A simplified approach for assessment of intracardiac baffles and extracardiac conduits in congenital heart surgery with two- and three-dimensional magnetic resonance imaging

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Background Intracardiac baffles and extracardiac conduits have been used in the reconstructive surgery of a broad spectrum of congenital cardiac malformations. Periodic evaluation of these structures may not lend itself readily to echocardiographic and angiographic imaging. The purpose of the study was to describe the experience of our institution with the use of magnetic resonance imaging (MRI) in evaluating conduits and baffles and to describe the simplified approach we developed to image these structures, which allows for grouping individual lesions into broad categories.

Methods and Results We retrospectively reviewed our MRI experience in visualizing these structures from 1989-1996. One hundred thirty-nine patients underwent MRI to visualize 144 structures (116 baffles, 28 conduits). The 116 baffles included 86 Fontan, 16 Mustard, 6 Senning, 6 left ventricle to aorta, 1 right ventricle to aorta, and 1 pulmonary vein to left atrium baffle. The 28 conduits included 15 right ventricle to pulmonary artery, 4 left ventricular apical to aorta, 2 left ventricle to pulmonary artery, 3 aorta to aorta, 2 inferior vena cava to left atrium conduits, and 2 aortic root replacements. Of the 3 aortic-aortic conduits, 1 was in conjoined twins. Both inferior vena cava–left atrial conduits were in a Fontan procedure. An infectious mass missed by echocardiography in a right ventricle to pulmonary artery conduit was visualized by MRI. With multiplanar reconstruction, contiguous images were stacked atop each other and resliced to define the salient points of the anatomy. Three-dimensional reconstruction further added to this delineation. All structures were visualized successfully, and an assessment of obstruction was made. Multiple examples of conduit and baffle narrowing were diagnosed by spin echo and cine MRI and were subsequently confirmed by catheterization and surgical inspection.

Conclusion MRI, with multiplanar and 3-dimensional reconstruction, is useful in examining the variety of baffles and conduits used in congenital heart surgery. MRI can add to the care of patients whose echocardiographic windows or whose angiographically overlapping structures do not allow adequate delineation of conduits and baffles. (Am Heart J 2001;142:1028-36.)

Intracardiac baffles and extracardiac conduits play an important role in congenital heart disease.1,6 Reconstructive surgery of complex congenital malformations depends on these types of structures for successfully separating the circulations and allowing for unobstructed flow in the systemic and pulmonary venous pathways as well as the systemic and pulmonary arterial pathways. Some of these structures are commonly used, such as the Fontan baffle4 and some are rarely used, such as a left ventricle to pulmonary artery conduit.2 Some reconstructive surgery even requires 2 structures in the same heart, such as a left ventricle to aorta baffle and a right ventricle to pulmonary artery conduit in a Rastelli procedure1 to repair transposition of the great arteries with subpulmonic stenosis and a ventricular septal defect.

Conduits and baffles are usually made of synthetic materials that do not grow with the patient and periodically need to be assessed for the adequacy of the pathway. Noninvasive assessment of these structures can frequently be performed by echocardiography; however, in many instances, echocardiography cannot delineate all that is necessary for the successful evaluation of these hearts. Structures such as the Fontan baffle may be too posterior in older individuals to be viewed by the transthoracic method and other structures such as a right ventricle to pulmonary artery conduit may be too anterior, lodged beneath the sternum.

Magnetic resonance imaging (MRI) provides a noninvasive alternative to transesophageal echocardiography and cardiac catheterization to delineate these structures...
in the management and follow-up of these patients. Previous reports cite the use of MRI for individual lesions 7-10; however, a comprehensive evaluation of the utility of MRI to image the many types of baffles and conduits found in congenital heart surgery has not been reported.

The purpose of this study was to review the experience of a single institution’s use of MRI in evaluating conduits and baffles used in congenital heart surgery. This study describes the simplified approach we have developed for imaging these structures by MRI, which allows for grouping of individual lesions into broad categories.

**Methods and material**

**Patients**

We retrospectively reviewed all the cardiac MRI scans performed at the Children’s Hospital of Philadelphia from December 1, 1989, through September 1, 1996, to identify patients with conduits and baffles. One hundred thirty-nine patients were identified. A breakdown by the types of conduits and baffles imaged is shown in Table I. Ages were 9.8 ± 8.5 years (range 5 days to 22 years) at the time of MRI evaluation. Heart rate was 76 ± 24 beats/min. Time from operation was 7.6 ± 6.7 years.

