Chapter 131

Ischemic Heart Disease, Angina Pectoris, and Myocardial Infarction

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More than 65 million Americans live with cardiovascular disease, including hypertension, coronary artery disease, rheumatic heart disease, and stroke. Approximately 45% of all deaths in the United States are due to cardiovascular disease, and nearly half of these deaths are in patients younger than age 65. More than 1.5 million patients with suspected acute ischemic heart disease (IHD) are admitted to coronary care units (CCUs) in the United States each year. At least 250,000 patients with IHD experience prehospital cardiac arrest each year, and only approximately 6% of these patients survive to be discharged from the hospital. IHD is thus a major national health concern as well as a common problem encountered in the emergency department.

Of increasing importance is the effective triage of patients with symptoms suggestive of acute IHD. Unnecessary admission to the hospital of patients with chest pain is estimated to cost more than $12 billion annually.13

The coronary arterial lesion most commonly encountered in the patient with typical, stable angina pectoris is a smooth-surfaced atherosclerotic plaque that may permit sufficient coronary arterial flow at rest or with minimal exercise to meet the metabolic demands of the myocardium. The determinants of myocardial oxygen supply and the factors that determine myocardial oxygen demand are listed in Table 131.1. During physical exertion or emotional stress, myocardial oxygen demand increases due to an increase in heart rate and blood pressure (the double product). To meet an increase in oxygen demand, either coronary arterial flow or myocardial oxygen extraction must increase. Because myocardial oxygen extraction is near maximal under normal circumstances, the only way to balance myocardial oxygen supply and demand is to increase coronary flow. If a fixed obstructive lesion is present, flow cannot increase sufficiently to meet augmented demands. Supply-demand imbalance ensues, with the development of ischemia, contractile dysfunction, and the classic symptoms of angina.23 When supply and demand are equalized, the supply-demand imbalance ceases and symptoms subside. This pathophysiologic substrate is the basis for medical management of chronic stable angina. Nitroglycerin preparations, beta blockers, and calcium channel blockers either increase myocardial oxygen supply or decrease demand.

TABLE 131.1. Determinants of Myocardial Oxygen Supply and Demand

Unstable coronary artery syndromes encompass unstable angina pectoris and acute myocardial infarction (MI). The pathologic substrate is a complex, irregular, and thrombogenic atherosclerotic plaque that may not be flow-limiting, even during activities that increase the double product. The occurrence of chest pain is thought to result from

intermittent flow limitations caused by platelet or fibrin thrombi, an increase in coronary vasomotor tone (i.e., vasospasm), or a combination of both, in the area of the unstable arterial plaque. Myocardial supply-demand imbalance, therefore, occurs because of a decrease in oxygen supply rather than an increase in demand, as in the stable coronary syndrome. Such patients may present with a history of chest pain and may have had a normal exercise stress test or coronary angiography that demonstrated noncritical coronary obstruction.6,31

Myocardial ischemia can also occur in the absence of coronary atherosclerosis. Common causes of nonatherosclerotic myocardial ischemia are listed in Table 131.2.

TABLE 131.2. Causes of Nonatherosclerotic Myocardial Ischemia

CLINICAL PRESENTATION

History of Present Illness

No single presenting symptom is uniformly diagnostic of IHD. Chest pain or chest discomfort is the most common chief complaint.

Such pain or discomfort may be described as a burning, tightness, squeezing, or heaviness, and as dull, sharp, or knifelike in character. Substernal or retrosternal chest pain may radiate to the left shoulder or to the arm, neck, or jaw due to convergence of sympathetic and somatic afferent pathways at the spinal level. Patients with IHD may also complain of similar types of abdominal discomfort. Chest pain caused by IHD is of visceral origin and is poorly localized. Chest pain that can be localized with a fingertip is unlikely to be of ischemic cardiac origin.21

Chest pain caused by IHD usually occurs abruptly, increases in intensity over time, and reaches peak intensity within 2 to 5 minutes of onset. If the pain occurs during or immediately after exertion, it typically resolves gradually within minutes of cessation of physical activity. Chest discomfort that lasts for only seconds or chest pain that is constant and lasts for hours to days is not consistent with IHD. Similarly, chest pain that is pleuritic, reproduced by palpation, and is sharp, stabbing, or positional has a low likelihood of being due to IHD25 (Table 131.3).

