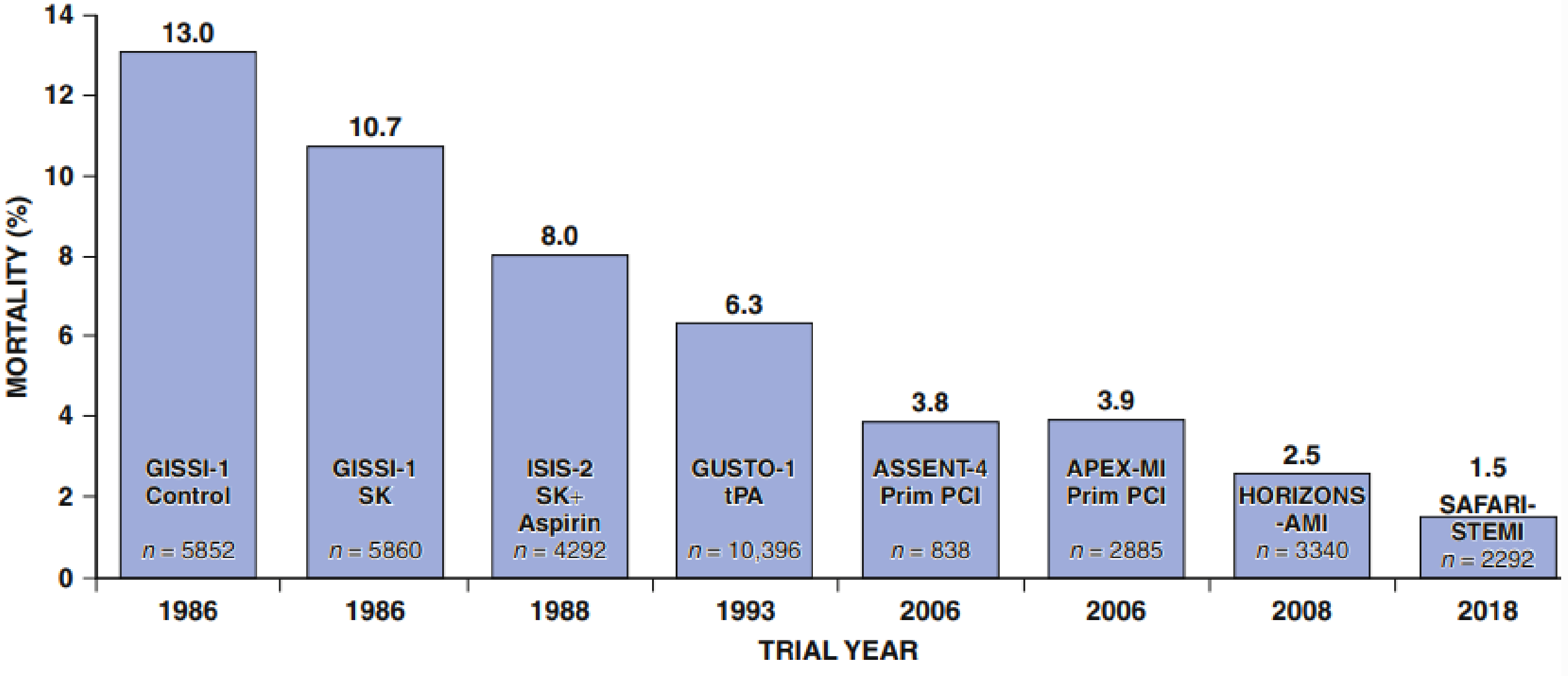
ESC
European Society of Cardiology
European Heart Journal (2018) **39**, 119–177
doi:10.1093/eurheartj/ehx393

ESC GUIDELINES

2017 ESC Guidelines for the management of acute myocardial infarction in patients presenting with ST-segment elevation

The Task Force for the management of acute myocardial infarction in patients presenting with ST-segment elevation of the European Society of Cardiology (ESC)

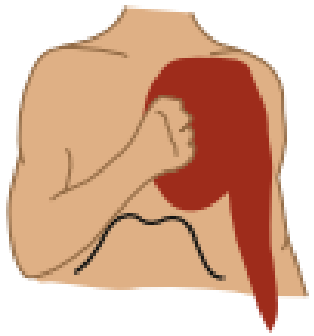
Early mortality rates have declined in major randomized trials of STEMI patients



Recommendations	Class	Level
ECG monitoring		
12-lead ECG recording and interpretation is indicated as soon as possible at the point of FMC, with a maximum target delay of 10 min.	I	B
ECG monitoring with defibrillator capacity is indicated as soon as possible in all patients with suspected STEMI.	I	B
The use of additional posterior chest wall leads (V7–V_9) in patients with high suspicion of posterior myocardial infarction (circumflex occlusion) should be considered.	IIa	B
The use of additional right precordial leads (V_3R and V_4R) in patients with inferior myocardial infarction should be considered to identify concomitant RV infarction.	IIa	B
Blood sampling		
Routine blood sampling for serum markers is indicated as soon as possible in the acute phase but should not delay reperfusion treatment.	I	C

Intervals	Time targets
Maximum time from FMC to ECG and diagnosis.	≤10 min
Maximum expected delay from STEMI diagnosis to primary PCI (wire crossing) to choose primary PCI strategy over fibrinolysis (if this target time cannot be met, consider fibrinolysis).	≤120 min
Maximum time from STEMI diagnosis to wire crossing in patients presenting at primary PCI hospitals.	≤60 min
Maximum time from STEMI diagnosis to wire crossing in transferred patients.	≤90 min
Maximum time from STEMI diagnosis to bolus or infusion start of fibrinolysis in patients unable to meet primary PCI target times.	≤10 min
Time delay from start of fibrinolysis to evaluation of its efficacy (success or failure).	60-90 min
Time delay from start of fibrinolysis to angiography (if fibrinolysis is successful).	2-24 hours

System goals and initial reperfusion treatment of patients with STEMI



Patient symptom onset of STEMI

Activate EMS

EMS dispatch

EMS on scene
Encourage 12-lead ECGs
Consider prehospital fibrinolytic if capable and EMS-to-needle time ≤30 min

EMS triage plan

Hospital arrival

STEMI confirmed 12-lead ECG (≤10 min)

Hospital fibrinolysis: Door-to-needle time ≤30 min

Not PCI capable

Interhospital transfer

PCI capable

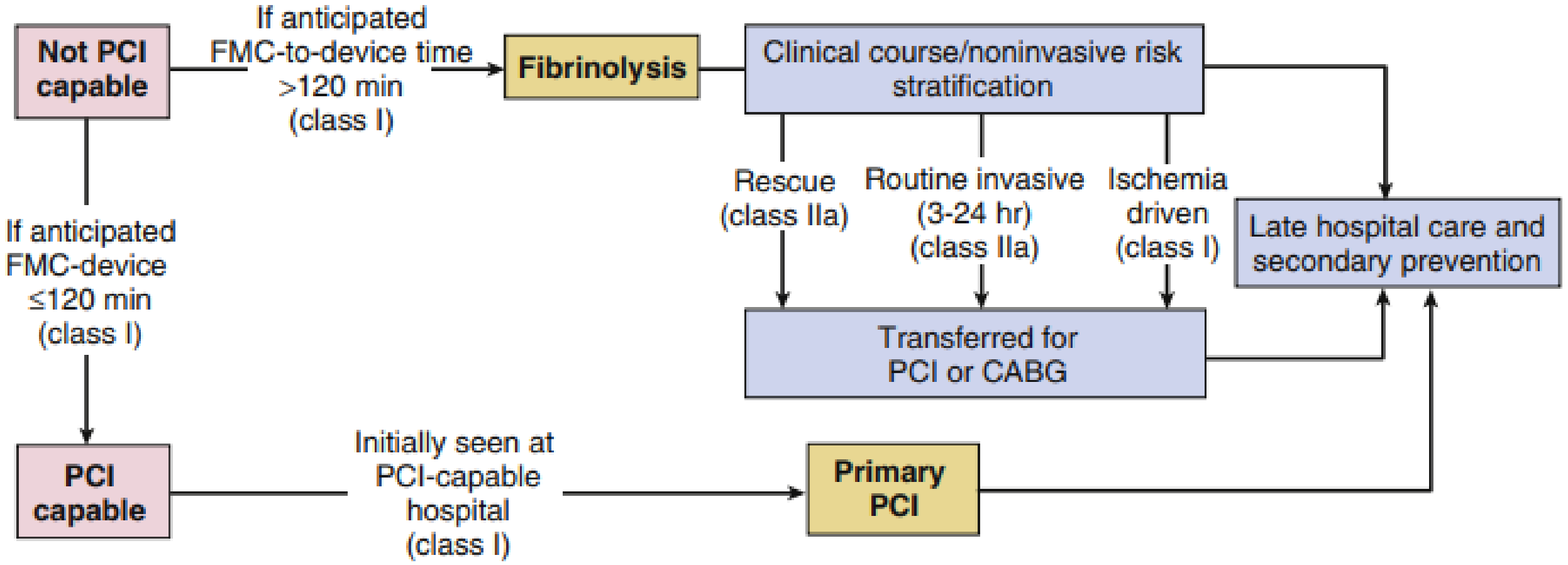
Goals

Patient	Dispatch	EMS on scene	EMS transport
5 min after symptom onset	1 min	≤8 min	EMS transport: EMS-device ≤90 min Patient self-transport: hospital door–to-device ≤90 min

