

Optical diagnostics of bile duct tissues state with tumor compression

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Introduction

The problem of searching for new diagnostic methods and approaches for increasing the accuracy of diagnosis of malignant tumors in minimally invasive surgery remains relevant. This is significant for diagnosing and treatment of obstructive jaundice. Optical methods for visualization and analysis can increase the prevalence and effectiveness of these interventions in clinical practice by providing additional diagnostic information for surgeon intraoperatively. This approach is often called "optical biopsy". These methods allow evaluating metabolic processes in tissues, chromophores content, blood perfusion and oxygenation.

The aim of the work

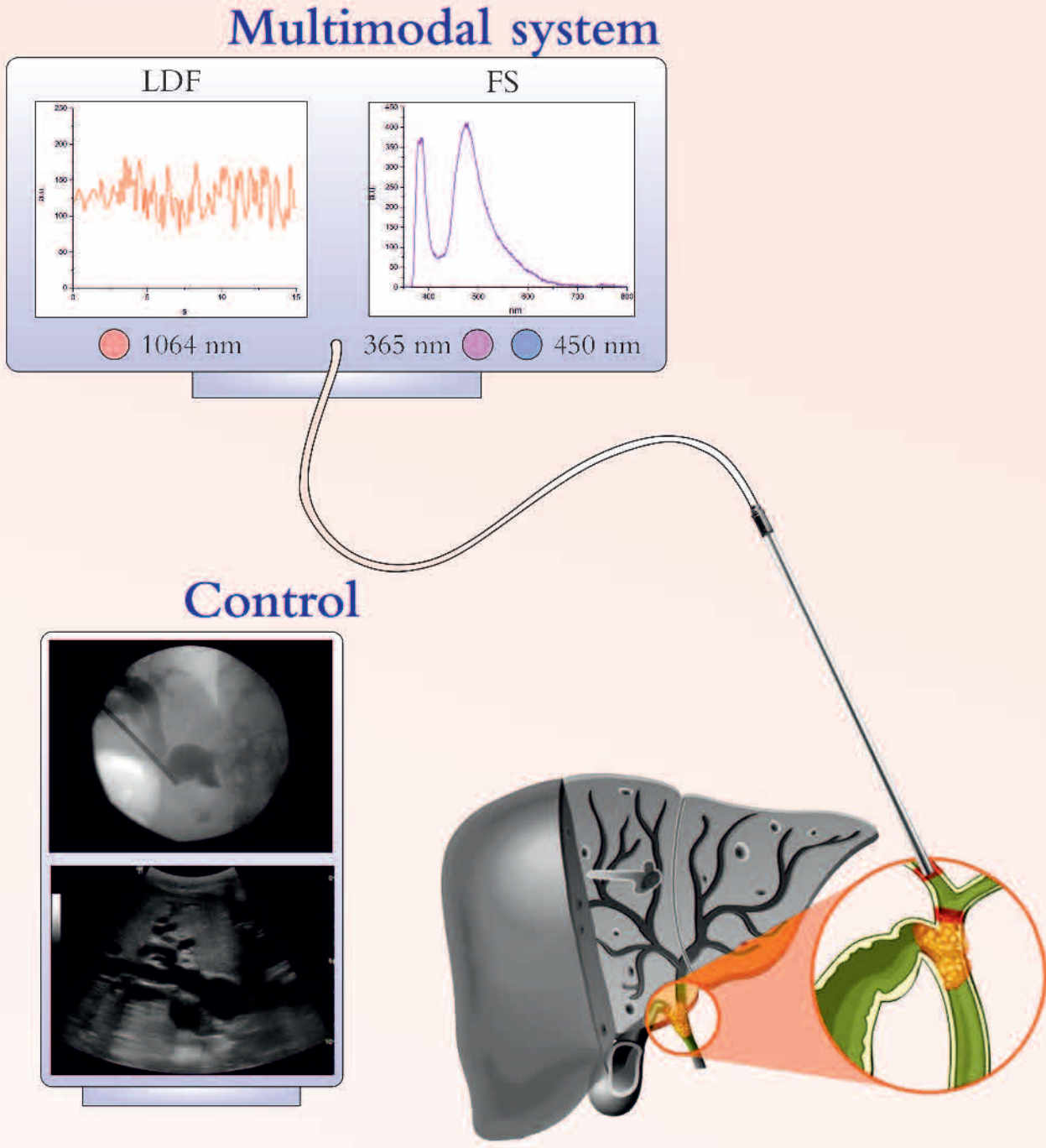
Studying the fluorescence of common bile duct tissues in obstructive jaundice during minimally invasive interventions.

