MRI/MRS of Neurodegenerative disease and epilepsy

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Synopsis: This talk will review use of MR imaging for early detection, diagnosis, prognosis, monitoring of therapy, and investigation of neurodegenerative diseases and epilepsy. Neurodegenerative diseases include a wide variety of conditions characterized by loss of nerve cells including: Alzheimer's disease, vascular dementia, frontotemporal dementia, Lewy Body dementia, ALS, Parkinsons's disease, and other conditions. There are many types of epilepsy, all characterized by the common manifestation of seizures. Neurodegenerative diseases are frequently not detected by radiologists, because they often do not produce distinctive lesions or other obvious abnormalities. However, these conditions do produce changes of brain structure, perfusion, diffusion, and metabolites which are detected by a variety of MR techniques.

Abstract:
This talk will review use of MR imaging for early detection, diagnosis, prognosis, monitoring of therapy, and investigation of neurodegenerative diseases and epilepsy.
Neurodegenerative diseases: Neurodegenerative diseases include a wide variety of conditions characterized by loss of nerve cells in the brain including: Alzheimer's disease, vascular dementia, frontotemporal dementia, Lewy Body dementia, amyotropic lateral sclerosis (ALS, or Lou Gehrig's disease), and Parkinsons's disease. In addition a wide variety of other processes are associated with neurodegeneration including: normal aging, stroke, excess glucocorticoids, cardiac surgery, radiation, alcoholism, substance abuse (especially cocaine), schizophrenia, and other conditions. Aside from normal aging, Alzheimer's disease is the most common neurodegenerative disease, and as a growing cause of death and morbidity as the population ages. Depending on the region of the brain where neurodegeneration occurs, these conditions produce a wide variety of signs and symptoms. Alzheimer's disease affects memory and other aspects of cognition (thinking). ALS causes progressive weakness and paralysis. Parkinson's disease is associated with tremor and rigidity. Frontotemporal dementia often presents as emotional or behavioral abnormalities. Therefore, correlation of functional change with changes of structure, perfusion, and metabolism of various brain regions provides new information concerning the function of these regions. In contrast to brain tumors, multiple sclerosis and other conditions which show visible lesions in the brain, neurodegenerative diseases are not usually characterized by visible lesions, and often the brain may appear completely normal. This is certainly the case in ALS, Parkinson's disease, and the early stages of Alzheimer's disease. In the late stages of these conditions, extensive neuron loss results in tissue atrophy, manifested by loss of gray and white matter and expansion of cerebrospinal fluid regions in the ventricles and sulci. Currently there are no treatments available which reliably slow the progression of any neurodegenerative disease, but billions are being invested by the Pharmaceutical Industry to develop treatments for Alzheimer's and similar conditions. This emphasizes the need to develop improved diagnostic techniques
Many investigators have used the entire spectrum of MR techniques to investigate neurodegenerative diseases. Most of these studies have been cross sectional, comparing patients with a particular disease with controls. A few studies have compared different conditions in an effort to determine the specificity of change. Furthermore, several longitudinal studies have been performed to measure rate of change in different brain regions, mostly in Alzheimer's disease. Structural MRI (with a wide variety of image processing techniques including tissue segmentation and region of interest analyses; hand marked, semi automated, and fully automated) has been extensively in Alzheimer's, and less so in the other conditions. Reduced NAA has been reported in many neurodegenerative conditions; specificity is found in different anatomical patterns of change. Myo inositol is increased in AD, but also seems to be increased in other neurodegenerative diseases. Perfusion MRI and Diffusion Tensor MRI also show changes in these conditions, but their value has yet to be established. The major use of MR techniques for neurodegenerative disease is currently: 1) to exclude other conditions such as tumors, stroke, MS which might be causing the symptoms. 2) to investigate pathophysiology and mechanism of disease, and 3) to determine outcome measures (as surrogate markers) in clinical trials. 4) Furthermore, as new treatments for these conditions undergo clinical trials, and finally are approved for clinical use, the need for non-invasive methods to monitor treatment effects, and for early detection and diagnosis should rapidly grow. Alzheimer's disease is the last major disease for which no effective treatment currently exists, but there seems to be rapid progress in developing new treatments. Thus it is expected that the demand for effective MR techniques to detect and monitor neurodegeneration will rapidly grow in the future.
A quick glance at the Abstracts of ISMRM, or the contents of Magnetic Resonance in Medicine or JMRI demonstrates that there is currently abundant research concerning MR techniques to measures the heart, or cancer, or abdominal organs. In contrast, there is a paucity of research concerning neurodegenerative diseases, which is out of proportion to the epidemiologic, clinical, and financial impact of these conditions. In conclusion, there is a great deal of exciting work to be done in this area and ISMRM attendees are encouraged to consider applying their efforts to this important field.