Perfusion CMR

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Introduction

Perfusion CMR is an accurate non-invasive test used to assess areas of myocardial ischaemia. It's diagnostic performance, risk stratification capabilities and ability to guide appropriate use of coronary intervention is well established. In undertaking perfusion CMR there are a number of practical considerations and differing methods to be considered – including choice of pharmacological vasodilator agent and pulse echo sequence.

Key Words

Stress CMR, Perfusion, pulse echo sequence, stress agents

Main Body

Stress perfusion CMR provides information regarding the presence and amount of myocardial ischaemia. It has been shown to have excellent sensitivity and specificity in detecting functionally relevant coronary artery stenosis as well as being of strong prognostic value in clinical risk stratification.

Perfusion CMR is usually performed during pharmacological vasodilation with agents such as dipyridamole, adenosine and regadenoson®. When these agents are administered intravenously, they cause vasodilation which increases coronary blood flow by approximately 2-4 times. This results in visible differences in myocardium supplied by normal coronary arteries than that supplied by coronary arteries with significant stenosis. Through the administration of gadolinium based contrast agents these flows differences can be detected as differences in signal intensity of the myocardium.

Stress perfusion may be undertaken at both 1.5T and 3T. A form of parallel imaging is needed for this technique. At least 3 slices, with slice thickness of 8-10mm, are acquired in the short axis plane. An in-plane resolution of <2.5mm is recommended and the dataset is ideally acquired every heart beat – parameter adjustment immediately prior to contrast administration may be required in order to achieve this. A higher resolution image may be acquired at 3T due to the inherent greater signal at this field strength. However, this may be offset by other factors encountered while undertaking CMR at 3T. The "3 out of 5" technique may be used to aid slice prescription and it is always recommended to run a "dummy scan" to check for correct slice positioning and artefacts.

There are a number of vasodilator stress agents that may be used:

1. Adenosine – standard dose 140mcg/kg/min for at least 3 mins. Higher dose of 170mcg or 210 mcg/kg/min may be considered if haemodynamic response is considered inadequate.
2. Regadenoson® – 0.4mg single bolus injection
3. Dipyridamole – 0.56mg/kg in 4 minutes.

The choice of agent is dependent on local practices and policies. However, all have contraindications – known hypersensitivity, 2nd/3rd AV nodal block and severe reversible airways disease.

A low contrast uptake in the spleen at first pass, "splenic switch off" is indicative of adequate adenosine effect. However, regadenoson® does not cause splenic switch off. Dobutamine may be used also for stress imaging but causes high heart rate and ischaemia.

Regardless of the choice of stress agent, the patient preparation should, as much as possible, be carried out prior to the exam, with cannulation of appropriate number and gauge of cannula, explanation and practice of breath holding technique done outside the magnetic field, prior to the examination.

There are a number of sequences that may be used for image acquisition:

1. Fast spoiled gradient echo (FGE)
2. Balanced steady state free precession (bSSFP)
3. Echo planar imaging (EPI)

There is no consensus as to which is the optimal sequence to use. Theoretically, FGE is less susceptible to ghosting artefacts. However, it has been shown practically that hybrid EPI is less prone to artefact then FGE. bSSFP generates the greatest signal of the three methods. This higher signal to noise ratio can be used to make it a faster sequence then FGE and it has been shown to have a better sensitivity for detecting perfusion defects; however, it is the most prone to artefacts caused by off resonance magnetisation, ghosting and is also prone to Gibbs ringing (dark rim artefact) in the myocardium due to the increase difference in signal intensity between the blood and myocardium. The dark rim artefact will be present at first and second pass.

A perfusion defect will appear as a hypointensity along the subendocardium in a coronary distribution. This is because the gadolinium based contrast agent enters the normally perfused myocardial segments more quickly and at higher concentrations compared to abnormally perfused segments. Therefore, the normal myocardium has a more rapid and greater increase in T1 signal when compared to abnormally perfused myocardial segment. . Perfusion images should be interpreted in conjunction with late gad enhancement images to determine if perfusion defects are due to ischaemia or established infarction.

The most common method of reporting myocardial perfusion is by visual assessment/analysis of the dynamic series played as a movie loop, similar to cine imaging. Regions that appear as transient areas of relative reduced signal intensity are taken to be due a physiologically significant reduction to myocardial blood flow and deemed to be perfusion defects. Quantitative analysis may also be undertaken.

Conclusion

Perfusion CMR is a technique used for the assessment of myocardial ischaemia, involving the administration of a pharmacological stress agent to achieve maximum hyperaemia and gadolinium based contrast agent. There are a number of imaging sequences available for image acquisition; fast imaging techniques must be used in order to acquire all the data is each R-R interval. Perfusion imaging may be used to monitor and assess severity of known or suspected coronary artery disease. It can play an increasing part in the care of patients with known or suspected coronary artery disease.

References/Links

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