CV Sunrise Course: Cardiac MRI

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HIGHLIGHTS

- Case based demonstration of clinical cardiac MR imaging techniques
- Case based explanation of clinical approaches to cardiac MRI
- Explanation of cardiac morphology, function, perfusion and myocardial texture in content of cardiac disease.

TALK TITLE: Comprehensive Cardiac MRI: Clinical

TARGET AUDIENCE: – Clinicians with basic/intermediate skill level, Physicists with interest in clinical cardiac MRI applications

OUTCOME/OBJECTIVES: – Audience will become familiar with questions, clinical applications of challenges in cardiac

BACKGROUND:
The heart as the center of the cardiovascular system is a complex machine (ital.: “la macchina”) drives two serial circulations that act as an essential transport system for required substrates, body generated waste, signaling substances and other. In its location it has to quickly response to changes in demand and while is exposed to various influencing factors that may harm its generally ability to adequately maintain function primary diseases of the heart on the other hand may influence dependent aspects of the cardiovascular system as well as end-organs. Knowledge about the main aspects to assess to screen for cardiac health or potential damage will be reviewed in this course. The main aspects relate to proper anatomical structures and connections (morphology), maintenance of its functional aspects including supporting structures such as valves (function), the hearts own blood supply (perfusion) as well as potential primary or secondary structural changes of the heart muscle (myocardial composition).

MORPHOLOGY:
Imaging of the cardiac morphology is of outmost importance in the setting of primary or repaired congenital heart disease (CHD). With improvement in therapy, surgical/interventional corrections and care the number of adults and adolescents with CHD is constantly increasing. Applied imaging techniques in MRI need to be able to demonstrate the general connection of structures (e.g. atrio-ventricular/ventricular-arterial connections) as well as potential complications of previous surgical attempts or general morphologic sequelae of CHD. Of outmost importance is a homogenous signal behavior of the flowing and partially stagnant blood enabling high and reliable contract been blood pool and even subtle structures (e.g. atrial septum). Selection of imaging planes for morphologic assessment often follows standard orthogonal planes with a transverse orientation being the most often selected primary orientation. Morphologic imaging is also applied in assessment of cardiac tumors and masses in MRI with the focus of imaging being the differentiation of possible various tumor contents as well as the delineation of the mass extent.

FUNCTION:
Maintaining proper function is the primary task of the heart as the central pump in the cardiovascular system. Cardiac MRI is without doubt the most adequate method to noninvasively assess the ventricular

function and is based on the application of Cine MRI techniques. While several methods of quantification have been proposed (including RV analysis in transverse orientation) functional imaging of the heart is performed along the cardiac axis with application of consecutive short axis slices for ventricular analysis. In clinical cardiac MR imaging the focus is on assessment of ventricular size (e.g. end-diastolic volume), global ventricular function (ejection fraction) as well as regional wall motion to assess for localized abnormalities. Findings in regional functional assessment of the heart are reported according to general conventions and nomenclatures (e.g. AHA segmental model) in order to allow for “common language” among imaging modalities.

Findings of biventricular functional assessment may also help in identification of potential valvular pathology and may be supplemented by phase contrast flow imaging in the great thoracic vessels (e.g. aorta, pulmonary artery) or at the valvular levels.

The accuracy of cardiac MR imaging in assessment of ventricular function makes it a perfectly suited tool for follow-up exams to identify response/non-response to therapeutic interventions.

**PERFUSION:**
Diseases like atherosclerosis may demonstrate predominance in certain aspects of the vascular system but do generally affect the entire vascular system and may as such also affect the hearts’ own blood supply. Invasive testing such as coronary angiography or even coronary CT angiography may only provide morphologic information about the coronary arteries.

The potential hemodynamic significance of coronary artery narrowing/stenosis in MRI is assessed by stress/rest first pass perfusion imaging. This technique requires the bolus injection of a Gd-based contrast agent that is followed by rapid repeated imaging in order to capture an adequate SI-time curve in the ventricles (input) as well as the myocardium. Pharmacologic stress is required in order to recrute the perfusion reserve as even relatively high degree stenosis may be mimicked at rest status. Challenges in first pass perfusion imaging include imaging artifacts and of course potential breathing motion.

Clinical use is currently mainly based on eyeballing of perfusion data while various approaches may allow for quantification also in routine applications.

**MYOCARDIAL COMPOSITION:**
The myocardium and its subtle structural organization and composition remain crucial for adequate functional performance. Primary disease and secondary changes may affect this performance and may also bring other harm such as arrhythmia or even sudden cardiac death. With the identification of more and more genetically linked cardiomyopathies the imaging of the myocardial texture & composition will play an outstanding role in tomorrows cardiac MRI. In todays’ cardiac imaging approaches especially techniques such as Late Gadolinium Enhancement (LGE) are important to identify and differentiate ischemic from non-ischemic cardiomyopathies. From a clinical perspective especially the distribution pattern and the location of pathologic findings in LGE imaging are of outmost importance. These techniques are predominately used to identify fibrosis and scar areas but will generally identify areas of not-normal myocardium based on its contrast mechanism.

Beside fibrosis also the identification of myocardial edema and the location of potential fat infiltration with T1 or T2 weighted techniques are important in clinical routine.

**CONCLUSION:**
The above listed imaging foci and the related imaging techniques are the backbone of todays’ cardiac MR imaging. While each component can be assessed by its own the key to successful clinical cardiac MR imaging and diagnostic performance is the linkage of findings gained in the various components as findings often interact. Diseases such as coronary artery disease (CAD) may result in myocardial
infarction (assessed by LGE imaging), myocardial hypoperfusion (assessed by perfusion imaging) and ultimately result in global or regional functional abnormality (as assessed by functional cardiac imaging). Knowledge about the basics in diseases, anatomy and function are therefore crucial for a successful implementation of cardiac MRI. It is also important to recognize that cardiac MR is not required in every single cardiac patient and that other modalities may complement findings of cardiac MRI.