TABLE 131.3. Characteristics of Chest Pain Typical and Atypical for Ischemic Heart Disease

Patients with IHD, usually the elderly or those who also have diabetes mellitus or hypertension, may present with symptoms other than chest pain during acute ischemia. Such patients may complain of dyspnea, early fatigue, or declining exercise tolerance, symptoms that are caused by diastolic myocardial dysfunction. Decreased ventricular compliance leads to an increase in left ventricular (LV) end-diastolic pressure and

pulmonary artery pressure, resulting in an increase in pulmonary interstitial fluid.

Patients with a history of chest pain or with known medically controlled angina pectoris may present with new symptoms, such as chest pain at rest, chest pain associated with previously tolerated levels of exertion, chest pain unrelieved by a previously effective dose of a nitrate preparation, or chest pain of increasing severity, duration, or frequency. These patients should be considered to have unstable angina. Patients with typical exertional angina of less than 2 months' duration that is severe or frequent (three or more episodes per day) should also be considered to have unstable angina.31

Coronary artery vasospasm may produce symptoms that are atypical for classic angina pectoris. Episodes of chest pain or discomfort may occur at rest, pain may persist longer than is common for typical angina, and symptoms more commonly occur during the early morning. Such patients may also relate no risk factors for IHD.

The symptoms of an acute MI may not be distinguishable from those of a severe stable anginal episode or of unstable angina, although patients with acute MI usually have chest pain of typical anginal quality for at least 30 minutes. This consideration has served as a major entry criterion in studies of the efficacy of thrombolytic agents in acute MI.

Based on a number of epidemiologic studies, major and minor risk factors for coronary artery disease have been defined. Major risk factors include family history (MI in a first-degree relative of age less than 55 years), smoking, hypertension, hypercholesterolemia, diabetes mellitus, and male sex.

Physical Examination

Most patients with chest pain caused by IHD have one or more abnormal physical findings, but these are not specific for IHD and may occur in patients with valvular or congenital heart disease, or cardiomyopathy. If the finding of an S_4 is excluded, about 25% of patients with symptomatic IHD have a normal physical examination.

Common physical findings during myocardial ischemia are noted in Table 131.4 with their respective pathophysiologic explanations. The clinician should also seek evidence of risk factors for IHD, for example, hypercholesterolemia (xanthomas and arcus senilis) and hypertension (elevated arterial blood pressure and funduscopic changes).

TABLE 131.4. Physical Signs That Occur during Ischemia

DIFFERENTIAL DIAGNOSIS

A detailed discussion of the differential diagnosis of chest pain is included elsewhere in this volume. Diseases that are life-threatening and which may be confused with IHD include aortic dissection, pulmonary thromboembolism, pneumothorax, and esophageal rupture. Pneumonia, mitral valve prolapse, pericarditis, reflux esophagitis, esophageal spasm, peptic ulcer disease, and chest wall pain should also be included in the differential diagnosis. Particular attention to the character of the pain, precipitating factors, associated

symptoms, and the physical examination usually allows the clinician to rule out a number of these other causes for chest pain.

EMERGENCY DEPARTMENT EVALUATION

The emergency department evaluation, management, and triage of patients suspected of having chest pain caused by myocardial ischemia have changed dramatically in the past decade. These changes are the result of cost-containment concerns as well as the demonstration that early administration of thrombolytic agents in the setting of acute MI significantly decreases mortality.5,27,35

Annually, about 1.5 million patients are hospitalized in CCUs in the United States for suspected acute MI. Only about 30% of these patients subsequently have an acute MI diagnosed by conventional standards during hospitalization. Large-scale studies have shown that emergency department chest pain units (CPUs) can quickly identify and stratify patients with chest pain of suspected ischemic origin into low- and high-risk groups in

an effort to more effectively use the resources uniquely available in the CCU setting.35 Diagnostic efforts in the emergency department should be directed toward *ruling in* acute IHD, not just ruling out acute MI. In nearly all instances, patients with suspected acute IHD, not just those with acute infarction, require hospitalization.

Acute transmural MI is caused by complete occlusion of the infarct-related coronary artery by thrombus. Numerous large-scale, multicenter trials have demonstrated that dissolution of the thrombus by intravenous administration of thrombolytic agents and early reperfusion of the occluded coronary artery can preserve ventricular function and reduce mortality from acute MI by nearly 30%. This beneficial effect depends on the time from onset of symptoms to reperfusion.5,11,14,34 Diagnostic techniques for the early recognition of acute MI in patients who are likely to benefit from thrombolytic therapy are an active area of investigation.28

Electrocardiography

The electrocardiogram (ECG) and clinical history are the major screening methods available in most emergency departments when acute IHD is suspected. It has been stated that the emergency department ECG is often “normal” in patients subsequently diagnosed as having acute MI. Recent data indicate that the admission ECG is rarely normal but that nonspecific findings are frequent in this group of patients.

