

contribute to risk. Reduced left ventricular relaxation may stem from myocardial fibrosis (e.g., in cardiomyopathies and ischemic heart disease), and infiltrative disorders associated with restrictive cardiomyopathies (e.g., cardiac amyloidosis). Diastolic failure may appear in older patients without any known predisposing factors, possibly as an exaggeration of the normal stiffening of the heart with age. Constrictive pericarditis (discussed later) can also limit myocardial relaxation and therefore mimics primary diastolic dysfunction.

## Right-Sided Heart Failure

**Right-sided heart failure is most commonly caused by left-sided heart failure**, as any increase in pressure in the pulmonary circulation from left-sided failure inevitably burdens the right side of the heart. Consequently, the causes of right-sided heart failure include all of those that induce left-sided heart failure. Isolated right-sided heart failure is infrequent and typically occurs in patients with one of a variety of disorders affecting the lungs; hence it is often referred to as *cor pulmonale*. Besides parenchymal lung diseases, *cor pulmonale* can also arise secondary to disorders that affect the pulmonary vasculature, for example, primary pulmonary hypertension (Chapter 15), recurrent pulmonary thromboembolism (Chapter 4), or conditions that cause pulmonary vasoconstriction (obstructive sleep apnea, altitude sickness). *The common feature of these disorders is pulmonary hypertension* (discussed later), which results in hypertrophy and dilation of the right side of the heart. In extreme cases, leftward bulging of the interventricular septum can even cause left ventricular dysfunction. The major morphologic and clinical effects of primary right-sided heart failure differ from those of left-sided heart failure in that pulmonary congestion is minimal while engorgement of the systemic and portal venous systems is pronounced.

### MORPHOLOGY

**Heart.** As in left-heart failure, the cardiac morphology varies with cause. Rarely, structural defects such as tricuspid or pulmonary valvular abnormalities or endocardial fibrosis (as in carcinoid heart disease) may be present. However, since isolated right heart failure is most often caused by lung disease, most cases exhibit only hypertrophy and dilation of the right atrium and ventricle.

**Liver and Portal System.** Congestion of the hepatic and portal vessels may produce pathologic changes in the liver, the spleen, and the GI tract. The liver is usually increased in size and weight (**congestive hepatomegaly**) due to prominent **passive congestion**, greatest around the central veins (Chapter 4). Grossly, this is reflected as congested red-brown pericentral zones, with relatively normal-colored tan periportal regions, producing the characteristic “nutmeg liver” appearance (Chapter 4). In some instances, especially when left-sided heart failure with hypoperfusion is also present, severe centrilobular hypoxia produces **centrilobular necrosis**. With long-standing severe right-sided heart failure, the central areas can become fibrotic, eventually culminating in **cardiac cirrhosis** (Chapter 18). Portal venous hypertension also causes enlargement of the spleen with platelet sequestration (**congestive**

**splenomegaly**), and can also contribute to chronic congestion and edema of the bowel wall. The latter may be sufficiently severe as to interfere with nutrient (and/or drug) absorption.

**Pleural, Pericardial, and Peritoneal Spaces.** Systemic venous congestion can lead to fluid accumulation in the pleural, pericardial, or peritoneal spaces (**effusions**; peritoneal effusions are also called **ascites**). Large pleural effusions can impact lung inflation, causing atelectasis, and substantial ascites can also limit diaphragmatic excursion, causing dyspnea on a purely mechanical basis.

**Subcutaneous Tissues.** Edema of the peripheral and dependent portions of the body, especially ankle (pedal) and pretibial edema, is a hallmark of right-sided heart failure. In chronically bedridden patients presacral edema may predominate. Generalized massive edema (**anasarca**) may also occur.

The kidney and the brain are also prominently affected in right-sided heart failure. Renal congestion is more marked with right-sided than left-sided heart failure, leading to greater fluid retention and peripheral edema, and more pronounced azotemia. Venous congestion and hypoxia of the central nervous system can also produce deficits of mental function akin to those seen in left-sided heart failure with poor systemic perfusion.

Although we have discussed right and left heart failure separately, it is again worth emphasizing that in many cases of chronic cardiac decompensation, patients present in biventricular CHF with symptoms reflecting both right-sided and left-sided heart failure.

Standard therapy for CHF is mainly pharmacologic. Drugs that relieve fluid overload (e.g., diuretics), that block the renin-angiotensin-aldosterone axis (e.g., angiotensin converting enzyme inhibitors), and that lower adrenergic tone (e.g., beta-1 adrenergic blockers) are all particularly beneficial. The efficacy of the latter two classes of drugs supports the concept that neurohumoral changes in CHF (e.g., renin and norepinephrine elevations) are maladaptive contributions to heart failure.

Newer approaches to improving cardiac function include mechanical assist devices, and resynchronization of electrical impulses to maximize cardiac efficiency. Interestingly, some patients treated by mechanical assist can recover sufficient function to be weaned from the device. There is also considerable enthusiasm for novel therapies, including cell-based approaches, although several hurdles remain in their implementation.

### KEY CONCEPTS

#### Heart Failure

- CHF occurs when the heart is unable to provide adequate perfusion to meet the metabolic requirements of peripheral tissues; inadequate cardiac output is usually accompanied by increased congestion of the venous circulation.
- Left-sided heart failure is most commonly due to ischemic heart disease, systemic hypertension, mitral or aortic valve disease, and primary diseases of the myocardium; symptoms are mainly a consequence of pulmonary congestion and edema, although systemic hypoperfusion can cause secondary renal and cerebral dysfunction.