

# Arterial Switch Operation With Separate Coronary Arteries Arising From a Single Aortic Sinus

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In some patients, the coronary arteries originate in a single aortic sinus, and this anatomical configuration is regarded as a significant risk factor in the arterial switch operation for transposition of the great arteries. In these cases, the coronary transfer technique has to be individualized to suit the coronary anatomy (ie, a single ostium or separate ostia). Since 2001, we have operated on 3 patients who had separate coronary arteries arising from a single sinus. In 1, coronary transfer was carried out using the double-button technique and, in the other 2, using the aortocoronary flap technique. The aortocoronary flap procedure gave excellent results in patients with this coronary artery configuration.

**Key words:** Congenital heart disease. Transposition of the great arteries. Surgery. Coronary anomalies.

## Switch arterial con arterias coronarias separadas que se originan en un solo seno aórtico

El origen de las arterias coronarias de un solo seno aórtico ha sido considerado como un importante factor de riesgo para la realización del *switch* arterial en la transposición de grandes arterias. En estos casos la técnica de transferencia coronaria debe ser individualizada según la anatomía de las coronarias (ostium único o separado). Desde 2001 hemos operado 3 casos con arterias coronarias separadas que se originan en un solo seno. En uno se realizó la transferencia coronaria con técnica de doble botón y en los otros dos, con técnica de *flap* aortocoronario. El procedimiento de *flap* aortocoronario ofrece excelentes resultados en pacientes con este patrón coronario.

**Palabras clave:** Cardiopatías congénitas. Transposición de grandes arterias. Cirugía. Malformaciones coronarias.

## INTRODUCTION

According to the literature, some 5%-15% of patients with transposition of the great arteries have their coronary arteries arising from the same aortic sinus (CASS). The difficulty this causes when trying to transfer the coronary arteries to the neo-aorta without distorting them means such anatomy is associated with increased surgical risks.<sup>1-5</sup> The transfer technique needs to be individualized depending on the vascular arrangement and the relationship between the initial section of the coronary arteries and the great vessels. Coronary arteries arising from the same aortic sinus may have a single ostium

(often referred to as a “single coronary artery”) or 2 independent ostia. Generally they arise from sinus 2 (posterior right). It is common for the epicardial route taken to be unusual, and the left coronary artery may have an intramural trajectory, which increases the risk of causing it injury.<sup>4</sup> In CASS arising from a single ostium, the coronary arteries have a common trunk and all 3 run on the same side of the aorta; normally none of them run between the aortic and pulmonary artery roots. This means they can all be transferred as a single button using the trap door technique with excellent results.<sup>6</sup>

Transfer surgery in patients with 2 separated coronary arteries that arise from a single sinus is more complicated since one of the arteries crosses between the aorta and pulmonary artery, commonly with an intramural trajectory. Thus, the coronary arteries pass on either side the pulmonary artery root and impede the surgical rotation of the coronary button for its reimplantation in the neo-aorta. Patients with this anatomy suffer a higher mortality rate.<sup>4</sup> On some occasions, if the distance between the ostia is sufficient, the coronary arteries can be separated

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Received November 29, 2007.

Accepted for publication February 11, 2008.

**Patient Pre- and Postoperative Clinical Data**

	Patient 1	Patient 2	Patient 3
Age, d	10	24	11
Sex	Male	Male	Male
Weight, g	3200	3700	3100
Cardiopathy	TGA-SI	Taussig-Bing	TGV-SI
Coronary artery pattern	2LCx-R	2L-CxR (L Int)	2L-CxR (L Int-OS)
Surgical technique	ASO, independent buttons	Closure VSD-ASO, aortocoronary flap	ASO, aortocoronary flap
Duration of ischemia, min	100	135	110
Duration of ECC, min	260	260	155
Complications	Myocardial ischemia	Atrioventricular block	None
Concomitant procedures	IMA bypass	DDD pacemaker	None
Outcome	Intraoperative death	No complications	No complications

ASO indicates arterial switch operation; ECC, extracorporeal circulation; IMA, internal mammary artery; L Int, intramural left coronary artery; L Int-OS, intramural coronary artery with ostial stenosis; TGA-SI, transposition of the great arteries-septum intact; VSD, ventricular-septal defect.

so that they can be reimplanted independently using the usual technique.<sup>7</sup> In other cases the aortocoronary flap technique offers excellent results, even in patients in whom the trajectory of the left coronary artery is intramural.<sup>6,8,9</sup>

