Chapter 13
High Intensity Focused Ultrasound (HIFU) Ablation Therapy for Thyroid Nodules

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INTRODUCTION AND RATIONALE
High Intensity Focused Ultrasound (HIFU) is a unique process that delivers a large amount of heat energy to a confined space. HIFU can coagulate tissue at a distance. The effect of HIFU on tissues and tumors was first established in the early to mid-1950s (1,2), and more recently partial or complete destruction of tumor (3–8) was shown in the animal; HIFU is already being used to treat localized prostate cancer. This technique has been shown to lower costs, shorten hospitalization stays and represents a valuable alternative for patients for whom surgery is contraindicated.

Thyroid nodules are frequently discovered during routine physical examinations or during investigations for other purposes (cervical ultrasonography, carotid duplex exams, cervical scans). Recently, systematic ultrasonographic exploration of a French large adult cohort indicated that 14.5% of the subjects had nodular thyroid structures (9). In the United States, 40% of the female population age 50 or older presented with thyroid nodules at ultrasonography, and the prevalence of thyroid nodules increases throughout life (10). Fortunately, more than 95% of thyroid nodules are the result of benign disease processes and the incidence of thyroid cancer is low. Fine needle aspiration biopsy (FNAB) is considered the most reliable test for the diagnosis of malignant thyroid nodule. In large published series, adequate cytological material is classified as benign, malignant, or suspicious in 69%, 4% and 10% of cases, respectively (11). Benign cytological results correspond to colloid or macrofollicular adenomas, nodular and/or cystic goiters,
or thyroiditis. Patients presenting with such benign nodules are subjected to long follow-up. However, the best therapeutic strategy after the discovery of such nodules is still a matter of debate (12). Some nodules are treated with thyrotropin (TSH)-suppressive levothyroxine (LT4) therapy. Unwanted effects of thyroxine treatment on the skeletal and cardiovascular systems (13) lead physicians to take a wait-and-see policy that is often preferred (12, 14). Moreover, the effectiveness of suppressive thyroxine therapy in reducing the volume of benign thyroid nodules is controversial (13, 15). Despite reassuring cytological results, some physicians advise removing them, especially in cases of increases in a nodule’s volume, pressure symptoms or cosmetic complaints. Then the goal of the physician is to delay the time of surgery, or even to switch to another treatment which could represent an alternative to surgery. Ideally a new method must be minimally invasive and be done in an ambulatory setting. HIFU meets these requirements. Compared to other alternative treatments such as percutaneous laser ablation, radiofrequency or ethanol injection, HIFU represents a promising non-invasive procedure that patients would favor. The project’s aim is four-fold:

- firstly, to assess the feasibility of using HIFU to obtain localized ablation of thyroid tissue without affecting neighboring structures on sheep’s thyroid,
- secondly, to evaluate the safety, feasibility and efficacy of HIFU for the destruction of thyroid nodules in patients who are indicated for thyroid surgery,
- thirdly, to confirm safety of HIFU treatment and study ultrasonographic nodule changes after HIFU in non-operated patients (the hypothesis is that HIFU treatment would delay surgery and should, therefore, represent an alternative treatment for patients with benign nodular disease)
- lastly, to study other applications of HIFU as treatment of toxic adenomas, primary or secondary hyperparathyroidism, treatment of recurrent thyroid cancer and define indications of HIFU treatment in the management of thyroid diseases.

HIFU TECHNOLOGY

Principle of HIFU

High Intensity Focused Ultrasound (HIFU) is a unique process of delivering a large amount of heat energy to a confined space. The acoustic energy is produced by an ultrasonic transducer and concentrated on the tissue to be treated. The energy heats