Patients were stable enough to undergo a 1-hour MRI scan because scans lasted from 30 minutes to 1 hour. Many had their scans performed under sedation. Patients who were sedated before imaging tolerated sedation without incident. Sedation consisted of either chloral hydrate 75 to 120 mg/kg (oral) or pentobarbital sodium (Nembutal) 2 to 6 mg/kg (intravenous) (if <2 years old). If >2 years old, the patient was given either pentobarbital sodium 4 mg/kg orally and meperidine hydrochloride (Demerol) 3 mg/kg orally or pentobarbital sodium 2 to 6 mg/kg intravenously. No patient had an arrhythmia that precluded imaging in the scanner.

**Magnetic resonance imaging**

Studies were performed on a 1.5-Tesla Siemens Vision or SP-63 system (Siemens Medical Systems, Islen, NJ). The scanning protocol was as follows:

1. Localizers were performed with a fast low-angle shot (FLASH) sequence to locate cardiovascular structures in the chest.
2. Electrocardiogram (ECG)-gated, T1-weighted, spin-echo transverse images were acquired spanning the region of the heart and great vessels. The effective repetition time (TR) was the RR interval (range 300-1000 milliseconds), the echo time (TE) ranged from 7 to 15 milliseconds, the number of excitations (NEX) was usually 3, the image matrix size ranged from 128 × 256 to 256 × 256 pixels, the field of view (FOV) ranged from 140 to 450 mm, and the slice thickness ranged from 2 to 10 mm. These transverse images were used to evaluate general cardiovascular anatomy, to identify and evaluate the conduit and baffle, and as localizers for subsequent imaging. This image set was obtained first so that, in the unlikely event that the study had to be terminated prematurely, one full volume set was obtained for multiplanar reconstruction or 3-dimensional imaging.
3. Various sets of ECG-gated, T1-weighted, spin echo images were then acquired to obtain short- and long-axis images of the conduit and baffle for morphologic evaluation of these structures. Stenosis, dilation, and tortuosity of these structures were identified in this image set. Image parameters were the same as in (2).
4. ECG-gated, gradient-echo images were obtained for functional evaluation of the conduit and baffle. Eight to 20 images were obtained spanning the entire cardiac cycle. TR ranged from 30 to 60 ms (depending on the R-R interval), the TE was 7.3 ms, the FOV was 180 to 450 mm, the matrix was 128 × 256 pixels, which was interpolated to 256 × 256 pixels, the NEX was 3, and slice thickness ranged from 4 to 10 mm.

**Offline data analysis**

**Two-dimensional MRI imaging.** Both static and dynamic (cine) 2-dimensional images were viewed on the scanner console with proprietary software to evaluate morphologic features and function.

**Three-dimensional MRI imaging.** Two types of 3-dimensional MRI imaging were performed by offline analysis: (1) multiplanar reconstruction (also referred to as oblique sectioning) and (2) 3-dimensional shaded surface display.

In multiplanar (Figure 1) reconstruction, contiguous transverse MRI images are stacked one atop the other, and the user can select any oblique planes necessary to view the salient parts of the anatomy. The calculation is performed in real time with interpolation. Once the optimal view is achieved, this image can be used for measurements and saved for future displays. This was performed on the scanner console. In addition, images were also downloaded from the Magnetom onto a Sun SPARC station 10 (Sun Microsystems, Palo Alto, Calif) and VIDA (Volumetric Image Display and Analysis), 11,12 a soft-

### Table I. Number various types of conduits and baffles imaged by MRI*

<table>
<thead>
<tr>
<th>Baffles</th>
<th>No.</th>
<th>Conduits</th>
<th>No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fontan</td>
<td>86</td>
<td>Right ventricle to pulmonary artery</td>
<td>15</td>
</tr>
<tr>
<td>Mustard</td>
<td>16</td>
<td>Left ventricle to pulmonary artery</td>
<td>2</td>
</tr>
<tr>
<td>Senning</td>
<td>6</td>
<td>Left ventricle apical to aorta</td>
<td>4</td>
</tr>
<tr>
<td>Left ventricle to aorta</td>
<td>6</td>
<td>Aorta to aorta</td>
<td>3</td>
</tr>
<tr>
<td>Right ventricle to aorta</td>
<td>1</td>
<td>Aorta to root replacement</td>
<td>2</td>
</tr>
<tr>
<td>Pulmonary vein to left atrium</td>
<td>1</td>
<td>Inferior vena cava to left atrium</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>116</td>
<td>Total</td>
<td>28</td>
</tr>
</tbody>
</table>

