

# Quantitative Myocardial Perfusion in Surgically Repaired Coronary Artery Anomaly

Shiro Miura, MD, MSc,  
Atsutaka Okizaki, MD, PhD,  
Osamu Manabe, MD, PhD,  
Shunsuke Ohori, MD, Ryo Suzuki, MD,  
Chihoko Miyazaki, MD, PhD, and  
Takehiro Yamashita, MD, PhD

Department of Cardiology, Hokkaido Ohno Memorial Hospital, Sapporo, Japan; Department of Radiology, Asahikawa Medical University, Asahikawa, Hokkaido, Japan; Department of Radiology, Saitama Medical Center, Jichi Medical University, Saitama-shi, Japan; Department of Cardiovascular Surgery, Hokkaido Ohno Memorial Hospital, Sapporo, Japan; and Department of Diagnostic Radiology, Hokkaido Ohno Memorial Hospital, Sapporo, Japan

The anomalous aortic origin of the right coronary artery with an intramural course is rare and can cause myocardial ischemia, for which surgical repair is indicated. We present the case of a 49-year-old man with this anomaly whose preoperative myocardial perfusion positron emission tomography revealed inducible ischemia. Comparison of the preoperative and follow-up (6 months) positron emission tomography findings showed significant improvement in regional myocardial flow reserve and relative flow reserve, in keeping with the improvement in symptoms. However, positron emission tomography/myocardial perfusion imaging findings were difficult to interpret.

(Ann Thorac Surg Short Reports 2022;■:1-4)

© 2022 The Author(s). Published by Elsevier Inc. on behalf of The Society of Thoracic Surgeons. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

**T**he anomalous aortic origin of a coronary artery (AAOCA) from the inappropriate sinus of Valsalva is being increasingly detected with the help of multimodality imaging. Although most AAOCA subtypes are benign, high-risk anatomic features (ie, interarterial course, slitlike ostium, intramural course, acute takeoff angle with tangential vessel course, and proximal narrowing of the anomalous vessel) are associated with increased risks of myocardial ischemia (MI), ventricular arrhythmias, heart failure, and sudden

cardiac death.<sup>1</sup> Although the pathophysiologic mechanism of sudden cardiac death in patients with AAOCA has not been completely elucidated, it is principally the result of insufficient myocardial blood flow (MBF) and MI. Therefore, surgical intervention is generally warranted in patients with symptoms suggestive of MI or inducible ischemic changes on stress testing. However, accurately documenting the evidence of MI using conventional imaging modalities may be challenging. The patient provided written consent for the publication of the following information.

A 49-year-old man was referred for a 30-year history of frequent chest pain at rest and during exercise. The patient had no remarkable medical history. Electrocardiography, echocardiography, and 24-hour Holter monitoring revealed no significant abnormalities. Coronary computed tomography angiography (CCTA) identified an anomalous right coronary artery (RCA) arising from the left coronary sinus with an interarterial and intramural course through a separate stenotic ostium slightly below the aortic valve commissure (Figures 1A, 1C). Invasive coronary angiography confirmed the anomalous RCA without concomitant obstructive coronary artery disease (Figure 1E). Adenosine triphosphate-induced stress <sup>13</sup>N-ammonia positron emission tomography (PET) revealed a perfusion abnormality in the inferoposterior area of the left ventricle (Figure 2A). Both stress MBF and myocardial flow reserve (MFR) were lower than in the nonanomalous vessel territory. Surgical intervention was considered on the basis of the typical symptoms and evidence of MI. As the course of the intramural part was close to the right and left aortic valve commissure, we performed fenestration by creating a neo-ostium at the right coronary sinus without involving the commissure (Figure 3).<sup>4</sup> CCTA performed 10 days postoperatively showed a widely open neo-ostium (Figures 1B, 1D). PET performed 14 days postoperatively revealed partial improvement in stress-induced ischemia, but regional stress MBF and MFR were lower than preoperative values in the anomalous RCA-supplied territory (Figure 2B). The patient hoped to remain in the inpatient rehabilitation program for as long as possible mainly because hospital access was difficult and because of the incomplete improvement in his symptoms. We reassured him that the postoperative exercise electrocardiography testing had not provoked typical symptoms and ST-segment change suggestive of ischemia, and the patient was discharged 28 days after operation. At the 6-month follow-up, he was asymptomatic. Repeated PET revealed a regional defect at rest, which normalized on the stress

