

Connecting biology and MR imaging in brain tumor

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As brain is in stationary organ and tumor has a certain volume of interest, many updated imaging is applied in brain tumor. Among them, diffusion-weighted imaging, perfusion-weighted imaging such as dynamic susceptibility contrast and arterial spin labeling, and 2hG MR spectroscopy are of ongoing interest with useful clinical implications.

Diffusion-weighted imaging contains information of tumor cellularity, and useful to predict high grade transformation in low grade glioma and tracking response for anti-angiogenic therapy. Perfusion-weighted imaging shows blood volume and blood flow of the tumor, and benefits in tumor grading, monitoring treatment response, and also survival prediction. 2hG MR spectroscopy is useful in predicting IDH mutation noninvasively. This talk contains biophysical view point of tumor imaging, connecting the biology and MR physics in the brain tumor. Relevant research using advanced imaging technique will be given to expand knowledge, and demonstrable cases will be shown.

Learning Objectives

To learn tumor biology and reflective imaging features in advanced MRI technique.

Target Audience

Researchers who are interested in tumor biology and relevant MRI physics.

Keywords: Brain tumor, Glioma, Diffusion, Perfusion, 2hG MRS

Recent update of Stroke Neuroimaging

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Magnetic resonance imaging (MRI) has an established role in diagnosis of acute ischemic stroke (AIS). Especially diffusion-weighted image (DWI) can identify ischemic lesions and differentiate acute ischemic stroke (AIS) from stroke-mimics with high sensitivity and specificity. In endovascular thrombectomy (EVT) era, treatment selection is based on fixed time windows, with the imaging component being exclusion of intracranial hemorrhage or extensive infarct core. Although MRI can provide sufficient information regarding those issues, computed tomography (CT) is the imaging of modality most widely employed for this purpose with rapid acquisition and interpretation.

According to the recent revision of guidelines, identifying patients who would benefit from EVT outside of the usual 6-hour or 8-hour time windows has become a big issue. It emphasizes eligibility criteria based on clinical-imaging mismatch or perfusion-core mismatch and maximum core size to select patients with 6 to 16 or 24 hours from last known normal for EVT. The only randomized controlled trials (DAWN and DEFUSE 3) showing benefit of mechanical thrombectomy >6 hours from onset estimated the volume of the ischemic core and penumbra regions from perfusion data of CT or MRI. Therefore, multimodal MRI might provide useful information for evaluation of the risks and benefits of reperfusion therapy under the expanded therapeutic time window.

Perfusion-weighted image (PWI) can depict ischemic penumbra that is the surrounding part of the ischemic core exhibiting minimum blood flow from collateral circulation and suspended neuronal function. Various perfusion parameters can be obtained from time-concentration curve after injection of contrast agent. Cerebral blood flow (CBF) reflects the blood supply to the brain tissue in a given time and is mostly directly associated with the viability of the infarcted tissue. Cerebral blood volume (CBV) is measured by the whole blood quantity within the target area of which decreased CBV is well-correlated with the final infarct size. Mean transition time (MTT) is the average time required for blood flow to enter the artery and maintain the inside of the cerebral artery. Time to maximum of the residue function (Tmax) is the time at which maximum value of the deconvoluted residue function in each voxel is reached. It has been used as a predictor of tissue viability in recent studies examining the use of EVT exceeding therapeutic time window. DEFUSE 3 trial included patients with an initial infarct volume (ischemic core) of less than 70 ml, a ratio of volume of ischemic tissue to initial infarct volume of 1.8 or more, and an absolute volume of potentially reversible ischemia (penumbra) of 15 ml or more. Estimates of the infarct and penumbral volumes from PWI or CT perfusion were calculated with the use of RAPID software (iSchemaView), an automated image postprocessing system. The size of the penumbra was estimated from the volume of tissue with Tmax exceeding 6 seconds.

Understanding the clinical implication of various useful MRI findings and comprehensively incorporating those variables into therapeutic decision-making may be a more reasonable approach for expanding the indication of EVT.

