

Study of liver parenchyma in obstructive jaundice using fluorescence and diffuse reflectance spectroscopy methods

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Abstract— We report on the application of fluorescence and diffuse reflectance spectroscopy for *in vivo* measurements during biliary drainage. The results show high potential in developing new diagnostic and prognostic markers in liver state evaluation.

Keywords— liver; obstructive jaundice; liver failure; fluorescence spectroscopy; diffuse reflectance spectroscopy

I. INTRODUCTION

Obstructive jaundice (OJ) remains a widespread disorder of the biliary tract leading to a number of serious complications, including liver failure. To detect this condition during the treatment of OJ prior to the treatment of the initial disease, surgeons require the information on the functional state of the liver parenchyma [1].

Traditionally, clinicians use biochemical parameters derived from complete blood count or indirect prognostic scales and systems to predict and assess the severity of hepatic dysfunction. Since these indicators do not involve any direct information from the liver, the problem of finding additional objective criteria and developing technologies for direct *in vivo* estimation of liver state remains relevant. Biophotonics techniques are promising tools for diagnostics of biological tissues suitable for intraoperative use. This work was aimed at development of new diagnostic criteria for assessing the functional state of the liver based on combined *in vivo* application of fluorescence spectroscopy (FS) and diffuse reflectance spectroscopy (DRS) to study liver tissue in patients with OJ.

II. MATERIALS AND METHODS

The study was performed at Orel Region Clinical Hospital. A total of 39 patients (age 65±13 years) voluntarily participated in the study. Spectroscopic measurements were performed during the antegrade decompression of the biliary tract under ultrasound and X-ray control. For each patient, 5 fluorescence spectra at two excitation wavelengths and 5 diffuse reflectance spectra were recorded at 1 or 2 points for averaging. As a control group, we used the FS data obtained from 11 patients without diagnosed OJ who were subject for optical measurements during planned percutaneous needle biopsy [2].

The multimodal equipment used a 365 nm LED and a 450 nm laser diode in FS and a 360-2400 nm tungsten halogen lamp HL-2000-FHSA (Ocean Optics, USA) in DRS for illumination

of the investigated area. A 350-1000 nm range CCD spectrometer FLAME-T-VIS-NIR-ES (Ocean Optics, USA) was used as a detector. The light was delivered and collected through a specially designed needle optical probe of 1 mm in diameter. The custom-developed deconvolution procedure was applied to fluorescence spectra to represent them as linear combinations of individual spectra of fibrous proteins, NAD(P)H, fatty acids, flavins, bilirubin, vitamin A, lipofuscin and porphyrins fitted by Gaussian functions. Tissue oxygenation was extracted from the recorded DRS spectra.

III. RESULTS AND DISCUSSION

The analysis of FS spectra revealed statistically significant increased levels of NAD(P)H, bilirubin, flavins, and vitamin A in patients with OJ with respect to the control group. These observations are associated with hepatocyte dysfunction caused by accumulation of bilirubin and bile acids (increased levels of bilirubin) with subsequent impairment of oxygen utilization (increased levels of NAD(P)H). DRS spectra complementarity revealed alterations in tissue saturation in the liver parenchyma of patients with OJ, in comparison to the control group. Comparison of the fluorescence levels of NAD(P)H, bilirubin, flavins, and vitamin A in patients with different severity of OJ indicated the potential in differential diagnosis. The data extracted from FS measurements demonstrated good correlation with biochemical parameters derived from complete blood count.

The obtained results demonstrate high potential of the employed approach in assessing the severity of the liver functional disorder and predicting the course of the postoperative period in patients after biliary decompression.

ACKNOWLEDGMENT

The study was supported by the Russian Science Foundation (project 23-25-00487; <https://rscf.ru/en/project/23-25-00487/>).

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