Operative Techniques in Thoracic and Cardiovascular Surgery

Magnetic Resonance Imaging as a Decision-Making Tool in Congenital Heart Disease Surgery

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Magnetic resonance imaging (MRI) is an integral imaging modality that provides information regarding cardiovascular anatomy, blood flow velocities and volumes, regional and global ventricular functions, and myocardial healthiness.[1] As compared with other imaging modalities, such as echocardiography and computed tomography (CT), MRI has the following strengths: (1) MRI is the gold standard tool for measuring the volumes of the cardiac chambers,[2] (2) phase-contrast velocity mapping technique is the most accurate tool for measuring blood flow volumes,[3] (3) MRI is able to detect and measure diffuse as well as focal myocardial fibrosis,[4-7] and (4) MRI provides 3-dimensional (3D) volume data that allow reconstruction of the sectional or volume-rendered images in any plane.

Several new techniques introduced in the last few years have further enhanced the use and accuracy of MRI in pediatric cardiovascular MRI. They are as follows: (1) *MR angiography with an intravascular contrast agent* (gadofosveset trisodium [Ablavar, Lantheus Medical Imaging, N. Billerica, MA]) that stays in the blood for an extended period of time. Injection of an intravascular agent allows enough imaging time not only for acquisition of high-definition images but also for elimination of cardiac and respiratory motion artifact by implementing electrocardiographic gating and respiration navigation (Fig. 1).[8,9] (2) *Rapid prototyping or 3D printing* by which physical replicas of the patient's heart can be manufactured using 3D volume data from MRI or CT (Fig. 2).[10,11] The MRI or CT image data are reconstructed and reformatted into very thin slices, and the printer continuously builds up the printing material layer by layer according to the digital data of each reformatted slice until the whole object is composed. The replicas can be made for the blood and also for the endocardial surface anatomy by putting a shell outside the blood. (3) *4D MR flow technique* that allows acquisition of blood flow information for all vessels included in the 3D imaging volume at the same time and therefore under the same physiological status.[12,13] In addition to blood flow data of all vessels, the ventricular volumes can also be assessed from the same image data set, as phase-contrast velocity mapping technique is a modification cine-imaging technique.[13] (4) *Feed-and-sleep MRI* in which a sleeping infant is placed in a vacuum immobilizer after 4 hours of fasting and then given a generous amount of milk.[14] Others and we have employed this approach successfully in almost all infants aged less than 3 months and in most infants aged between 3 and 6 months.[14,15]

With the strengths and newly developed techniques listed earlier, MRI is indicated when the surgical anatomy is complex and difficult to understand using echocardiograms alone or the quantification of the ventricular and blood flow volumes is required for a management decision. When its use is finely tuned for each individual case, MRI is a powerful and valuable tool for surgical decision making and planning. In this review article, we illustrate clinical examples where cardiovascular MRI plays a key role in decision making for congenital heart disease surgery (Figs. 3-6).

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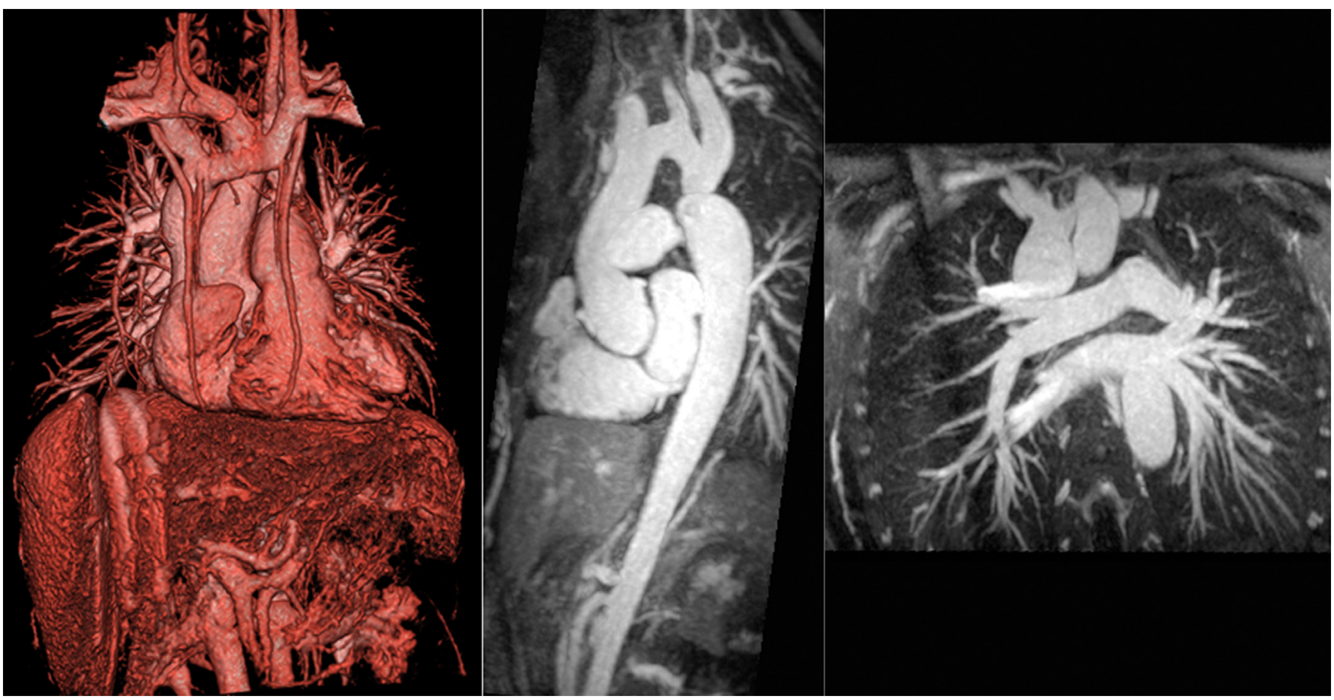

Figure 1 Maximum intensity projection (MIP) and 3D volume-rendered (VR) (left panel) images reformatted from ECG-gated and respiration-navigated 3D angiogram using an intravascular agent in a 16-year-old patient with severe coarctation of the aorta. The images are almost free of motion artifact. As the images are obtained in the equilibrium phase of contrast distribution, all vessels show homogeneous signal intensity without artifacts from turbulent flow. ECG = electrocardiographic. (Color version of figure is available online at www.optechtcs.com.)