PART

1

CARDIOVASCULAR DISORDERS

CASE STUDY

1 ACUTE MYOCARDIAL INFARCTION

For the Patient Case for this case study, see the printed book.

DISEASE SUMMARY

Definition

Acute myocardial infarction (AMI) is defined as a medical emergency characterized by rapid (i.e., acute) development of cellular death of a segment of cardiac muscle caused by a prolonged (>30 minutes) imbalance between the oxygen supply and demand of the myocardium. AMI is most commonly due to obstruction in one of the coronary arteries by a ruptured atherosclerotic plaque with rapid development of an overlying thrombus (i.e., intravascular blood clot). Since regeneration of heart muscle is minimal, dead heart muscle is replaced by scar tissue and loss of heart function is permanent. AMI is more commonly known by the general public as a "heart attack." Medical professionals often use the term *acute coronary syndrome* to indicate AMI.

Prevalence

According to data released in 2008 by the American Heart Association (AHA), approximately 8.1 million Americans are living today with AMI. Another 9.1 million Americans are susceptible to AMI, having been diagnosed with chest pain from poor coronary artery blood flow. In the United States, approximately 1.4 million AMIs occur each year. Approximately 770,000 episodes are first-time, symptomatic heart attacks, while nearly 430,000 are recurrent AMIs. It has also been estimated that an additional 190,000 "silent" (i.e., asymptomatic) first AMIs occur each year. Although AMI may occur at any age, frequency increases with advancing age and most cases occur after age 45. The average age at first AMI is 64.5 years for men and 70.4 years for women. However, certain subpopulations younger than 45 years are also at risk, particularly cocaine users, people with insulin-dependent diabetes mellitus or an abnormal lipid profile, and those with a positive family history for early coronary artery disease. Male predilection exists in persons aged 40–70 years. It has been estimated that American males have greater than a one in five probability of sustaining an AMI before the age of 65. Furthermore, males younger than 45 years have a six-fold greater risk for AMI than females of the same age. After menopause, the rate of AMI in women approaches that of men and becomes equal by age 80.

Significance

AMI is a leading cause of morbidity and mortality in the United States and kills more than 220,000 Americans every year. Heart attacks account for 8% of all deaths nationally, represent the *single leading cause of death in the United States today,* and are a major cause of sudden cardiac death in adults. Sudden cardiac death is usually defined as *unexpected death from cardiac causes within one hour after the onset of symptoms*. People who have experienced an AMI have a sudden death rate that is 4–6 times that of the general population. Approximately 20% of deaths from a heart attack occur before the patient reaches a hospital. The current overall mortality rate from AMI is approximately 38%.

Major complications of AMI include:

- progressive heart failure
- mitral valvular insufficiency (i.e., inability of the mitral valve to close completely, causing a reflux of blood into the left ventricle after each contraction)
- dysrhythmias (i.e., irregular heart rhythms, e.g., ventricular fibrillation)
- cardiogenic shock, which, in the setting of AMI, is associated with an 80% in-hospital mortality rate

It is also common for individuals who have suffered an AMI to develop recurrent heart attacks during their lifetime.

Causes and Risk Factors

AMI is most commonly caused by an obstruction in one of the coronary arteries, leading to myocardial ischemia (i.e., decreased blood flow to a segment of the heart) and a critical imbalance between oxygen supply and demand within the heart. The most common cause of obstruction is a ruptured plaque with subsequent rapid development of spasm of the involved blood vessel and a thrombus that together result in partial or total occlusion of one of the coronary arteries. Plaques build up over years within the walls of arteries from a slowly progressive, inflammatory disease known as *atherosclerosis*. Plaques are composed primarily of cholesterol, smooth muscle cells, and connective tissue and insidiously reduce blood flow through blood vessels as they expand. Total obstruction of the blood vessel for more than 4 hours can result in irreversible injury to the heart. Risk factors for atherosclerotic plaque formation include the following:

- advancing age
- male gender
- cigarette smoking
- abnormal lipid profile, especially high plasma concentrations of low-density lipoproteins (LDL) and low plasma concentrations of high-density lipoproteins (HDL)
- diabetes mellitus
- poorly controlled hypertension
- positive family history of atherosclerosis
- high levels of serum homocysteine

A positive family history includes any first-degree male relative aged 45 years or younger or any first-degree female relative aged 55 years or younger who experienced an AMI.