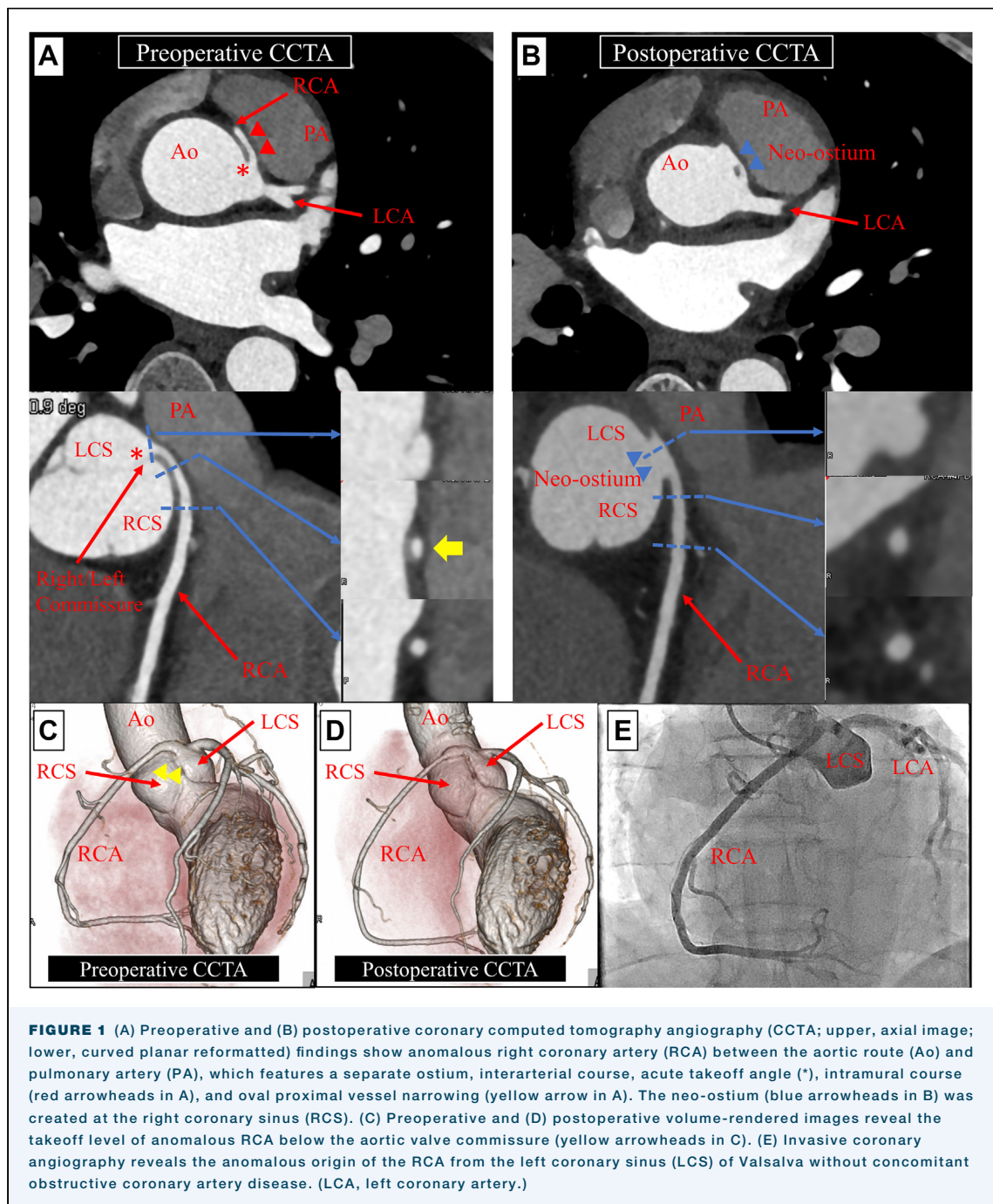
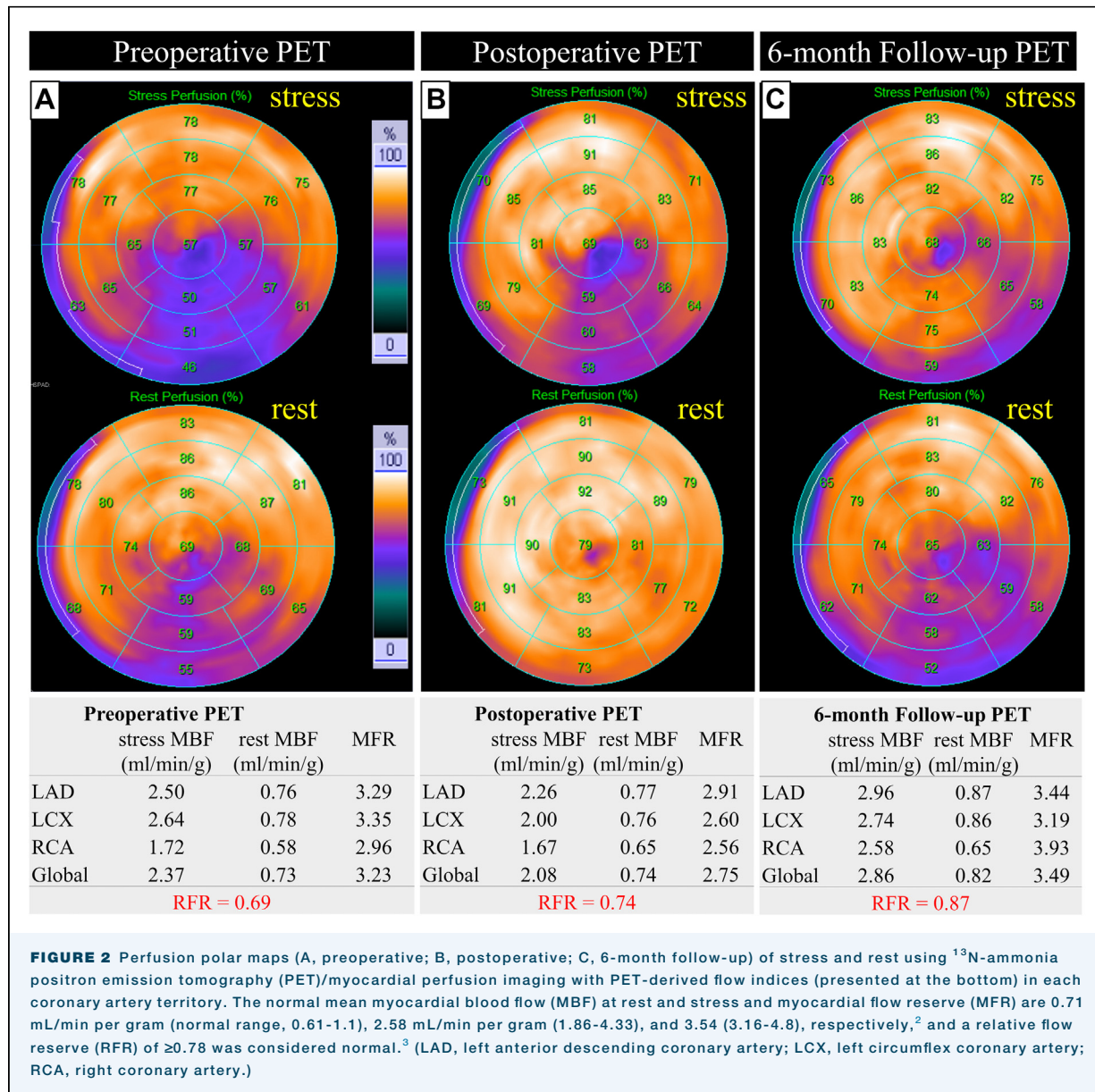


