Challenges of advanced clinical MRS

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The reliability of ^{1}H MRS examinations is steadily improving, thanks to developments from the side of the MR manufacturers as well as to increasing familiarity of the users with MRS. Improvements of MR scanners include ease of positioning of volumes-of-interest, automatic shimming, and automatic combination of signals from individual coil elements in case of phased-array receive coils. Improved knowledge of the user includes familiarity with post-processing algorithms, and awareness of the influence of spectral quality on the results [1]. Of course, it remains a challenge to keep all users alert and critical towards the results of an MRS exam, not only the clinical users but also those that use MRS mainly for research purposes.

With regard to quantification methodology, the use of an internal reference such as water or creatine remains popular and robust, as long as one keeps in mind that the concentration of these “references” are not necessarily stable in all stages of a disease. A new external reference method is the use of an electric reference signal, but this is still in development [2]. Typically, quantification based on external calibration relies on the value of the transmitter amplitude which initially required the use of a transmit-receive coil. However, a similar principle can also be applied when using a phased-array receive-only coil, as demonstrated both for single voxel spectroscopy [3] and for spectroscopic imaging [4].

Thanks to the unique properties of MRS to provide biochemical and metabolic information, it has applications in several diseases. Tumours are a main clinical target, but metabolism and the applications of clinical MRS in brain tumours, prostate and breast cancer are the topic of other lectures in this course. Also muscle, liver, and pancreas are increasingly studied with MRS, to investigate fat distribution, especially in disorders like metabolic syndrome and diabetes [5,6].

In diseases like multiple sclerosis (MS), Alzheimer’s disease, and mild cognitive impairment, MRS is used generally in combination with other MRI techniques to investigate therapeutic interventions or to establish early diagnosis [7]. Some studies tried to interpret the results of MRS from a new point-of-view. For instance, in a combined MRS, DTI, and structural MRI study of the spinal cord in MS, the concentration of NAA was modelled according to its separate contributions to axonal structural integrity and mitochondrial metabolism [8]. Recently, a diagnostic value for spectroscopic imaging has been suggested in acute stroke [9]. The level of Cho was increased in peri-ischemic normal-appearing brain tissue that became infarcted a few days later, as observed on DTI. The degree of elevation was associated with the amount of infarct expansion. Because of the potential need for early thrombolytic treatment in the acute phase, it is a challenge to perform a fast and reliable clinical MRS examination with regard to acquisition as well as to post-processing and interpretation.

In child neurology, MRS remains extremely valuable for the diagnosis of metabolic disorders with their unique spectra. Combination of MRS with quantitative MR techniques may help discriminate different leukodystrophies [10]. Even in 'difficult' infratentorially located regions (brainstem, vermis and cellebellar hemispheres), an accurate MRS examination is able to provide sensitive markers of neurochemical status in children with spinocerebellar ataxia [11].

Challenges especially remain with regard to MRS examinations at higher field strength. The higher SNR and increased spectral resolution will yield additional knowledge about brain diseases. However, problems with B_0 homogeneity, the need for outer-volume suppression and a large chemical shift displacement are just a few examples of issues that have a large effect. They need to be taken into account before MRS at high field can be applied within a clinical setting.

References

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