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HIFU: Local Treatment of Prostate Cancer

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Abstract

Objective: Treatment of carcinoma of the prostate (CaP) begs some complex questions. Different disease stages call for different treatment modalities and no universally 'gold standard' treatment has yet been agreed upon. In the present work we will present the results, indications and limitations of HIFU in the treatment of CaP.
Methods: Relevant information on HIFU treatment was identified through a literature search of published studies and review articles.
Results: HIFU can be considered for patients with (recurrent) localized CaP and a prostate volume of 40 cc or failure after radiotherapy. Treatment outcome is evaluated with PSA measurements and prostate biopsies. Mid-term follow up (2–5 years) reveals a PSA of 0.15 ng/ml and in 85% of cases the PSA level remains at the post HIFU nadir. The negative control biopsies are found in 90% of patients. A combination with a TURP reduces the treatment related morbidity.
Conclusions: HIFU has proven mid-term high local and biochemical efficacy in patients with local confined prostate cancer. A HIFU also shows promising results in local recurrence of prostate cancer after external beam radiation.

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1. Introduction

At the time of diagnosis, prostate cancer is organ confined in 70% of the cases. Approximately a quarter of these patients undergo local therapy: surgery or external beam radiation. The rest of the remaining patients are subjected to watchful waiting or hormonal ablation or a combination of the above mentioned. Because patients often do not fit these treatments, the quest continues for a reliable and minimally invasive alternative to open surgery or external beam radiation (Fig. 1).

Several treatment modalities have faced the surface in the armamentarium of the management of localised prostate cancer: brachytherapy, cryotherapy and HIFU. The latter is the new kid on the block with very attractive features and promising initial results. HIFU destroys prostate cells by coagulative necrosis of the tissue [1] without damaging the intervening structures passed by HIFU

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Fig. 1 – Patient positioned on treatment table and physician behind operating module.

and without an increase in metastasis formation [2]. In addition to being a primary therapy to combat prostate cancer, HIFU can also be considered as a salvage treatment for radiation and brachytherapy failures. And, as experience and improving techniques will become available in the future, even high and locally advanced stages of prostate cancer may be treated with HIFU [0]as a palliative approach to improve patients QOL and reduce disease progression rate. High intensity focused ultrasound has the potential to provide the clinician with another truly non-invasive, targeted treatment option in targeting local prostate cancer.

2. History and background

The initial work on ultrasound in the treatment of the benign prostatic hyperplasia (BPH) began in the early 1990s, but already during the 1950s, the Fry brothers imagined the first medical application of ultrasonic waves [3]. Their first works were related to the extra-corporeal treatment of neurological disorders such as Parkinson disease. Using a set of ultrasound transducers focused on the area to be treated, they could realize tiny biological lesions located deep inside the cerebral cortex [4,5]. But the lack of an imaging device with adequate performance and accuracy stopped the development of this type of therapies[0]. By 1956, Burov had suggested that high intensity ultrasound could be used for the treatment of cancer [6]. At the end of the 80s, studies using HIFU to irradiate experimental tumours followed [7,8]. The main purpose of this work was to develop applications to treat malignant tumours, and after this the role HIFU for treating prostate cancer was picked up.

3. Procedure

HIFU relies on the same principles as conventional ultrasound. It can propagate harmlessly through living tissue, but if the ultrasound beam carries sufficient energy and is brought into a tight focus, the energy within the focal volume can cause a local rise in temperature of 80 to 90 degrees Celsius or more in two or three seconds [9], which is lethal to prostate cancer tissue. There is a steep temperature gradient between the focus and neighbouring tissue, which is demonstrated by the sharp demarcation between the volume of necrotic lesion and normal surrounding cells on histology [10]. The lesion extension is about 3/4 in front of the transducer focus and 1/4 beyond. The lesion dimension is related to the firing duration: the lesion starts at the transducer focus and progresses toward the transducer during the firing sequence. Since ultrasound is non-ionizing (as opposed to ionizing in radiation), tissue in the entry and exit path of the HIFU beam is not injured and allowing the treatment to be applied multiple times without increased risk. The ability to cause cell death in a volume of tissue distant from the ultrasound source makes HIFU an attractive option for development as a non-invasive surgical tool. Depending on which device is used, the patient is either placed on his back with legs elevated in the dorsal lithotomy position or on his right side. The HIFU probe is placed into the rectum and multiple gland images are taken. The transrectal non-invasive approach avoids the percutaneous treatment that HIFU requires in other diseases. Ultrasound and MRI have made real-time monitoring of the procedure possible. The major advantage of HIFU is its extra corporal approach for destruction of deep tissues without making an incision in the skin. Then, at the HIFU control panel, all of the images are reviewed, and the treatment zones are defined and logged into the treatment computer. Not every prostate can be treated all at once, so the prostate is divided into zones, but a 40 g prostate can be entirely treated in one session.

The entire procedure can take between 1 to 3 hours, depending on the size of the gland. The procedure is performed on an outpatient basis under epidural or general anaesthesia. Due to oedema secondary to the thermal effects a urethral Foley or a suprapubic catheter is placed into the bladder for 2 weeks on average after the procedure, but 2 to 3 days