Coronary allograft vasculopathy remains the main limiting survival factor after heart transplantation and the major cause of mortality after the first year post-transplant, ultimately leading to graft loss. Coronary x-ray angiography is the clinical gold standard and the most widely used diagnostic technique for coronary allograft vasculopathy in the majority of transplant centers. However, repeated x-ray procedures have inherent risks related to the cumulative radiation dose. Coronary magnetic resonance angiography (CMRA) has emerged as a useful imaging modality in pediatric patients as a noninvasive and radiation-free approach and appears very promising for imaging the coronary arteries in heart transplant recipients, although it has yet to be clinically established.

A 16-year-old girl who had received a heterotopic heart transplant (HHT) at 5 months of age because of an undersized graft attended our follow-up clinic. She had been diagnosed with dilated cardiomyopathy at 3.5 months of age. Heterotopic heart transplant can be used in rare cases in which orthotopic heart transplantation is contraindicated, such as for elevated pulmonary vascular resistances or small graft and size mismatch when no other size-matched recipient is available. The patient also presented with a horseshoe kidney and had a history of renal impairment. As part of her routine follow-up she underwent x-ray angiography every 3 years. Of note, because both femoral arteries were blocked, the patient had previously had difficult arterial access for the angiographic procedure. In addition to the x-ray angiography, a whole-heart CMRA was performed to evaluate coronary allograft vasculopathy.

CMRA was performed on a 1.5-T Philips Achieva clinical scanner (Philips Healthcare, Best, The Netherlands) with a 32-channel cardiac coil using a free-breathing, whole-heart balanced, steady-state free precession sequence. CMRA imaging parameters included the following: field-of-view of 300×300×80 mm³, Δx of 1.2×1.2×1.2 mm³, α of 70°, repetition time/echo time of 4.6/2.3 ms, sensitivity encoding of 2, and coronal section orientation (Figure 1). For respiratory motion correction, a recently developed 2-dimensional image-based navigator (iNAV) was used. The iNAV allows for direct respiratory motion tracking of a targeted region of interest, in this case the target being the donor heart as shown in Figure 1. Four consecutive iNAs are shown in Figure 2, demonstrating the ability of iNAV to directly measure and correct for respiratory motion of the donor heart throughout the respiratory cycle. CMRA data reformatted to visualize the coronary arteries of the donor heart are shown in Figure 3A, along with the x-ray angiogram of the left coronary tree Figure 3B and a volume rendering of the CMRA of the left coronary tree in a similar view Figure 3C showing excellent agreement with the x-ray image. Another view of the x-ray angiogram of the left circumflex is shown in Figure 4A, with comparable images obtained with CMRA reformatted to visualize the left circumflex Figure 4B and with a volume rendering in a view similar to that of the x-ray angiogram Figure 4C.

The CMRA data provided comparable information to the x-ray angiography but were acquired noninvasively, which represents a major advantage in a patient with difficult and limited intravenous access. Furthermore, the CMRA scan was performed without general anesthesia. Finally, the CMRA did not require the use of a contrast agent, providing a significant benefit in this patient because of the history of renal impairment.

To our knowledge, this is the first time that CMRA with novel respiratory navigator technology has been used to image the coronary arteries in a patient with a heterotopic heart transplant. Respiratory gating is challenging in these patients, because the donor heart typically occupies the right hemidiaphragm, precluding conventional respiratory motion compensation techniques. Using iNAV overcomes this limitation and will hopefully support further use of this technology in complex cardiac patients.
References


Figure 1. Whole-heart coronary magnetic resonance angiography (CMRA) scan planning in a coronal orientation (red volume). Two-dimensional respiratory image navigator planning (iNAV), also in a coronal orientation, but targeting the donor heart to allow for direct respiratory motion tracking of the anatomy of interest (green volume) is shown.

Figure 2. Sequence of 4 consecutive low-resolution 2-dimensional image navigators (iNAV) throughout the respiratory cycle, demonstrating the ability of the iNAV to directly capture and correct for respiratory induced motion of the donor heart. The measured displacement values in millimeters in foot-head (dFH) and left-right (dLR) direction for each iNAV are also shown.
Figure 3. Coronary magnetic resonance angiogram of the donor heart (DH) and original heart (OH) showing good delineation of the coronary arteries of the DH (A). X-ray angiography of the left anterior descending DH (LAD$_{DH}$) and left circumflex artery DH (LCX$_{DH}$; B) and volume rendering of the LADDH and LCXDH from the coronary magnetic resonance angiogram (C) are shown. Ao indicates aorta.

Figure 4. X-ray angiogram of the left anterior descending (LAD) artery and left circumflex (LCX) artery of the donor heart (A) and coronary MR angiogram reformatted to visualize the same coronary segments (B). Volume rendering of the coronary magnetic resonance angiogram of the LAD and LCX in a comparable view (C).
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Circulation. 2014;129:1453-1455
doi: 10.1161/CIRCULATIONAHA.113.006844
Circulation is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
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Print ISSN: 0009-7322. Online ISSN: 1524-4539

The online version of this article, along with updated information and services, is located on the
World Wide Web at:
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