

ROSS SURGERY: OUR EXPERIENCE

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Abstract

Objectives: At Santa Marta Hospital, Ross Surgery was performed for the first time in 1999. Twenty years later, we feel it is desirable to evaluate the mid and long-term results of our experience, as well as estimate the future of this procedure.

Methods: Between March 1999 and June 2016, 23 Ross procedures were performed at our institution. We did a retrospective analysis of the patients' data, results of the surgery, complications, freedom from reoperation and mortality.

Results: The majority (36,4%) of the patients had aortic stenosis, 22,7% had aortic regurgitation and 27,3% had aortic stenosis and regurgitation. Sub-valvular stenosis was present in 13,6% of patients. The mean follow-up is 15 years. The overall mortality was 9%, without early mortality. In our series, 83% of the patients are free from reoperation. Eighty percent (n=16) of the survivors are in NYHA class I, with the remaining 20% (n=4) in class II.

Conclusion: Ross surgery has strict indications and in this group of patients the advantages are undeniable and the outcomes, according to our results (with 83% of patients free from reoperation, at a mean follow-up of 15 years), are positive and encouraging.

INTRODUCTION

Performed for the first time in July 1967, by Donald Ross, Ross procedure is one of the surgical options for aortic valve replacement and correction of complex left ventricle outflow tract obstruction syndromes, using for that purpose the pulmonary autograft.

During the early years, Ross surgery faced skepticism motivated mainly by two reasons: the slow learning curve, especially in the sub-coronary implantation technique, and the fact that it involves the manipulation of two heart valves for correction of a single valve disease. Despite this, Ross surgery presents undeniable advantages, not achieved by any other surgical alternative, namely, growth potential, absence of need of anticoagulation, a theoretically lower incidence of infective endocarditis and a better hemodynamic profile.

Presently, more than 50 years later, the main concern about this procedure is the pulmonary autograft potential for dilatation, when submitted to systemic blood pressure,

ultimately resulting in neo-aortic valve insufficiency.

Twenty years after the first Ross surgery performed at our institution, we feel it is desirable to review the mid and long-term results of our experience as well as estimate the future of this procedure.

MATERIAL AND METHODS

Retrospective study of all patients submitted to Ross surgery or Ross-Konno Surgery, in our Department, from January 1999 to December 2019. All procedures were performed by a single surgeon. Our electronic patient database was searched for patients' identity, and outcomes were determined from clinical file consultation. All data was stored in Microsoft Excel, and descriptive statistics was utilized. Kaplan Meier analysis was performed for survival and event-free survival estimation. Operative mortality was defined as mortality in the first 30 days after surgery or during the same hospital admission.

Table 1 Surgical indication for Ross procedure

Surgical indication	Prevalence % (n)
Aortic stenosis	36,4% (n=8)
Aortic regurgitation	22,7% (n=5)
Aortic stenosis and regurgitation	27,3% (n=7)
Sub-valvular aortic stenosis	13,6% (n=3)

Population

Between 1999 and 2016, 23 Ross procedures were performed at our institution. 68% of patients (n=15) were male. The mean age at operation was 10,7 years (minimum 0,3 and maximum 20 years). All patients had congenital aortic diseases. The most prevalent surgical indication was aortic stenosis (36% (n=8)). Surgical indications are presented in Table 1.

Surgical Technique

In all patients, surgery was performed under cardiopulmonary bypass, with bicaval cannulation, aortic cross clamping, and antegrade blood cardioplegia. Broad mobilization of the great arteries was performed. Main pulmonary artery was transected almost at the level of its bifurcation and the pulmonary autograft was excised

using the enucleation method described by Donald Ross, keeping the integrity of the first septal artery. Aorta was transected and the coronary ostia were removed with a broad button. When indicated, complementary procedures like sub-aortic membrane excision were performed. In all cases, the autograft was implanted using the total root technique. Autograft implantation was performed using interrupted polypropylene sutures, reinforced with bovine pericardium or Teflon® (Figures 1 and 2). The left coronary artery ostium was reimplanted. Then, the ascending aorta was reconstructed, followed by the reimplantation of right coronary artery ostium. Lastly, right ventricle to pulmonary artery continuity was reestablished with a conduit, most frequently a pulmonary homograft (Figures 3 and 4).

RESULTS

Mean cardiopulmonary bypass and aortic cross clamping times were 171 and 127 minutes, respectively. In 72,7% of cases, the right ventricle to pulmonary artery conduit used was a pulmonary homograft, while in 27,3% (n=6) was a xenograft (Contegra®, Medtronic plc, Dublin).

Mean homograft and xenograft sizes were 22 and 18, respectively. Nine patients were submitted to additional surgical procedures, namely sub-aortic membrane excision (n=3), Morrow myectomy (n=3) and Konno procedure (n=2).

Mean follow-up time is 15 years (minimum 4, maximum 21 years). There was no intra-operative or immediate post-operative mortality. Regarding post-operative complications, there were two cases of sepsis and one case of temporary atrioventricular conduction block.

