

Surgical Management of TGA, VSD, and LVOTO

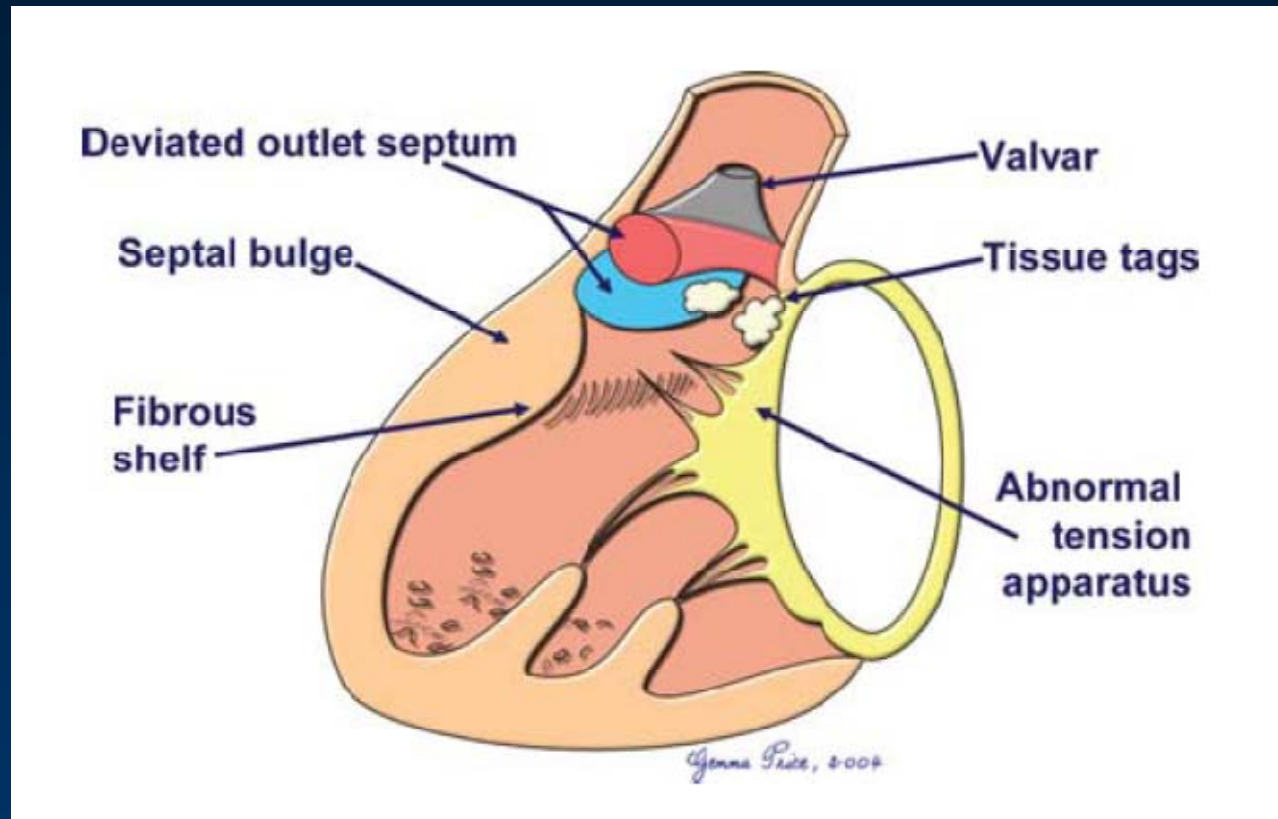
Cheul Lee, MD

**Department of Thoracic and Cardiovascular Surgery
Sejong General Hospital**

TGA, VSD, and LVOTO

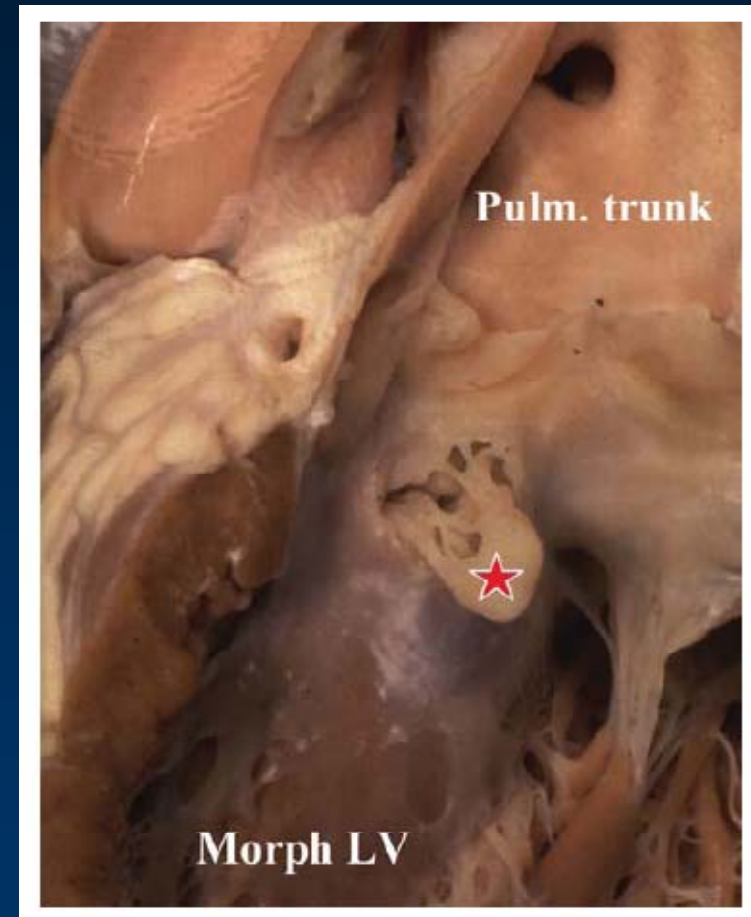
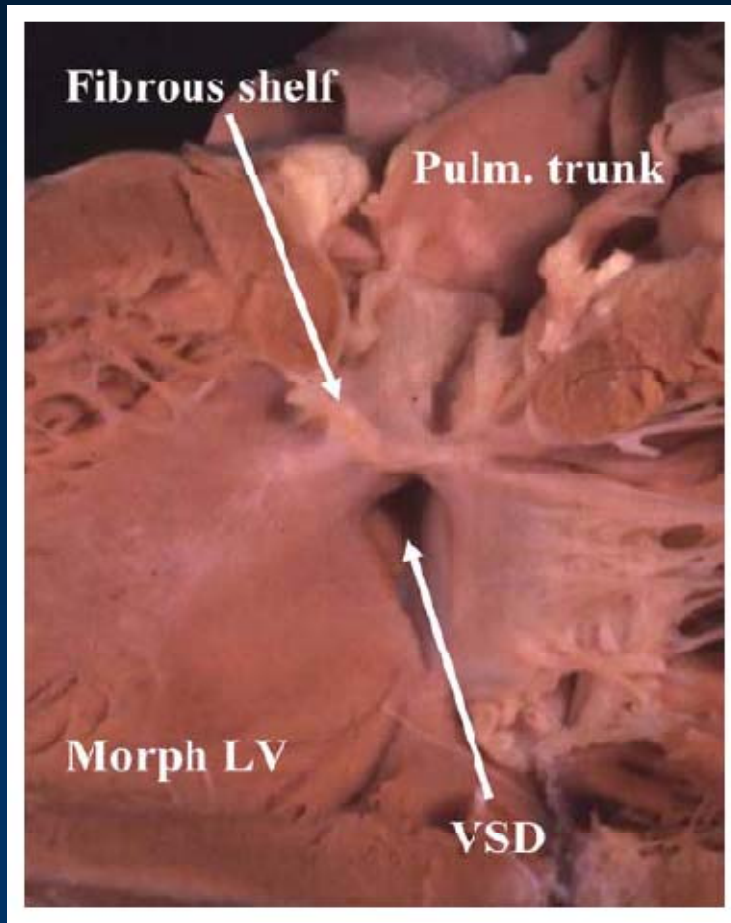
- **Incidence : 0.7% of all CHD**
- **20% of TGA with VSD**
- **4% of infants undergoing surgery for TGA**

Potential Anatomic Substrates for LVOTO in TGA with VSD



Cardiol Young 2005;15(Suppl.1):76-87

Surgically Resectable LVOTO in TGA with VSD



Cardiol Young 2005;15(Suppl.1):76-87

Surgical Option for Resectable LVOTO

Arterial Switch in Hearts With Left Ventricular Outflow and Pulmonary Valve Abnormalities

Young-Sang Sohn, MD, Christian P. R. Brizard, MD, Andrew D. Cochran, FRACS, James L. Wilkinson, FRCP, Carlos Mas, MD, and Tom R. Karl, MD

Cardiac Surgical Unit and Department of Cardiology, Royal Children's Hospital, Melbourne, Australia

Background. Pulmonary valve and left ventricular outflow tract abnormalities (LVOT) may not be absolute contraindications to arterial switch operation (ASO).

Methods. In this study we analyze long-term outcome for 26 such transposition patients (6.3% of our ASO cohort). Median age and weight were 69 days (7 to 3,631 days) and 4.5 kg (2.6 to 34 kg). Pulmonary valve abnormalities included bicuspid valve ($n = 4$) and dysplastic valve ($n = 5$). The LVOT abnormalities ($n = 17$) included accessory atrioventricular valve/endocardial cushion tissue, fibromuscular ring, anomalous muscle bands, and septal malalignment. Patients with dynamic LVOT obstruction were excluded. The median preoperative left ventricular to pulmonary artery peak systolic pressure gradient was 30 mm (0 to 93 mm), or 50 mm (16 to 93 mm) if patients with isolated valve abnormalities are excluded. The ASO was performed according to our standard technique with or without LVOT resection or pulmonary valvotomy as required.

Results. There were two perioperative deaths (7.7%; 95% confidence interval, 0.9% to 25%), and no late deaths

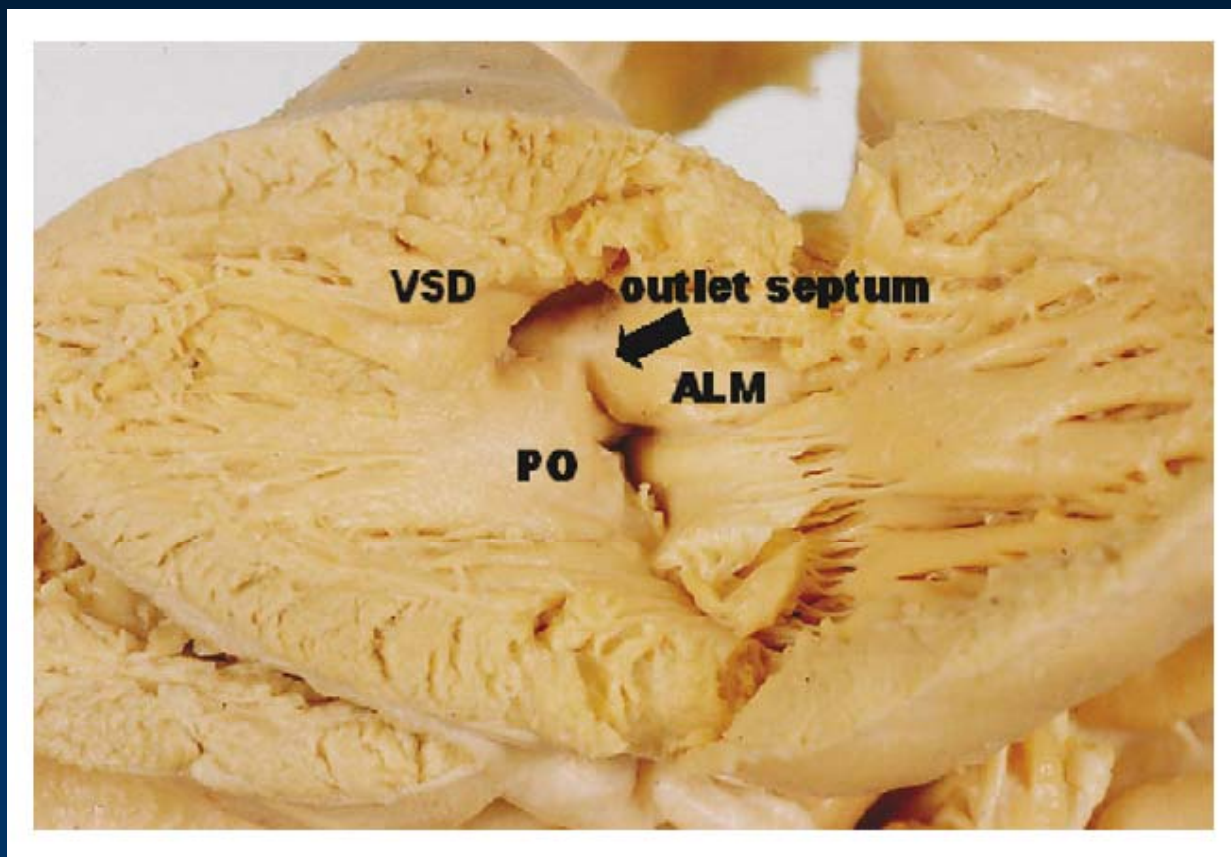
during 1,934 patient-months of follow-up time. Actuarial freedom from reoperation for neo-aortic valve or LVOT problems is 87% (± 7) at 130 months, representing two reoperations. One was performed for neo-aortic insufficiency plus LVOT obstruction, and the other for isolated LVOT obstruction. One patient currently has significant neo-aortic insufficiency, and median gradient at last follow-up is 0 mm Hg (range, 0 to 35 mm Hg).

Conclusions. The ASO can be performed in selected patients with transposition of the great arteries and with LVOT abnormalities with early and late survival and functional status similar to that of matched patients with normal pulmonary valves and LVOT ($p > 0.05$), but with a greater hazard for reoperation ($p < 0.05$). Selection for ASO should be based on anatomic criteria rather than left ventricular to pulmonary artery gradient alone, to avoid assigning these patients with transposition of the great arteries to treatment strategies less satisfactory than ASO.

(Ann Thorac Surg 1998;66:842-8)

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Surgically Unresectable LVOTO in TGA with VSD



Eur J Cardiothorac Surg 2007;31:880-8

Surgical Options

(When LVOTO Resection + ASO Contraindicated)

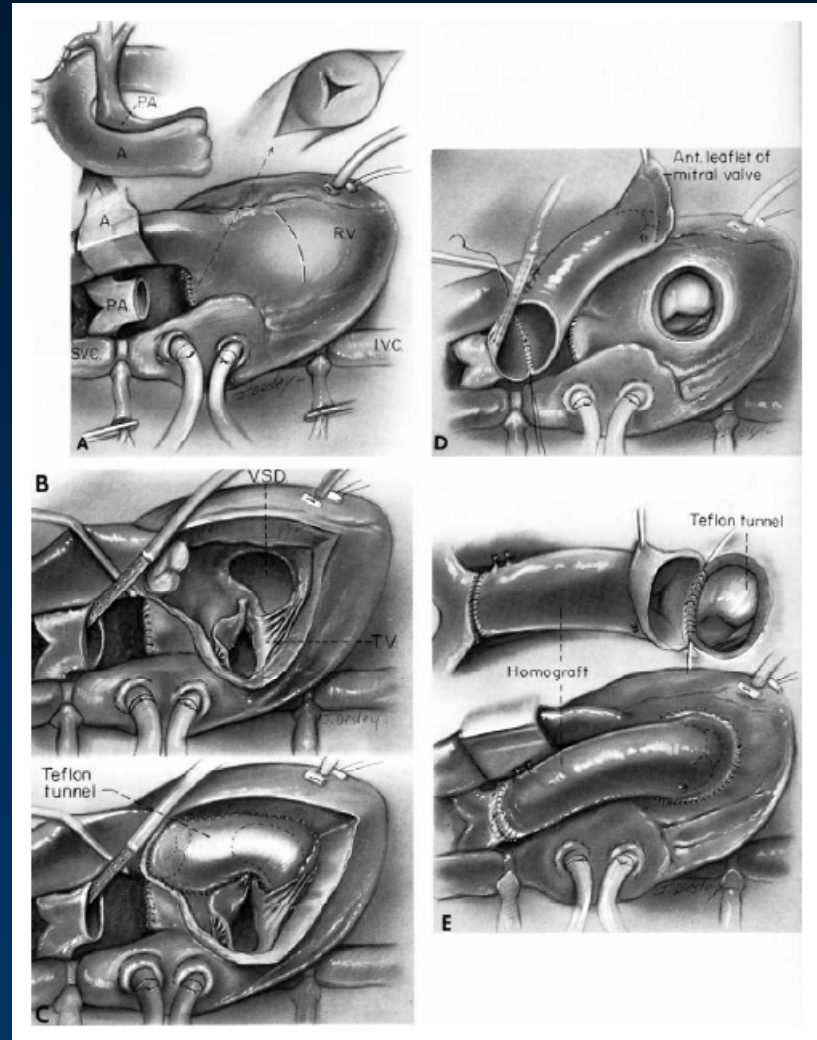
1. Rastelli procedure (1968)
2. REV (*Réparation à l'Étage Ventriculaire*) procedure
(Lecompte procedure, 1980)
3. Nikaidoh procedure (Aortic translocation, 1983)

Rastelli Procedure

Gian Carlo Rastelli (1933 – 1970)