image (reverse fill-in; [Figure 2C](#)). The 3-dimensional integration of PET/myocardial perfusion imaging (MPI) with CCTA at the preoperative, postoperative, and follow-up phases clearly illustrated a more accurate assignment of vascular distribution in relation to the serial change of MPI in the anomalous RCA territory ([Video](#)). In contrast to the preoperative status, regional stress MBF and MFR improved postoperatively. Of note, the relative flow reserve (RFR),<sup>3</sup> defined as the ratio of stress MBF in the anomalous RCA-supplied territory to

that in the left anterior descending artery-supplied territory, significantly increased (preoperative, postoperative, and follow-up RFR values: 0.69, 0.74, and 0.87, respectively).

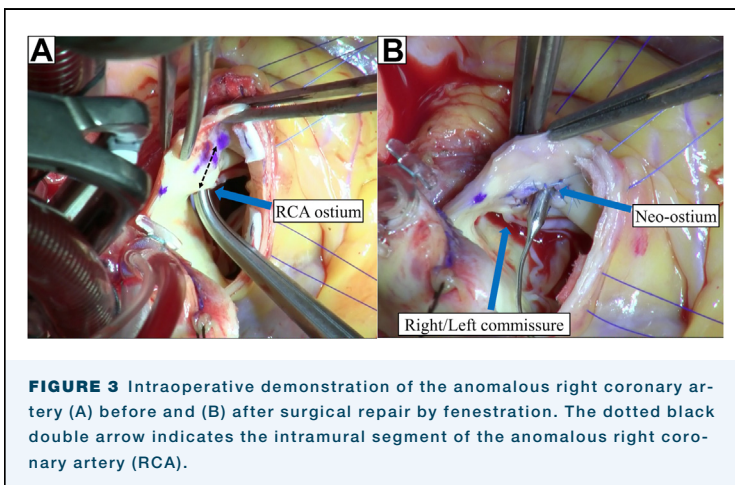
#### COMMENT

In this AAOCA case, serial changes (preoperative, postoperative, and 6-month postoperative status) in quantitative PET assessments, PET/MPI findings, and



