A combined MR Imaging/Angiographic Assessment of Collateral Blood Flow In Acute Aortic Coarctation Before and After Stent Deployment

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Introduction: Coarctation repair by transcatheter balloon angioplasty and stent deployment under x-ray fluoroscopy is widely used in children. Detection and repair of aortic coarctation by x-ray angiography requires radiation exposure. On the other hand, MRI provides images at any angle without the use of potentially damaging radiation. However,MRI has limited use in visualizing stent lumen post stent delivery due to susceptibility artifacts and rf shielding effects.

Purpose: To use the XMR system for assessment of acute aortic coarctation and for the deployment of aortic nitinol stents to repair aortic coarctation in canine model.

Methods: Seven dogs were anesthetized and mechanically ventilated. Catheters were placed in the right carotid and iliac arteries to monitor blood pressure proximal and distal to coarctation. After left thoracotomy, the descending aorta was dissected distal to the left subclavian artery and looped with a plastic band. The aortic band was tightened to reduce femoral arterial pressure by ~60% of baseline.

A short bore MR imager (1.5 T Intera, Philips Medical Systems) and digital x-ray fluoroscopy system (Integris V5000, Philips Medical Systems) were used to detect and assess morphology and flow of aortic coarctation. A movable tabletop was used to transfer the subject between the systems. The following MR sequences were used: 1) retrospectively-gated T1-FFE sequence for measurement of aortic flow (TR=8.3 ms, TE=5.1ms, phases=16, VENC=50-200cm/s, flip angle=15°), 2) T1-FFE sequence for MRA (TR=4.9ms, TE=1.57ms, flip angle=30°), and 3) B-FFE sequence for MR fluoroscopy (TR=3.7ms, TE=1.9ms, flip angle=75°, scan matrix=160x160, FOV=270x270mm, SENSE=2). A self-expandable (14x24 or 12x24mm) nitinol stent was mounted on the tip of a dilator. The delivery system was guided cross the coarctation by nitinol guidewire (0.035“).

Results: Aortic coarctation was demonstrated on x-ray fluoroscopy and contrast-enhanced MRA (Figure 1, left images). Jet flow was observed distal to the coarctation on VEC-MRI. On MR fluoroscopy, the guide-wire was observed as a dark line in the aorta and the delivery system was free of susceptibility artifacts. Contrast enhanced MRA was also used to ensure the proper location of the stent in the stenotic region prior to release. The delivery procedure took less than 10min. The nitinol stent appeared as a dark object in the aorta after delivery and blood signal in the aortic lumen was not visible on contrast enhanced MRA (Figure 2). In contrast, the coarctation lumen was visible on x-ray fluoroscopy (Figure 1, bottom-right). Thus, MR compatible and friendly stents are critical.

Prior to coarctation the flow distal to the subclavian artery (1.3±0.3 L/min, mean±SEM) was greater than that at the diaphragm level (1.2±0.2 L/min). After coarctation aortic blood flow was significantly reduced to 0.2±0.2 L/min distal to coarctation and 0.9±0.1 L/min at diaphragm. The greater blood flow at the diaphragm compared to that distal to coarctation indicated the presence of collateral blood flow and the collateral formation is a rapid physiologic process. Deployment of the stent increased aortic flow distal to the coarctation to 0.8±0.04 L/min. Aortic coarctation abolished phasic blood pressure in the iliac artery and reduced mean blood pressure from 108±9 to 51±2 mmHg. Deployment of nitinol stent restored phasic and mean blood pressure (117±4 mmHg).

Conclusions: Deployment of endovascular stents to repair aortic coarctation is feasible under MR-guidance. Collateral vessels in the thorasic cavity accommodate rapidly to acute aortic coarctation. Both imaging modalities showed the changes in flow direction and volume after coarctation and repair. MR imaging provides quantitative assessment of aortic blood flow and demonstrates the success of intervention. Visualisation of the aortic lumen after stent placement was possible on x-ray fluoroscopy, but not on contrast enhanced MRA. Thus, combination of x-ray angiography/MR imaging (XMR) may be necessary in stent patency assessment.

Figure 1

Figure 2