Medical Xpress

An MRI technique to improve the detection of tumors

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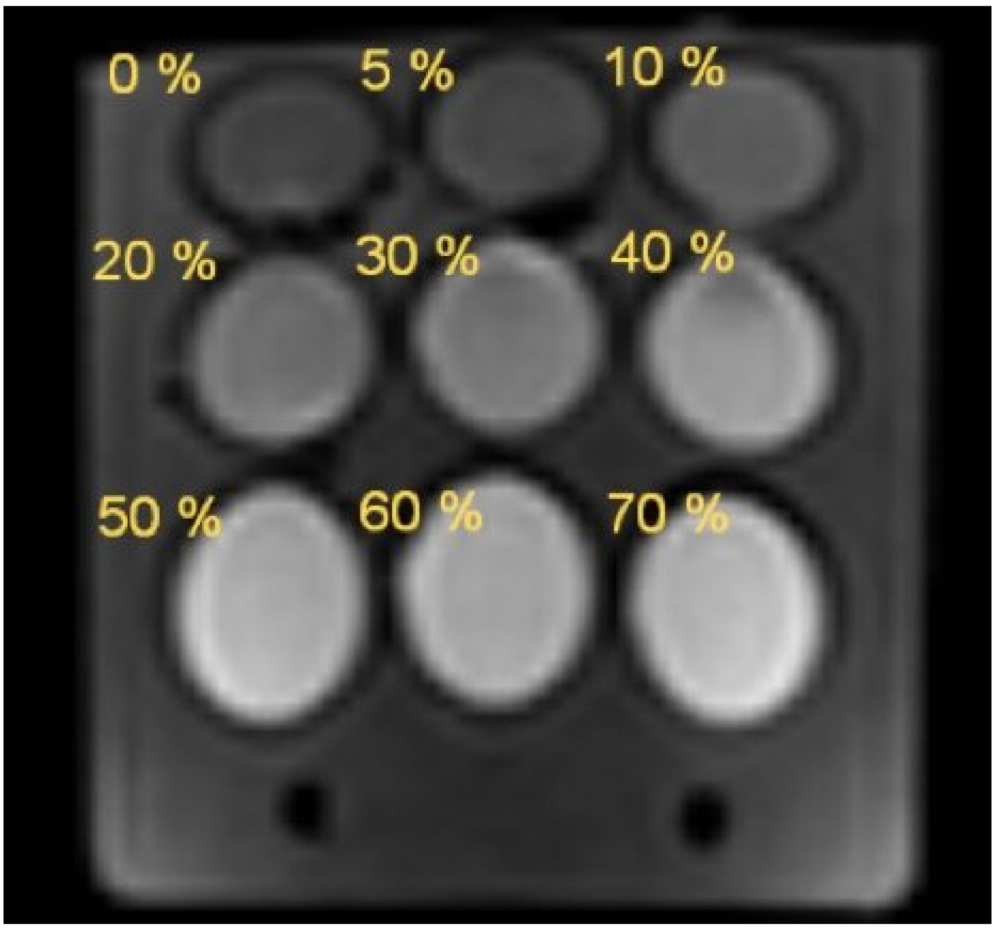

DWI of the phantom with polyvinylpyrrolidone (PVP) solutions (b value 500 s/mm2). Credit: Kristina Sergunova et al.

A research group from the Moscow Center for Diagnostics and Telemedicine has created a physical model to maintain the quality of one of the most commonly used MRI pulse sequences: diffusion-weighted imaging (DWI). Since the sequence is highly sensitive to various types of tumors, the method will can be applied to MR scanners.The results are published in *Insights into Imaging*.

Early diagnosis of cancer is one of the highest-priority problems in healthcare systems because it is critical for overall treatment success and saving patients' lives. DWI may be used to detect a malignancy in various tissues and organs. It has the advantage of providing insight into the diffusion of water molecules in body tissues without exposing patients to radiation.

The way the H_2O molecules move depends on whether they are inside or outside the cells. Inside the cell, water movement is somewhat restricted by organelles that sometimes get in the way (slow diffusion) and semi-permeable cell membranes (hindered diffusion). Since there is more room in between the cells, the only thing that restricts water movement is the cell membrane.

Such movement can be estimated through the mathematical processing of DWI data using apparent diffusion coefficient (ADC) maps. In the absence of pathological tissues, the intracellular ADC is lower compared to intercellular ADC. However, an increase in cell density (in the presence of malignancies, especially those made up of many small-sized cells) leads to a decrease in intercellular diffusion.

Since ACD is not an absolute value, it is dependent on external factors such as sequence and reconstruction parameters, image quality and hardware features. In order to boost the efficacy of tumor differential diagnostics, ACD must be estimated with greater accuracy and reproducibility. This can be achieved with phantoms (also called test objects) that allow assessing the imaging quality and building various diffusion models (i.e. non-restricted, hindered, and restricted diffusion with permeable and semi-permeable membranes). Such a phantom has been developed by a research team from the Innovation Technology Department of the Moscow Center for Diagnostics & Telemedicine.

Application of existing phantoms developed by the U.S. National Institute of Standards and Technology, the Quantitative Imaging Biomarkers Alliance and the Institute of Cancer Research in the U.K. is limited because they use polymer solutions. Instead, the authors of this paper suggested using a combination of siloxane-based water-in-oil (W/O) emulsions and aqueous solutions of polyvinylpyrrolidone (PVP). These components allow emulating both hindered and restricted diffusion while maintaining relatively high signal intensity. Additionally, the newly designed phantom can be used to assess image quality control in terms of fat suppression, which again is critical for detecting pathological processes.

To simulate hindered diffusion, the investigators used aqueous PVP solutions with concentrations of 0 to 70%. The W/O emulsions imitated restricted diffusion in intracellular space. To attain high DWI signal (maximum radiolucent areas), the authors incorporated silicone oil: cyclomethicone and caprylyl-methicone. This phantom was scanned using 1.5T magnetic resonance scanner with various fat suppression techniques.

After a series of control experiments, the authors came to the conclusion that the phantom with the control substances allows modelling the apparent diffusion coefficients ranging from normal tissue to benign and malignant lesions from 2.29 to 0.28mm^2/s. Correspondingly, it is suitable for assessing the ACD measurement quality and the efficacy of fat suppression, as well as for calibrating MR scanners from varioous manufacturers.

This study is a part of the larger research project started in the Moscow

Center for Diagnostics & Telemedicine in 2017 that addresses standardization and optimization of MR scanners. The project is also aimed at developing the means of control over the scanner parameters to secure high image quality and increase the diagnostic value of imaging studies.

More information: Sergey Morozov et al, Diffusion processes modeling in magnetic resonance imaging, *Insights into Imaging* (2020). DOI: 10.1186/s13244-020-00863-w

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