



# Coronary artery bypass grafting for an anomalous origin of the right coronary artery: is it a valid surgical procedure?

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## Abstract

The right internal thoracic artery to the right coronary artery bypass with ligation of the proximal native vessel is a simple and reliable option for the treatment of an anomalous aortic origin of the right coronary artery arising from the left sinus of Valsalva without an intramural course. Coronary artery bypass grafting is an uncomplicated option for elderly patients, those with connective tissue diseases, and those for whom combined aortic valve procedures are planned. Herein, we present four cases of this anomaly that underwent right internal thoracic artery anastomosis to the distal right coronary artery along with proximal right coronary artery ligation using a surgical clip. There was no occurrence of complications such as hypoperfusion syndrome, graft occlusion, recurrent symptoms, or late cardiac events.

**Keywords** Anomalous aortic origin of the right coronary artery · Coronary artery bypass grafting · Ligation of the proximal native vessel

## Introduction

Anomalous aortic origin of the right coronary artery (AAORCA) is a rare congenital cardiac abnormality causing myocardial ischemia or sudden death [1]. Multiple treatment options have been described for correcting this condition. Coronary artery unroofing and reimplantation are considered effective procedures [2, 3]. However, they are not preferred procedures for patients with a short intramural coronary artery course or slit-like ostium or those scheduled for concomitant procedures [1, 3]. Coronary artery bypass grafting (CABG) is a surgical option, but the results are unsatisfactory without proximal vessel ligation [1, 4]. However, the outcomes of CABG with proximal vessel ligation are unknown.

Herein, we describe the outcomes of four consecutive patients with this anomaly who underwent right internal thoracic artery (RITA) anastomoses to the distal right coronary artery (RCA) with proximal RCA ligation.

## Case report

The clinical course of four patients with AAORCA who underwent a RITA bypass to the distal RCA with proximal RCA ligation using a surgical clip was reviewed (Table 1). In patient 1, the fractional flow reserve value was 0.72 in the RCA ostium. Patient 3 had Marfan syndrome.

The surgical technique used in our patients is described below. The stabilizers immobilized the heart, and the proximal RCA was exposed in the atrioventricular groove. The end-to-side anastomosis of the RITA to the RCA was completed using 8-0 sutures with the use of an intracoronary shunt. The transit-time flow measurement was used to investigate the graft flow characteristics and coronary circulation physiology with and without a clamp (silicone material tape). The proximal RCA was ligated using a surgical clip after confirming an increase in the graft flow following clamping of the proximal RCA.

Patients 1–3 underwent off-pump CABG, whereas patient 4 underwent aortic valve replacement (AVR) and CABG. Weaning from the cardiopulmonary bypass was smooth. Each coronary computed tomography angiography (CCTA) revealed a slit-like ostium of the RCA without an intramural course (Fig. 1a–d). The graft flow before and after proximal RCA ligation was 31 and 69 mL/min in patient 1, 48 and 89 mL/min in patient 2, 32 and 65 mL/min in patient 3, and

