Hand-held NMR instrument yields rapid analysis of human tumors

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Using a handheld molecular imaging device in combination with magnetic nanoparticles and a smartphone, a team of investigators from the Massachusetts General Hospital and Harvard Medical School has developed a fast, portable and potentially inexpensive method of detecting cancer from human biopsy samples. Initial results obtained using fine need biopsies taken from human cancer patients show this device trumps traditional pathological methods, both in terms of speed and diagnostic accuracy.

Ralph Weissleder, co-principal investigator of the MIT-Harvard Center for Cancer Nanotechnology Excellence, led this development project. He and his colleagues published the results of their work in the journal Science Translational Medicine.

Typically, cancer is diagnosed by collecting human tissue samples, either removed surgically or via a fine needle inserted into a lump, and sending the samples to a histopathology laboratory, where over the course of several days the sample is analyzed using various tissue stains that highlight cellular features characteristic of tumors for visualization under a microscope. Such analysis is not only time-consuming, it is semi-quantitative at best and requires the technical expertise of a trained pathologist.

The new approach to cancer diagnosis pioneered by Dr. Weissleder and his collaborators relies on the exquisite sensitivity afforded by nuclear magnetic resonance spectroscopy (NMR), an analytical technique used routinely by chemists to characterize complex molecules and one that forms the basis of magnetic resonance imaging (MRI). But rather than using a standard, table-sized NMR machine, the Mass General team designed and built a far-less-expensive handheld NMR machine that interfaces with a microfluidic device and sends its results to a smartphone, which is also used to control the device. The device can detect the presence of multiple magnetic nanoparticles, each designed to bind to a specific tumor-associated molecular marker.

In the first round of evaluation, the investigators analyzed fine needle biopsies taken from 50 patients suspected of having malignant abdominal tumors. After a quick preparatory step, the suspension of cells from the biopsy was treated with a mixture of magnetic nanoparticles, each designed to bind to one of nine specific cancer biomarkers, and then injected into the device's microfluidic channels. Data signals from the microNMR machine were sent wirelessly to a smartphone for analysis and readout. The instrument correctly identified all 44 samples diagnosed as malignant by standard histopathology.

Based on the data generated in this first set of experiments, the investigators analyzed fine needle biopsies from an additional 20 patients using just four of the tagged nanoparticles. The results from this experiment were even better, demonstrating 96% diagnostic accuracy, far exceeding the 84% accuracy of histopathology, the gold standard of cancer diagnosis. Moreover, the microNMR-smartphone device provides a diagnosis within an hour, compared to three days to obtain results from histopathology.

This work, which is detailed in a paper titled, "Micro-NMR for Rapid Molecular Analysis of Human Tumor Samples," was supported in part by the NCI Alliance for Nanotechnology in Cancer, a comprehensive initiative designed to accelerate the application of nanotechnology to the prevention, diagnosis, and treatment of cancer. An abstract of this paper is available at the journal's website.

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