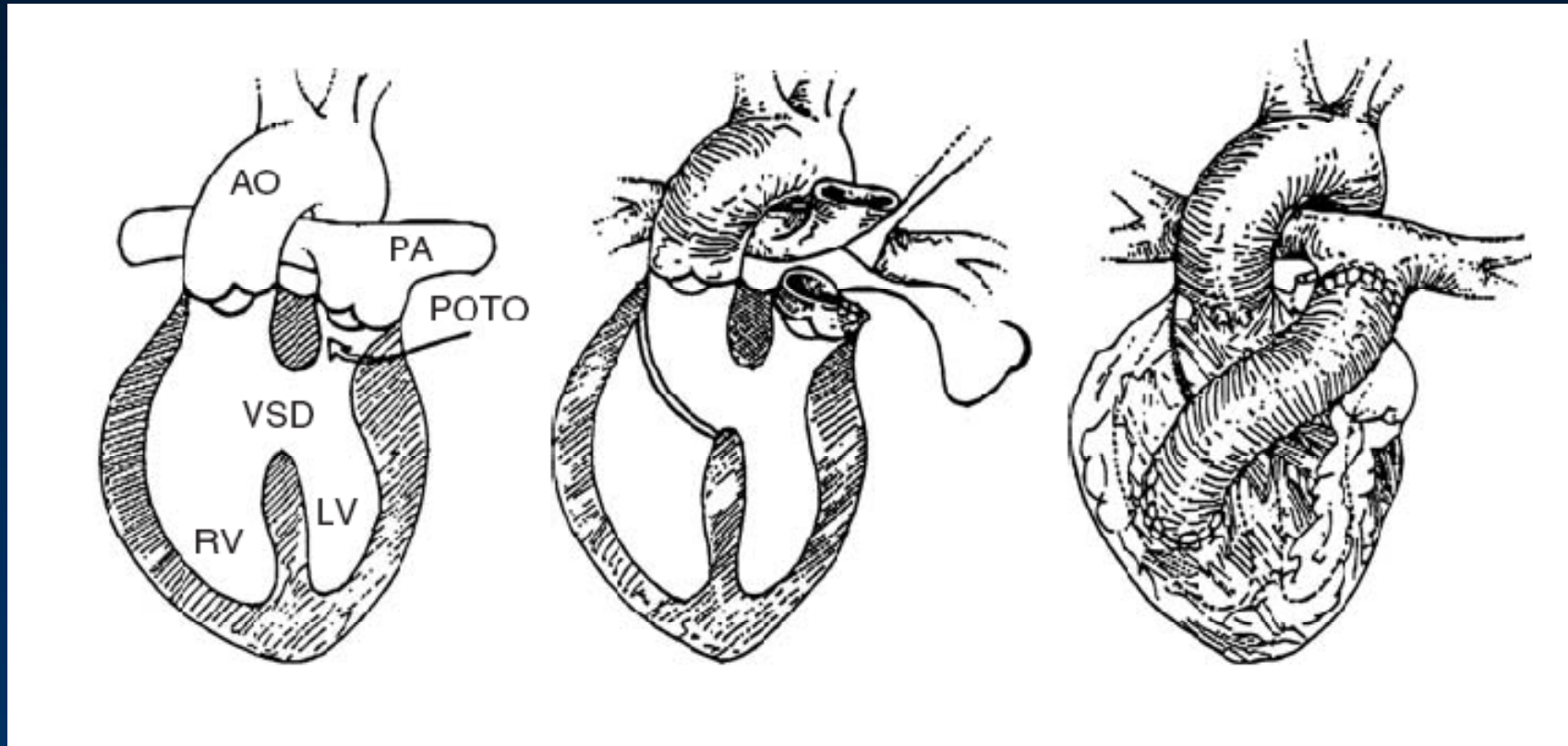


Rastelli Procedure



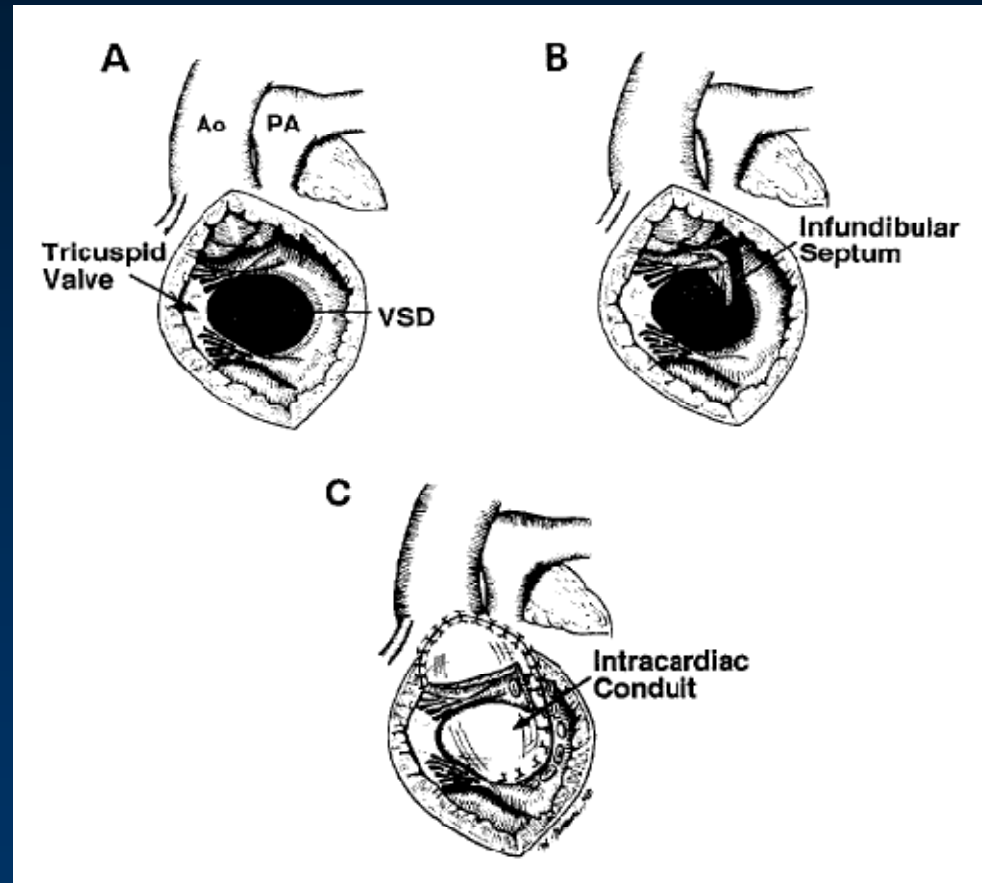
Circulation 1969;39:83-95

Rastelli Procedure



J Thorac Cardiovasc Surg 1992;103:428-436

Tricuspid Malinsertion in the Rastelli Operation Conal Flap Method

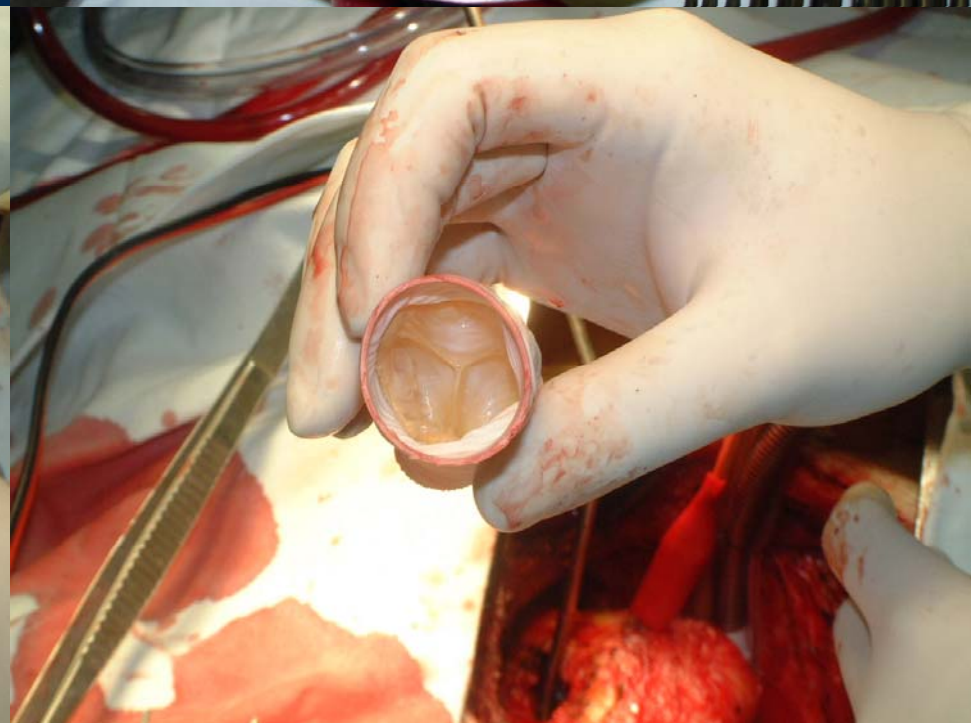
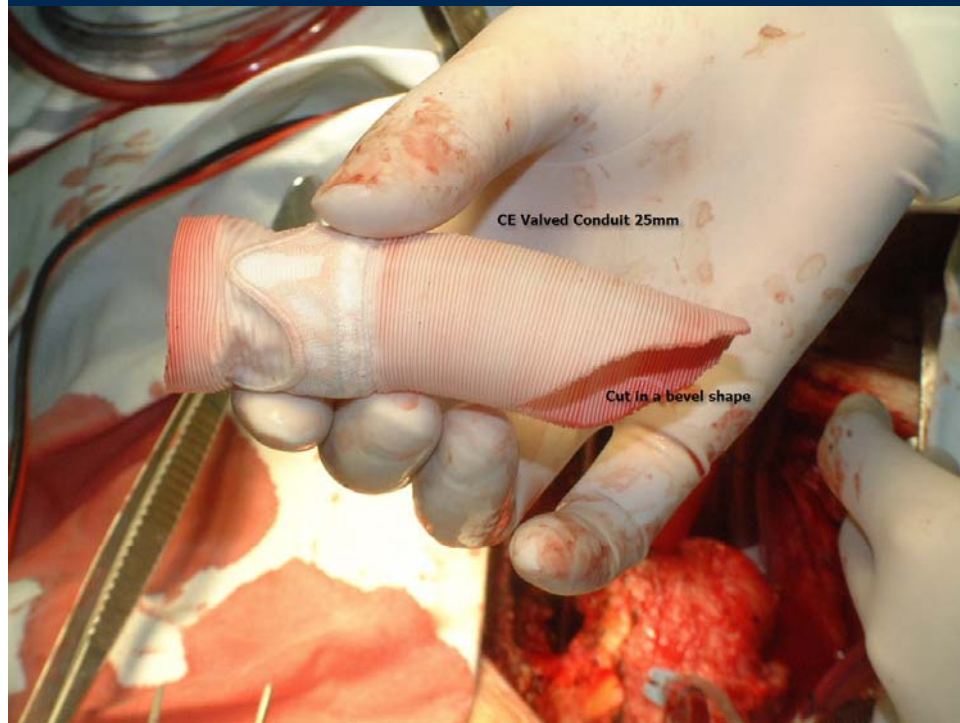


Ann Thorac Surg 1995;59:1476-80

“Rastelli Procedure”

- D-TGA, VSD, and LVOTO
- Truncus arteriosus
- VSD with pulmonary atresia / stenosis
- Double outlet right ventricle (DORV)
- cc-TGA, VSD, and LVOTO

Valved Conduit

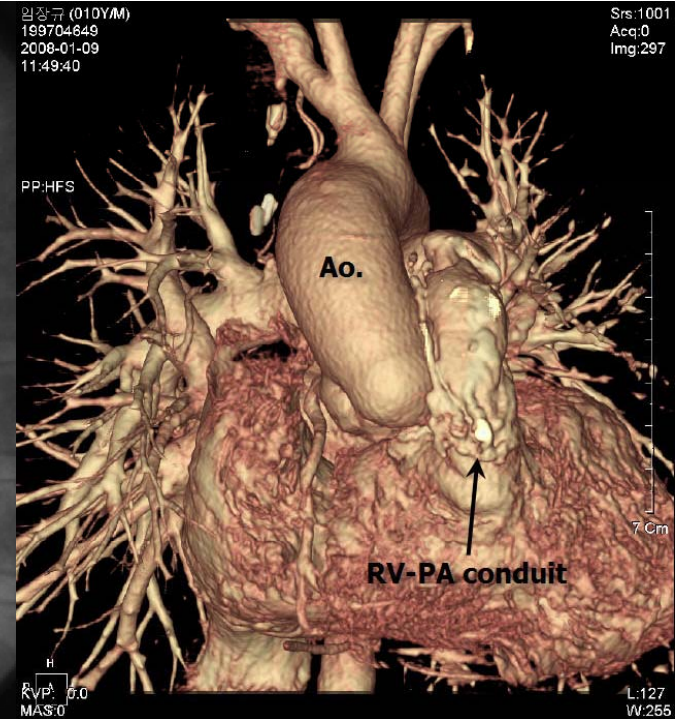
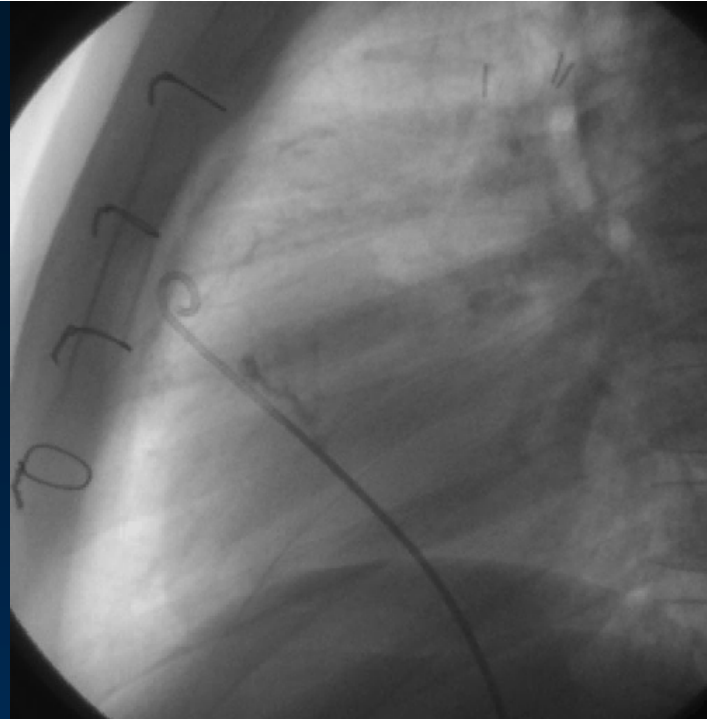


**M / 10 years
D-TGA, VSD, LVOTO**

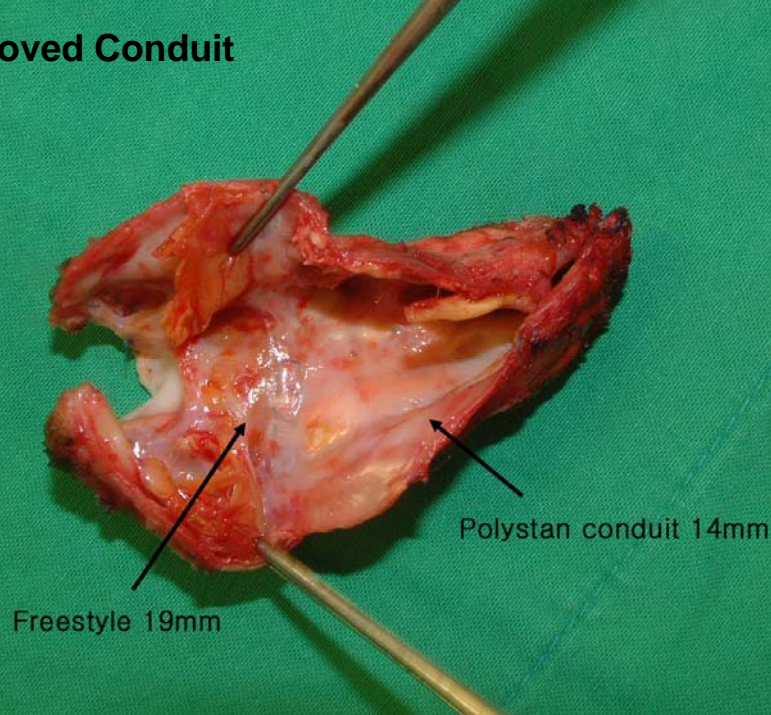
**s/p RMBT shunt (2m)
s/p Rastelli procedure (1y)
s/p PVR (6y)
s/p Conduit change (10y)**

Currently potential LVOTO

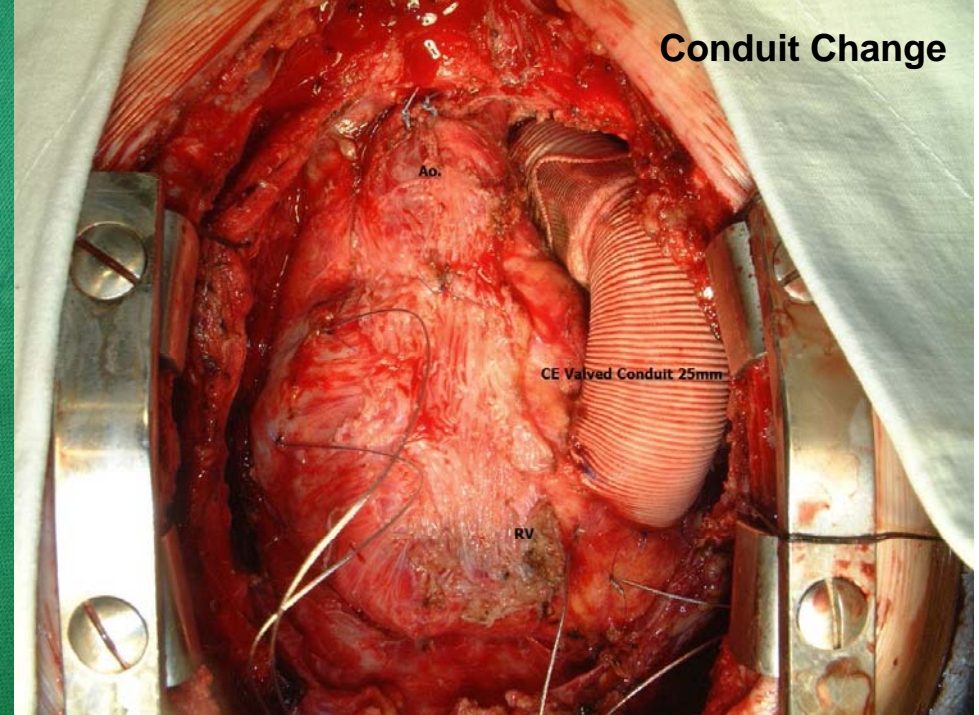
What else in the future?



Removed Conduit



Conduit Change



Boston Children's Hospital Experience

TWENTY-FIVE-YEAR EXPERIENCE WITH RASTELLI REPAIR FOR TRANSPOSITION OF THE GREAT ARTERIES

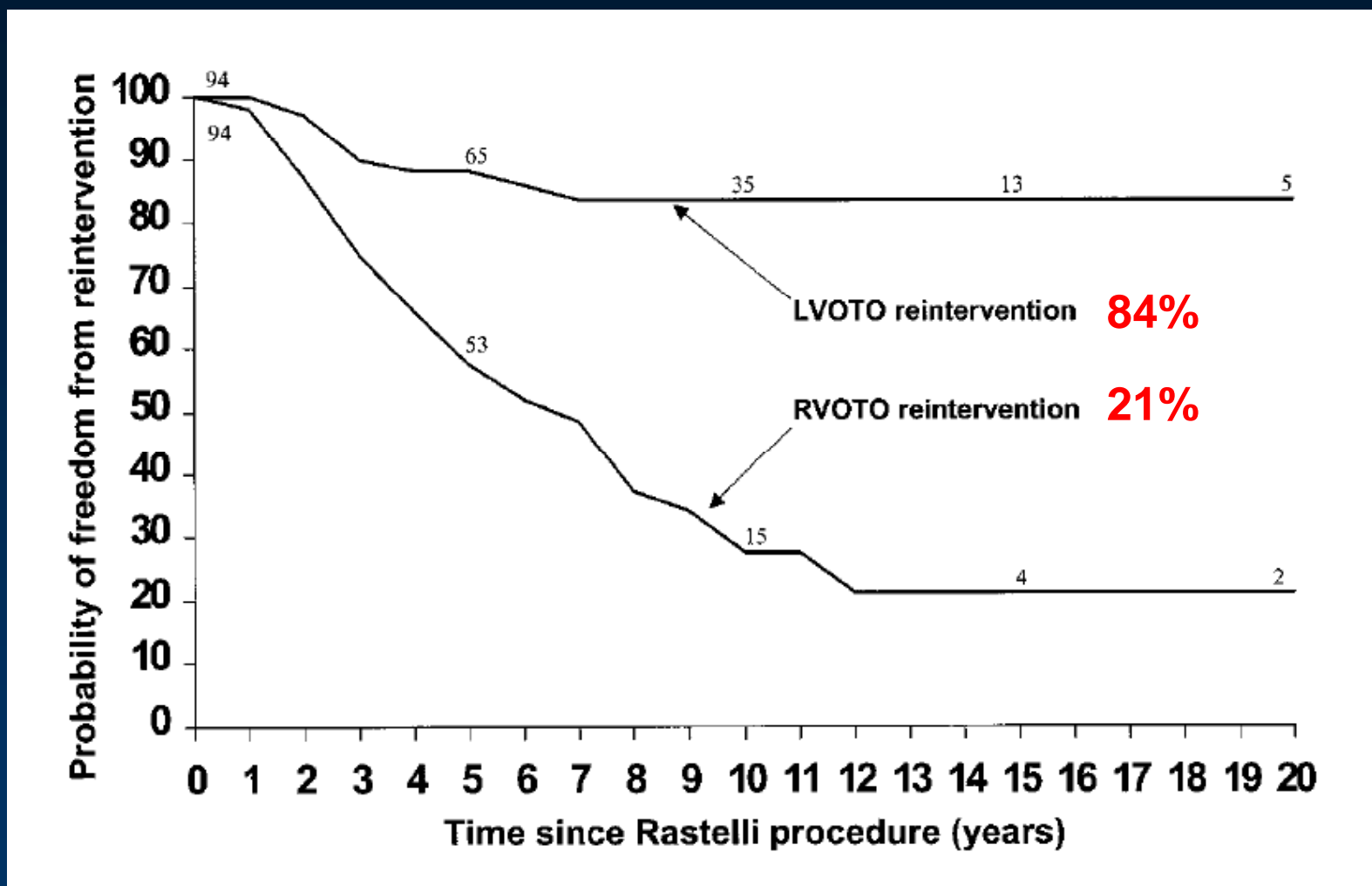
Christian Kreutzer, MD*
Julie De Vive, MD
Guido Oppido, MD
Jacqueline Kreutzer, MD
Kimberlee Gauvreau, ScD
Michael Freed, MD
John E. Mayer, Jr, MD
Richard Jonas, MD
Pedro J. del Nido, MD

Objective: Our purpose was to describe the outcome of the Rastelli repair in D-transposition of the great arteries and to determine the risk factors associated with unfavorable events.