The *metabolic syndrome*, also recognized as a major contributor to risk for AMI, has been increasing in prevalence at an alarming rate. The metabolic syndrome is defined as a constellation of *three or more of the following*:

- abdominal obesity
- serum triglyceride concentration $\geq$150 mg/dL
- HDL cholesterol level $<$40 mg/dL for men and $<$50 mg/dL for women
- fasting blood glucose concentration $\geq$110 mg/dL
- hypertension

Other contributing factors to AMI include:

- low levels of circulating oxygen (i.e., *hypoxemia*) from carbon monoxide poisoning (in which oxygen is replaced on the hemoglobin molecule of red blood cells by carbon monoxide) or acute respiratory disease (in which fluid accumulation within the alveoli of the lungs impairs gaseous exchange)

- emboli that travel to and lodge within coronary arteries (most of which originate as thrombi in other parts of the body)
- coronary artery vasospasm not associated with formation of a thrombus overlying a ruptured plaque
- use of cocaine, amphetamines, or ephedrine (which can significantly increase blood pressure and/or the force of contraction of the heart, both of which increase myocardial demand for oxygen) should be considered as a cause of AMI in young people who do not have other risk factors
- inflammation of the aorta (i.e., *aortitis*) or coronary artery (i.e., *arteritis*), both of which can trigger thrombus formation
- abnormally low systemic blood pressure (i.e., *hypotension*), e.g., due to shock, which decreases blood flow to the heart when blood pools in small peripheral blood vessels throughout the body or is lost to the outside from hemorrhage
- severe emotional stress (which can cause the release of stress hormones, e.g., epinephrine and cortisol, that significantly increase blood pressure and cardiac contractility)

Disease Summary Question 1. Why are low-density lipoproteins commonly referred to as "bad cholesterol" and high-density lipoproteins as "good cholesterol"?

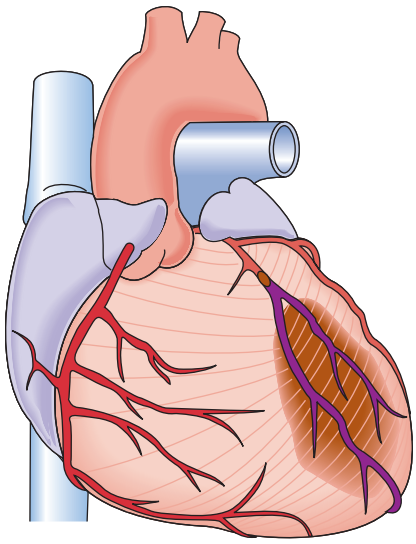
Pathophysiology

The predominant cause of AMI is rupture or fracture of an atherosclerotic plaque in one of the coronary arteries with subsequent spasm of the vessel and thrombus formation. Arteries that are narrowed by atherosclerosis (AS) cannot deliver enough blood to maintain normal function of the tissues of the body that they supply. For example, AS of the arteries in the legs (known as *peripheral arterial disease*) causes reduced blood flow through the legs and can lead to leg pain while walking, leg ulcers, and a delay in the healing of leg wounds. AS of arteries that furnish blood to the brain can lead to dementia (i.e., mental deterioration due to gradual death of brain tissue) or stroke (sudden death of brain tissue). In many people, AS remains silent and causes no symptoms for decades. Although the disease can begin as early as the adolescent years, symptoms usually do not appear until later in adulthood when arterial narrowing becomes severe.

The most common initiating event of AMI is a sudden change in the structure of an atherosclerotic plaque (usually due to rupture or fracture) with exposure of underlying collagen to elements within the blood. Although heart attacks can occur at any time of day, most occur between 4 AM–10 AM. This phenomenon may, in part, be caused by elevated blood pressure from the natural and cyclical release of stress hormones every morning. Platelets passing by the exposed surface of a ruptured plaque adhere to it, initiate formation of a collection of platelets known as a *platelet plug*, and activate the clotting sequence. Ultimately, plaque rupture results in formation of a thrombus from aggregated platelets, fibrin, and red blood cells at the site of rupture. There are also varying degrees of vasospasm caused by vasoconstricting chemicals (e.g., thromboxane A_2) discharged by platelets. The combination of developing thrombus and vasospasm results in partial or total obstruction of the artery and subsequent myocardial ischemia to cells downstream. Total occlusion of the blood vessel for more than 4 hours can result in irreversible cell injury and cell death within the heart. Re-establishment of blood flow (i.e., *reperfusion*) within this period can salvage myocardial tissue and reduce both morbidity and mortality.

