Myocardial Infarction

Myocardial infarction (MI) is defined as a clinical (or pathologic) event in the setting of myocardial ischemia in which there is evidence of myocardial injury (Anderson & Morrow, 2017; Thygesen, Alpert & Jaffe, 2018). The diagnosis is made with cardiac biomarkers (high sensitivity troponin or troponin-I) in association with cardiac symptoms, suggestive electrocardiographic changes, and/or imaging with echocardiography or nuclear studies indicating new regional wall motion abnormality, or loss of viable myocardium.

Classification of Acute Coronary Syndrome (ACS) (Reeder & Kennedy, 2022)

ACS is classified based on the presence or absence of ST segment elevation. There are three classifications of ACS:

- **Unstable Angina (UA)**
  Clinical symptoms suggestive of ACS without elevation in cardiac biomarkers (troponin); with or without electrocardiogram (ECG) changes indicative of ischemia. ECG changes can be transient and dynamic. Diagnosis may be made by clinical history alone.

- **Non-ST Segment Elevation Acute Coronary Syndrome (NSTE-ACS): Non-ST Segment Elevation Myocardial Infarction (NSTEMI)**
  Clinical symptoms suggestive of ACS with elevated cardiac biomarkers (troponin); with or without ECG changes indicative of cardiac ischemia.
  Note: ECG changes suggestive of cardiac ischemia include ST depression, transient ST elevation or prominent T wave inversions.

- **ST-Segment Elevation Myocardial Infarction (STEMI)**
  Clinical symptoms suggestive of ACS with elevated cardiac biomarkers (troponin); ECG shows persistent ST elevation or new left bundle branch block (LBBB). These patients should be considered for immediate reperfusion therapy (fibrinolysis or percutaneous coronary intervention [PCI]).

Joint Task Force Definitions (Thygesen, Alpert & Jaffe, 2018)

The Joint Task Force of the European Society of Cardiology, American College of Cardiology Foundation, the American Heart Association, and the World Heart Federation (ESC/ACCF/AHA/WHF) define acute MI as the presence of acute myocardial injury detected by abnormal cardiac biomarkers in the setting of evidence of acute myocardial ischemia. The Joint Task Force refined the definition of MI by developing a clinical classification according to the assumed proximate cause of myocardial ischemia:

- **Type 1:** MI caused by atherothrombotic CAD and precipitated by atherosclerotic plaque disruption (rupture or erosion) (examples: NSTEMI and STEMI)
- **Type 2:** MI due to mismatch between oxygen supply and demand (examples: coronary dissection, vasospasm, emboli, microvascular dysfunction, sustained tachycardia, severe anemia)
- **Type 3:** Typical presentation of MI such as ischemic ECG changes or ventricular fibrillation with unexpected death before biomarkers could be drawn or the patient expires soon after the onset of symptoms before elevation of biomarkers has occurred.

- **Type 4a:** MI associated with percutaneous coronary intervention within 48 hours after procedure (determined by troponin elevation, ECG changes, imaging evidence, or known procedure related complications)
- **Type 4b:** PCI-related MI due to stent/scaffold thrombosis documented by angiography or autopsy
- **Type 5:** CABG-related MI within 48 hours after procedure (determined by troponin elevation, development of new pathological Q waves, angiographic evidence of a new graft or native artery occlusion, and/or evidence of new loss of viable myocardium or new regional wall motion abnormality

Guidelines for the Identification of Patients with ACS in the Emergency Room (Anderson et al., 2013; Reeder et al., 2022)

Clinical History

Patients with the following signs and symptoms require immediate assessment by the triage nurse for initiation of the ACS protocol and a STAT ECG:

- Chest pain or severe epigastric pain, nontraumatic in origin, with components typical of myocardial ischemia or myocardial infarction (MI)
    - Central/substernal compression or crushing chest pain
    - Pressure, tightness, heaviness, cramping, burning, aching sensation
    - Unexplained indigestion, belching, epigastric pain, nausea
    - Radiating pain in neck, jaw, shoulders, back, and/or one or both arms
- Dyspnea
- Hypotension
- Syncope
- Diaphoresis
- Malaise
- New heart failure
- Sudden cardiac arrest

Medical History

Obtaining a medical history must not delay entry into the ACS protocol. The triage nurse should take a brief, targeted, initial history with an assessment of current history of:

- CAD, CABG, PCI, MI or angina with exertion (unstable angina)
- Nitroglycerin (NTG) use to relieve chest discomfort
- Risk factors, including smoking, hyperlipidemia, hypertension, diabetes mellitus, peripheral artery disease, cerebral vascular disease (CVA/TIA), cocaine and/or methamphetamine use, family history of CAD
- Regular and recent medication use

Pathogenesis of ACS (Anderson et al., 2013; Anderson et al., 2017; Crea et al., 2024)

STEMI

- Thrombus or thromboembolism, usually arising on disrupted or eroded plaque
- Occlusive thrombus without collateral vessels