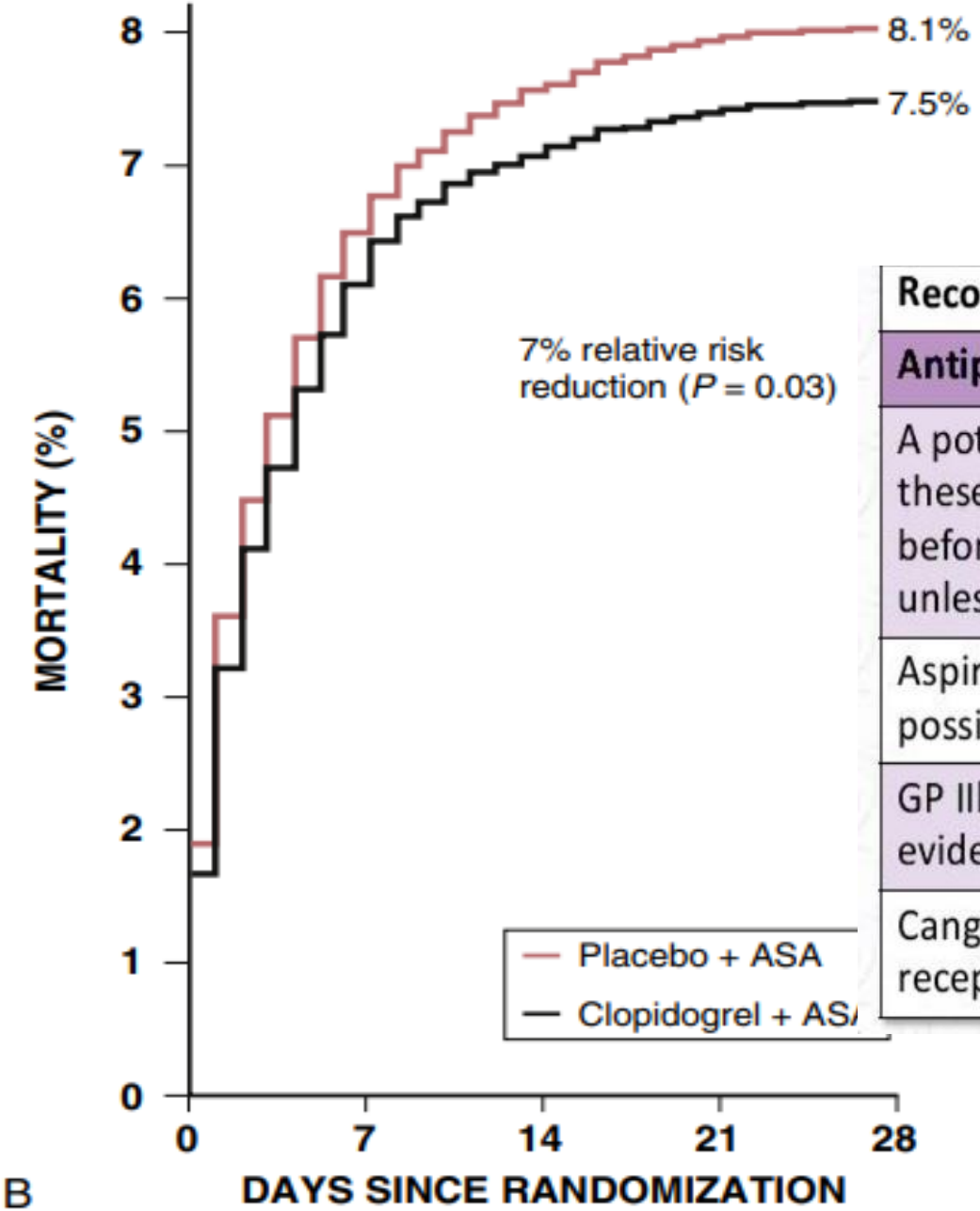
Total ischemic time: <120 min

A

Reperfusion strategies for patients with STEMI



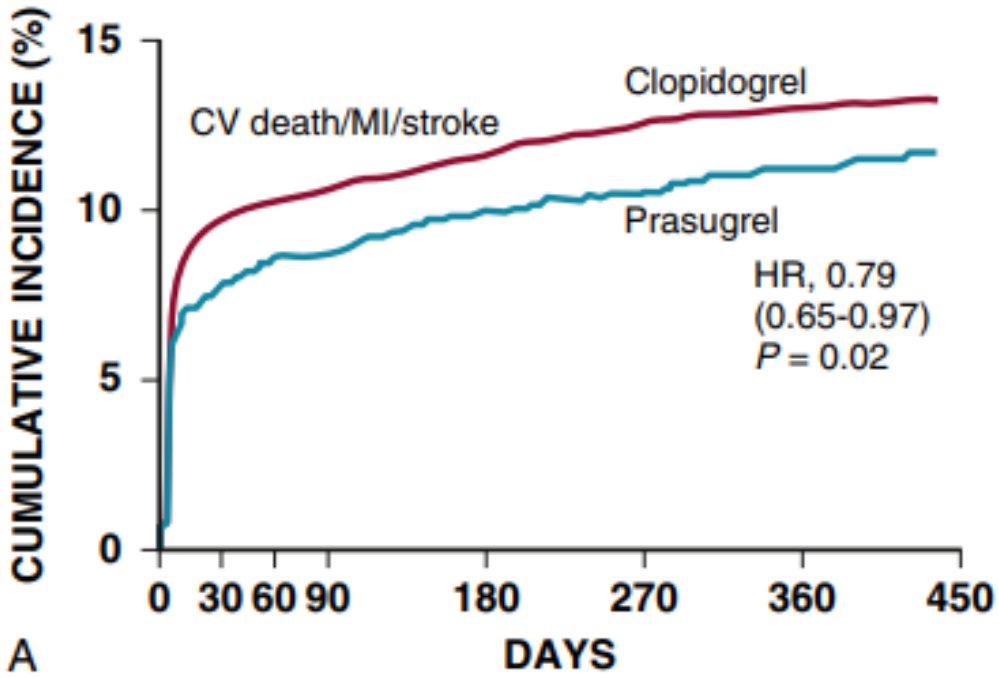
Recommendations	Class	Level
Anticoagulant therapy		
Anticoagulation is recommended for all patients in addition to antiplatelet therapy during primary PCI.	I	C
Routine use of UFH is recommended.	I	C
In patients with heparin-induced thrombocytopenia, bivalirudin is recommended as the anticoagulant agent during primary PCI.	I	C
Routine use of enoxaparin i.v. should be considered.	IIa	A
Routine use of bivalirudin should be considered.	IIa	A
Fondaparinux is not recommended for primary PCI.	III	B

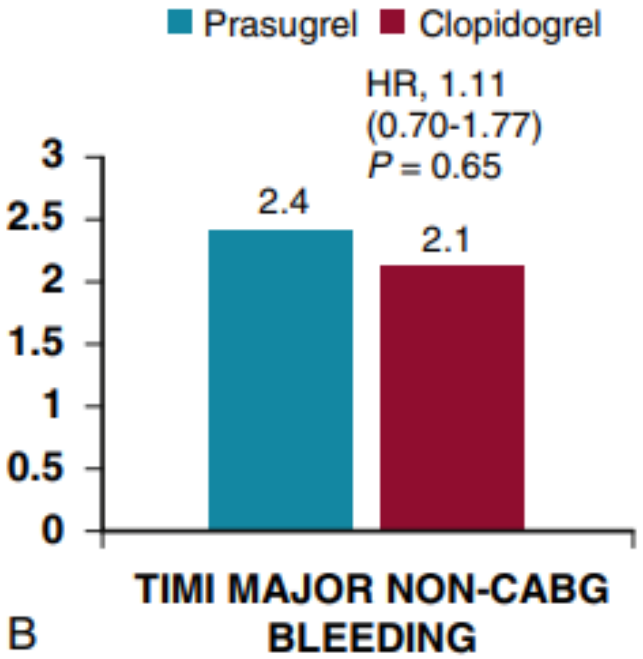


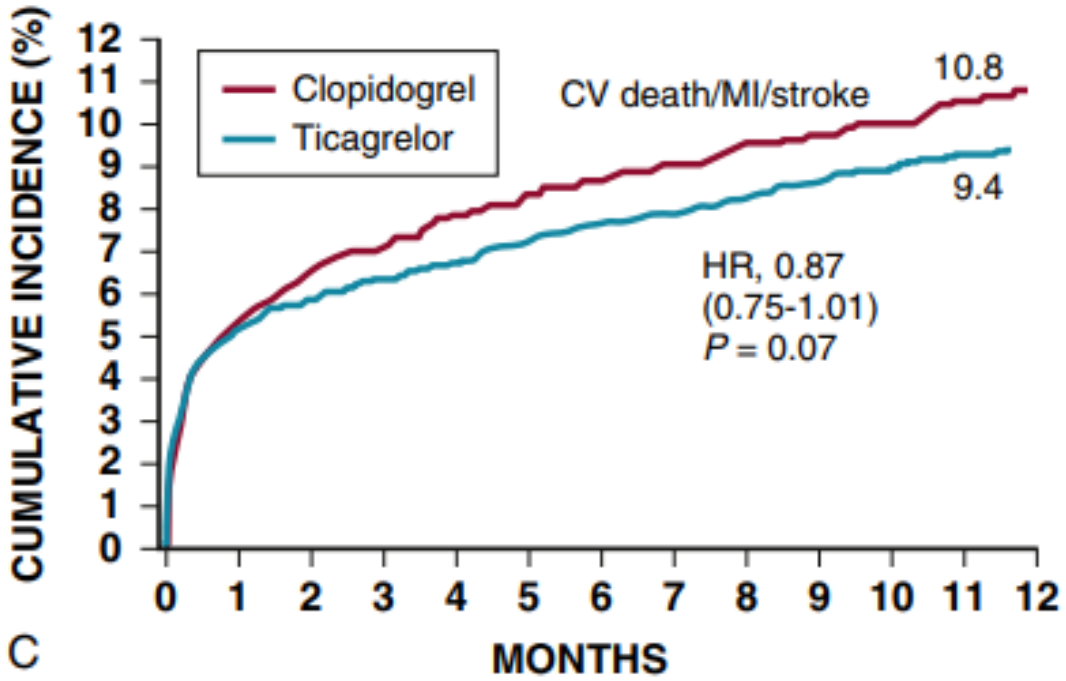
B

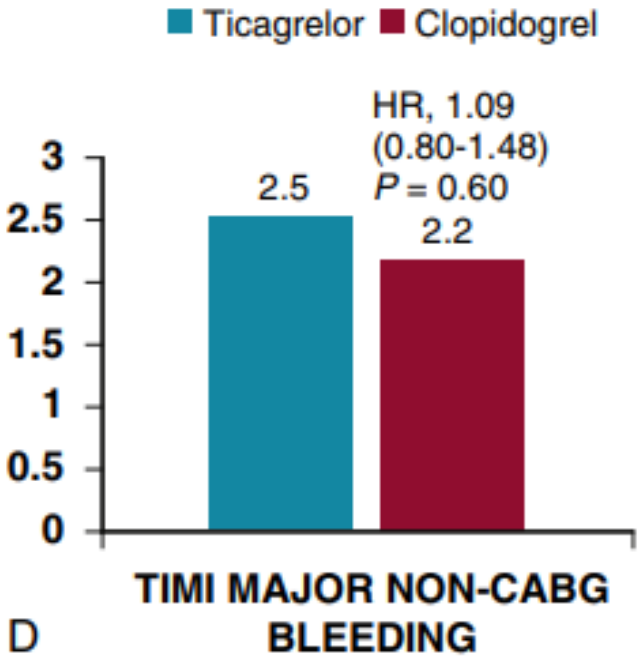
Recommendations	Class	Level
Antiplatelet therapy		
A potent $P2Y_{12}$ inhibitor (prasugrel or ticagrelor), or clopidogrel if these are not available or are contra-indicated, is recommended before (or at latest at the time of) PCI and maintained over 12 months unless there are contra-indications such as excessive risk of bleeding.	I	A
Aspirin (oral or i.v, if unable to swallow) is recommended as soon as possible for all patients without contra-indications.	I	B
GP IIb/IIIa inhibitors should be considered for bailout if there is evidence of no-reflow or a thrombotic complication.	IIa	C
Cangrelor may be considered in patients who have not received $P2Y_{12}$ receptor inhibitors.	IIb	A

Addition of clopidogrel to aspirin in 45,852 patients with acute myocardial infarction: randomised placebo- controlled trial. Lancet. 2005;366:1607.)



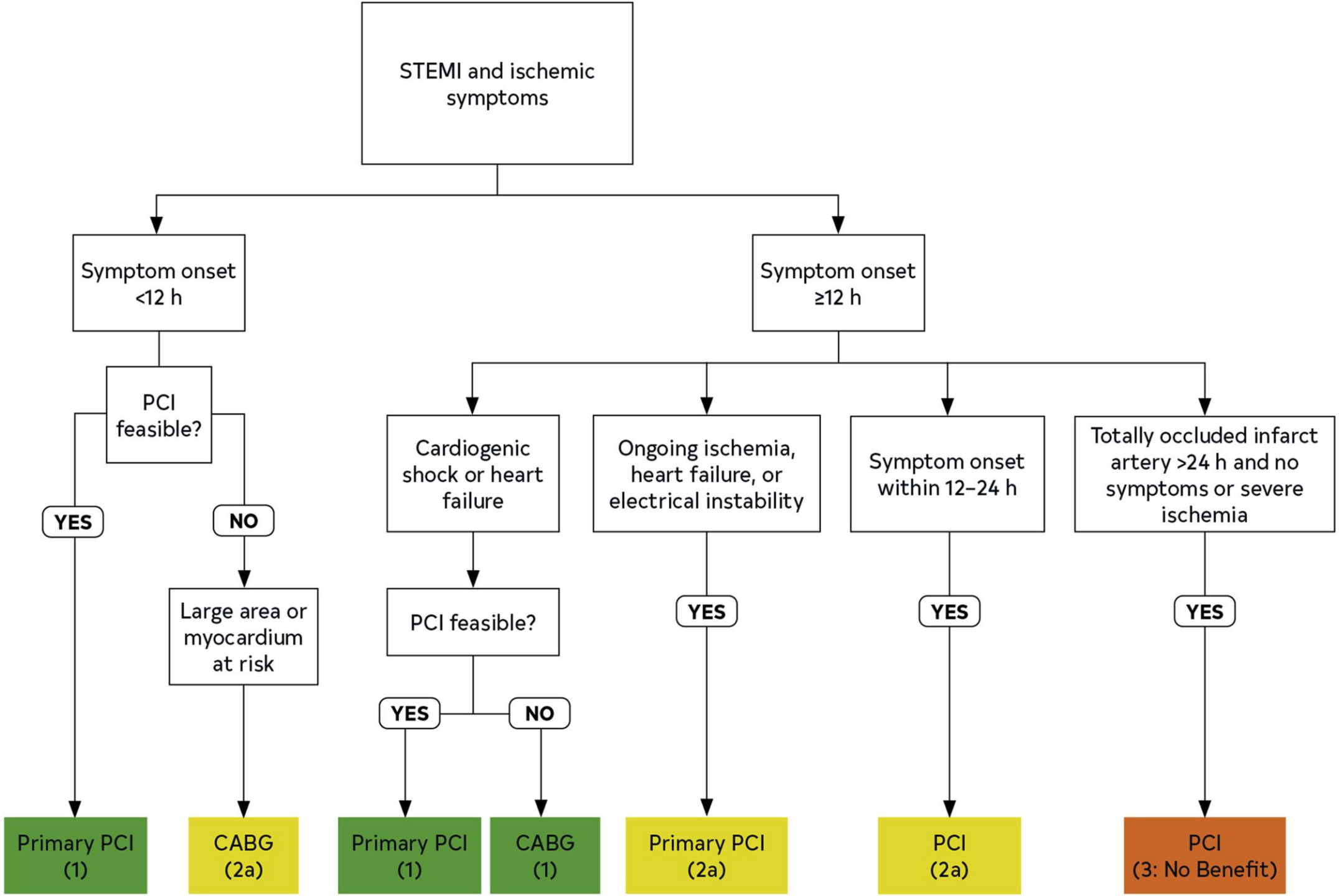






Prasugrel/Ticagrelor vs clopidogrel in patients with ST-elevation acute coronary syndromes

Recommendations	Class	Level
When fibrinolysis is the reperfusion strategy, it is recommended to initiate this treatment as soon as possible after STEMI diagnosis, preferably in the prehospital setting.	I	A
A fibrin-specific agent (i.e. tenecteplase, alteplase, reteplase) is recommended.	I	B
A half-dose of tenecteplase should be considered in patients ≥75 years of age.	IIa	B
Antiplatelet co-therapy with fibrinolysis		
Oral or i.v. aspirin is indicated.	I	B
Clopidogrel is indicated in addition to aspirin.	I	A
DAPT (in the form of aspirin plus a $P2Y_{12}$ inhibitor) is indicated for up to 1 year in patients undergoing fibrinolysis and subsequent PCI.	I	C
Anticoagulation co-therapy with fibrinolysis		
Anticoagulation is recommended in patients treated with lytics until revascularization (if performed) or for the duration of hospital stay up to 8 days. The anticoagulant can be:	I	A
• Enoxaparin i.v. followed by s.c. (preferred over UFH).	I	A
• UFH given as a weight-adjusted i.v. bolus followed by infusion.	I	B
• In patients treated with streptokinase: fondaparinux i.v. bolus followed by an s.c. dose 24 hours later.	IIa	B


STEMI and ischemic symptoms
Symptom onset <12 h
Symptom onset ≥12 h
PCI feasible?
YES
NO
Large area or myocardium at risk
Primary PCI (1)
CABG (2a)
Cardiogenic shock or heart failure
Ongoing ischemia, heart failure, or electrical instability
Symptom onset within 12–24 h
Totally occluded infarct artery >24 h and no symptoms or severe ischemia
PCI feasible?
YES
NO
Primary PCI (1)
CABG (1)
YES
Primary PCI (2a)
YES
PCI (2a)
YES
PCI (3: No Benefit)