The precise location and extent of cell death within the heart depends primarily on the following factors:

- precise location and extent (partial or total) of the obstruction
- presence of additional plaques that further reduce blood flow
- duration of the obstruction
- adequacy of collateral blood vessels that bypass the site of obstruction
- critical cardiovascular parameters, such as the patient's blood pressure, heart rate, and cardiac rhythm



DISEASE SUMMARY FIGURE 1.1
Anteroseptal myocardial infarction (*darkened area*) caused by occlusion of anterior descending branch of left coronary artery. (Reprinted with permission from Willis MC. Medical Terminology: A Programmed Learning Approach to the Language of Health Care. Baltimore: Lippincott Williams & Wilkins, 2002.)

AMI can occur in various regions of the heart and may be described as anterior, inferior, posterior, septal, or lateral depending on anatomic location. The most common site that is obstructed during AMI (45% of all AMIs) is the anterior descending branch of the left coronary artery. The location of obstruction causes tissue damage in an anteroseptal location (i.e., anterior wall of the left ventricle and apex of the heart and anterior two thirds of the interventricular septum). This type of AMI is illustrated in Disease Summary Figure 1.1. Thirty-five percent of all AMIs occur when the right coronary artery becomes obstructed, which leads to a posterior-inferior pattern of cell death (i.e., posterior-inferior wall of the left ventricle and posterior one third of the interventricular septum). Fifteen percent of all AMIs occur when the left circumflex artery becomes obstructed, which leads to cell death in the lateral wall of the left ventricle. When the left coronary artery is obstructed at a site near its origin from the aorta, a massive anteroseptal AMI of the left ventricle can result, and death often ensues from cardiogenic shock.

AMIs may be *transmural* (i.e., extend entirely through the wall of the heart) or *subendocardial* (i.e., involves one third to one half of the ventricular wall). Transmural AMIs are usually the result of a total, prolonged (>4 hours) obstruction. Subendocardial AMIs result from a partial or a total obstruction that spontaneously resolves or lyses with therapy within 4 hours after onset.

Experiments with animal models indicate that complete occlusion of a coronary artery results in a predictable pattern of cellular dysfunction and death. The principal biochemical consequence of AMI is the conversion from aerobic to anaerobic metabolism with inadequate production of energy in the form of adenosine triphosphate (ATP) to sustain myocardial function. Depletion of ATP in acutely ischemic cardiac cells begins immediately, followed within 1–2 minutes by an impaired ability of the heart to contract. Within 10 minutes, cellular concentrations of ATP decrease by 50% and irreversible cell injury begins to occur after 30 minutes of complete occlusion. Ischemic necrosis begins in the subendocardial zone of the heart (just beneath the inner endocardial lining) and spreads through the thick myocardial layer toward the epicardial surface. The subendocardium is most vulnerable to a reduction in blood flow, because coronary arteries enter the heart at the outer epicardial surface and traverse thick ventricular walls before delivering blood to endocardial

regions. Epicardial areas (at the surface of the heart) are spared for longer periods because they have the greatest collateral network of arterial vessels. With a typical AMI, approximately 20% of the cells die from the process of necrosis and the remaining 80% succumb to apoptosis (i.e., genetically programmed cell death).

The "superimposed thrombus theory" of AMI was controversial for many years because only half of all persons dying from an AMI had a demonstrable thrombus at autopsy. Then, cardiologists showed that approximately 90% of persons diagnosed with AMI had an intracoronary thrombus within 4 hours of the onset of symptoms, but only 60% had thrombi 12–24 hours later. This observation suggested that, in many cases, thrombi are quickly lysed (i.e., broken up) by natural physiologic mechanisms that degrade fibrin, a protein that serves as "glue" for the thrombus and causes platelets and red blood cells to stick together.

Diagnosis: Clinical Manifestations and Laboratory Tests

The diagnosis of AMI is based on four primary indicators: patient history, clinical manifestations, electrocardiogram (ECG) abnormalities, and elevations of specific marker proteins in the blood. Other diagnostic examinations such as chest radiography, echocardiography, and radionuclide scintigraphy may also be performed to provide supportive information.

