

Localization of prostate cancer by contrast-ultrasound diffusion imaging

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LOCALIZATION OF PROSTATE CANCER BY CONTRAST-ULTRASOUND DIFFUSION IMAGING

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Introduction

In western countries, prostate cancer is the form of cancer with the highest incidence in men. One in six men is diagnosed with prostate cancer during his life, and prostate cancer accounts for 25% and 10% of all cancer diagnoses and deaths, respectively [2]. Because of the low specificity of the available noninvasive diagnostics, today's diagnosis is based on systematically distributed biopsies [1]. This is an invasive procedure causing discomfort to the patient and providing poor cancer localization.

New techniques are thus required for a noninvasive early detection of those forms of prostate cancer that are clinically significant. Given the absence of means for cancer localization, imaging methods can potentially provide a breakthrough, as they could reduce the number of biopsies by efficient targeting and enable the use of focal therapies.

Several imaging methods have been proposed for the detection of blood perfusion, in an effort to detect the microvascular network that is associated to aggressive forms of cancer [3]. However, this has not resulted in reliable cancer detection up until now.

We propose a new ultrasound imaging method for the detection and localization of prostate cancer. Our method is based on the quantification of the local intravascular diffusion of an ultrasound contrast agent that is injected intravenously. We expect the local diffusion to correlate better than perfusion with the complex microvascular networks associated with cancer growth.

Materials and Methods

An ultrasound contrast agent bolus is injected intravenously. In our study, we adopted a 2.4 mL bolus of SonoVue® (Bracco, Milan). Transrectal contrast-enhanced ultrasound echography by an iU22 ultrasound scanner (Philips Healthcare, Best) is adopted for imaging the bolus passage through the prostate. The resulting B-mode video contains a large set of indicator dilution curves (IDCs).

These IDCs are fitted using the Local Density Random Walk model, in which we incorporated the

logarithmic compression of the signal dynamic range made by the ultrasound scanner. The model provides a physical explanation of the diffusion process, because it is a solution of the convective diffusion equation.

We present a fast fitting algorithm that estimates a parametric diffusion image of the prostate. Dedicated spatio-temporal filtering, based on our analysis of the IDC noise, is adopted to improve the fitting robustness.

A preliminary validation was conducted by comparing the obtained parametric image with the histology data in two patients. The histology data were obtained after radical prostatectomy at the Academic Medical Center in Amsterdam.

Results

There was a good agreement between the parametric diffusion image and the histology, with a sensitivity and specificity of over 80%. In comparison with other IDC parameters that were proposed in literature, such as the IDC time to peak, mean transit time, and area, local diffusion showed a better agreement.

Conclusions

The quantification of local diffusion of ultrasound contrast agents is promising for the localization of prostate cancer. For optimization of the method and a comparison with other techniques, a more extensive validation is however required.

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