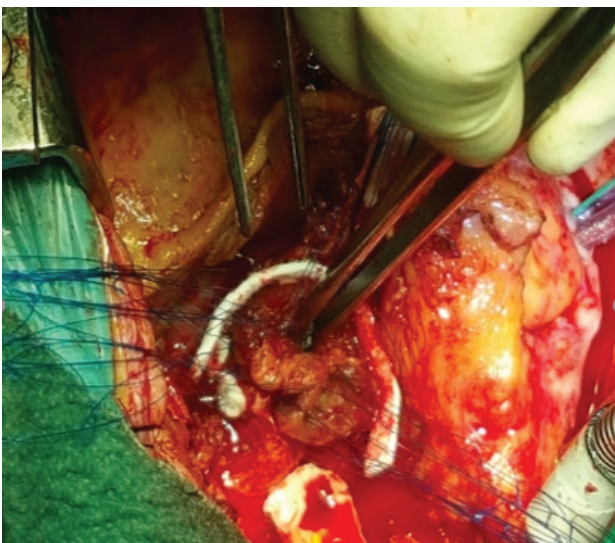
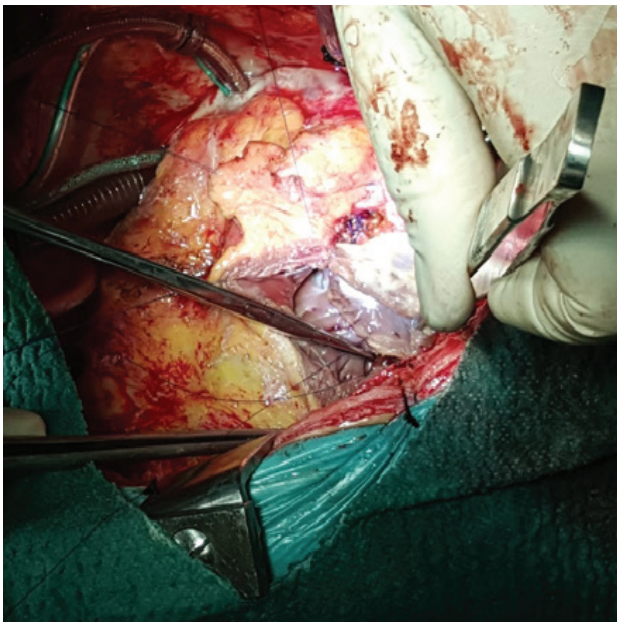


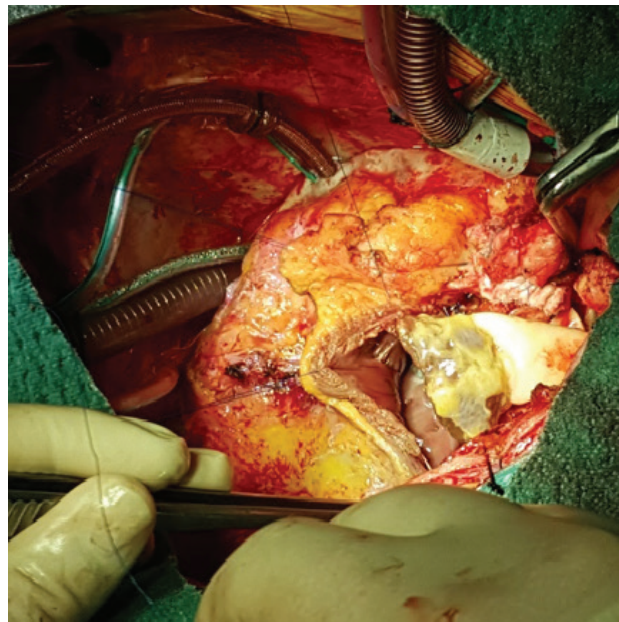
Figure 1 Reinforcement of the sinotubular crest using a Teflon® band.



Figure 2 Reinforcement of the sinotubular crest using a Teflon® band.


Figure 3

Reconstruction of right ventricle to pulmonary artery continuity using a pulmonary homograft.


Figure 4

Reconstruction of right ventricle to pulmonary artery continuity using a pulmonary homograft.

In our series, 83%(n=19) were free from reoperation, while 4 patients were reoperated (Graphic 1). One patient underwent 2 reoperations. Mean time for reoperation was 9 years after Ross surgery. Reoperations were due to infectious endocarditis of the right ventricle to pulmonary artery conduit, namely a Contegra® (2 years later), mitral valve insufficiency and heart transplant (same patient, 5 and 6 years later, respectively), sub-aortic membrane (13 years later) and aortic insufficiency (16 years later). Accordingly with the last echocardiographic evaluation, four patients have moderate aortic insufficiency, four patients present moderate pulmonary insufficiency and one patient presents moderate pulmonary valve stenosis.

Cumulative mortality is 9% (n=2). One patient died suddenly at home, 7 months after the surgery. The cause of death was not determined. The other patient died 6 years after surgery, following heart transplantation.

Presently, 80% (n=16) of patients are in NYHA class I, while the remaining 20% (n=4) are in class II.