*There are more structures than there are patients because a number of patients had both a conduit and a baffle.
ware package developed at our institution, was used to perform the same type of analysis called “oblique sectioning” when multiplanar reconstruction on the scanner console was unavailable.

It should be noted that data from this study predates many newer and faster MRI sequences such as true fast imaging with steady-state precession (FISP) and breath-hold cine. As an alternative to multiplanar reconstruction, in select patients these sequences may be used to quickly obtain oblique views to visualize the salient parts of the anatomy.

Figure 1

A, Systemic venous baffles (B): Fontan procedure. Various views of the standard Fontan baffle. This patient has hypoplastic left heart syndrome and has undergone the Fontan procedure. Top left and top middle, T1-weighted off-axis sagittal and cine off-axis coronal (respectively) images of the systemic venous pathway along the direction of flow. The other images are axial views. Top and bottom right, T1-weighted images of the systemic venous pathway in cross-section at the level of the superior vena cava (SVC) to right pulmonary artery (RPA) anastomosis. The native aortic (nAo) to native pulmonary artery (nPAA) anastomosis can be seen. Bottom right, Discontinuity between the branch pulmonary arteries (open arrow). Lower left and middle, Cine and T1-weighted images, respectively, performed at the midbaffle level. The cine demonstrates turbulent flow across a fenestration (Fen). B, Various views of nonstandard Fontan baffles. The patients in these panels have single ventricles and heterotaxy syndrome. Top and middle bottom, T1-weighted axial and off-axis sagittal images, respectively, of an extracardiac conduit connecting the right inferior vena cava (RIVC) to the left superior vena cava (LSVC). Top, from left to right, progress from inferior to superior. Bottom left, An off-axis sagittal image of an intracardiac baffle that connects a left inferior vena cava (LIVC) to a right superior vena cava (RSVC). The full pathway can be visualized. Lower right, Three-dimensional (3-D) shaded surface display in the axial view demonstrating the systemic venous pathway (SVP), including the anastomosis of the right inferior vena cava to the right pulmonary artery and Fontan baffle dilation. C, Multiplanar reconstruction (MPR) of Fontan baffle. Left, T1-weighted axial images of the systemic venous pathway; right, computer reconstructions of the long-axis views in the off-axis coronal (top) and sagittal (middle) planes. Bottom, demonstrating bilateral systemic venous pathway to pulmonary artery (PA) connections, in a complex double oblique plane. Dashed lines, Plane of reconstruction. V, Ventricle; PVP, pulmonary venous pathway; LPA, left pulmonary artery; LV, left ventricle; RV, right ventricle; RA, right atrium, IVC, inferior vena cava; SVC, superior vena cava; RPA, right pulmonary artery; LPA, left pulmonary artery.
For the 3-dimensional shaded surface display (Figures 1 and 2), VIDA was used to manipulate the images and create the display. The process of creating such a display is described briefly:

- On each image, every cavity of interest is identified by thresholding and classified (labeled) by assigning a unique value to each pixel whose original signal value was below the threshold. All other structures are eliminated by decreasing their pixel intensity below that of all selected and labeled cavities.
- The software then stacks the cavity images one atop the other, interpolates the data, and joins and smoothes the edges of each unique cavity. A shading algorithm automatically adjusts the pixel values to create a 3-dimensional appearance.

It should be noted that data from this study predates the widespread use of high-definition 3-dimensional gadolinium sequences, which, in a select group of patients and select purposes, may be used as an alternative to the 3-dimensional shaded surface displays.

**Results**

The full extent of the conduit and baffle were visualized successfully in all cases, which enabled an assessment for obstruction. Multiple examples of conduit and baffle narrowing were diagnosed by spin echo and cine MRI and were subsequently confirmed by catheterization and surgical inspection.

