EXPERT CONSENSUS DOCUMENT

Fourth Universal Definition of Myocardial Infarction (2018)

Joint ESC/ACC/AHA/WHF Task Force for the Universal Definition of Myocardial Infarction

Fourth Joint ESC/ACC/AHA/WHF Universal Definition of Myocardial Infarction
European Heart Journal 2019; 40: 237-269 - doi:10.1093/eurheartj/ehy462

Fourth Universal Definition of Myocardial Infarction (2018)

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History of Documents on the Definition of Myocardial Infarction

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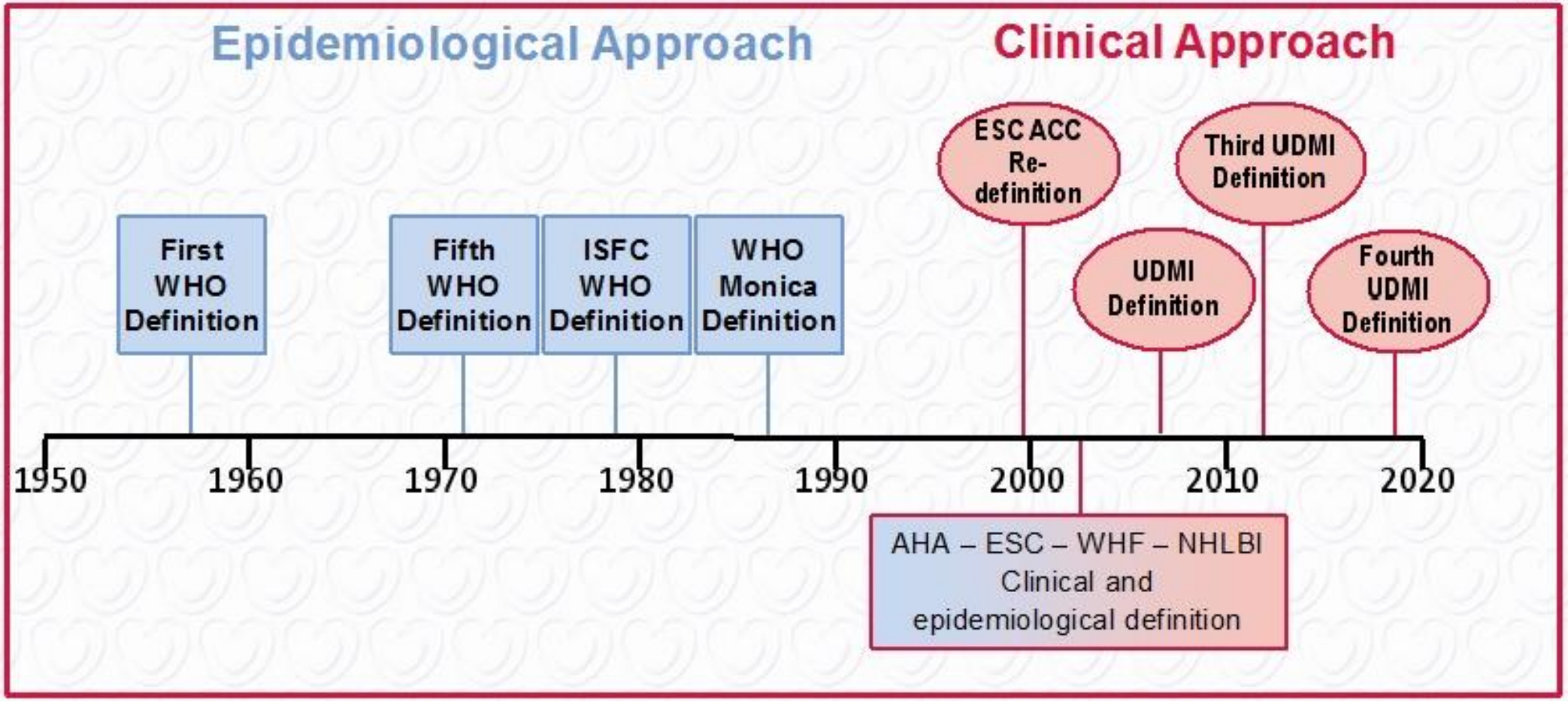

ACC = American College of Cardiology; AHA = American Heart Association; ESC = European Society of Cardiology; ISFC = International Society and Federation of Cardiology; NHLBI = National Heart, Lung, and Blood Institute; WHF = World Heart Foundation; WHO = World Health Organization; UDMI = Universal Definition of Myocardial Infarction

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Universal Definition of Myocardial Infarction

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Criteria for Clinical Myocardial Infarction

Clinical definition of myocardial infarction denotes presence of acute myocardial injury detected by abnormal cardiac biomarkers in the setting of evidence of acute myocardial ischaemia.

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Universal Definition of Myocardial Injury

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Criteria for Myocardial Injury

Detection of elevated cardiac troponin (cTn) values above the 99th percentile upper reference limit (URL) is defined as myocardial injury. The injury is considered acute if there is a rise and/or fall of cTn values

Criteria for Cardiac Procedural Myocardial Injury

Cardiac procedural related myocardial injury is defined by elevation of cTn values (>99th percentile URL) in patients with normal baseline value(s) or a rise of cTn values >20% of the baseline value when it is >99th percentile URL but is stable or falling

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Conceptual Illustration of Troponin Kinetics after Acute Myocardial Injury and Infarction