Revascularization of Infarct Artery in STEMI to Improve Survival/Clinical Outcomes

Patient with STEMI

PCI if…

- **ischemic symptoms for <12 hr (1)**
- **failed reperfusion after fibrinolytic**
- **therapy, then rescue PCI (1)**
- **cardiogenic shock or hemodynamic instability (1)**

- **Fibrinolytics w/ angiography 3 to 24 hr with PCI intent (2a)**
- **stable &12 to 24 hr after symptom onset (2a)**
- **ongoing ischemia, acute severe HF, or life-threatening arrhythmia (2a)**

In asymptomatic stable STEMI w/ total occlusion >24 hr after symptom onset & no severe ischemia, PCI should not be performed. (3:No Benefit)

CABG if…

- **mechanical complications:**
  - **ventricular septal rupture**
  - **mitral valve insufficiency due to papillary muscle infarction or rupture**
  - **free wall rupture) (1)**
- **cardiogenic shock or hemodynamic instability (1)**

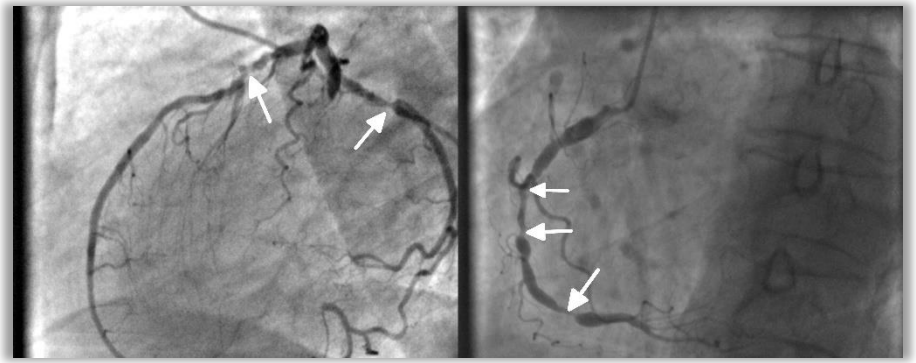
If PCI is not feasible or successful, with a large area of myocardium at risk (2a)

In STEMI, emergency CABG should NOT be performed after failed primary PCI: In absence of ischemia or large area of myocardium at risk, or If surgical revascularization is not feasible because of a no-reflow state or poor distal targets. (3:Harm)

Abbreviations: CABG indicates coronary artery bypass grafting; HF, heart failure; hr, hour; MI, myocardial infarction; PCI, percutaneous coronary intervention; STEMI, ST-segment–elevation myocardial infarction; and w/, with.

Revascularization of Non–Infarct-Related Coronary Artery Lesions in STEMI

Patients without significant comorbidities with large non-infarct vessels



In selected hemodynamically stable patients with STEMI and …

multivessel disease, after successful primary PCI, staged PCI of a significant non-infarct artery stenosis is recommended. (Class 1)

low-complexity multivessel disease, PCI of a non-infarct artery stenosis may be considered at time of primary PCI to reduce cardiac events. (Class 2b)

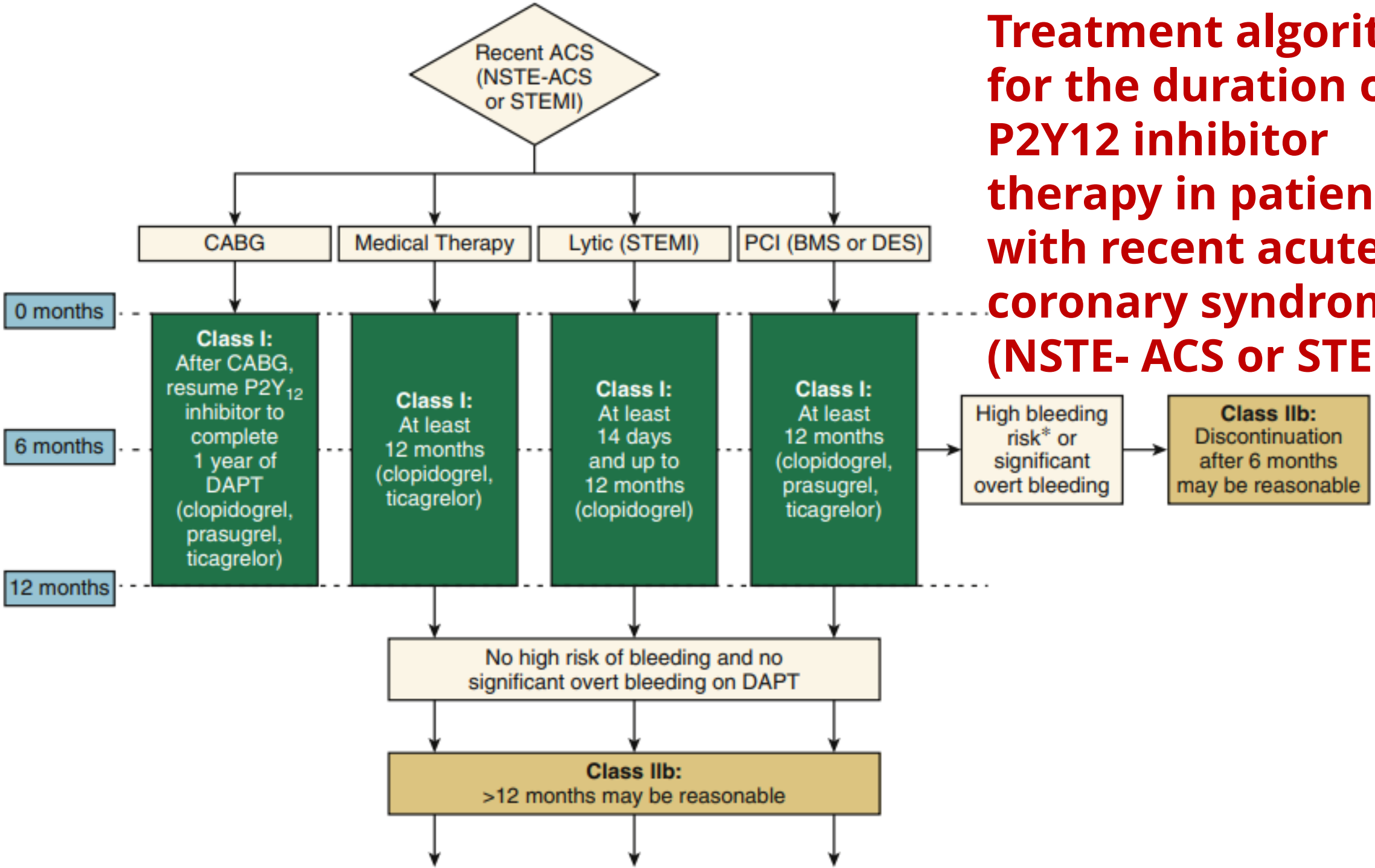
In STEMI…

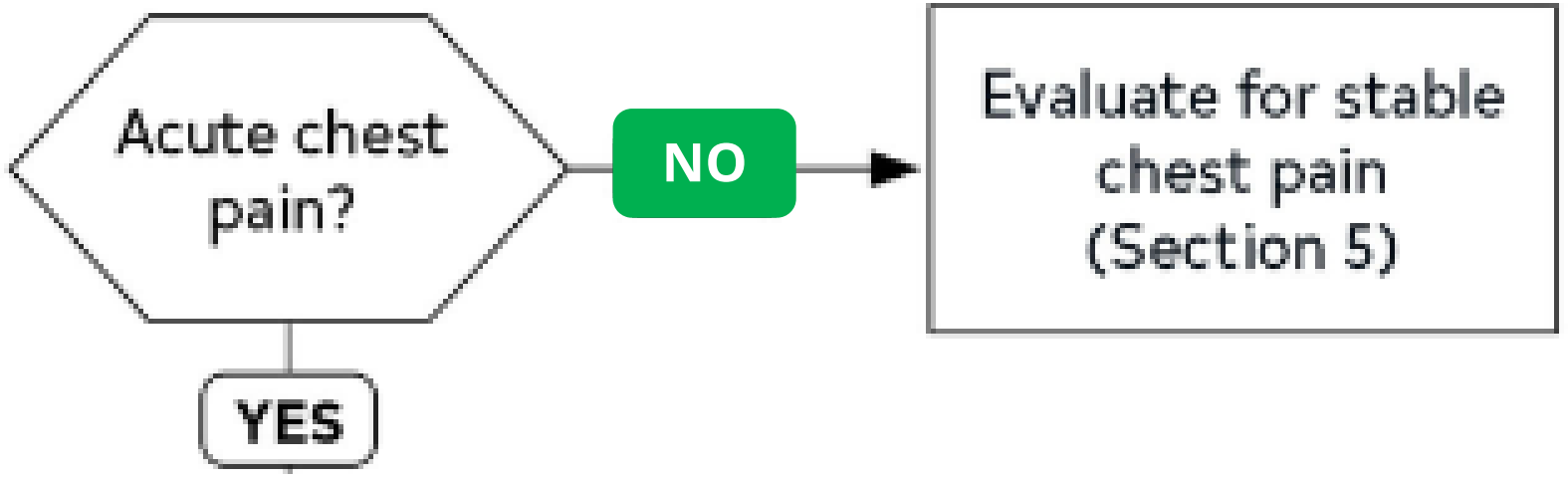
in selected patients with complex multivessel non-infarct artery disease, after successful primary PCI, elective CABG is reasonable. (Class 2a)

complicated by cardiogenic shock, routine PCI of a non-infarct artery at time of primary PCI should NOT be performed due to higher risk of death or renal failure. (Class 3:Harm)

Abbreviations: CABG indicates coronary artery bypass grafting; MI, myocardial infarction; PCI, percutaneous coronary intervention; and STEMI, ST-segment–elevation myocardial infarction.

Treatment algorithm for the duration of P2Y12 inhibitor therapy in patients with recent acute coronary syndrome (NSTE- ACS or STEMI).





CCS - CRONIC CORONARY SYNDROME

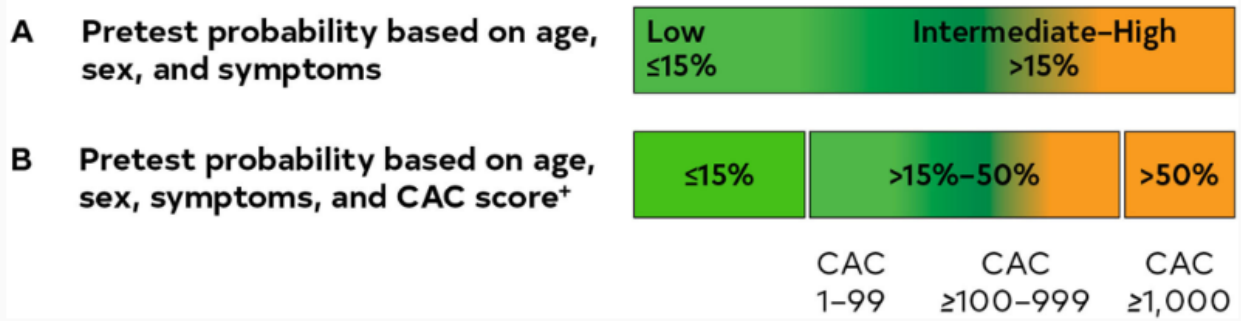
Stable chest pain is a symptom of myocardial ischemia characterized by chest pain that is provoked with stress (physical or emotional). Risk status in suspected stable ischemic heart disease (SIHD) is not well defined.

Originally published 28 Oct 2021
https://doi.org/10.1161/CIR.0000000000001029Circulation. 2021;144:e368–e454

Pretest Probabilities of Obstructive CAD in Symptomatic Patients According to Age, Sex, and Symptoms

Pretest Probabilities of Obstructive CAD in Symptomatic Patients
(A) according to age, sex, and symptoms;
(B) according to age, sex, symptoms, and CAC

Age, y	Chest Pain		Dyspnea	
	Men	Women	Men	Women
30–39	≤4	≤5	0	3
40–49	≤22	≤10	12	3
50–59	≤32	≤13	20	9
60–69	≤44	≤16	27	14
70+	≤52	≤27	32	12



Pretest Probabilities Modified from Juarez-Orozco et al and Winther et al

- use of validated scores to predict the pretest probability of obstructive CAD may be useful to identify low-risk patients for whom testing may be deferred.
- Among the remaining patients classified as intermediate-high risk, selective testing may improve the diagnosis of CAD and for risk stratification purposes.

