

# Assessment of Glenn-Fontan Shunts in Congenital Heart Disease using Low-Dose Time-Resolved and Multi-Phase High Spatial Resolution CEMRA

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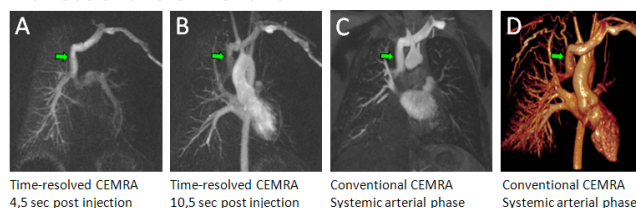
**Background:** Low-dose, time-resolved contrast-enhanced magnetic resonance angiography (CEMRA) and conventional multiphase CEMRA have been successfully applied to patients with congenital heart disease (CHD)<sup>1</sup>. These techniques often provide complementary information but their relative diagnostic roles in the assessment of surgical shunts have not previously been addressed. **Objective:** To evaluate low-dose time-resolved CEMRA and conventional multiphase CEMRA for assessment of Glenn shunts and Fontan variants in patients with CHD.

**Methods:** This retrospective IRB approved study included 35 adult patients who underwent the following surgical procedures: superior vena cava-to-pulmonary artery shunt (Glenn shunt), n = 26; right atrio/inferior vena cava-to-pulmonary artery conduit/tunnel/anastomosis (Fontan variants), n = 28. All patients underwent low-dose time-resolved CEMRA (TWIST, TR 2.45 msec, TE 0.92 msec, flip angle 25°, GRAPPA 2, voxel size 1.6 × 1.3 × 6.0 – 7.0 mm<sup>3</sup>; temporal resolution 1.2 - 1.5 sec) and conventional high spatial resolution multi-phase CEMRA (3D GRE, TR 2.7 msec, TE 0.9 msec, flip angle 25°, GRAPPA 3, voxel size 1.3 × 1.0 × 1.3 mm<sup>3</sup>). Conventional CEMRA was acquired during both the systemic arterial and the early systemic venous phases. In patients with Fontan variants, additional non-enhanced ECG-gated 3D steady state free precession MRA (SSFP-MRA, n = 6) or contrast-enhanced fat-saturated GRE imaging (2D GRE FS, n = 9; 3D GRE FS, n = 4; acquired during the steady state) was performed. In all patients, contrast agent was administered via an antecubital vein. In one patient, additional contrast agent administration via a leg vein was performed. For each MRA technique, overall image quality and visualization of the surgical shunts was rated on a 4-point scale (from 1 = non-diagnostic, to 4 = excellent image quality / unequivocal visualization). Moreover, diagnostic confidence in the assessment of pulmonary perfusion and the patency of the surgical shunts was documented.

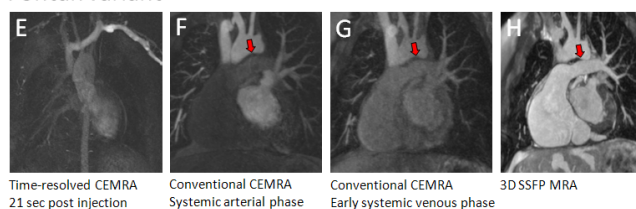
**Results:** Overall image quality ratings of time-resolved CEMRA, systemic arterial CEMRA, and early systemic venous CEMRA were 3.2 ± 0.8, 3.3 ± 0.8, and 3.0 ± 0.7, respectively. Glenn shunts were visualized with good or excellent image quality in 17 of 26 patients on time-resolved CEMRA, in 2 of 26 patients on systemic arterial CEMRA, and in 24 of 26 patients on early systemic venous CEMRA. The combination of both time-resolved and conventional CEMRA provided high diagnostic confidence for assessment of Glenn shunts in 26 of 26 patients. Fontan variants were visualized with good or excellent image quality in 2 of 28 patients on time-resolved CEMRA, in 7 of 28 patients on systemic arterial CEMRA, and in 15 of 28 patients on early systemic venous CEMRA. High diagnostic confidence in the assessment of Fontan variants was achieved in 13 of 28 patients using the combined time-resolved and conventional multiphase CEMRA approach. If SSFP-MRA was included in the MR examination, Fontan variants were visualized with excellent image quality and assessment of Fontan variants could be performed with high diagnostic confidence in all patients (6 of 6 patients). In contrast, additional 2D or 3D FS GRE imaging improved diagnostic confidence in only 1 of 11 patients with Fontan variants. Diagnostic confidence in the assessment of regional pulmonary perfusion via the surgical shunts was improved by time-resolved CEMRA in 25 of 35 patients compared to conventional CEMRA alone.

**Conclusion:** The combination of low-dose, time-resolved CEMRA and conventional multi-phase CEMRA allows for comprehensive assessment of Glenn-Fontan shunts and pulmonary perfusion in CHD patients. However, in some patients with Fontan variants, the combined CEMRA approach yielded insufficient diagnostic confidence. In these patients, additional non-contrast SSFP MRA or time-resolved CEMRA using contrast bolus injection via the leg veins<sup>2</sup> should be performed.

## Bidirectional Glenn shunt



## Fontan variant



**Figure 1:** 25-year old man with bidirectional Glenn shunt (indicated with green arrow) and Fontan variant (right atrio-to-pulmonary artery anastomosis; indicated with red arrow). Time-resolved CEMRA (A, B) and systemic arterial CEMRA (C, D) depict the bidirectional Glenn shunt with excellent image quality. In contrast, the Fontan pathway is visualized with diagnostic image quality only on early systemic venous CEMRA (moderate image quality, G) and on SSFP-MRA (excellent image quality, H).

<sup>1</sup> Fenchel M et al. Juvenile and adult congenital heart disease: time-resolved 3D contrast-enhanced MR angiography. *Radiology*. 2007 Aug;244(2):399-410. <sup>2</sup> Goo HW et al. Time-resolved three-dimensional contrast-enhanced magnetic resonance angiography in patients who have undergone a Fontan operation or bidirectional cavopulmonary connection: initial experience. *J Magn Reson Imaging*. 2007 Apr;25(4):727-36.