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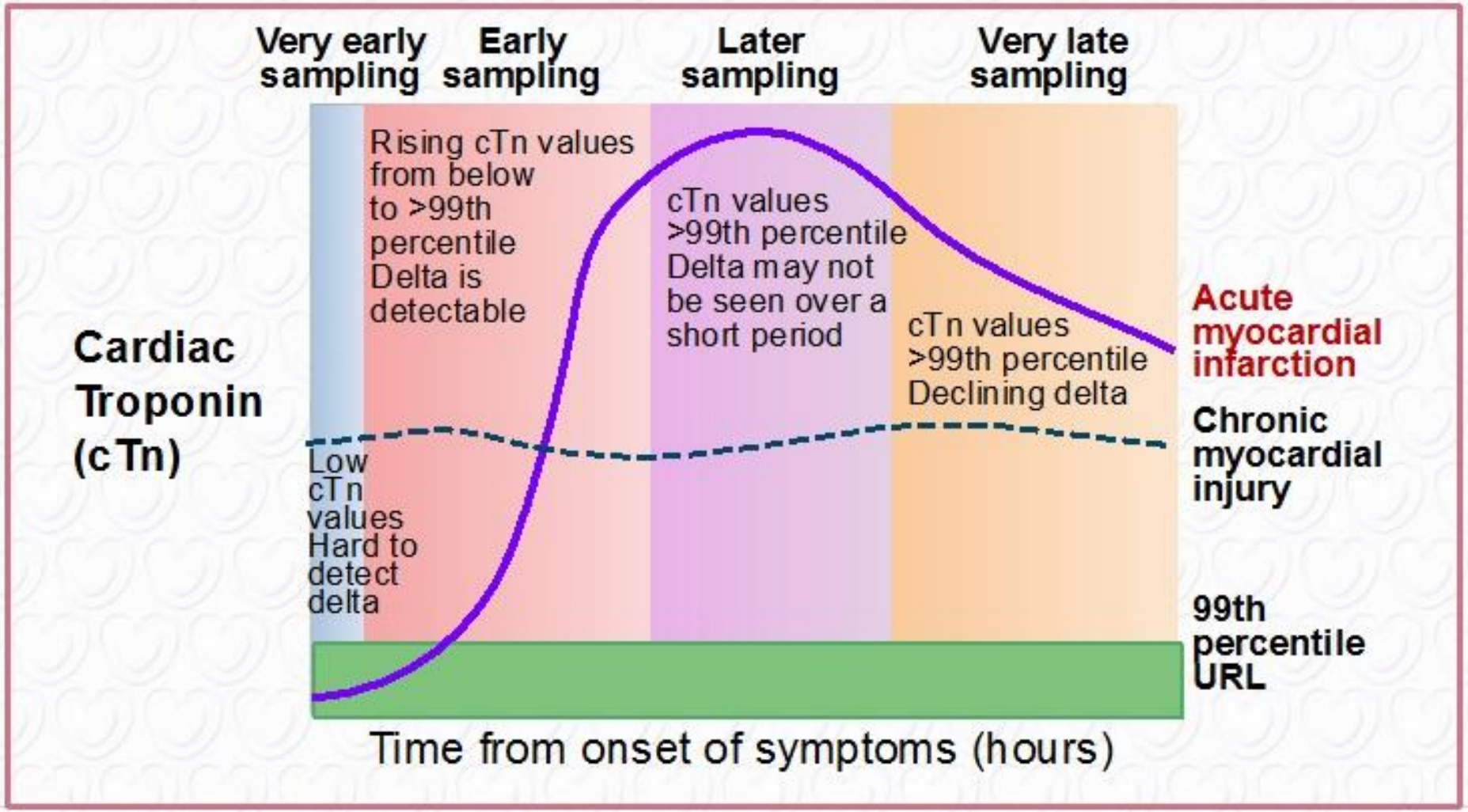

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Spectrum of Myocardial Injury, ranging from no Injury to Myocardial Infarction

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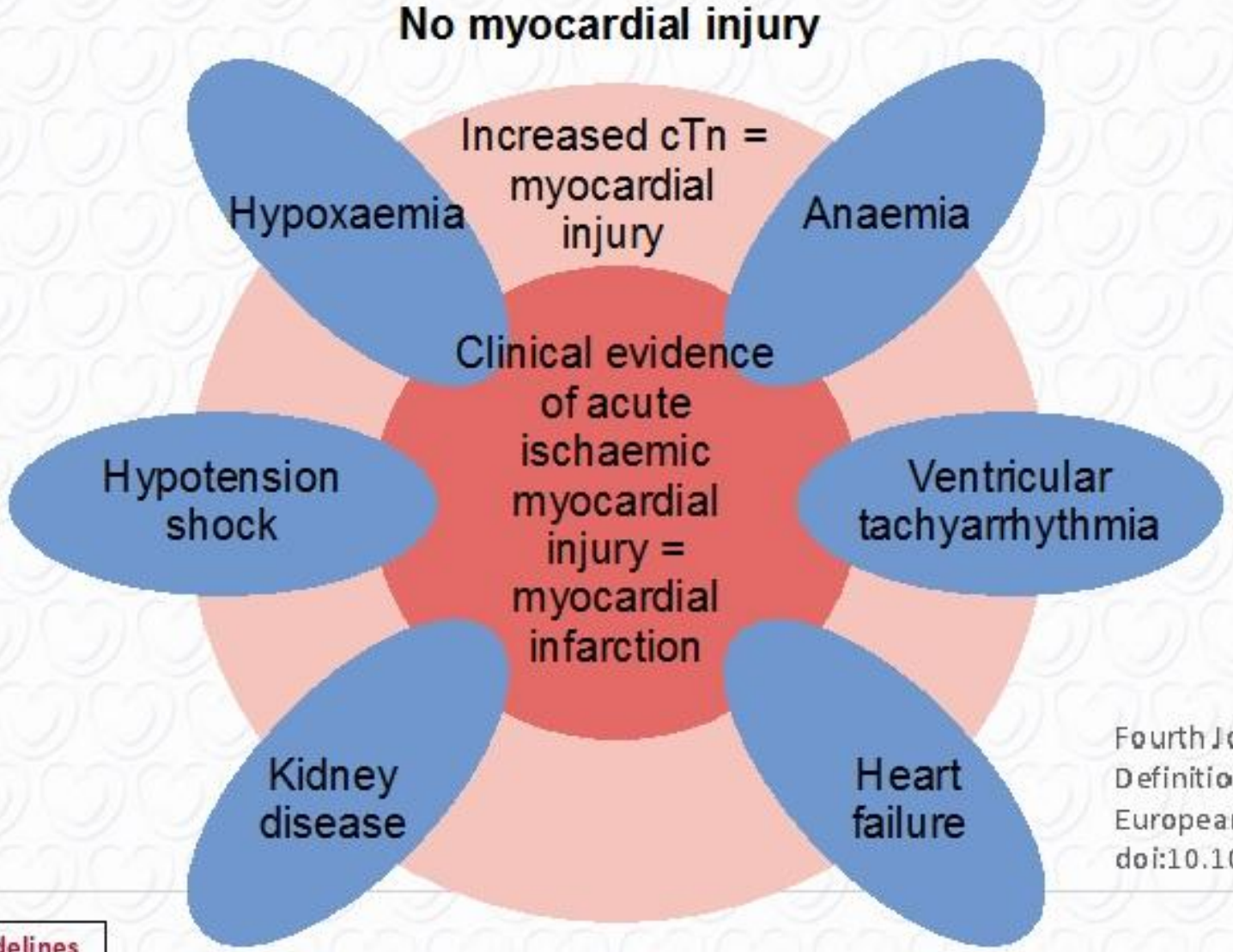