The early ECG signs of MI are ST-segment and T-wave changes that may also be seen with transient reversible ischemia or in patients with an established diagnosis of coronary artery disease. ST-segment elevation of more than 1 mm (0.1 mV) in two contiguous limb leads or 2 or more mm in two contiguous precordial leads is reported in the setting of acute transmural (Q-wave) MI. ST-segment elevation is seen in approximately 40% to 50% of patients with chest pain and acute MI at the time of initial evaluation. This population of patients is most likely to benefit from early administration of thrombolytic agents.

ST-segment depression of a similar degree (greater than or equal to 1 mm) or T-wave inversion is most commonly seen in nontransmural (non-Q-wave) infarction. Approximately

75% of patients with non-Q-wave infarction present with ST-segment depression. As a corollary observation, about one-third of patients with chest pain who have ST-segment depression or T-wave inversion subsequently evolve a non-Q-wave infarction.

ST-segment and T-wave changes are not always due to acute IHD. Common nonischemic causes for ST and T-wave changes suggestive of acute IHD are listed in Table 131.5. Although the presence of new nonspecific ECG changes increases the likelihood that chest pain is due to myocardial ischemia, the predictive value of such a finding is only about 50%.

TABLE 131.5. Nonischemic Causes of Precordial ST-Segment Elevation

Nonconventional surface ECG recordings are of value in some patients with suspected acute MI. The right coronary artery supplies the inferior wall of the LV as well as the right ventricle (RV) in 90% of patients. In the setting of inferior MI, a right precordial electrogram should be recorded to detect RV infarction. The right precordial electrogram is obtained by placing the V leads over the anterior right chest in a pattern that is the mirror image of the standard left-sided placement. RV infarction occurs in about 60% of patients who suffer an inferior MI and is detected by ST-segment elevation of greater than 1 mm in lead V_{3R} or V_{4R}, or both. Although RV infarction commonly accompanies infarction of the inferior wall of the LV, RV contractile dysfunction becomes hemodynamically significant in only about 10% of patients. Patients with hemodynamically significant RV infarction typically present with arterial hypotension and jugular venous distention, but clear lung fields. RV involvement with inferior infarction is associated with a greater 1-year mortality than inferior wall infarction alone.

The optimal time interval at which to perform a repeated emergency department ECG in patients with initial nondiagnostic findings has not been determined. Repeated ECGs are most commonly performed in patients who experience recurrent chest pain during emergency department observation or in those who have received a thrombolytic agent and are being monitored for ST-segment changes suggestive of reperfusion.

Chest Radiography

The most common chest film abnormality in patients with IHD is cardiomegaly, usually associated with prior infarction or chronic arterial hypertension. Additional radiographic signs of LV dysfunction may also be found (e.g., pulmonary venous hypertension, Kerley B lines, and chronic pleural effusions).

The primary value of the chest radiograph in the evaluation of the patient with chest pain and suspected IHD is in the detection of other causes of chest pain (e.g., pneumothorax, pneumonia, or a widened mediastinum suggesting aortic dissection).

Biochemical Markers

After the clinical history and 12-lead ECG, the third tool readily available to assist in the

diagnosis of an acute ischemic cardiac event is the serial measurement of enzymes and proteins released into the blood during myocardial ischemia.8 When myocytes are damaged, there is loss of cell membrane integrity, and these macromolecules diffuse into the interstitium and subsequently into the intravascular space and lymphatics. Their patterns of appearance in blood depends on the intracellular location, molecular weight (heavier molecules diffuse more slowly), local blood and lymph flow, and rate of elimination from the blood. The enzyme creatine kinase (CK), its myocardial subunit (CK-MB), and the proteins troponin I and T are the most readily available and most commonly used biochemical markers of cardiac ischemia. CK is typically reported as total enzyme activity (units per liter) and CK-MB as a concentration (CK-MB mass, nanograms per milliliter) or as a percentage of total CK (CK-MB activity). The former measurement of CK-MB is now available as a microparticle enzyme immunoassay based on monoclonal antibody technology. It is analytically and clinically more sensitive than the CK-MB percentage activity measured by electrophoresis. Elevations above the reference range or normal value for total CK and CK-MB mass are not specific for myocardial injury. CK and CK-MB are also present in skeletal muscle, and elevations may be seen after vigorous exercise, rhabdomyolysis, skeletal muscle trauma, dermatomyositis or polymyositis, renal failure, and cardiac contusion. Interpretation of total CK and CK-MB mass values must take this nonspecificity into consideration. Elevations of total CK and CK-MB mass are detectable 4 to 6 hours after acute infarction. Peak CK-MB mass is typically observed 12 to 18 hours after ischemia, while the peak of total CK occurs slightly later (12 to 24 hours). Both measurements return to normal values 24 to 36