**METHODS**

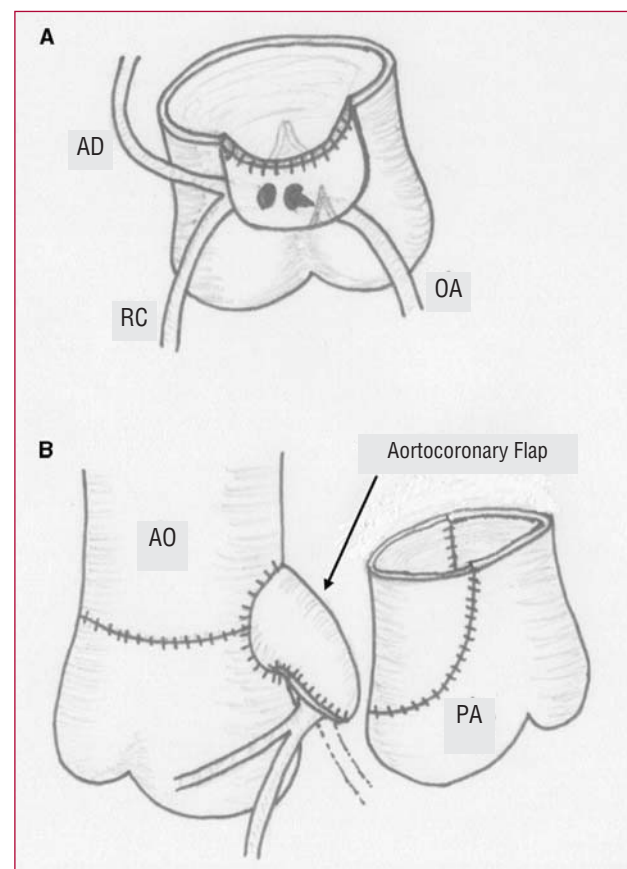
Since 2001, 3 patients with transposition of the great arteries plus CASS showing separate coronary arteries have undergone surgery at the Cardiovascular Surgery Unit of the Hospital Reina Sofía in Córdoba. Table 1 shows their pre- and postoperative data. The first patient underwent the independent reimplantation of each coronary artery following the normal technique. In the second and third patients, the aortocoronary flap technique was followed.

To make the aortocoronary flap, the origin of the coronary arteries was dissected out as a single wide button, avoiding any damage to the left coronary artery following an intramural trajectory. This required the deinsertion of the posterior commissure of the aortic valve. If the ostium of the intramural coronary artery shows any stenosis, this should be corrected by resecting a wedge of tissue from the wall of the aorta that forms the edge of the orifice, following the technique of Mee.<sup>7</sup> The upper part of the coronary button was sutured to the anterior zone of the neo-aortic root, without rotating the coronary arteries, and the anterior face of the connection was reconstructed with pericardium (Figure 1).

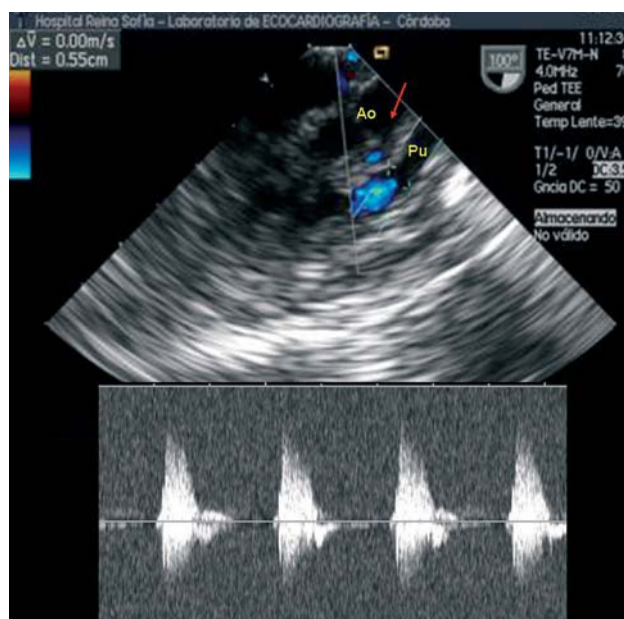
**RESULTS**

In the first patient, who had a single ostium for the DA-Cx and another for the CD (2LCx-R), each ostium was transferred independently of the neo-aorta. The patient suffered severe ischemic ventricular dysfunction, which prevented the disconnection of the extracorporeal circulation, even though the revascularization of the left coronary artery was attempted using a mammary bypass.

