- Hypercoagulability, either primary (e.g., factor V Leiden, increased prothrombin synthesis, antithrombin III deficiency) or secondary (e.g., bed rest, tissue damage, malignancy, or development of antiphospholipid antibodies [antiphospholipid antibody syndrome]) or antibodies against platelet factor IV/heparin complexes [heparin-induced thrombocytopenia])
- Thrombi may propagate, resolve, become organized, or embolize.
- Thrombosis causes tissue injury by local vascular occlusion or by distal embolization.

Disseminated Intravascular Coagulation

DIC is not a specific disease but rather a complication of a large number of conditions associated with systemic activation of thrombin. Disorders ranging from obstetric complications to advanced malignancy can be complicated by DIC, which leads to widespread formation of thrombi in the microcirculation. These microvascular thrombi can cause diffuse circulatory insufficiency and organ dysfunction, particularly of the brain, lungs, heart, and kidneys. To complicate matters, the runaway thrombosis "uses up" platelets and coagulation factors (hence the synonym *consumptive coagulopathy*) and often activates fibrinolytic mechanisms. Thus, symptoms initially related to thrombosis can evolve into a bleeding catastrophe, such as hemorrhagic stroke or hypovolemic shock. DIC is discussed in greater detail along with other bleeding diatheses in Chapter 14.

Embolism

An embolus is a detached intravascular solid, liquid, or gaseous mass that is carried by the blood from its point of origin to a distant site, where it often causes tissue dysfunction or infarction. The vast majority of emboli are dislodged thrombi, hence the term *thromboembolism*. Other rare emboli are composed of fat droplets, nitrogen bubbles, atherosclerotic debris *(cholesterol emboli)*, tumor fragments, bone marrow, or even foreign bodies. Emboli travel through the blood until they encounter vessels too small to permit further passage, causing partial or complete vascular occlusion. Depending on where they originate, emboli can lodge anywhere in the vascular tree; as discussed later, the clinical consequences vary widely depending on the size and the position of the lodged embolus, as well as the vascular bed that is impacted.

Pulmonary Embolism

Pulmonary emboli originate from deep venous thromboses and are the most common form of thromboembolic disease. Pulmonary embolism (PE) has had a fairly stable incidence since the 1970s of roughly 2 to 4 per 1000 hospitalized patients in the United States, although the numbers vary depending on the mix of patient age and diagnosis (i.e., surgery, pregnancy, and malignancy all increase the risk). PE causes about 100,000 deaths per year in the United States. In more than 95% of cases, PEs originate from leg DVTs.

Figure 4-15 Embolus from a lower extremity deep venous thrombosis, lodged at a pulmonary artery branchpoint.

Fragmented thrombi from DVTs are carried through progressively larger veins and the right side of the heart before slamming into the pulmonary arterial vasculature. Depending on the size of the embolus, it can occlude the main pulmonary artery, straddle the pulmonary artery bifurcation *(saddle embolus)*, or pass out into the smaller, branching arteries (Fig. 4-15). Frequently there are multiple emboli, occurring either sequentially or simultaneously as a shower of smaller emboli from a single large mass; in general, **the patient who has had one PE is at high risk for more.** Rarely, a venous embolus passes through an interatrial or interventricular defect and gains access to the systemic arterial circulation *(paradoxical embolism)*. A more complete discussion of PEs is presented in Chapter 15; the following is an overview of the major functional consequences of pulmonary emboli.

- Most pulmonary emboli (60% to 80%) are clinically silent because they are small. With time they become organized and are incorporated into the vascular wall; in some cases organization of the thromboembolus leaves behind a delicate, bridging fibrous *web.*
- Sudden death, right heart failure *(cor pulmonale)*, or cardiovascular collapse occurs when emboli obstruct 60% or more of the pulmonary circulation.
- Embolic obstruction of medium-sized arteries with subsequent vascular rupture can result in pulmonary hemorrhage but usually does not cause pulmonary infarction. This is because the lung is supplied by both the pulmonary arteries and the bronchial arteries, and the intact bronchial circulation is usually sufficient to perfuse the affected area. Understandably, if the bronchial arterial flow is compromised (e.g., by left-sided cardiac failure), infarction may occur.
- Embolic obstruction of small end-arteriolar pulmonary branches often does produce hemorrhage or infarction.
- Multiple emboli over time may cause pulmonary hypertension and right ventricular failure.

Systemic Thromboembolism

Most systemic emboli (80%) arise from intracardiac mural thrombi, two thirds of which are associated with left ventricular wall infarcts and another one fourth with