UA/NSTEMI

- Thrombus or thromboembolism, usually arising on disrupted or eroded plaque:
  - Occlusive thrombus with collateral vessels
  - Subtotal occlusive thrombus on pre-existing plaque
  - Distal microvascular thromboembolism from plaque-associated thrombus
- MI without obstructive CAD (Type 2 MI)
  - Coronary artery dissection
  - Coronary artery spasm
  - Coronary microvascular dysfunction

Clinical Presentations of ACS (Anderson et al., 2013; Reeder et al., 2022)

- New onset (less than 2 months) severe angina that significantly limits physical activity
- Angina that is more frequent, longer in duration, or occurs with less exertion than prior angina
- Rest angina (angina commencing when the patient is at rest), usually lasting more than 20 minutes in duration

**Carefully assess women, patients with diabetes mellitus, older patients, those with unexplained dyspnea, history of heart failure or stroke, and patients who complain of chest discomfort but now have a permanent pacemaker that may conceal 12-lead ECG changes.*

Goals of Therapy (Reeder, Awtry & Mahler, 2022) and Management Strategies

RECOMMENDATIONS FOR ALL MI (REGARDLESS OF CLASSIFICATION)	
Goals	**Management**
Early identification	• Electrocardiogram (ECG) should be performed within 10 minutes upon arrival to the emergency department if not obtained by Emergency Medical System (EMS) prearrival. • If initial ECG is not diagnostic and patient remains symptomatic, repeat ECG every 15-30 minutes to detect ischemic changes.
Acute triage	• Assess responsiveness, airway, breathing, and circulation. • Look for evidence of systemic hypoperfusion (hypotension; tachycardia; impaired cognition; cool, clammy, pale skin); cardiogenic shock requires aggressive management. • Left heart failure with hypoxia (dyspnea, hypoxia, pulmonary edema, and/or impending respiratory compromise) requires aggressive oxygenation, airway stabilization, diuretic therapy and afterload reduction. • Treat ventricular arrhythmias immediately due to effect on cardiac output and exacerbation of myocardial ischemia.
Initial therapy	• Continuous cardiac monitoring with emergency resuscitation equipment nearby. • Administer oxygen to patients with arterial saturation less than 90%, patients in respiratory distress including those with heart failure, or those with other high-risk factors for hypoxia. *Note: Supplemental oxygen shows no benefit to patients with oxygen saturation greater than or equal to 90%.* • Establish intravenous (IV) access.

	• Obtain serial cardiac troponin I or T levels at presentation and 2-3 hours after symptom onset. • Obtain basic electrolyte panel, kidney function tests, complete blood count with platelets, and coagulation panel if patient is on warfarin therapy or has liver disease.
Relief of ischemic pain	• Administer sublingual NTG every 5 minutes up to 3 times for continuing ischemic pain; administer IV NTG for persistent ischemia, heart failure, or hypertension. Contraindicated in patients with one or more of the following: hypotension (SBP less than 90 mm Hg), suspicion/confirmed right ventricular failure, marked bradycardia (HR less than 50 bpm) or tachycardia (HR greater than 100 bpm), known hypertrophic cardiomyopathy, severe aortic stenosis or if phosphodiesterase inhibitor (e.g., Viagra) has been taken within the previous 24 hours. • IV morphine should be avoided unless patient has an unacceptable level of pain. Initial dose is 2-4 mg, with increments of 2-8 mg at 5- to 15-minute intervals. • Discontinue nonsteroidal anti-inflammatory drugs (NSAIDs), except aspirin, because of increased risk of adverse cardiac events.
Stabilize hemodynamics/ prevent and manage arrhythmias	• Atrial fibrillation and flutter can cause symptomatic hypoperfusion; ventricular tachycardia and fibrillation are life-threatening. • Treat with prophylactic IV β-blocker and maintain serum potassium between 3.5 and less than 4.5 mEq/L and serum magnesium above 2.0 mEq/L. • Avoid prophylactic lidocaine. • Treat symptomatic bradycardia and heart block with atropine or temporary pacing.
Estimation of risk	• High risk patients require aggressive management. This includes those of advanced age, or those with low blood pressure, tachycardia, heart failure, and an anterior MI. *(See TIMI score below).*
β-Blocker therapy	• Used to prevent recurrent ischemia and life-threatening ventricular arrhythmias. • Start β-blocker (metoprolol or atenolol) in all patients without contraindications within 24 hours; defer in patients that are hemodynamically unstable. • Contraindications are heart failure, low output state, risk for cardiogenic shock, bradycardia, PR interval greater than 0.24 seconds, second- or third- degree heart block without permanent pacemaker, reactive airway disease/active bronchospasm.
Dual antiplatelet therapy (O'Gara et al., 2013; Cutlip & Lincroft, 2022)	• Aspirin: loading dose 325 mg uncoated aspirin, to be chewed or crushed to allow for rapid absorption; maintenance dose 81mg/day is preferred as there is no benefit to higher doses but there is a higher risk of bleeding with higher daily dosages, especially gastrointestinal bleeding events. Also note, 81 mg/day is the *only* dose option when used concomitantly with ticagrelor. • P2Y12 inhibitors for 12 months, regardless if treated with primary- PCI or ischemia-guided strategy. Loading and maintenance doses are the same

