Biventricular Repair in Patients with Transposition of the Great Arteries, Ventricular Septal Defect and Pulmonary Stenosis: Rastelli, Nikaidoh or REV Procedures?

Cirugía de reparación biventricular en pacientes con transposición de los grandes vasos, comunicación interventricular y estenosis pulmonar: ¿Rastelli, Nikaidoh, REV?

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ABSTRACT

Background: Biventricular repair of the great arteries with ventricular septal defect and pulmonary stenosis includes the Rastelli operation, the REV (reparation a l’etage ventriculaire) and the Nikaidoh procedure. The treatment of choice is still controversial due to the anatomic variability of this condition and to the suboptimal results of the different surgical techniques proposed.

Objectives: To evaluate the results of biventricular repair procedures performed in our hospital in patients with the great arteries with ventricular septal defect and pulmonary stenosis. 2. To compare morbidity and mortality with the Rastelli operation and the Nikaidoh procedure in the subgroup of patients with non-committed ventricular septal defect.

Methods: Between 1991 and 2015, 76 patients operated on in our center underwent the Rastelli operation [n=60 (78.9%)], the Nikaidoh procedure [n=13 (17%)] and the REV procedure [n=3 (4%)].

Results: In the immediate postoperative period, 24 patients presented ventricular dysfunction, 18 had arrhythmias and 11 developed subaortic stenosis. None of the patients presented signs of significant aortic regurgitation. During a mean follow-up of 9.9 years (± 6 years), 52 patients developed dysfunction of the right ventricle-to-pulmonary artery conduit, 14 patients presented left ventricular outflow tract obstruction, 12 patients had arrhythmias and 1 patient developed moderate aortic regurgitation. Long-term survival at 5 and 10 years was 96%, and 92% at 15 years. Fifty-five percent of the patients required reintervention at 6.2 years (±5), particularly due to dysfunction of the right ventricle-to-pulmonary artery conduit (77%). Nine patients died, 7 in the immediate postoperative period. Mortality was associated with non-committed ventricular septal defect (p=0.02), ventricular dysfunction (p=0.02), arrhythmias (p=0.01) and reoperations (p=0.0000) in the immediate postoperative period. In the group of patients with non-committed ventricular septal defect, the Rastelli operation was associated with higher mortality (p=0.01) and subaortic obstruction in the immediate and late postoperative periods (p=0.04 and p=0.01, respectively), compared with the Nikaidoh procedure.

Conclusions:
- Patients undergoing the Rastelli operation, the Nikaidoh procedure and the REV procedure have favorable long-term survival.
- Reinventions are common (55%), particularly due to dysfunction of the right ventricle-to-pulmonary artery conduit.
- In patients with non-committed ventricular septal defect, the Nikaidoh procedure emerges as a better therapeutic option than the Rastelli operation.

Key words: Heart Defects, Congenital - Cardiac Surgical Procedures/methods - Heart Septal Defects, Ventricular/surgery - Transposition of Great Vessels - Pulmonary Stenosis - Postoperative Period

RESUMEN

Introducción: La corrección biventricular de la transposición de los grandes vasos con comunicación interventricular y estenosis pulmonar incluye las cirugías de Rastelli, REV (reparation a l’etage ventriculaire) y Nikaidoh. El tratamiento de elección aún es controvertido, dada la gran variabilidad anatómica de esta entidad y los resultados subóptimos de las diferentes técnicas quirúrgicas propuestas.

Objetivos: Evaluar los resultados de las cirugías de corrección biventricular realizadas en nuestro hospital en los pacientes con transposición de los grandes vasos con comunicación interventricular y estenosis pulmonar. 2. Comparar las cirugías de Rastelli y Nikaidoh en términos de morbimortalidad en el subgrupo de pacientes con comunicación interventricular no relacionada con la aorta.
INTRODUCTION

Transposition of the great arteries (TGA) with ventricular septal defect (VSD) and pulmonary stenosis (PS) is an uncommon congenital heart defect that can be repaired with several surgical techniques. The method described by Giancaro Rastelli in 1969, known as the Rastelli operation, has been the conventional treatment of this congenital heart defect for many decades. (1, 2) Nowadays, the Rastelli operation is a surgical procedure with low short-term mortality, (3) but with marked mid and long-term morbidity and mortality. (3-13)

In 1982, Lecompte proposed the reparation a l’etage ventriculaire (REV), a technique that reduces the incidence of left ventricular tract obstruction, but generates significant residual pulmonary regurgitation. (14-18)