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Reasons for Elevation of Cardiac Troponin Values because of Myocardial Injury (1)

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Myocardial injury related to acute myocardial ischaemia
Atherosclerotic plaque disruption with thrombosis.
Myocardial injury related to acute myocardial ischaemia because of oxygen supply/demand imbalance
Reduced myocardial perfusion, e.g. • Coronary artery spasm, microvascular dysfunction • Coronary embolism • Coronary artery dissection • Sustained bradyarrhythmia • Hypotension or shock • Respiratory failure • Severe anaemia
Increased myocardial oxygen demand, e.g. • Sustained tachyarrhythmia • Severe hypertension with or without left ventricular hypertrophy

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Reasons for Elevation of Cardiac Troponin Values because of Myocardial Injury (2)

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Other causes of myocardial injury
Cardiac conditions, e.g. • Heart failure • Myocarditis • Cardiomyopathy (any Type) • Takotsubo syndrome • Coronary revascularization procedure • Cardiac procedure other than revascularization • Catheter ablation • Defibrillator shocks • Cardiac contusion

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Reasons for Elevation of Cardiac Troponin Values because of Myocardial Injury (3)

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Other causes of myocardial injury
Systemic conditions, e.g. • Sepsis, infectious disease • Chronic kidney disease • Stroke, subarachnoid haemorrhage • Pulmonary embolism, pulmonary hypertension • Infiltrative diseases, e.g. amyloidosis, sarcoidosis • Chemotherapeutic agents • Critical ill patients • Strenuous exercise

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Model for interpreting Myocardial Injury and Myocardial Infarction

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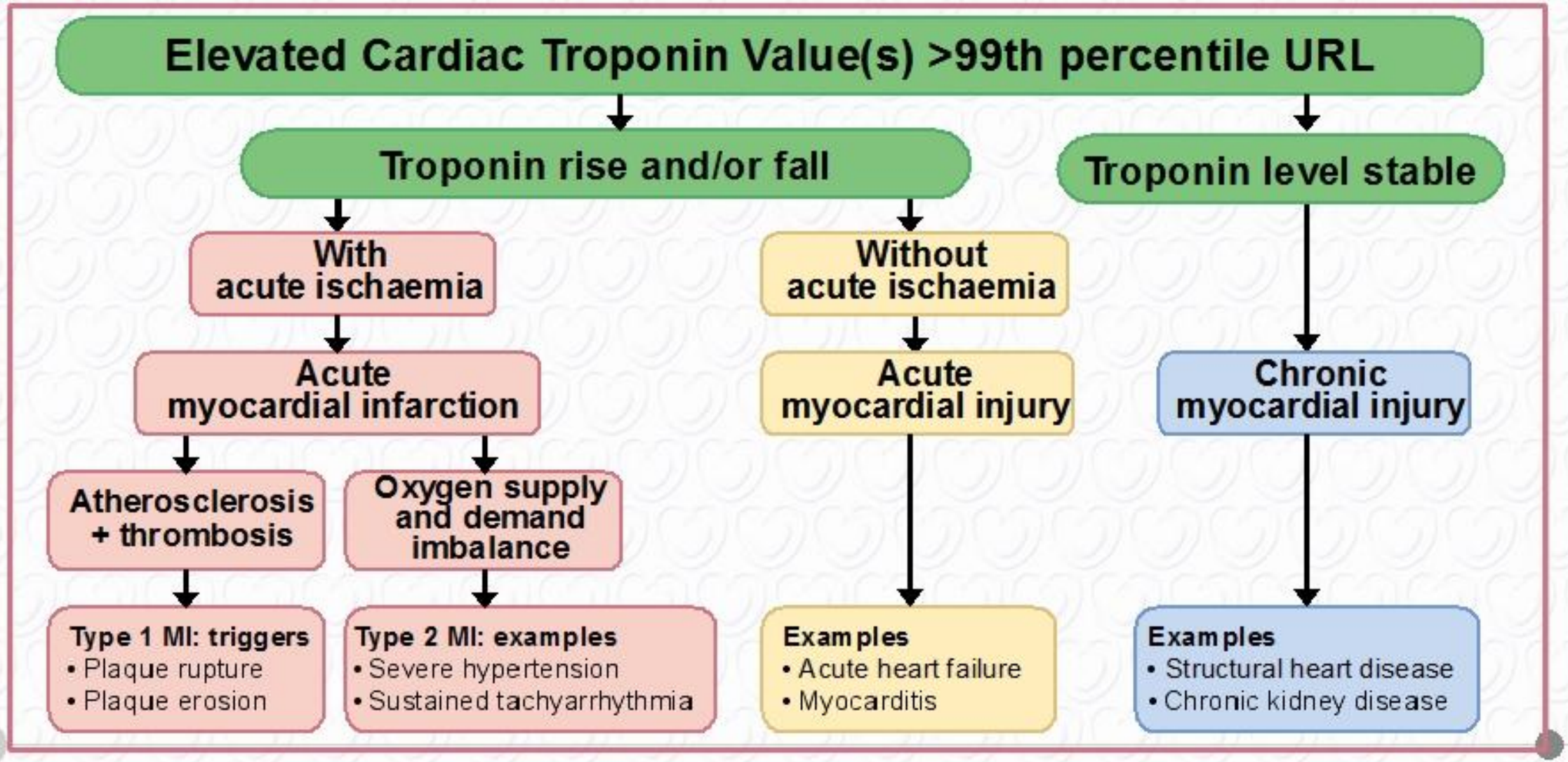

