Hemodynamic parameters predict adverse outcomes following biventricular conversion with single-ventricle palliation takedown

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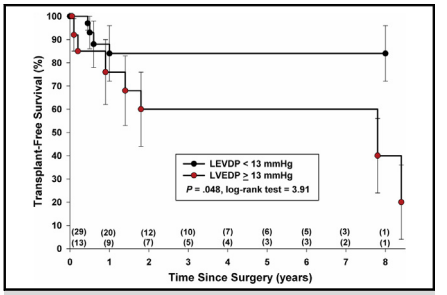
ABSTRACT

Objective: Patients with a borderline left ventricular hypoplasia in the hypoplastic left heart syndrome variant or an unbalanced atrioventricular canal who undergo initial single-ventricle palliation may be candidates for biventricular (BiV) conversion following left ventricle (LV) recruitment procedures. We investigated associations among preoperative parameters and postoperative outcomes in patients undergoing BiV conversion.

Methods: We performed a retrospective review of patients who underwent BiV conversion to determine variables associated with clinical outcomes. Predictor variables included cardiac diagnosis, age and weight, LV dimension, LV end diastolic volume, LV mass, preoperative LV end diastolic pressure (LVEDP), and preoperative left atrial pressure. Primary outcome was a composite of death, heart transplant, or BiV takedown.

Results: Of 51 patients, 11 experienced primary outcome (22%). Patients with hypoplastic left heart syndrome variant were more likely to experience primary outcome than those with an unbalanced atrioventricular canal (30% vs 6%; $P = .03$). Receiver operating characteristic analysis demonstrated that preoperative LVEDP had good predictive accuracy in classifying patients with and without the primary outcome (area under the curve, 0.757; 95% confidence interval, 0.594-0.919; $P = .012$). The Youden J-index indicated a cutoff of LVEDP $\geq$ 13 mm Hg as optimal for predicting the primary outcome. Multivariable Cox regression demonstrated that LVEDP $\geq$ 13 mm Hg (adjusted hazard ratio, 4.00; $P = .037$) and postoperative right ventricle pressure > 3/4 (adjusted hazard ratio, 21.75; $P < .001$) were significantly associated with primary outcome, independent of age, weight, and diagnosis.

Conclusions: Elevated preoperative LVEDP is a risk factor for suboptimal postoperative hemodynamic parameters and adverse outcome following BiV conversion from single-ventricle palliation. (J Thorac Cardiovasc Surg 2017;154:572-82)



Freedom from death, transplant, and biventricular (BiV) takedown: Preoperative left ventricular end diastolic pressure (LVEDP) < 13 mm Hg versus ≥13 mm Hg.

Central Message

Preoperative elevated left ventricular end diastolic pressure is associated with adverse events following biventricular conversion.

Perspective

We found that elevated preoperative left ventricular end diastolic pressure was associated with adverse events and suboptimal hemodynamic parameters in patients with borderline left heart following biventricular (BiV) conversion. This study will inform clinical management of patients who have undergone single-ventricle palliation and left ventricle recruitment who may be candidates for BiV conversion.

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Patients with borderline left ventricular (LV) hypoplasia, including those with borderline hypoplastic left heart syndrome (bHLHS) and right-dominant atrioventricular canal

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Abbreviations and Acronyms

ASD = atrial septal defect
BiV = biventricular
bHLHS = borderline hypoplastic left heart syndrome
EFE = endocardial fibroelastosis
LAp = left atrial pressure
LV = left ventricle
LVD = left ventricle dimension
LVEDP = left ventricular end diastolic pressure
ROC = receiver operating characteristic
RVP = right ventricular pressure
SBP = systolic blood pressure
SLVR = staged left ventricular recruitment
SVP = single-ventricle palliation
uAVC = right-dominant unbalanced atrioventricular canal

(uAVC) defects, commonly undergo single-ventricle palliation (SVP). Patients with certain anatomic features (ie, valve regurgitation, ventricular dysfunction, pulmonary vascular disease, or parenchymal disease) experience poor long-term outcomes following SVP.[1-5]