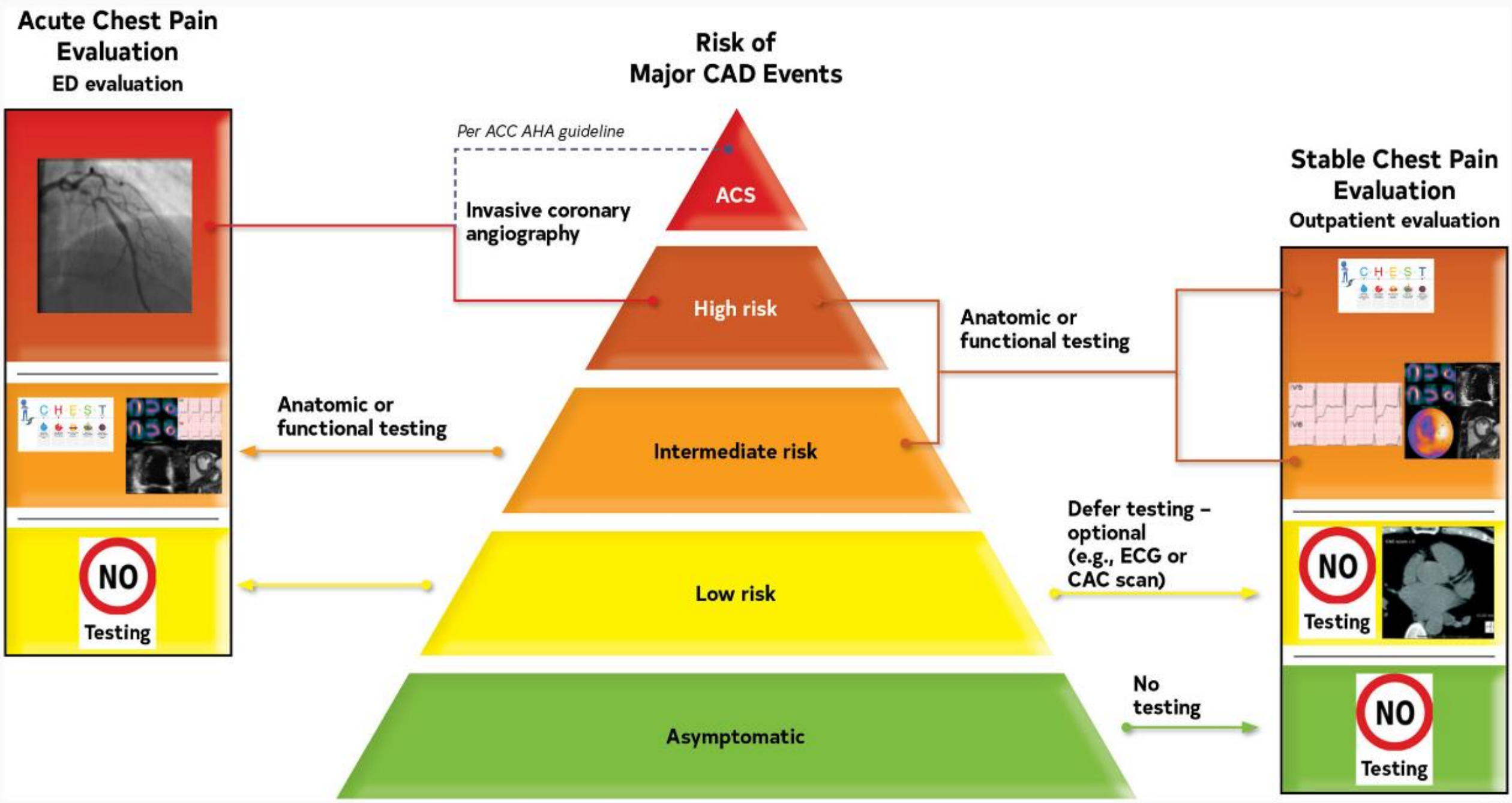
Pretest Probabilities of Obstructive CAD

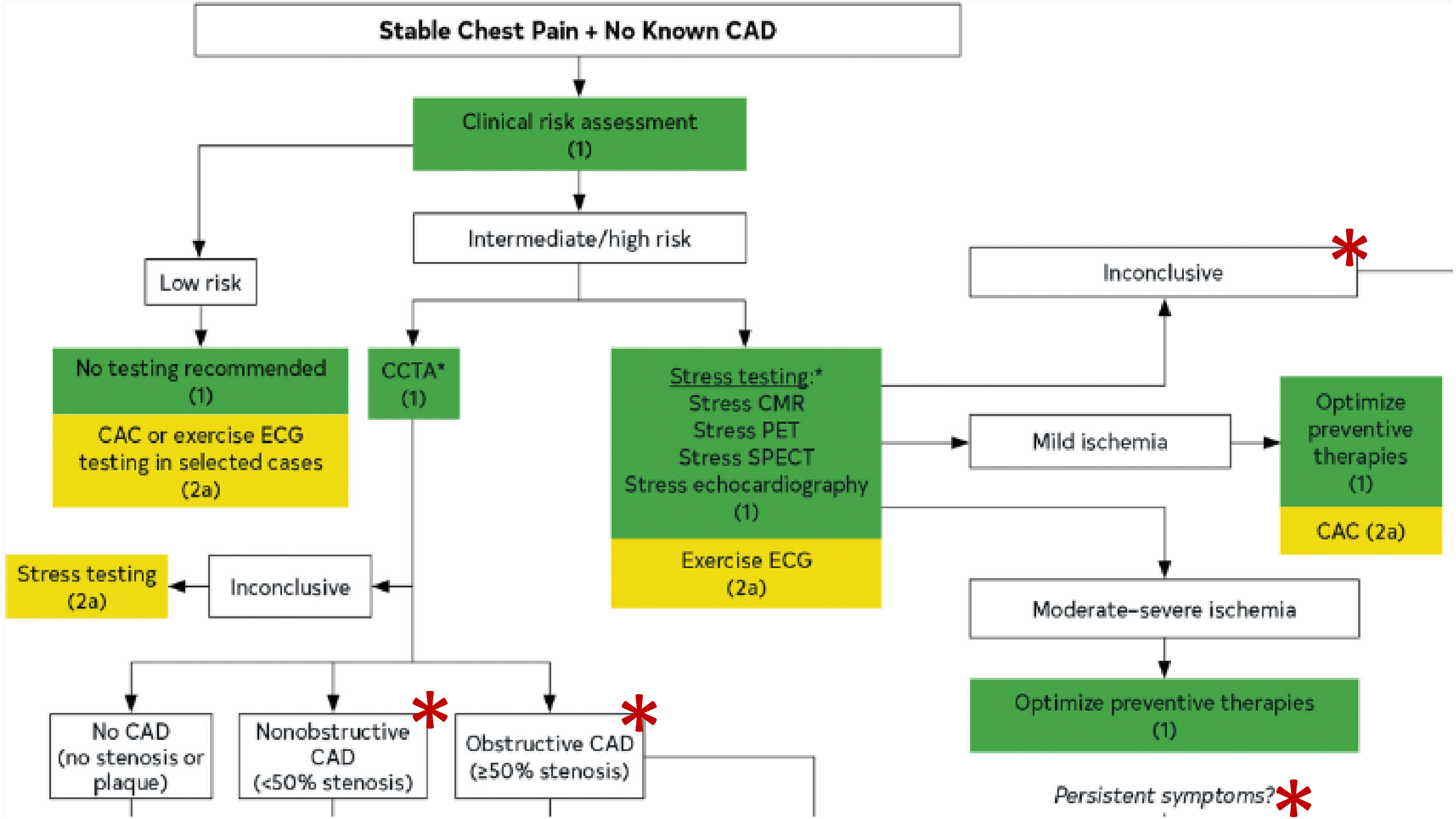
- Among patients undergoing a diagnostic evaluation, there is a relatively **low prevalence of obstructive CAD and ischemia (~10%)**.

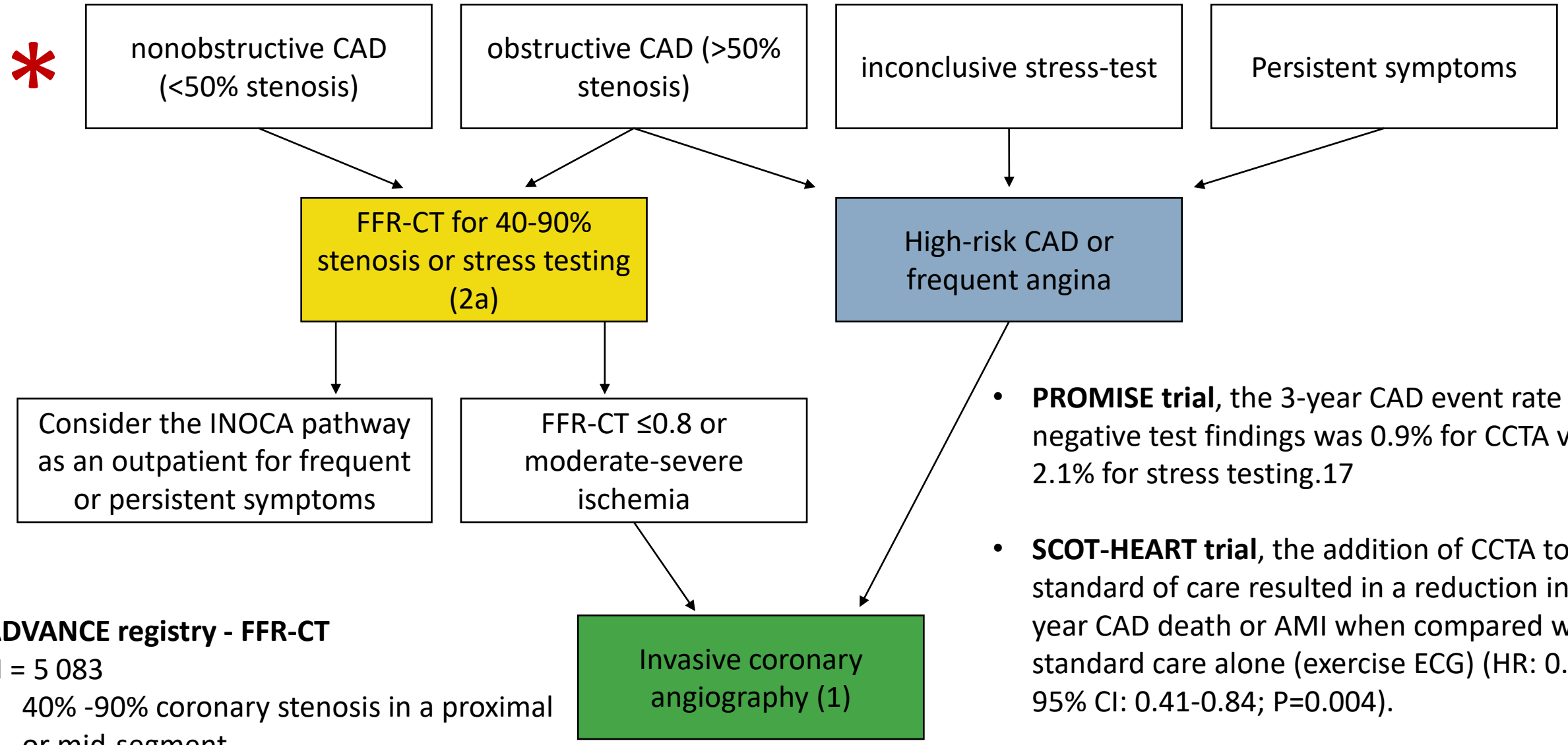
- Traditional pretest risk scores **largely overestimate** disease probability and contribute to **overtesting**.

- Current testing patterns result in a **high normal coronary angiography rate (upward of 50%–60%).**

Originally published 28 Oct 2021
https://doi.org/10.1161/CIR.0000000000001029Circulation. 2021;144:e368–e454


Acute Chest Pain Evaluation
ED evaluation
NO
Testing
Risk of Major CAD Events
Per ACC AHA guideline
ACS
Invasive coronary angiography
High risk
Anatomic or functional testing
Intermediate risk
Anatomic or functional testing
Low risk
Asymptomatic
Defer testing – optional (e.g., ECG or CAC scan)
No testing
Stable Chest Pain Evaluation
Outpatient evaluation
NO
Testing
NO
Testing


Stable Chest Pain + No Known CAD
Clinical risk assessment (1)
Low risk
Intermediate/high risk
No testing recommended (1)
CAC or exercise ECG testing in selected cases (2a)
CCTA* (1)
Stress testing:* Stress CMR Stress PET Stress SPECT Stress echocardiography (1)
Exercise ECG (2a)
Inconclusive
Stress testing (2a)
Inconclusive
Mild ischemia
Optimize preventive therapies (1)
CAC (2a)
Moderate–severe ischemia
Optimize preventive therapies (1)
No CAD (no stenosis or plaque)
Nonobstructive CAD (<50% stenosis)
Obstructive CAD (≥50% stenosis)
Persistent symptoms?