hours after the ischemic event; a secondary rise suggests reinfarction. Time to peak levels of total CK and CK-MB mass vary, depending on the extent of myocardial injury. Peaks generally occur earlier with non-Q-wave or subendocardial infarction and later with Q-wave or transmural infarction.

The troponins (troponin [Tn] I and T) are proteins that regulate calcium-dependent interactions between myosin and actin. The cardiac troponins (cTnI, CTnT) are highly specific for myocardial tissue and are immunologically distinct from the skeletal muscle troponins. Due to this specificity, the concomitant use of a troponin measurement and CK-MB mass assists in differentiating myocardial from skeletal muscle injury in the presence of an elevated CK-MB measurement. Elevated cardiac Tn levels are detectable in serum within 4 to 6 hours following acute cardiac ischemia, reach peak concentrations in approximately 12 hours, and remain elevated after an ischemic event for 3 to 10 days. This temporal pattern allows detection of an acute cardiac event days after it has occurred and should replace lactate dehydrogenase (LDH) isoenzyme determinations for the diagnosis of “remote” acute myocardial injury. Due to its lower molecular weight, TnT appears earlier in the plasma than TnI. This advantage may be offset by the fact that TnT can be artificially elevated in the setting of renal failure.

At present, there is an indeterminate range of Tn values (typically 0.4 to 2.0 ng/mL) that are not normal yet are below the levels accepted for the diagnosis of acute MI. Such values may be seen in the clinical settings of unstable angina (presumably due to “microinfarction”), chronic congestive heart failure, and myocarditis, and after cardiac

surgery.

A single measurement of total CK, CK-MB mass, and Tn has a low sensitivity (30% to 40%) in ruling out acute MI, despite a specificity of 80% to 99%. Because of this low sensitivity, single normal values cannot be relied on to eliminate acute infarction as a diagnostic possibility in a patient with chest pain. Measurements should be performed serially, usually at 3- to 6-hour intervals for 12 to 18 hours. The reported sensitivities, specificities, and positive and negative predictive values for the various biochemical markers vary considerably in the literature (Table 131.6).8 This variation is due to the reported timing of blood sampling (from onset of symptoms or from time of emergency department arrival), the use of one marker or a panel of markers, and the populations studied (e.g., patients with diagnostic vs. nondiagnostic ECGs). In general, sensitivity increases over this time period (0 to 6 hours), while specificity remains relatively constant (greater than 90%). Within 8 to 10 hours after the ischemic event, the sensitivity of CK-MB mass and the troponins is approximately 90%.36

TABLE 131.6. Sensitivity and Specificity of Biochemical Markers of Ischemia at 0 to 6 Hours

Other biochemical markers for acute MI may facilitate the earlier diagnosis of acute infarction, particularly in the patient with a nondiagnostic ECG. Myoglobin is released from the myocardium within 2 to 4 hours of the onset of ischemia and appears earlier in the plasma than CK-MB. Serial measurements of myoglobin using newer rapid assays have been shown to be 100% sensitive, but with a specificity of approximately 80%, in detecting acute MI within 6 hours of symptom onset. Similarly, measurement of CK-MB isoforms (MB1 and MB2) has a sensitivity and specificity of greater than 90% of detecting acute MI within 6 hours of onset of symptoms. These latter markers are currently not widely used.

Noninvasive Assessment of Myocardial Perfusion and Cardiac Function in the Emergency Department

Patients who present with chest pain suggestive of acute cardiac ischemia, a nondiagnostic ECG or an ECG demonstrating “nonspecific” ST-segment or T-wave changes, and normal total CK, CK-MB, and Tn on serial measurements present a diagnostic problem. This patient population is the one most likely to have acute MI and unstable angina ruled out after hospital admission to a CCU or intensive care unit, at a cost of billions of dollars annually. These patients are also those most likely to benefit from extended observation in a CPU. The CPU has been shown to be a cost-effective alternative to hospital admission for these patients and to result in a decrease in the incidence of “missed” MI. Standard treadmill exercise stress testing (EST), myocardial scintigraphy at rest and during exercise, and stress echocardiography are standard diagnostic tests performed in patients with suspected coronary artery disease. The sensitivities, specificities, and positive and negative predictive values of these tests have been defined largely in the population of patients with a moderate-to-high probability of coronary artery disease (Table 131.7). These tests are now being applied to the broader group of patients who present to the emergency department with a chief complaint of chest pain. The diagnostic accuracy of

these tests in this population has not been well established and is likely to be different from those with a greater probability of having significant coronary artery disease due to selection criteria or bias. It is likely that these tests will be more useful in risk stratification than in diagnosis.

