Ross procedure in the setting of anomalous aortic origin of a coronary artery

Amit Pawale, MD, Bobby Yanagawa, MD, PhD, Robin Varghese, MD, and Paul Stelzer, MD, New York, NY

From the Department of Cardiovascular Surgery, Mount Sinai Medical Center, New York.

Disclosures: Authors have nothing to disclose with regard to commercial support.

Received for publication April 30, 2015; revisions received July 3, 2015; accepted for publication July 17, 2015; available ahead of print Aug 13, 2015.

Address for reprints: Paul Stelzer, MD, Department of Cardiovascular Surgery, Mount Sinai Medical Center, New York, NY 10029-6574 (E-mail: Paul.Stelzer@mountsinai.org).

J Thorac Cardiovasc Surg 2015;150:1000-2

0022-5223/\$36.00

Copyright © 2015 by The American Association for Thoracic Surgery

<http://dx.doi.org/10.1016/j.jtcvs.2015.07.055>

Intraoperative images. A, LAD from the right sinus. B, RCA from the left main. C, CX from the right sinus.

Central Message

The Ross procedure can be safely performed in patients with AAOCA.

See Editorial Commentary page 1002.

The Ross procedure offers long-term freedom from degeneration, endocarditis, thromboembolism, and anticoagulation.^{1,2} It is particularly suited in the young and women of childbearing age.²

Anomalous aortic origin of a coronary artery (AAOCA) has been associated with coronary ischemia, myocardial infarction, and sudden cardiac death. The incidence ranges from 0.1% to 0.2%, and higher with bicuspid aortic valves.

Over the last 28 years, 570 patients underwent the Ross procedure using a full root technique; 7 had AAOCA (1.25%). We describe our surgical approach to this unique patient population. The Ross procedure can be safely performed in patients with AAOCA.

CLINICAL SUMMARY

Between 1987 and 2014, 7 patients with AAOCA underwent the Ross procedure (Table 1). The mean age was 39 years, and 87% were male. Four patients had bicuspid aortic valve; 1 each had rheumatic, endocarditic, and trileaflet calcific disease. The aortic valve was stenotic in 4 patients and regurgitant in 2 patients, and 1 patient had aortic root aneurysm with bicuspid aortic valve with mild stenosis and insufficiency.

Computed tomography coronary angiography was obtained before surgery. The coronary anomalies were right coronary artery (RCA) originating from the left sinus in 4 patients and left coronary artery originating from the right sinus in 3 patients.

The strategies for repair of anomalous coronaries are shown in Table 1. In patient 1 (Figure 1), the left internal thoracic artery (LITA) was used to bypass the left anterior descending (LAD) as it coursed between the aorta and the pulmonary artery to avoid the risk of ischemia or sudden death from compression between the great vessels. The LAD was ligated proximally to avoid competitive flow. In patient 2 (Figure 2), with anomalous RCA, the RCA was divided at its origin, mobilized proximally, and reimplanted in the right neo-aortic sinus. In patient 3 (Figure 3), the anomalous circumflex (CX) coronary artery arose from the right ostium and ran along the noncoronary sinus, which was carefully mobilized and protected. In patients 4 and 6, the left and right ostia were in close proximity. Both ostia

TABLE 1. Details of patients undergoing Ross procedure and concomitant repair of anomalous aortic origin of a coronary artery

Patient	Age, y	Sex	Aortic valve diagnosis	AAOCA	AAOCA procedure	Last follow-up (y)
1	52	Male	Bicuspid AS	LAD from RCA	LITA to LAD	2.6
2	39	Male	Rheumatic AI	RCA from LM	RCA Reimplantation	2.1
3	39	Male	BAV, AS + AI, aortic root aneurysm	CX from RCA	Mobilization	1.8
4	36	Male	Endocarditic AI, trileaflet	RCA from left sinus	RCA and LM Reimplantation as single button	16
5	25	Female	Bicuspid AS	LAD and CX from distal RCA	LITA to LAD	16.3
6	52	Male	Calcific AS, trileaflet	RCA from left sinus	RCA and LM Reimplantation as single button	15
7	30	Male	Bicuspid AS	RCA from left sinus	RCA Reimplantation	1.1

AAOCA, Anomalous aortic origin of a coronary artery; AI, aortic insufficiency; AS, aortic stenosis; BAV, bicuspid aortic valve; CX, circumflex; LAD, left anterior descending; LITA, left internal thoracic artery; LM, left main; RCA, right coronary artery.

FIGURE 1. Patient 1. A and B, Three-dimensional reconstructed CT scan showing LAD arising from the right coronary sinus with an inter-arterial course. C, Intraoperative view showing LAD arising from the right coronary sinus, coursing behind the right ventricular outflow tract. CX, Circumflex; LAD, left anterior descending; RCA, right coronary artery; RI, ramus intermedius; RVOT, right ventricular outflow tract.

were reimplanted in the left neo-aortic sinus as a single button. In patient 5, the left main stem was absent, and the RCA supplied collaterals to the CX and LAD. The RCA ostium was reimplanted, and a LITA to LAD bypass was performed. In patient 7, the anomalous RCA was at a high position in the left sinus. The RCA was reimplanted in the neo-right sinus.

All patients were extubated on postoperative day 1. There were no complications, and all patients were discharged within 7 days. There were no abnormal findings on predischarge echocardiography. The mean follow-up was 7.8 years. No patient developed ischemic symptoms or required repeat revascularization with midterm follow-up.