DISCUSSION

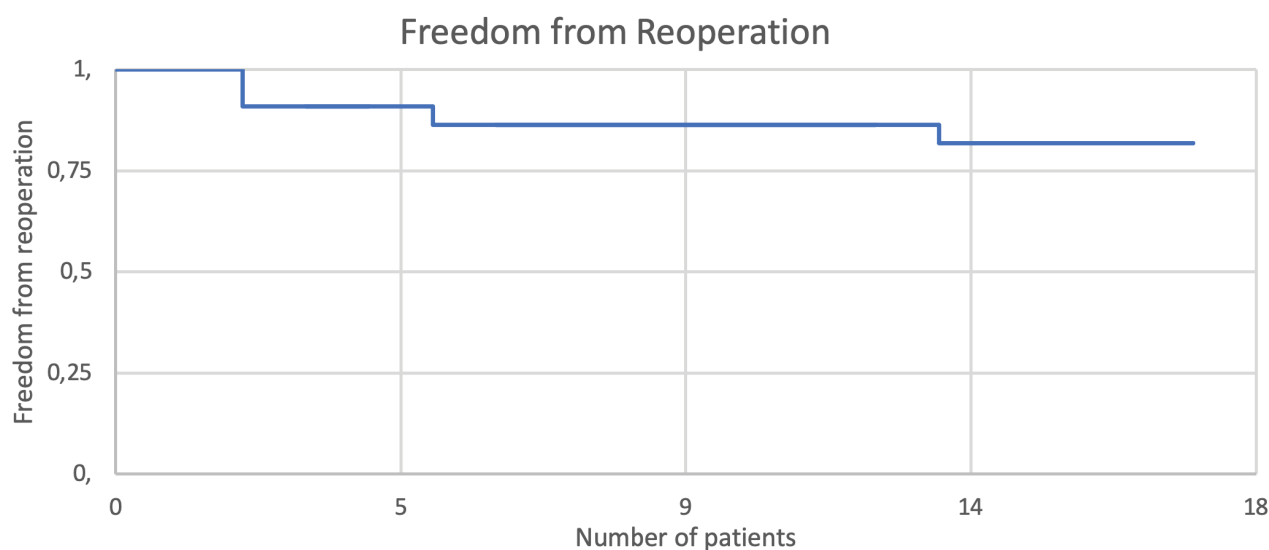
Literature reports an early mortality rate between 0.7-6,8% and a late mortality rate between 0.1-1,25%¹. Currently, the main concern associated with Ross surgery is pulmonary autograft progressive dilatation, leading to aortic regurgitation. However, this is not apparent in our series. It is also consensual that this progressive dilatation does not happen homogeneously in all patients and does

not affect the autograft uniformly. Progressive autograft dilatation occurs mainly in the presence of bicuspid aortic valve, male patients, younger ages at operation and aortic valve insufficiency^{1,2}. Interestingly, in our series, with 70% of patients being male and 22,7% having aortic regurgitation, only one reoperation was due to pulmonary autograft dilatation and neo-aortic regurgitation. Although this is a small series, this is probably the result of an adequate selection of patients and of the reinforcement of the sinotubular crest performed in all patients. We also favor a short pulmonary autograft.

The survival and freedom from reoperation, in our series are actually very similar to the ones reported by Guerreiro et al.³ In this retrospective portuguese single center study, a 80% freedom from reoperation, in a mean follow-up of 20 years, is reported³. Interestingly, this group used predominantly the subcoronary approach³.

Ross surgery benefits predominantly children/adolescents given the growth potential, not achieved by any other surgical alternative. This procedure also exempts the patients from anti-coagulation required with mechanical heart prosthesis^{4,5}, which is especially relevant in this group given the associated active lifestyle, sports participation and, in female patients, possibility of future pregnancies. While bioprosthesis do not require anti-coagulation, they present an accelerated deterioration in younger ages⁶.

Sinotubular crest reinforcement has been strongly recommended^{7,8}. However, traditionally, this has been done using synthetic materials like Dacron or Teflon, re-


Graphic 1

Freedom from reoperation after Ross procedure.

ducing growth potential, stated as the main advantage of the procedure when performed in younger ages⁹. The solution may depend on the use of biocompatible materials providing structural support and inducing, at the same time, histological modifications in the autograft wall, therefore increasing tolerance to the higher systemic pressure conditions. Nappi and colleagues recently introduced the idea of the use of reabsorbable scaffolds as reinforcement of the pulmonary artery in an experimental model of Ross operation in the growing lamb⁹. A polydioxanone external mesh prevented pulmonary artery dilation and induced in vivo a favorable elastic remodeling of the autograft. A complex histoarchitectural rearrangement including medial thickening and increase in the elastic wall component was triggered leading to the creation of a "neovessel" similar to the native aorta⁹. They propose that a new impulse should be given to translational research to stimulate the development of bio-artificial vascular substitutes and provide a future for the Ross procedure, given its advantages in a very specific population.

CONCLUSION

Ross surgery has strict indications. However, in that group of patients, advantages are undeniable. Despite the reduced number of patients, we believe that our results, with 83% freedom from reoperation with a mean follow up of 15 years, are positive and encouraging. Fifty years after the first Ross surgery, the development of new materials may improve the performance of the pulmonary autograft.

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