

Safety of Magnetic Resonance Imaging in Cardiac Surgery Patients: Annuloplasty Rings, Septal Occluders, and Transcatheter Valves

To the Editor:

We read with interest the review by Baikoussis and colleagues on the safety of magnetic resonance imaging (MRI) in patients with implanted cardiac prostheses and metallic cardiovascular electronic devices [1]. We congratulate the authors for their extensive review of the literature. The subject is of obvious interest to the practicing cardiac surgeon, as we are not infrequently asked if a patient on whom we have operated can safely undergo MRI. Such a review, if complete, could be a useful tool to keep at hand.

We would like to discuss additional issues, unfortunately not addressed in the review. The authors do not discuss 2 major categories of devices: annuloplasty rings and cardiac/septal occluder devices. There is little data in the literature regarding MRI safety for annuloplasty rings [2]. Several rings have displayed measurable yet relatively minor magnetic field interactions. The Carpentier-Edwards Physio Annuloplasty Ring (Edwards Lifesciences, Irvine, CA) in particular, which contains elgiloy, appears to have a significantly smaller margin of safety at 4.7 T compared with the other implants, and it was noted that this particular annuloplasty ring appeared to develop an increasing magnetism on reentry into the MR system [3]. MR-related heating of annuloplasty rings is minor and likely dissipated by flowing blood.

Regarding septal occluder devices, several closure devices have been evaluated, and acceptable deflection angles, torque, and MR-related heating were found [4]. There is very little data regarding left atrial occluder devices [5], but most appear "MRI safe." With the plethora of annuloplasty and occluder devices on the market and so little data, could the authors comment on what we should know about these devices and their MRI safety?

One further point of interest, and particularly timely, is the MRI safety of transcatheter-placed heart valves. The forces required to pull a suture through degenerative valve annulus tissue are significantly greater than magnetically induced forces at less than 4.7 T, and it has been considered unlikely that valve dehiscence would be induced during exposure to static magnetic fields up to 4.7 T [6]. Does this remain true for sutureless, transcatheter-placed valves? MRI after percutaneous pulmonary valve replacement has been done safely [7]. As for the aortic valve, the potential for dislodgment and coronary occlusion is real, although it has not been reported to date in clinical settings [8]. The closest current comparison could be made with septal occluder devices, as these devices also risk dislodgment and embolization. Current guidelines recommend waiting 6 weeks after implantation of a weakly ferromagnetic septal occluder device [5]. Should similar recommendations be made for these new devices?

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Reply

To the Editor:

We thank Dr Patrick Myers and colleagues [1] for their interest in our review regarding the safety of magnetic resonance imaging (MRI) in patients with implanted cardiac prostheses and metallic cardiovascular electronic devices [2] and appreciate the opportunity to respond.

Annuloplasty rings, except those containing Elgiloy, appear to be safe in static magnetic fields up to 4.7 T. The translational and rotational forces of such a magnetic resonance (MR) environment are minor, although measurable with regard to some rings. However, prostheses made from Elgiloy demonstrated deflection angles three times greater at 4.7 T than those previously measured at 1.5 T, so they may not be MRI safe at 4.7 T [3]. Furthermore, MR-related heating of annuloplasty rings is also minor at 3 T. Consequently, patients having annuloplasty rings formally assessed for MR safety can safely undergo an MR examination at 3 T or less (and possibly even at 4.7 T in some cases), no matter the time of the implantation [4].

Several septal occluder devices (CardioSEAL Septal Repair Implant, and STARFlex Septal Repair Implant, NMT Medical,

Boston, MA) subjected to an MR environment of 3 T have also been proved to be related with minor magnetic field interactions, not excessive heating and artifacts creating a problem just at the close vicinity of the device, so MRI at 3 T can safely be performed immediately after the implantation of the aforementioned devices [5]. Therefore, patients having nonferromagnetic occluder devices may undergo MR procedures at any time after implantation [4], whereas those with weakly ferromagnetic closure devices can more safely undergo an MR examination of 3 T or less at approximately 6 weeks after device implantation [4, 6] to ensure that the device is fixed to the endocardial tissue, providing additional retentive force [6].

Regarding MRI safety for sutureless and transcatheter valves, data in the current literature are unfortunately nearly absent. According to the official instructions for use, a static magnetic field of 3 T or less is safe for the Edwards SAPIEN and the Medtronic CoreValve bioprostheses currently used for transarterial aortic valve implantation *in vivo*. Moreover, these devices generate a maximal temperature increase of 0.5°C and up to 3.6°C for 15 minutes of MRI, respectively [7]. Magnetic resonance imaging has also been performed safely within just 1 month after percutaneous pulmonary valve implantation [8]. However, further studies are required to elucidate this topic.

Generally, weighing the benefits and risks will determine the necessity of MRI performance when a weakly ferromagnetic device has been implanted. In cases in which the benefits of MRI outweigh its risks (such as in acute back pain after trauma), the MRI should be performed at any time after implantation, but when the performance of an MR scan is not urgent (such as in chronic back pain for years), the deferment of the MR examination until approximately 6 weeks after device implantation is more reasonable [9].

We sincerely appreciate Patrick Myers and colleagues' constructive comments, and we hope that our discussion will shed some light on these absolutely important issues.

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Impact of Annuloplasty Device Aggressiveness on Leaflet Coaptation

To the Editor:

We wish to congratulate Dr Vergnat and colleagues on demonstrating the utility of analytic real-time three-dimensional (3D) echocardiography in the analysis of mitral repair strategies [1]. However, we wish to point out that the analyses used by the authors for atrial and ventricular coaptation edges were incompletely characterized. Independent leaflet coaptation zone lengths can be calculated for both the anterior and the posterior leaflet components for each segment of the valve (A1–P1, A2–P2, A3–P3) [2] as well as along the entire line of coaptation. Therefore, data are available for the coaptation area for leaflet surfaces plus the actual coaptation contact area for each segment. A more complete analysis would reveal the amount of “leaflet reserve” and perhaps give a better understanding of a particular repair strategy's robustness, particularly in the search for a “restoration of an optimal area of leaflet coaptation.” We need to point out that this was the analysis performed in the article by Gogoladze and colleagues that was cited; ie quantified multidimensional coaptation lengths (multiple valve zones) were measured, not just a central coaptation length, as claimed by the authors.

Finally, we question why the authors choose to compare annuloplasty devices with different degrees of remodeling aggressiveness. The Profile 3D has roughly a height-to-width ratio of 0.63, whereas the Physio has a height-to-width ratio of 0.75 (manufacturers' brochures). Aggressive anterior–posterior remodeling by itself will increase coaptation in the central portion of the valve, and the devices tested were not equivalent in this regard. Consequently, this zone is where the authors noted the greatest differential in coaptation length (Fig 5 in the article). Thus, the height-to-width ratio may potentially account for this difference rather than the saddle-shape design of the device, or

Drs Grossi and Galloway disclose that they have financial relationships with Edwards and Medtronic.