

Current Concepts in MR Based Therapy Assessment

Michael V. Knopp¹

¹The Ohio State University, Columbus, Ohio, United States

Synopsis

Advances in therapeutics have led to increased clinical demand for accurate, effective, non-invasive assessment of therapies. Modern therapies require improved capabilities for early assessment as the socio-economic impact of ineffective therapies is high. MR has excellent capabilities in all three essential areas, the structural, functional and molecular assessment of response to therapy. Acquisition of large volumes of interest with adaptable resolution and high tissue contrast, combined with functional procedures such as perfusion and molecular techniques such as targeted agents and spectroscopy has brought MR based therapy response assessment into clinical drug development and patient management of advanced, elaborate therapies.

Advances in therapeutic capabilities and options have led to increased clinical demand for accurate and effective, non-invasive assessment of therapies. Modern therapies include mono- and combined approaches including pharmaco-, radiation-, immunologic-, genetic-, viral- and molecular therapies as well as the broad array of surgical approaches. Those require improved capabilities for early assessment as the socio-economic impact of ineffective therapies is high. While MR has been readily embraced by the clinical imaging community for morphologic assessment, its utilization for functional assessment has been low and slow. Positron Emission Tomography (PET) has been leading in clinical utilization and visibility for advanced therapy monitoring in the recent past and combined PET/CT systems are now able to provide both functional and morphologic imaging during the same exam. Therefore, MR based approaches need to be able to deliver clinical value, robustness and reproducibility, as well as ease in use and interpretation in addition to the scientific innovation, if we want to bring those procedures into broader clinical use. MR has excellent capabilities in all three essential areas, the structural, functional and molecular assessment. MR can achieve these capabilities through the use of different pulse sequences alone which can be further enhanced by the use of contrast agents. MR capable contrast agents beyond the standard extra cellular fluid agents (Gd-DTPA and analogues) have slowly evolved and promise now to further substantially expand the MR based capabilities. MR is further being recognized as a safe procedure, both in terms of its technical safety as well as its lack of ionizing radiation. Further technical improvements in MR are achieved by higher field strength (3T has already entered the level of clinical care), advanced coil design, advanced electronics and nearly endless innovations in pulse sequences. Therefore, the MR capabilities are stellar to tackle the challenges of advanced therapy assessment of modern therapies. While oncologic therapy is currently the largest area of need, therapy assessment is not limited to it and many clinical applications are being recognized in neurologic / psychiatric, cardio-vascular, musculoskeletal, inflammatory and geriatric diseases and ailments. The advances in our pathophysiologic understanding of diseases, the recognition of heterogeneity of lesions and the potential heterogeneity in response to therapy demand that non – invasive therapy assessment enables a more detailed insight than reporting on the change in diameter of a process. This need however coincides greatly with the inherent capabilities of MR. Acquisition of large volumes of interest with adaptable resolution and high tissue contrast enable detailed structural segmentation for truly volumetric assessment of processes and lesions. MR can thus enable a highly accurate, truly volumetric assessment of therapy response. With this as a basic capability, additional fast and repetitive imaging of the target volume of interest without concerns about ionizing radiation is possible during the same exam to enable time resolved, functional assessment using inherent or exogenous contrast. Here, perfusion based techniques or dynamic contrast enhanced procedures have been established to bring detailed insight, not only at the level of a lesion, but already at its substructures. Combining these capabilities now with targeted contrast agents or with spectroscopic techniques using even multiple nuclei, facilitate insight into molecular pathways and processes. The true strength of the MR based approach to therapy assessment is the wide scalability in evaluation of response within a single patient exam to enable insight at the characteristics and changes in the three essential areas.

MR based therapy response assessment is being extensively embraced in clinical drug development and patient management of advanced, elaborate therapies. Further standardization in imaging approaches, postprocessing, visualization and quantification is needed to reach the clinical potential this methodology has and can deliver, even in a healthcare environment that is cost-conscious and outcome driven. The scientific MR community has to recognize that we can only bring the stellar advances in technology and science into clinical care, if we facilitate and intensify the complete and integrated development from a scientific experiment to a clinical application.