Keywords: Acute ischemic stroke, Diffusion-weighted image, Perfusion-weighted image, Endovascular thrombectomy

Neuroimaging: Recent Update in Dementia

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The recent 2018 NIA-AA Research Framework outlines a biomarker system to classify individuals in the Alzheimer's disease (AD) continuum using imaging biomarkers and cerebrospinal fluid biomarkers focused on amyloid- β [A], tau [T], and neurodegeneration [(N)]—the “AT(N)” biomarker system as it is increasingly recognized that neurodegeneration also occurs in non-AD conditions. The Research Framework defines an individual with biomarker evidence of both amyloid- β deposition and pathologic tau as having AD yet acknowledges that amyloid and tau deposits may not be causal to AD but rather AD has been shown to be a multifactorial disease with and mixed pathologies.

Therefore, in the present lecture, we will provide a brief overview of recent updates of AD pathomechanisms beyond amyloid- β or tau protein, especially focused on vascular and glymphatic dysfunctions which are the prominent and early features in prodromal AD and that will help us to better characterize and understand AD pathologies. Furthermore, previous and updated literature regarding new imaging biomarkers to reflect multifactorial aspect of AD and its possible role as an early diagnostic biomarker will be also reviewed.

- [1] Jack CR, Jr., Bennett DA, Blennow K, et al. **NIA-AA Research Framework: Toward a biological definition of Alzheimer's disease.** *Alzheimers Dement* 2018;14:535-62
- [2] Sweeney MD, Montagne A, Sagare AP, et al. **Vascular dysfunction-The disregarded partner of Alzheimer's disease.** *Alzheimers Dement* 2019;15:158-67
- [3] Rasmussen MK, Mestre H, Nedergaard M. **The glymphatic pathway in neurological disorders.** *Lancet Neurol* 2018;17:1016-24
- [4] Absinta M, Ha SK, Nair G, et al. **Human and nonhuman primate meninges harbor lymphatic vessels that can be visualized noninvasively by MRI.** *Elife* 2017;6
- [5] Ohene Y, Harrison IF, Nahavandi P, et al. **Non-invasive MRI of brain clearance pathways using multiple echo time arterial spin labelling: an aquaporin-4 study.** *Neuroimage* 2018;188:515-23
- [6] Montagne A, Barnes SR, Sweeney MD, et al. **Blood-brain barrier breakdown in the aging human hippocampus.** *Neuron* 2015;85:296-302

Keywords: Dementia, MRI

Neuroimaging: Recent update in head and neck tumor

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Head and neck cancer accounts for approximately 5% of cancer worldwide. It comprises various histological types originating from different tissues in the complex structures. The most common type is squamous cell carcinoma (SCC) from the aero-digestive tract, which is rapidly increasing with the rise of human papilloma virus (HPV)-related cancer.

Magnetic resonance imaging (MRI) has advantages in the assessment of the head and neck cancer, especially in detecting tumor and assessing treatment response. Morphological MRI techniques have been combined with computed tomography (CT) and 2-[¹⁸F]-fluoro-2-deoxyD-glucose (FDG) positron-emission tomography (PET) to identify tumor or to capture post-treatment changes in the volume or morphological characteristics. Recently, advanced MRI techniques provide not only anatomical details, but also physiologic processes of the tumor including molecular and metabolic information. Functional MRI can demonstrate biologic factors and treatment changes in cellular, perfusion and/or metabolic activities of the tumor.

Diffusion-weighted imaging (DWI) can assess the water diffusion reflecting tumor cellularity. It is most promising sequence for 1> differentiating malignancy from benign condition, 2> predicting treatment response, and 3> detecting recurred tumor in post-treatment setting.

