Changes in DTI Post Stroke.

Until the more recent addition of new and more effective treatment options for acute ischemic stroke the main clinical objective for acute ischemic stroke has been to reduce the risk for progressive injury, primary or secondary. The role for neuroimaging at that time was mainly to exclude hemorrhage and other, sometimes treatable conditions for the stroke as early as possible. With the introduction of thrombolytic drugs and mechanical retrieval of thrombi the need for early and accurate diagnose became even more important, but now with the goal to also reduce the impact and progression of the ischemia. In most instances it is enough with a simple routine DWI examination to establish an ischemic injury and its extent. However, with the development of new treatment options with the goal to achieve improved neuronal protection and reduce the negative impact of the ischemia, there is now an increasing need for better means to predict also the long-term prognosis and to follow the effect of treatment, and then conventional DWI is no longer sufficient.

To obtain more information about the underlying cause(s) for changes in diffusion it is better to perform a diffusion tensor imaging (DTI) study. In contrast to conventional DWI, DTI may allow for a more detailed description of microstructural changes in the parenchyma and can also be used to produce fiber tracking maps. Both of these can give important clues to the immediate impact of the ischemic event and to better predict the long term prognosis, including the ability of the brain re-wiring of tracts and re-allocation of various functions. The drawback of DTI in most instances has been the extended time needed to complete these examinations, at least if one expects any reliable data with regard to fractional anisotropy (FA) and mean diffusivity (MD). Although the higher field strength of 3T and the use of parallel imaging have reduced the examination time, it is still in the range of 5-6 minutes in most instances. In the hyper-acute setting of an ischemic stroke this is often too long when time is most critical to reduce neuronal damage, and when the patient is most distressed and has difficulty to stay still. However, the technique should lend itself extremely well in the next stage, the acute stage and beyond, when treatment has been instituted and the patient generally is more cooperative.

So far the knowledge about the factors causing changes in diffusion after stroke is still rather limited but there is a fast growing knowledgebase regarding the correlation of DTI findings and histology. However, in the clinical setting this is really not possible to obtain, in particular not in a temporal setting. So far in humans one has largely been relying on the outcome of various treatment effects and how these relate to changes seen on consecutive DTI examinations. For a better understanding of the histological changes one will presently have to rely on experimental studies in animals and transfer that knowledge to the clinical situation.

Immediately following an ischemic attac the brain will start a chain of events that involve various aspects of “healing” and re-direction of functions. However, there is at the same time an imminent risk of a further progression of the damage, primarily to involve the penumbra, but secondarily also other regions, e.g. due to the mass effect from the developing edema. There are multiple mechanisms that have been suggested that may
have an effect on the recovery after stroke and to study these processes in humans there are several imaging techniques. All of these imaging techniques can to some degree provide insight into the cellular as well as the molecular processes involved, such as dendritic sprouting, axonal regrowth and cell migration; one of these is DTI. Following an acute stroke event DTI has shown that there is a development of focal FA changes that will develop in relation to the white matter tracts involved. This change in anisotropy can be further studied by means of the eigenvalues to investigate e.g. axonal damage, which has shown some promise with regard to functional recovery. The field is still relatively young and for the future one may expect, and hope that more detailed evaluations of the various DTI parameters will be helpful also in the evaluation of treatment effects.

This presentation will concentrate on the present knowledge about temporal changes on DTI parameters post stroke as shown in various animal experiments. It will also illustrate the present application of DTI in patient care and how it might be used in the future to study the effects of treatment, both short terms in the acute stage and with regard to the re-establishment of functions in the long term.

Sven E. Ekholm, MD, PhD
Professor of Radiology and Neurosurgery
Department of Imaging Sciences
University of Rochester Medical Center
Rochester, NY, USA