Robotic transcatheter aortic valve replacement with magnetic resonance imaging is feasible in animal models, but is it feasible in patients?

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Imaging remains one of the most critical aspects in the evaluation of a patient in consideration for transcatheter valve procedures. The preoperative assessment of the patient undergoing transcatheter aortic valve replacement (TAVR) includes a combination of computed tomography and transthoracic or transesophageal echocardiography. The use of cardiac-phased computed tomography has led to a significant change in the determination for the size of the prosthesis used, leading to an improvement in paravalvular leaks after TAVR. To date, however, there has been a paucity of advances from the most common intraoperative imaging strategies: fluoroscopy and either transthoracic or transesophageal echocardiography. A noted disadvantage of fluoroscopy potentially includes the high doses of ionizing radiation to which the patient and surgical team are exposed, as well as the relatively poor tissue penetrance in obese patients during the valve replacement procedure. Recently, Horvath and his group have explored magnetic resonance imaging (MRI) as a possible alternative imaging modality during TAVR.¹⁻⁵ This innovative technique may offer superior tissue contrast, nonionizing radiation, and the ability to visualize anatomic landmarks more clearly than with echocardiography. In addition, MRI allows the option to assess myocardial perfusion immediately after the TAVR procedure.

One of the drawbacks of using real-time MRI for TAVR in patients includes the challenge for the medical team of working within the confines of the MRI scanner.^{1,2} Most recently, in their article published in this issue of the *Journal*, Miller and colleagues³ have proposed a novel solution to the technical challenges imposed on a physician operating within the MRI machine by removing the physician from the operative field entirely! To facilitate this, an “MRI compatible robotic surgical assistant system” was designed to position and deliver the aortic valve prosthesis

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Central Message

Is magnetic resonance imaging–assisted transcatheter aortic valve replacement feasible in real-world practices?

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with 1-mm accuracy controlled by custom software. This has the potential for very precise deployment of the TAVR prosthesis, leading to reduced paravalvular leaks. With these techniques, this group has previously done some ground-breaking work by showing excellent long-term survival in a porcine model undergoing intraoperative real time MRI and TAVR.⁴ In this study of Miller and colleagues,³ although proper valve placement was confirmed with MRI in all animals after deployment, at necropsy it was noted that the stents were displaced by 1 to 4 mm relative to the perioperative imaging. Miller and colleagues³ mentioned that all 8 stents were implanted 4 mm below the annulus. In patients with heterogeneous anatomy coupled with a variable root, annular, and subannular calcifications, however, this technique may prove to be difficult.

Another concern with the robotic assistant system described is that the degree of angulation is stated to be up to 5 degrees of freedom. Although this may be sufficient in routine cases, a surgeon may need more extreme angles to ensure coaxial alignment for optimal valve deployment. In case of an apical catastrophe, does this system allow quick access to the patient?

In an era when it is anticipated that more than 90% of TAVR procedures will be performed with transfemoral techniques, does this technique lead to a more complex procedure instead of simplification of the

TAVR procedure, as in the minimalist procedure?⁶ Moreover, among the 400 US programs performing TAVR, how many have a hybrid operating room with MRI capability? The relative difficulty of performing intraoperative MRI versus transthoracic echocardiography for a minimalist TAVR procedure or transesophageal echocardiography in an intubated patient is tremendous. The additional cost of a robotic assistant may also be beyond the infrastructure of the majority of TAVR programs.

Miller and colleagues³ are to be complimented on their advancements in the development and refinement of the robotic MRI-guided TAVR procedure. Further improvements in this technology with the adoption of transfemoral procedures may truly represent the dawn of a new era.

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