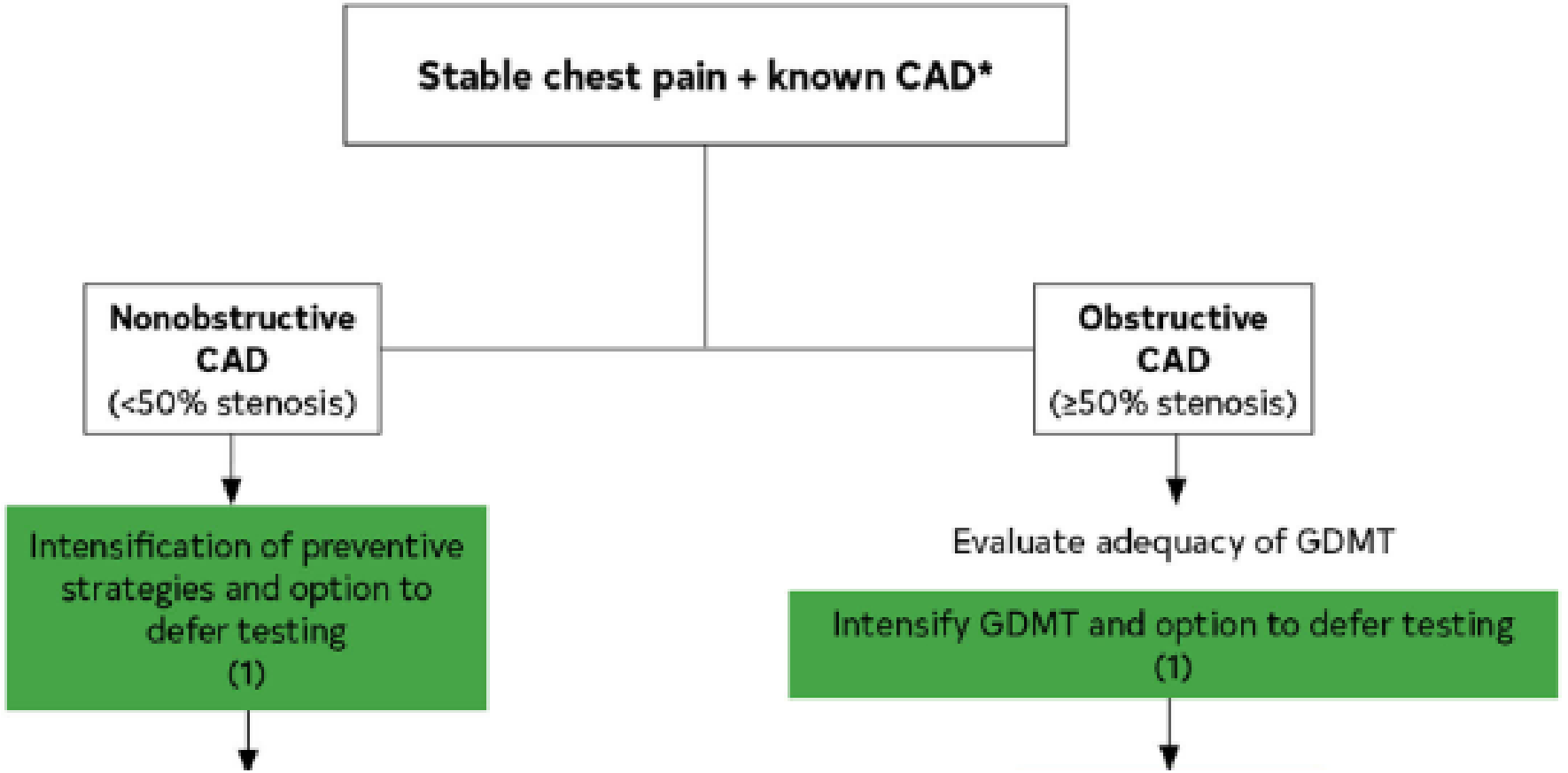


ADVANCE registry - FFR-CT

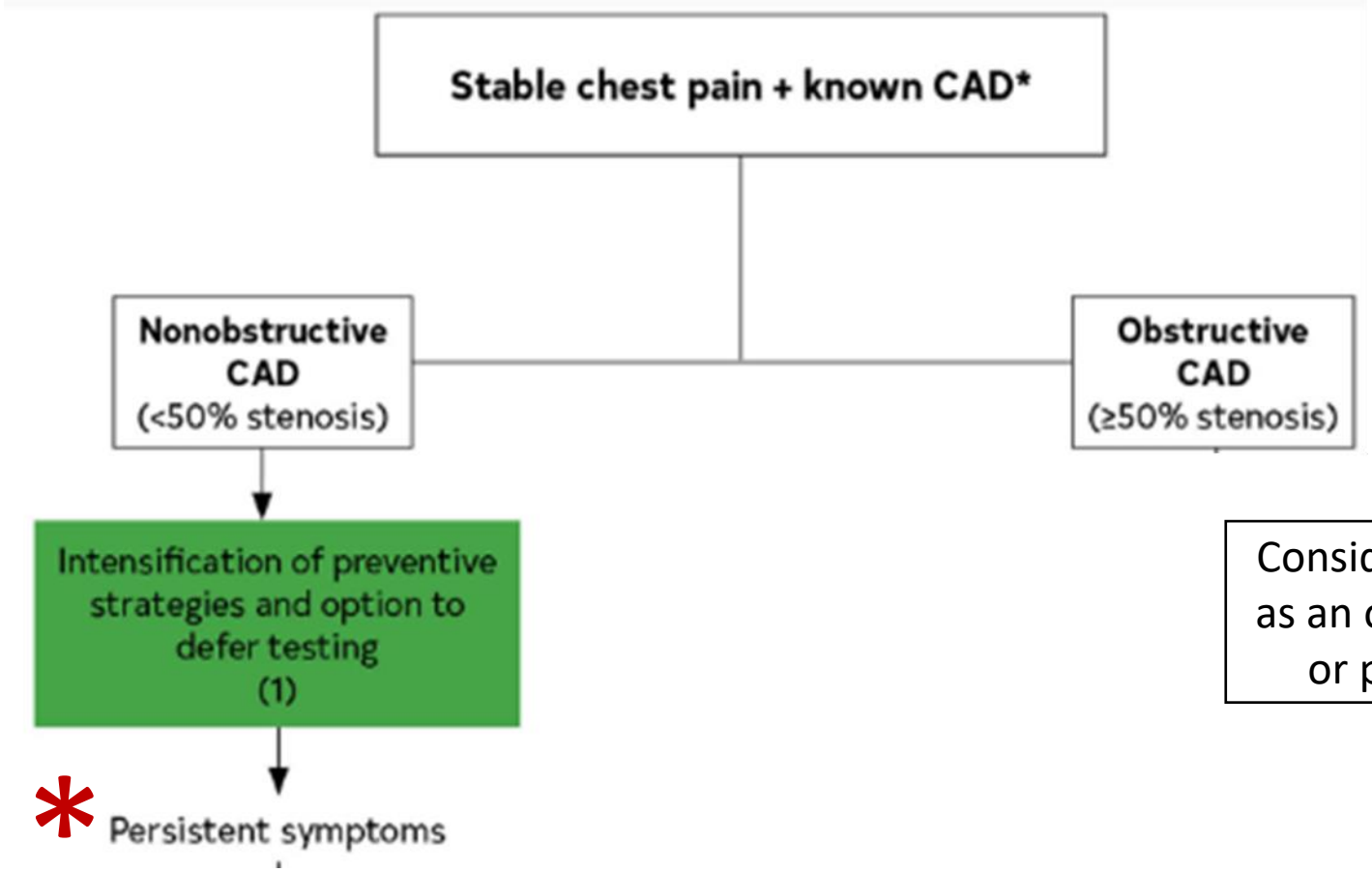
N = 5 083

- 40% -90% coronary stenosis in a proximal or mid-segment
- changed treatment recommendations in two-thirds of patients
- no MACE at 90 days for negative FFR-CT

- **PROMISE trial**, the 3-year CAD event rate for negative test findings was 0.9% for CCTA versus 2.1% for stress testing.17
- **SCOT-HEART trial**, the addition of CCTA to standard of care resulted in a reduction in 5-year CAD death or AMI when compared with standard care alone (exercise ECG) (HR: 0.59; 95% CI: 0.41-0.84; P=0.004).
- **CONSERVE trial**, a strategy of initial CCTA was associated with lower cost but similar 1-year MACE rates as direct ICA



BUT IF THE GDMT IS NOT ENOUGH?



*

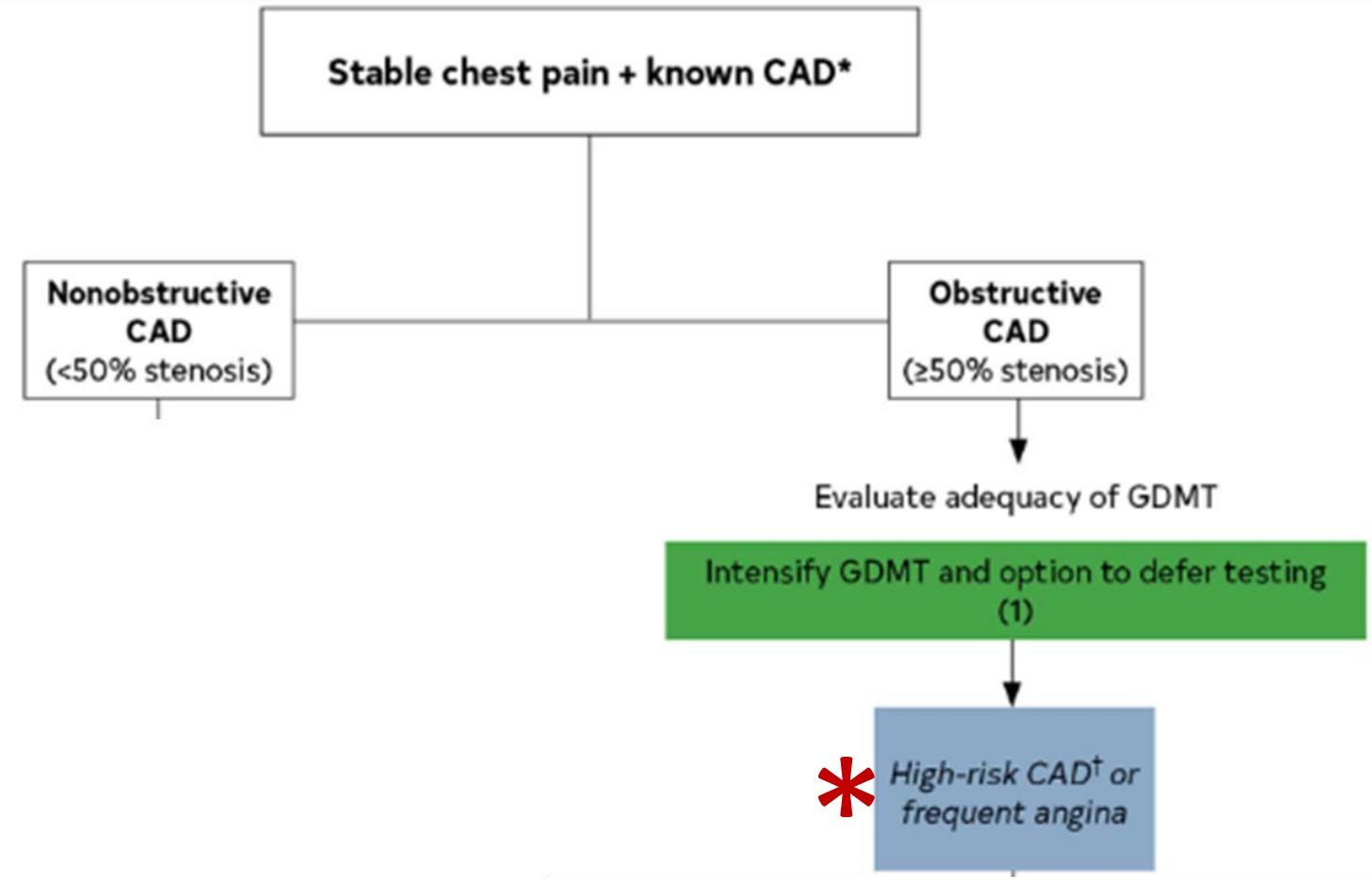
Persistent symptoms

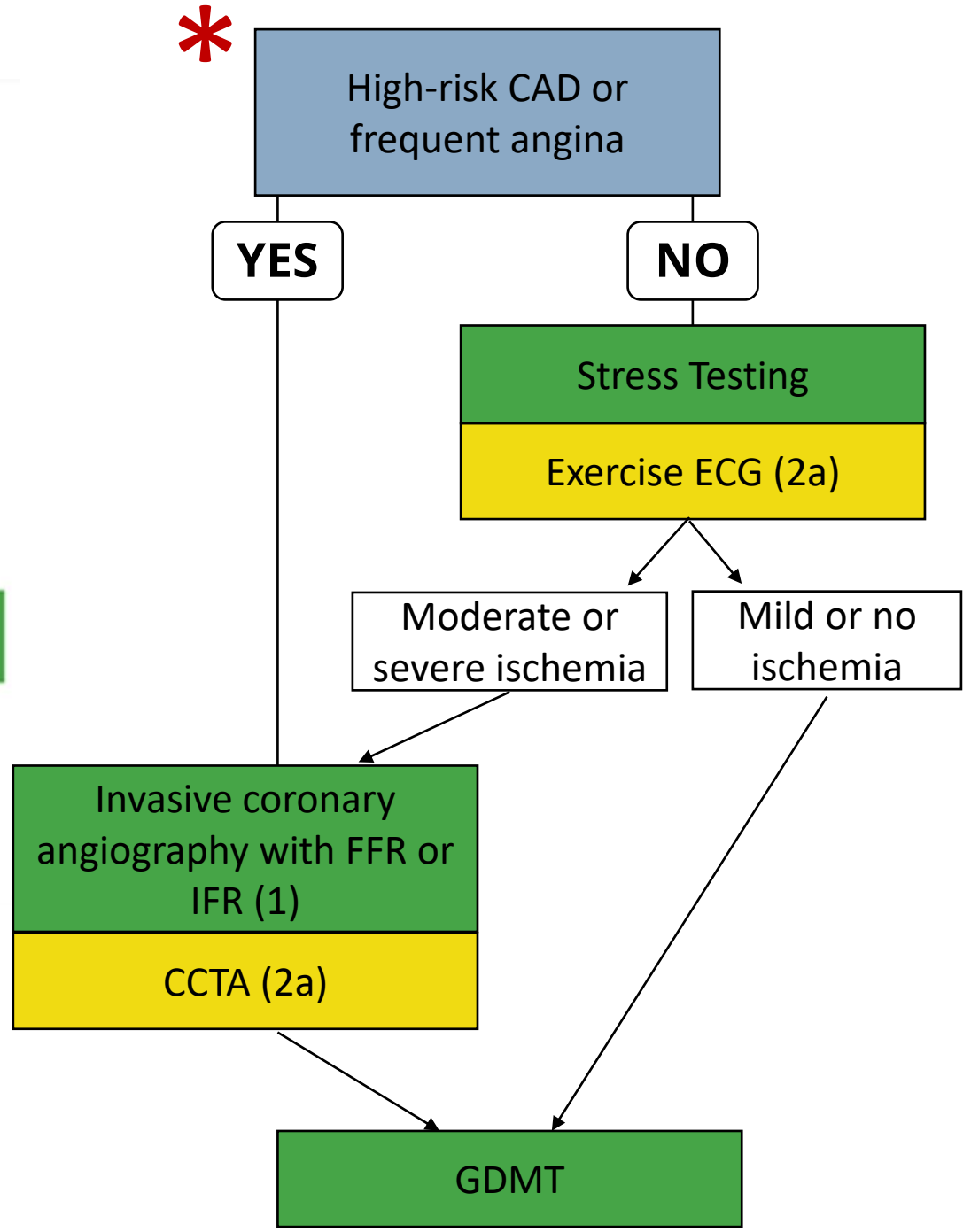
CCTA + FFR-CT for 40-90% stenosis or stress testing (2a)