In the other 2 patients, who showed a common ostium for the CD-Cx and an intramural exit of the DA (2L-



**Figure 1.** Surgical technique used with patient 3. A: preparation of the coronary button to be sutured to the upper border of the neo-aorta without rotating or displacing the coronary arteries. The deinsertion zone of the aortic commissure can be seen, as well as amplification of the left coronary artery ostium. B: appearance of the aortocoronary flap (arrow) after completing the connection with the patient's own pericardium, and its relationship with the pulmonary artery root. AD indicates anterior descending artery; Ao, aorta; Cx, circumflex artery; Pa, pulmonary artery; RC, right coronary artery.



**Figure 2.** Echographic image (transesophageal) of the aortocoronary connection between the aortic root and the pulmonary artery (arrow) in patient 3. Pulsed Doppler analysis showed a normal systolic flow coming from the aorta in the aortocoronary flap.

CxR), the coronary arteries were transferred using an aortocoronary flap. Both patients progressed well. One patient who showed closure of the ventricular-septal defect required the implantation of a definitive DDD epicardial pacemaker via left thoracotomy owing to persistent postoperative atrioventricular block. Postoperative and follow-up echocardiograms of these two patients showed normal biventricular function and normal flow at the aortocoronary connection (Figure 2). No angiographic monitoring was performed.

## DISCUSSION

The main cause of early death in patients who have undergone arterial switch is myocardial ischemia owed to technical problems encountered during coronary reimplantation. The origin of the coronary arteries in a single aortic sinus is an important risk factor, despite the development of techniques designed to deal with such cases. In addition, the coronary arteries of such patients commonly take unusual epicardial routes and have intramural trajectories, making their transfer even more risky. Although in the past some authors recommended treating such patients via physiological correction (atrial switch),<sup>10</sup> it is now accepted that all coronary artery patterns can be transferred with acceptable risk if the right technique is used.<sup>11</sup> Nonetheless, a meta-analysis by Pasquali et al.<sup>4</sup> shows that the existence of a “single coronary artery” (odds ratio [OR]=2.9) and, especially of an “intramural coronary artery” (OR=6.5) have

persisted as risk factors over the last 2 decades. The term “intramural coronary artery” includes any pattern in which the coronary arteries cross between the great vessels, which we have here termed CASS.

Numerous techniques have been described for the reimplantation of the coronary arteries in patients with CASS. In patients in whom the initial courses of the coronary arteries do not lie on either side of the pulmonary artery root (when there is a single ostium) the trap door technique provides excellent results.<sup>6</sup> Some authors recommend the use of pericardial patches in the reimplantation of coronary arteries with a single ostium.<sup>12</sup> When there are 2 independent coronary arteries, one (normally the left) runs between the aorta and pulmonary artery and commonly has an intramural trajectory; the arteries therefore pass on either side of the pulmonary artery root. In such cases, 2 transfer techniques can be used<sup>13</sup>:

- Separating the coronary arteries and transferring them independently, following the normal technique
- Maintaining the arrangement of the coronary arteries, obtaining a single button and creating a para-aortic connection either directly<sup>8</sup> or using a pericardial patch (Quaegebeur JM, personal communication, 1992)

The main problem of separating coronary buttons is the lack of tissue for suturing without leaving any stenosis of the ostium. Although some authors report good results,<sup>7</sup> others have reported frequent coronary complications, as shown by the first of our 3 patients.<sup>6</sup>

Using an aortocoronary flap avoids rotating the aortic button that includes the origin of the 2 coronary arteries, and therefore reduces the risk of their distortion. However, the risk of compressing the aortocoronary connection between the aorta and pulmonary artery exists. This risk is low if the pulmonary arteries are adequately mobilized, but it may be necessary to displace the distal pulmonary anastomosis towards the right or left pulmonary artery. Another cause for concern with this technique is the possibility of the retraction or degeneration of the pericardial patch obstructing the coronary flow.

Different techniques have been described for keeping the coronary arteries in situ, involving an intrapulmonary tunnel with pericardium connecting the coronary ostia to an “aorto-pulmonary window,”<sup>14</sup> or via aorta wall flaps that create an aorto-coronary connection within the neopulmonary root.<sup>15-17</sup> However, experience with these techniques is limited.

The results obtained with the present patients treated using the aortocoronary flap technique were satisfactory, while the patient who underwent independent transfer of the coronary arteries died due to myocardial ischemia. Thus, we believe it is safer to transfer separate coronary arteries that arise from a single sinus via the use of a single button, except in exceptional cases when there is sufficient distance between the coronary ostia.

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