TABLE 131.7. Reported Sensitivity and Specificity of Noninvasive Diagnostic Tests for Coronary Artery Disease (CAD) in Patients with a High Pretest Probability of CAD

Acute myocardial ischemia depletes adenosine triphosphate stores, resulting in ventricular contractile dysfunction and ventricular wall motion abnormalities that may occur in the absence of diagnostic ECG changes. Two-dimensional echocardiography with the patient at rest is sensitive in detecting regional wall motion abnormalities that accompany acute ischemia, and has been used in the screening of patients with chest pain and suspected acute ischemia. However, echocardiography cannot reliably differentiate prior infarction (with myocardial scarring) from a new ischemic event. The sensitivity and specificity of the test appear to depend on whether the test is performed during chest pain or after its resolution. Based on limited studies, it is estimated that the sensitivity of standard echocardiography in the emergency department for acute cardiac ischemia or infarction is approximately 50% to 90%, with a specificity of 50% to 100%.28,35

Technetium-99m-labeled sestamibi is a radionuclide agent that is taken up by the myocardium in proportion to regional blood flow and is therefore capable of demonstrating myocardial perfusion defects. With ECG-gating, the technique can also detect wall motion abnormalities. Limited studies indicate that

this method of perfusion imaging is greater than 90% sensitive for detecting coronary artery disease in an emergency department population, with a specificity of approximately 70%. The accuracy of the test does not appear to be affected by the presence or absence of chest pain at the time of imaging.35

Standard treadmill EST has also been used for evaluation and risk stratification in this patient population. EST can be safely performed, requires less technical expertise than does echocardiography, and is less expensive that radionuclide imaging. Based on limited studies, EST in the emergency department assessment of chest pain has a sensitivity ranging from 29% to 90% for detecting coronary artery disease, with a specificity of 50% to 99%.16a,35a As clinical experience with EST in the emergency department increases, it is likely that the reported range of sensitivity and specificity will narrow.

EMERGENCY DEPARTMENT MANAGEMENT

The initial management of all patients with chest pain and suspected acute IHD should include administration of low-flow oxygen, establishment of vascular access, and continuous cardiac rhythm monitoring combined with frequent blood pressure determinations. Continuous pulse oximetry should also be employed, if available.

Interventions in the Patient with Chest Pain and Suspected

Unstable Angina Pectoris or Non-Q-Wave Infarction

Unstable angina is generally defined as a clinical syndrome falling between stable angina and acute MI. Typical presentations of unstable angina are presented in Table 131.8. Clinical features usually include a history of typical chest pain or a history of stable angina or MI and two or more risk factors for coronary artery disease. The ECG may be normal, nonspecific (ST-segment depression, 0.05 mm; T-wave flattening or inversion of less than 1 mm in leads with dominant R waves), or highly suggestive (ST-segment depression greater than or equal to 1 mm or marked symmetrical T-wave inversion in multiple leads) of ischemia. Therapeutic interventions in this clinical setting are directed toward decreasing myocardial oxygen demand and stabilizing thrombogenic atherosclerotic plaques.2,31

TABLE 131.8. Clinical Presentations of Unstable Angina

Nitroglycerin

Sublingual nitroglycerin decreases myocardial oxygen demand by decreasing ventricular preload, improves myocardial perfusion by dilating the coronary vascular bed, and has antiplatelet properties. This combination of pharmacologic effects often results in relief of chest pain. The usual starting dose is 0.3 to 0.4 mg of nitroglycerin sublingually via a tablet or spray. If chest pain persists, this dose may be repeated every 5 minutes if the systolic blood pressure remains greater than 100 mm Hg. If chest pain persists after three to five sublingual doses, the administration of intravenous nitroglycerin should be considered (50 mg of nitroglycerin in 250 mL of dextrose 5% in water). The initial infusion rate is 10 to 20 µg/min and can be increased in increments of 5 to 10 µg/min at 5- to 10-minute intervals until chest discomfort resolves or mean arterial pressure decreases by 10%. Most patients respond to infusion rates of 50 to 200 µg/min. At low doses, nitroglycerin acts principally as a venous and coronary vasodilator. At high doses, it acts as an arterial vasodilator as well, thereby affecting an additional component of myocardial oxygen demand.

