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Abstract

The paper refers to the safety of MRI in patients with prosthetic heart valves or coronary stents. This is commonly regarded as a contraindication for MRI excluding patients from the diagnostic imaging information provided by one of the most important noninvasive imaging modalities. Based on available evidence to date, all patients with prosthetic heart valves or coronary stents can safely undergo MRI at 1.5 Tesla and the vast majority at 3 Tesla too.

Keywords: metallic mechanical valve; bioprosthetic valve; coronary stent; bare-metal, drug-eluting; coronary artery disease; valvular heart disease
Patients with prosthetic valves (mechanical or bioprosthetic) or coronary stents may have an indication to undergo magnetic resonance imaging (MRI). Sometimes these patients are excluded from MRI, on the basis that they have an implant that makes them unsuitable for the magnetic resonance (MR) environment. The aim of this paper is to educate patients and physicians about the safety of MRI in individuals with prosthetic heart valves or coronary stents.

For the generation of MRI pictures we need a constant static magnetic field, a rapidly changing magnetic gradient field, and radiofrequency pulses. The higher the static magnetic field of the MR system, the greater the resultant ferromagnetic forces on weakly or overtly ferromagnetic materials. Currents in electrically conductive devices and peripheral nerve excitation can be induced by changing magnetic fields. As a result of ferromagnetic interactions (attractive force in the presence of a magnetic field), a device may be moved, rotated, dislodged, or accelerated toward the magnet. A ferromagnetic object might be accelerated toward the magnet at high velocities creating a “projectile effect” that could lead to significant patient injury or damage to the MR system. Device function may also be altered as a result of interactions with the strong static magnetic fields. Certain metallic devices, such as pacemaker leads, may concentrate radiofrequency energy resulting in significant local heating. Furthermore, exposure to the electromagnetic field used by MRI scanners may adversely affect the operational or functional settings of an electronic device.

Practically all prosthetic heart valves, mechanical or bioprosthetic, and all coronary stents are considered safe in the MR environment at field strengths of up to 1.5-Tesla. This is also true for most prosthetic valves at the higher field strength of 3-Tesla, although evaluation is still pending for some valves. Even patients who carry old mechanical prostheses such as the Pre 6000 Starr–Edwards caged-ball prosthesis (available from 1960 to 1964) are safe to undergo MRI at 1.5-Tesla, including assessment of the heart itself (cardiovascular magnetic resonance-CMR). It should be noted that the forces exerted on prosthetic valves and coronary stents are less than the forces exerted by gravity or the beating heart and resultant pulsatile blood flow. Temperature changes due to radiofrequency pulses are also considered minimal. MRI can be safely performed, even 24 hours post-implantation, if needed. Importantly, scanning patients with sternal wires is safe. In patients with retained epicardial pacing wires following cardiac surgery, there are no reports of adverse events or arrhythmias during MRI up to 1.5T with conventional pulse sequences.
All novel prosthetic valves and coronary stents are undergoing safety assessment in the MR environment at the commonly used field strengths of 1.5 and 3-Tesla. Notably, there has never been an adverse event reported in association with performing MRI in patients with these particular implants. Two options are available when uncertainty exists about the safety of a specific valve prosthesis or coronary stent. First the manufacturer should mention on the instructions for use pertinent MRI labelling information indicating whether the valve prosthesis or coronary stent is safe and under which conditions. Another option is to look for relevant safety information on online resources e.g. www.mrisafety.com which are available for checking on safety on any devices for MR imaging. Importantly, MRI is safe to be performed in patients with transcatheter heart valves, as well as other similar valve implants used in association with minimally invasive procedures and annuloplasty rings.6-7

By adhering to the following guidelines, all patients with heart valve prostheses and annuloplasty rings or coronary stents (bare-metal or drug-eluting) can undergo MRI:

(1) Patients with all commercially available heart valve prostheses and annuloplasty rings can be scanned at 1.5-Tesla/64-MHz or 3-T/128-MHz, regardless of the value of the spatial gradient magnetic field.

(2) Patients with all commercially available heart valve prostheses and annuloplasty rings can undergo MRI immediately after placement of these implants.

(3) The MRI examination must be performed using the following parameters:

- 1.5-Tesla or 3-Tesla, only
- Whole body averaged specific absorption rate (SAR) of 2-W/kg, operating in the Normal Operating Mode for the MR system
- Maximum imaging time, 15 minutes per pulse sequence (multiple sequences per patient are allowed)

Image quality in patients with prosthetic heart valves undergoing cine CMR varies depending on the ferromagnetic components of the prosthesis.4 For example bileaflet and titanium-containing valves cause fewer artifacts than monoleaflet valves or cobalt-chromium alloys. Even some annuloplasty rings can cause significant image distortion when they contain metal. In general, bioprosthetic valves are friendlier with image quality, with stentless bioprostheses causing practically no artifacts at all. Recently, the European Association of Cardiovascular Imaging (EACVI) has included CMR as one of the available options to assess patients with prosthetic heart valves,8 indicating that the role of CMR is not yet routine
practice but it increasing. Overall, there is an increasing body of literature that supports the use of CMR in patients with prosthetic heart valves, and this tears down the myth that MRI is not safe for these patients. Image quality is not affected in patients with coronary stents, with the exception of MR coronary angiography which may be hampered by artefacts, but the assessment of coronary stent patency is not an appropriate clinical indication for CMR imaging.

To conclude, according to available evidence to date, no patient who has a prosthetic valve or annuloplasty ring, or has undergone transcatheter valve replacement or percutaneous edge-to-edge mitral valve repair, or percutaneous coronary stent implantation should be excluded from MRI, including imaging of the heart itself. Image quality on CMR varies depending on the valve prosthesis, but remains diagnostic in most centers with relevant experience.
REFERENCES