Consider the INOCA pathway as an outpatient for frequent or persistent symptoms

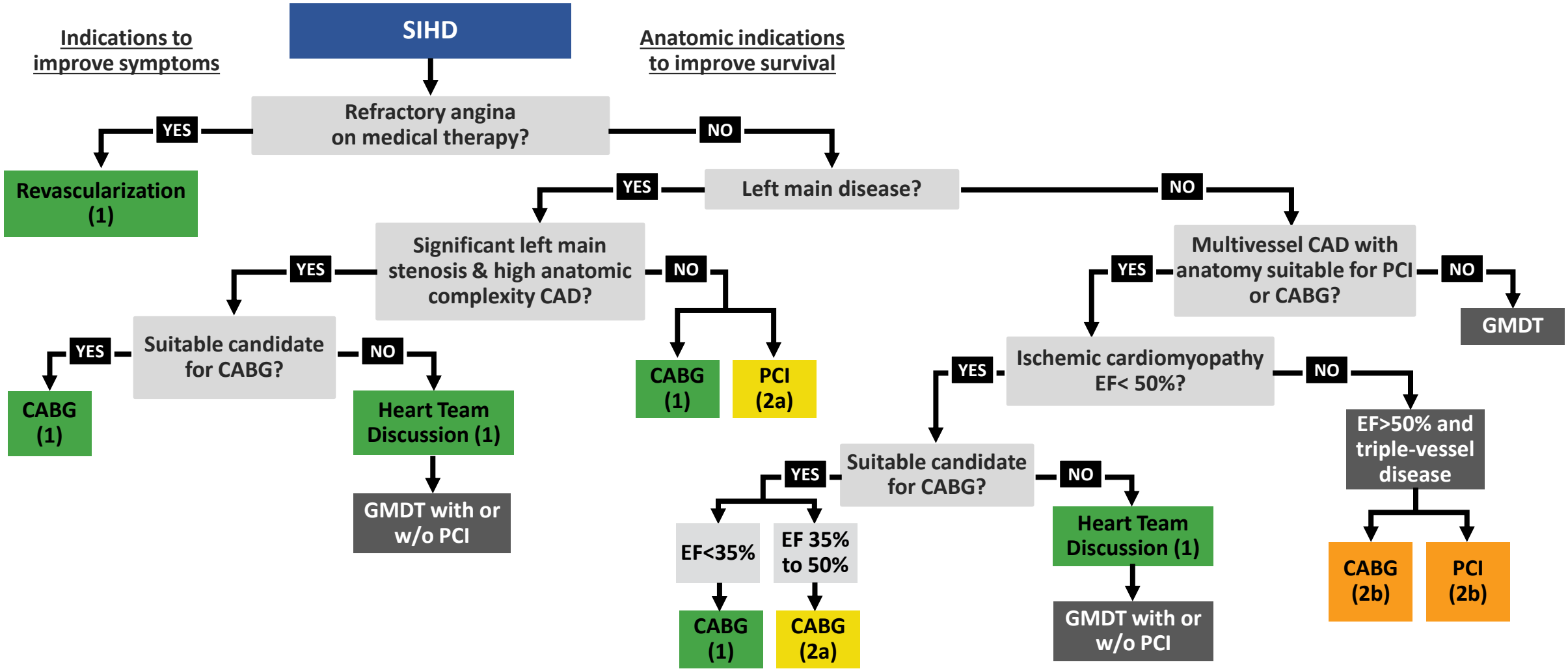
FFR-CT ≤0.8 or moderate-severe ischemia

Invasive coronary angiography (1)


Stable chest pain + known CAD*
Nonobstructive CAD (<50% stenosis)
Obstructive CAD (≥50% stenosis)
Evaluate adequacy of GDMT
Intensify GDMT and option to defer testing (1)
*
High-risk CAD† or frequent angina


*
High-risk CAD or frequent angina
YES
NO
Stress Testing
Exercise ECG (2a)
Moderate or severe ischemia
Mild or no ischemia
Invasive coronary angiography with FFR or IFR (1)
CCTA (2a)
GDMT

Revascularization in Patients With SIHD



Abbreviations: CABG indicates coronary artery bypass grafting; CAD, coronary artery disease; EF, ejection fraction; GDMT, guideline-directed medical therapy; PCI, percutaneous coronary intervention; and SIHD, stable ischemic heart disease.

ICA - Invasive coronary angiography

Lesion Severity

Coronary Physiology (Class 1)

In patients with angina or an anginal equivalent, undocumented ischemia, and angiographically intermediate stenoses, the use of FFR or iFR is recommended to guide the decision to proceed with PCI.

Coronary Physiology (Class 3: No Benefit)

In stable patients with angiographically intermediate stenoses and FFR >0.80 or iFR >0.89, PCI should not be performed.

IVUS (Class 2a)

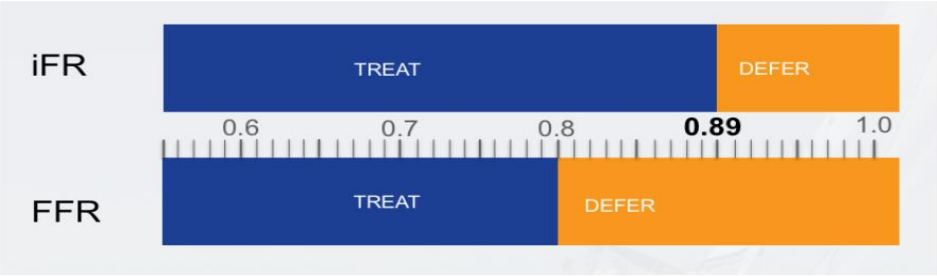
In patients with intermediate stenosis of the left main artery, intravascular ultrasound (IVUS) is reasonable to help define lesion severity.

SYNTAX Score (Class 2b)

In patients with multivessel CAD, an assessment of CAD complexity, such as the SYNTAX score, may be useful to guide revascularization.

Coronary Angiography

- Significant stenosis is defined as >70% for non-LMT and >50% for LMT.
- Intermediate stenoses (40-69%) generally warrant additional investigation.
- No standard cutoffs for lesion length used to classify a severe stenosis.



Abbreviations: CAD indicates coronary artery disease; FFR, fractional flow reserve; iFR, instantaneous wave-free ratio; IVUS, intravascular ultrasound; LMT, left main trunk; PCI, percutaneous coronary intervention; and SYNTAX, Synergy Between PCI With TAXUS and Cardiac Surgery.

Revascularization Based Approach to Improve Mortality Compared with GDMT

Patient Subsets Deriving Class I Benefits of Revascularization

COR	RECOMMENDATIONS
1	**Left ventricular dysfunction and multivessel CAD** with severe LVEF<35%, CABG is recommended (Class 1)
1	**Left main CAD** with significant left main stenosis, CABG is recommended (Class 1)

Patient Subsets Deriving Class 2a or 2b Recommendations

COR	RECOMMENDATIONS
2a	**Left ventricular dysfunction and multivessel CAD** with mild-to-moderate LVEF 35%–50%, CABG is recommended (Class 2a)
2a	**Left main CAD** in selected patients: if PCI can provide equivalent revascularization to that possible with CABG, PCI is reasonable (Class 2a)
2b	Multivessel CAD: normal EF, significant stenosis in 3 major coronary arteries (with or without proximal LAD), and anatomy suitable for CABG, CABG may be reasonable to improve survival (Class 2b)
2b	Multivessel CAD: normal EF, significant stenosis in 3 major coronary arteries (with or without proximal LAD), and anatomy suitable for PCI, the usefulness of PCI to improve survival is uncertain (Class 2b)
2b	Stenosis in the proximal LAD artery: normal LVEF and significant stenosis in the proximal LAD, the usefulness of coronary revascularization to improve survival is uncertain (Class 2b)

Patient Subsets Deriving Class 3 Recommendations

COR	RECOMMENDATIONS
3	**Single- or double-vessel disease not involving the proximal LAD:** normal LVEF, and 1- or 2-vessel CAD not involving the proximal LAD, coronary revascularization is not recommended to improve survival (Class 3: No Benefit)
3	**Single- or double-vessel disease not involving the proximal LAD:** with >1 coronary arteries not anatomically or functionally significant (<70% diameter of non–left main coronary artery stenosis, FFR >0.80), coronary revascularization should **NOT** be performed with the primary or sole intent to improve survival (Class 3: Harm)

Revascularization Approach to Reduce Cardiovascular Events in SIHD Compared with Medical Therapy

COR	RECOMMENDATIONS
2a	In patients with SIHD and multivessel CAD appropriate for either CABG or PCI, revascularization is reasonable to lower the risk of cardiovascular events such as spontaneous MI, unplanned urgent revascularizations, or cardiac death.

Revascularization Approach to Improve Symptoms

COR	RECOMMENDATIONS
1	In patients with refractory angina despite medical therapy and with significant coronary artery stenoses amenable to revascularization, revascularization is recommended to improve symptoms.

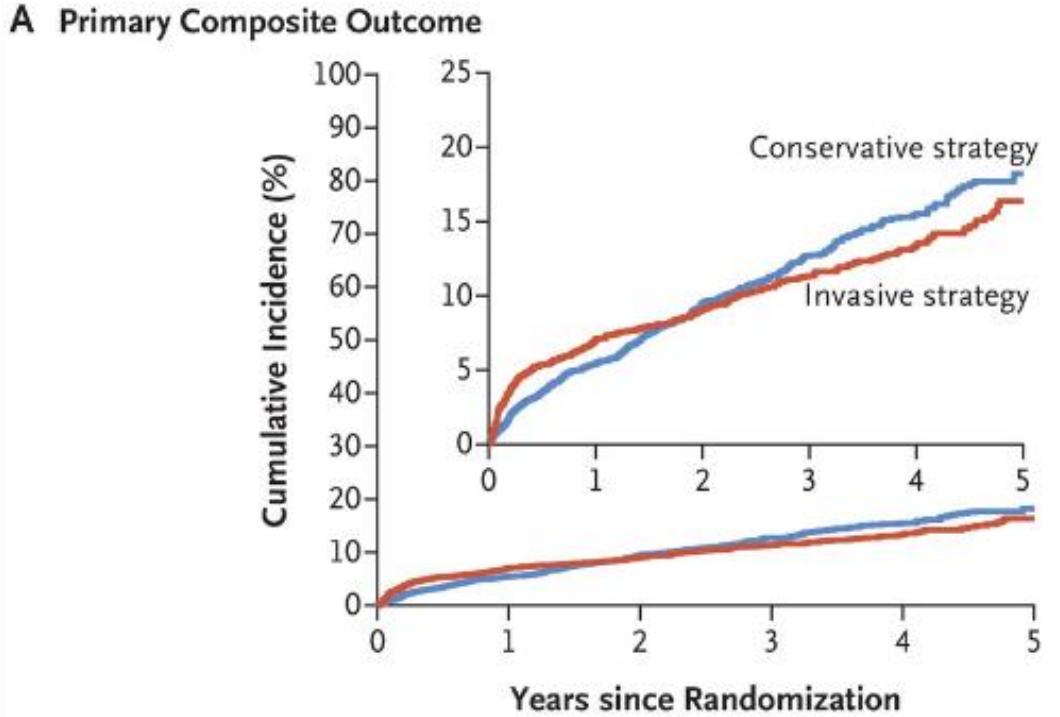
The NEW ENGLAND JOURNAL of MEDICINE

ISCHEMIA trial

Initial Invasive or Conservative Strategy for Stable Coronary Disease

David J. Maron, M.D., Judith S. Hochman, M.D., Harmony R. Reynolds, M.D., Sripal Bangalore, M.D., M.H.A., Sean M. O'Brien, Ph.D., William E. Boden, M.D., Bernard R. Chaitman, M.D., Roxy Senior, M.D., D.M., Jose López-Sendón, M.D., Karen P. Alexander, M.D., Renato D. Lopes, M.D., Ph.D., Leslee J. Shaw, Ph.D., et al., for the ISCHEMIA Research Group*

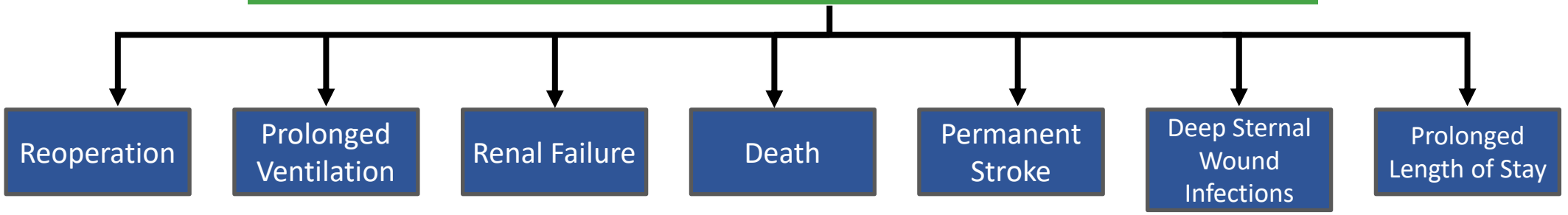
- N = 5179
- patients with stable CAD and site-determined moderate-severe ischemia on stress testing were randomized to invasive vs conservative care strategies.
- No difference in the composite primary MACE endpoint was observed at ~3.3 years of follow-up.
- Patients presenting with daily, weekly, or monthly angina had a prompt and durable improvement in symptoms when randomized to invasive compared with conservative management



April 9, 2020 - N Engl J Med 2020; 382:1395-1407
DOI: 10.1056/NEJMoa1915922

Assessing Risk for Patients Undergoing CABG

In patients who are being considered for CABG, calculation of the Society of Thoracic Surgeons (STS) risk score is recommended to help stratify patient risk (Class 1).*



Risk Factors Not Quantified in the STS Score	
Cirrhosis	Meld
Frailty	Gait Speed
Malnutrition	MUST

Guiding Principle: In patients who are being considered for CABG, calculation of the STS risk score is recommended to help stratify patient risk. The MELD score, gait speed, and the MUST score may help in patients with cirrhosis, frailty, and malnutrition respectively.

