

Optical spectroscopy in the assessment of the functional state of the liver

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One of the current issues in emergency surgery is the assessment of the functional state of the liver at different stages of treatment of obstructive jaundice syndrome using simple and objective techniques. The primary goal in the treatment of patients with diseases complicated by obstructive jaundice is to decompress the biliary system. Minimally invasive procedures provide access to the liver tissue, allowing a single optical biopsy of the liver parenchyma when drainage systems are installed and subsequent study of bile in dynamics as a direct product of hepatocyte secretion. The methods used in this work included fluorescence spectroscopy, which is highly sensitive to metabolic changes in tissues [1], and Raman spectroscopy, which provides information on the chemical composition of biological tissues and fluids [2].

The aim of this work was to study the effect of the degree of liver failure on the optical properties of the parenchyma in vivo using the fluorescence spectroscopy and on the optical properties of the bile in vitro using the Raman spectroscopy.

The study included 20 patients with obstructive jaundice and 11 patients without obstructive jaundice as a comparison group. The latter group of patients has been previously studied in fine needle biopsy of liver neoplasms [1]. The fluorescence spectra were recorded with a fine needle probe and subjected to deconvolution analysis to assess the contribution of the major tissue fluorophores. In the first group of patients with obstructive jaundice, bile samples were collected through a drainage catheter to study Raman spectra dynamically (every 3-4 days). The typical spectral bands for bilirubin in the Raman spectra ($1258\text{-}1264\text{ cm}^{-1}$ and $1615\text{-}1620\text{ cm}^{-1}$) were analyzed after post-processing.

The results of fluorescence spectroscopy showed a statistically significant increase in the contribution of curves reflecting the fluorescence of NAD(P)H, bilirubin, flavins, and vitamin A in the group of patients with obstructive jaundice. These parameters may be used for further studies as promising diagnostic and prognostic markers for the development of liver failure. We also demonstrated that the detection of changes in bilirubin concentration in bile secreted through the drainage catheter by Raman spectral bands allows one to predict the dynamics of recovery in patients with obstructive jaundice syndrome after antegrade biliary decompression.

The studies conducted by fluorescence and Raman spectroscopy have shown that optical spectroscopy offers great opportunities for evaluating liver function in patients with obstructive jaundice syndrome. The results can be used by surgeons in clinical practice to adjust treatment algorithms.

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[1] V. Dremin et al, Sci. Rep. 10, 14200, 2020.

[2] K. Kong et al, Adv. Drug Deliv. Rev. 89, 121–134, 2015.