Optical percutaneous needle biopsy to differentiate liver cancer from normal parenchyma

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This work presents results of optical percutaneous needle biopsy to differentiate liver cancer from normal parenchyma *in vivo* and *in situ* measurements by two developed optical biopsy systems. The accuracy characteristics of optical systems are shown, technology development prospects are described.

Keywords: optical biopsy, liver cancer, hepatocellular carcinoma, percutaneous needle biopsy, fluorescence spectroscopy, diffuse reflectance spectroscopy, time-resolved fluorescence spectroscopy.

I. Introduction

Liver cancer is the fourth leading cause of cancer death in the world and is characterized by rapid progression; therefore, issues of timely diagnosis and treatment remain relevant[1]. Surgeries performed at the first stages of liver cancer in many cases significantly improve the prediction and quality of the patient's life. The final diagnosis is verified with histological and cytological analysis of a biopsy sample obtained with a percutaneous needle biopsy, which remains a gold standard for diagnosing liver cancer[2]. Unfortunately, due to many factors, the percentage of the production of non-phase samples at percutaneous needle biopsy reaches 10-20% according to various data. The use of new optical methods can help increase the efficiency of traditional diagnostic procedures.

II. Methods and materials

Two optical biopsy systems have been developed to study the metabolic condition of tissues. Developed technologies were tested in a pilot animal and clinical study. Multimodal optical percutaneous needle biopsy system included fluorescence spectroscopy (FS) and diffuse reflectance spectroscopy (DRS) channels[4]. A 365 nm LED and a 450 nm laser diode were used to excite NADH and FAD autofluorescence. A CCD spectrometer FLAME-T-VIS-NIR-ES (Ocean Optics, USA) was used to record fluorescence and diffuse reflectance spectra in the range of 350-1000 nm. To attenuate the backscattered radiation from monochromatic sources FGL400 and FGL495 filters (Thorlabs, Inc., USA) with cutoff wavelengths of 400 nm and 495 nm respectively were placed in receiving channel before the spectrometer. DRS channel included a broadband tungsten halogen lamp HL-2000-FHSA (Ocean Optics, USA) with a range of 360-2400 nm. The fluorescence lifetime optical biopsy system[5] included a TCSPC system (Becker&Hickle, Germany) based on a SPC-130-EMN photon counting board, HPM-100-40 detectors and a 375 nm BDL-SMN laser. FS emission detection range was 445 ± 25 nm. Both optical diagnostic technologies were incorporated using the 1 mm optical needle probe compatible with the standard equipment for the puncture biopsy procedure – a 17.5G Chiba-type biopsy needle.

III. Experimental Results and discussion

In order to divide the tissues into two classes (liver cancer and normal parenchyma) the decision rules were synthesized for both developed optical systems. The multimodal optical system has shown the highest level of diagnostic accuracy when the combinations of maximum fluorescence amplitude excited at a wavelength of 450 nm and oxygen saturation or of all three parameters (sensitivity – 0.90 and specificity – 0.95) were used as a diagnostic parameter. The sensitivity and specificity of the fluorescence lifetime optical biopsy system reached 0.90 and 1.0 respectively.

Despite the higher accuracy features of the fluorescence lifetime optical biopsy system, we believe that a multimodal optical system can be more quickly implemented in clinical practice, as it is cheaper and has high diagnostic efficiency for differentiating liver cancer from normal parenchyma. The development of a fluorescence lifetime optical biopsy system is necessary for a detailed analysis of metabolic processes in the tumor tissues of the liver to directly identify the type of tumors *in vivo* in real-time.

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