Tumor vascularity can be assessed with dynamic contrast-enhanced (DCE) MRI. It can be semi-quantitative analysis using time intensity curve (TIC); or, it can produce quantitative parameters such as K_{trans} , K_{ep} , and V_e by fitting a kinetic model. Compared with DWI, DCE-MRI has been slower to be implemented in clinical practices due to its poor reliability and variable parameters. Other perfusion MRIs such as arterial spin labelling (ASL) and blood oxygen level dependent (BOLD) MRI do not require gadolinium injection; however, substantial susceptibility artifact in head and neck region can be problematic for these sequences. Perfusion parameters have been actively studied in pre- and post-treatment setting of head and neck cancer. For example, high K_{trans} is the parameter that correlates with a good treatment response; yet, tumors with high total blood flow on ASL are known to have unfavorable characteristics. These results need further validation for clinical use.

Functional MRI technique can reveal tumor metabolites and compounds. Especially, chemical exchange transfer saturation (CEST) imaging can detect a range of metabolites by exchanging free water with the mobile protons of interest. Amide CEST is one of the most popular techniques in cancers, but only very early results have been reported in the head and neck area. Amide CEST may be capable of differentiating benign and malignant tumors and treatment-responding and non-responding tumors.

Radiomics can utilize computer algorithms to measure quantitative parameters from morphological and functional MRI. Early results in head and neck cancer using textural MRI features have showed that radiomics can distinguish HPV positive and negative SCC, characterize tumors, and assess treatment outcomes. However, there are still many challenges, and yet many potentials, in this area.

In conclusion, MRI for head and neck cancer is now widely used in the routine clinical setting. Especially, advanced functional MRI sequences are utilized for tumor characterization and treatment assessment. Further research and technical development will be needed to reduce artifact and/or scan time, to standardize techniques and parameters, and to provide multi-parametric imaging.

Keywords: Head and neck, Magnetic resonance imaging, Diffusion weighted imaging, Dynamic contrast-enhanced MRI, Chemical exchange transfer saturation imaging

High resolution cranial nerve imaging

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High-resolution MR imaging is essential for the image-based evaluation of cranial nerves. Due to the small caliber of cranial nerves, most of cranial nerves are not usually visible with conventional MR imaging, except several large cranial nerves such as the optic nerve and trigeminal nerve. In addition, MR imaging for small cranial nerves are challenging, because small structures produce fewer signals, and tend to be more susceptible to various artifacts including motion artifact, pulsation artifact from blood and CSF, and susceptibility artifacts from the air-bone interface. Thus, cranial nerve imaging has been focused to acquire thinner slice thickness ($< 1\text{mm}$) and smaller volume ($< 1\text{ mm}^3$) within an acceptable signal-to-noise ratio.

The 3D steady-state free precession sequences provide augmented visualization of cranial nerves (dark cranial nerves contrast sharply with a background of bright cerebrospinal fluid). Furthermore, modified fully refocused steady-state sequences, such as constructive interference in steady state (CISS)/fast imaging employing steady-state acquisition cycled phases (FIESTA-C)/balanced fast field echo (B-FFE), provide shorter scan times, better signal-to-noise ratios and contrast-to-noise ratios. These imaging sequences are best for the diagnosis of congenital malformation or neurovascular compression of the cranial nerves, especially in the cisternal spaces. However, these sequences have poor contrast between vessels and nerve (both are low in intensity). This feature potentially limit detection and characterization of higher grade neurovascular conflict when there is little or no intervening CSF, and need more time to follow course of nerves for proper diagnosis of neurovascular compression syndrome.

Other 3D imaging sequences, such as 3D T2-weighted fast spin-echo sequences, with or without driven equilibrium radiofrequency reset pulse, and ultrafast gradient-echo 3D T1-weighted sequences, such as 3D turbo field echo and 3D MPRAGE, are also widely used for evaluating cranial nerve diseases. Postcontrast 3D T1 MPRAGE and 3D FLAIR with/without contrast enhancement are useful to detect enhancement of inflammatory and neoplastic diseases of the cranial nerve.

In terms of post-processing method, multi-plana reconstruction is useful to understand a complex relationship with the brainstem, vascular structures, skull base foramina and cranial nerves. In addition, maximum intensity projection can demonstrate the internal auditory canal, and membranous labyrinth. MR neurography which is dedicated to peripheral nerve evaluation and characterization of neuropathies.

Keywords : High resolution MRI; Cranial nerve