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Myocardial Infarction Type 1

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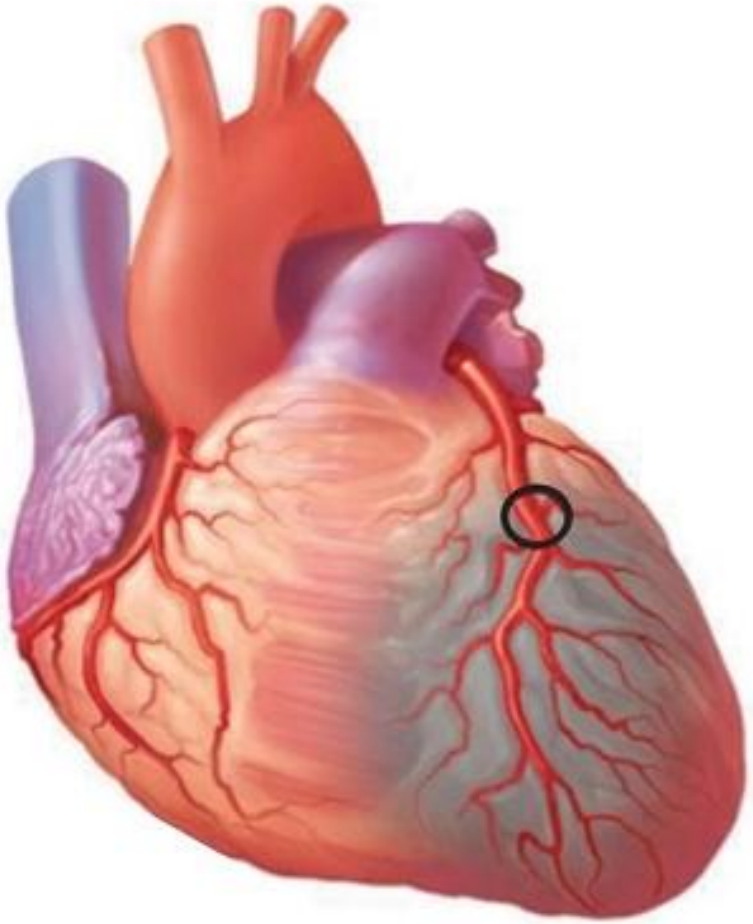

Plaque rupture/erosion with occlusive thrombus

Plaque rupture/erosion with non-occlusive thrombus

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Criteria for Type 1 Myocardial Infarction

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Detection of a rise and/or fall of cTn with at least one value above the 99th percentile URL and with at least one of the following:

- **Symptoms of acute myocardial ischaemia;**
- **New ischaemic ECG changes;**
- **Development of pathological Q waves;**
- **Imaging evidence of new loss of viable myocardium or new regional wall motion abnormality in a pattern consistent with an ischaemic aetiology;**
- **Identification of a coronary thrombus by angiography including intracoronary imaging or by autopsy.**

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Myocardial Infarction Type 2

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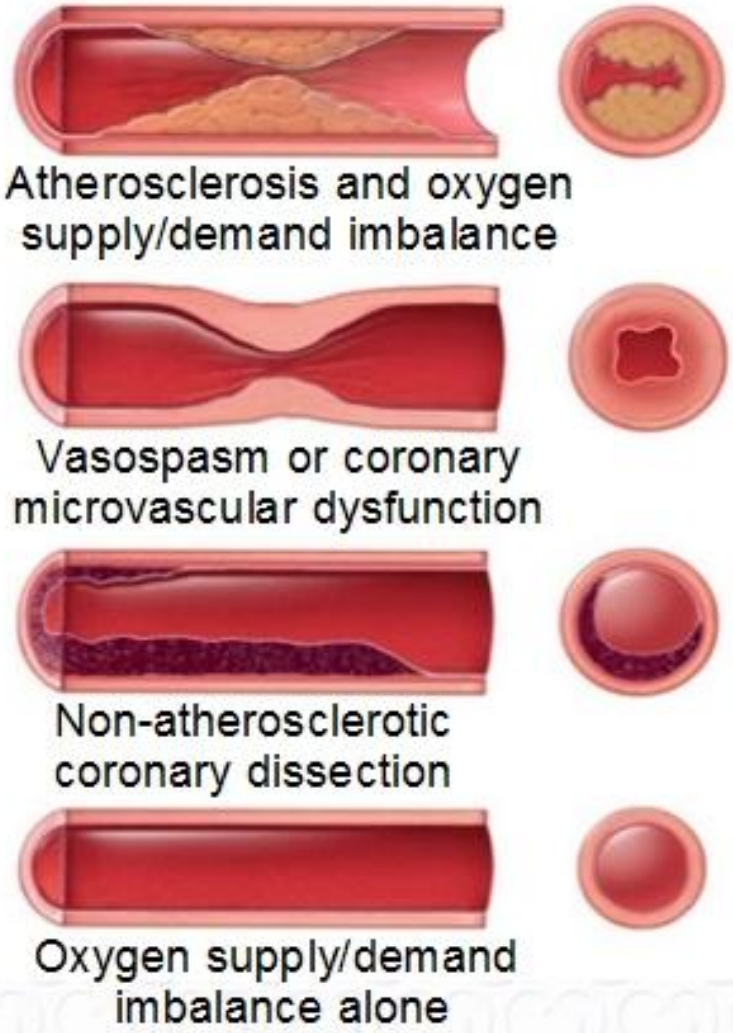