In 1984, Hisashi Nikaidoh published a new surgical technique: “aortic translocation and biventricular outflow tract reconstruction”. (19) This procedure is presented as a promising therapeutic option, (20-32) particularly for patients with unfavorable anatomy to undergo the Rastelli procedure, as non-committed VSD, (5) restrictive VSD, overriding of the atrioventricular valves, hypoplastic right ventricle and some coronary artery anomalies. (19, 33)

Today, the treatment of choice for TGA with VSD and PS is still controversial due to the anatomic variability of this condition and to the suboptimal results of the different surgical techniques proposed. (34-38)

In the present study, we analyze the mid and long-term surgical outcomes of the Rastelli, Nikaidoh and REV procedures, and also compare the morbidity and mortality of the Rastelli operation and the Nikaidoh procedure in the complex subgroup of patients with TGA and double outlet right ventricle (DORV) with non-committed VSD and PS.

METHODS

We conducted a retrospective study in a cohort of 76 patients with TGA associated with VSD and PS or DORV with TGA like physiology, VSD and PS undergoing biventricular surgery in our center between 1991 and 2015.

Patients were excluded if they had congenitally corrected TGA with VSD and PS requiring double switch plus atrial switch, or had pulmonary atresia or unsuitable pulmonary vascular tree anatomy.

The following anatomical variants were identified: TGA with VSD and PS [n=42 (55%)] and DORV with TGA like physiology [n=34 (45%)].

All patients had moderate or severe left ventricular outflow tract obstruction (LVOTO) secondary to PS (n=69) or pulmonary atresia (n=7).
The anatomical location of the VSD was subaortic in 32 patients (42.1%), subpulmonary in 4 (5.3%), doubly committed in 7 (9.2%), of the inlet in 19 (25%) and muscular in 14 (18.4%).

In 33 patients (43.4%) the VSD was non-committed with the aorta and was restrictive in 9 patients (11.8%).

The most commonly associated congenital heart defects were tricuspid valve anomalies (10 cases), consisting of straddling in 5, overriding in 3 and tricuspid valve dysplasia in 2 cases; coronary artery anomalies (7 cases); pulmonary branch anomalies (4 cases); hypoplastic right ventricle (RV) (3 cases); situs inversus with dextrocardia (3 cases); atrial septal defect (2 cases); multiple VSDs (2 cases), double VSD (1 case), complete atrioventricular canal defect (2 cases) and right-sided aortic arch (2 cases).

The diagnosis was made on the basis of clinical, radiological and electrocardiographic findings, and on echocardiographic, angiographic and computed tomography angiography results.

Eighty-four percent of the patients underwent intervention- nal cardiology procedures (16 patients) or palliative surgeries (62 patients) before the operation.

**Surgical technique**

All the patients included in this study underwent a biventricular repair surgery: Rastelli operation (n=60), Nikaidoh procedure (n=13) or REV (n=3).

Median age at the moment of surgery was 3.7 years [interquartile range (IQR) 25%-75%: 2.4 months-4.8 years; range: 2.4 months-10.8 years] and mean weight was 13.8 kg (± 4.2Kg; range: 4.5-24 kg).

**Follow-up**

All the patients were followed-up in our hospital with a mean follow-up of 9.9 years after surgery (± 6 years; range: 6 months-24 years).

All patients were assessed by means of physical examination, chest-X ray, electrocardiogram, color-Doppler echocardiography, tissue-Doppler echocardiography, exercise stress test and 24-hour Holter monitoring. Some patients also underwent stress echocardiography, cardiac magnetic resonance imaging, multislice computed tomography and/or cardiac catheterization.

The diagnosis of heart valve stenosis or regurgitation was made according to echocardiographic findings and following the current guidelines (39, 40); only moderate and severe valve diseases were considered significant.

Functional capacity was assessed using the New York Heart Association classification.

Left ventricular (LV) function was determined by Doppler echocardiography (M-mode, two-dimensional and tissue-Doppler) and magnetic resonance imaging was used to evaluate right ventricular function.

**Statistical analysis**

Data were stored using Microsoft Office Excel®2013. All the calculations were performed using Statistix 8.0 software package.

Qualitative variables were expressed as absolute values or percentages, while quantitative variables with normal and non-Gaussian distribution were expressed as means and standard deviation or medians and IQR, respectively.