Many patients have a history of risk factors that are associated with atherosclerosis (e.g., smoking, hypertension, and abnormal serum lipid levels), and approximately half of them report warning signs of previous chest pain, often with exertion. During an AMI, patients often provide a history of alteration in the pattern of their chest pain. Chest pain previously may have been associated with exertion, lasted <15 minutes before resolving, and responded quickly to nitroglycerin therapy or rest. However, chest pain of AMI typically occurs with minimal exertion or at rest, is more severe, and builds rapidly or in waves to maximum intensity. Furthermore, chest pain associated with AMI lasts longer than 30 minutes, and both nitroglycerin and rest have little effect.

The chest pain of AMI is substernal, often described as "crushing," "excruciating," or "squeezing" and may radiate to the arms, shoulders, neck, jaw, upper back, or into the teeth. This latter phenomenon is known as *referred pain*. The left arm is affected more frequently than the right arm. In some cases, however, patients complain of chest discomfort that feels like "gas," "pressure," or "tightness." Patients may break out in a cold sweat, feel weak and anxious, and move about seeking a position of comfort. Light-headedness, pallor, shortness of breath, cough, wheezing, nausea, and vomiting may be present individually or in any combination. In some instances, however, AMI is entirely asymptomatic (i.e., "silent AMI") and may be detected with an ECG at a later date. Up to one third of patients with AMI present without chest pain. Elderly patients and those with diabetes can have subtle presentations and may complain of fatigue, faintness (i.e., *syncope*), or weakness. Women also more commonly complain of atypical symptoms such as fatigue, nausea, back pain, and abdominal discomfort. Atypical complaints in patients with risk factors for atherosclerosis should prompt a high suspicion of AMI.

Physical examination findings may be normal. Heart rate may range from marked bradycardia (seen most commonly with an inferior ventricular wall AMI) to tachycardia from increased sympathetic nervous system activity or dysrhythmia. Blood pressure may be high, especially in patients with hypertension, or low in patients who have developed shock. A dangerously low blood pressure usually indicates a large region of infarction in the left ventricle. Respiratory distress usually suggests left heart failure. Fever, usually low grade, may appear after 12 hours and persist for several days. Cyanotic and cold extremities suggest low cardiac output from heart failure.

Auscultating abnormal lung sounds (e.g., "crackles" which suggest pulmonary edema and left ventricular failure) is a critical part of the physical examination. The Killip classification (shown in Disease Summary Table 1.1) is a common method to categorize heart failure and has strong prognostic value.

The cardiac examination may be unremarkable or significantly abnormal. An abnormally located ventricular impulse often represents the infarcted region of the heart. Jugular venous distension may indicate right ventricular infarction and the onset of right heart failure with increased systemic venous pressure. Soft heart sounds suggest left ventricular dysfunction. Atrial gallops (S_4) are the rule, whereas ventricular gallops (S_3) are less common

Disease Summary Table 1.1 Killip Classification for Determining Severity of Heart Failure

Killip Class	Clinical Signs
I	(−) for crackles and S_3
II	(+) for crackles over one third or less of lung fields that do not clear with coughing or (+) for S_3
III	(+) for crackles over more than one third of lung fields that do not clear with coughing
IV	(+) for crackles and hypotension (i.e., systolic blood pressure <90 mm), suggesting cardiogenic shock

Source: Bashore TM, Granger CB, Hranitzky P. Acute myocardial infarction. In: McPhee SJ, Papadakis MA, Tierney LM Jr., eds. 2007 Current Medical Diagnosis and Treatment. 46th Ed. New York: McGraw-Hill, 2007:363.

and indicate significant left ventricular dysfunction. Mitral valve regurgitation murmurs usually indicate papillary muscle dysfunction.

Approximately one half of patients who have experienced an AMI show diagnostic abnormalities on their initial ECG. The classic evolution of ECG changes occurs from a few hours after onset of symptoms to several days and progresses from peaked T waves to ST segment elevations to Q wave development to T wave inversions. *The evolution of new Q waves is diagnostic for AMI;* however, Q waves are not seen in as many as half of all AMIs. These types of AMIs are designated *non-Q wave infarctions*. ST segment elevations >1 mm in contiguous leads indicate a high probability that an AMI has occurred. Although normal findings on ECG indicate a low probability for AMI, they do not exclude the possibility of AMI. Localization of an AMI can also be assessed by the distribution of ECG abnormalities. For example, new Q waves in leads V_1–V_3 indicate that an anteroseptal infarction has occurred, while the same anomaly in leads V_1–V_6 indicates an anterolateral AMI.