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Criteria for Type 2 Myocardial Infarction

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Detection of a rise and/or fall of cTn with at least one value above the 99th percentile URL and evidence of an imbalance between myocardial oxygen supply and demand unrelated to coronary athero-thrombosis, requiring at least one of the following:

- **Symptoms of acute myocardial ischaemia;**
- **New ischaemic ECG changes;**
- **Development of pathological Q waves;**
- **Imaging evidence of new loss of viable myocardium or new regional wall motion abnormality in a pattern consistent with an ischaemic aetiology.**

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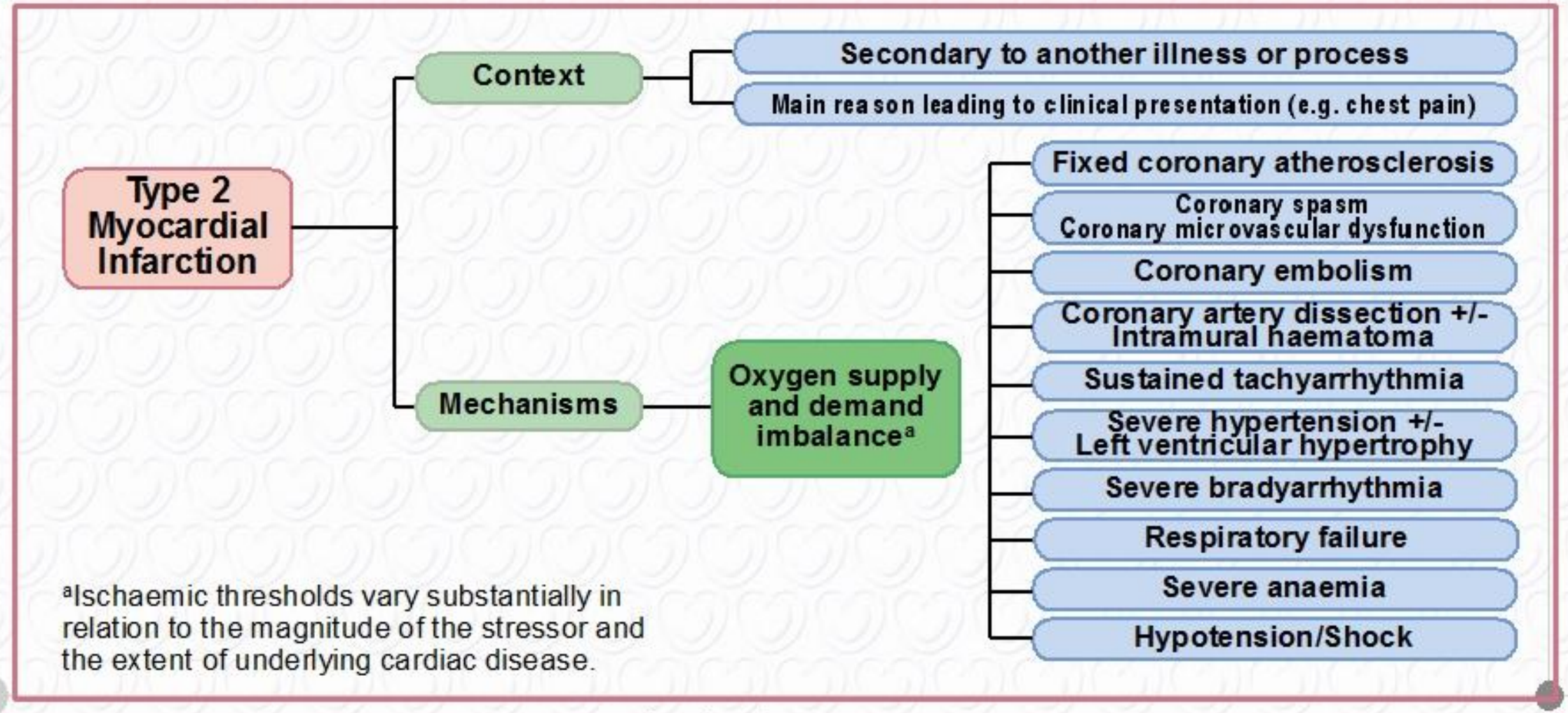
Framework for Type 2 MI considering Context and Mechanisms attributable to Acute Myocardial Ischaemia



[a]Ischaemic thresholds vary substantially in relation to the magnitude of the stressor and the extent of underlying cardiac disease.

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Criteria for Type 3 Myocardial Infarction

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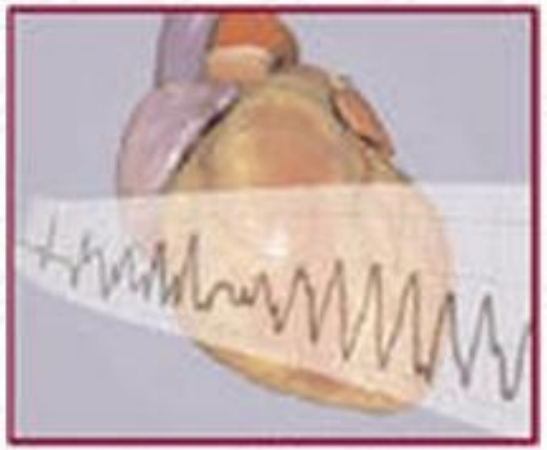
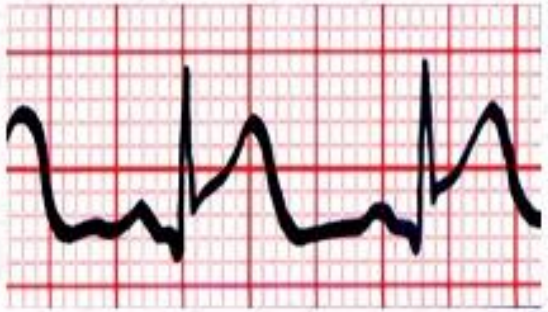
Patients who suffer cardiac death, with symptoms suggestive of myocardial ischaemia accompanied by presumed new ischaemic ECG changes or ventricular fibrillation, but die before blood samples for biomarkers can be obtained, or before increases in cardiac biomarkers can be identified or myocardial infarction detected by autopsy examination.





