OPTICAL TOMOGRAPHY IN TREATMENT PLANNING AND TREATMENT CONTROL IN ONCOLOGY

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We present examples of clinical application of optical coherence tomography (OCT) and experimental results of diffuse optical tomography (DOT).

The problem of adequate tradeoff between radical tumor removal and maximum preservation of organs is very important for cancer management and patient’s quality of life. Thereupon the detection of exact tumor borders is one of the critical questions. Results of using conventional methods are still unsatisfactory. OCT is one of the promising methods for solving this problem.

A conventional time-domain OCT-device (IAP RAS, Nizhny Novgorod, Russia) has been used. It utilizes near-infrared light to enable real-time cross-sectional imaging with spatial resolution 10-20 µm at the depth of approximately 2 mm. In our research we use flexible endoscopic forward-looking probes 2.7 mm and 2.4 mm in diameter with linear transverse scanning, that may be introduced through biopsy channels of standard endoscopes. More than 850 patients with urinary bladder, gastrointestinal tract and cervical pathology have been examined. Multicentral study has been carried out. Written informed consent was obtained from all patients. Earlier studies made it possible to define OCT signs correlating with benign and malignant histopathology. We have evaluated OCT for pre- and intraoperative planning of the tumor resection margins on the examples of bladder, esophageal and rectal carcinoma. In cervical cancer OCT has been used for decision on biopsy, control in cases of biopsy renunciation and post-treatment follow-up. According to our data OCT can help to define the exact tumor margins in real time and has the potential to improve biopsy precision, adequacy of tumor resection and reduce the recurrence rate.

The necessity of creation of new methods for breast cancer detection is determined by the requirements of safety for patients with possibility of obtaining specific information, that cannot be provided by routine methods. DOT is recognized to be available to satisfy such demands. It is based on acquiring information from multiply scattered light that penetrates into tissue at depths up to several centimeters. This
method allows imaging of absorbing and scattering inclusions inside tissue and provides information on distribution of main absorbers: oxygenated hemoglobin ($\text{HbO}_2$) and deoxygenated hemoglobin (HHb. Growing comprehension of hypoxia importance in treatment prognosis gives an essential impetus to try DOT as an imaging modality with potential to provide information related to tissue oxygenation.

In this study DOT has been tested for hypoxia identifying on tumor models with different biological features and in clinical examination of female patients with breast cancer. Study has been performed using the experimental setup with parallel plane geometry and single source and detector pair (IAP RAS, Nizhny Nogorod, Russia). Three laser fibers coupled in a single bundle illuminate the studied volume at 684 nm, 794 nm, and 850 nm. The frequency of amplitude modulation is 140 MHz. Independent scanning of source and detector in corresponding planes is performed by computer controlled stepping motors; scanning area is 15x15 square centimeters.

DOT technique confirms a possibility of investigating the internal structure of deep tissues and of detecting neoplastic changes. The sensitivity of the created system allows to locate tumors at the depth up to 8-10 cm. Illumination at multiple wavelengths provides determination of component distributions under appropriate image processing. Distribution of oxygenated and deoxygenated forms of hemoglobin may give additional information which reflects tumor oxygenation that can be essential for prognosis and therapy selection.

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