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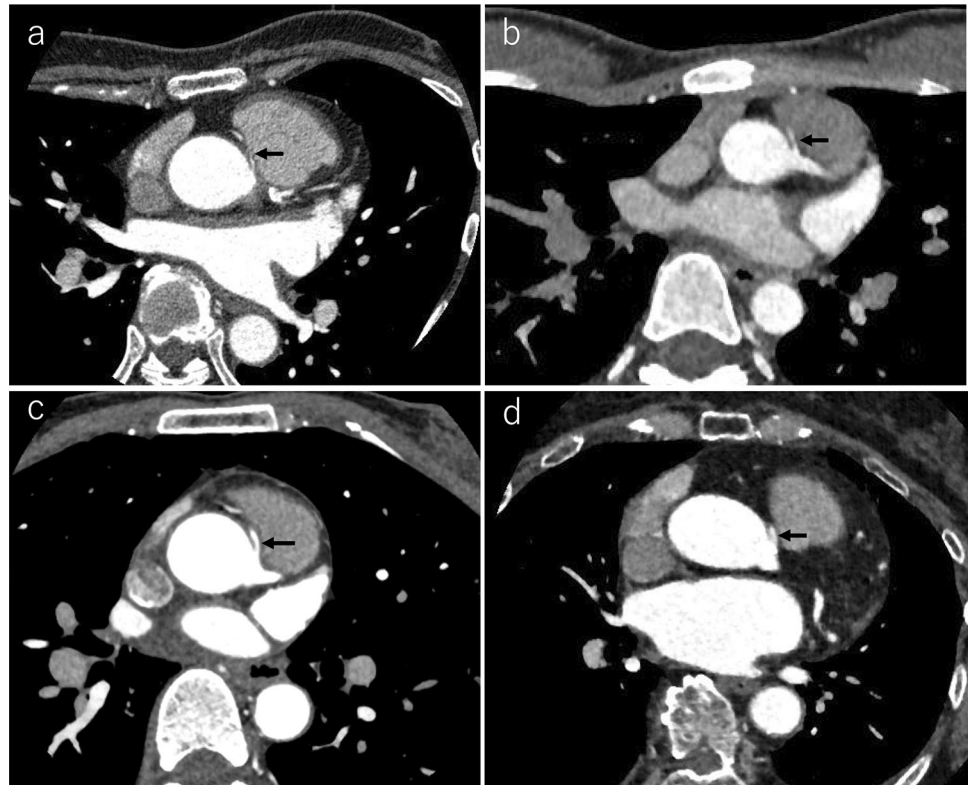
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**Table 1** Clinical presentation of 4 patients with AAORCA

Patient (age, sex)	Symptom	Intramural course	Anastomosis	Use of CPB/concomitant procedure	Graft flow (pre/post ligation) (mL/min)	Outcome (follow-up period)
1 (70, M)	Chest pain	No	RITA-RCA	No/No	31/69	No symptom (3 y)
2 (18, F)	Chest pain	No	RITA-RCA	No/No	48/89	No symptom (3 y)
3 (46, F)	Chest pain	No	RITA-RCA	No/No	32/65	No symptom (6 m)
4 (68, F)	Syncope	No	RITA-RCA	Yes/AVR	36/52	No symptom (3.5 y)

AAORCA, anomalous aortic origin of the right coronary artery; RITA, right internal thoracic artery; RCA, right coronary artery; AVR, aortic valve replacement; CPB, cardiopulmonary bypass

**Fig. 1** Coronary computed tomography angiography showing the anomalous origin of the right coronary artery (black arrow) from the left coronary sinus of Valsalva without an intramural course. **a** Patient 1. **b** Patient 2. **c** Patient 3. **d** Patient 4



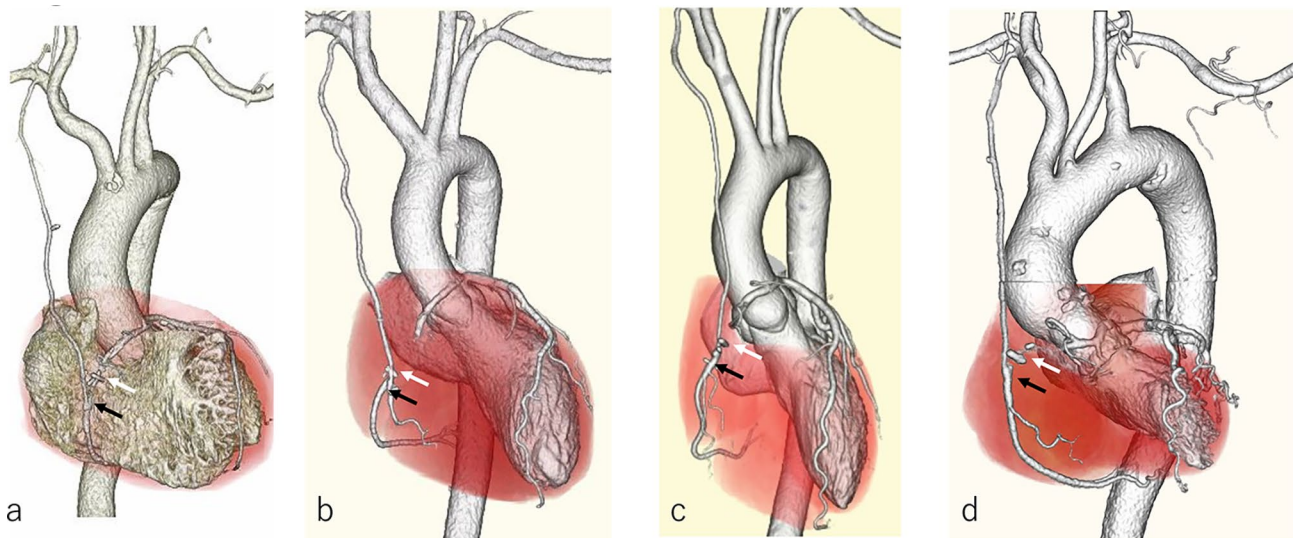
36 and 52 mL/min in patient 4, respectively. Each postoperative CCTA showed a patent graft (Fig. 2a–d). The postoperative course was stable in all patients without hypoperfusion syndrome or ischemia. All patients are doing well and have not exhibited any signs of ischemia at postoperative follow-up.

