Evaluating Prostate Cancer by Functional Photoacoustic Imaging with Nanoprobe

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Background

The standard diagnostic procedure for aggressive prostate cancer (PCa) is transrectal ultrasound (TRUS)-guided needle biopsy. However, due to the low sensitivity of TRUS to cancerous tissues in the prostate, small yet clinically important tumors are frequently missed. A real-time, functional imaging modality that can sensitively detect spatially distributed tumors and, more importantly, differentiate aggressive tumors from non-aggressive ones could largely improve the guidance of biopsy sampling to prevent metastasis and death.

Methods

The emerging photoacoustic (PA) imaging, when powered by biocompatible cancer-targeting functional nanoprobes, offers unique opportunities for resolving these long-standing challenges in PCa diagnosis. Cancer-targeting polyacrylamide (PAA) nanoparticles (NPs) containing optical contrast agents are used for their capability of "staining" the prostate tissue architecture on both macroscopic and microscopic scales with frequency domain analysis of PA signals to quantify the tissue microarchitectural changes during the progression of PCa. Our PAA NPs loaded with a pH-sensing optical agent (i.e. SNARF-5F) has enabled quantitative mapping of acidosis and hypoxia in tumor microenvironment. Aiming at upscaling the PA imaging technology to human patients, we have validated the feasibility of imaging throughout the entire volume of an intact human prostate by combining transurethral light illumination with transrectal ultrasound receiving.

Results

To evaluate the PCa, we used SNARF PAA NPs for staining, characterizing tissue microarchitecture and measuring pH level. The fluorescence microscopy images were demonstrated the stained prostates and PA images were capable of assessing the histological microstructure in the prostate tissues. Tumor pH was imaged using quad-wavelength PA imaging technique and quantitative pH imaging *in vivo* glioma tumors.

Conclusions

In the study, the PA imaging, when powered by functional PAA NPs and conducted together with TRUS, is capable of sensitively detecting PCa tumors and characterizing tumor aggressiveness in vivo by evaluating cancer microenvironment and microarchitecture heterogeneity; the new imaging biomarkers of PCa accessible by the proposed PA imaging technique can guide the PCa biopsy sampling and guide cancer therapy. The study will be continued to understand the performance and limitations of the PAA NP

powered PA imaging in PCa tumor characterization and treatment via the experiments on clinically relevant orthotopic xenograft mouse models of PCa.