Special issue on magnetic resonance imaging biomarkers of renal disease

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Editorial

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The idea of using MRI to assess renal function dates back to the early 1980's, when Runge *et al* demonstrated that serial MRI after contrast agent injection revealed temporal patterns that were able to diagnose acute changes in renal function (1). In the same period, Pettigrew *et al* demonstrated that fast imaging sequences could isolate renal perfusion (2), and concluded that "in the future, MR imaging […] may simultaneously provide good morphological detail and the type of physiologic information currently offered noninvasively by nuclear medicine techniques". Ever since, functional renal MRI has been an active field of research within the MRI community. Commonly cited methods include diffusion-weighted imaging (3), diffusion-tensor imaging (4), blood-oxygenation level dependent MRI (5) and arterial spin labelling (6), but many others have shown a relevant signal in the kidney: phase-contrast, T1-mapping, T2-mapping, Sodium, magnetisation transfer, chemical exchange saturation transfer, spectroscopy, rotating frame relaxation, elastography, volumetry, quantitative susceptibility mapping and hyperpolarised MRI.

For 30 years these ideas were largely confined to the MR physics and radiology community, but the past few years have seen a rapidly increasing interest by nephrologists. To a large extent this is driven by the ever growing burden of chronic kidney disease (CKD) and the well-recognised need for "novel prognostic biomarkers that help to predict future risk and understand the underlying molecular mechanisms" (7). One possible avenue lies in the identification of novel biomarkers in blood or urine, but these have so far failed to produce a clear solution (8). It is increasingly recognised that MRI biomarkers may be part of the solution due to their ability to probe different pathophysiological hallmarks of CKD progression (9). Despite known limitations in terms of biological specificity, it appears plausible that a direct observation of parenchymal changes in-situ can pick up disease progression well before it manifests itself downstream in blood or urine.

These converging interests of MR physicists, radiologists, nephrologists, drug developers, transplant surgeons, physiologists and pathologists have given rise to a dynamic and multi-disciplinary community of researchers with a common interest in renal MRI biomarkers. In Europe an international research network was founded in 2017 (www.renalmri.org) and only recently, in october 2019, a third international meeting on renal MRI was held attracting over 200 scientists from across these disciplines (10). As a result of this broadening interest MRI biomarkers are also

increasingly visible in the nephrology literature (11), with one recent study hinting at a potential role in the long-standing problem of predicting disease progression (12).

This special issue on MRI biomarkers of renal disease is intended to offer a cross-section of the ongoing developments in this area, and to encourage a more coordinated approach to MRI biomarker development in order to generate the evidence levels required by regulators (13).

The four review papers in this issue cover ongoing areas of research including relatively well-established methods (Caroli *et al*) and entirely novel contrast mechanisms (Laustsen *et al*), image processing (Zoellner *et al*) and clinical applications (Schutter *et al*). The original work in this issue is representative of the wider field and includes: the application of MRI to improve patient management (Serai *et al*) and our understanding of disease progression (Van Raalte et al); studies on sequence optimisation (Harteveldt *et al*, Miyazaki *et al*) and image processing methods (Rankin *et al*, Li *et al*) that may inform future technical recommendations; and technical developments that can open up new avenues of translational research (Boehmert *et al*).

This special issue places a particular emphasis on research coordination, and presents a rigorous process developed by the community to generate expert consensus on technical aspects (Mendichovszky *et al*). Four papers present the results of applying this process to the most common contrast mechanisms and have jointly generated over 160 consensus statements (Nery *et al*, Dekkers *et al*, Ljimani *et al*, Bane *et al*). Apart from identifying areas where consensus already exists, this process has also served to identify research priorities by highlighting areas where experts are currently unable to agree on a recommendation. Our hope is that this mechanism will ultimately cause an alignment of the methods for measuring renal MRI biomarkers and create the necessary conditions for international harmonization. This in turn will allow clinical trials to be scaled up to the levels needed to demonstrate the utility of this promising new paradigm in the diagnosis of renal disease.

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