Emerging Spinecare Trends

The Future of Diagnostic Imaging of the Spine

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Advances in diagnostic imaging will transform the field of spinecare. Molecular imaging studies will direct emerging technology and foster further discoveries in spinecare. Molecular imaging techniques will be used to directly and indirectly monitor and record the spatiotemporal distribution of molecular or cellular processes in spinecare. There are many different imaging techniques which will be applied for the purpose of molecular imaging such as radiotracer imaging/nuclear medicine, MR imaging, MR spectroscopy, optical imaging, and ultrasound. Magnetic resonance spectroscopy (MRS) will likely emerge to become one of the most practical and safest forms of assessing spinal tissue biochemistry in vivo. Molecular imaging will have a huge impact on future spinecare. It will be sued to reveal the clinical biology of the disease process and it has the potential to help personalize a patient's care. The combination of magnetic resonance imaging (MRI) with MRS will yield the relationship between structure and molecular biochemistry in ways we can not achieve through other diagnostic methods.

The current use of MRS is contributing to a growing list of disease specific biomarkers. The term biomarker refers to a reliable measure of disease which can be used to detect a disease process, to monitor disease progression, and to assess treatment outcome. In the past biomarkers were primarily limited to blood tests and tissue biopsies. MRS is currently being used to assess biomarkers and biochemical relationships within neurological tissue of the brain, brainstem, and spinal cord regions. In the future it will likely be used to perform "in vivo" chemical mapping of the intervertebral disc, cerebrospinal fluid, the vertebral body (bone marrow) and for characterizing spinal tumors. .

Molecular imaging such as MRS will have a profound effect on the future of spinecare through its application in translational medicine, a phrase which refers to a continuum often known as the "bench to bedside" transition of basic research to clinical application. It is the process of moving research discoveries from the laboratory into clinical practice where the information can be applied to diagnose and treat patients. The phrase translational medicine is often used interchangeably with terms such as "Molecular Medicine" or "Personalized Medicine".

MRI will likely remain the modality of choice for detailed evaluation of most intraspinal pathology. Future diagnostic imaging of actual or suspected spinal cord compromise will likely include diffusion weighted imaging, spectroscopy, fiber tractography, and MR neurography. The spinal column will be navigated using advanced digital reconstruction virtual reality technology and tools. Imaging technology will allow for non-invasive biochemical assay of regions of the spine and the central nervous system. Future imaging will also provide better visualization of spinal and spinal cord vasculature. Expanded imaging field of view (FOV) combined with better tissue resolution will led to the discovery of subtle abnormalities at various stages of development. Greater use of quantitative imaging techniques will provide better measure of change. The full spine imaging study will become common place. Diagnostic imaging will continue to trend toward earlier detection of dysfunction and disease.

Diagnostic imaging advances will change the way we view and detect early stage spine disease. It will also have a profound impact on how we treat and monitor spine disorders and related complications. Molecular imaging will have a profound influence

on how we diagnose disease. It will allow us to view molecules (metabolites) in vivo and tissue remodeling in disease. Molecular imaging will be used to reveal characteristic biosignatures of disease. Magnetic resonance spectroscopy (MRS) uses nuclear magnetic resonance techniques to reveal the biochemistry and metabolism within targeted regions of tissues such as the brain, brainstem and in the near future the spinal cord. MRS may eventually prove to be an effective method for identifying the location of pain in the spine. Before this can be realized in vivo chemical biomarkers for inflammation and the provocation of pain must be identified. MRS will be used to help evaluate and follow the underlying mechanisms of osteoporosis.

When MRI and MRS are performed together we learn about how the tissue looks and what is going on chemically within the tissue. In general abnormal chemistry precedes the development of structural pathology; therefore, MRS may be used to identify early stage pathology and pre-disease states. Bioinformatic databases will be used to define the correlates between metabolite levels and metabolite ratios and their relationships to health and disease. The current list of chemicals detectable with MRS is limited but the list is growing. MRS and related technology will provide us with a practical non-invasive window into the spine revealing metabolite levels, chemical shifts, and chemical signatures indicative of disease or other abnormalities.

Diagnostic imaging will continue to play an increasing important role in spinecare. MRI will likely remain the best overall modality for this purpose for years to come. Future applications will include faster scanning speed (data acquisition time) speed, broader fields of view, sophisticated image postprocessing (data manipulation) and improved tissue resolution (signal to noise ratios). Additional advances will include multicoil and multichannel data acquisition leading to better spatial resolution.

Advanced imaging and formatting capabilities will give spine specialists the ability to virtually fly through and investigate areas of interest. Software will be used to segment tissues, acquire quantitative measurements, and to perform in vivo biochemical mapping of selected tissues or pathology. In the future regional imaging surveys of the spine will be replaced by full spine imaging with subsequent focused assessment. Complex "add on" protocols will become a routine part of profiled image sequencing. The growing trend will be in the direction of quantitative imaging and expanded field of view (FOV).

Specilialized MRI protocols such as diffusion-weighted imaging (DWI), diffusion tensor imaging (DTI) and tractography, perfusion, MR spectroscopy (MRS), MR angiography (MRA), and functional MRI (fMRI) sequencing and acquisitions have become routine in the assessment of the brain for strokes, tumors and inflammatory lesions. In the near future these approaches will be equally promising for evaluation of the spinal cord.

Post image processing will become an invaluable tool of the radiologist and surgeon. The data and reports will also be accessed by other members of the spinecare team through electronic healthcare record systems. Software will become more capable of integrating functions currently available such as volume rendering, virtual endoscopy, surface modeling, tissue segmentation, data sorting as well as offer different methods for making quantitative measurements within the region of interest (ROI).