Palliative pulmonary artery banding versus anatomic correction for congenitally corrected transposition of the great arteries with regressed morphologic left ventricle: Long-term results from a single center

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Objective: We aimed to compare the long-term results between palliative pulmonary artery banding and anatomic correction for congenitally corrected transposition of the great arteries with regressed morphologic left ventricle.

Methods: From 2003 to 2012, 40 consecutive patients underwent first-stage pulmonary artery banding. The second-stage operation—double switch—was performed in 15 patients (double-switch group). The other 25 patients retained pulmonary artery banding without further operation (pulmonary artery banding group). In-hospital mortality, long-term mortality, and heart function were studied as primary outcomes.

Results: The median time of follow-up was 3.4 ± 0.7 years (range, 6 months-9.5 years). Overall survival rate was 66.7% in the double-switch group versus 96.0% in the pulmonary artery banding group ($P = .03$). The ratio of New York Heart Association functional class I-II (80.0% vs 95.9%; $P = .02$) and the mean functional left ventricle ejection fraction (51.4% ± 9.6% vs 61.0% ± 6.4%; $P = .01$) were higher in the pulmonary artery banding group at follow-up. In univariate analysis, age at pulmonary artery banding was the only risk factor for late deaths (odds ratio, 7.30; $P = .01$) and left ventricle dysfunction (odds ratio, 4.77; $P = .03$) after the double switch. For patients who experienced prolonged pulmonary artery banding, mean oxygen saturation was 95% ± 3.1% and the trans-banding pressure gradient was 46.9 ± 21.5 mm Hg.

Conclusions: In patients with congenitally corrected transposition of the great arteries with deconditioned morphologic left ventricle pulmonary artery banding may be considered an ideal procedure because it allows left ventricle training while improving tricuspid regurgitation. Compared with the double-switch procedure after pulmonary artery banding, prolonged palliative pulmonary artery banding provided a lower mortality rate and indicated better cardiac function. (J Thorac Cardiovasc Surg 2014;148:1566-71)

CHD

Congenitally corrected transposition of the great arteries (ccTGA) is characterized by the combination of atrioventricular and ventriculoarterial discordance. The morphologic left ventricle (mLV) and morphologic right ventricle (mRV) support the pulmonary and systemic circulations, respectively. The mRV is not ideally suited for the long-term maintenance of the systemic circulation. In time it may fail under these conditions because of its anatomic and physiologic substrate. The major manifestation of mRV dysfunction is tricuspid regurgitation (TR), which is associated with increased morbidity and mortality in patients with ccTGA.

Surgical approaches for ccTGA include conventional and anatomic repair. It has become apparent that the long-term outcomes of conventional repair, whereby the right ventricle remains in the systemic circulation, are not satisfactory.[1-5] As such, the lesion itself is far from corrected. True correction, in terms of restoring the mLV to the systemic circulation, has been achieved by double-switch (DS) operation.

The success of DS procedures depends on the ability of the left ventricle to support systemic circulation. In the absence of unrestrictive ventricular septal defect and pulmonary arterial hypertension, the mLV will be deconditioned and cannot undertake the workload of systemic circulation. Pulmonary artery banding (PAB) is considered to be the ideal method for training mLV function. If the

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Abbreviations and Acronyms

ccTGA = congenitally corrected transposition of the great arteries
DS = double switch
mLV = morphologic left ventricle
mRV = morphologic right ventricle
NYHA = New York Heart Association
PAB = pulmonary artery banding
TR = tricuspid regurgitation

function of the mLV is strong enough to be the main blood pump after PAB, the DS procedure will be done safely. This 2-stage strategy is now considered the optimal choice for patients with a deconditioned mLV. However, deterioration in left ventricle function in trained groups of patients has been reported, and there is concern that this will be a significant long-term problem.[6] Is it better to enroll patients who have a regressed mLV in a program of retraining of the left ventricle followed by a DS procedure than to perform palliative PAB alone? We followed all patients who underwent PAB (with or without the second-stage DS) to compare the outcomes between DS and PAB as the long-term palliative procedure.

