Takedown of cavopulmonary shunt at biventricular repair

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Objective: With advances in valve repair and ventricular recruitment strategies, patients initially palliated with single ventricle physiology have been increasingly brought to biventricular circulation. Few data are available on the technical aspects and outcomes after takedown of the superior cavopulmonary anastomosis (bidirectional Glenn [BDG]). We reviewed a single-institutional experience in BDG takedown.

Methods: The demographic, procedural, and outcome data were obtained for all children who had undergone BDG takedown at our institution from 2000 to 2012. The primary outcome measures were achievement of biventricular circulation, reoperation, and mortality. The secondary outcome measures were postoperative arrhythmias, superior vena cava (SVC)-right atrium (RA) or pulmonary artery stenosis at the BDG takedown site.

Results: A total of 40 patients were included during the study period, with a mean age of 4.4 years (range, 7 months to 22 years). Primary SVC-RA anastomosis was performed in 7 patients (18%), and an anterior patch was used in 33 patients (82%). Of the 40 patients, 38 were discharged with biventricular physiology (98%) and mild or less ventricular dysfunction. During a mean follow-up period of 3.4 ± 2.9 years, 3 patients died and 1 required heart transplantation; 2 patients developed more than mild SVC stenosis requiring reintervention and 1 developed pulmonary artery stenosis. Finally, 34 patients were in normal sinus rhythm and 4 had heart block (1 pacemaker placement).

Conclusions: BDG takedown can be undertaken with a low operative risk and a low incidence of SVC or pulmonary artery stenosis or sinus node dysfunction. Additional follow-up is required to see how the reconstructed SVC grows. (J Thorac Cardiovasc Surg 2014;148:1506-11)

CHD

The direct anastomosis of the superior vena cava (SVC) to the right pulmonary artery (PA), or bidirectional Glenn (BDG) shunt, was first described in 1958.[1] Longitudinal studies have since demonstrated its efficacy as a useful palliation method to augment effective pulmonary blood flow and unload the single ventricle.[2] The pursuit of single ventricle palliation in a patient with 2 ventricles potentially adequate for biventricular circulation can unnecessarily subject the patient to the morbidity of single ventricle physiology. With improvement in valve repair techniques[3-7] and refinement in secondary ventricular recruitment maneuvers,[8,9] significant progress has been made in identifying patients amenable for biventricular repair, who were initially palliated with single ventricle physiology and subsequent cavopulmonary connections. More recently, the BDG shunt has also been used as an adjunctive strategy to assist ventricular unloading in patients with Ebstein's anomaly[10] and in patients with hypoplastic right or left ventricles undergoing attempted biventricular repair.

The surgical decisions surrounding these patients are often complex and require multiple techniques to achieve biventricular repair. However, biventricular repair often requires takedown of the cavopulmonary anastomosis by reestablishing continuity between the right atrium (RA) and SVC and reconstruction of the PA. Historically, a number of concerns have been raised regarding BDG takedown owing to potential damage to the sinoatrial (SA) node, atrial arrhythmias, resulting SVC-RA stenosis, and PA stenosis from the anterior PA dislocation. Several small series from the mid-1970s have reported the feasibility of BDG takedown.[11-13] More recently, Baird and Forbess[14] reported the technical considerations. However, the number of reported patients was small with minimal follow-up. Only limited conclusions have been drawn regarding the perioperative morbidity and short-term complications associated with BDG takedown. The aim of the present study was to review the techniques and outcomes of patients undergoing biventricular repair with BDG takedown from a single center's experience during an 11-year period.

METHODS

Study Design

The present study was a retrospective medical record review of all patients who had undergone takedown of BDG from January 2000 to January 2012 at Boston Children's Hospital. The cardiac surgery and cardiology databases were queried for all takedown of BDG procedures during the study

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Abbreviations and Acronyms

BDG = bidirectional Glenn
CAVC = common atrioventricular canal
PA = pulmonary artery
RA = right atrium
SA = sinoatrial
SN = sinus node
SVC = superior vena cava

period, and all operative notes, echocardiograms, and most recent follow-up records were reviewed. The institutional review board approved the present study, and individual patient consent was waived. The primary outcome measures were achievement of biventricular physiology, perioperative arrhythmias, greater than mild SVC-RA anastomotic stenosis, PA stenosis at the BDG takedown site, reoperation, and mortality. The clinical and treatment variables were recorded in an attempt to determine the predictors of the endpoints.