Written informed consent was obtained from the patients for the publication of these cases and supporting images.

## Discussion

We treated patients with AAORCA with a RITA bypass to the distal RCA and proximal RCA ligation. Multiple surgical therapies, including unroofing, reimplantation,

and osteoplasty, are available for treating AAORCA [1–3]. Since the internal thoracic arteries have shown great long-term patency rates [5], we performed off-pump bypass (except in patient 4). The surgical repair technique is simple and does not require aortic root manipulation. In patient 1, CABG was selected since he was old and had significant RCA stenosis. In patient 2, though she was young, CABG was selected because she refused to provide consent for reimplantation or osteoplasty. In patient 3, aortic root manipulation procedures, such as unroofing and reimplantation, did not appear to be a good surgical option owing to vascular fragility from Marfan syndrome. In patient 4, we preferred AVR with CABG to complex procedures such as AVR with unroofing because of the risk of coronary artery occlusion.



**Fig. 2** Postoperative computed tomography showing the bypass of the right internal thoracic artery to the right coronary artery (black arrow) and ligation of the proximal right coronary artery using a surgical clip (white arrow). **a** Patient 1. **b** Patient 2. **c** Patient 3. **d** Patient 4

Previous studies reported that arterial grafts often failed because of ‘competitive flow’ without supplementary proximal RCA ligation [6, 7]. We decided to ligate the native vessel proximal to the anastomosis site to prevent graft occlusion from ‘competitive flow.’ There were concerns about proximal RCA ligation as it could have resulted in an increased incidence of hypoperfusion syndrome, ischemia, and mortality. This is because the flow from the RITA is expected to be poor initially and might not be enough to compensate for the requirements after acute ligation [4]. To mitigate this, proximal RCA ligation was performed after confirming increased graft flow and no worsening of circulatory hemodynamics on clamping. In our patients, the graft flow was twice its usual flow after proximal RCA ligation. We believe that the RITA could supply adequate blood to the heart even if proximal RCA ligation was performed because the flow through the RCA was less owing to its slit-like origin. Furthermore, the diameter of the internal thoracic artery has the potential to change according to the myocardial blood flow demand [8]. Therefore, RITA–RCA anastomosis was performed as proximally as possible onto the RCA. The patients did not show recurrent symptoms or experience late cardiac events. Hence, when the performance of RITA–RCA bypass is obligatory, proximal RCA ligation seems acceptable. While anatomical repair is the gold standard procedure for young patients with AAORCA, our surgical plan may be suitable for elderly patients, those with connective tissue diseases, and those for whom combined aortic valve procedures are planned. Additionally, this surgical technique may be a better alternative method in some special AAORCA cases.

One of the major drawbacks of this procedure is the uncertain long-term durability of the graft in young patients. Nevertheless, despite this concern, we believe that a more physiological graft design and a native coronary artery with less atherosclerotic change can positively affect the long-term outcomes of our surgical repair technique.

## Conclusion

The RITA bypass to the distal RCA with proximal RCA ligation is an easy and effective procedure for treating an AAORCA.

## Compliance with ethical standards

**Conflicts of interest statement** All authors declare no conflicts of interest.

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