Radiology

SCIENCE TO PRACTICE

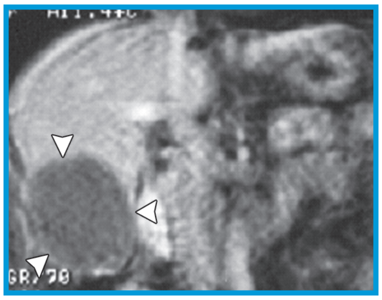
SEE PAGE 659

Science to Practice

High-Intensity Focused Ultrasound Ablation: Will Image-guided Therapy Replace Conventional Surgery?

The Setting

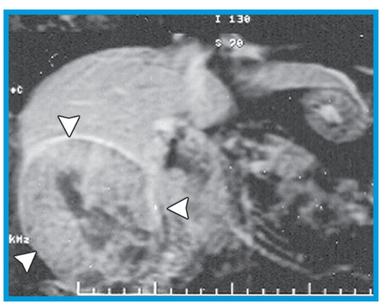
In the past decade, new, less invasive surgical options have altered the paradigm for local therapy of malignant disease. Laparoscopic surgery has replaced many open surgical procedures, with reduction in cost, morbidity, and hospital stay. Ultrasonographically (US)-guided radiofrequency ablation, thermotherapy, and cryoablation present less invasive alternatives to laparoscopy but still require percutaneous insertion of an instrument. High-intensity focused ultrasound ablation offers a truly noninvasive treatment method with no skin incision but with precise targeting of tissues for therapy.



In the current issue of *Radiology*, Wu et al (1) describe a survival advantage with high-intensity focused ultrasound therapy in a clinical trial involving patients with advanced unresectable hepatocellular carcinoma.

The Science

The mechanisms of tissue destruction with high-intensity focused ultrasound ablation are related to hyperthermia and cavitation (2). Low-intensity ultrasound energy, as used in diagnostic imaging, propagates harmlessly through tissue. High-intensity focused ultrasound ablation focuses an extracorporeal source of ultrasound to a specific target tissue. The ultrasound energy passes harmlessly through overlying tissues en route to a tightly focused target area. The rapid rate of energy deposition at the target tissue far exceeds the rate of heat dissipation, resulting in a rapid rate of temperature rise. While other thermal ablation techniques are limited by dissipation of heat into adjacent tissues, the rapid, focused deposition of ultrasound energy with high-intensity ultrasound ablation (0.5–1.0 seconds) produces local cavitation and temperatures of 65°–100°C with little heating of adjacent tissues. Temperatures above 56°C for a period of 1 second result in irreversible cell death, with a sharply defined region of tissue necrosis. The ability to focus and accurately target a lesion with high-intensity focused ultrasound by using real-time US or magnetic resonance imaging guidance allows precise ablation of lesions of any shape without damage to surrounding structures. The elegant study design by Wu et al (1), in which consecutive patients were alternately assigned to one of two treatment protocols, provides convincing evidence that subjects treated with chemoembolization and high-intensity focused ultrasound ablation have greater tumor regression and a significant survival advantage compared with the group treated with chemoembolization alone.



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The Practice

Clinical use.—Focused ultrasound therapy may be used alone, or, as demonstrated in the study by Wu et al, in combination with other therapies for cancer. Clinical trials have evaluated the use of high-intensity focused ultrasound therapy for tumors of the breast, liver, prostate (benign prostatic hyperplasia and cancer), bladder, and kidney. Results of early trials have demonstrated the feasibility of focused ultrasound to provide therapy in situations not amenable to conventional surgery or as salvage therapy for recurrent disease. Advantages of focused ultrasound therapy include the ability to focus the area of therapy with remarkably sharp margins. In contrast to radiation therapy, there is no limitation on the cumulative focused ultrasound dose, so the procedure can be repeated as many times as required. Also, performance of focused ultrasound abla-

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tion does not preclude other therapeutic options, including subsequent surgery. Clinical side effects in early trials involved damage to tissue outside the target area.

As the technical performance of high-intensity focused ultrasound ablation has been optimized, side effects have been reduced, with improved ablation of target lesions. Technical problems related to overlying osseous structures and calcifications are being addressed. Results of a European multicenter trial of focused ultrasound for therapy of prostate cancer suggest that the technique is safe and may be useful as primary therapy for prostate cancer (3). A recent study evaluated focused ultrasound therapy for the ablation of benign disease (4).

Future opportunities and challenges.—Given the noninvasive, versatile nature of high-intensity focused ultrasound ablation, this technique presents a competitive alternative to conventional surgical treatment. Even within the calvarium, neurosurgical applications of focused ultrasound may become a reality (5). The potential of focused ultrasound ablation to replace surgical therapy is certain to attract the interest of many medical specialties. If radiologists wish to retain an important role in the utilization of focused ultrasound ablation, it is critical that we maintain an active translational research effort. It is essential that we perform well-designed randomized trials of high-intensity focused ultrasound ablation before this modality is moved into the realm of clinical practice.

Summary

Wu et al (1) have demonstrated clear clinical advantage to the combination of high-intensity focused ultrasound therapy with chemoembolization compared with chemoembolization alone. Now that the technical feasibility of high-intensity focused ultrasound ablation has been established, studies of clinical effectiveness should precede widespread clinical use of this technique.

References

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