

Quantitative Assessment of Coarctation Repair

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Introduction: Coarctation of the aorta is a congenital narrowing of the thoracic aorta. With severe coarctation, aortic pressure distal to the stenosis is reduced, resulting in inverted flow in the intercostals arteries and establishment of collateral flow through these vessels, contributing to the total aortic flow at lower levels. It was demonstrated that phase-contrast (PC)-MRI can be used to indirectly measure collateral flow in patients with moderate to severe coarctation [1]. This approach was based on flow measurements close to the coarctation and at the level of the diaphragm. Under normal circumstances, distal flow is reduced as compared to proximal flow due to vessel branches. In the presence of hemodynamically significant coarctation of the aorta however proximal flow values are lower than the distal values, and collateral flow can be determined as the difference between the two. Common treatment of aortic coarctation consists of transcatheter balloon angioplasty and/or stent deployment. We investigated changes in flow within 24 hours after interventional therapy, and compared them to baseline values obtained immediately before treatment.

Methods: Seven patients (4 females, 3 males; mean age, 17.2±6.8 years; range, 12-27 years) with suspected recurrent coarctation and scheduled for interventional treatment were included in the study. All patients had previously undergone operative repair of the coarctation and had clinical signs and/or symptoms of re-stenosis. Immediately prior to the interventional treatment, a MRI examination was performed on a 1.5 T cardio-vascular MR imager (Intera I/T, Philips Medical Systems, Best, the Netherlands). The following sequences were used: 1) Dual-inversion black blood single shot turbo spin echo (TSE) in transverse and oblique-sagittal orientation; TR = 2 heart beats, TE = 42 ms, SENSE = 2, flip angle = 90°. 2) Velocity-encoded phase-contrast MRI at two sites in the descending aorta (immediately distal to the coarctation and at the level of the diaphragm); TR = 7.7 ms, TE = 4.8ms, flip angle = 15°, 16 heart phases, velocity encoding 200-400 cm/s. 3) Gadolinium-enhanced 3D MR angiography; TR = 5.1 ms, TE = 1.4 ms, flip angle 40°, acquired in a single breathhold. Gd-DTPA-BMA (Omniscan; Amersham Health, Princeton, NJ) was injected at 2ml/sec for a total volume of 0.2 mmol/kg and was timed using a real-time bolus tracking sequence.

Patients then underwent x-ray angiography and treatment of the coarctation with balloon angioplasty and stenting (2910 Genesis stainless steel balloon-expandable stent; Cordis Corp., Miami Lakes, FL). Within 24 hours (either immediately after the intervention, or the next day), the patients came back to the MRI, where the black-blood TSE and the flow measurements were repeated at identical locations. The contrast-enhanced MRA was not repeated due to the artifact caused by the stainless steel stent.

Image analysis: Flow values were determined on an image processing workstation (EasyVision; Philips). Collateral flow was determined by subtracting proximal aortic flow from distal aortic flow. Relative collateral flow was calculated according to the formula: Collateral flow = (proximal flow – distal flow) / proximal flow.

Statistical analysis: Differences in collateral flow prior to and after intervention were analyzed by means of a two-sided Wilcoxon matched-pairs signed-ranks test at a significance level of 0.05.

Results: Quantitative flow determination was successful in all patients. Mean flow values are shown in Table 1. All patients had substantial collateral flow prior to coarctation, which was significantly reduced after treatment. Proximal flow significantly increased with treatment, whereas distal flow did not change significantly.

Conclusions: The study shows the feasibility of PC-MRI to assess changes in collateral circulation after stenting of aortic coarctation. Collateral circulation appears to diminish immediately after treatment. A possible application of this technique is the assessment of the success of stenting by using a combined x-ray interventional and MR imaging suite.

Reference: [1] JC Steffens et al, Circ 90, 937 (1994).



Figure 1: X-ray angiography (left) and black-blood MRI (right) prior to (top) and after (bottom) interventional treatment showed good agreement in severity of stenosis.

Table 1: Flow results.

	Prior to intervention	After intervention
Proximal flow (coarctation)	44±4 ml/s	60±8 ml/s *
Distal flow (diaphragm)	54±3 ml/s	61±8 ml/s
Collateral flow	10±2ml/s	1±1 ml/s *
Rel. coll. flow	24±5 %	4±2 % *

*, significant difference to prior to intervention