immunosuppression. Although antiphospholipid antibodies are clearly associated with thrombotic diatheses, they have also been identified in 5% to 15% of apparently normal individuals, implying that they are necessary but not sufficient to cause the full-blown syndrome.

MORPHOLOGY

Thrombi can develop anywhere in the cardiovascular system and vary in size and shape depending on the involved site and the underlying cause. Arterial or cardiac thrombi usually begin at sites of turbulence or endothelial injury, whereas venous thrombi characteristically occur at sites of stasis. Thrombi are focally attached to the underlying vascular surface, particularly at the point of initiation. From here, arterial thrombi tend to grow retrograde, while venous thrombi extend in the direction of blood flow; thus both propagate toward the heart. The propagating portion of a thrombus is often poorly attached and therefore prone to fragmentation and embolization.

Thrombi often have grossly and microscopically apparent laminations called **lines of Zahn,** which are pale platelet and fibrin deposits alternating with darker red cell–rich layers. Such laminations signify that a thrombus has formed in flowing blood; their presence can therefore distinguish antemortem clots from the bland nonlaminated clots that occur postmortem (see later).

Thrombi occurring in heart chambers or in the aortic lumen are designated **mural thrombi.** Abnormal myocardial contraction (arrhythmias, dilated cardiomyopathy, or myocardial infarction) or endomyocardial injury (myocarditis or catheter trauma) promotes cardiac mural thrombi (Fig. 4-13*A*), while ulcerated atherosclerotic plaque and aneurysmal dilation are the precursors of aortic thrombi (Fig. 4-13*B*).

Arterial thrombi are frequently **occlusive**; the most common sites in decreasing order of frequency are the coronary, cerebral, and femoral arteries. They typically consist of a friable meshwork of platelets, fibrin, red cells, and degenerating leukocytes. Although these are usually superimposed on a ruptured atherosclerotic plaque, other vascular injuries (vasculitis, trauma) may be the underlying cause.

Venous thrombosis (phlebothrombosis) is almost invariably occlusive, with the thrombus forming a long luminal cast. Because these thrombi form in the sluggish venous circulation, they tend to contain more enmeshed red cells (and relatively few platelets) and are therefore known as **red,** or **stasis, thrombi.** Venous thrombi are firm, are focally attached to the vessel wall, and contain lines of Zahn, features that help distinguish them from postmortem clots (see later). The veins of the lower extremities are most commonly involved (90% of cases); however, upper extremities, periprostatic plexus, or the ovarian and periuterine veins can also develop venous thrombi. Under special circumstances, they can also occur in the dural sinuses, portal vein, or hepatic vein.

Postmortem clots can sometimes be mistaken for antemortem venous thrombi. However, clots that form after death are gelatinous and have a dark red dependent portion where red cells have settled by gravity and a yellow "chicken fat" upper portion, and are usually not attached to the underlying vessel wall.

Thrombi on heart valves are called **vegetations**. Bloodborne bacteria or fungi can adhere to previously damaged valves (e.g., due to rheumatic heart disease) or can directly cause valve damage; in either case, endothelial injury and disturbed blood flow can induce the formation of large thrombotic masses (**infective endocarditis**; Chapter 12). Sterile vegetations can also develop on noninfected valves in persons with hypercoagulable states, so-called **nonbacterial thrombotic endocarditis** (Chapter 12). Less commonly, sterile verrucous endocarditis (**Libman-Sacks endocarditis**) can occur in the setting of systemic lupus erythematosus (Chapter 6).

Fate of the Thrombus

If a patient survives the initial thrombosis, in the ensuing days to weeks thrombi undergo some combination of the following four events:

- *Propagation.* Thrombi accumulate additional platelets and fibrin (discussed earlier).
- *Embolization.* Thrombi dislodge and travel to other sites in the vasculature (discussed later).
- *Dissolution.* Dissolution is the result of fibrinolysis, which can lead to the rapid shrinkage and total disappearance of recent thrombi. In contrast, the extensive fibrin deposition and cross-linking in older thrombi renders them more resistant to lysis. This distinction explains why therapeutic administration of fibrinolytic

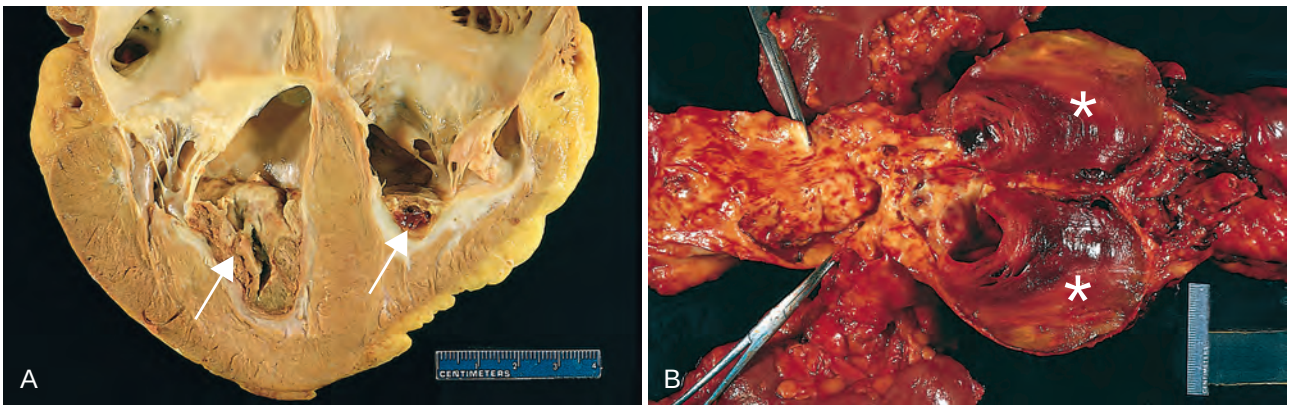

Figure 4-13 Mural thrombi. **A,** Thrombus in the left and right ventricular apices (arrows), overlying white fibrous scar. **B,** Laminated thrombus in a dilated abdominal aortic aneurysm (denoted by asterisks). Numerous friable mural thrombi are also superimposed on advanced atherosclerotic lesions of the more proximal aorta *(left side of picture).*