The major complication of nitrate therapy, whether sublingual or intravenous, is hypotension. This is most likely to occur in patients who are hypovolemic at the time of emergency department presentation or in those who have suffered an RV infarction complicating inferior wall infarction. If hypotension occurs, nitrate therapy should be discontinued and intravenous normal saline administered, with careful monitoring of vital signs and lung sounds. Hemodynamically significant bradyarrhythmias have been reported during nitrate therapy; these should be treated with atropine.

Morphine Sulfate

Intravenous morphine may be administered if chest pain is not relieved with sublingual or intravenous nitroglycerin. The usual dose is 2 to 4 mg administered every 5 to 30 minutes if systolic blood pressure remains greater than 100 mm Hg.1 Morphine may decrease venous tone and decrease ventricular preload, but the required dose for these desired pharmacologic effects may produce respiratory depression. In addition, morphine may relieve pain but not necessarily reverse or modify the pathophysiologic processes involved

in acute myocardial ischemia. Other potential complications of morphine therapy are hypotension and bradycardia, which may be treated with normal saline and atropine, respectively.

Antiplatelet and Antithrombin Agents

Aspirin prevents platelet aggregation and platelet-induced coronary vasoconstriction via acetylation of platelet cyclooxygenase and prevention of the formation of thromboxane A_2. All patients with suspected acute ischemic heart disease who have no contraindications to the use of aspirin (such as allergy or active gastrointestinal hemorrhage) should receive a dose of 80 to 325 mg as soon as possible after the onset of symptoms.11 Concomitant aspirin and heparin therapy have been shown to be more effective than either agent alone.24

Unfractionated heparin is a heterogeneous mixture of polysaccharides, which activates antithrombin III, which in turn inhibits thrombin and coagulation factors X to XII. It also inhibits platelet aggregation, platelet vascular adhesion, and leukocyte chemotaxis.11 Heparin is often administered intravenously as a 5,000-U bolus, followed by an infusion of 1,000 U/h. The infusion rate is adjusted based on periodic measurement of the partial thromboplastin time (goal, 45 to 75 seconds).

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Low-molecular-weight heparin can also be used. It does not require monitoring of coagulation times, is associated with fewer clinically significant bleeding complications, and may be more effective than unfractionated heparin in preventing infarction, recurrent pain, and the need for early revascularization.10,19 Similarly, the glycoprotein IIb/IIIa inhibitors, although not extensively evaluated in the emergency department, may offer benefit in preventing recurrent symptoms or acute infarction in this patient group.16,33

Beta Blockers

Beta blockers reduce myocardial oxygen demand by decreasing ventricular contractility (dP/dt), heart rate, and afterload (blood pressure). These agents also have antiarrhythmic properties (class III antiarrhythmics) and may counteract the effects of catecholamines of the myocardium. These agents should be administered in the setting of suspected unstable angina or acute MI if contraindications to their use are not present.2 (Dosing and contraindications are discussed later.)

Patients with chest pain suggestive of acute cardiac ischemia who have ST-segment depression or T-wave inversions on the ECG are usually treated as if they are having a non-Q-wave (subendocardial) infarction. This diagnosis is supported if the ECG findings are new or “dynamic” (change in depth or amplitude over time). These patients are treated the same as patients with unstable angina. Thrombolytic agents have not been shown to improve survival in this patient population.2,32

Specific Interventions in Patients with Suspected Acute Transmural Myocardial Infarction (Q-Wave Infarction)

Acute MI is most commonly caused by abrupt thrombotic occlusion of a coronary artery at

the site of a “thrombogenic” atheromatous plaque (i.e., one that is ulcerated or fissured).5 Clot dissolution using thrombolytic agents in acute MI is safe and effective. A number of large prospective, controlled clinical trials comparing an intravenous thrombolytic agent with placebo have shown significant reductions in mortality with minimal risk (25% to 30% mortality reduction when used early).5,11,34 Other trials10,24 have compared thrombolytic agents with and without other adjunctive interventions (e.g., aspirin, beta blockers). The latter studies have resulted in controversies regarding the thrombolytic agent of choice and the timing or method of administration. However, it is generally agreed that (1) the promptness of administration of a thrombolytic agent after the onset of symptoms is more important than the choice of agent and (2) adjunctive drugs add to the mortality reduction observed with thrombolysis alone.

