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Atrial volume and function in univentricular patients after Fontan palliation

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Introduction: Left atrial volume can be derived from cardiac magnetic resonance (CMR) cine images. Unlike biplane area-length (AL) calculations, the disc summation (DS) method does not require a specific atrial geometry. We hypothesized that both atria are deformed in patients with functionally univentricular hearts and area-length calculations are inaccurate even for that atrium which corresponds to the functional ventricle, and that atrial emptying may be impaired in Fontan patients.

Methods: Fontan patients and controls with normal cardiac anatomy were prospectively imaged by CMR. Right and left atrial areas and lengths as well as volumes from short axis stacks were obtained at atrial end-diastole, before atrial contraction, and at atrial end-systole. Volumes were indexed to body surface area. Atrial volumes by AL and DS and emptying fractions were compared between Fontan and normal groups, as well as within Fontan patients by ventricular morphology and type of cavopulmonary anastomosis.

Results: 29 Fontan patients with sinus/atrial rhythm during CMR (age 16.5±4 years, 83% male) and 19 controls (age 14.5±3.5 years, 37% male) were included (age p=0.91).
Left atrial AL mildly overestimated end-diastolic DS measurements in Fontans (29.2±14.2 ml/m2 vs. 25.1±10.2 ml/m2; 95%-CI of the difference 0.01-8.91 ml/m2), but not in controls (40±7.8 ml/m2 vs. 37±7.4 ml/m2; 95%-CI -0.41-6.25 ml/m2).
Fontan patients with functional right ventricles had larger right atria at atrial end-diastole than those with functional left ventricles by both methods (AL: 33.8±18 ml/m2 vs. 7.9±4.2 ml/m2; p=0.001) and smaller left atria by AL (22.3±8.6 ml/m2 vs. 36.6±15.5 ml/m2; p=0.044. Not by DS: p=0.573). In Fontan patients, ejection fractions of both atria combined did not differ by ventricular morphology or type of cavopulmonary anastomosis. Fontans showed lower atrial active emptying fractions than controls (left: 15.3±9.5% vs. 32.3±7.6%; p<0.001; right: 16.8±11.6% vs. 27.2±10.3%; p=0.03) and lower total emptying fractions (left: 33.1±15.6% vs. 61.7±7.2%; p<0.001; right: 34.6±12.3% vs. 52.7±7.5%; p<0.001).

Conclusions: Atrial volumes should be measured by DS in Fontan patients, rather than by calculations based on geometrical assumptions. Atrial volume distribution in Fontan patients depends on ventricular morphology. Biatrial active and total emptying fractions are lower in Fontans compared to controls.