Biology and Pathology

Cardiovascular Disease

MR Imaging for Electrophysiology Disorders and Multimodal Image Visualization Techniques

Kawal Rhode
Division of Imaging Sciences & Biomedical Engineering, King's College London, London, United Kingdom

Learning Objectives:

- Understand the role of magnetic resonance imaging (MRI) in cardiac electrophysiology (EP) disorders
- Understand the different types of MRI scans used for EP disorders and the information that can be obtained from these scans
- Understand the techniques for extraction of useful information from cardiac MRI data for EP disorders
- Understand the uses of data fusion techniques to support the management of EP disorders

Patients with rhythm disorders of the heart are increasingly treated using interventional cardiac electrophysiology (EP) procedures, such as ablation therapy and pacemaker implantation. Interventional procedures offer the distinct advantage over long-term pharmacotherapy that they can provide a cure. However, the success rate for these procedures is still sub-optimal and many patients require redos. Examples include ablation treatments for atrial fibrillation (AF) and ventricular tachycardia (VT). These treatments aim to disrupt the arrhythmogenic electrical circuits by appropriate destruction of the myocardial substrate. For AF, the success rates improve after multiple procedures and are lower for those patients with persistent or permanent AF versus those with paroxysmal AF (PAF). In a recent worldwide survey consisting of 16309 AF patients it was found that ablation therapy for AF was approximately 80% successful after an average of 1.3 procedures. For VT, the figures are lower, varying from 50% upwards, since locating the correct ablation substrate can be very difficult. Cardiac resynchronisation therapy (CRT) has been a popular treatment for patients with heart failure. This treatment involves implantation of a pacemaker device that targets both the right and left sides of the heart. This expensive treatment has the ability to improve cardiac function and reduce morbidity and mortality for these patients. However, the success rate is again sub-optimal with one-third of patients failing to respond as shown by the MIRACLE and FREEDOM trials.

There may be a variety of reasons for sub-optimal success rates that include (1) inappropriate patient selection; and (2) incomplete or incorrect delivery of treatment during the intervention. Recent advances in medical imaging coupled to recent advances in image processing and cardiac biophysical modelling may improve patient outcome.

This educational talk will focus on the role of magnetic resonance imaging (MRI) in the management of patients with EP disorders. MRI is a versatile tool for this purpose and can be used to measure both the anatomy and function of the heart. Topics that will be covered include the imaging and segmentation of cardiac anatomy, the measurement of myocardial motion, the imaging and measurement of myocardial fibrosis and scarring, and finally the use of these measurements to provide an integrated approach to EP disorder management through data fusion.

Relevant Publications:

1. Evaluation of current algorithms for segmentation of scar tissue from late Gadolinium enhancement cardiovascular magnetic resonance of the left atrium: an open-access grand challenge. Karim R, Housden RJ, Balasubramaniam M, Chen Z, Perry D, Uddin A, Al-Beyatti Y, Palkhi E, Acheampong P, Obom S, Hennemuth A, Lu Y, Bai W, Shi W, Gao Y, Peitgen HO, Radau P, Razavi R, Tannenbaum A, Rueckert D, Cates J, Schaeffter T, Peters D, MacLeod R, Rhode K.J Cardiovasc Magn Reson. 2013 Dec 20;15:105.
2. Benchmarking framework for myocardial tracking and deformation algorithms: an open access database. Tobon-Gomez C, De Craene M, McLeod K, Tautz L, Shi W, Hennemuth A, Prakosa A, Wang H, Carr-White G, Kapetanakis S, Lutz A, Rasche V, Schaeffter T, Butakoff C, Friman O, Mansi T, Sermesant M, Zhuang X, Ourselin S, Peitgen HO, Pennec X, Razavi R, Rueckert D, Frangi AF, Rhode KS.Med Image Anal. 2013 Aug;17(6):632-48.
3. Cardiac magnetic resonance-derived anatomy, scar, and dyssynchrony fused with fluoroscopy to guide LV lead placement in cardiac resynchronization therapy: a comparison with acute haemodynamic measures and echocardiographic reverse remodelling. Shetty AK, Duckett SG, Ginks MR, Ma Y, Sohal M, Bostock J, Kapetanakis S, Singh JP, Rhode K, Wright M, O'Neill MD, Gill JS, Carr-White G, Razavi R, Rinaldi CA.Eur Heart J Cardiovasc Imaging. 2013 Jul;14(7):692-9.
4. Acute Pulmonary Vein Isolation is Achieved by a Combination of Reversible and Irreversible Atrial Injury following Catheter Ablation: Evidence from Magnetic Resonance Imaging. Aruna Arujuna, Rashed Karim, Dennis Caulfield, Benjamin Knowles, Kawal Rhode, Tobias Schaeffter, Bernet Kato, C. Aldo Rinaldi, Michael Cooklin, Reza Razavi, Mark D O'Neill, Jaswinder GillCirc Arrhythm Electrophysiol. 2012 Aug 1;5(4):691-700. Epub 2012 May 31
5. Modeling and registration for electrophysiology procedures based on three-dimensional imaging. Rhode KS and Sermesant M.Curr. Cardiovasc. Imaging Rep. 2011.

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