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.

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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.

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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).

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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.

FIGURE 1. Schematic presentation of coronary artery anomalies. Retroarterial course of the A₁, right coronary artery or A₂, left coronary artery. Interarterial course of the B₁, right coronary artery or B₂, left coronary artery. C, Atresia of the left main coronary artery. LCX, Left circumflex coronary artery; LAD, left anterior descending coronary artery; RCA, right coronary artery; L, left coronary sinus; R, right coronary sinus; N, noncoronary sinus; LITA, left internal thoracic artery.

in dealing with an exceedingly rare anomaly? A brief article published in the current issue of the *Journal*¹ provides a look at a concentrated experience gained in 570 patients who underwent Ross operation using a full root technique. Only 7 patients (1.25%) had an AAOCA. The management of these 7 patients leaves a lasting impression. The importance of this article cannot be overemphasized. It should become a part of any cardiac surgeon's armamentarium because this coronary anomaly could be encountered during routine aortic valve replacement. In view of the very rare and heterogeneous coronary artery anomalies described in the article, a few comments appear appropriate.

RETROARTERIAL CORONARY ARTERY

Most patients with AAOCA who undergo aortic valve or root replacement have retroarterial, or retroaortic, course of either the right coronary artery (Figure 1, A₁) or the left coronary artery. The latter is often limited to the left circumflex (LCX) coronary artery, but may also include the left anterior descending coronary artery (Figure 1, A₂). Although in selected patients the right coronary artery can be reimplanted into its anatomic sinus, most patients would have single button transfer of both coronary arteries. Anomalous LCX coronary artery has been previously described as a risk factor for coronary complications after aortic valve or root surgery.² If properly implanted,

overstretching of the anomalous coronary artery by the aortic root does not occur, because the new root will be smaller. A dilated aortic annulus index (ie, >15 mm/m²) is an independent predictor of late aortic insufficiency and Ross operation should, perhaps, not be performed in those patients³ unless the annulus is stabilized. Because the origin of the LCX artery from the right sinus of Valsalva is the most common variant in transposition of the great arteries, most congenital cardiac surgeons who perform Ross operation would not consider such a coronary artery anomaly particularly challenging. It would, certainly, require uninterrupted attention to detail, because care should be taken to ensure proper coronary mobilization and to prevent ligation or injury of the retroaortic coronary artery by sutures during aortic root or valve replacement.^{4,5}

INTERARTERIAL CORONARY ARTERY

On the other hand, interarterial course of the right coronary artery (Figure 1, B₁) or the left anterior descending artery with or without LCX (Figure 1, B₂) is much more problematic. Leaving such a coronary artery in situ would, most likely, result in coronary compression between the aortic root and the pulmonary artery conduit, especially as calcification and rigidity of the conduit progresses. This may result in sudden death. Furthermore, the pulmonary conduit is the Achilles' heel of the Ross procedure,³ particularly in children.⁶ Should reoperation be required,

the interarterial course of the coronary artery would add complexity to already extensive reoperation.⁷ Thus, the coronary artery should be reimplanted to eliminate its interarterial course. Bypass with the left internal thoracic artery, although controversial in patients without coronary artery disease, could be done if coronary reimplantation is deemed impossible. Limited long-term durability of such bypass in young patients is of concern and may nullify the benefits of Ross operation.

LEFT MAIN CORONARY ARTERY ATRESIA

Finally, left main coronary artery atresia is not of much relevance to the Ross operation as such, or to other aortic root or valve surgery, but is rather a separate, extremely rare entity. Whereas children with poor collaterals can be overtly symptomatic early in life, adults with good collaterals are asymptomatic and may develop symptoms late in life as coronary atherosclerosis progresses.^{8,9} Asymptomatic elderly patients have been described.^{8,9} It is reasonable to bypass the coronary artery in patients with poor collaterals. The role of coronary artery bypass grafting in patients with left main coronary artery atresia and good collateral flow during Ross operation or any other heart surgery is not defined. Clearly, competitive flow will be an issue in patients with good collaterals. The coronary artery bypass in a patient with good collaterals remains controversial.

A thorough understanding of coronary anatomy is necessary in planning aortic surgery in a patient with

suspected AAOCA. In patients with a bicuspid aortic valve the index of suspicion of AAOCA should be higher. In addition to routine coronary angiogram, preoperative multidetector computed tomography is very helpful in precise delineation of the coronary arteries. Attention to minor perioperative details averts major problems in these rare patients.

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