Percutaneous radiofrequency (RF) ablation has received much attention as an image-guided minimally invasive strategy for the treatment of focal malignant disease. This chapter reviews the concept of thermal ablation and the principles of RF application. The early limitations in success and subsequent developments in RF technology are also discussed. Finally, recent advancements in RF ablation and current directions of research, including possible combination and adjuvant therapies are highlighted. A clear understanding of the underlying principles of RF ablation can facilitate its application to clinical practice with favorable results.

Physics of RF

RF energy, a well-defined portion of the electromagnetic spectrum (10 kHz to 2.59 GHz), forms relatively long wavelengths when electrical charges are accelerated. Body tissues are permeated by a saline solution and are relatively poor conductors. Hence, when RF current flows through the body, it results in lost energy in the form of moving ions and water molecules. This “ionic agitation” is manifest as tissue heating that is directly proportional to current density (Fig. 1.1). Direct heating by RF is localized to the active electrode, as current density, defined as current flow per unit area of the electrode, falls rapidly with distance from the electrode. Generated heat spreads into surrounding tissue by conduction until a steady state is achieved, described as
thermal equilibrium. Higher energy amounts are required for ablating larger volumes of tissue. However, high current densities that have been applied too rapidly desiccates tissue immediately surrounding the probe, resulting in small, irregular ablation volumes. Desiccated cellular tissue functions as an electrical insulator, which reduces the electrode surface and further increases current density. Eventually, charring, tissue adherence, and associated thrombus formation results in dielectric breakdown if power is not terminated. However, large ablation volumes can be achieved by carefully regulating energy deposition to achieve maximum current density without overheating.

**Induction of Coagulation Necrosis**

Thermal strategies for ablation attempt to destroy tumor tissue in a minimally invasive manner while limiting injury to nearby structures. Treatment also includes a 5- to 10-mm surgical margin of normal tissue, based on the uncertainty concerning the exact tumor margin and the possibility of potential microscopic disease in the rim of tissue immediately surrounding visible tumor. Cosman et al. have shown that the resistive heating produced by RF ablation techniques leads to heat-based cellular...