The following was found to be the optimal way to image baffles and conduits by MRI, and examples of each are given. In all cases, T1-weighted axial images through the heart and great vessels were obtained as a first step.

**Baffles**

**Systemic venous baffles (Figures 1 and 2).** In the 108 baffles examined, optimal imaging of the systemic venous pathway used oblique sagittal or coronal images to visualize the long axis of the pathway, although, on occasion, double-oblique angles were needed to image the full extent of the baffle in one view. Axial images yielded short-axis views of the systemic venous pathway in patients with the Fontan procedure and long-axis images in patients with transposition of the great arteries who had undergone an atrial inversion operation. The pulmonary arteries were best imaged in the axial and oblique sagittal or coronal planes to view their long axes. To image the pulmonary venous pathway, axial or oblique coronal images were best. In patients with the Fontan procedure, to look at the presence of fenestrations, gradient echo images in the axial or oblique coronal view were optimal.

In this series, MRI was able to identify fenestrations, pulmonary artery discontinuities (Figure 1, A), baffle dilation (Figure 1, B and Figure 1, C with use of multiplanar reconstruction), and stenosis (Figure 2, A). The pulmonary artery discontinuity and baffle stenosis seen...
in the figures were subsequently confirmed by surgery and cardiac catheterization, respectively. In addition, complex baffle anatomy was visualized well, such as connections between:

- Left inferior vena cava and right superior vena cava
- Right inferior vena cava and left superior vena cava (Figure 1, B)
- Bilateral superior vena cavae to pulmonary artery anastomoses (all structures demonstrated in one image by multiplanar reconstruction, Figure 1, C)
- Systemic and pulmonary venous pathways of a Mustard operation with use of 3-dimensional shaded surface displays (Figure 2, A) and of a Senning operation with use of multiplanar reconstruction (Figure 2, B).

**Ventricular to aortic baffle (Figure 3).** In the 7 patients imaged, we determined that the initial step should use axial images as localizers for oblique coronals in a left anterior oblique view. MRI was able to identify areas of stenosis as well as baffle leaks.

False-negative results may occur if the diagnosis of adequate patency is made on the static T1-weighted axial and oblique coronal images alone because of the dynamic nature of the outflow tract. Therefore, gradient-echo sequences were found to be essential to making the diagnosis definitively by noting the changing size of the outflow tract as well as presence of signal loss with turbulence. This is especially evident on Figure 3, where left ventricular outflow tract obstruction is demonstrated (a patient with a nonobstructive left ventricular outflow tract is shown as a comparison). This patient’s outflow tract was unable to be visualized by transthoracic echocardiography because of poor acoustic windows, and the obstruction was subsequently confirmed by cardiac catheterization.

**Pulmonary venous baffle (Figure 4, upper images).** In the one patient with scimitar syndrome whose right pulmonary vein was baffled to the left atrium, axial images were used as localizers for off-axis coronal images. Gradient echo images were also performed and outlined the blood vessel and baffle better than the spin echo images did.

**Conduits**

**Ventricular to pulmonary artery conduits (Figure 5).** In the 17 conduits imaged, we found that axial images can be used to follow conduits from ventricle to pulmonary artery and can also be used as localizers for off-axis sagittal imaging. In general, sagittal or off-
axis images were adequate to outline conduits; however, at times, with tortuous conduit geometry, even off-axis sagittal images were insufficient to image the entire conduit in one view. Figure 5 is one such example of a patient where axial images were more useful. This patient had a right ventricle to pulmonary artery conduit that had an oblique course underneath the sternum, which caused stenosis of the conduit. This was subsequently confirmed by cardiac catheterization.

MRI was used to correctly diagnose conduit stenosis as in Figure 5, regurgitation (confirmed by catheterization in 4), as well as an infectious mass that was missed by transthoracic echocardiography because of its position underneath the sternum (Figure 5, A). This ended a work-up for fever of unknown origin. Figure 5, B shows an example of a patient without any problem with the conduit.

**Ventricular to aorta conduits, including aortic root replacement (Figure 6).** Of the 6 patients imaged (4 with left ventricular apical to descending aortic conduit and 2 with aortic root replacement), axial and coronal images were used to follow the conduit and aortic root replacement from ventricle to aorta. Both orthogonal planes gave remarkably clear views of the full extent of the left ventricular to aortic conduit in the long axis and the insertions in the left ventricular apex and the descending aorta. We found sagittal images for left ventricle to aortic conduits unhelpful. On the other hand, axial and off-axis coronal and sagittal images were very useful in aortic root replacement.