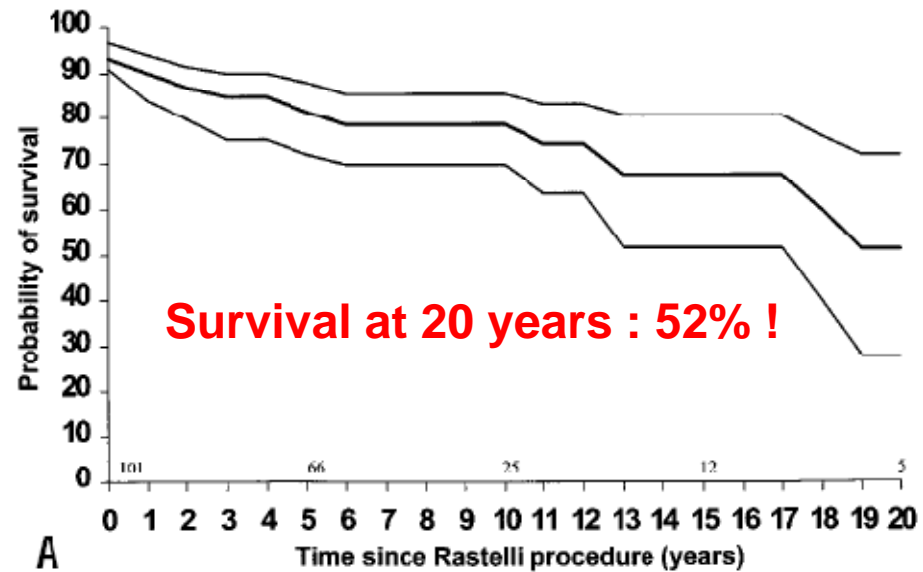
Methods: From March 1973 to April 1998, 101 patients with D-transposition of the great arteries and ventricular septal defect underwent a Rastelli type of repair. Median age and weight were 3.1 years (10th to 90th percentiles 0.3-9.9 years) and 12.8 kg (5.9-28.2). Pulmonary stenosis was present in 73 patients and pulmonary atresia in 18; 10 patients had no left ventricular outflow tract obstruction.

Results: There were 7 early deaths (7%) and no operative deaths in the last 7 years of the study. Risk factors for early death, by univariable analysis, included straddling tricuspid valve ($P = .04$) and longer aortic crossclamping times ($P = .04$). At a median follow-up of 8.5 years, there were 17 late deaths and 1 patient had undergone heart transplantation. Forty-four patients had

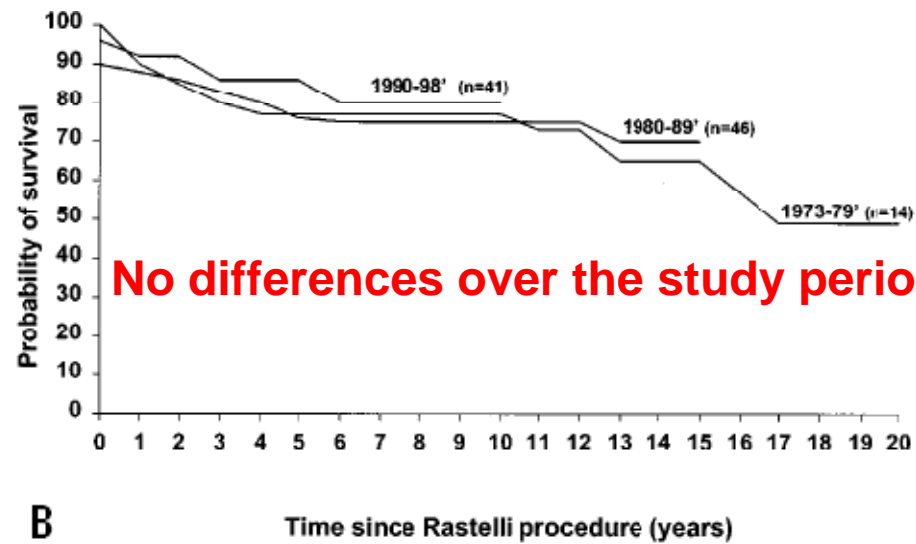
Freedom from Reoperation



J Thorac Cardiovasc Surg 2000;120:211-23



A



B

Causes of Late Death

- **LV dysfunction**
- **Sudden death (arrhythmia)**
- **At reoperation**
- **Unknown**
- **Conduit pseudointima rupture**
- **Myocarditis**

Mayo Clinic Experience

COMPLEX REPAIRS

Late Results of the Rastelli Operation for Transposition of the Great Arteries

Joseph A. Dearani, Gordon K. Danielson, Francisco J. Puga, Douglas D. Mair, and Cathy D. Schleck

The Rastelli operation, first performed in 1968, was developed for repair of transposition of the great arteries with associated ventricular septal defect and severe pulmonary stenosis. This operation includes placement of an intracardiac baffle to direct left ventricular blood to the aorta and an extracardiac valved conduit to establish continuity between the right ventricle and the pulmonary arteries. Over the last 3 decades, the Rastelli operation has been performed with a progressive decline in early mortality, and it remains the preferred repair for transposition, ventricular septal defect, and severe fixed valvular or subvalvular pulmonary stenosis. This chapter examines the late results of our 33-year experience with the Rastelli operation and describes our operative technique.

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Key words: Transposition of the great arteries, Rastelli operation, congenital heart surgery.

Mayo Clinic Experience

- 1968 – 1990
- 160 early survivors
- Follow-up : 12 years

- 53 late deaths (sudden, CHF, PHT...)
- Freedom from conduit reoperation : 27%
- 2 LVOT reoperations
- **Survival at 20 years : 59% !**

German Heart Center Munich Experience

Long-Term Results After the Rastelli Repair for Transposition of the Great Arteries

Jürgen Hörer, MD,* Christian Schreiber, MD, PhD,* Eva Dworak, MD,
Julie Cleuziou, MD, Zsolt Prodan, MD, Manfred Vogt, MD, PhD,
Klaus Holper, MD, PhD, and Rüdiger Lange, MD, PhD

Departments of Cardiovascular Surgery, and Pediatric Cardiology and Congenital Heart Disease, German Heart Center Munich at the Technical University, Munich, Germany

Background. This study sought to assess risk factors for late mortality after the Rastelli operation for patients with transposition of the great arteries, ventricular septal defect, and left ventricular outflow tract obstruction.

Methods. Records of 39 patients who underwent the Rastelli operation between 1977 and 2004 were reviewed. Median age at the time of operation was 5.1 years (2.2 years within the last 5 years).

Results. There were no early deaths. During a median follow-up of 8.9 years (range, 0 to 25 years), 2 patients died of sudden death, 1 of pneumonia, 1 during reoperation, and 2 received heart transplantation. Freedom from death or transplantation was $93.8\% \pm 4.3\%$ and $57.5\% \pm 15.1\%$ at 10 and 20 years, respectively. Freedom from conduit replacement was $48.8\% \pm 10.3\%$ and $32.5\% \pm 10.3\%$ at 10 and 20 years, respectively. Subvalvular and valvular left ventricular outflow tract obstruction ($p = 0.012$), stenosis of the peripheral pulmonary arteries ($p < 0.001$), enlargement of the ventricular septal defect

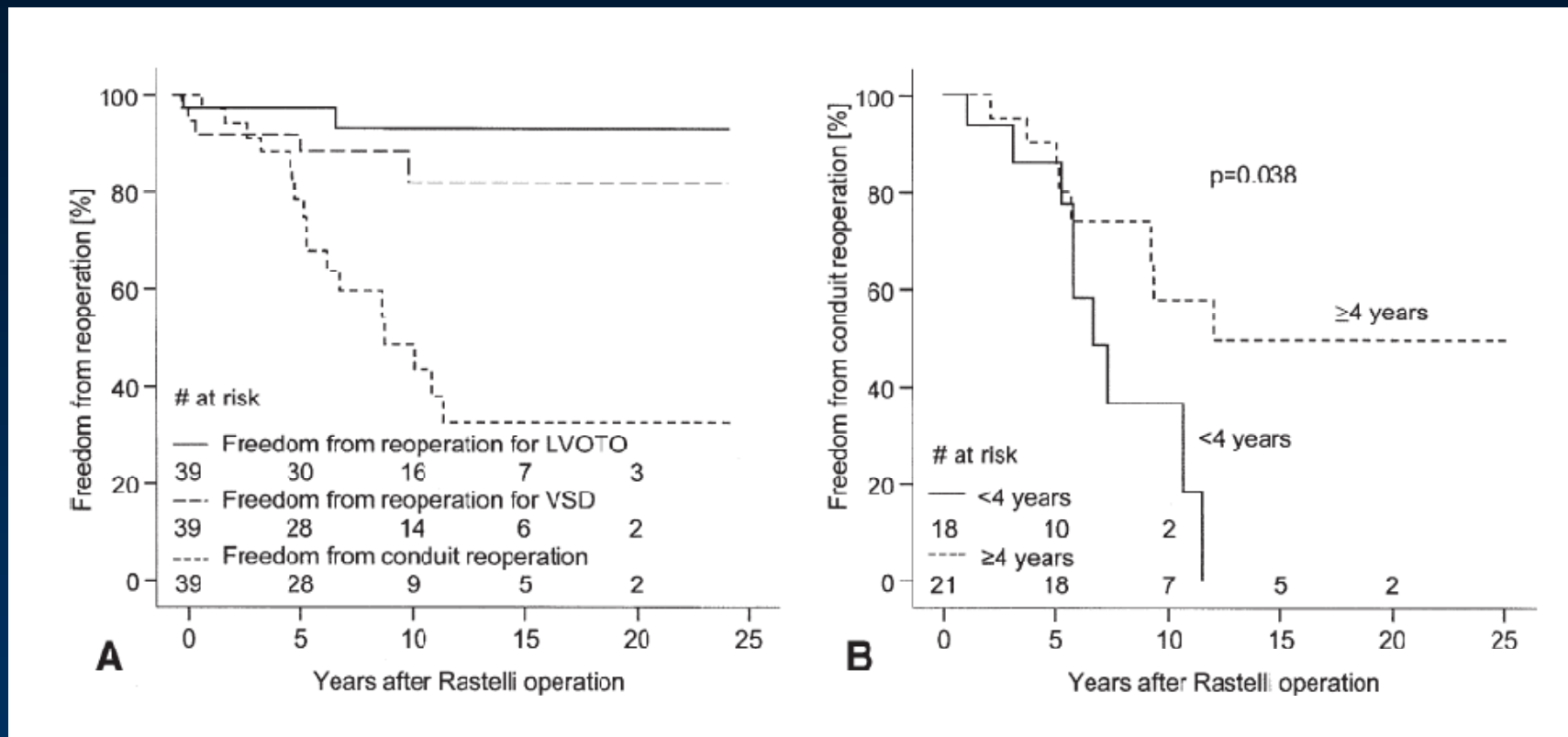
($p = 0.030$), and longer ischemic time ($p = 0.015$) were predictive for death or transplantation. Patients younger than 4 years at the time of the Rastelli operation showed a trend toward a better freedom from death or transplantation ($p = 0.068$), but needed significantly more conduit replacements ($p = 0.038$) compared with patients 4 years or older.

Conclusions. The Rastelli operation is a low-risk procedure with regard to early mortality. The status of the pulmonary arteries and ventricular septal defect enlargement are predictive for long-term survival. Patients 4 years of age or older at the time of the Rastelli operation require fewer reoperations for conduit exchange. Nevertheless, early Rastelli repair is recommended because patients 4 years or older are at risk for a higher long-term mortality.

(Ann Thorac Surg 2007;83:2169–75)

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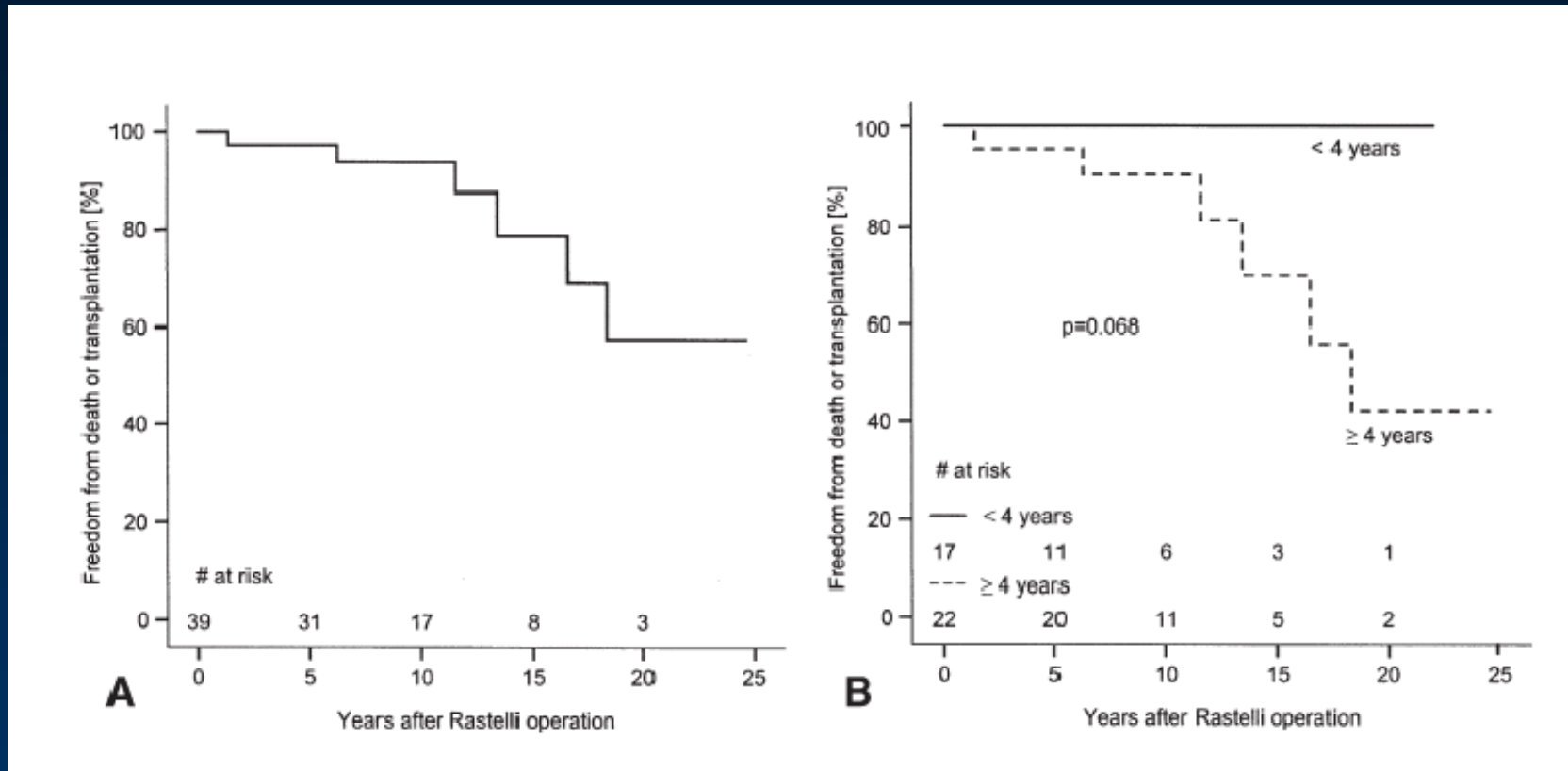
German Heart Center Munich Experience



Freedom from reoperation for LVOTO at 20 years : 93%

Ann Thorac Surg 2007;83:2169-75

German Heart Center Munich Experience



Survival at 20 years : 58% !

Ann Thorac Surg 2007;83:2169-75

Sejong General Hospital Experience

- 1987 – 2007
- N = 17 (data unavailable for 1 patient)
- Age : 3.3 y
- Follow-up : 10.3 y (1 follow-up loss)

- No early / late mortality
- 100% RVOT reoperation
- 2 LVOT reoperation
- 1 late arrhythmia (frequent VT)

What about Single Ventricle ?

Toronto Experience

Outcomes of Tricuspid Atresia in the Fontan Era

Rekwan Sittiwangkul, MD, Anthony Azakie, MD, Glen S. Van Arsdell, MD,
William G. Williams, MD, and Brian W. McCrindle, MD

Departments of Pediatrics and Surgery, Divisions of Cardiology and Cardiovascular Surgery, The Hospital for Sick Children, University of Toronto School of Medicine, Toronto, Ontario, Canada

Background. Whereas indications expand and results improve with increasing refinements to the Fontan procedure the overall impact on outcomes related to tricuspid atresia remains suboptimally defined.

Methods. We reviewed 225 consecutive patients presenting between 1971 and 1999. All patients had classic tricuspid atresia with absent right atrioventricular connection and with D-transposition of the great arteries in 21%, pulmonary outflow obstruction in 75%, and aortic outflow obstruction in 11%.

Results. Ten patients died before any intervention and 3 patients were lost to follow-up. Palliative procedures (includes 151 with systemic shunt, 27 pulmonary artery banding, 60 venous shunt) were performed in 203 patients, with 44 deaths, 8 patients awaiting Fontan, 12 patients Fontan contraindicated, and 11 patients lost-to-follow-up. A total of 137 patients had the Fontan procedure (9 patients without previous procedures) with 7

early deaths, 11 late deaths, and 3 patients progressing to heart transplantation. Total survival for the cohort was 90% at the age of 1 month, 81% at 1 year, 70% at 10 years, and 60% at 20 years with no significant change over the time period. Independent factors associated with ineligibility or death without Fontan (n = 68, 30%) included earlier birth date, lower birth weight, presence of aortic arch anomaly and greater right ventricular hypoplasia, and no palliative procedure. There were no significant changes in mortality with Fontan over the study time period with survival of 95% at 1 month, 93% at 1 year, and 82% at 10 years.

Conclusions. Improvements in outcomes with tricuspid atresia will require attention to management and risk factors before Fontan.

(Ann Thorac Surg 2004;77:889-94)

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60% survival at 20 years !