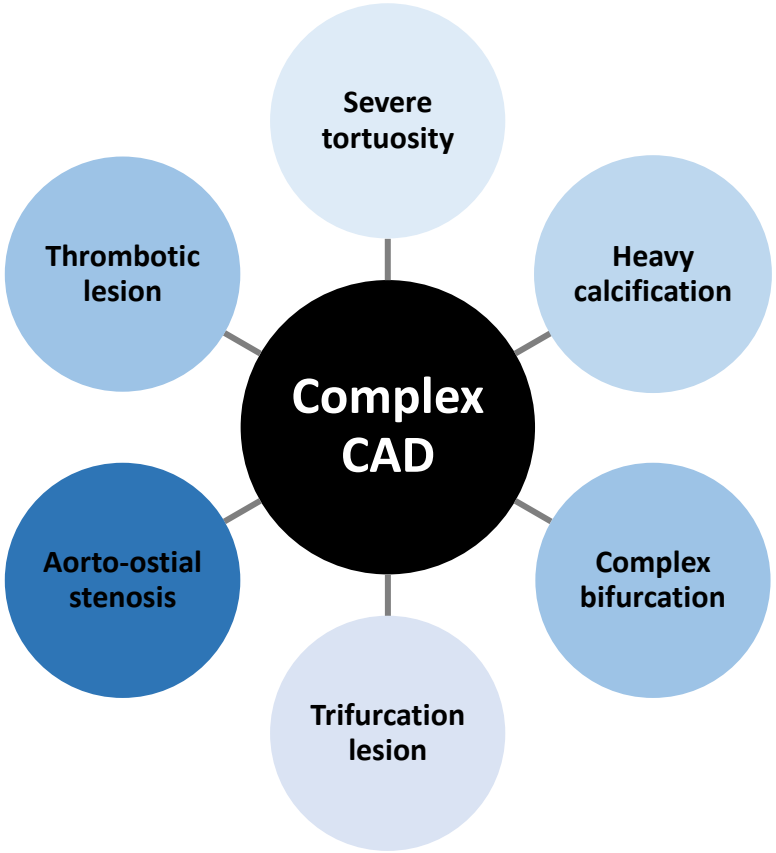
Abbreviations: CABG indicates coronary artery bypass grafting; MELD, Model for End-Stage Liver Disease; MUST, Malnutrition Universal Screening Tool; and STS, Society of Thoracic Surgeons.

*** See:** https://www.sts.org/resources/risk-calculator

PCI vs CABG

COR	RECOMMENDATIONS
1	In patients who require revascularization for significant left main CAD with high-complexity CAD, it is recommended to choose CABG over PCI to improve survival.
2a	In patients who require revascularization for multivessel CAD with complex or diffuse CAD (e.g., SYNTAX score >33), it is reasonable to choose CABG over PCI to confer a survival advantage.

Guiding Principle:
CABG improves survival compared with PCI in patients with **left main and complex CAD**.



COR	RECOMMENDATIONS
2a	PCI can be useful in diabetics who have multivessel CAD and are poor candidates for surgery.
2b	PCI may be considered to reduce MACO in diabetics with LM stenosis and low/intermediate complexity CAD.

Guiding Principle:
CABG compared to PCI has a benefit in mortality and repeat revascularizations in **diabetics**.

Diabetes with multivessel CAD → Appropriate candidate for CABG

Revascularization in CKD patients

Chronic Kidney Disease

COR	RECOMMENDATIONS
1	1. In patients with CKD undergoing contrast media injection for coronary angiography, measures should be taken to minimize the risk of contrast-induced AKI.
1	2. In patients with STEMI and CKD, coronary angiography and revascularization are recommended, with adequate measures to reduce the risk of AKI.
2a	3. In high-risk patients with NSTE-ACS and CKD, it is reasonable to perform coronary angiography and revascularization, with adequate measures to reduce the risk of AKI.
2a	4. In low-risk patients with NSTE-ACS and CKD, it is reasonable to weigh the risk of coronary angiography and revascularization against the potential benefit.
3: No Benefit	5. In asymptomatic patients with stable CAD and CKD, routine angiography and revascularization are not recommended if there is no compelling indication .

Best Practices in Cath Lab for Patients with CKD Undergoing Angiography

RECOMMENDATIONS

Assess the risk of contrast-induced AKI before the procedure.

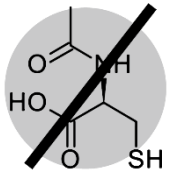
Administer adequate preprocedural hydration.

Record the volume of contrast media administered, and minimize contrast use.

Pretreat with high-intensity statins.

Use radial artery if feasible.

Delay CABG in stable patients after angiography beyond 24 hours when clinically feasible.



Do not administer N-acetyl-L-cysteine to prevent contrast-induced AKI.

Do not give prophylactic renal replacement therapy.

Special Clinical Situations: Nonatherosclerotic Lesions

Spontaneous coronary artery dissection

Expert consensus recommends conservative care for most patients.

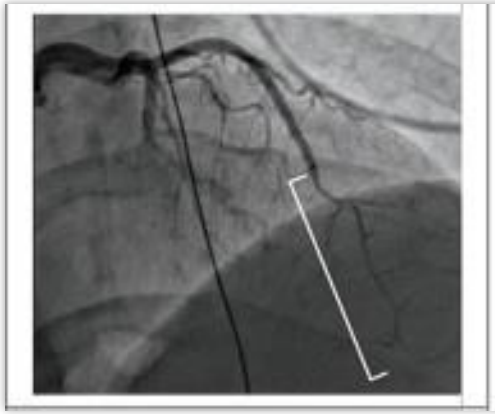
Research is needed to understand optimal management in patients with ongoing symptoms, hemodynamic instability, or severely compromised flow to a large myocardial territory.

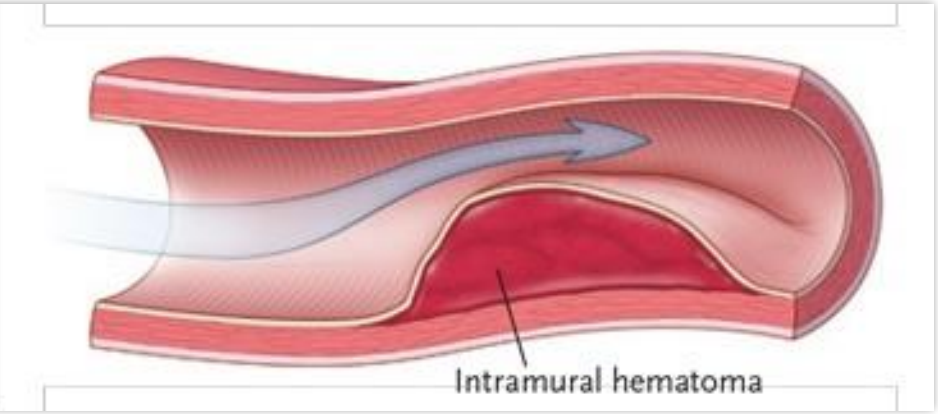
Coronary artery aneurysms

Coronary artery aneurysms can be asymptomatic or lead to ischemia, thrombosis, fistula formation, or rupture. The ideal timing and mode of intervention is unknown.

Myocardial bridging

In cases of severe ischemia and significant myocardial bridging, surgical approaches are available, but the long-term risks and benefits are uncertain.

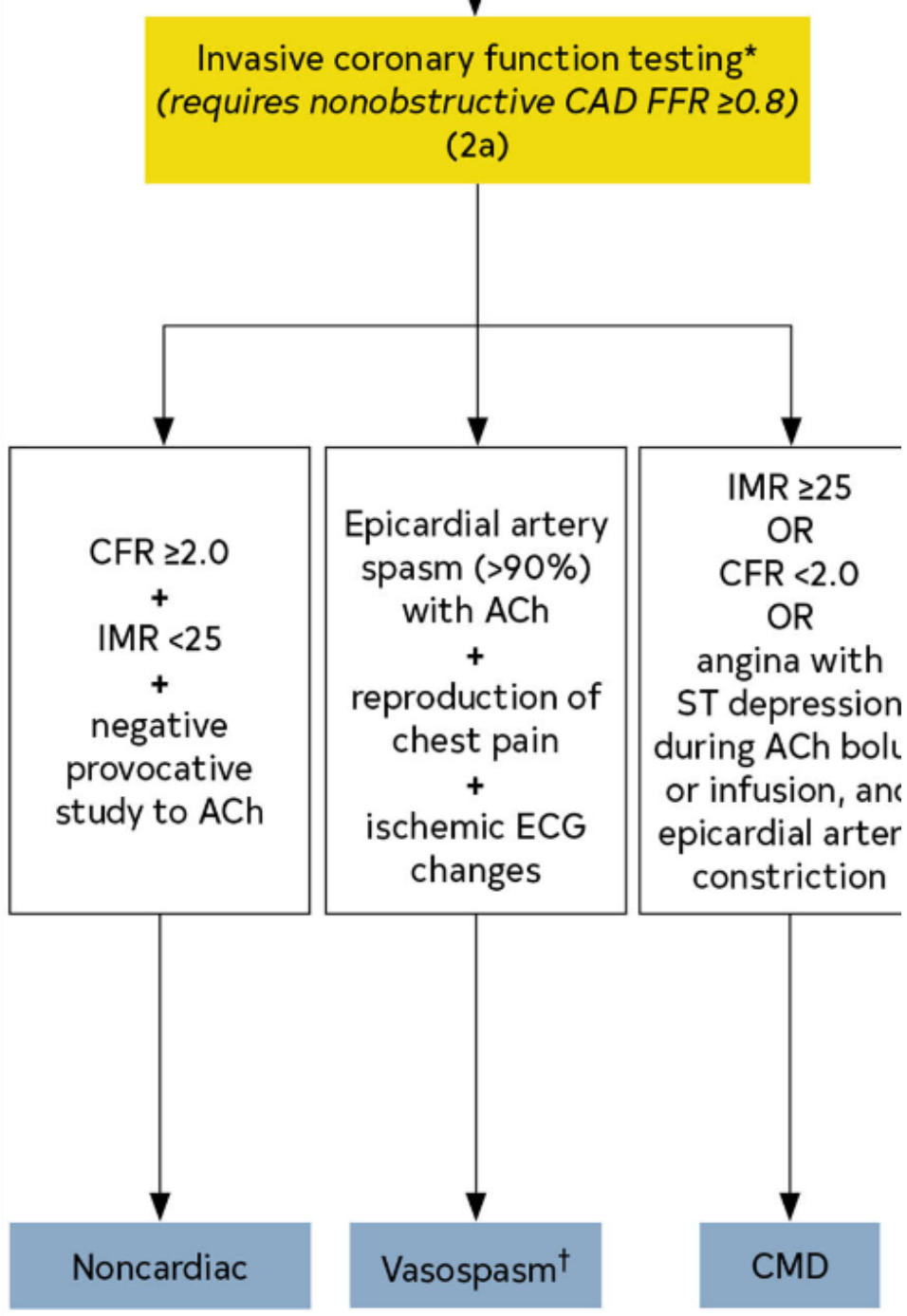




INOCA PATHWAY

- alterations in flow within the microvasculature.
- symptomatic patients without obstructive CAD may be candidates for assessment of coronary microvascular dysfunction
- Patients at highest risk for coronary microvascular dysfunction: women with hypertension, diabetes or insulin-resistant states.