In a patient with typical symptoms of heart attack and characteristic changes of AMI on ECG, a secure diagnosis of AMI can be made quickly and treatment started immediately. However, if a patient's symptoms are non-specific or atypical or if there are pre-existing ECG abnormalities (e.g., from previous heart attacks or abnormal electrical patterns that make interpretation of the ECG difficult), diagnosis can be made only hours later with specialized blood tests.

The most valuable laboratory parameters are serum cardiac-specific markers of myocardial cell injury, including the MB isoenzyme of creatine kinase (i.e., CK-MB) and the cardiac contractile proteins troponin I and T. Elevation of these cardiac markers correlates with the amount of heart muscle that has died. Serum concentrations of CK-MB begin to rise within 4 hours after injury, peak at 18–24 hours, and subside within 2–3 days. A single assay has a sensitivity of only 34%, but serial sampling over 24 hours increases sensitivity to near 100%.

The cardiac troponins are the most specific indicators and have become the criterion standard for diagnosing AMI. For earlier detection of AMI, sensitivity of troponin I is superior to that of CK-MB. Troponin I is elevated in serum as early as 3 hours after onset and its concentration may remain elevated for as long as 14 days. The kinetics and specificity for AMI of troponin T is similar to that of troponin I; however, troponin T is less sensitive than troponin I within the first 6 hours.

Total serum lactic dehydrogenase levels rise above the reference range within 24 hours of an AMI, peak within 3–6 days, and return to normal within 8–12 days. Leukocytosis may be observed within several hours after an AMI occurs. White blood cell counts peak in 2–4 days and return to a normal reference range within 1 week. Erythrocyte sedimentation rate rises above reference range values within 3 days and may remain elevated for several weeks.

Disease Summary Question 2. Describe the pathophysiology of *referred pain* associated with a heart attack.

Disease Summary Question 3. What causes the skin to become pale, cool, and moist during acute myocardial infarction?

Disease Summary Question 4. Why are leukocytosis and an elevated erythrocyte sedimentation rate expected when a diagnosis of AMI is established?

Chest x-rays may provide clues to an alternative diagnosis and will often reveal complications of AMI, particularly pulmonary edema due to heart failure. *Echocardiography* provides convenient bedside assessment of ventricular wall motion abnormalities and overall ventricular function and is helpful with respect to both diagnosis and management of AMI. Normal heart wall motion makes AMI an unlikely diagnosis.

Technetium-99m pyrophosphate scintigraphy may also be used to diagnose AMI. Technetium-99m is a radioisotope that, when infused at least 18 hours post-infarction, complexes with calcium in dead myocardium to provide a "hot spot" image of the infarcted region. This test is insensitive with small infarctions and its use is limited to patients in whom diagnosis by ECG and cardiac enzymes is not possible. *Scintigraphy with thallium-201* demonstrates "cold spots" in regions of diminished blood flow (which usually suggests infarction); however, abnormalities do not distinguish recent from longstanding myocardial injuries.

Appropriate Therapy

The primary goal of treatment is to quickly restore blood flow to the heart muscle, a process known as *reperfusion*, which minimizes the extent of heart muscle damage. Optimal benefit is obtained if reperfusion can be established within the first 6 hours. *The amount of healthy heart muscle remaining after a heart attack is the most important determinant of future quality of life and longevity.*

All patients with definite or suspected AMI should receive aspirin at a dose of 162–325 mg immediately following the onset of chest pain and regardless of whether thrombolytic therapy is being considered or the patient has been taking aspirin previously. Research has shown that aspirin can reduce mortality rates from AMI by as much as 25%. Chewable aspirin is more rapidly effective. Patients with an aspirin allergy may be treated with the platelet aggregation inhibitor clopidogrel (300 mg), although the onset of action is slower. Some primary healthcare providers believe in giving aspirin and clopidogrel together in order to provide "double protection" against the progressive nature of a thrombus. Pulse oximetry should be performed and low-flow (2–4 L/min) supplemental oxygen should be given if oxygen saturation <91%. An initial attempt should be made to relieve chest pain with sublingual nitroglycerin. However, if no response occurs after 3 tablets, intravenous opioids provide the most rapid and effective analgesia and may also reduce respiratory distress. Morphine sulfate (4–8 mg) or meperidine (50–75 mg) should be given initially, and small doses can be given every 15 minutes until pain abates.

