# Cardiovascular Magnetic Resonance Imaging:
## What Are the Clinical Applications?

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MRI is a widely used diagnostic imaging technique worldwide, with established applications in neurological, musculoskeletal, oncological, and abdominal imaging. Although cardiovascular MRI represents only a small fraction of the examinations performed each year, it has emerged as a powerful tool for the evaluation of cardiovascular anatomy and function in selected patients.

The use of cardiovascular magnetic resonance (CMR) imaging for the diagnosis and management of cardiovascular disease has several potential advantages. First, CMR has the ability to produce high resolution, high soft contrast images in any desired plane of the entire body. Furthermore, this is accomplished noninvasively without the use of ionizing radiation. This facilitates the subsequent monitoring of conditions without incurring the risks associated with ionizing radiation exposure. This makes CMR an extremely safe imaging method provided some precautions are taken. Ferromagnetic items can become dangerous projectiles in the scanner room; therefore pacemakers, defibrillators, and cerebrovascular clips are contraindicated for CMR. The MRI contrast agent gadolinium has proved extremely safe in millions of patients, but the occurrence of nephrogenic systemic fibrosis, which is a potentially fatal condition, has been associated with its use in patients with pre-existing renal disease. Additionally, CMR has been proven to be more accurate and reproducible than other techniques, which makes it the technique of choice for the longitudinal study of patients over time to monitor the effects of therapy. Finally, CMR can evaluate multiple indexes of cardiac status: function, anatomy, flow, tissue characterization, perfusion, angiography, and metabolism. This versatility relies on the availability of multiple imaging sequences that provide complementary information. This comprehensive evaluation comes at the price of long and complex examinations requiring patients to hold their breath several times. This makes CMR unfeasible in an unstable/frail patient who is unable to co-operate. The duration of a CMR study typically ranges from 30 to 60 minutes.

### Clinical Indications

CMR can be used in the clinical setting across a broad range of clinical applications. The challenge is to identify as clearly as possible the unique capabilities of each imaging technique and to develop algorithms for their best integration into patient care pathways.[1]

CMR can measure ventricular volumes, mass, calculate ejection fraction, and detect the presence of wall motion abnormalities using a multi stack acquisition of contiguous short-axis cine images covering both ventricles. These data are used to decide therapy and need for interventions in patients with heart failure, ischemic and valvular heart disease.[2]

CMR is often used for imaging the great vessels. The ability of CMR to visualize the entire thorax allows the depiction of aortic coarctation, aortic aneurysm and dissection, pulmonary artery and branches stenosis as well as detection of anomalous pulmonary venous connections. Velocity mapping provides reliable quantification of blood flow velocity.

The assessment of patients with congenital heart disease with CMR has significantly reduced the need for diagnostic catheterizations in these patients. CMR is particularly useful because it provides a noninvasive and comprehensive evaluation not only, of the often complex, intracardiac, but also of the extracardiac anatomy, which is frequently abnormal in patients with congenital heart disease. CMR can be used to quantify the severity of shunting, which is required to determine the need for repair of congenital lesions like ventricular or atrial septal defects. In addition, CMR can depict the origin, initial course and spatial relationship of the coronary arteries in (generally young) patients with suspected coronary anomalies that are known to occur in 0.5 to 1% of the population. CMR is, however, not a good technique to detect coronary artery stenoses because of limited spatial resolution.

## *Ischemic Heart Disease*

Myocardial ischemia can be detected with stress perfusion CMR using adenosine or dipyridamole. This method has been shown to be more accurate than stress echocardiography, particularly in patients with poor acoustic windows (30% of subjects).

Myocardial infarction can be detected using late gadolinium enhancement (LGE). Infarcts as small as 2 g can be visualized. Additionally, as considerable additional information becomes available, (this includes infarct size, location, and extent, as well as type of infarction, subendocardial vs. transmural, presence of microvascular obstruction or hemorrhagic component, all of which carry prognostic significance) LGE can also be used to detect viable myocardium. Detection of transmural enhancement predicts low likelihood of functional recovery after coronary revascularization.

Studies have shown that CMR can determine the cause of symptoms in 65% of patients presenting with chest pain, positive troponins, and unobstructed coronary arteries on invasive angiography. This is not an uncommon situation. Myocarditis was found in 50%, myocardial infarct with normal coronaries in 11%, apical ballooning (also known as Takotsubo cardiomyopathy) in 2%, and other forms of cardiomyopathy in 2%.

## *Cardiomyopathy*

CMR features, especially the location and extent of LGE, can help determine the etiology of cardiomyopathies. Hypertrophic cardiomyopathy is associated with areas of increased wall thickness, and, predominantly, a patchy enhancement involving the interventricular septum. The later correlates very closely with fibrotic replacement of the myocardium and is associated with a higher risk of ventricular arrhythmia. Cardiac amyloid is characterized by diffuse hypertrophy involving the left and right ventricular myocardium and by a distinctive pattern of diffuse subendocardial enhancement. Other cardiomyopathies, such as arrhythmogenic right ventricular cardiomyopathy, cardiac sarcoidosis, Fabry disease, and iron overload cardiomyopathy, can also be diagnosed and characterized using CMR. Finally, CMR shows the pericardium with good resolution as a thin line over the heart. CMR can be used to measure pericardial thickness and help differentiate between restrictive cardiomyopathy from pericardial constriction.

## Conclusions

Recent improvements in noninvasive cross-sectional CMR imaging have led to a broader utilization of this technique for the detection and management of cardiovascular disease. The precise role of each imaging modality will evolve over time. Currently, echocardiography remains the first line imaging technique used for the great majority of patients. However, echocardiography can be difficult to perform providing suboptimal imaging and does not provide good visualization of extra-cardiac structures. In these situations, CMR is particularly useful to define anatomy and physiology as well as when myocardial characterization and detection of infarcted myocardium is clinically relevant.

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References

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