# Title: Bioimpedance of human liver and tumor measured in vivo from tip of biopsy needle

**Authors:**
*Sanna Halonen, Ali Ovissi, Sonja Boyd, Juho Kari, Kai Kronström, Juhani Kosunen, Hanna Laurén, Kirsti Numminen, Harri Sievänen and Jari Hyttinen*

**Keywords:**
biomedical engineering, clinical medicine, bioimpedance, *in vivo*, liver tumor

## Abstract
Biopsies are essential in cancer-diagnostics, however, for example liver biopsy is a highly challenging procedure. Bioimpedance-based tissue-detection from a tip of a biopsy needle might help targeting the needle to the tumorous tissue. Here, we studied if tumorous tissue differentiates *in vivo* from surrounding liver tissue with our biopsy needle integrated with highly local bioimpedance measurement and is the method feasible in clinical setting. In this study, human liver and tumor impedance data was measured *in vivo* during diagnostic ultrasound-guided liver biopsy from 26 patients. The device measures impedance spectra in real-time from the very tip of the needle (frequencies 1 kHz-349 kHz). The position of the needle tip was verified using ultrasound and the harvested tissue type was determined using histological analysis. Impedance values between individual cases varied substantially and liver and tumorous data overlapped each other. Yet, based on Mann–Whitney U test, the medians of liver and tumor bioimpedance were significantly different regarding the impedance magnitude at frequencies below 25 kHz and the phase angle at frequencies below 3 kHz and above 30 kHz. Even though coherent tumor identification was not achieved due to high variation in tumor types, this study provides preliminary evidence that the bioimpedance of tumor tissue differs from surrounding liver tissue *in vivo* and the developed bioimpedance-based tissue-detection method from needle tip could have potential in tumor detection and improving the biopsy procedure.