To promptly restore blood flow through the heart, the current appropriate therapy is to treat patients with ST segment elevations and without contraindications and who present within 12 hours of the onset of symptoms with thrombolytic therapy or percutaneous coronary intervention. Thrombolytic therapy reduces mortality and limits the size of infarcted tissue in patients with ST segment elevations. The greatest benefit occurs if treatment is initiated within the first 3 hours when up to a 50% reduction in mortality rate can be achieved. The magnitude of benefit declines rapidly thereafter, but a 10% relative mortality reduction can still be achieved up to 12 hours after the onset of chest pain. Survival benefit is greatest in patients with large, usually anterior, infarctions. Patients without ST segment elevations do not benefit from and may actually be harmed by thrombolytic intervention. Major bleeding complications occur in up to 5% of patients, the most serious of which is intracranial hemorrhage.

In the United States, the most commonly used thrombolytic agents (aka *clot-buster drugs*) are alteplase, reteplase, and tenecteplase. These medications are all biosynthetic forms of the naturally occurring enzyme, human tissue-type plasminogen activator. In contrast to anticoagulants, like heparin, which prevent the propagation or buildup of thrombi, thrombolytic agents promote the breakdown of thrombi by converting plasminogen to plasmin, a protease that can degrade fibrin within a thrombus. As a result of this action, these drugs are also known as *fibrinolytic* agents. Differences in efficacy between them are negligible, and it is best that they be administered as soon as an AMI is diagnosed. Tenecteplase may be given as a single bolus and provides a feature that facilitates earlier treatment. To prevent gastrointestinal bleeding, all patients who undergo thrombolytic therapy should be pre-treated with an antacid and H_2 blocker. Restoration of blood flow in the heart can be recognized clinically by the relief of chest pain and resolution of ST segment elevations. ST segment resolution is a strong predictor of a good outcome. After completion of a thrombolytic infusion, aspirin should be continued and the patient is anticoagulated with heparin for at least 24 hours.

Immediate coronary angiography and percutaneous transluminal coronary angioplasty (PTCA) of the infarction-related artery are superior to thrombolysis when performed by experienced personnel (i.e., >75 such procedures/year) in large medical centers and when time from first medical contact to intervention is <90 minutes. With PTCA, a catheter is guided by x-ray images from a vein in the groin or arm into the area of occlusion. A balloon at the tip of the catheter is inflated, crushing both the atherosclerotic plaque and its overlying thrombus, dilating the affected coronary artery, and re-establishing blood flow. PTCA can be effective in restoring blood flow in 95% of blocked coronary arteries. It is important that a surgical team is always available to perform coronary artery bypass grafting (CABG) in the event that PTCA is unsuccessful or there is a serious complication of the procedure. CABG provides a detour for blood to circumvent the blockage. A short piece of blood vessel is taken from another location in the body (often a leg vein) and is connected to the aorta on one end and to the coronary artery downstream of the obstruction on the other. Angiography allows evaluation of the status of the other coronary arteries so that long-term treatment strategies may be designed. Several trials have shown that, if an efficient patient transfer system is in place, transport of patients with AMI from hospitals without PTCA to hospitals with PTCA capability can improve outcome compared with thrombolytic therapy. PTCA is the method of choice to restore myocardial blood flow in patients with contraindications for thrombolytic therapy and in those who have developed cardiogenic shock. The results of this approach in specialized centers are excellent. Placement of a stent (i.e., a small, hollow cylinder) at the site of the obstruction to maintain patency in the diseased artery and administration of the platelet aggregation inhibitor abciximab is now widely used in patients who have undergone PTCA. Abciximab is nine times more potent than aspirin and three times more potent than clopidogrel. State-of-the-art coated stents have reduced the frequency of re-closure of arteries to <10%.