Problems of Rastelli Procedure

- RVOTO : *no ideal conduit*
- LVOTO : *multi-factorial*
- **Poor long-term survival :**
LV dysfunction, arrhythmia

Mechanisms of LVOTO

- **Restrictive VSD**

 - Originally restrictive*

 - Reduced LV volume load*

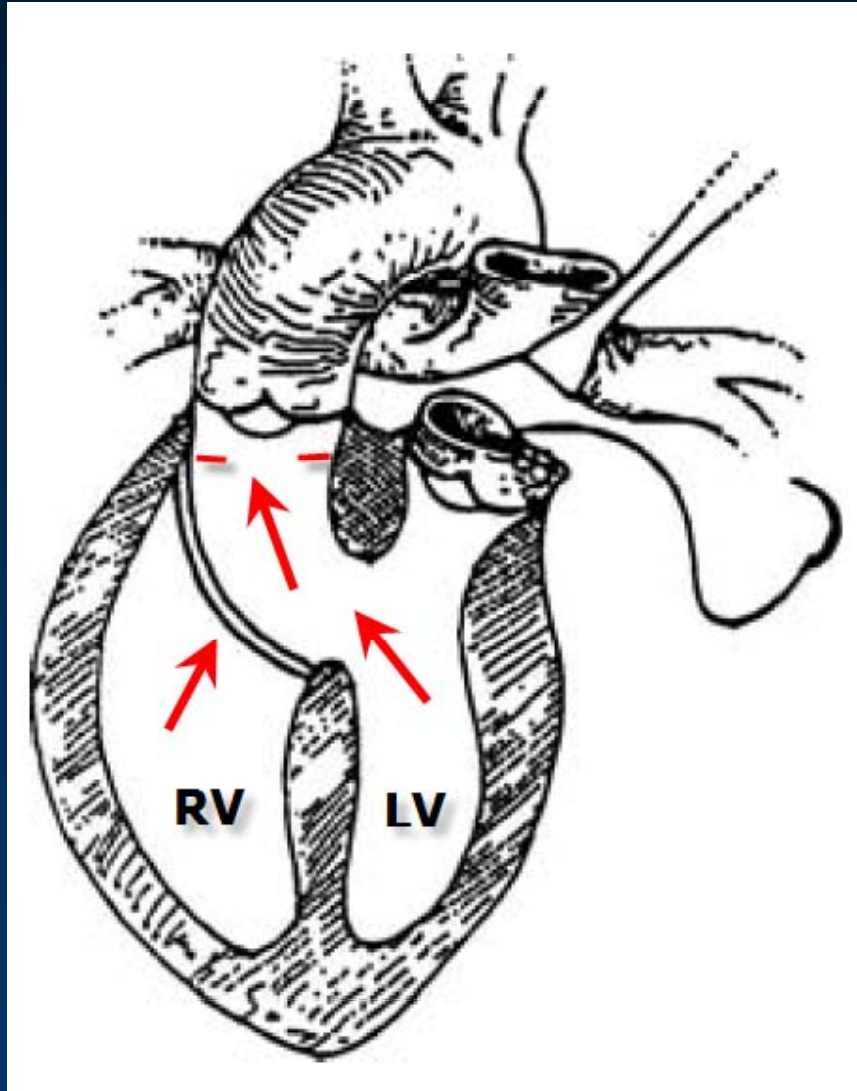
 - Septal hypertrophy d/t RV hypertension*

- **Baffle(tunnel)-related problems**

- **Non-anatomical LVOT course**

 - turbulence → subaortic membrane*

Mechanisms and Prevention of LVOTO



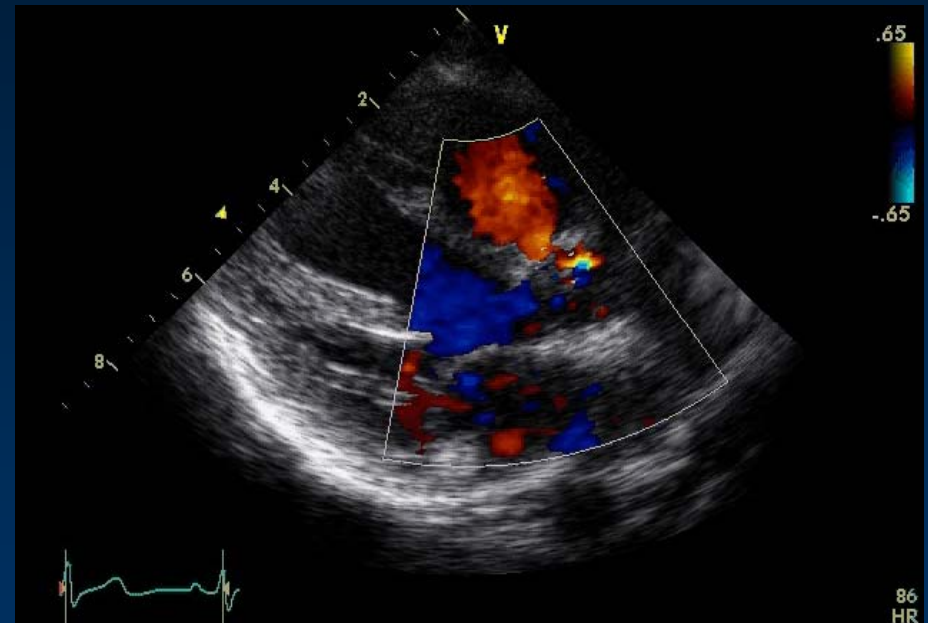
1. VSD enlargement

2. Correct baffle design

3. Straight LVOT course

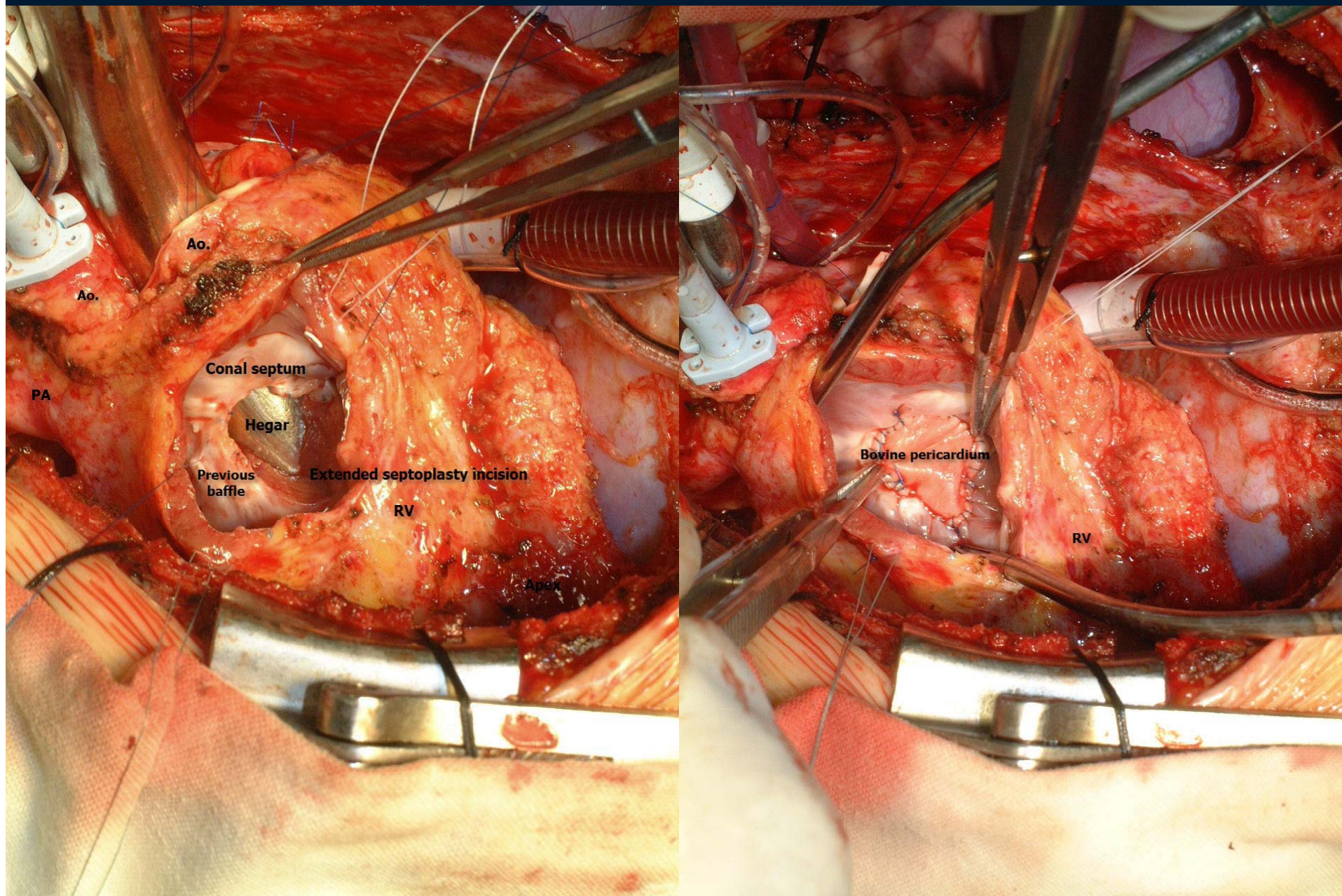
S/P DORV Tunnel Repair

Tunnel Stenosis + Subaortic Membrane



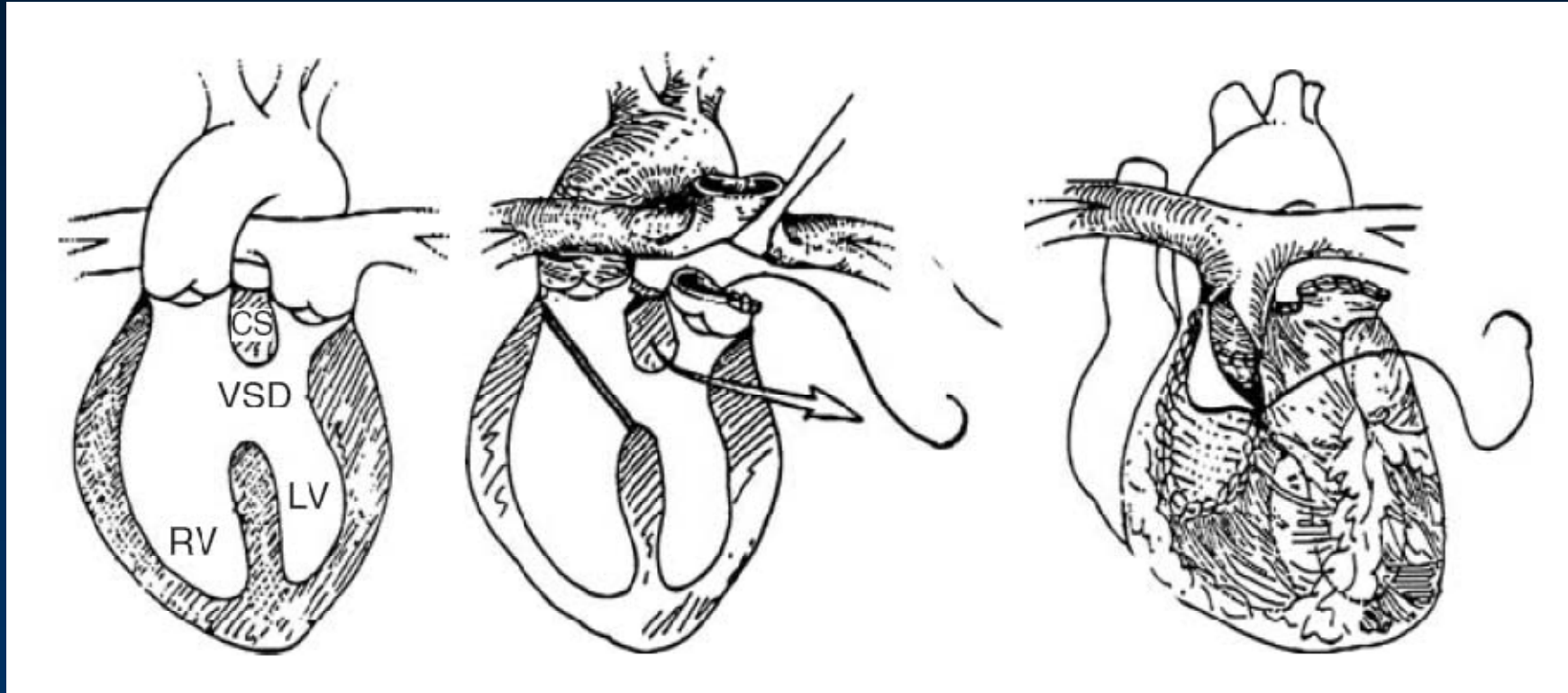
Peak LV-to-Ao PG 80 mmHg

Extended Septoplasty



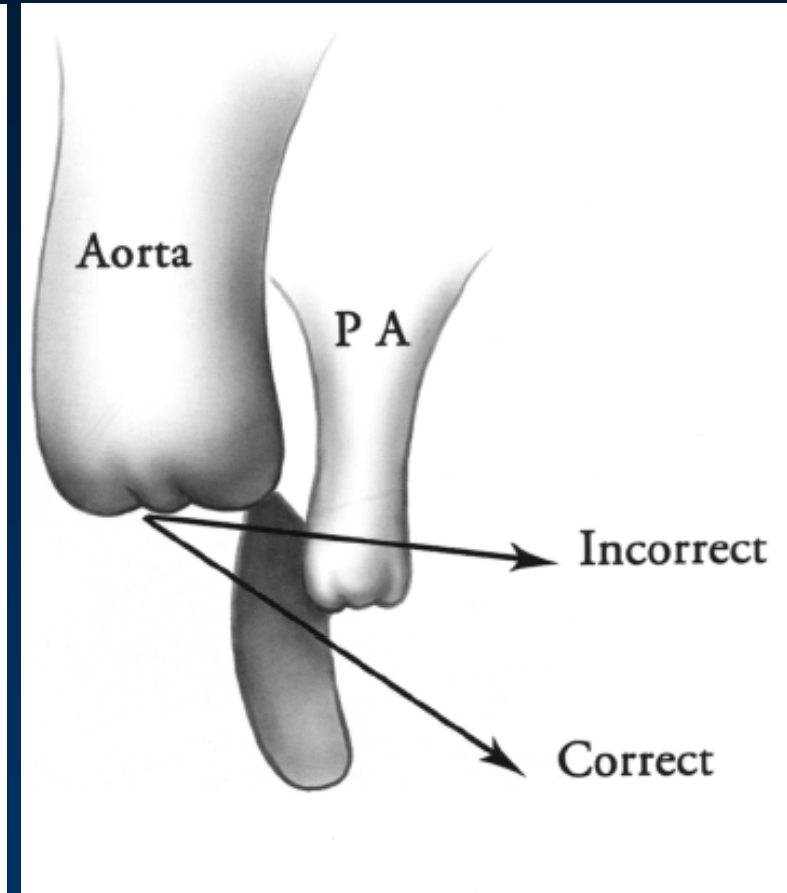
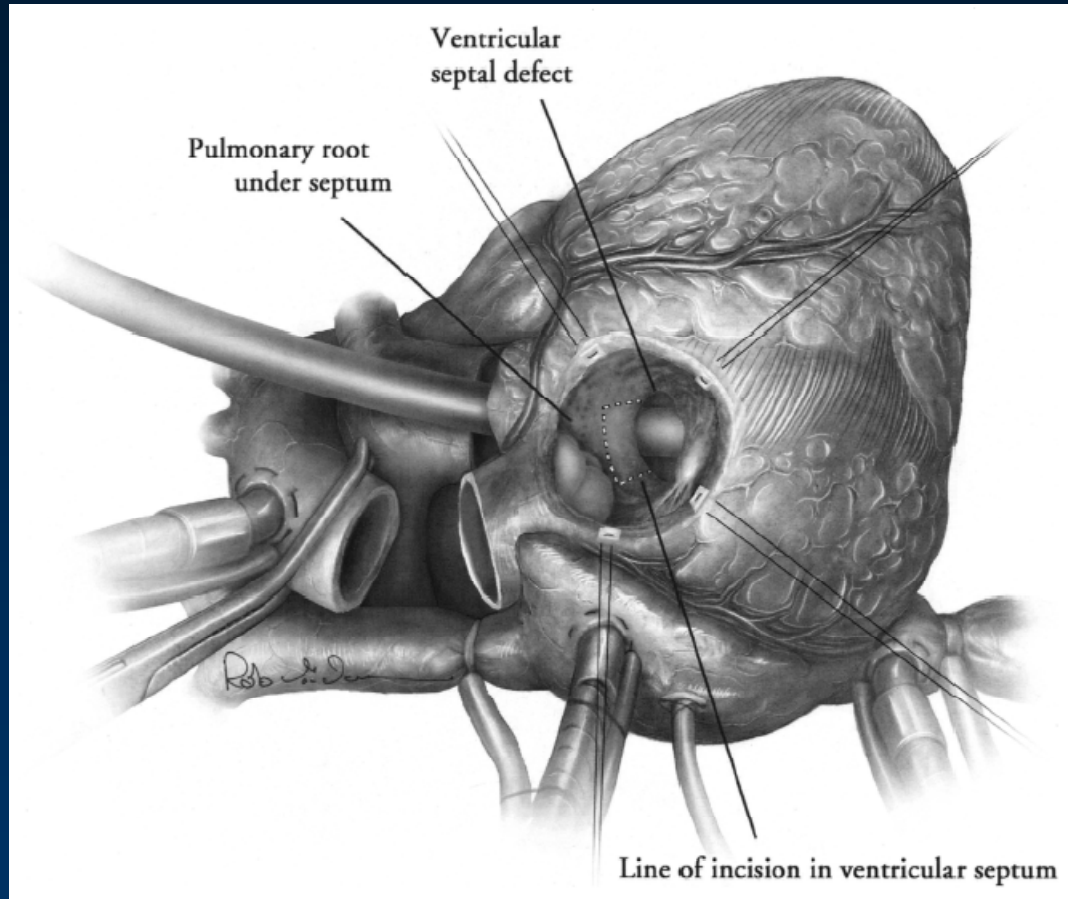
REV Procedure

REV Procedure



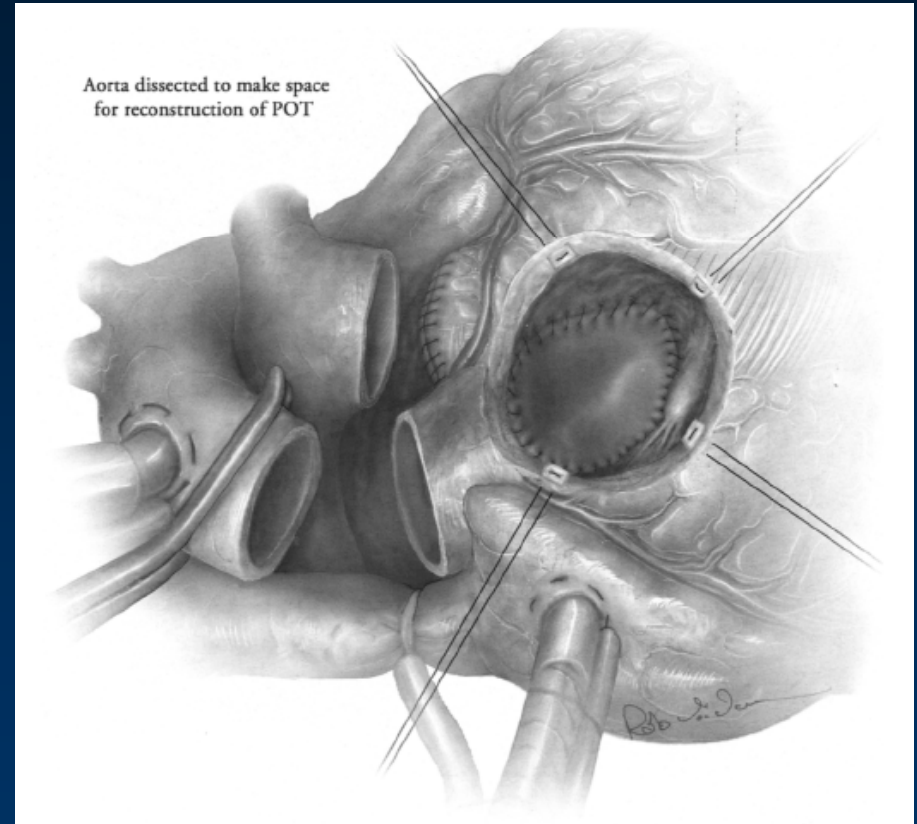
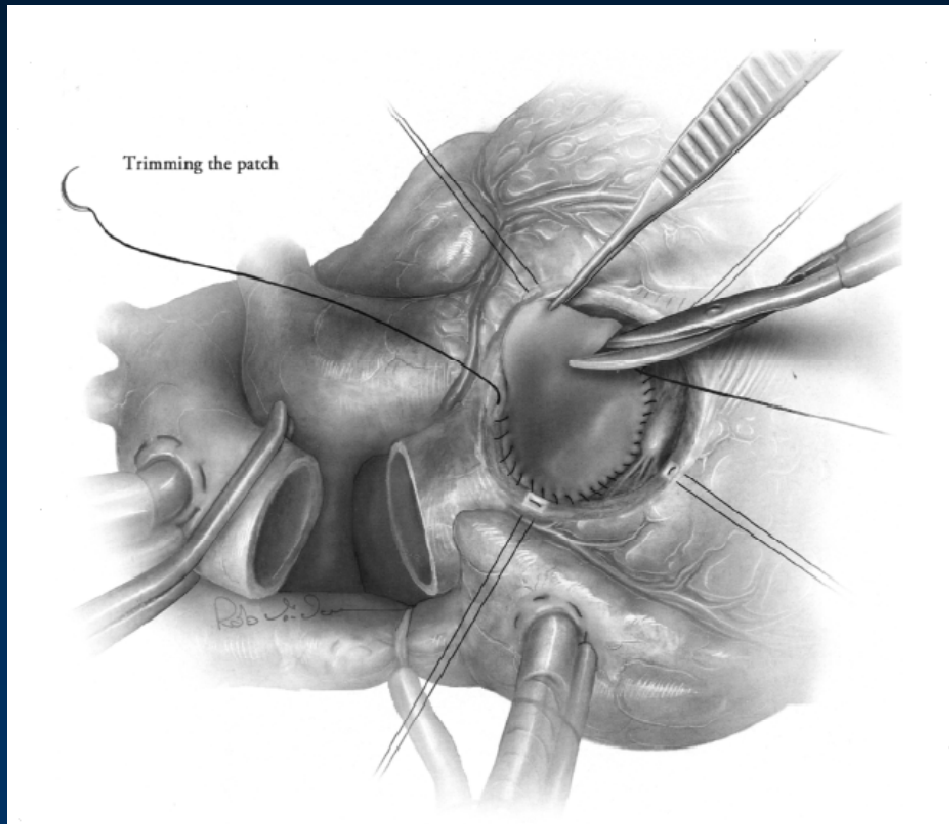
J Thorac Cardiovasc Surg 1992;103:428-436