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Myocardial Infarction Type 4a

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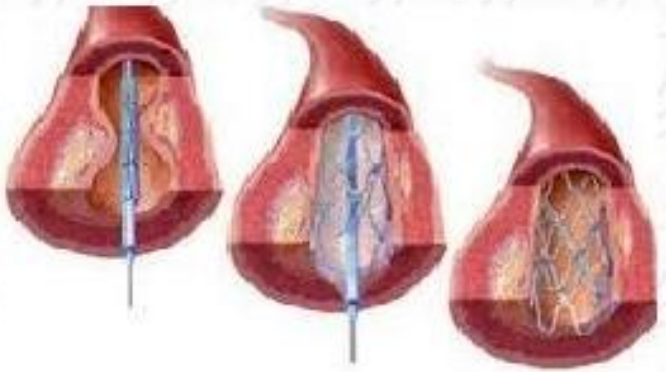
PCI-related MI ≤48 h after the index procedure is defined by elevation of cardiac troponin values >5 times 99th percentile URL. In addition, either

- **New ischaemic ECG changes or**
- **Imaging demonstration of new loss of viable myocardium or new regional wall motion abnormality consistent with an ischaemic aetiology**
- **Angiographic findings consistent with a procedural flow-limiting complication such as coronary dissection, occlusion of a major epicardial artery or a side-branch occlusion/ thrombus, disruption of collateral flow or distal embolization**



Isolated development of new Q waves meets the criteria if cTn values are elevated and rising but less than the pre-specified thresholds for PCI

If cTn values are not >5 X 99th percentile URL, then the term myocardial injury should be used

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Myocardial Infarction Type 4b

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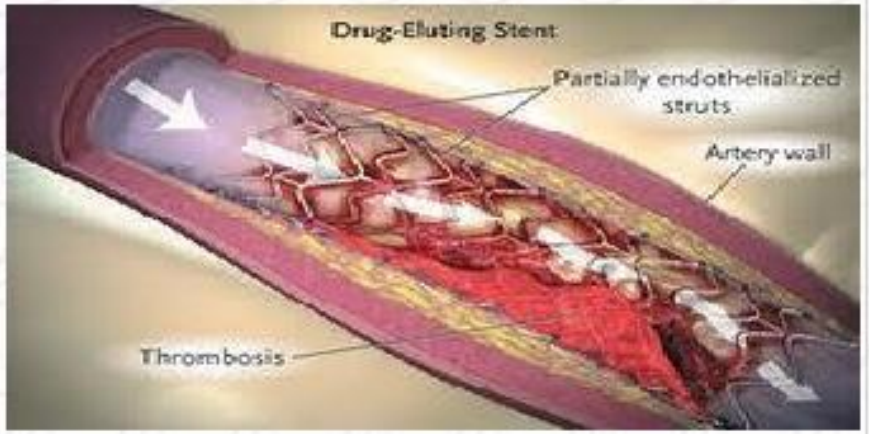
Myocardial infarction related to stent-thrombosis is detected by coronary angiography or autopsy in the setting of myocardial ischaemia and with a rise and/or fall of cardiac troponin values with at least one value >99th percentile URL.

The following temporal categories are suggested:

- **Acute, 0–24 h**
- **Subacute, > 24 h to 30 days**
- **Late, > 30 days to 1 year**
- **Very late > 1 year**



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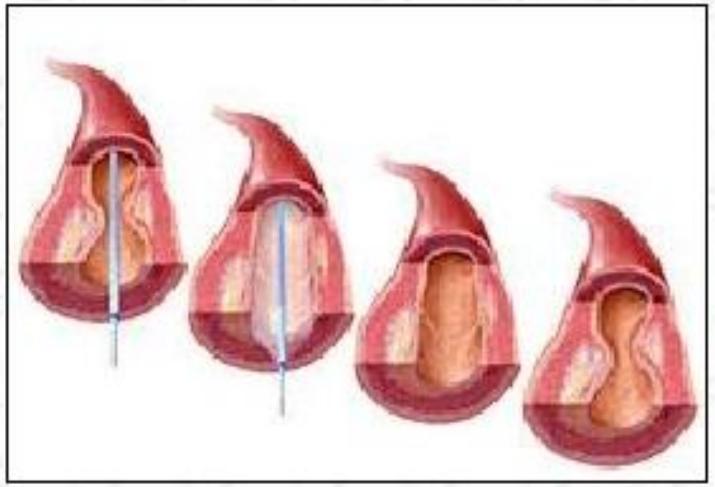
Myocardial Infarction Type 4c

Myocardial infarction related to in-stent restenosis, or restenosis following balloon angioplasty in the infarct territory is detected by coronary angiography in the setting of myocardial ischaemia and with a rise and/or fall of cardiac troponin values with at least one value >99th percentile URL



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Myocardial Infarction Type 5

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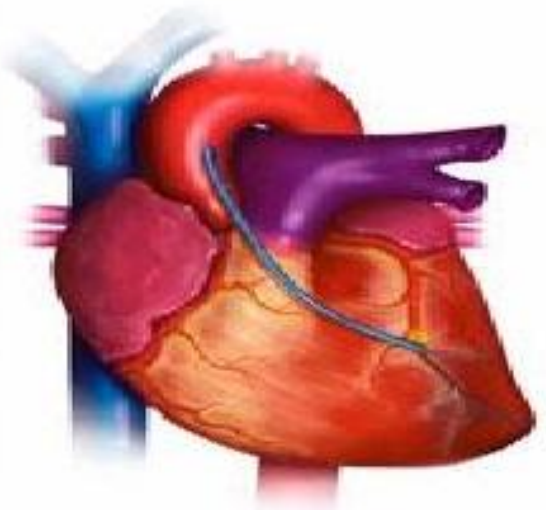
CABG-related MI ≤48 h after the index procedure is defined by elevation of cardiac troponin values >10 times 99th percentile URL. In addition, either