DISCUSSION

Although the Ross procedure has been described in the setting of AAOCA,³⁻⁵ we believe this is the largest series to date. Our experience demonstrates the use of several different techniques to deal with this problem.

When both coronary ostia were of adequate size and with inadequate tissue to form 2 buttons, they were implanted as a single button on the largest pulmonary autograft sinus. The autograft is rotated to accommodate this button. Mobilization is particularly important to avoid tension or torsion.

Pulmonary autograft harvest risks injury to an anomalous LAD that arises from the right sinus and courses posterior to the pulmonary artery or an anomalous RCA that arises from the left sinus. The aortotomy should be made higher in case of higher take-off of an anomalous RCA.

For patients with anomalous CX originating from the right coronary sinus and coursing along the noncoronary annulus, it is essential to make a transverse aortotomy and not to extend it into the noncoronary sinus. The CX should be dissected away from the aortic wall along the noncoronary sinus, and the proximal suture line bites must not fully penetrate that wall to avoid CX injury. The reinforcing felt strip on the proximal autograft suture line should be kept thin.

Patency of the ostia and proximal coronary artery can be confirmed by (1) use of a coronary probe, (2) visualization of retrograde cardioplegia ostial flow, and (3) intraoperative transesophageal echocardiography.

For the 2 highly selected patients requiring a single bypass, we used LITA to optimize long-term patency. Adding 1 distal coronary anastomosis does not significantly affect the clamp or bypass time. For patients needing multivessel revascularization for ischemic heart disease along with aortic valve or root replacement, we mostly use bioprosthetic valve or root replacement along with coronary bypass with future potential for transcatheter valve in valve.

FIGURE 2. Patient 2. A, Three-dimensional reconstructed CT scan showing RCA arising from left main stem. B, Intraoperative view of the RCA arising from left main stem and anomalous RCA (C) reimplanted in the pulmonary autograft. AA, Ascending aorta; CX, circumflex; LAD, left anterior descending; RCA, right coronary artery; RVOT, right ventricular outflow tract.

FIGURE 3. Patient 3. A, Anomalous CX arising from the right coronary sinus and coursing around the noncoronary and left coronary sinuses. B, Intraoperative view of anomalous CX arising from the right coronary sinus, with a probe in the CX showing its course and RCA and CX origins (C) reimplemented as a single button in the pulmonary autograft. CX, Circumflex; RCA, right coronary artery; RVOT, right ventricular outflow tract.

CONCLUSIONS

The Ross procedure can be safely performed in patients with AAOCA by an experienced Ross surgeon. Computed tomography coronary angiography is helpful. The precise surgical strategy for anomalous coronary repair should be individualized.

The authors thank Javier Sanz, MD, for the 3-dimensional reconstructions of the computed tomography coronary angiograms.

References

1. Stelzer P, Jones DJ, Elkins RC. Aortic root replacement with pulmonary autograft. *Circulation*. 1989;80:III209-13.
2. Stelzer P. The Ross procedure: state of the art 2011. *Semin Thorac Cardiovasc Surg*. 2011;23:115-23.
3. Morikawa M, Bando K, Sato S. The Ross procedure performed in the setting of congenitally bifoliate aortic valve with anomalous right coronary artery. *Cardiol Young*. 2005;15:213-5.
4. Mwambu TP, Cherian VK, Sankar MN, Sumithran G, Coelho R, Snehal K, et al. Reimplantation of the two coronary ostia as a single button in Ross procedure. *J Heart Valve Dis*. 2002;11:624-6.
5. O'Blens SB, Feindel CM. Aortic root replacement with anomalous origin of the coronary arteries. *Ann Thorac Surg*. 2002;73:647-9.

EDITORIAL COMMENTARY

Anomalous aortic origin of a coronary artery in the Ross operation: Attention to minor details averts major problems

Igor E. Konstantinov, MD, PhD, FRACS

From the Department of Cardiothoracic Surgery, Royal Children's Hospital; University of Melbourne; and Murdoch Children's Research Institute, Melbourne, Victoria, Australia.

Disclosures: Author has nothing to disclose with regard to commercial support.

Received for publication July 28, 2015; accepted for publication July 29, 2015; available ahead of print Sept 3, 2015.

Address for reprints: Igor E. Konstantinov, MD, PhD, FRACS, Department of Cardiothoracic Surgery, Royal Children's Hospital, University of Melbourne, Flemington Rd, Parkville, VIC 3029, Australia (E-mail: igor.konstantinov@rch.org.au).

J Thorac Cardiovasc Surg 2015;150:1002-4

0022-5223/\$36.00

Crown Copyright © 2015 Published by Elsevier Inc. on behalf of The American Association for Thoracic Surgery <http://dx.doi.org/10.1016/j.jtcvs.2015.07.097>

An experience is defined as an event or occurrence that leaves an impression. To be experienced means to gain knowledge or skill in a particular field over time. If one is not experienced in coronary artery transfer, dealing with an anomalous aortic origin of the coronary artery (AAOCA) while performing a Ross operation could be an overwhelming experience. How does one get experience

Schematic presentation of the coronary artery anomalies encountered during Ross operation.

Central Message

Anomalous aortic origin of a coronary artery is rare and may present a problem during Ross operation and other aortic root surgery.

See Article page 1000.