REV Procedure (1)

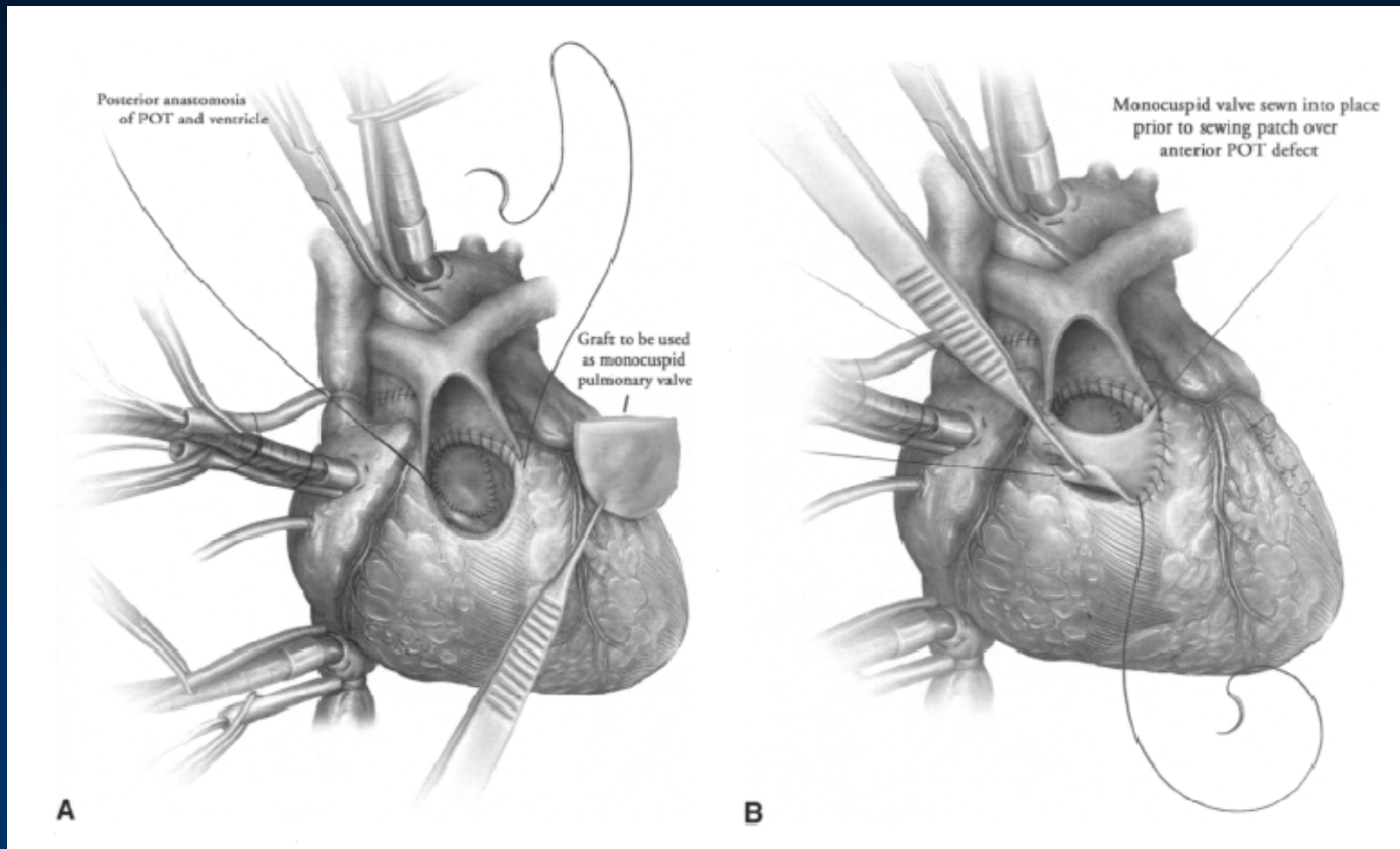


Oper Tech Thorac Cardiovasc Surg 2003;8:150-159

REV Procedure (2)

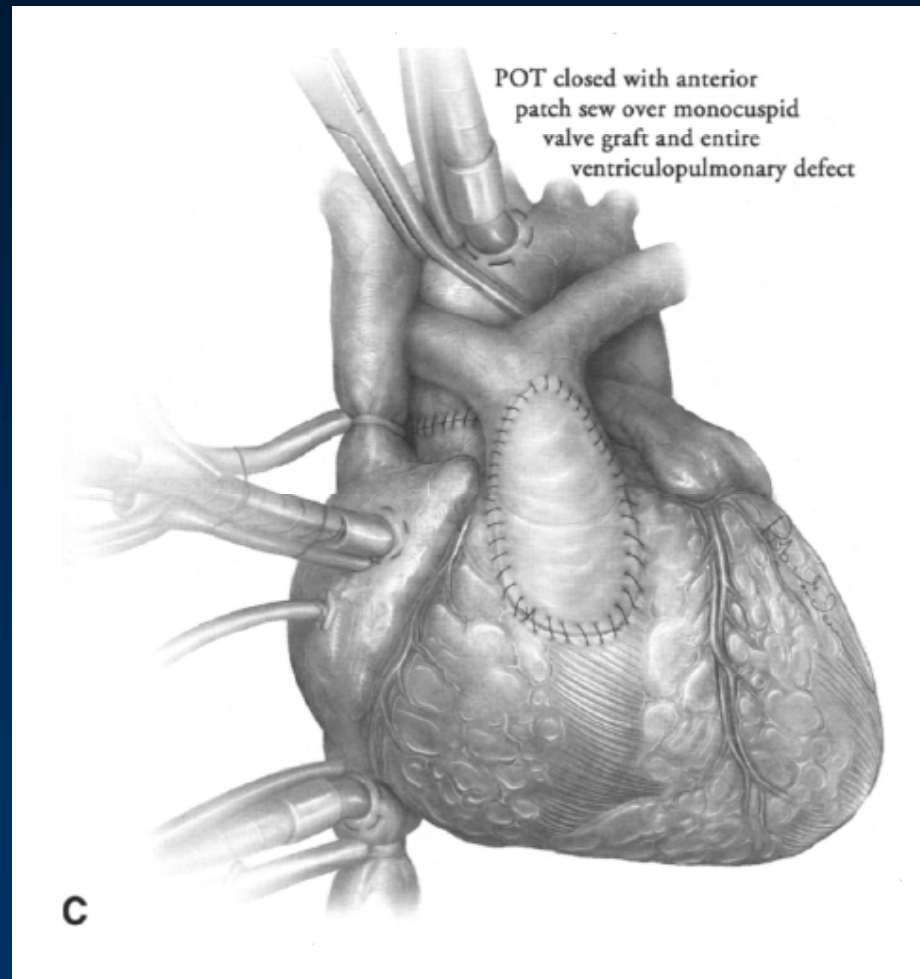


REV Procedure (3)



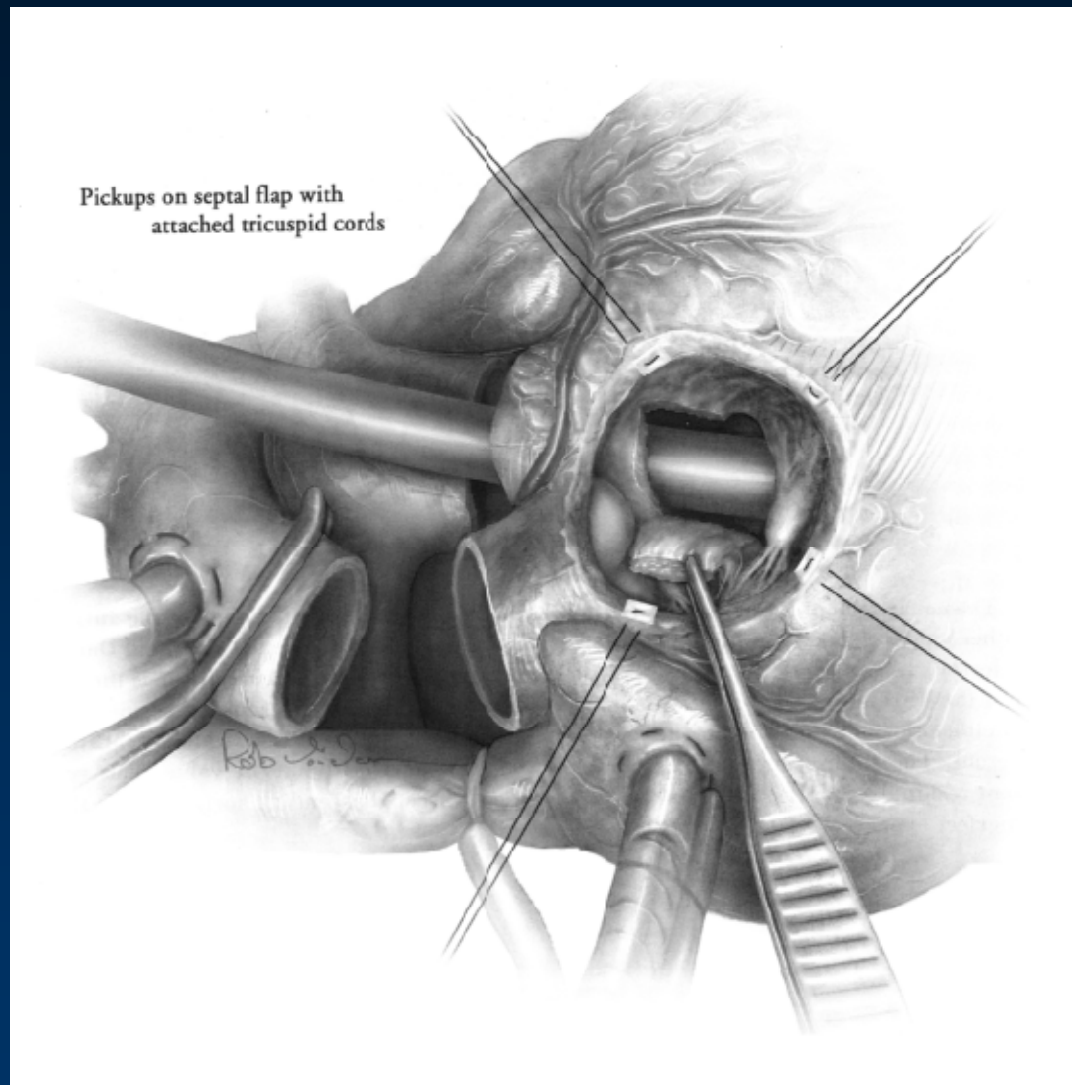
Oper Tech Thorac Cardiovasc Surg 2003;8:150-159

REV Procedure (4)



Oper Tech Thorac Cardiovasc Surg 2003;8:150-159

Conal Flap Technique



Oper Tech Thorac Cardiovasc Surg 2003;8:150-159

French Experience

❑ 1: [J Thorac Cardiovasc Surg.](#) 1992 Mar;103(3):428-36.

Transposition of the great arteries, ventricular septal defect, and pulmonary outflow tract obstruction. Rastelli or Lecompte procedure?

[Vouhé PR](#), [Tamisier D](#), [Leca F](#), [Ouaknine R](#), [Vernant F](#), [Neveux JY](#).

Department of Thoracic and Cardiovascular Surgery, Laennec Hospital, Paris, France.

During a 10-year period (1980 to 1990), 62 patients underwent complete repair for transposition of the great arteries, ventricular septal defect, and pulmonary outflow tract obstruction. Twenty-two patients (35%) (mean age 8.1 +/- 7.2 years) underwent the Rastelli operation: The ventricular septal defect was enlarged anteriorly in eight patients, and right ventricular-pulmonary artery continuity was established with an extracardiac valved (9/22) or nonvalved (13/22) conduit. Forty patients (65%) (mean age 3.3 +/- 3.2 years) underwent the Lecompte modifications: The conal septum was extensively excised when present (30/40), anterior translocation of the pulmonary bifurcation was performed in 32 patients, and right ventricular-pulmonary artery continuity was established by direct anastomosis without a prosthetic conduit. There were seven early deaths (11%; 70% confidence limits, 7% to 17%): two after the Rastelli procedure (9%; 70% confidence limits, 3% to 20%) and five after the Lecompte operation (12.5%; 70% confidence limits, 7% to 20%). Four patients were lost to follow-up, yielding a 93% complete follow-up (mean follow-up 55 months). There were two late deaths (one in each group). Actuarial probability of survival (+/- standard error) at 5 years was 83% +/- 9% after the Rastelli operation and 84% +/- 6% after the Lecompte procedure. All long-term survivors (except one in the Rastelli group) were in functional class I. Five patients in the Rastelli group underwent late reoperation for obstruction of the extracardiac conduit (28%; 70% confidence limits, 16% to 42%). Three late reoperations (10%; 70% confidence limits, 4% to 19%) were required after the Lecompte operation (one for residual ventricular septal defect and two for residual pulmonary outflow tract obstruction). At most recent examination, residual pulmonary outflow tract obstruction was present in seven patients of the Rastelli group (39%; 70% confidence limits, 26% to 53%) and in six patients of the Lecompte group (19%; 70% confidence limits, 12% to 29%). The combined likelihood of reoperation for pulmonary outflow tract obstruction and residual pulmonary outflow tract obstruction was significantly higher in the Rastelli group (67% versus 26%; $p = 0.005$). Both procedures provide satisfactory early and late results. The Lecompte operation allows complete repair in infancy, is feasible in patients with anatomic contraindications to the Rastelli operation, and may reduce the need for reoperation and the prevalence of residual pulmonary outflow tract obstruction.

PMID: 1545541 [PubMed - indexed for MEDLINE]

French Experience

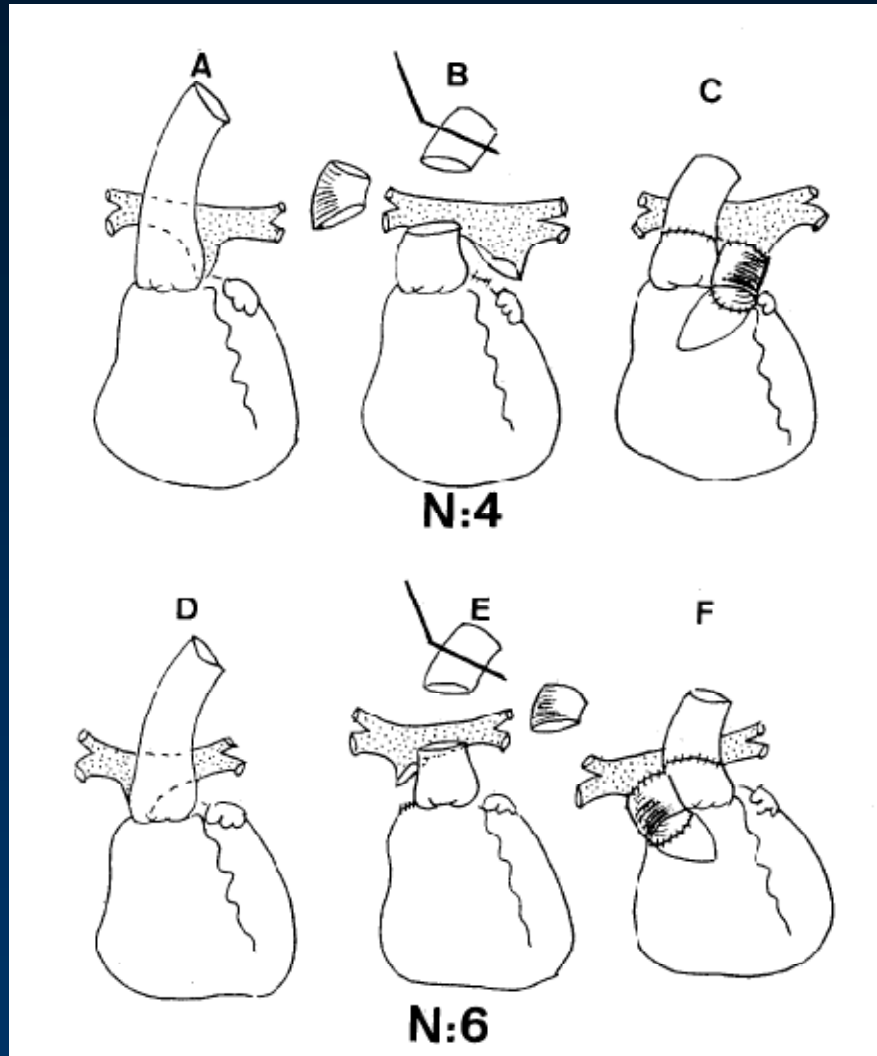
- 1980 – 1990
- REV group : N = 40 (3.3 y)
- Rastelli group : N = 22 (8.1 y)
- Follow-up : 4.6 y
- No difference in survival
- **Less RVOT reoperations in REV group**

EXTENDING THE CONCEPT OF THE AUTOGRAFT FOR COMPLETE REPAIR OF TRANSPOSITION OF THE GREAT ARTERIES WITH VENTRICULAR SEPTAL DEFECT AND LEFT VENTRICULAR OUTFLOW TRACT OBSTRUCTION: A REPORT OF TEN CASES OF A MODIFIED PROCEDURE

Dominique Metras, MD
Bernard Kreitmann, MD
Alberto Riberi, MD
John-Godson Yao, MD
Elie El-Khoury, MD
François Wernert, MD
Adrienne Pannetier-Mille, MD