Surgical Technique

Cardiopulmonary bypass was generally performed with moderate systemic hypothermia. Myocardial protection consisted of antegrade cold blood cardioplegia. The intracardiac portion of the repair varied, depending on the associated anatomy. The technique for cavopulmonary takedown with SVC-RA reconstruction has been previously reported.[14] In brief, takedown of the cavopulmonary connection and pulmonary arterioplasty was generally performed before aortic crossclamping. The PA was either closed primarily or patched, depending on its size. Once the intracardiac portion of the repair was completed, the SVC-RA reconstruction was completed. To avoid SA nodal disruption, the RA appendage was extensively mobilized, particularly in the atrioventricular groove, and a flap of RA free wall was rotated cephalad toward the SVC to use as much native tissue as possible in re-creating the cavoatrial connection. Generally, this anastomosis was completed with 5-0 or 6-0 polypropylene suture in a running, interlocking fashion, starting at the back wall with a primary SVC-RA approximation and either primary closure of the anterior aspect, if feasible, or anterior augmentation with a patch of pericardium, pulmonary homograft (Gore-Tex; W. L. Gore & Associates, Inc, Elkton, Md; or CorMatrix; CorMatrix Cardiovascular, Inc, Alpharetta, Ga).

Statistical Analysis

Statistical analyses were performed using the Statistical Package for Social Sciences software, version 21 (SPSS, Inc, Chicago, Ill). Data are presented as the mean ± standard deviation or median and range for continuous variables and number and percentage for categorical variables. Survival estimates were calculated using the Kaplan-Meier method.

RESULTS

Demographic Data

Of all the operations converting from single ventricular to biventricular physiology, 40 patients who had undergone takedown of BDG, including 3 patients (7.5%) who underwent bilateral-BDG takedown during the study period, with a median age of 4.4 years (range, 7 months to 22 years) and median weight of 14.9 kg (range, 4.7-94.1). Of the 40 patients, 39 underwent SVC-RA reconstruction and 1 was left to drain by way of a large azygous vein. An unbalanced common atrioventricular canal (CAVC) and ''borderline hypoplastic left heart'' was the most common primary diagnosis, occurring in 15 and 14 patients, respectively (Table 1). A greater proportion of patients had undergone BDG takedown with biventricular conversion in the more recent era (Figure 1). All the patients had undergone ≥1 additional procedure, with the most common being takedown of the Damus-Kaye-Stansel anastomosis (Table 2). Primary SVC-RA anastomosis was achieved in 7 patients (18%), and a patch of pericardium, Gore-Tex (W. L. Gore & Associates) or CorMatrix (CorMatrix Cardiovascular, Inc), was used as an anterior hood in the remaining 33 patients (82%). More operative characteristics are listed in Table 3.

Early Outcomes

One patient died before discharge. The patient had had an unbalanced CAVC and died 5 months after biventricular conversion. An additional patient, with an unbalanced CAVC, who had undergone underwent Fontan takedown, was in the hospital for 37 days before discharge and died 3 days after discharge (cause unknown).

The mean intensive care unit and total hospital length of stay was 28.2 ± 49.88 and 38 ± 59.66 days, respectively. Of the 40 patients who had undergone BDG takedown, 38 (98%) were discharged with biventricular physiology and mild or less biventricular dysfunction.

No evidence was found of any patient having greater than mild stenosis at the SVC-RA anastomotic site using intraoperative direct measurement or intraoperative or discharge echocardiography. No evidence was found of any patient having greater than mild PA stenosis at the previous BDG site using intraoperative assessment of the PA reconstruction, direct intraoperative measurement, intraoperative echocardiography, discharge echocardiography, or on the latest follow-up echocardiogram. After BDG takedown, 34 patients (85%) were in normal sinus rhythm immediately postoperatively.

No patients presented with primary SA node dysfunction. Four patients had evidence of postoperative heart block, one of whom required a pacemaker before discharge. Two other patients were discharged with first degree atrioventricular conduction block and one had already had a pacemaker before BDG takedown.

Follow-up

During a mean follow-up of 3.4 ± 2.9 years after BDG takedown (range, 1 month to 9.9 years), 1 additional patient died. Figure 2, *C*, summarizes the Kaplan-Meier survival curve, estimated at 94% ± 4.1% at 6 months and 1 year and 90.5% ± 5.3% at 2 years through the latest follow-up visit. One patient with hypoplastic left heart syndrome, who had undergone biventricular repair developed heart failure and required biventricular assist device placement and subsequent orthotopic heart transplantation 9 months