MRI was able to demonstrate the full length of the left ventricular apical to aortic conduits in all patients and permitted correct diagnosis of conduit stenosis and regurgitation (Figure 6, A). Conduit stenosis and regurgitation were subsequently confirmed by cardiac catheterization. In addition, a patient with Marfan’s syndrome who underwent an aortic “wrap” procedure (ascending aorta wrapped by a Gore-tex expanded polytetrafluoroethylene [W. L. Gore and Associates, Elkton, Md] patch) was referred to MRI because of a large echogenic mass seen near the ascending aorta by echocardiography. MRI allowed correct identification of dissection of blood into the potential space between the native aorta and the Gore-tex patch, causing aneurysm formation and impingement on the ascending aorta (Figure 6, B). The patient was taken to surgery, where confirmation of this finding was made and his aortic root and ascending aorta were replaced.

**Aorta to aorta conduit (Figure 7).** In the 3 patients imaged, axial and off-axis sagittal images were used to follow the conduit from both sections of aorta (as in the conduit from ascending to descending aorta in a patient with interrupted aortic arch shown in Figure 7, A) or to connect 2 separate aortas (as in conjoined twins). This is truly best viewed as a 3-dimensional shaded surface display as shown in Figure 7, B.

The patient in Figure 7, A had the diagnosis of truncus arteriosus with interrupted aortic arch and under-
went a surgical repair that included a conduit between ascending and descending aorta. This conduit was quite inferior, which resulted in superior impingement on the right pulmonary artery causing stenosis. As can be seen, the left pulmonary artery has dilated to compensate. This patient's anatomy was unable to be visualized by transthoracic echocardiography because of poor acoustic windows. The patient subsequently underwent cardiac catheterization, where this finding was confirmed, and then was brought to surgery to have the conduit revised.

**Inferior vena cava to left atrial conduit (Figure 4, lower images).** In the 2 patients with transposition of the great arteries who underwent a Baffé’s procedure, axial images were used to follow the conduit from the inferior vena cava to the left atrium. These images were also used as localizers for off-axis coronal images, which demonstrated the conduit more clearly. One
patient went to surgery where the Baffle’s anatomy demonstrated on MRI was confirmed.

Discussion

Individual surgically created structures in congenital heart surgery have been reported to be imaged by MRI in various series; however, to be used as a routine imaging tool, it is important to define the breadth of the various types of surgical structures that can be imaged successfully. In addition, imaging protocols for conduits and baffles are useful for the efficient utilization of an imaging tool such as MRI. The current study was undertaken to determine both the breadth of the various types of surgical structures that can be imaged successfully as well as efficient protocols to image each structure. In our simplified approach, we are able to group individual lesions into broad categories and use applicable protocols successfully.

MRI was found to be extremely useful in the evaluation of intracardiac baffles and extracardiac conduits. All these structures were imaged successfully in routine follow-up studies. In some cases, new diagnoses were made that changed the management and care of the patient. The patient with the right ventricle to pulmonary artery conduit who was found to have an infectious mass in the distal part of the conduit, the patient with Marfan’s syndrome who had a dissection of his aorta after the aortic “wrap” procedure, and the patient with truncus arteriosus and interrupted aortic arch with an aortic to aortic conduit impinging on the right pulmonary artery are examples of the ability of MRI to visualize diagnostic problems that had not been elucidated by other means. Furthermore, by ending a fever of unknown origin work-up in the first patient and by surgical revision of the conduits in the latter 2 patients, MRI was used to change the management of these patients.

Not only was 2-dimensional MRI useful, but 3-dimensional MRI was very helpful in conceptualizing the spatial geometry of complex conduits such as the aortic to aortic conduit in the patient who was a conjoined twin (Figure 7, B) or as in the patients with transposition of the great arteries who underwent a Mustard or Senning operation (Figure 2, A and B).

Limitations

MRI has few limitations as an imaging modality. Patients with pacemakers, marked arrhythmias, coils, clips in head, metal fragments in eyes or patients who are claustrophobic (and do not want sedation) are unable to be imaged. Patients must lie still for extended periods of time, sometimes requiring sedation. ECG gating can, in some cases, be difficult.