Continuous variables were compared using Student’s t test or the Mann-Whitney test, as applicable. Fisher’s exact test or the chi square test was used to compare proportions. A p value <0.05 was considered statistically significant. Mid and long-term survival was estimated using the Kaplan-Meier method.

**Ethical considerations**

The study was approved by the institutional Ethics Committee according to valid regulations for observational studies and following the recommendations of the Declaration of Helsinki.

**RESULTS**

Median cardiopulmonary bypass time was 182 min (IQR 25%-75%: 149-220) and mean aortic cross-clamp time was 101.5 min (IQR 25%-75%: 75-131.75).

Patients were hospitalized for a median of 9 days (IQR 25%-75%: 3-17, median inotropic support requirement was 5 days (IQR 25%-75%: 2-9) and median mechanical ventilation was 2 days (IQR 25%-75%: 1-7).

Overall mortality was 11.8%. Nine patients died, 7 in the immediate postoperative period.

Surgical mortality was 9.2% (7 patients) but in the second half of the period (since 2003) mortality decreased to 2.6%.

In-hospital mortality occurred at a median of 17 days after surgery (IQR 25%-75%: 1.5–88 days) and was secondary to severe isolated ventricular dysfunction in 1 patient and in the rest of the patients (n=6) was due to arrhythmias (n=5): ventricular tachycardia in 1, complete atrioventricular block (AVB) in 1, and nodal tachycardia in 1; residual defects (n=3): residual VSD in 2, LVOTO and hypoplastic RV in 1, and sepsis or infective endocarditis (n=4).

Long-term mortality was 2.9%. Two patients died at 1.5 and 11.9 years after surgery due to uncontrolled infective endocarditis and leukemia.

At univariate analysis, mortality was associated with VSD non-committed with the aorta (p=0.02), reoperations (p=0.000), ventricular dysfunction (p=0.02) and arrhythmias (p=0.01) in the immediate postoperative period.

Long-term survival at 5 and 10 years was 96%, and 92% at 15 years (Figure 1 A).

Ninety-seven percent of the surviving patients are in functional class I with good ventricular function.

In the immediate postoperative period, 34.2% of patients (n=26) presented ventricular dysfunction with favorable response to medical treatment, except for one case that required ventricular assist device for 72 hours.

During follow-up, 97% of the patients presented good ventricular function with a mean shortening fraction of 36.8% (±4.87) and mean ejection fraction of 68.33% (±4.58).

**Arrhythmias**

In the immediate postoperative period, 18 patients presented arrhythmias: junctional tachycardia in 8, AVB in 8, atrial flutter in 1 and ventricular premature beats (VPB) in 1 patient.
One patient presented first-degree AVB and 7 patients had complete AVB. Complete AVB was transient in 6 patients and a definite pacemaker was implanted in only 1 patient.

Junctional tachycardia was successfully treated with medical therapy in all cases.

The incidence of arrhythmias at the long-term outcome was 19.4% (n=13) at a median time of 8.5 years after surgery (IQR 25%-75%: 5.7-11).

The following arrhythmias were recorded: ventricular tachycardia (VT) in 4 patients, ventricular fibrillation in 1, non-sustained VT in 1, atrial tachycardia in 1, accelerated His bundle rhythm in 1, frequent VBP in 3 and frequent supraventricular extrasystoles in 2.

Ventricular fibrillation occurred during a diagnostic cardiac catheterization performed 6 months after the Rastelli operation in a patient with residual VSD and left ventricular dilation with severe dysfunction.

Ventricular tachycardia occurred at a median of 8.5 years after surgery (IQR 25%-75%: 2.9-10.5). A hemodynamic substrate [right ventricular pressure overload and/or volume overload due to severe dysfunction of the right ventricle to pulmonary artery (RV-PA) conduit] was identified in 3 patients, requiring an interventional cardiology procedure (n=1) and surgery (n=2). Implantable cardioverter defibrillator therapy was indicated in 3 patients.

Non-sustained VT and atrial tachycardia were identified in 24-hour Holter monitoring in asymptomatic patients and were managed with medical treatment.

**Left ventricular outflow tract**

Left ventricular outflow tract obstruction was a complication observed only in patients undergoing the Rastelli operation (Figure 2).

Eleven patients (14.4%) presented subaortic stenosis in the immediate postoperative period with a mean gradient of 30 mm Hg (±13.27). Two of them required reoperation for LV-to-aorta baffle revision, one at 12 hours and the other 15 days after surgery.

During follow-up, subaortic stenosis affected 14 patients (20.8%) with a mean gradient of 38 mm Hg (±25.19), which was significant in 8 patients (11.9%).