There is some evidence that pharmacotherapy can improve patient outcome. Several studies have shown modestly improved short-term outcome when intravenous metoprolol, a β-blocker, is given immediately after an AMI. The drug acts primarily by reducing heart rate, force of contraction of the heart, and myocardial oxygen demand and may also reduce the frequency of life-threatening dysrhythmias. A series of trials has shown both short- and long-term improvement in survival when blood pressure-lowering angiotensin-converting enzyme (ACE) inhibitors (e.g., captopril) are given early. Benefit is greatest in patients with cardiac ejection fractions <40%, large areas of infarction, or clinical evidence of heart failure. Valsartan, an angiotensin receptor blocking agent, is equivalent to captopril in reducing mortality and is a reasonable, albeit more expensive, alternative to captopril for patients who cannot tolerate ACE inhibitors. Aldosterone antagonists, such as spironolactone and eplerenone, have also been shown to reduce mortality rates in patients with heart failure secondary to AMI.

Bed rest is required for the first 24 hours, but progressive ambulation should be started as soon as possible thereafter. For patients without complications, discharge by day 4 appears to be appropriate. Since aspirin is highly effective, inexpensive, and generally well-tolerated, aspirin maintenance is often strongly encouraged.

Disease Summary Question 5. Why is it necessary for nurses to ambulate patients as soon as possible following bedrest for a heart attack?

Disease Summary Question 6. How is aspirin effective in preventing heart attacks?

Serious Complications and Prognosis

Even when treatment is initiated promptly following a definitive diagnosis, a variety of serious complications can occur. Approximately one third of patients who undergo thrombolytic therapy develop recurrent ischemia and require percutaneous coronary intervention.

Abnormalities of cardiac rhythm and conduction from chaotic electrical activity that disrupts normal cardiac function are also common. Sinus bradycardia, atrial fibrillation, ventricular tachycardia, and ventricular fibrillation are among the more common dysrhythmias that occur in patients with AMI. Most deaths from heart attacks are caused by ventricular fibrillation that occurs before the victim can reach the hospital.

Disease Summary Table 1.2 Classification Criteria for Predicting Mortality Rates Following Acute Myocardial Infarction

Clinical Signs	Mortality Rate
Normal	<5%
Tachycardia	<5%
Hypotension and tachycardia but preserved left ventricular function	4–8%
Mild left ventricular failure	10–20%
Severe left ventricular failure	20–40%
Shock	>60%

Adapted with permission from Bashore TM, Granger CB, Hranitzky P. Acute myocardial infarction. In: McPhee SJ, Papadakis MA, Tierney LM, Jr., eds. 2007 Current Medical Diagnosis and Treatment. 46th Ed. New York: McGraw-Hill, 2007;Table 10–6:365.

The severity of cardiac dysfunction is usually proportionate to the extent of tissue injury in the heart. Cardiogenic shock is an extremely serious complication that occurs when more than 40% of the left ventricle is infarcted.

Prognosis of AMI is highly variable and depends on a number of factors, including timing and nature of the intervention, success of the intervention, area of the infarction, and post-AMI management. Better prognoses are associated with a normal blood pressure and urine output, early restoration of myocardial blood flow, preservation of left ventricular function, and treatment with metoprolol, aspirin, and captopril. Poorer prognoses are associated with a delay in reperfusion or unsuccessful reperfusion and poor ventricular function. *Left ventricular function is the strongest indicator of outcome in the post-AMI patient.*

Twenty percent of patients with AMI die before they reach the hospital. Survival rates in hospitalized patients range from 90–95% and are determined primarily by the size of the infarcted region and the age and general health of the patient. Several other classification criteria have been developed to predict mortality rates. These criteria are shown in Disease Summary Table 1.2.

Prognosis after discharge is determined by three major factors: extent of left ventricular dysfunction, extent of residual ischemic myocardium, and the presence/absence of ventricular dysrhythmias. The overall mortality rate during the first year after discharge is approximately 7%, with more than half of the deaths occurring in the first 3 months and chiefly among patients with heart failure. Subsequently, mortality rates average 4% each year. After a mild heart attack, patients can usually resume normal activities 2 weeks later; after a moderate heart attack, 4 weeks later; and after a severe AMI, 6 weeks or longer.

Prompt cardiopulmonary resuscitation and a rapid response by paramedics can significantly improve the chances for survival from a heart attack. Furthermore, many public venues now have defibrillators that provide the electrical shock needed to restore a normal heart rhythm even before paramedics arrive.

Disease Summary Question 7. Suggest *two non-pharmacologic* and *two pharmacologic* methods for post-infarction management that may help to improve the patient's prognosis.

Disease Summary Question 8. What might you suspect is the most common, serious complication in patients who are taking any combination of aspirin, clopidogrel, heparin, and abciximab?

Suggested Readings

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