Background: In most cases of transposition of the great arteries with ventricular septal defect and left ventricular outflow tract obstruction, a Lecompte procedure (*réparation à l'étage ventriculaire*) is possible without interposition of a conduit between the right ventricle and pulmonary artery. However, the anterior location of the pulmonary arteries after the Lecompte maneuver may be a potential cause for right ventricular outflow obstruction, which continues to be reported in 5% to 25% of cases. We have used a tubular segment of aortic autograft to connect the pulmonary artery, left in the orthotopic posterior position (without the Lecompte maneuver), to the right ventricle in 10 consecutive patients with transposition, ventricular septal defect, and left ventricular outflow tract obstruction. **Methods:** Ten consecutive patients aged 2 months to 11 years (mean 32 months) have undergone a modified Lecompte operation. Eight had severe pulmonary stenosis, two had pulmonary atresia, and four had a restrictive ventricular septal defect at the time of the operation. Two had multiple ventricular septal defects. Seven had undergone one ($n = 5$) or two ($n = 2$) previous modified Blalock-Taussig shunts. All patients underwent a total correction with left ventricular-aortic intraventricular connection (four needed a ventricular septal defect enlargement), connection between the right ventricle and pulmonary arteries with a tubular segment of autograft aorta, without the Lecompte maneuver (anterior location of the bifurcation of the

Metras Modification



J Thorac Cardiovasc Surg 1997;114:746-54

French Experience



ELSEVIER

European Journal of Cardio-thoracic Surgery 19 (2001) 283–289

EUROPEAN JOURNAL OF
CARDIO-THORACIC
SURGERY

www.elsevier.com/locate/ejcts

Results of the Lecompte procedure in malposition of the great arteries and pulmonary obstruction[☆]

R. Prêtre^{a,*}, G. Gendron^a, D. Tamisier^a, F. Vernant^b, D. Sidi^b, P. Vouhé^a

^a*Service de Chirurgie Cardiaque, Hôpital Necker-Enfants Malades, 149 Rue de Sèvre, Paris, France*

^b*Cardiologie, Hôpital Necker-Enfants Malades, 149 Rue de Sèvre, Paris, France*

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French Experience

- 1986 – 1999
- N = 42
- Mean age : 1.4 years
- Mean follow-up : 5.4 years
- No LVOTO

Freedom from RVOT reoperation

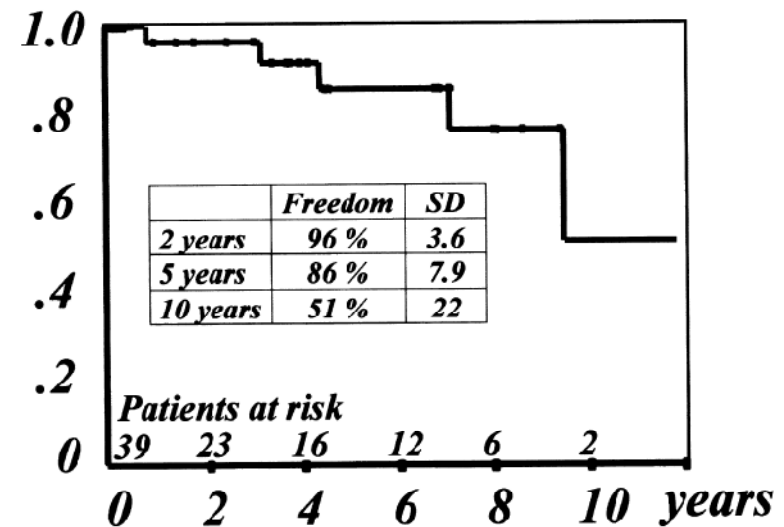


Fig. 4. Kaplan–Meier estimation of the freedom from reoperation after the Lecompte procedure.

SNUCH Experience

Modified Lecompte Procedure for the Anomalies of Ventriculoarterial Connection

Yong Jin Kim, MD, Jeong-Jun Park, MD, Jeong Ryul Lee, MD, Joon Ryang Rho, MD, Yong Soo Yun, MD, Jung Yun Choi, MD, and Chung Il Noh, MD

Departments of Thoracic and Cardiovascular Surgery and Pediatrics, Seoul National University Hospital, Seoul, Korea

Background. The Lecompte procedure for correcting transposition of the great arteries has an advantage because it obviates the need for an extracardiac conduit for the reconstruction of the pulmonary outflow tract. In this study, we evaluated the effectiveness and the application of the Lecompte procedure based on our experiences.

Methods. A retrospective review was conducted of the records of 45 patients who underwent the Lecompte procedure during the past 11 years to achieve direct right ventricle to pulmonary artery continuity. Mean age at operation was 2.4 ± 1.7 years (range 3.5 months to 6.9 years). The diagnoses involved anomalies of the ventriculoarterial connection with ventricular septal defect and pulmonary outflow tract obstruction, such as transposition of the great arteries, double-outlet right ventricle, and double-outlet left ventricle.

Results. Early mortality was 4.4% (2 of 45 patients) and late mortality was 4.7% (2 of 43). The mean follow-up was 4.9 ± 3.1 years. Fourteen patients (34.1% of survivors, n =

41) had pulmonary stenosis (pressure gradient above 30 mm Hg), the main reason for which was a calcified monocusp valve (n = 10, 71.4%). Eight of 45 patients (17.8%) underwent reoperation: 2 for residual ventricular septal defect, 1 for recurrent septic vegetation, and 5 for pulmonary stenosis. The cumulative survival rates were $91.1\% \pm 4.2\%$ at 10 years. The actuarial probabilities of freedom from reoperation for pulmonary stenosis were $93.8\% \pm 4.3\%$ and $71.4\% \pm 11.8\%$ at 5 and 10 years, respectively.

Conclusions. Our review suggests that the Lecompte procedure is an effective treatment modality for anomalies of the ventriculoarterial connection with ventricular septal defect and pulmonary outflow tract obstruction. Repair in early age is possible with acceptable morbidity and mortality, but recurrent right ventricular outflow tract obstruction caused by degeneration of the monocusp valve is a problem that needs resolution.

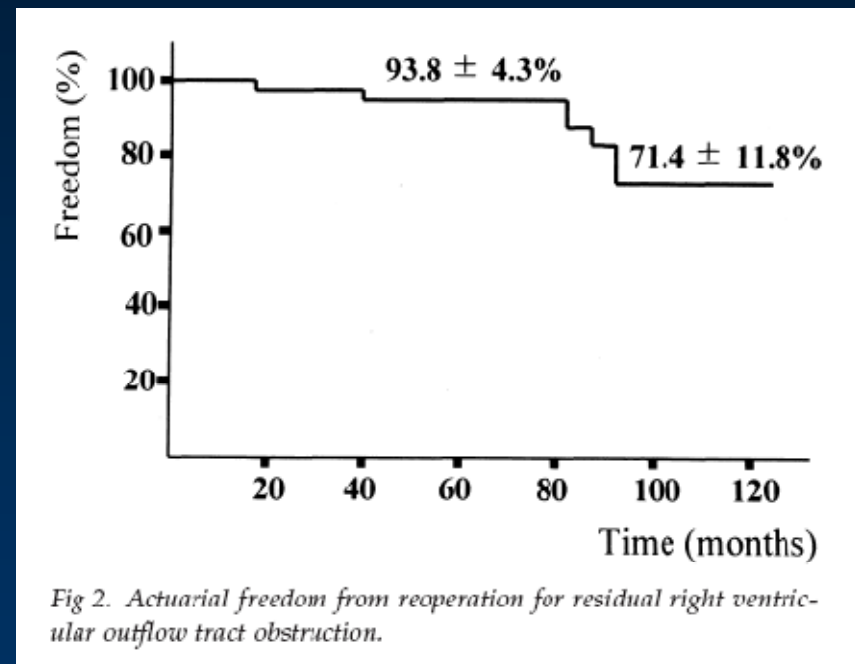
(Ann Thorac Surg 2001;72:176–81)

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SNUCH Experience

- 1988 – 1999
- N = 45
- Mean age : 2.4 years
- Mean follow-up : 4.9 years
- No LVOTO
- No Lecompte maneuver

Freedom from RVOT reoperation



SNUCH Experience



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European Journal of Cardio-thoracic Surgery 25 (2004) 735–741

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Repair of transposition of the great arteries, ventricular septal defect and left ventricular outflow tract obstruction

Jeong Ryul Lee^{a,*}, Hong Gook Lim^a, Yong Jin Kim^a, Joon Ryang Rho^a,
Eun Jung Bae^b, Chung Il Noh^b, Yong Soo Yun^b, Curie Ahn^c

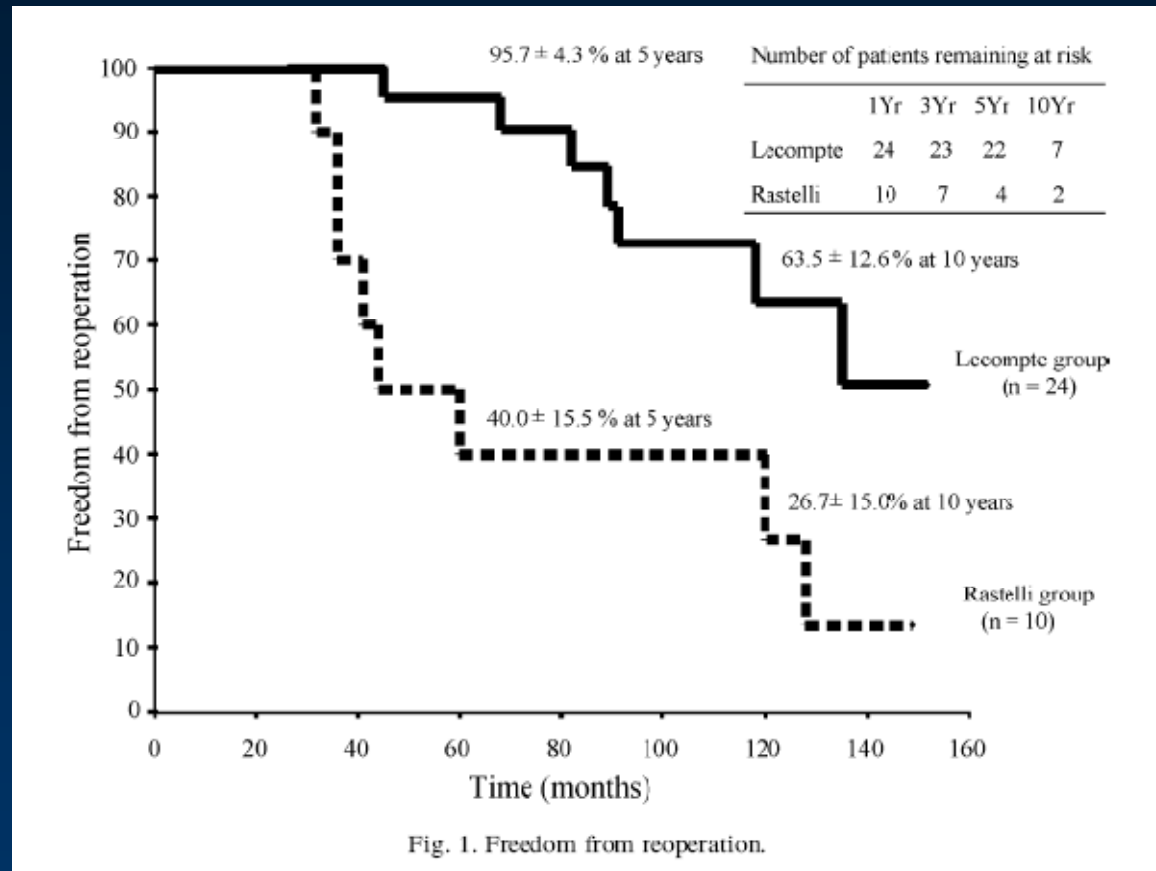
^a*Department of Thoracic and Cardiovascular Surgery, Seoul National University Children's Hospital, Seoul National University College of Medicine, Seoul National University Medical Research Center, Xenotransplantation Research Center, 28 Yongon-dong, Jongro-gu, Seoul 110-744, South Korea*

^b*Department of Pediatrics, Seoul National University Children's Hospital, Seoul National University College of Medicine, Seoul National University Medical Research Center, Xenotransplantation Research Center, 28 Yongon-dong, Jongro-gu, Seoul 110-744, South Korea*

SNUCH Experience

- 1990 – 2002
- REV group : N = 25 (2.0 y)
- Rastelli group : N = 10 (3.3 y)
- Follow-up : 5.9 years

Freedom from Reoperation (RVOTO & LVOTO)



Pros and Cons of the REV Procedure

Table 1

Pros and cons of the Lecompte procedure in comparison with the Rastelli operation

Advantages

Early biventricular repair^a

Avoidance of chronic cyanosis and of pressure/volume overload^a

Few anatomic contraindications

Possible in unfavorable intracardiac anatomy^a

Inadequate size of the ventricular defect

Straddling of the tricuspid valve

Reduced risk of subaortic stenosis^a

Independence regarding small homograft availability^a

Growth potential of the reconstructed outflow tract^b

Reduced need for subsequent reoperation^b

Disadvantages

Increased incidence of early pulmonary regurgitation

^a Confirmed advantages.

^b Theoretical advantages.

Nikaidoh Procedure

Nikaidoh Procedure

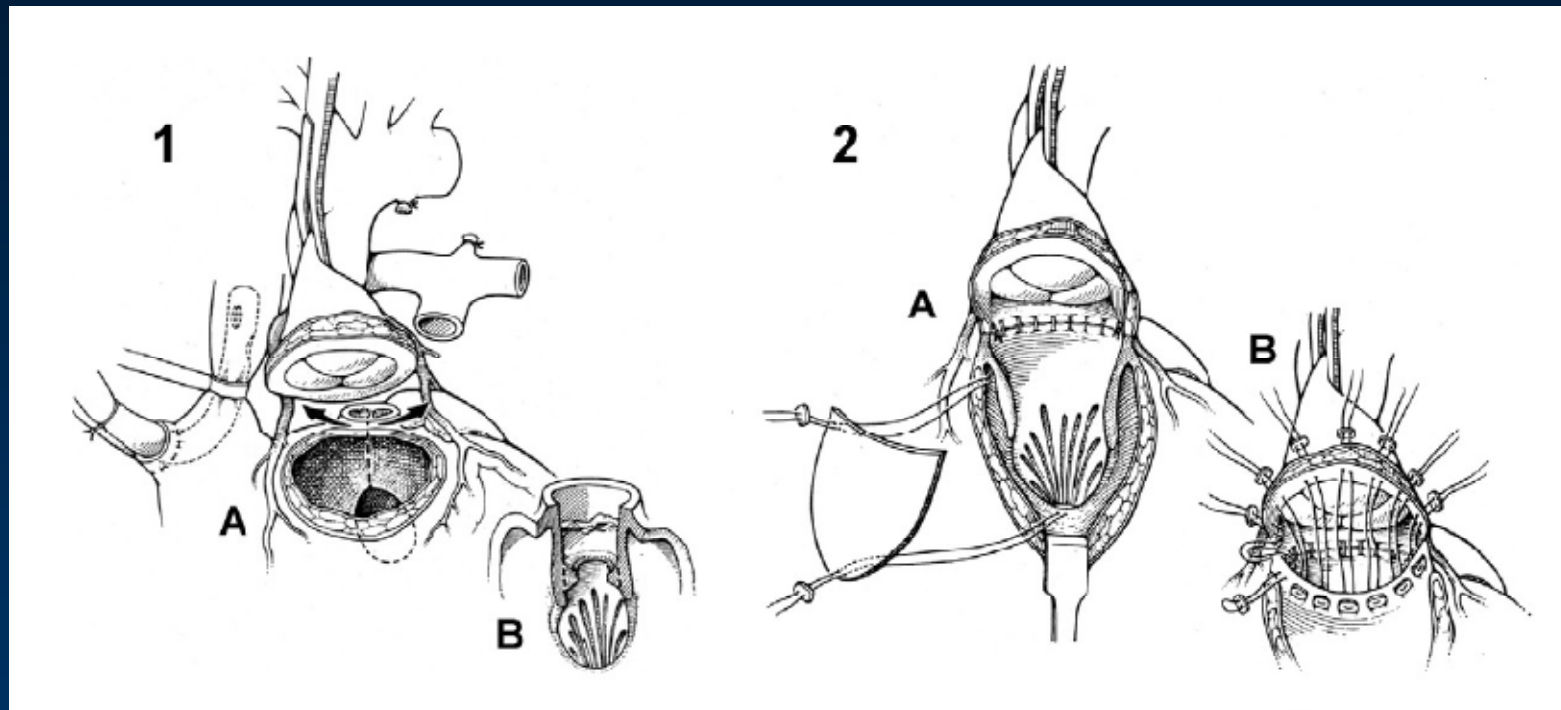
Aortic translocation and biventricular outflow tract reconstruction. A new surgical repair for transposition of the great arteries associated with ventricular septal defect and pulmonary stenosis

H Nikaidoh

Transposition of the great arteries associated with ventricular septal defect and left ventricular outflow tract obstruction remains a serious surgical challenge. A new surgical technique that utilized aortic root mobilization and transfer combined with reconstruction of the right and left ventricular outflow tracts was applied successfully in two children. This technique provides an additional type of arterial switch operation for complex transposition and is an alternative to (1) the conventional combination of Mustard (Senning) procedure with closure of the ventricular septal defect and relief of left ventricular outflow tract obstruction and (2) the Rastelli operation.

