A method for discriminating hepatocellular carcinoma based on fluorescence lifetime parameters

Shupletsov V.V.[1], Potapova E.V.[1], Zherebtsov E.A.[1], Dremin V.V.[1,2], Kandurova K.Y.[1], Sumin D.S. [1,3], Mamoshin A.V.[1,3] , Dunaev A.V. [1]

[1]Research & Development Center of Biomedical Photonics, Orel State University, Orel, Russia
[2]College of Engineering and Physical Sciences, Aston University, Birmingham, UK
[3]Orel Regional Clinical Hospital, Orel, Russia

Due to their low concentrations and strong tissue absorption, various forms of endogenous fluorophores, including NAD(P)H and FAD++, are practically indistinguishable in biological tissue by their fluorescence spectra. The fluorescence lifetime (FL) parameters of these molecules change, however, when they are bound to proteins. This effect allows malignant tissues to be identified by analyzing the short and long FL of these components. Recently, we showed that the technology can detect hepatocellular carcinomas (HCCs) in murine models. This study aims to verify the method in limited clinical trials.
For measuring FL parameters, a TCSPC system (Becker & Hickle, Germany) was used. It consisted of the SPC-130-EMN photon counting board, HPM-100-40 detector with the MF530-43 filter, and a BDL-SMN 375 nm ultraviolet laser. The protocol included three patients with histologically confirmed HCC in the liver. During puncture biopsy procedure, optical needle probe compatible with biopsy equipment were used to determine fluorescence lifetime parameters for every patient. In the biopsy channel, fluorescent signals were measured in both the HCC node and intact liver tissue. The measurements performed in the department of interventional radiology of the Orel Regional Clinical Hospital (Orel, Russia), and approved by the Ethics committee of Orel State University (No. 14 of 24.01.2019) in accordance with the Declaration of Helsinki of the World Medical Association.
The linear discriminant analysis (LDA) is used to determine the discriminant function and classify the diseased tissue. For the measured pairs of FL parameters, the sensitivity and specificity were calculated as follows: $\tau 1$, $\alpha 1/\alpha 2$ (0.96; 0.7); $\tau 2$, $\alpha 1/\alpha 2$ (1.0; 0.7), $\tau 1$, If (0.97; 0.68); $\tau 2$, If (0.99, 0.68). For a comprehensive evaluation of the technique, further work will focus on extending the dataset. The study was supported by the Russian Science Foundation under the project № 21-15-00325.