myocardium distal to a flow-limiting stenosis is no longer able to augment flow by additional dilation. An overall limitation in the ability to increase coronary blood flow due to flow-limiting stenosis and endothelial dysfunction results in supply/demand mismatch and myocardial ischemia.

The major clinical manifestation of myocardial ischemia is chest discomfort (angina pectoris), which is usually described as a pressure or sensation of midsternal tightness. It may be quite pronounced in intensity or relatively subtle. Myocardial ischemia produces not only the sensation of angina pectoris but also a number of derangements in myocyte function. As in any tissue, inadequate oxygen delivery leads to a transition to anaerobic glycolysis, increased lactate production causing cellular acidosis, and abnormal calcium homeostasis. The net consequences of these cellular abnormalities include reductions in myocardial contractility and relaxation. Decreased myocardial contractility results in systolic wall motion abnormalities in the area of ischemia, and the abnormality of relaxation causes reduced ventricular compliance. These changes cause an increase in LV filling pressures above the normal range. The cellular abnormalities related to myocardial ischemia also translate into changes in cellular electrical activity that appear as abnormalities in the electrocardiogram (ECG). Myocardial ischemia may result in either ST depression or ST elevation, depending on the duration, severity, and location of the ischemia. The cellular, mechanical, and electrical abnormalities caused by ischemia typically precede the patient's perception of angina.

Myocardial dysfunction due to ischemia may recover quickly to normal if the duration of ischemia is brief. Prolonged myocardial ischemia can lead to conditions of myocardial stunning or myocardial hibernation. In the case of stunning, the mechanical dysfunction induced by prolonged ischemia persists for hours or days until function returns to normal. In the face of chronic ischemia, myocyte viability may be maintained, but because of ischemia, mechanical dysfunction persists; in this condition, known as hibernation, restoration of blood flow can result in recovery of myocardial function.

The heart's conduction system is less prone to ischemic injury, but ischemia can lead to impaired conduction. Ischemic disruption of myocyte electrical homeostasis also sets the stage for potentially life-threatening arrhythmias.

Angina Pectoris and Stable Ischemic Heart Disease

Definition

Angina pectoris is a clinical manifestation of obstructive CAD, which in turn is usually the result of atherosclerotic plaque formation over a number of years. The term *angina pectoris* refers to the symptom of chest discomfort that may be described by the patient as a sensation of chest tightness or burning. Of the 17,600,000 adults in the United States with heart disease, as many as 10,200,00 have angina pectoris. It is estimated that 785,000 people experience a new ischemic episode annually, and recurrent events occur in at least 470,000 Americans each year.

Pathology

As a symptom, angina pectoris is experienced when myocardial ischemia develops. Myocardial ischemia and angina pectoris may occur in the face of obstructive atherosclerotic plaque that limits blood flow in the face of increased demand such as exertion or emotional excitement. Myocardial oxygen demand is directly related to increases in heart rate and blood pressure; these variables, in turn, can be manipulated with medical therapy to reduce the demand. Restricted oxygen supply, in the form of reduced blood flow, can also induce myocardial ischemia. Blood flow reduction is a prominent feature of acute presentations of CAD such as NSTEMI and STEMI, but atherosclerosis-mediated coronary vasoconstriction, or coronary vasospasm, is also a potential cause of flow limitation leading to myocardial ischemia. Another example of supply limitation is anemia, whereby reduced oxygen-carrying capacity coupled with obstructive lesions leads to myocardial ischemia and symptoms of angina pectoris. The term *stable* angina pectoris refers to myocardial ischemia caused by either plaque-mediated flow limitation in the face of excess demand or supply limitation due to coronary vasospasm.

Clinical Presentation

Angina pectoris may manifest in either stable or unstable patterns (Table 8-2), but the symptom expression is similar. Typically, patients complain of retrosternal discomfort that they may describe as pressure, tightness, or heaviness. The symptom can be subtle in its presentation, and inquiry as to the presence of

TABLE 8-2 ANGINA PECTORIS

TYPE	PATTERN	ECG	ABNORMALITY	MEDICAL THERAPY
Stable	Stable pattern, induced by physical exertion, exposure to cold, eating, emotional stress Lasts 5-10 min Relieved by rest or nitroglycerin	Baseline often normal or nonspecific ST-T changes Signs of previous MI ST-segment depression during angina	≥70% Luminal narrowing of one or more coronary arteries from atherosclerosis	Aspirin Sublingual nitroglycerin Anti-ischemic medications Statin
Unstable	Increase in anginal frequency, severity, or duration Angina of new onset or now occurring at low level of activity or at rest May be less responsive to sublingual nitroglycerin	Same as stable angina, although changes during discomfort may be more pronounced Occasional ST-segment elevation during discomfort	Plaque rupture with platelet and fibrin thrombus, causing worsening coronary obstruction	Aspirin and clopidogrel Anti-ischemic medications Heparin or LMWH Glycoprotein IIb/IIIa inhibitors
Prinzmetal or variant angina	Angina without provocation, typically occurring at rest	Transient ST-segment elevation during pain Often with associated AV block or ventricular arrhythmias	Coronary artery spasm	Calcium channel blockers Nitrates

AV, Atrioventricular; ECG, electrocardiography; LMWH, low-molecular-weight heparin; MI, myocardial infarction.