

Title –Left Ventricular growth after Norwood operation with Staged Left Ventricular Recruitment

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Objective – The purpose of this study is to analyze changes in the left ventricular (LV) capacity and function in patients with hypoplastic left heart syndrome (HLHS) that underwent the Norwood and left ventricular recruitment (LVR) procedures.

Background – LVR refers to procedures added to surgical management of HLHS, which are aimed at restoration of functional LV capacity with a goal of eventual establishment of a biventricular circulation. LVR procedures include resection of endocardial fibroelastosis (EFE), mitral valvotomy or repair, aortic valvotomy or repair and maintenance of a restrictive atrial septum, thereby relieving inflow and outflow obstructions and promoting blood flow through the hypoplastic LV. Whether these procedures should be added to the initial palliation, as opposed to beginning later in life is not yet clear. We sought to assess changes in LV capacity and function during the period between Norwood and next operation, in patients who underwent LVR procedures at our institution.

Methods – Seven patients with HLHS who underwent Norwood with staged LVR were retrospectively analyzed. LV dimensions were obtained from echocardiograms (Echo) performed immediately after Norwood with LVR (Echo 1) and up to 3 months of age (Echo 2). Maximal LV cavity measurements were taken from the apical imaging views and indexed to body surface area based on the Haycock formula. The LV major length (midpoint of the mitral annulus to the apex), minor length (at mid-level perpendicular to the long axis), and area (endocardial border tracing) were measured and LV volume calculated (area x minor length). The end diastolic (ED) and end systolic (ES) phases were identified as coincident with mitral valve closure and aortic valve closure respectively, and indexed LV end diastolic (LVEDVi) and end systolic volumes (LVESVi) were determined. The indexed LV stroke volume (LVSVi) was calculated as (LVEDVi – LVESVi).

Results – Mean \pm SD (range) patient age at initial palliation was 7 ± 2 days (4-10). Age at the time of Echo 1 was 10 ± 2 days (7-11), and at Echo 2 was 86 ± 18 days, (51-106). Of 7, 6 had EFE resection, 1 had mitral valve procedures, 4 had aortic valve procedures and all had maintenance of restrictive atrial septum at initial palliation. Mean interval between Echo 1 and Echo 2 was 76 ± 17 days (44-98). Mean LVEDVi at Echo 1 was 11.4 ± 4.2 ml/m² (6.7-17.9), and at Echo 2 was 23.1 ± 8.4 ml/m² (13.3-34.7). Mean LVSVi at Echo 1 was 5.2 ± 2.5 ml/m² (2.3-8.9) and at Echo 2 was 9.4 ± 3.7 ml/m² (5.7-14.3). Both LVEDVi and LVSVi were significantly higher at Echo 2 ($p < 0.005$), with roughly a two-fold increase in LVEDVi and LVSVi. At the time of this report, 1 patient has established biventricular circulation, 4 patients continue to have a single ventricle physiology with LVR procedures done twice, and 2 patients are deceased.

Conclusions – LVR performed concomitant with the Norwood operation results in increased left heart growth and functional ejection during the next 3 months.