This late complication was the reason for reoperation in 9 patients at a mean time of 6.5 years after surgery (±2.1). The remaining 5 patients are under control. Three of them have residual stenosis and subaortic stenosis developed in 2 during the long-term follow-up. All the patients remain stable with
mild stenosis after a mean follow-up time of 11 years (±6.8) after surgery.

Significant aortic regurgitation did not occur in the immediate postoperative period. During follow-up, only one patient who underwent the Nikaidoh procedure developed moderate aortic regurgitation (1.6%).

Right ventricular outflow tract
Fifty-two patients developed RV-PA conduit dysfunction: 40 with the Rastelli operation, 10 with the Nikaidoh procedure and 2 with REV (p 0.58).

Thirty-eight patients presented significant stenosis of this conduit with a mean gradient of 62.78 mm Hg (±16.8), which was severe in 22 patients.

Significant insufficiency of the RV-PA conduit was seen in 33 patients, which was severe in 10.

Seventy-five patients required reoperations due to severe dysfunction of the RV-PA conduit: 32 patients underwent an interventional cardiology procedure (balloon dilation) and 43 patients were reoperated to replace the conduit.

Reinterventions
Fifty-five percent (42 patients) of the patients required reinterventions (interventional cardiology procedures and/or surgery) after a mean of 6.2 years (± 5).

Freedom from interventional cardiology procedures occurred in 72%, 51% and 32% of the patients at 5, 10 and 15 years, respectively (Figure 1B).

A total of 42 interventional cardiology procedures were performed in 29 patients at a mean time of 6.5 years (± 4.5).

The main indication (32 procedures (76.2%)) was severe stenosis of the RV-PA conduit, requiring balloon angioplasty (Figure 3).

The rest of the procedures were: balloon angioplasty or stent implantation of pulmonary artery branches (n=3), stent implantation in the right pulmonary branch + embolization of the left superior vena cava (n=1), embolization of aortopulmonary collaterals (n=2), LV-right atrium closure (n=1) and radiofrequency catheter ablation (n=3).

Freedom from reoperation occurred in 76%, 37% and 21% of the patients at 5, 10 and 15 years, respectively (Figure 1 C).

Fifty-five reoperations were performed in 39 patients after a mean time of 6.05 years after surgery (±4.7; range: 0-18.8 years).

Among the patients undergoing reoperations, 12 required a second reoperation, 3 a third reoperation and 1 patient required 4 reinterventions at a mean time of 7 (±5.4), 7.5 (±4.9), and 10.2 years after surgery, respectively. One patient is scheduled for implantable cardioverter defibrillator insertion.

Reoperations are detailed in Table 1.

Subgroup of patients with non-committed ventricular septal defect
Thirty-three patients had non-committed VSD; 20 underwent the Rastelli operation and 13 the Nikaidoh procedure.

The immediate and long-term outcomes of this subgroup are summarized in Table 2.

Among these 33 patients, those undergoing the Rastelli operation had greater mortality (p=0.01) and greater incidence of subaortic stenosis in the immediate (p=0.04) and long-term (p =0.01) follow-up period than those who underwent the Nikaidoh procedure.

DISCUSSION

The surgery of choice for TGA with VSD and PS and for DORV with PS and TGA like physiology is still controversial. Several surgical techniques have been proposed for biventricular repair, as the Rastelli operation, the REV procedure and the Nikaidoh procedure.

In the present study, we corroborated that these three surgical techniques provide favorable long-term survival, as most of the patients are asymptomatic, with good functional class and preserved ventricular function.

In the long-term, the Rastelli operation, the Nikaidoh procedure and the REV procedure clearly demonstrate to be surgical repair techniques but not corrective procedures, with development of complications and need of reinterventions.

Fig. 3. Interventional cardiology procedure in a patient who developed severe stenosis of the right ventricle-pulmonary artery homograft 5 years after the Rastelli operation. The stenosis is observed in A, B and C. Stenosis dilation using balloon catheter. D. Angiography after effective dilation.
Reoperations indicated (total n=55)

