

## Association of Increased Total Atrial Volume with Clinical Heart Failure Status in Hypoplastic Left Heart Syndrome

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**Introduction:** Increased indexed left atrial volume is a predictor of mortality in adults with heart failure (HF). Less is known about the implications of increased atrial volume in patients with complex congenital heart disease (CHD). Our objective was to determine whether increased atrial volumes are associated with clinical HF in hypoplastic left heart syndrome (HLHS).

**Methods:** Subjects included HLHS patients participating in a prospective research program. Patients were classified at each visit as either no/mild HF or clinical HF [NYHA class  $\geq 3$ , growth failure, cardiomegaly on chest X-ray, or hepatomegaly (edge  $>2.5$  cm below costal margin)]. Atrial volumes were measured by transthoracic echocardiogram (TTE) at end-systole by area-length method and indexed to body surface area for statistical analyses.

**Results:** Fifty one patients had 75 visits. Nineteen visits (25%) were post stage 2 palliation (pre-Fontan) and 56 were post Fontan completion (38 fenestrated). Sixteen of 76 met criteria for HF (21%; 6/18 pre-Fontan and 10/57 Fontan patients). Although increased RAV was associated with clinical HF ( $p = 0.04$ ) when analyzing all patients, subgroup analysis showed little association between HF status and atrial volumes post-Fontan. In pre-Fontan patients, HF was associated with increased RA and LA volumes, with total atrial volume index (RAV+LAV) showing the most striking relationship with HF status. In fact, total atrial volume index  $>43$  ml/m<sup>2</sup> predicted clinical HF with 86% sensitivity and 80% specificity.

**Conclusion:** Total atrial volume by TTE in pre-Fontan HLHS patients provides a useful marker of clinical HF, predicting HF status with good sensitivity and specificity. Atrial volumes appear to be less closely associated with HF after Fontan, possibly secondary to multiple factors (including sample heterogeneity/size, and postoperative changes in RA compliance or geometry). Additional evaluation of the utility of atrial volume analysis is warranted in patients with complex CHD.

	No or mild HF	Clinical HF	p value*	Odds Ratio	95% CI
<b>Entire HLHS cohort (n = 75)</b>	<b>n = 59</b>	<b>n = 16</b>			
Age (years)	9.2	13.5	NS		
BSA (m <sup>2</sup> )	1.00	1.18	NS		
Indexed RAV (mL/m <sup>2</sup> )	23.2	33.2	0.04	1.06	1.00 - 1.12
Indexed LAV (mL/m <sup>2</sup> )	6.4	5.9	NS		
Indexed total AV (mL/m <sup>2</sup> )	29.6	39.1	NS		
<b>Pre-Fontan (post stage II, n = 18)</b>	<b>n = 12</b>	<b>n = 6</b>			
Age (years)	1.7	7.7	0.002	1.02	1.01 - 1.03
BSA (m <sup>2</sup> )	0.49	0.83	0.03	13.9	1.27 - 151.59
Indexed RAV (mL/m <sup>2</sup> )	26.9	46.8	0.01	1.20	1.04 - 1.39
Indexed LAV (mL/m <sup>2</sup> )	4.8	7.2	0.02	1.80	1.11 - 2.91
Indexed total AV (mL/m <sup>2</sup> )	31.7	54.0	0.002	1.71	1.22 - 2.39
<b>Post-Fontan (n = 57)</b>	<b>n = 47</b>	<b>n = 10</b>			
Age (years)	11.1	17.0	0.03	1.01	1.00 - 1.03
BSA (m <sup>2</sup> )	1.13	1.39	NS		
Indexed RAV (mL/m <sup>2</sup> )	22.3	25.1	NS		
Indexed LAV (mL/m <sup>2</sup> )	6.6	5.1	0.005	0.58	0.40 - 0.85
Indexed total AV (mL/m <sup>2</sup> )	28.9	30.2	NS		

Data are reported as mean values.

\*Association of variable with HF by univariate analysis. P values  $\leq 0.05$  are considered significant.

AV, atrial volume; BSA, body surface area; HF, heart failure; HLHS, hypoplastic left heart syndrome; RAV, right atrial volume; LAV, left atrial volume.