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Optical biopsy of abdominal tissues in mini-invasive surgery

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The recent development of the instrumental methods for two- and three-dimensional imaging allows one to upgrade minimally invasive surgical methods for the abdominal organs to a new level. This type of surgical interventions makes possible to achieve recovery with minimal trauma, reducing the incidence of complications, effectively maintaining and restoring affected organs functions. This leads to an improvement of quality and life expectancy of patients, optimizing the economic component of the treatment process.

Currently, the general problem of available diagnostic methods for a surgeon, performing minimally invasive interventions, is the inability to monitor perfusion and metabolic processes in the biological tissue in real-time mode during the surgery intervention. Microcirculatory disorders play a central pathogenetic role in the progression of various diseases of abdominal organs. Therefore, the measurements of microcirculation have the potential to become a new tool for the optical image-guided surgery. Newly emerging methods for optical biopsy are one of the most promising directions to provide the surgeon with vital information about the state of tissues in operative site.

This work presents recent results on the development and validation of the optical biopsy technique based on the multimodal approach and applied for both optical fiber probe measurements and imaging.

At first stage, a fiber optic system has been developed to be applied in minimally invasive surgical interventions and allows for assessing the vitality of biological tissues during the procedures. The method combines data obtaining by fluorescence spectroscopy and laser Doppler flowmetry in one diagnostic classifier. The sensitivity of the tool has been assessed for several types of pathological changes in abdominal tissues. The technology augmented by the measurements of the diffuse reflectance has been implemented in a form factor of a fine-needle optical probe for the optical biopsy. The probe is of 1 mm outer diameter, and has been developed to be compatible with the 17.5G biopsy needle. The studies have been combined with the standard procedure of the biopsy sampling. The obtained results demonstrate a significant increase in the specificity and sensitivity for the classifier based on the multimodal approach compared with ones based on the two optical measurement techniques applied separately.

To test the approach for imaging, a setup combining hyperspectral imaging and laser speckle contrast measurements through standard minimally invasive surgical tools has been developed and tested in an animal model. In trials in the animal model of acute pancreatitis, the technique has demonstrated to be a useful tool for the mapping of the necrotic areas of the pancreas.

The proposed techniques promise to be a robust, useful tool in diagnostics of the profound changes in tissue perfusion and metabolism for the practice of guided surgery to objectify the criteria for selecting surgical tactics.

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