<table>
<thead>
<tr>
<th>Table 1. Reoperations on the 76 patients operated</th>
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<tbody>
<tr>
<td><strong>On the right side (n=33)</strong></td>
</tr>
<tr>
<td>- RV-PA conduit replacement (23)</td>
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<tr>
<td>- RV-PA conduit replacement + VSD closure + mitral valve repair + tricuspid valve repair (1)</td>
</tr>
<tr>
<td>- RV-PA conduit replacement + punctiform VSD closure + tricuspid valve repair (2)</td>
</tr>
<tr>
<td>- RV-PA conduit replacement + VSD closure (2)</td>
</tr>
<tr>
<td>- RV-PA conduit replacement + tricuspid valve repair (1)</td>
</tr>
<tr>
<td>- RV-PA conduit replacement + mitral valve replacement (2)</td>
</tr>
<tr>
<td>- RV-PA conduit replacement + mitral valve annuloplasty (1)</td>
</tr>
<tr>
<td>- Subpulmonary resection + VSD closure (1)</td>
</tr>
<tr>
<td><strong>On the left side (n=3)</strong></td>
</tr>
<tr>
<td>- Baffle enlargement (1)</td>
</tr>
<tr>
<td>- Baffle enlargement + Glenn cavo-pulmonary shunt (1)</td>
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<tr>
<td>- Resection of subaortic membrane (1)</td>
</tr>
<tr>
<td><strong>On both outflow tracts (n=11)</strong></td>
</tr>
<tr>
<td>- RV-PA conduit replacement + resection of subaortic membrane (5)</td>
</tr>
<tr>
<td>- RV-PA conduit replacement + resection of subaortic membrane + LV-Ao baffle revision (1)</td>
</tr>
<tr>
<td>- RV-PA conduit replacement + VSD enlargement (1)</td>
</tr>
<tr>
<td>- RV-PA conduit replacement + LV-Ao baffle revision: patch replacement (TV and patch vegetations) (1).</td>
</tr>
<tr>
<td>- RV-PA conduit replacement + RPAB repair + replacement of the ascending aorta (1)</td>
</tr>
<tr>
<td>- RV-PA conduit replacement + resection of subaortic membrane and myomectomy (1)</td>
</tr>
<tr>
<td>- RV-PA conduit replacement + closure of the aneurysm mouth (1)</td>
</tr>
<tr>
<td><strong>Others (n=8)</strong></td>
</tr>
<tr>
<td>- Closure of residual VSD (3)</td>
</tr>
<tr>
<td>- Closure of VSD with LV-RA shunt + tricuspid valve repair (1)</td>
</tr>
<tr>
<td>- Pacemaker implant (1)</td>
</tr>
<tr>
<td>- ICD implant (2)</td>
</tr>
<tr>
<td>- Mitral valve replacement with mechanical prosthesis.</td>
</tr>
</tbody>
</table>

Dysfunction of the RV-PA conduit was the most common adverse event and the main cause of reoperation. Although in the Nikaidoh procedure the aortic translocation to a posterior position leaves more room for the RV-PA conduit connection, avoiding exposure to sternal anterior compression, in our series we did not find significant differences in RV-PA conduit durability with this technique. This result evidences that dysfunction of the RV-PA conduit responds not only to anatomical factors but also to the natural history of homografts.

Subaortic stenosis was the cause of reoperation in 11% of our population undergoing the Rastelli operation, while no cases of LVOTO were reported after the Nikaidoh procedure, in agreement with previous reports. (4, 9, 24, 27, 28) This confirms one of the main foundations of aortic translocation, which is to achieve a better LV-aorta alignment, avoiding long intracardiac tunneling to reduce the risk of subaortic obstruction.

Aortic regurgitation was not a significant adverse event in our series, as opposed to other groups that reported this complication in the outcome of the Nikaidoh procedure. (20) As this procedure preserves the aortic root and the morphologically normal left semilunar valve, the incidence of significant aortic regurgitation is lower than the one described in patients operated on with arterial switch or the Ross procedure.

Arrhythmias were common in our series as in previous reports (4) and secondary to hemodynamic and electrical substrates, confirming the importance of a thorough follow-up in this complex group of patients, where electrocardiogram, color-Doppler echocardiography, 24-hour Holter monitoring and exercise stress test should be routine complementary studies.

