Emerging Spinecare Trends

Future Imaging of the Spinal Cord

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Chronic spinal cord compression represents one of the most common causes of muscle weakness and paralysis in the elderly. People are living longer; therefore, there is a rising incidence of degenerative narrowing of the spinal canal (spinal stenosis) which can lead to slow and clinical silent progressive spinal cord compromise. It often goes undetected until there are obvious clinical deficits. This typically occurs after a significant number of spinal nerves are compromised, often permanently. Surgical decompression of the spinal cord is usually not performed until there is some degree of permanent neurological compromise. In the future new imaging techniques will be used to help identify spinal cord compromise earlier.

In the future emphasis will be placed on identifying high risk patients before there is obvious loss of spine functions. This will be accomplished by using various methods including MRS for assessing for "in vivo" chemical evidence of spinal cord cellular compromise within the narrowed region of the spinal canal. This will involve identification of ischemic biomarkers, inflammatory biomarkers, and biomarkers of demyelination and/or axonopathy.

In the field of magnetic resonance imaging (MRI) the use of stronger magnets will improve a signal-to-noise ratio which improves imaging quality and reduces data acquisition (scan) times. The improved imaging capacity will reveal more subtle pathological and structural details not otherwise detectable. It will allow for visualization of inracanicular and intraneural tissues. Advances in diffusion-weighted imaging (DWI) will be used to asses those at risk for ischemic injury within the spinal cord and other spinal structure. A derivative technique, diffusion tensor imaging (DTI) will be used to evaluate scalar properties of the diffusivity of extracellular water molecules within white matter fiber tracts. The dataset is will more routinely be used for 3-D reconstruction of white matter tracts in the spinal cord. DWI will be used to asses the altered matrix of neoplastic tissues within or adjacent to the spinal cord. In the future a needless biopsy using MRS will help characterize the lesion.

The nerve fibers of white matter tracts have properties which direct the diffusion pattern of water. The proposed mechanisms of underlying diffusion anisotropy include the myelin sheath, the axonal cytoskeleton, local susceptibility artifacts and fast axonal transport. The diffusion pattern of water can be measured and turned into an image. The current clinical application of diffusion-weighted imaging (DWI) of the human spinal cord is limited by a few technical challenges. These challenges will be overcome in the near future.

Fractional anisotropy (FA) will routinely be used to perform specific spinal cord fiber tract studies. FA refers is derived from DTI computations and represents the global anisotropy of tissues. These studies will be used to characterize myelination, axonal thickness, collective nerve fiber/fiber tract volume, and spinal intraparenchymal morphological parameters. Changes in fractional anisotropy and mean diffusivity may become sufficient enough to differentiate between potentially reversible edema and irreversible gliosis in the spinal cord in patients who have spinal canal narrowing secondary to spondylosis. The determination of eiginvalues will be used to help stratify subgroups of patients with spinal cord compression, a step which will help determine the best treatment options. DWI will also be used to assess structural integration of the vertebral body including the subchondral

endplate region adjacent to the intervertebral disc.

In vivo magnetic resonance spectroscopy (MRS) (proton spectroscopy) will be used to measure metabolite concentration, biochemical ratios, and to perform metabolic mapping of the spinal cord and other spinal tissues. A growing number of metabolites can be identified with MRS, many within the central nervous system. Spinal cord spectroscopy has the potential to add metabolic information to the routine spinal cord MRI. Currently, spinal cord spectroscopy remains challenging due to technical factors such as magnetic field inhomogeneities, CSF pulsation and the relatively small field of view. These factors limit the quality of the acquired data although these challenges will soon be overcome. Metabolite quantification in the spinal cord will offer new opportunities for clinical correlation and research. For example, the metabolite N-acetyl aspartate (NAA) has been shown to be a biomarker of axonal integrity within the central nervous system. Its levels correlate well with motor disability. MRS may be used to assess the pre-myelopathic state.

In the future acquired spectroscopy data may be merged with magnetic resonance angiography (MRA) data to help detect early disease/compromise. Intraparenchymal assessment of blood flow could be correlated with region specific ischemic biomarkers. This can further be correlated with the diffusivity of water within white matter tracts along with the evaluation of segmented spinal tract morphology and volumetrics.

Some functional MRI (fMRI) studies of the spine have been performed with limited success due to technical challenges which will likely be overcome in the future. It the challenges are overcome future fMRI studies may be used to help investigate the spinal cord processing of pain stimuli. Progression to the use of perfusion-based fMRI could help reveal ischemic regions within the spin cord which are vulnerable for progression to infarction. In the future perfusion based fMRI may be correlated with the use of MRS to evaluate for metabolites which serve as ischemic biomarkers.

Magnetic resonance myelographic (MRM) will be perfected to provide a non-invasive method for assessment of nerve root sheaths, the effect of intradural adhesions/masses on CSF flow and to evaluate other perineural pathology. Emerging techniques will be applied to imaging the intervertebral disc and related pathology. The dynamics of intradiscal metabolite concentration and water diffusivity will be revealed which will help determine the prognosis and stability of disc degeneration and disruption. All of these advances will improve the post-operative imaging workup. Improved 3D reformatting will enhance the detection of tissue and instrument displacement as well as the presence of scar as well as recurrent and/or residual pathology. DTI hat high field strength shows promise in the assessment of all spinal cord pathologies.