2a	B-NR	1. 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.[1-4]



ISCHEMIA WITH NON-OBSTRUCTIVE CORONARY ARTERIES[1]

Coronary Microvascular Dysfunction (CMD)/Vasospastic Angina (VSA)

Non-invasive evaluation

- Step 1 : Patient evaluation
- Step 2 : Non-invasive evaluation
  Functional Imaging
  ±Coronary CT Angiography

Invasive evaluation

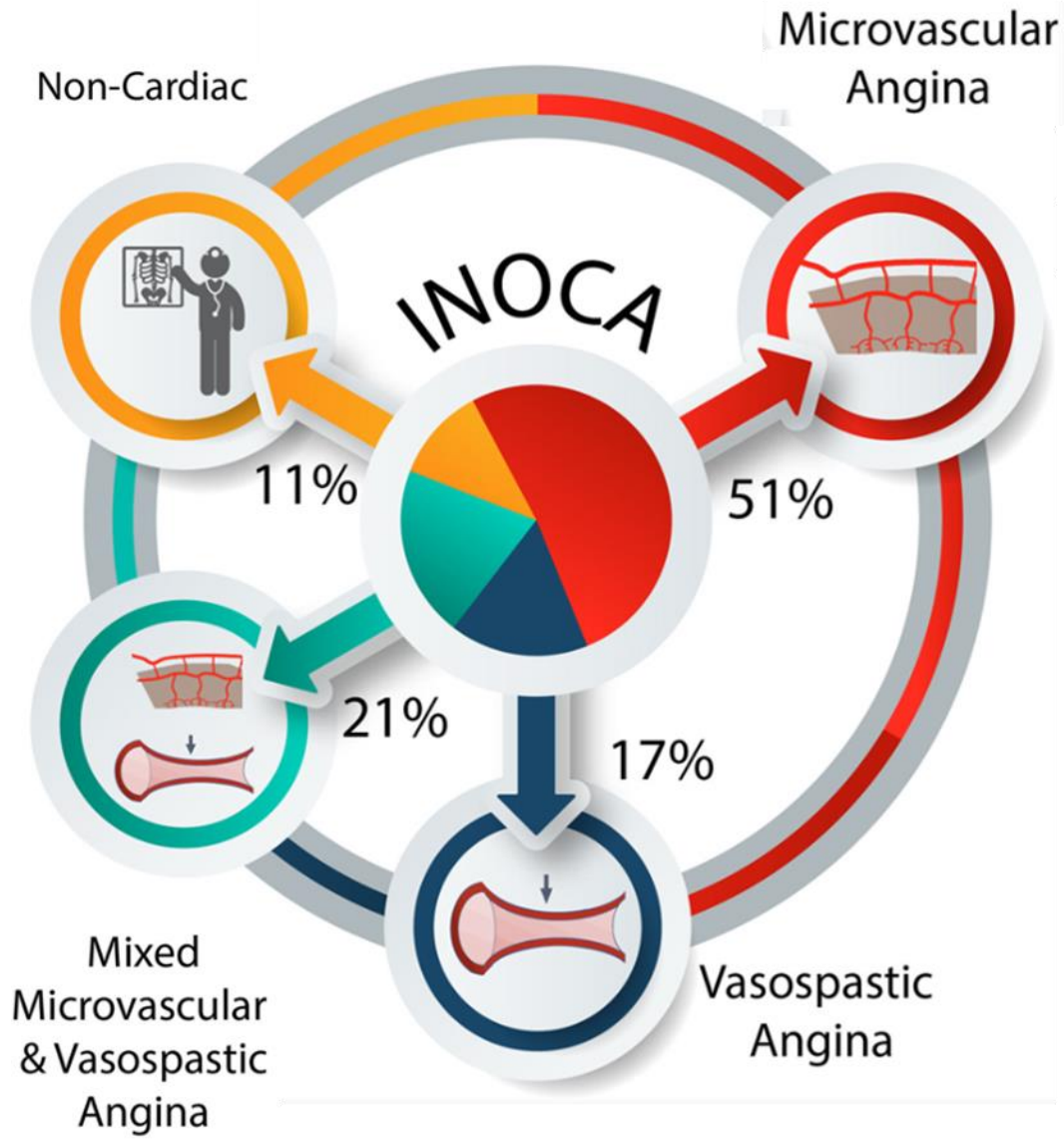
- Step 1: Invasive Coronary Angiography
- Step 2: FCA guidewire and Adenosine test
- Step 3: FCA Vasoreactivity (ACH test)

- Epicardial Vasospastic Angina
- Microvascular Angina
- Microvascular and Epicardial Vasospastic Angina

INOCA ENDOTYPES

Management of INOCA

1. Lifestyle factors
2. Risk factor management
3. Antianginal medications



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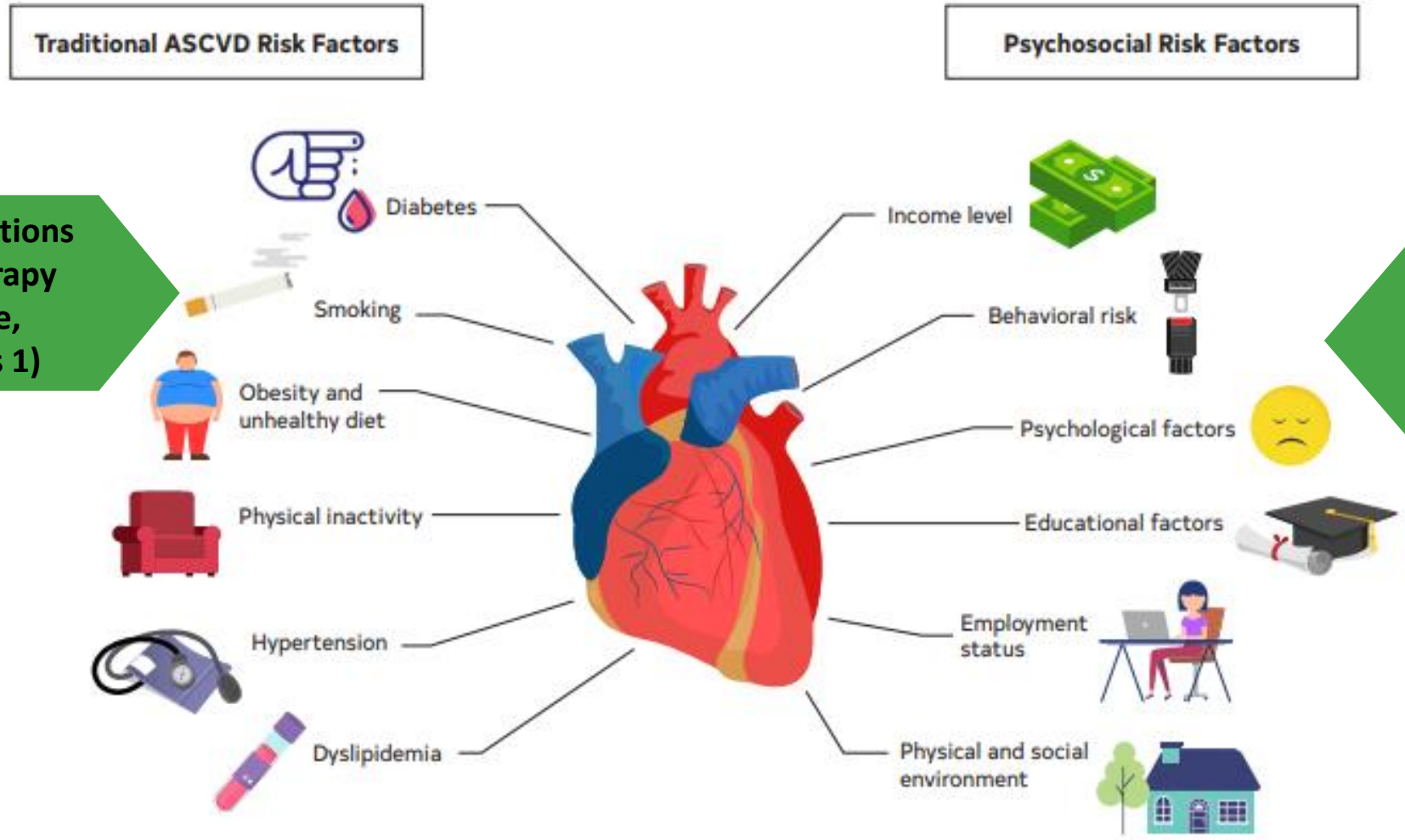
Traditional and Non-Traditional Risk Factors for CVD

After revascularization, patients should be educated about CVD risk factors and their modification to reduce CV events (Class 1).

Behavioral interventions and pharmacotherapy (NRT, varenicline, bupropion) (Class 1)

Cognitive behavioral therapy, psychological counseling, and/or pharmacological treatment (Class 1)



Abbreviations: ASCVD indicates atherosclerotic cardiovascular disease; CV, cardiovascular; CVD, cardiovascular disease; and NRT, nicotine replacement therapy.

Aspirin and Oral P2Y12 Inhibitors in Patients Undergoing PCI

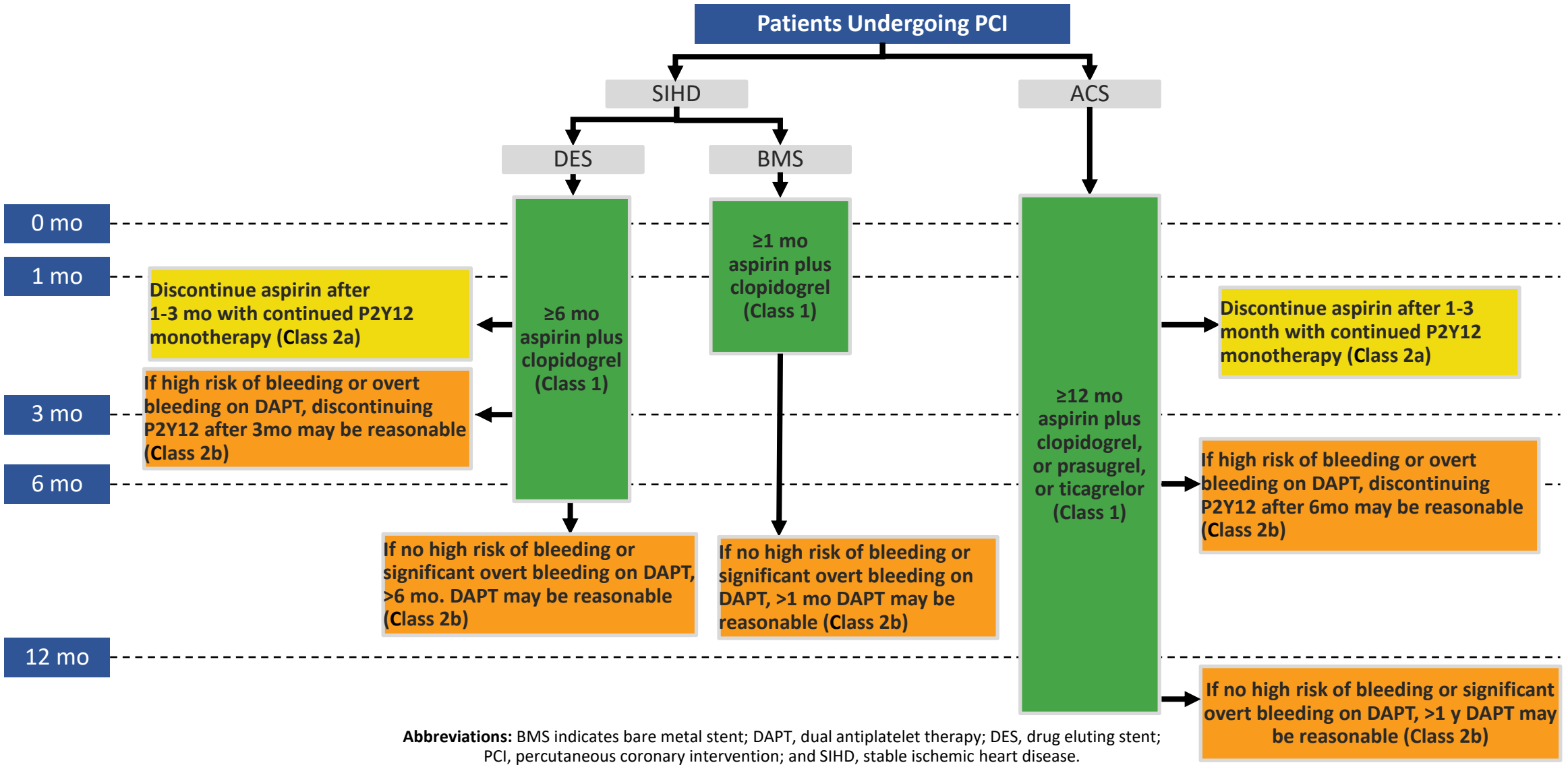
COR	RECOMMENDATIONS
1	1. In patients undergoing PCI, a loading dose of aspirin followed by a daily dosing is recommended.
1	2. In patients with ACS undergoing PCI, a loading dose of P2Y12 inhibitor followed by a daily dosing is recommended.
1	3. In patients with SIHD undergoing PCI, a loading dose of clopidogrel, followed by daily dosing is recommended.
1	4. In patients undergoing PCI within 24 hours after fibrinolytic therapy, a loading dose of 300 mg of clopidogrel, followed by daily dosing, is recommended.
2a	5. In patients with ACS undergoing PCI, it is reasonable to use ticagrelor or prasugrel in preference to clopidogrel to reduce ischemic events, including ST
2b	6. In patients undergoing PCI who are P2Y12 inhibitor naïve, intravenous *cangrelor may be reasonable to reduce periprocedural ischemic events **(See section 11.2. Intravenous P2Y12 Inhibitors in Patients Undergoing PCI for synopsis of rationale)**
3: Harm	7. In patients undergoing PCI who have a history of stroke or TIA, prasugrel should not be administered

COR	RECOMMENDATIONS
2a	1. In patients with ACS undergoing PCI with large thrombus burden, no reflow or slow flow, intravenous glycoprotein IIb/IIIa inhibitor agents are reasonable to improve procedural success.
3: Harm	2. In patients with SIHD undergoing PCI, the routine use of an intravenous glycoprotein IIb/IIIa inhibitor is not recommended

Guiding Principle:

The benefit of Gp IIb/IIIa inhibitors has decreased with shorter revascularization times and potent DAPT.

Use of DAPT for Patients After PCI



Abbreviations: BMS indicates bare metal stent; DAPT, dual antiplatelet therapy; DES, drug eluting stent; PCI, percutaneous coronary intervention; and SIHD, stable ischemic heart disease.

Anticoagulation in Patients Undergoing PCI

COR	RECOMMENDATIONS
1	1. In patients undergoing PCI, administration of intravenous unfractionated heparin is useful to reduce ischemic events.
1	2. In patients with heparin-induced thrombocytopenia undergoing PCI, bivalirudin or argatroban should be used to replace UFH to avoid thrombotic complications.
2b	3. In patients undergoing PCI, bivalirudin may be a reasonable alternative to UFH to reduce bleeding.
2b	4. In patients treated with upstream subcutaneous enoxaparin for unstable angina or NSTE-ACS, intravenous enoxaparin may be considered at the time of PCI to reduce ischemic events.
3: Harm	5. In patients on therapeutic subcutaneous enoxaparin, in whom the last dose was administered within 12 hours of PCI, UFH should not be used for PCI and may increase bleeding

Guiding Principle:

Antithrombotic therapy is a mainstay of treatment in patients undergoing PCI.