Surgical mortality decreased during the second period (learning curve) and long-term mortality was low and attributable to comorbidities rather than to surgery. Mortality was significantly higher in the group of patients with VSD non-committed with the aorta and was also associated with arrhythmias, ventricular dysfunction and reoperations in the immediate post-operative period. The adverse effect of remote VSD on morbidity and mortality related to the Rastelli operation is reaffirmed, as already published by our center,
Table 2. Postoperative results in the subgroup of patients with non-committed ventricular septal defect (n = 33)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Rastelli surgery (N = 20)</th>
<th>Nikaidoh procedure (N = 13)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPB time, minutes</td>
<td>208.9 (±64.5)</td>
<td>225.3 (±64.2)</td>
<td>0.50</td>
</tr>
<tr>
<td>Aortic cross-clamp time, minutes</td>
<td>124.4 (±30.5)</td>
<td>169.1 (±51.04)</td>
<td>0.004</td>
</tr>
<tr>
<td>Immediate postoperative period</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Days in MV</td>
<td>14.1 (±24.4)</td>
<td>10.6 (±13.3)</td>
<td>0.65</td>
</tr>
<tr>
<td>Days with inotropic support</td>
<td>10 (±12.3)</td>
<td>12.5 (±12.7)</td>
<td>0.58</td>
</tr>
<tr>
<td>Days of hospitalization</td>
<td>19.9 (±19.9)</td>
<td>23.2 (±31)</td>
<td>0.72</td>
</tr>
<tr>
<td>Surgical mortality</td>
<td>6</td>
<td>0</td>
<td>0.02</td>
</tr>
<tr>
<td>Ventricular dysfunction</td>
<td>9</td>
<td>6</td>
<td>0.94</td>
</tr>
<tr>
<td>Arrhythmias</td>
<td>8</td>
<td>2</td>
<td>0.31</td>
</tr>
<tr>
<td>LVOTO</td>
<td>5</td>
<td>0</td>
<td>0.04</td>
</tr>
<tr>
<td>Significant aortic valve regurgitation</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Interventional cardiology procedures</td>
<td>2</td>
<td>0</td>
<td>0.23</td>
</tr>
<tr>
<td>Reoperations</td>
<td>7</td>
<td>1</td>
<td>0.07</td>
</tr>
<tr>
<td>Long-term postoperative period</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Follow-up, years</td>
<td>9.06 (±6.05)</td>
<td>6.6 (±3.2)</td>
<td>0.24</td>
</tr>
<tr>
<td>Long-term mortality</td>
<td>1</td>
<td>0</td>
<td>0.41</td>
</tr>
<tr>
<td>Ventricular dysfunction</td>
<td>1</td>
<td>1</td>
<td>0.90</td>
</tr>
<tr>
<td>Arrhythmias</td>
<td>3</td>
<td>4</td>
<td>0.47</td>
</tr>
<tr>
<td>LVOTO</td>
<td>6</td>
<td>0</td>
<td>0.01</td>
</tr>
<tr>
<td>Significant aortic valve regurgitation</td>
<td>0</td>
<td>1</td>
<td>0.26</td>
</tr>
<tr>
<td>Significant stenosis of the RV-PA conduit</td>
<td>10</td>
<td>6</td>
<td>0.24</td>
</tr>
<tr>
<td>Significant insufficiency of the RV-PA conduit</td>
<td>11</td>
<td>9</td>
<td>0.85</td>
</tr>
<tr>
<td>Overall mortality</td>
<td>7</td>
<td>0</td>
<td>0.01</td>
</tr>
<tr>
<td>Interventional cardiology procedures</td>
<td>7</td>
<td>3</td>
<td>0.46</td>
</tr>
<tr>
<td>Reoperations</td>
<td>11</td>
<td>4</td>
<td>0.17</td>
</tr>
</tbody>
</table>


(5) which motivated a change in the therapeutic strategy of patients with this anatomic variant, initiating our experience with the Nikaidoh procedure. (22)

This subgroup of patients with non-committed VSD has also deserved a specific analysis related to the type of surgery. In patients undergoing the Nikaidoh procedure it was demonstrated that despite this was a very demanding technique with longer cardiopulmonary bypass time, the results were similar to those of the Rastelli operation in terms of ventricular dysfunction, days of hospitalization and requirements of MV and inotropic support, while the Rastelli operation presented higher morbidity and mortality and greater incidence of subaortic stenosis in the immediate and long-term follow-up than the Nikaidoh procedure.

Study limitations
These findings should be confirmed with a larger number of patients during a longer follow-up period.

CONCLUSIONS
The surgical procedures for biventricular repair of patients with TGA, VSD and PS offer good long-term survival rate despite the presence of adverse events and need for reinterventions. In this subgroup of patients with noncommitted VSD, the Nikaidoh procedure emerges as the best option. Patients who survive to these surgeries of biventricular repair should undergo a thorough and periodical follow-up.

Conflicts of interest
None declared. (See authors’ conflicts of interest forms on the website/Supplementary material).

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