Materials and methods

The study involved 20 patients of Orel Regional Clinical Hospital surgical department aged 67 ± 2 years diagnosed obstructive jaundice (approved by Ethics committee of Orel State University, record of the meeting №10 of 16.11.2017). The data was recorded at areas of common bile duct blocked by the tumor and at unblocked zones during minimally invasive interventions under ultrasound and X-ray control.

The specially designed fiber optic system with laparoscopic probe was used. The implemented methods are:

- fluorescence spectroscopy (FS) at excitation wavelengths of 365 nm and 450 nm for assessing metabolic activity by registering the fluorescence of NADH, FAD, collagen and other biomarkers;
- laser Doppler flowmetry (LDF) at 1064 nm for assessing blood perfusion of tissues.

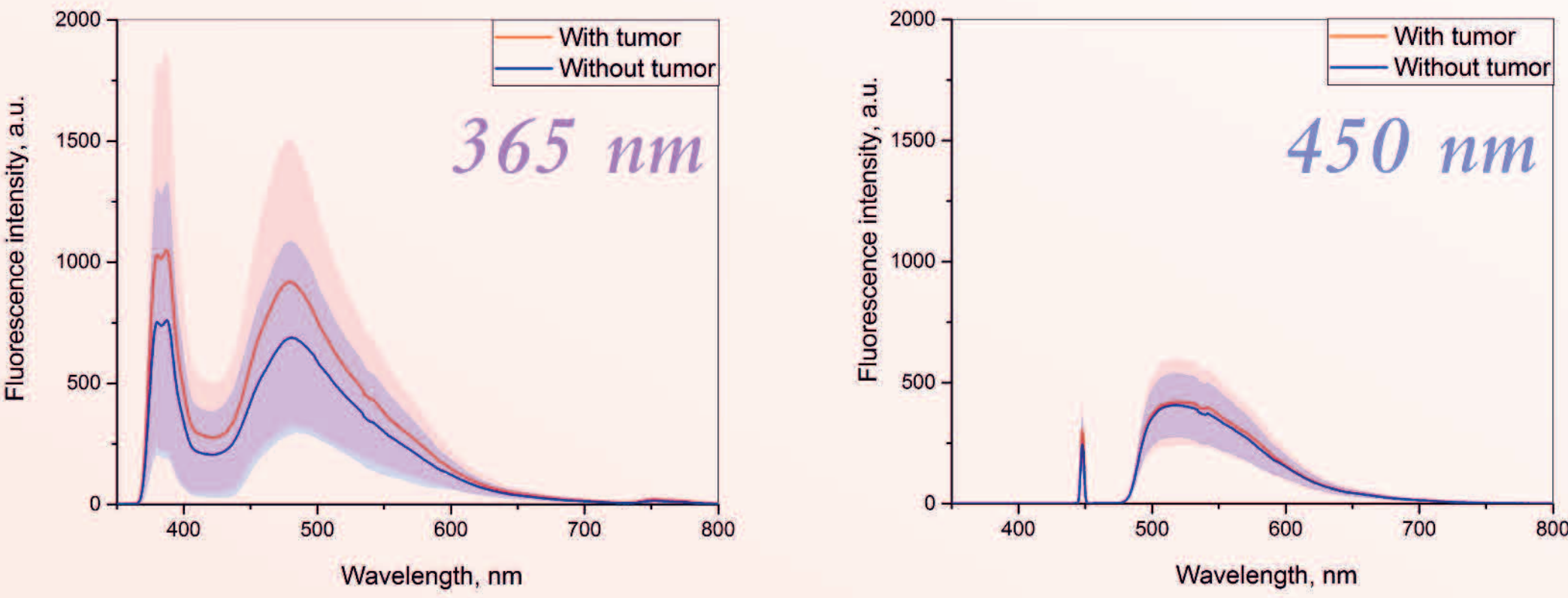


The schematic illustration of the experimental set up
The areas of interest are marked red