The generally accepted ECG criteria for thrombolytic therapy are ST-segment elevation of more than 1 mm in two or more contiguous limb leads or greater than 2 mm of elevation in two or more contiguous precordial leads, either persisting after sublingual nitroglycerin administration. It is well recognized that left bundle-branch block (LBBB) may obscure the diagnosis of acute MI because of the secondary ST-segment and T-wave changes that accompany altered ventricular depolarization. Criteria have been reported to identify acute MI in the presence of an LBBB, but although generally highly specific, they are insensitive in making this diagnosis.29,30 Due to this problem with recognition of acute MI in the setting of LBBB (either old or new) and the high mortality encountered when LBBB develops during the course of acute infarction, thrombolytic administration is recommended in patients with a history suggestive of acute cardiac ischemia and LBBB, regardless of whether it is new or old.14,30

The time to administration of thrombolytic therapy is critical for achieving maximum benefit. The best outcomes have been observed when the thrombolytic agent is administered within 4 to 6 hours of symptom onset. There still may be some benefit if the agent is given later (up to 12 hours), especially if symptoms have had a “stuttering” character (i.e., an intermittent resolution and recurrence of chest pain).

The patient who is a candidate for thrombolytic therapy but has a contraindication to its use (Table 131.9) should be considered for immediate coronary angiography and percutaneous transluminal angioplasty (PTCA).

TABLE 131.9. Thrombolytic Therapy in Acute Myocardial Infarction

Patient age alone should not be a consideration in the decision to administer a thrombolytic agent. Mortality with acute MI increases with age, and it can be reduced significantly with thrombolytic therapy.14

Choice of Thrombolytic Agent

Although thrombolytic agents have been shown unequivocally to reduce mortality from acute MI when compared with placebo or therapy previously considered “standard,” the best agent to use in the setting of acute MI is undecided; the choice remains with each

practitioner (Table 131.10). Tissue plasminogen activator (TPA) is, however, generally preferred in patients who have previously received streptokinase to avoid the risk of allergic reactions. Streptokinase is associated with a lower incidence of stroke and central nervous system hemorrhage in the elderly. An accelerated regimen of TPA (alteplase) administration is now routinely used in most centers (see Table 131.10).12 Reteplase (a mutant wild-type TPA that lacks several of the

molecular “domains” of alteplase, resulting in a longer plasma half-life) can be administered as a double bolus but has not been shown to be more effective than alteplase.17 Approximately 25% of patients receiving a thrombolytic agent will not recanalize the obstructed coronary artery, and approximately 20% will reocclude after successful reperfusion. ECG and biochemical marker changes after thrombolytic administration have been shown to be relatively reliable noninvasive markers of thrombolytic effect.9,26

TABLE 131.10. Thrombolytic Agents

Primary PTCA (i.e., used as the initial intervention to achieve coronary reperfusion) has been the subject of much recent investigation and appears to be at least as effective as, and possibly superior to, thrombolytic therapy. It is the reperfusion method of choice when acute MI is complicated by cardiogenic shock.4

Adjunctive Therapy with Thrombolysis

In addition to heparin, aspirin, and thrombolytics, beta blockers and the angiotensin converting enzyme (ACE) inhibitors have been shown to decrease both short- and long-term mortality after acute MI.18 Although a metaanalysis of published studies suggested that nitroglycerin and magnesium also were beneficial in the setting of acute MI, benefit has not been demonstrated in a large clinical randomized clinical trial.18,20 Nitroglycerin use for pain relief in acute MI is given according to the same regimen for the management of pain in unstable angina and non-Q-wave infarction (see previous discussion).

There have been a number of randomized trials of intravenous beta blockade initiated early in the course of acute MI.2,18 A metaanalysis of such studies indicates that early intravenous beta blockade reduces mortality by 13% by day 7 of treatment. Continued chronic oral therapy decreases long-term mortality. Beta blockers are contraindicated in the setting of obstructive airway disease (asthma or chronic obstructive pulmonary disease), atrioventricular (AV) block, hypotension, congestive heart failure, or known allergy. Esmolol, a beta blocker with an ultrashort half-life, may be administered by infusion and titrated to effect if beta blockade is necessary in patients with airways disease or depressed MI. Typical dosing schedules are shown in Table 131.11.