	for both indications, however prasugrel is an option only in primary PCI, not in ischemia-guided strategy. • Clopidogrel: Loading dose 300-600 mg; maintenance dose 75 mg/day • Ticagrelor: Loading dose 180 mg; maintenance 90 mg every 12 hours (must only be given with aspirin 81 mg/day) • Prasugrel (primary PCI only): Loading dose 60 mg; maintenance dose 10 mg/day (contraindicated with history of stroke or TIA, age 75 years or older, and weight less than 60 kg)
Cholesterol therapy (Rosenson, 2020)	• High-intensity statin therapy should be initiated as early as possible; obtain fasting lipid panel within 24 hours. • Atorvastatin 80 mg daily or rosuvastatin 20 or 40 mg daily • LDL goal is 50 mg/dL or less • Add ezetimibe 10 mg daily to high dose statin therapy if LDL not a goal. • Add PCSK9 inhibitor for patients with statin allergy or intolerance or if LDL not a goal with high dose statin therapy and ezetimibe alone.
Long-term management	• Antiplatelet therapy to reduce the risk of recurrent coronary artery thrombosis or, with PCI, coronary artery stent thrombosis • Statin therapy indefinitely • Oral anticoagulation in the presence of left ventricular thrombus or chronic atrial fibrillation to prevent embolization • Angiotensin converting enzyme (ACE) inhibitors, especially in STEMI patient with or without reduced left ventricular function and/or patients with diabetes, hypertension, and chronic kidney disease • β-blockers, if no contraindications

RECOMMENDATIONS FOR MI BASED ON CLASSIFICATION		
Goals	**Unstable Angina/NSTEMI**	**STEMI**
Invasive interventions (O'Gara et al, 2013)	• Urgent/immediate diagnostic angiography with intent to re-vascularize (within 2 hours) in NSTE-ACS patients with: ○ Hemodynamic instability or cardiogenic shock ○ Severe left ventricular dysfunction or heart failure ○ Recurrent or persistent rest angina despite intensive medical therapy ○ New or worsening mitral regurgitation or new ventricular septal defect ○ Sustained ventricular arrhythmias • Within 24 hours of admission for initially stabilized high-risk patients.	• Reperfusion therapy should be administered to all eligible patients with STEMI with symptom onset within the prior 12 hours: ○ PCI-capable hospitals – door-to-balloon time within 90 minutes upon arrival. ○ Non-PCI-capable hospitals transfer to PCI hospital for door-to-balloon time of 120 minutes. If arrive within 2 hours of onset of symptoms, administer lytic therapy then transfer. • Fibrinolysis is recommended for patients with symptom onset within 12 hours who cannot receive primary PCI within 120 minutes of first medical contact. Time from hospital arrival to initiation of fibrinolytic drug infusion (door-to-needle time) should

	• Not recommended in those with extensive co-morbidities, for whom the risks are likely to outweigh the benefits of revascularization OR in those with acute chest pain and low likelihood of ACS who are troponin negative (especially women).	be less than 30 minutes. High risk of bleeding with fibrinolysis.
Anticoagulant therapy	• Choice of agent (enoxaparin, bivalirudin, fondaparinux or unfractionated heparin [UFH]) depends on the intervention strategy planned.	• UFH to maintain therapeutic activated clotting time (ACT). If given with GP IIb/IIIa receptor antagonist planned: 50-70 U/kg IV bolus; if no GP IIb/IIIa receptor antagonist planned: 70-100 U/kg bolus • Bivalirudin 0.75 mg/kg IV bolus, then 1.75 mg/kg/h infusion with or without prior treatment with UFH. (Preferred if high risk of bleeding). • Fondaparinux: not recommended as sole anticoagulant for primary PCI.

Risk Assessment

- **Early Risk Stratification (UA/NSTEMI):** Identify patients at highest risk for future cardiac events.
  - Presence and extent of ST segment depression
  - Elevated cardiac biomarkers
  - Evidence of hemodynamic instability
  - Persistent chest pain despite appropriate medical therapy
- **Thrombolysis in Myocardial Infarction (TIMI) Risk Score (Antman, Cohen, & Bernink, 2000)**
  - Seven variables at presentation were independently predictive of outcome in patients with unstable angina or an acute non-ST elevation MI (1 = present, 0 = absent)
    - Age 65 years or older
    - Presence of at least 3 risk factors for coronary heart disease (hypertension, diabetes, dyslipidemia, smoking, or positive family history of early MI)
    - Prior coronary stenosis 50% or more
    - Presence of ST segment deviation on admission electrocardiogram
    - At least 2 anginal episodes in prior 24 hours
    - Elevated serum cardiac biomarkers
    - Use of aspirin in prior 7 days (possible marker of more severe coronary disease)
  - TIMI Scoring:
    - Low risk score = 0 to 2
    - Intermediate risk score = 3 to 4
    - High risk score = 5 to 7

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