MATERIALS AND METHODS

Patients

Forty consecutive patients underwent PAB with or without the second-stage DS at Fuwai Hospital from January 2003 through December 2012. All patients were diagnosed with ccTGA without left ventricular outflow tract obstruction. The second-stage DS was performed in 15 patients (DS group) and palliative PAB was regarded as the ending procedure in the other 25 patients (PAB group). This study was approved by the Ethics Committee at Fuwai Hospital. They gave us their approval to waive the need for patient consent for publishing follow-up data about these patients. Follow-up information was completed in all patients. The median time of follow-up was 3.4 ± 0.7 years (range, 6 months-9.5 years).

Clinical Protocols and Surgical Techniques

All patients had objective evidence of TR and mRV dilation. PAB was used as an interim measure to both train the mLV for future DS and relieve the TR. The target mLV:mRV pressure ratio after PAB was 0.50-0.75 irrespective of the patient's age, underlying diagnosis, or baseline left ventricular pressure. The DS procedure was performed only when the mLV was considered to be well conditioned. Assessment for suitability for DS procedure was by means of transthoracic echocardiography and/or cardiac catheterization. Criteria for second-stage DS included mLV pressures >75% of systemic pressure for at least several months, less than moderate ventricular dysfunction, and less than moderate mitral regurgitation. The mLV mass index and mass:volume ratios were not calculated and not used in decision making.

PAB

Access was obtained via median sternotomy. The mLV and mRV pressures were measured by direct manometry before PAB. The PAB procedure was performed on the pulmonary trunk away from the pulmonary valve with the use of a polytetrafluoroethylene band (Gore-Tex, W. L. Gore & Associates, Inc, Flagstaff, Ariz). The aim of banding was to achieve an intraoperative mLV pressure 0.50-0.75 of the systemic pressure.

DS

The DS approach was made through the previous incision for PAB. Ventricular septal defect repair was performed transatrially, through the aorta or through the right ventricle. The Senning procedure was used for atrial switch in all DS patients. The Lecompte maneuver was generally performed if the great arteries were not located side by side. Sinotubular junction plasty of the neoaorta was performed to repress root dilation. Tricuspid valvuloplasty was performed simultaneously in 3 patients.

Data Collection

Patient demographics and clinical data were obtained from our local database. Ventricle function and size were assessed by echocardiography. A single cardiologist reviewed all previous echocardiograms and performed independent measurements. In-hospital mortality was defined as both 30-day mortality and death any time after operation but before discharge. Follow-up mortality was defined as death after 30 days or after discharge if length of hospital stay was >30 days. Reoperation included only reoperations on the heart and excluded secondary closure of the sternum and revision for bleeding or mediastinitis. Valvular regurgitation was considered substantial when documented as moderate or severe. mLV dysfunction was defined as mLV ejection fraction <60%.

Statistical Analysis

Results are presented as mean ± standard deviation for continuous variables with normal distribution, as median and range for variables with nonnormal distribution, and as frequency and percent for categorical variables. Time to death and neoaortic regurgitation at follow-up are displayed by Kaplan-Meier curves. Comparisons of variables were made using the Student t test, the χ^2 test, or the Fisher exact test, as appropriate. Multivariate analysis could not be performed because the ratio of events per variable was too small. The level of significance was set at $\alpha = 0.05$. Analysis was conducted using SPSS version 17.0 (IBM-SPSS Inc, Armonk, NY) for Windows.

RESULTS

Patient Population and Anatomic Characteristics

The study group consisted of 23 men and 17 women. The median age at PAB of these patients was 3.1 years (range, 2 months-10 years), and their median weight at banding was 11.5 kg (range, 5.1-22.0 kg). In this cohort, 28 patients (70.0%) had a patent ductus arteriosus (≤3 mm on echocardiogram), 22 patients (55.0%) had an additional restrictive ventricular septal defect with no hemodynamic significance. TR was present in all patients, including 7 mild, 14 moderate, and 19 severe. One patient had dextrocardia. There were no pre-PAB procedures. The baseline data for these 2 groups are shown in Table 1.

Early Outcomes After PAB

There was no death in either group after PAB. The pressure gradient trans-banding was 53.2 ± 11.1 mm Hg, although the mLV:mRV pressure ratio increased from 0.31 ± 0.15 to 0.63 ± 0.16 immediately after banding (0.63 ± 0.14 in PAB group vs 0.65 ± 0.17 in DS group; $P = .89$). No patient required removal of the band for