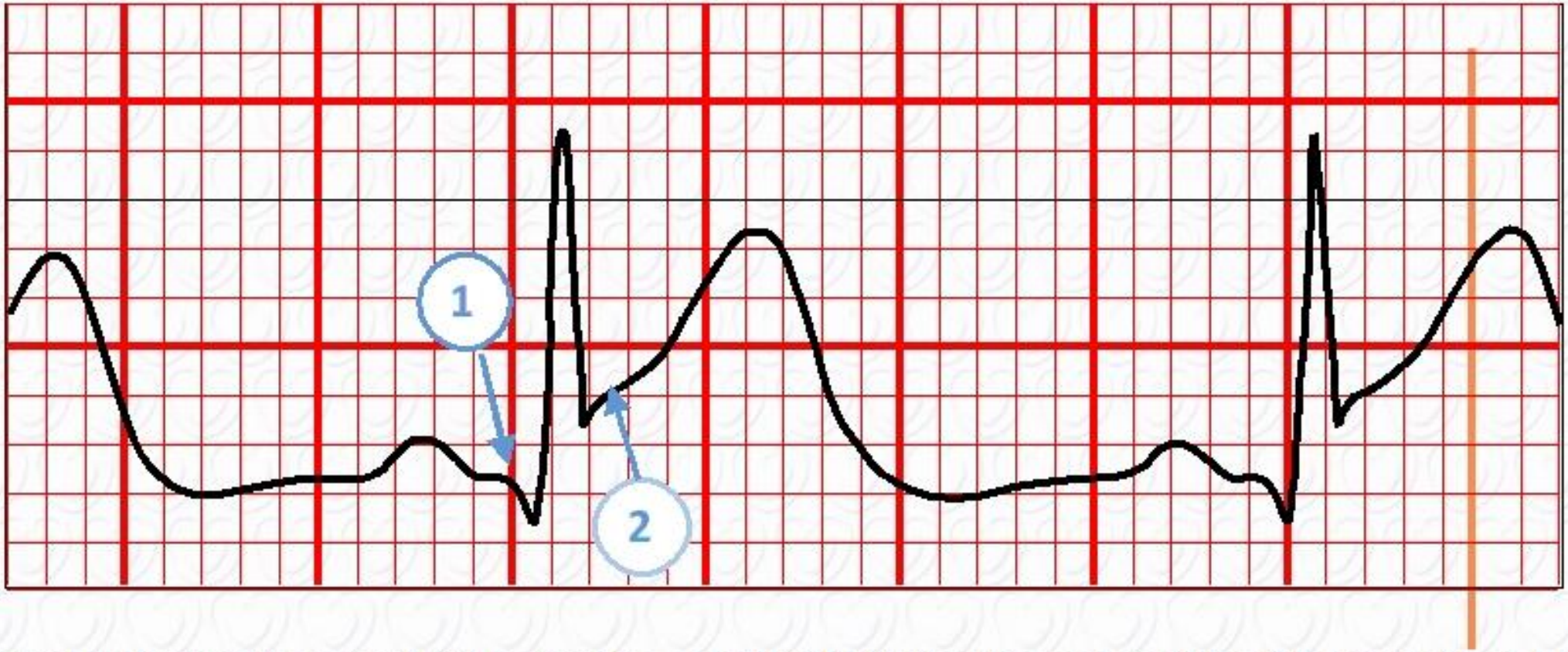
- **new pathological Q waves or**
- **angiographic documented new graft or new native coronary artery occlusion, or**
- **imaging evidence of new loss of viable myocardium or new regional wall motion abnormality and in a pattern consistent with an ischaemic aetiology.**



Isolated development of new Q waves meets the criteria if cTn values are elevated and rising but less than the pre-specified thresholds for CABG

If cTn values are not >10 X 99th percentile URL, then the term myocardial injury should be used

How to assess ST-segment elevation



Arrow 1 indicates the onset of the Q wave. Arrow 2 Indicates the onset of the ST-segment or J-point. The difference between points 1 and 2 denotes the magnitude of the ST-segment elevation

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Electrocardiographic Changes* suggestive of Acute Myocardial Ischaemia

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ST-elevation
New ST-elevation at the J-point in two contiguous leads with the cut points: ≥1 mm in all leads other than leads V_2–V_3 where the following cut points apply: ≥2mm in men ≥40 years; ≥2.5 mm in men <40 years, or ≥1.5 mm in women regardless of age.
ST-depression and T wave changes
New horizontal or down-sloping ST-depression ≥0.5 mm in two contiguous leads and/or T inversion >1 mm in two contiguous leads with prominent R wave or R/S ratio >1.

*in absence of left ventricular hypertrophy and bundle branch block

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Electrocardiographic Changes* associated with Prior Myocardial Infarction

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Any Q wave in leads V_2–V_3 >0.02 s or QS complex in leads V_2–V_3
Q-wave ≥0.03 s and ≥1 mm deep or QS complex in leads I, II, aVL, aVF or V_4–V_6 in any two leads of a contiguous lead grouping (I, aVL; V_1–V_6; II, III, aVF)
R wave >0.04 s in V_1–V_2 and R/S >1 with a concordant positive T wave in absence of conduction defect

*in absence of left ventricular hypertrophy and bundle branch block

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Prior or Silent/Unrecognized Myocardial Infarction