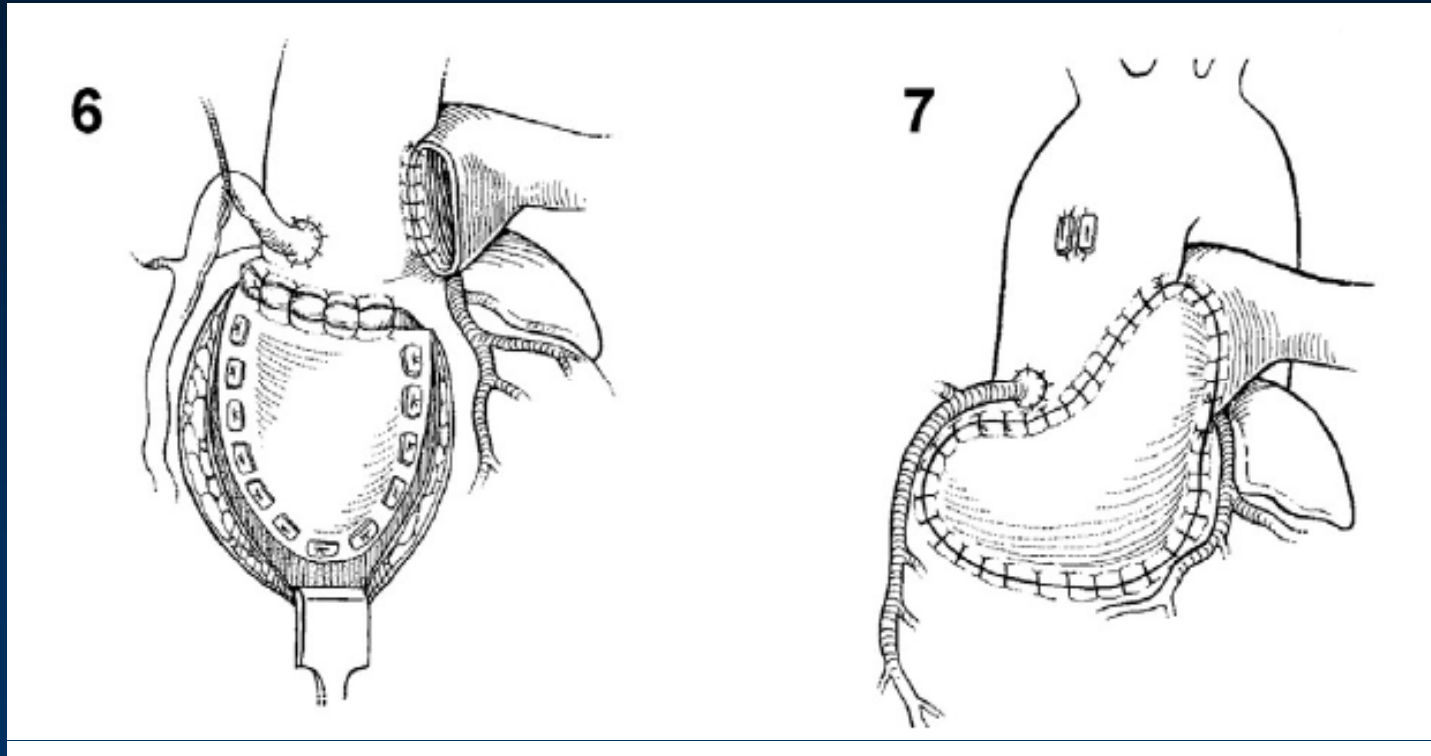
J Thorac Cardiovasc Surg 1984;88:365-72

Nikaidoh Procedure (1)

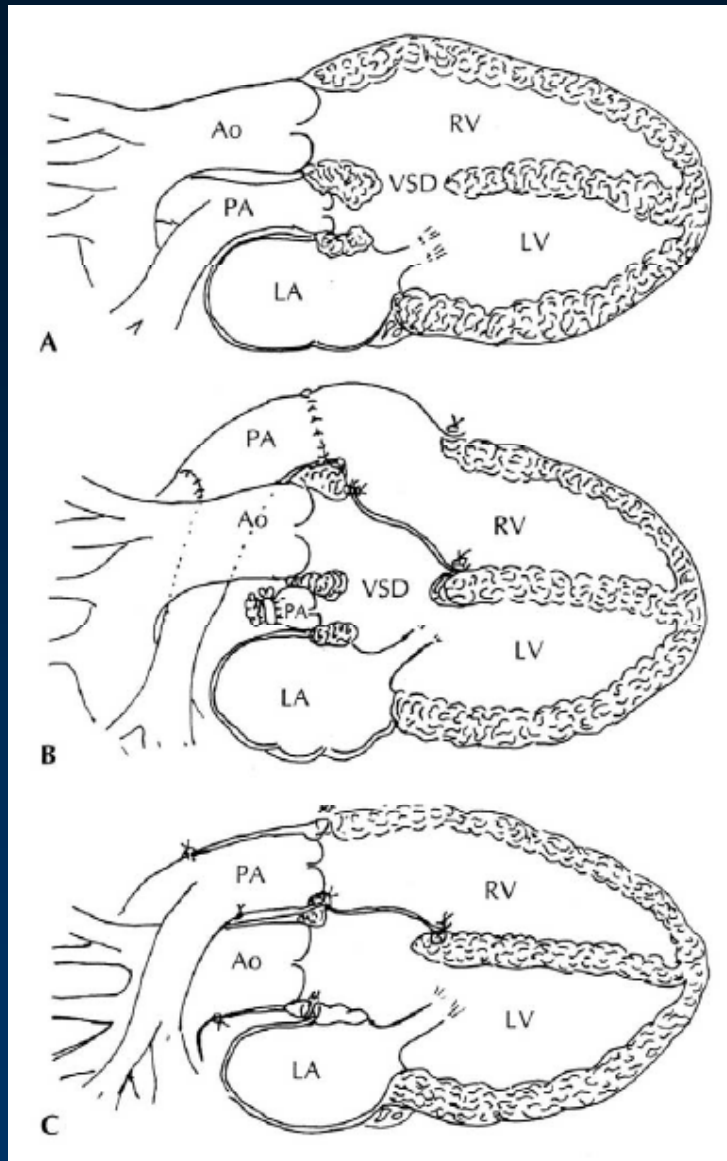


J Thorac Cardiovasc Surg 2007;133:461-9

Nikaidoh Procedure (2)



J Thorac Cardiovasc Surg 2007;133:461-9



TGA + VSD + LVOTO

Rastelli procedure

Nikaidoh procedure

Pittsburgh and Florida Experience

Aortic Translocation in the Management of Transposition of the Great Arteries With Ventricular Septal Defect and Pulmonary Stenosis: Results and Follow-Up

Victor O. Morell, MD, Jeffrey P. Jacobs, MD, and James A. Quintessenza, MD

Children's Hospital of Pittsburgh, University of Pittsburgh, Pittsburgh, Pennsylvania, and The Congenital Heart Institute of Florida, University of South Florida, Tampa, Florida

Background. The surgical management of patients with transposition of the great arteries, ventricular septal defect, and pulmonary stenosis remains a challenge. The Rastelli operation is the preferred surgical procedure, but its long-term results are not optimal. The objective in this retrospective study was to review our experience using aortic translocation and biventricular outflow tract reconstruction as an alternative surgical procedure for the management of these patients.

Methods. Since January 1996, 12 patients have undergone aortic translocation and biventricular outflow tract reconstruction for the management of transposition of the great arteries, ventricular septal defect, and pulmonary stenosis at our institution. All patients had ventriculoarterial discordance; 9 had atrioventricular concordance and 3 atrioventricular discordance. Associated lesions included a straddling atrioventricular valve in 3 patients. An inlet ventricular septal defect was present in 4 patients. The median age at operation was 2 years. Eight

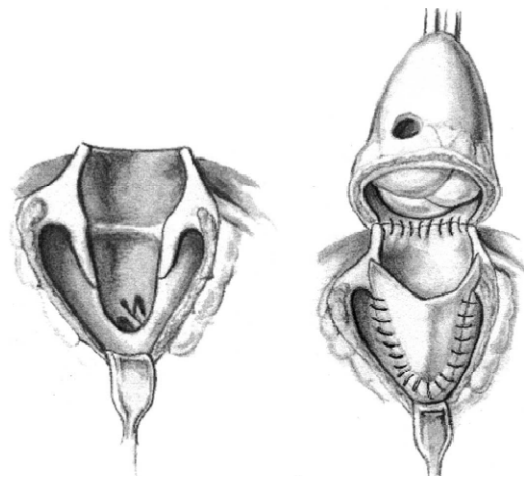
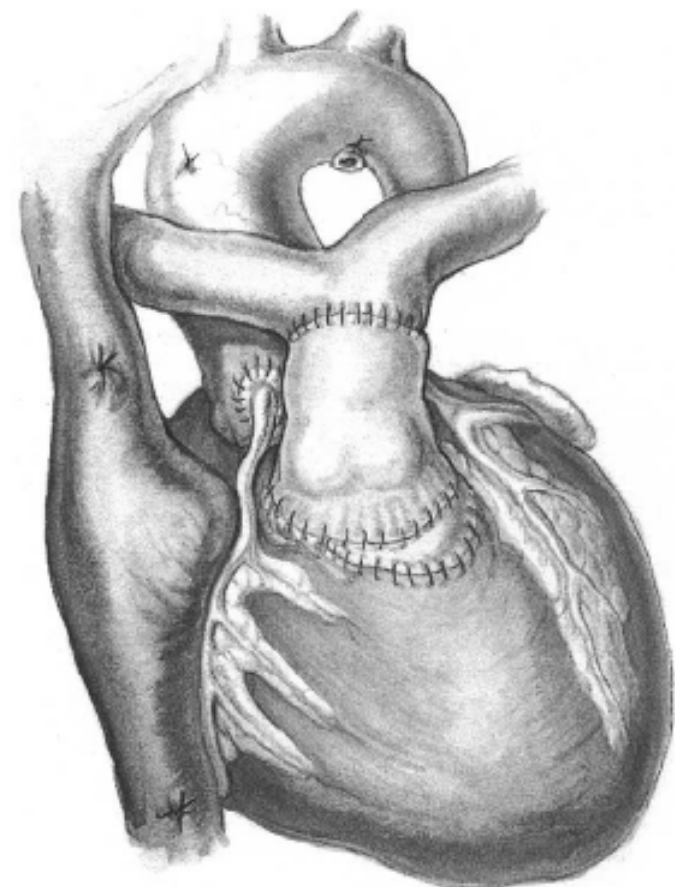
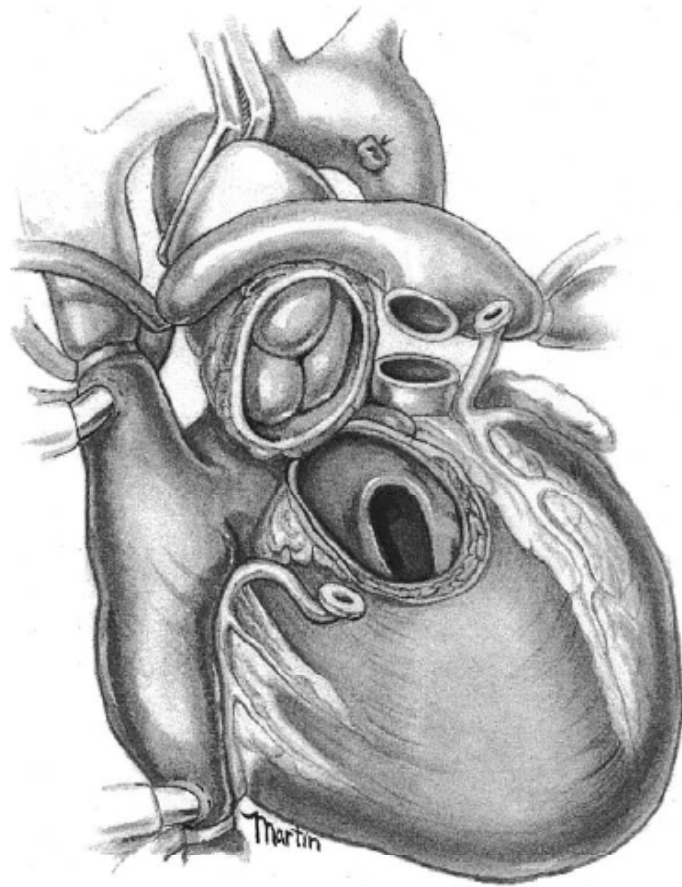
patients had previous palliative procedures. The surgical technique used was a modification of the Nikaidoh procedure. The 3 patients with atrioventricular discordance required a Senning procedure.

Results. There was one hospital death (8.3%) as a result of a massive cerebrovascular accident. The median intensive care unit and hospital stays were 15 and 18 days, respectively. At a median follow-up of 33 months, all patients are alive. Four late reoperations occurred in 3 patients, including two reoperations for conduit obstruction.

Conclusions. Aortic translocation and biventricular outflow tract reconstruction is a valuable surgical option for the surgical management of patients with transposition of the great arteries, ventricular septal defect, and pulmonary stenosis, especially in the presence of "inadequate anatomy" for a Rastelli repair.

(Ann Thorac Surg 2005;79:2089-93)

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Pittsburgh and Florida Experience

- 1996 –
- N = 12
- Mean age : 2 years
- Follow-up : 2.8 years

- 2 RVOT reoperations
- No LVOTO, No late death
- **3 moderate AR**

Pittsburgh and Florida Experience (Unpublished Data)

- 1996 –
- N = 21
- Follow-up : 5.9 years

- 1 early death, 1 transplantation
- 3 RVOT reoperations
- 3 late deaths
- 1 AVR d/t severe AR

Boston Children's Hospital Experience

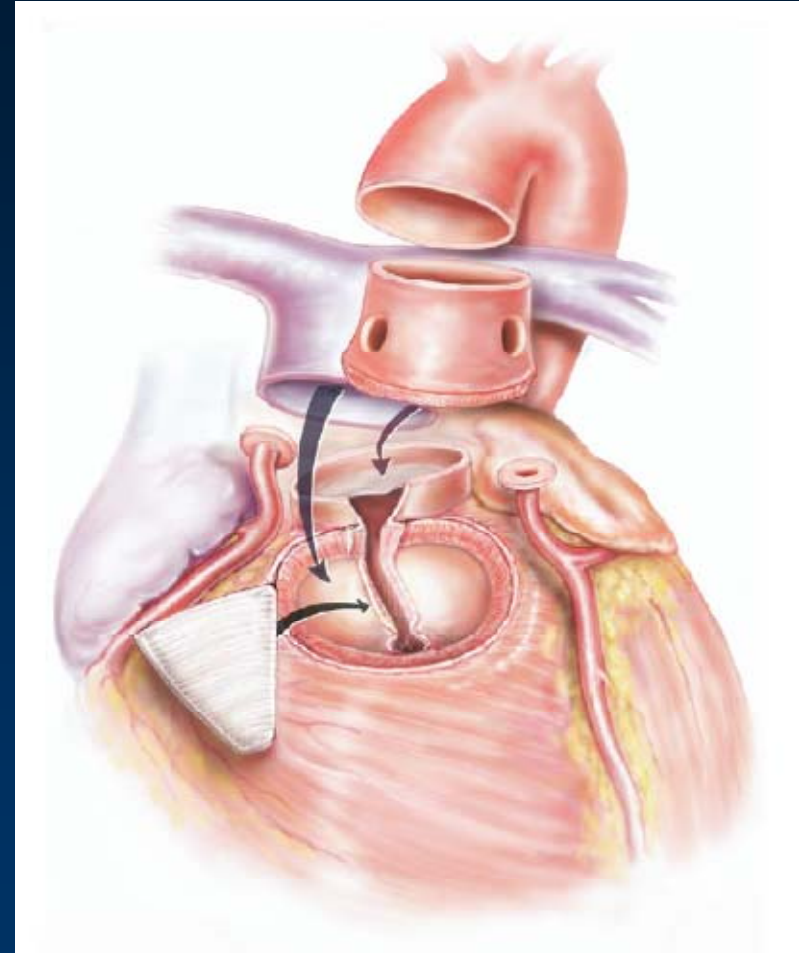
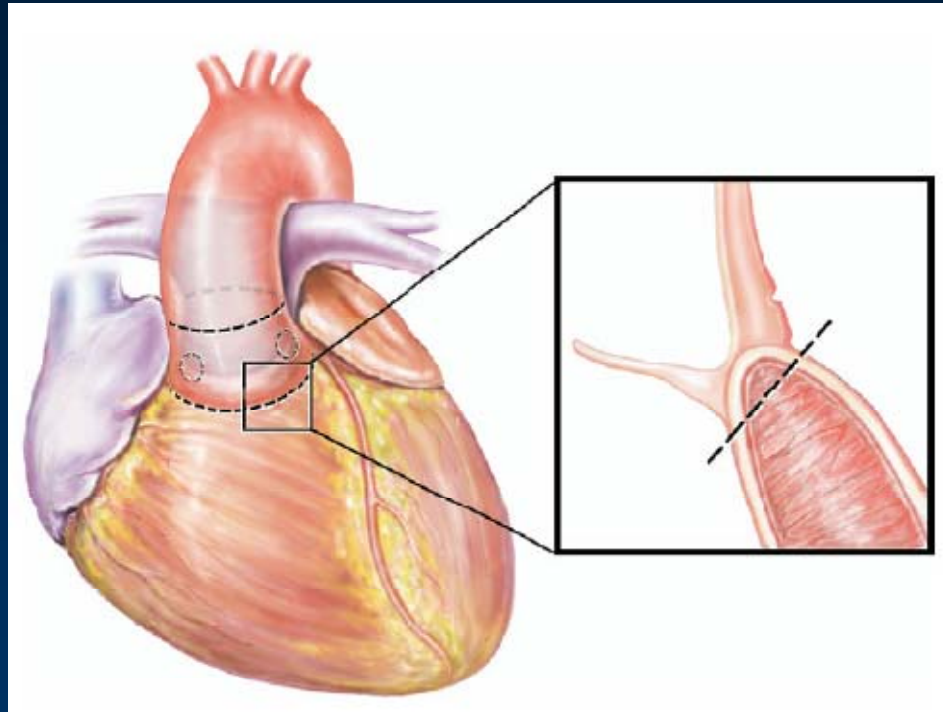
Aortic Root Translocation Plus Arterial Switch for Transposition of the Great Arteries With Left Ventricular Outflow Tract Obstruction

Intermediate-Term Results

Victor Bautista-Hernandez, MD, Gerald R. Marx, MD, Emile A. Bacha, MD, Pedro J. del Nido, MD
Boston, Massachusetts

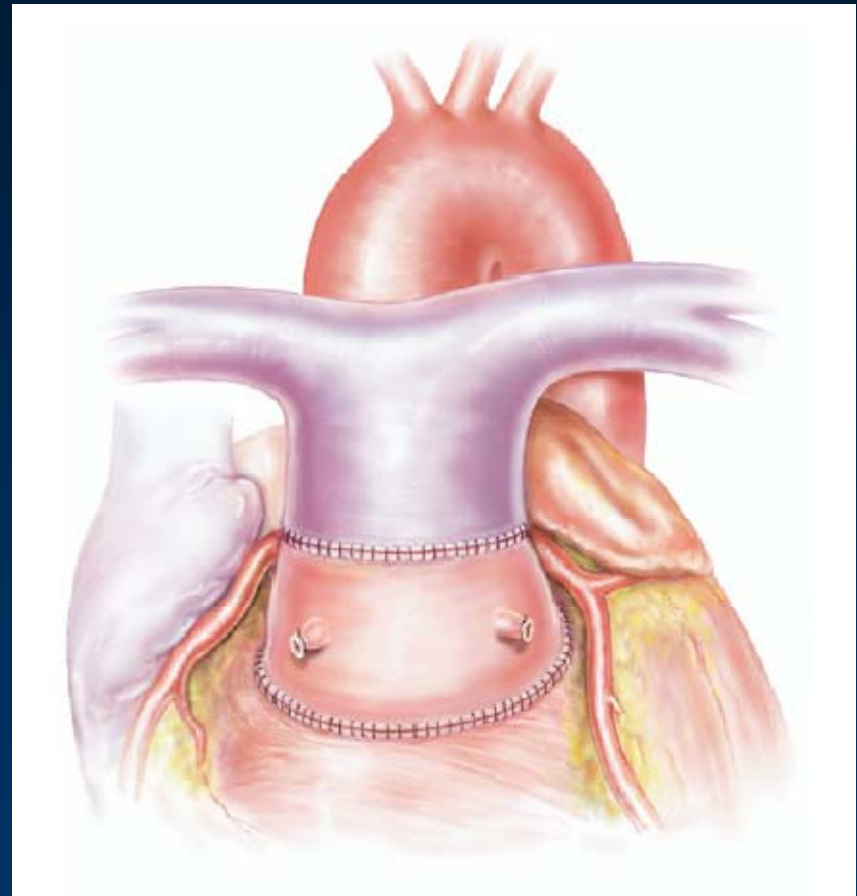
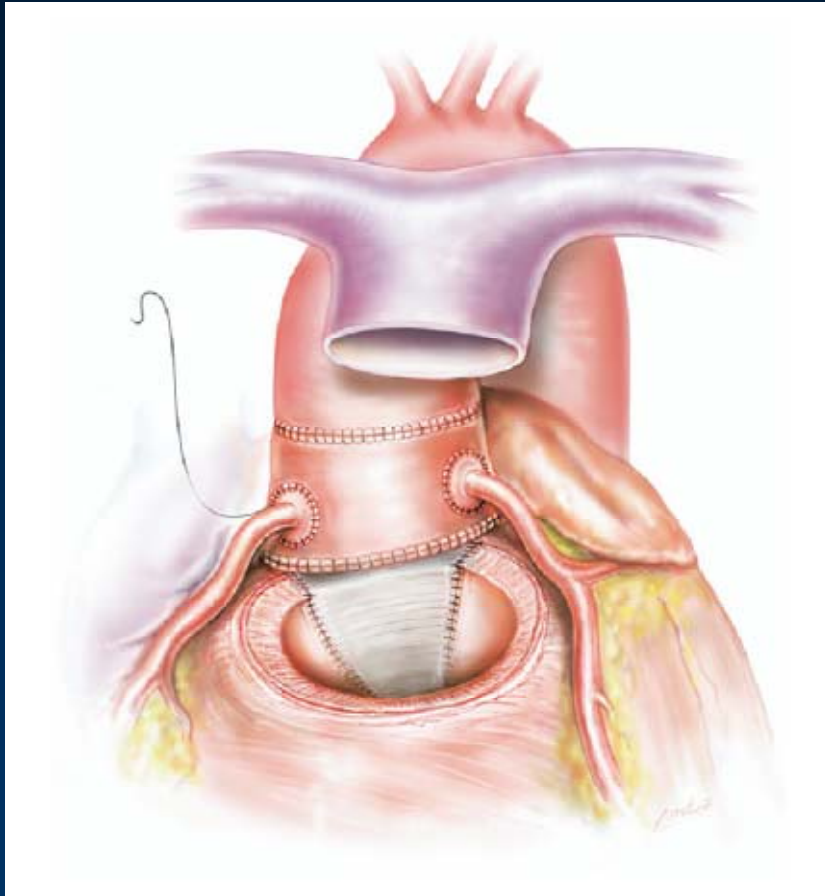
Objectives	The goal of our study was to report our intermediate-term results with aortic root translocation plus arterial switch for d-transposition of the great arteries with left ventricular outflow tract obstruction.
Background	A d-transposition of the great arteries with left ventricular outflow tract obstruction represents a difficult surgical problem. The Rastelli procedure is the usual approach to this condition. However, recurrent left ventricular outflow tract obstruction and early conduit obstruction as well as arrhythmias and troublesome late mortality are significant limitations.
Methods	From 1993 to 2005, 11 children (8 male, 3 female) ages 1 month to 11 years (median age 7 months) have undergone aortic root autograft translocation plus arterial switch to correct d-transposition of the great arteries with left ventricular outflow tract obstruction. The native aortic root was excised from the right ventricle infundibulum and inserted into the left ventricular outflow, enlarging the outflow tract by resecting the outlet septum and an appropriate-size ventricular septal defect patch. After coronary artery reimplantation, right ventricular outflow reconstruction was achieved with a homograft.
Results	There were no early or late deaths. With a median follow-up of 59 months (range 2 to 137 months), 5 patients required 6 conduit replacement procedures at a median time of 53 months. Two patients required an implantable defibrillator for ventricular arrhythmias. None of the patients have developed left ventricular outflow tract obstruction.
Conclusions	Aortic root autograft plus arterial switch procedure is a good option for the surgical management of infants and children with d-transposition of the great arteries and left ventricular outflow tract obstruction and results in a more anatomic repair compared with Rastelli operation. Intermediate-term results indicate good relief of left ventricular outflow tract obstruction and need for conduit replacement compares favorably with the Rastelli procedure for this lesion. (J Am Coll Cardiol 2007;49:485-90) © 2007 by the American College of Cardiology Foundation