TABLE 131.11. Dosing of Beta Blockers

The ACE inhibitors (captopril, enalapril, and lisinopril have been most extensively studied) have also been shown to improve survival after acute MI. Patients with large infarctions or a history of LV dysfunction appear to derive the most benefit from this intervention. The mechanism of benefit is related to the vasodilator and neurohumoral effects of these drugs. The ACE inhibitors appear to modify maladaptive ventricular remodeling, thereby decreasing LV volume, and to attenuate the effects of activation of the renin-angiotensin system during the early infarct period, and may improve collateral coronary flow.1 Although early use of these drugs (within 24 hours) is recommended, particularly in selected populations, they are rarely given in the emergency department.

Complications of Acute Ischemia or Infarction

Arrhythmias

Cardiac rhythm disturbances are common during unstable angina or acute infarction.3 The most common arrhythmias are of ventricular origin. Premature ventricular contractions (PVCs) are noted in 80% to 100% of patients who experience an acute MI. Ventricular ectopy should be treated with intravenous lidocaine. One regimen consists of an initial bolus of 1 mg/kg followed by an infusion of 1 to 4 mg/min. The major side effect of lidocaine is neurotoxicity, typically manifested as altered mental status and seizures. In low cardiac output states, lidocaine metabolism is decreased, and usual therapeutic doses may be toxic. Thus, in this setting, the initial intravenous loading dose should be halved and the continuous infusion should be started at 1 mg/min.

Lidocaine should not be used prophylactically. Such use does not improve mortality and may actually contribute to the morbidity and mortality of acute MI. Indications for the use of lidocaine include frequent PVCs (more than 6 per minute), closely coupled PVCs (R-on-T phenomenon), multiform PVC, and nonsustained ventricular tachycardia.

Bradyarrhythmias or tachyarrhythmias that compromise systemic or myocardial perfusion require immediate therapy (see Chapter 134 and Chapter 135).

Conduction Disturbances

Second- and third-degree AV block may occur during either inferior or anterior infarction. In the setting of inferior MI, these conduction disturbances are normally associated with an increase in vagal tone and are usually transient and responsive to atropine. The abrupt occurrence of complete heart block is rare. In anterior MI, high-degree AV block is due to ischemia of the conduction pathways, and complete heart block may occur abruptly. Bundle-branch blocks are usually associated with anterior infarction. The indications for temporary artificial pacing in the setting of acute ischemia are listed in Table 131.12.

TABLE 131.12. Indications for Temporary Pacing in Acute Myocardial Infarction

Cardiogenic Shock

LV pump failure begins to occur when approximately 40% of the ventricular muscle mass has been lost. Severe contractile dysfunction results and necessitates the use of a number of therapeutic interventions (see Chapter 132). Studies suggest that PTCA may improve both short- and long-term outcome; this intervention

should be considered early in the course of management in selected patients.4

DISPOSITION

All patients with suspected acute myocardial ischemic syndromes should be admitted to the hospital, typically to an intensive care unit or CCU. Recent studies have shown that a low-risk group of patients may be identified, based on clinical and ECG findings, that could be cared for in an intermediate care unit or a monitored short-term emergency department observation unit.27,35

When acute MI is suspected, the consulting cardiologist should be contacted as soon as possible to facilitate intervention therapy with intravenous thrombolytic or emergent PTCA, as indicated.

Patients in the acute phase of infarction or with unstable angina should not be transferred to another facility unless definitive care cannot be given at the institution where the initial evaluation is performed. In such an instance, transfer in an appropriately equipped vehicle is justified after initial treatment and stabilization. The transport team should include personnel trained in advanced cardiac life support. It has been demonstrated that patients having an acute MI can be safely transported to a referral center for thrombolytic or interventional therapy.

Patients discharged from the emergency department with a diagnosis of stable angina or atypical chest pain should be referred to a cardiologist for further evaluation (e.g., EST and ambulatory ECG monitoring).

COMMON PITFALLS

- Missed MI is the fourth most common cause of malpractice suits filed against emergency physicians, and it ranks first with respect to monetary awards.
- For patients in whom the diagnosis is uncertain, the threshold for admission should be low. Due to the limited diagnostic tools available in the emergency setting, only a minority of patients admitted to the hospital with suspected acute IHD (“rule out MI”) actually have an acute infarct.
- A single ECG or CK-MB determination cannot be used to rule out the diagnosis of

acute MI.

- Comparison of a current ECG to a prior or baseline ECG should not be relied on to exclude acute IHD.
- If the patient meets appropriate criteria, reperfusion therapy should be administered as soon as possible. Every institution needs to address the issues of appropriate early triage of ambulatory patients with chest pain and rapid access to 12-lead electrocardiography.

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