This study did not include velocity mapping in these structures. Although some studies have reported success in doing this, during the period reported in this

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Figure 7

**Ao > Ao Conduit: Truncus & IAA, S/P Repair, w/ conduit inferior to RPA resulting in stenosis**

**A**

1. Aorta to aorta conduit for separation of conjoined twins. Conjoined twins that shared a fused heart were separated by sacrificing one of them. To allow for coronary perfusion of the vessels arising from the aorta of the sacrificed twin, an aorta to aorta conduit was performed. Top, Three T1-weighted axial images that, from left to right, progress from inferior to superior; lower left, 3-dimensional shaded surface display, all demonstrating the aorta to aorta conduit and some of the other cardiac anatomy. Lower right, As a reference, the preoperative (preop) fused heart is displayed by T1-weighted axial imaging. MPA, Main pulmonary artery; PA, pulmonary artery; RVOC, right ventricular outflow chamber; S, spine.

**B**

1. Aortic (Ao) to aortic conduit (C). A, Ascending (AAo) to descending (DAo) aortic conduit. The patient has truncus arteriosus with interrupted aortic arch (IAA) and underwent repair, which included a conduit between the ascending and descending aortic arches. This conduit was quite inferior, which resulted in superior impingement on the right pulmonary artery (RPA), causing stenosis. Top, Three T1-weighted axial images that, from left (L) to right (R), progress from inferior to superior. Right pulmonary artery stenosis caused by the conduit with dilation of the left pulmonary artery (LPA). Bottom, Three T1-weighted off-axis sagittal images that, from left to right, progress from left to right. Both panels demonstrate right pulmonary artery stenosis caused by the conduit with dilation of the left pulmonary artery shown at top. B, Aorta to aorta conduit for separation of conjoined twins. Conjoined twins that shared a fused heart were separated by sacrificing one of them. To allow for coronary perfusion of the vessels arising from the aorta of the sacrificed twin, an aorta to aorta conduit was performed. Top, Three T1-weighted axial images that, from left to right, progress from inferior to superior; lower left, 3-dimensional shaded surface display, all demonstrating the aorta to aorta conduit and some of the other cardiac anatomy. Lower right, As a reference, the preoperative (preop) fused heart is displayed by T1-weighted axial imaging. MPA, Main pulmonary artery; PA, pulmonary artery; RVOC, right ventricular outflow chamber; S, spine.
study, velocity mapping was not routinely performed at our institution. Finally, it should be noted that newer MRI imaging techniques are available. Methods such as fast spin echo, breath-hold imaging, real-time imaging, 3-dimensional breath-hold, as well as newer display packages are all coming into more common use. This does not obviate the value of the study because the tomographic anatomic and 3-dimensional considerations are biologic, not technical. Furthermore, the following should be noted with regard to these newer techniques: (1) Newer techniques obtain the same type of images we used in our study, faster, and at a cost of temporal or spatial resolution. This cost, many times, is not acceptable in small children with fast heart rates. At times, these images are not as high fidelity as the images we have obtained, again, because of the trade-offs inherent in these newer technologies. (2) Some newer techniques use a breath-hold to obtain the image, which can be problematic in the sedated children we commonly see with congenital heart disease. (3) Whether 3-dimensional techniques such as a gadolinium sequence is used or conventional spin-echo or gradient echo sequences, structures must be identified and labeled. Some may find it easier to segment spin echo images to create 3-dimensional shaded surface displays than a 3-dimensional gadolinium image in which the borders of cardiovascular structures (eg, left ventricle and proximal aorta) are not clearly defined.

Having delineated these shortcomings of the newer and faster sequences, it must be noted that in select patients (eg, larger children, patients with slower heart rates), these newer technologies may be used successfully. These sequences bring down the imaging time considerably and, in some cases, produce superior image quality over the older techniques. They certainly should be integrated into the cardiac examination in many instances, substituting for the older spin-echo and cine sequences.

Conclusion

Our institution’s experience has demonstrated that MRI is a useful tool in the management and care of patients with a wide variety of extracardiac conduits and intracardiac baffles used in congenital heart surgery. These structures can be imaged successfully and protocols have been developed to efficiently visualize these structures. MRI should be used as a complementary imaging modality in the follow-up of these patients.

References