Ross-Switch-Konno Procedure (1)



J Am Coll Cardiol 2007;49:485-90

Ross-Switch-Konno Procedure (2)



J Am Coll Cardiol 2007;49:485–90

Boston Children's Hospital Experience

- 1993 – 2005
- N = 11
- Mean age : 7 months
- Follow-up : 4.9 years

- 6 RVOT reoperations
- No LVOTO, No late death
- 1 moderate AR

Nikaidoh's Experience

The aortic translocation (Nikaidoh) procedure: Midterm results superior to the Rastelli procedure

Thomas Yeh Jr, MD, PhD, Claudio Ramaciotti, MD, Steven R. Leonard, MD, Lonnie Roy, PhD, and Hisashi Nikaidoh, MD

Objective: Midterm follow-up is analyzed after the aortic translocation (Nikaidoh) procedure, an alternative to the Rastelli procedure for ventriculoarterial discordance, ventricular septal defect, and pulmonary stenosis.

Methods: Nineteen patients underwent a Nikaidoh procedure at a median age of 3.3 years (0.9-9.3 years). The native aortic valve was translocated from the right to the left ventricular outflow tract by full (n = 6) or partial (n = 13) mobilization of the aortic root. Seven patients with partial mobilization had the right coronary artery reimplanted as a button. The conal septum was divided in 13 patients. The right ventricular outflow tract was reconstructed with either a homograft (n = 4) or a right ventricular outflow tract patch (n = 15). The median follow-up was 11.4 years (0.1-23 years), and the median age at follow-up was 17.4 years (1-30 years). Left ventricular outflow tract obstruction and aortic insufficiency were assessed by echocardiography.

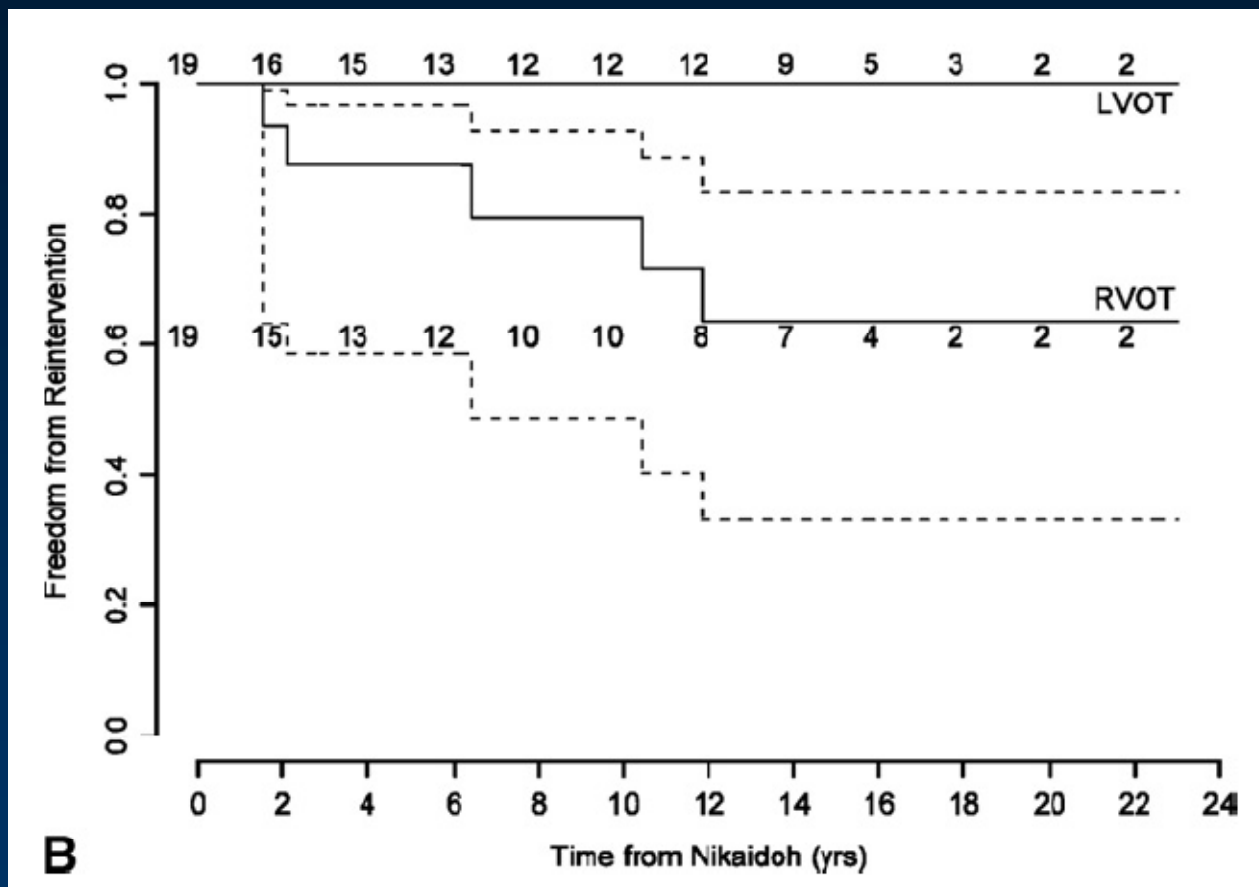
J Thorac Cardiovasc Surg 2007;133:461-9

Nikaidoh's Experience

- 1983 – 2006
- N = 19
- Mean age : 3.3 years
- Follow-up : 11.4 years

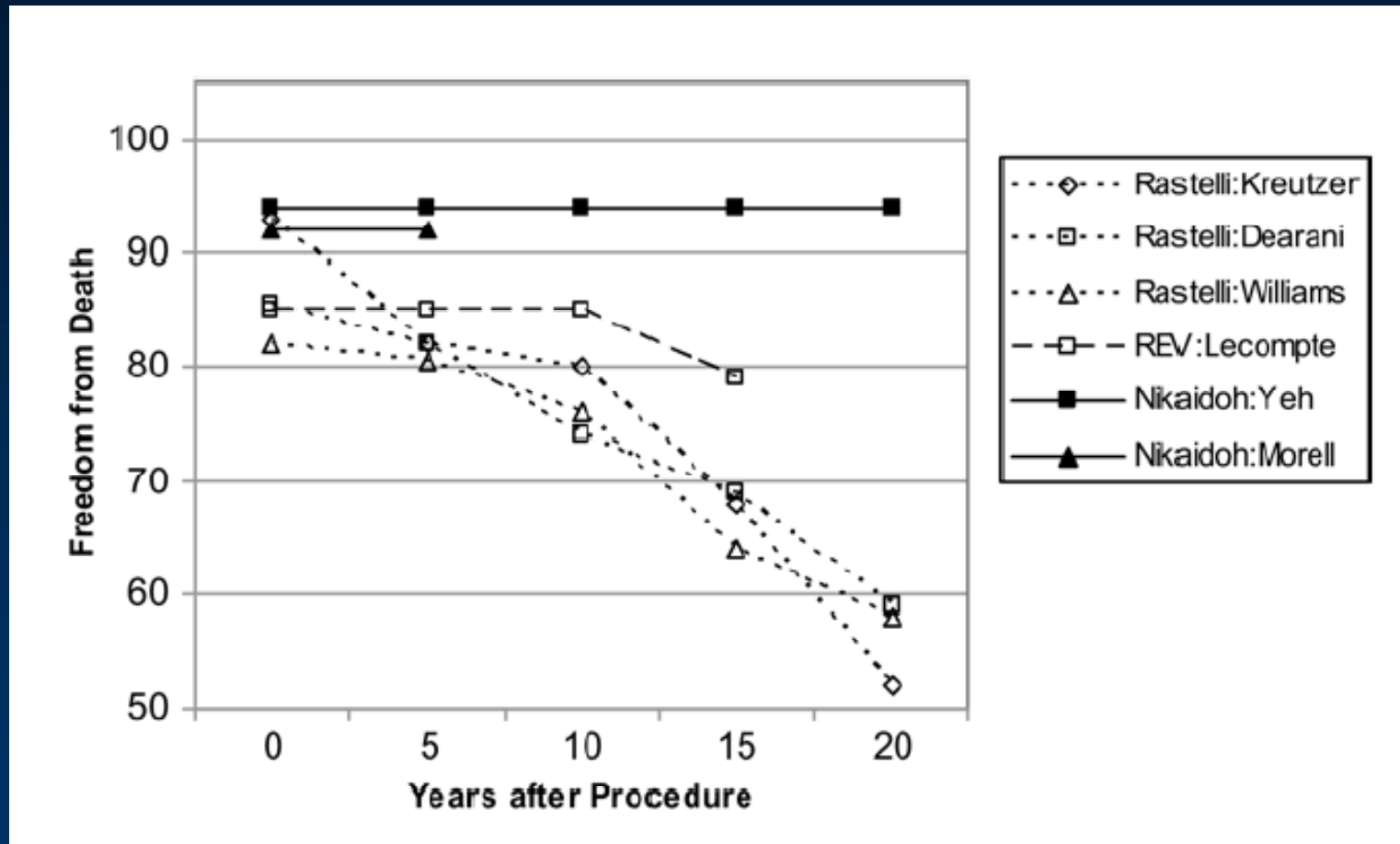
- 7 RVOT reoperations
- No LVOTO, No late death
- 9 mild AR

Freedom from LVOT and RVOT Reintervention



J Thorac Cardiovasc Surg 2007;133:461-9

Survival after Nikaidoh, REV, and Rastelli



J Thorac Cardiovasc Surg 2007;133:461-9

Chinese Experience

Pulmonary and aortic root translocation in the management of transposition of the great arteries with ventricular septal defect and left ventricular outflow tract obstruction

Sheng-shou Hu, MD, PhD, Shou-jun Li, MD, PhD, Xin Wang, MD, PhD, Li-qing Wang, MD, PhD, Hui Xiong, MD, PhD, Li-huan Li, MD, Fu-xia Yan, MD, and Xu Wang, MD, PhD, Beijing, China

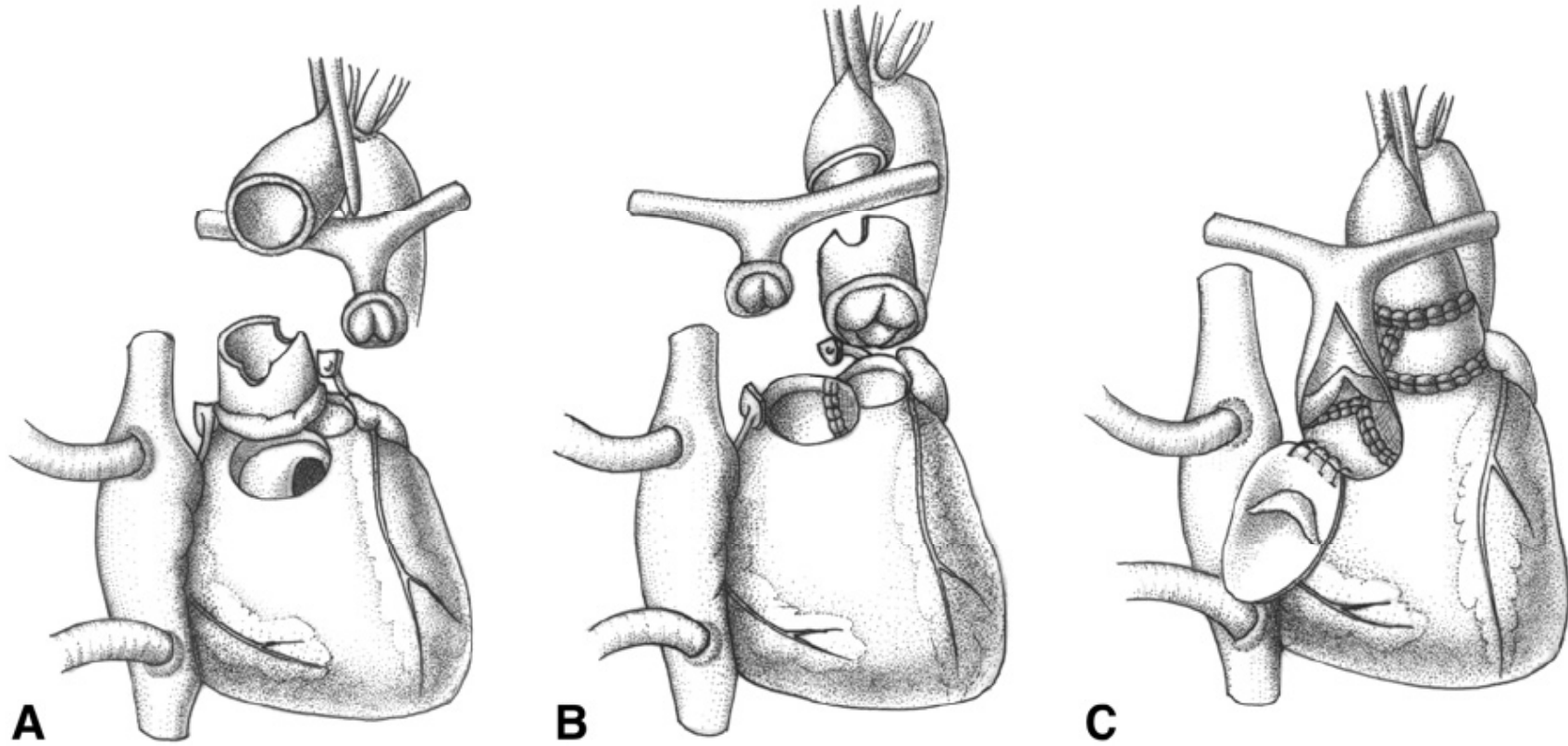
The Nikaidoh procedure, as an alternative to the Rastelli operation for dealing with transposition of the great arteries (TGA) with ventricular septal defect (VSD) and pulmonary stenosis (PS), could obtain a superior anatomic result.^{1,2} However, the extracardiac conduit is unable to grow and is inevitably calcified; thereafter, the patients required reoperation. We report our experience with a novel modification in which the native pulmonary valve was preserved to address these problems.

to the original pulmonary trunk position, and coronary arteries were reimplanted. After the Lecomte maneuver was performed, the aortic continuity was reestablished. The detached pulmonary root was then translocated anteriorly to the right ventricular outflow tract (RVOT). The pulmonary root was incised along its anterior wall, and a monocusp bovine jugular vein patch was used to enlarge the RVOT (Figure 1,



Dr Hu

Double Root Translocation



J Thorac Cardiovasc Surg 2008;135:331-8

Chinese Experience

Strategy for biventricular outflow tract reconstruction: Rastelli, REV, or Nikaidoh procedure?

Sheng-Shou Hu, MD, PhD, Zhi-Gang Liu, MD, PhD, Shou-Jun Li, MD, Xiang-dong Shen, MD, Xu Wang, MD, Jin-ping Liu, MD, Fu-Xia Yan, MD, Li-qing Wang, MD, and Yong-qing Li, MD



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Objective: Three techniques have been developed as the surgical management for patients with anomalies of ventriculoarterial connection, ventricular septal defect, and pulmonary outflow tract obstruction (stenosis): the Rastelli, Lecompte, (REV), and Nikaidoh procedures. This study was designed to compare these procedures in terms of hemodynamics of the reconstructed biventricular outflow tract, early clinical consequences, and follow-up.

Methods: Between March 2004 and September 2006, a total of 30 consecutive patients underwent double root translocation procedures (modified Nikaidoh n = 11, REV n = 7, Rastelli n = 12). In the Nikaidoh procedure, both aortic and pulmonary roots were translocated. A single-valved bovine jugular vein patch was used to repair the stenotic pulmonary artery in both Nikaidoh and REV procedures. The Senning procedure was added for those with atrioventricular discordance.

J Thorac Cardiovasc Surg 2008;135:331-8



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Double Root Translocation__ A true-meaning anatomic repair for anomalies of ventriculoarterial connection with pulmonary outflow tract obstruction

Sheng Shou Hu, Zhigang Liu, Shou Jun Li; The National Cardiovascular Institute and Fu Wai Hospital Beijing, Beijing, China

[▶ Comment on this Abstract](#)

Objective: Surgical management for patients with ventriculoarterial discordance, ventricular septal defect (VSD), and pulmonary outflow tract obstruction (PS) remains a challenge. As the conventional treatment for this lesion, Rastelli procedure has been revealed with poor long-term results, an alternative surgical technique is required. Aiming to preserve the competence and growth potential of the native pulmonary valve and acquire a better long-term results, we proposed the "double root translocation" technique for biventricular outflow tract reconstruction. Herein we present our successful experiences in 25 consecutive patients.

Methods: Between November 2004 and August 2007, 25 consecutive patients underwent "double root translocation" procedure. The median age at operation was 4.3 (range from 0.7 to 18) years. Transposition of great arteries (TGA) with VSD and PS were diagnosed in nineteen patients (four had atrioventricular discordance) and double outlet right ventricle (Taussig-Bing anomalies) with PS in six cases. The operative technique includes that both aortic and pulmonary root were mobilized, excised and translocated. A monovalved bovine jugular vein patch was used to repair the stenotic pulmonary artery. Coronary arteries re-attachment was needed in five patients. Major concomitant procedure included Senning operation in four cases and Glenn in one.

Pros and Cons of the Nikaidoh Procedure

- **Pros**

- Anatomical biventricular outflow tracts*

- Reduced risk of LVOTO*

- Excellent long-term survival*

- **Cons**

- Technically demanding*

- RVOT problems not solved*

- Possible development of AR*

Summary

- **Rastelli procedure : still “Gold Standard”**
- **REV and Nikaidoh procedure**
 - Likely to cause less LVOT problems*
 - Likely to have better long-term survival*
- **RVOT problems will continue.**
- **Improvement of long-term survival**
 - Early correction*
 - Meticulous surgical technique to prevent LVOTO*

Thank You !