Certain patients who have undergone SVP are candidates for staged LV recruitment (SLVR), a strategy in which procedures to relieve inflow and outflow tract obstruction and promote blood flow through the LV eventually lead to growth of left heart structures. SLVR allows decisions regarding long-term SVP or biventricular (BiV) circulation to be delayed until several years of age, based on response of the left heart to recruitment maneuvers. Patients can remain with SVP if LV growth is determined to be inadequate for BiV conversion. SLVR has been shown to result in normalization of left heart size, improve the ability of the LV to function as the systemic ventricle, and has allowed conversion to BiV circulation in a subset of patients.[6] However, patients undergoing BiV conversion following SLVR are at risk for perioperative mortality, pulmonary hypertension, LV systolic and diastolic dysfunction, and valve dysfunction.[6,7]

Criteria for patient selection for BiV conversion following SLVR have not been established, but are typically based on assessment of imaging and hemodynamic parameter data. Size and function of left heart structures (ie, LV, aortic valve, and mitral valve) are typically used as determinants of candidacy for BiV conversion. However, the ability of hemodynamic and echocardiographic parameters to predict long-term outcomes of BiV conversion has not been established.[7-10] The purpose of this study was to describe a single institution experience with biventricular conversion and investigate the association between preoperative echocardiographic and pre- and postoperative hemodynamic parameters and postoperative outcomes in pediatric patients who underwent BiV conversion following SVP.

PATIENTS AND METHODS

This study was a retrospective review of patients with a diagnosis of right-dominant uAVC or bHLHS who underwent initial SVP at any center followed by eventual BiV conversion at Boston Children's Hospital between January 2003 and November 2015. The study design and methods were approved by the Boston Children's Hospital Institutional Review Board.

Patients were included in our analysis if they were diagnosed with bHLHS or right-dominant uAVC and underwent stage I palliation with either aortopulmonary amalgamation (Damus-Kaye-Stansel procedure) or hybrid approach in infancy, subsequently underwent SLVR procedures, and underwent eventual conversion from single-ventricle to BiV circulation. The population with bHLHS who underwent SLVR have been defined previously, and included patients with Shones complex or hypoplastic left heart syndrome variants without aortic or mitral atresia.[6] Patients were excluded if they underwent initial SVP followed by BiV conversion for other diagnoses; that is, complex double-outlet right ventricle or transposition of the great arteries.

Patients were selected to undergo BiV conversion based on imaging studies demonstrating favorable increase in the size of left heart structures (ie, LV, aortic valve, and mitral valve) following initial palliation either with or without adjunctive SLVR procedures. BiV conversion involved reversal of Damus-Kaye-Stansel procedure or hybrid circulation, aortopulmonary shunts, cavopulmonary shunt, or Fontan baffles. Re-establishment of separate LV to aorta and right ventricle to pulmonary artery continuity was achieved by either direct reanastomosis or Ross procedure.

The following data were collected from review of preoperative imaging and medical records: gender, age, weight, and underlying cardiac diagnosis. Preoperative echocardiographic parameters (ie, LV end diastolic volume absolute value and z score, LV long axis dimension [LVD] absolute value and z score, and LV mass absolute value and z score), and catheterization data (ie, mean left atrial pressure [LAp] and LV end diastolic pressure [LVEDP]) were extracted from the most recent studies before BiV conversion. Operative details at stage I procedure, staged recruitment procedures, and BiV conversion were collected from the operative notes.

Postoperative echocardiogram and catheterization data were collected from the most recent study for most patients. However, for patients who died, underwent transplantation, or underwent BiV conversion takedown, data were collected from the most recent catheterization or echocardiogram immediately before an adverse event. From catheterization reports, postoperative hemodynamic parameters, including LAp, LVEDP, and systolic right ventricular pressure (RVP) were collected. From the echocardiogram, LV end diastolic volume, LV ejection fraction, and estimated RVP from tricuspid regurgitation jet were collected. When RVP was not available on catheterization study, the value obtained from echocardiogram was used. RVP was expressed as a percentage of systolic blood pressure measured simultaneously.

Postoperative clinical outcomes, including surgical or catheter-based reinterventions, cardiac transplantation, and mortality were recorded. Time to event was calculated. Clinical follow-up was calculated as the time between BiV conversion procedure and the latest recorded clinical encounter in the electronic medical record.

Primary outcome was a composite end point consisting of death, heart transplant (transplant), and BiV takedown to SVP (takedown). We used multivariable logistic regression and Cox regression modeling with time-dependent covariates to determine which predictor variables were significantly associated with primary outcome. Variables entered into the analysis included diagnosis, age and weight at time of surgery, LVD z score, LV end