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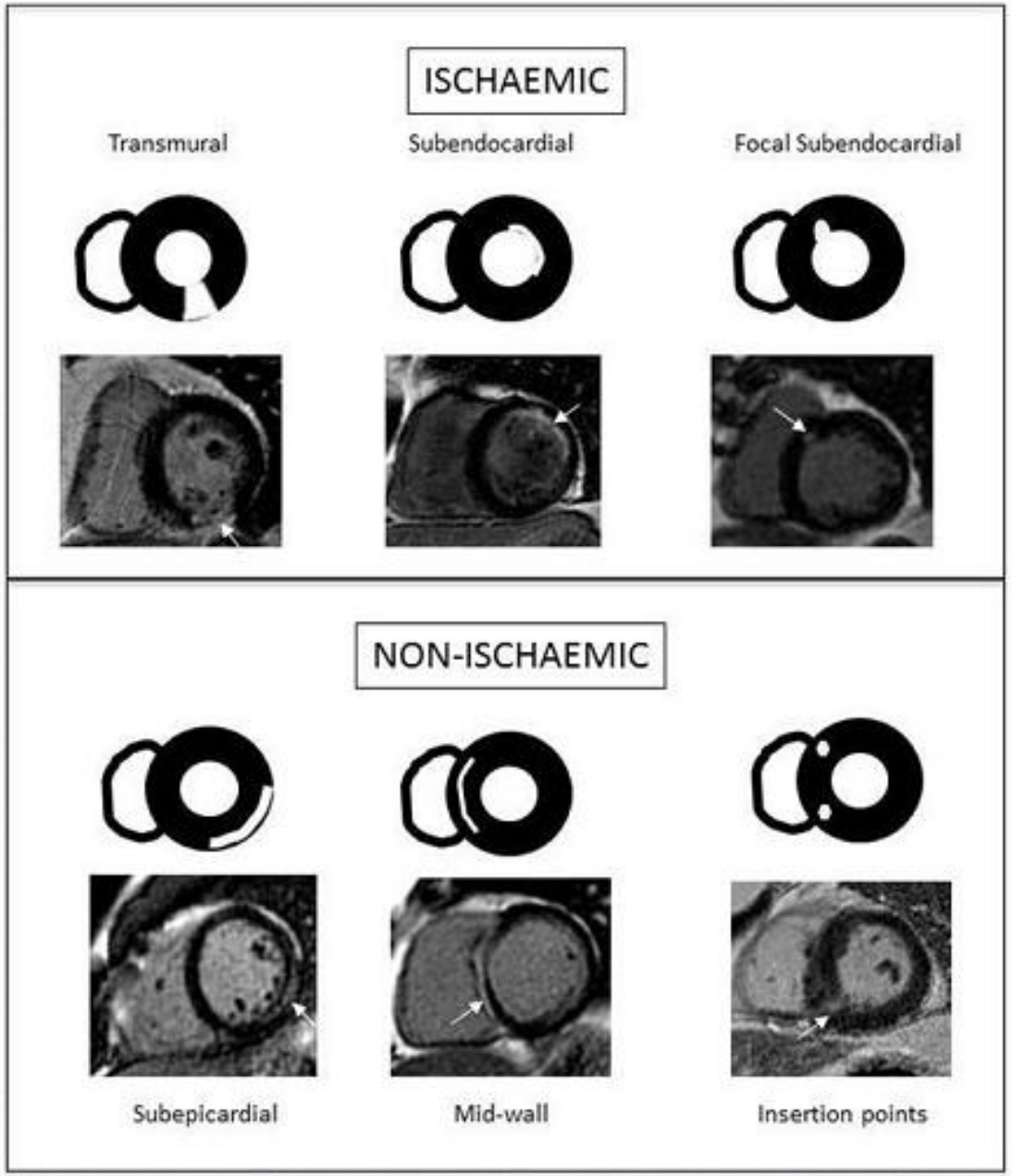
Criteria for Prior or Silent/Unrecognized Myocardial Infarction
Any one of the following criteria meets the diagnosis for prior or silent/unrecognized MI: • Abnormal Q waves with or without symptoms in the absence of non-ischaemic causes. • Imaging evidence of loss of viable myocardium in a pattern consistent with ischaemic aetiology. • Patho-anatomical findings of a prior MI

Cardiac Magnetic Resonance Images



Gadolinium-based contrasts wash out from myocardium with increased extracellular space such as fibrosis, thus enhancing areas of scar (white arrows).

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Ten commandments for the Fourth Universal Definition of Myocardial Infarction (1)

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Myocardial Injury and Myocardial Infarction

1) Myocardial injury is defined by the presence of cardiac troponin values (cTn) above the 99th percentile of the upper reference limit (URL).

2) Myocardial injury may be acute (rise and/or fall of cTn values) as in acute heart failure or chronic (≤20% variation of cTn values) as in chronic kidney disease.

3) Myocardial injury may occur in a variety of situations including after coronary procedural intervention and/or with cardiovascular and non-cardiovascular illnesses.

4) Occurrence of acute myocardial injury in the setting of acute myocardial ischaemia defines acute myocardial infarction.

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Ten commandments for the Fourth Universal Definition of Myocardial Infarction (2)

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Myocardial Infarction – Spontaneous Types

5) Myocardial infarction type 1 is acute myocardial injury related to acute athero-thrombotic coronary artery disease. It is usually precipitated by atherosclerotic plaque disruption that reduces blood supply to the myocardium.

6) Myocardial infarction type 2 is acute myocardial injury related to an imbalance between myocardial oxygen supply and demand secondary to stressors unrelated to acute coronary athero-thrombosis.

7) Myocardial infarction type 3 is related to patients who suffer cardiac death, with symptoms suggestive of acute myocardial ischaemia accompanied by new ischaemic ECG changes and die before biomarker values could be obtained.

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Ten commandments for the Fourth Universal Definition of Myocardial Infarction (3)

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Myocardial Infarction – Procedural Types

8) Myocardial infarction type 4a denotes PCI-related increases of cTn values >5 times the 99th percentile URL from a normal or if elevated, stable pre-procedural baseline. New myocardial ischaemia evidenced by ECG or imaging, or complications leading to reduced coronary blood flow are required.

9) Myocardial infarction type 4b is acute myocardial ischaemic injury related to stent thrombosis, and myocardial infarction type 4c is acute myocardial ischaemic injury associated with restenosis.

10) Myocardial infarction type 5 is CABG-related increases of cTn values >10 times 99th percentile URL from a normal or if elevated, stable pre-procedural baseline. New myocardial ischaemia or new loss of myocardial viability is required.

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