Cardiovascular magnetic resonance: at the heart of 21st Century imaging

Cardiovascular magnetic resonance (CMR) provides an exquisite anatomical and functional assessment of the heart and vascular system and does so without the use of ionizing radiation. Through the development of an array of specialised and complementary imaging sequences, clinical CMR has now become a "one-stop shop" for diagnostic and prognostic imaging to answer a wide range of clinical questions. Common indications for CMR include but are not limited to; coronary artery disease (using gadolinium contrast imaging for myocardial perfusion and myocardial viability), valvular heart disease (using phase contrast imaging for quantification of stenoses or regurgitation), cardiomyopathy and inherited (being the gold standard for quantification of ventricular volumes, mass and ejection fraction), congenital heart disease (unparalleled anatomical and flow quantification of shunts, conduits and anatomical communications), inflammatory heart disease and many others. This series of *Cardiovascular Diagnosis and Therapy* focuses the contemporary use of advanced CMR techniques in heart failure and left ventricular (LV) hypertrophy. It highlights not only the current state of the art CMR for clinical imaging but also the current and future tissue characterisation and multinuclear capabilities that define CMR as unique in the field of cardiac imaging.

Obesity is a global pandemic and not only causes LV hypertrophy and heart failure but can also severely limit the quality of ultrasound imaging. This series begins with an original article from Dr. Rayner *et al.*, demonstrating that obesity related ventricular remodelling is exacerbated in dilated and hypertrophic cardiomyopathy (Rayner *et al.*). This highlights both the importance of obesity as a modifiable risk factor in established cardiac disease, and also the capability of CMR to provide an accurate and reproducible volumetric assessment of the heart irrespective of the degree of chest wall adiposity.

One of the leading clinical indications for CMR is to determine the cause of undiagnosed LV hypertrophy. Drs. Lewis and Rider continue the edition with a review on the use of CMR in the assessment of undifferentiated LV hypertrophy, highlighting the typical structural, tissue characteristic, late gadolinium, T1 and T2 characteristics that typify, and allow the separation of, the common causes of LV hypertrophy, namely; amyloid, hypertrophic cardiomyopathy, cardiac sarcoidosis, Fabry disease and hypertensive heart disease (Lewis *et al.*).

Beyond anatomical and functional imaging, CMR can probe the metabolic mechanisms that underlie many cardiovascular diseases. In this series, Dr. Watson has reviewed the changes in cardiac metabolism that can be imaged with the unique multinuclear capabilities of CMR and magnetic resonance spectroscopy (Watson *et al.*). The article highlights the use of ^{1}H-MRS for the determination of cardiac fat and creatine content, ^{31}P-MRS for interrogation of cardiac high energy phosphate metabolism, ^{2}H-MRS for glucose metabolism, ^{23}Na imaging for myocardial viability, ^{17}O-MRS for oxygen consumption, and also introduces the state-of-the-art technique of hyperpolarized ^{13}C-MRS to image cardiac carbohydrate metabolism and tricarboxylic acid cycle metabolites.

Myocarditis due to viral aetiologies is a relatively common cause of acute chest pain syndromes in younger and middle-aged patients and often has a benign prognosis, though this and other forms of myocarditis also cause serious sequelae, including heart failure, arrhythmia and death. The series continues with a review on the use of CMR and specifically parametric T1 and T2 mapping for the detection of myocardial inflammation, and also the potential for future strategies including hyperpolarised 1-[^{13}C] lactate imaging as a readout for macrophage activity (Lewis *et al.*). These techniques are likely to have future applications to better understand the role of immune cells in the development of cardiovascular diseases.

Cardio-oncology is another rapidly growing sub-speciality within cardiology. Contemporary cancer therapy has resulted in significant survival gains for many patients. However, many current and emerging cancer therapies have an associated risk of cardiotoxicity, either acutely or later in life. Dr. Burrage continues this series with a review on the role for CMR as means to identify those at risk of cardiotoxicity, to precisely monitor cardiac function during cancer therapy and as a means of monitoring long term cancer survivors (Burrage *et al.*).

With both a range of exciting preclinical discoveries and recent clinical trial data supporting the use of metabolically active drugs as novel therapies for heart failure, imaging myocardial energy metabolism has become a priority. Dr. Peterzan shifts the focus of this series back to metabolism with a historical, current era and future perspectives review on the investigation of myocardial energetics in cardiac disease using ^{31}P magnetic resonance spectroscopy (Peterzan *et al.*).

This series concludes with two short perspective pieces considering the expanding roles for CMR internationally in both clinical and research settings. The first is by Dr. Nikolaidou who presents the arguments for and against "Should Everyone have an MRI in Heart Failure?" (Nikolaidou *et al.*). The second by Dr. Hundertmark discusses "*Should CMR be the default imaging modality in clinical trials for heart failure?*" (Hundertmark *et al.*).

Contemporary CMR is a powerful and versatile tool for the diagnosis and management of patients with cardiovascular diseases. It provides an unparalleled assessment of cardiac function and myocardial morphology and has unique abilities to probe tissue characteristic and myocardial metabolism. This special series highlights the many current and future benefits of CMR to optimise the diagnosis and management of patients with LV hypertrophy and heart failure.

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