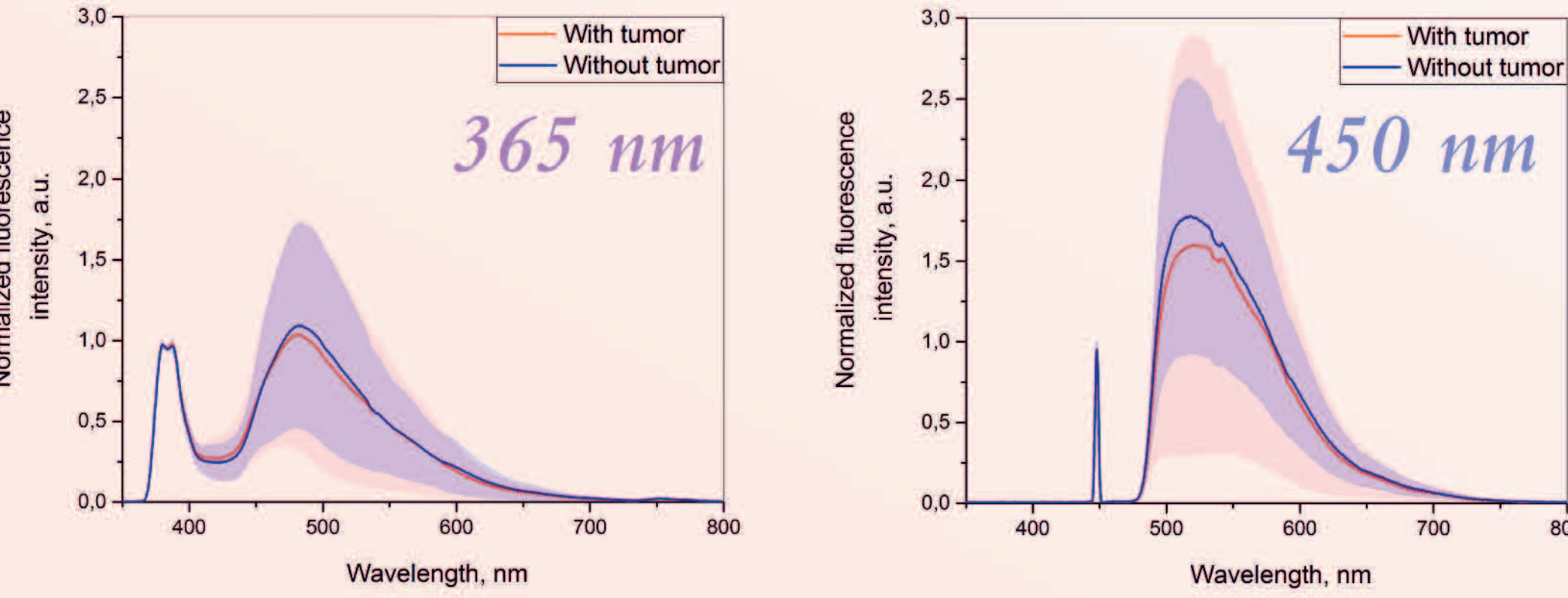
Results

Obtained fluorescence spectra were averaged for further processing. Significant distribution of data was observed. In order to correctly compare obtained data, fluorescence intensities $I_{norm}(\lambda)$ were normalized by backscattered radiation $I_{max,source}$:

$$I_{norm}(\lambda) = I(\lambda) / I_{max,source}$$

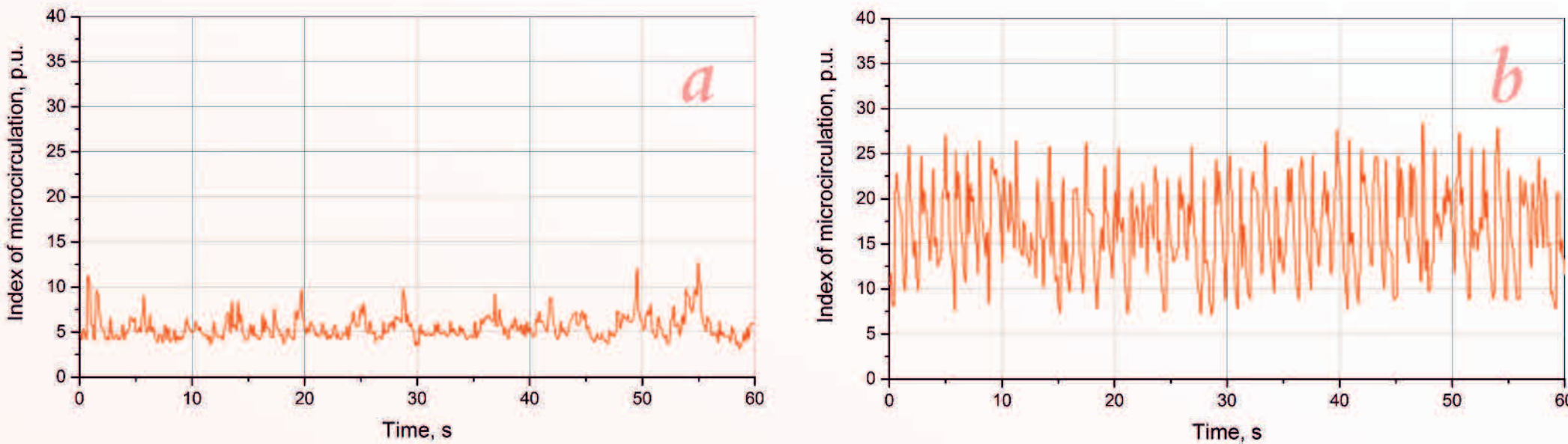


Raw averaged spectra



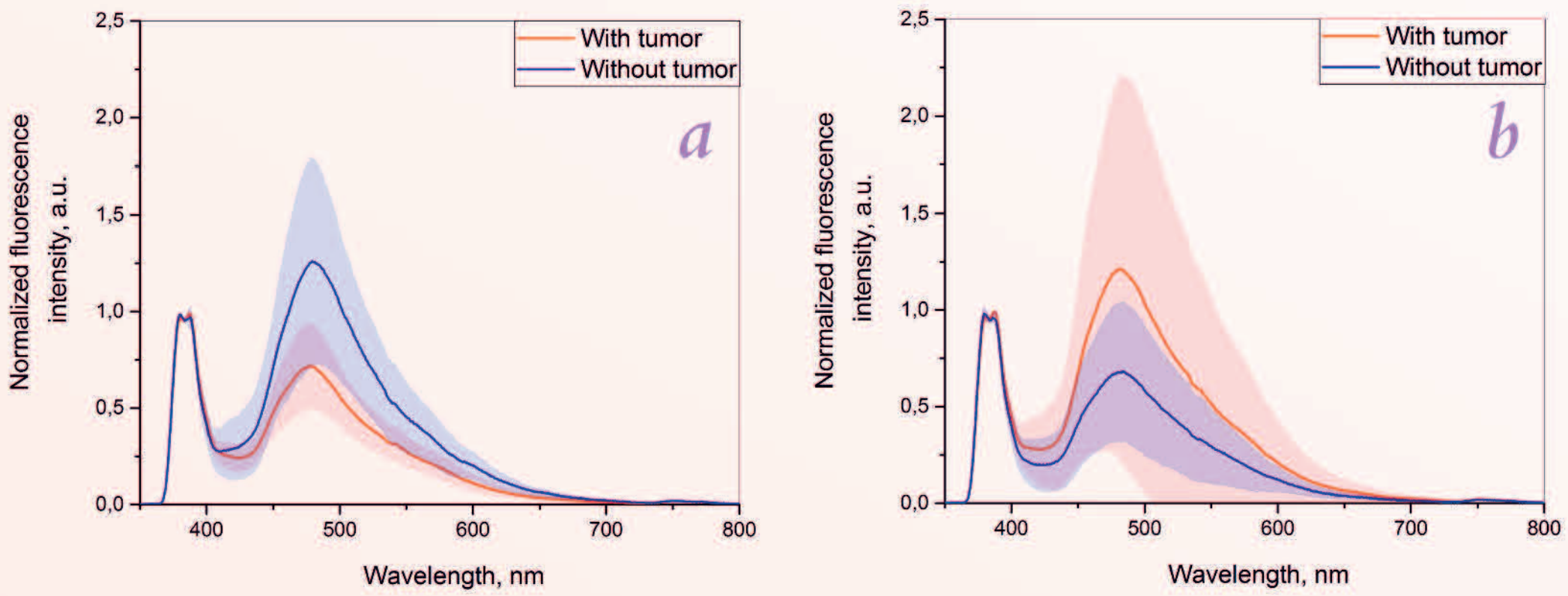
Normalized averaged spectra

LDF signals were recorded during interventions for continuous assessing of blood perfusion and viability of tissue. Some methodological difficulties occurred related to pressure caused by the probe, anatomical features of studied area, movements, inconvenience for patient during the procedure and other factors.



Examples of LDF signals in blocked (a) and unblocked (b) areas

The fluorescence spectra under 365 nm excitation were divided into 2 groups. The spectra of the first group (a) shared similarities in their form and amplitudes of fluorescence intensities. The difference between 2 groups of fluorescence spectra can be associated with the fluorescence of collagen, content of which changes during the course of disease.



Similar (a) and dissimilar (b) averaged normalized spectra

Conclusion

- Obtained preliminary data showed the prospects for applying optical diagnostic methods to minimally invasive surgery of common bile duct. The multimodal approach seems promising for further application.
- It is proposed to extend a number of methods by adding more spectroscopic and imaging techniques. At the initial stages of further research, a combination of optical and traditional biopsies will allow getting reference data for optical methods for accurate interpretation and development of diagnostic criteria needed to optimize the treatment process.
- Significant variability in obtained fluorescence spectra and LDF signals caused by influence of a number of factors was observed, including the presence of blood and other substances, shortcomings of existing control methods for minimally invasive surgery.

- Anatomical features and deflection affect accurate positioning of optical probe. Variability depends on the nature of tumor and the presence of exophytic growth into the mucous membrane of common bile duct as well.
- The problem of collagen affecting fluorescence spectra depending on duration of pathology requires additional studying.

Acknowledgements

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