symptoms are described. Notably, our patient showed various anatomic high-risk features.<sup>1</sup> Considering the presentation of typical symptoms and evidence of inducible MI, surgical repair was performed per current guidelines.<sup>5</sup> Surgical repair was performed with fenestration because the intramural course was below the sinotubular junction.<sup>4</sup> Extensive takedown and resuspension of aortic valve commissures, which can cause aortic regurgitation, were avoided with this method.

Evaluation of MI using  $^{13}\text{N}$ -ammonia PET before and after surgical repair is technically challenging with limited data. The patient initially showed stress-induced ischemia in the anomalous RCA-supplied territory, which partially improved in concordance with his symptoms. At





follow-up, PET/MPI demonstrated the reverse fill-in pattern, reportedly challenging to interpret.<sup>6</sup> Notably, the phenomenon might be a significant indicator of improved myocardial viability, as reported in a prior study of patients after coronary artery bypass grafting.<sup>7</sup> Residual postsurgical MI, which may be fatal, is common among children despite successful surgical repair for AAOCA.<sup>8</sup> Postoperatively, the regional stress MBF in the anomalous RCA-supplied territory did not increase, and the regional MFR dropped slightly from 2.96 to 2.56. Both parameters were markedly improved at the follow-up PET. These findings imply that recovery or normalization of myocardial hypoperfusion, ischemia, and microvascular dysfunction in the anomalous coronary territory might take longer than expected. RFR could be another useful noninvasive indicator in patients with AAOCA because it significantly improved with the improvement in symptoms.

In this case, the findings of serial quantitative assessments using <sup>13</sup>N-ammonia PET were concordant with symptomatic improvement, but those of qualitative assessments with PET/MPI were inconclusive, suggesting that performing quantitative assessments in addition to PET/MPI might help determine the indication, timing, and effectiveness of surgical repair for AAOCA.

---

The Video can be viewed in the online version of this article [<https://doi.org/10.1016/j.atssr.2022.06.003>] on <http://www.annalsthoracicsurgery.org>.

#### FUNDING SOURCES

The authors have no funding sources to disclose.

#### DISCLOSURES

The authors have no conflicts of interest to disclose.

#### PATIENT CONSENT

Obtained.

---

#### REFERENCES

1. Gräni C, Buechel RR, Kaufmann PA, Kwong RY. Multimodality imaging in individuals with anomalous coronary arteries. *JACC Cardiovasc Imaging*. 2017;10:471-481.
  2. Murthy VL, Bateman TM, Beanlands RS, et al. Clinical quantification of myocardial blood flow using PET: joint position paper of the SNMMI Cardiovascular Council and the ASNC. *J Nucl Med*. 2018;59:273-293.
  3. Stuijzand WJ, Uusitalo V, Kero T, et al. Relative flow reserve derived from quantitative perfusion imaging may not outperform stress myocardial blood flow for identification of hemodynamically significant coronary artery disease. *Circ Cardiovasc Imaging*. 2015;8:e002400.
  4. Gulati R, Reddy VM, Culbertson C, et al. Surgical management of coronary artery arising from the wrong coronary sinus, using standard and novel approaches. *J Thorac Cardiovasc Surg*. 2007;134:1171-1178.
  5. Brothers JA, Frommelt MA, Jaquiss RD, Myerburg RJ, Fraser CD Jr, Tweddell JS. Expert consensus guidelines: anomalous aortic origin of a coronary artery. *J Thorac Cardiovasc Surg*. 2017;153:1440-1457.
  6. Arrighi JA, Soufer R. Reverse redistribution: is it clinically relevant or a washout? *J Nucl Cardiol*. 1998;5:195-201.
  7. Watarida S, Onoe M, Sugita T, et al. Clinical significance of reverse redistribution phenomenon after coronary artery bypass grafting. *Ann Thorac Surg*. 1995;59:1528-1532 [discussion: 1532-1533].
  8. Brothers JA, McBride MG, Selim MA, et al. Evaluation of myocardial ischemia after surgical repair of anomalous aortic origin of a coronary artery in a series of pediatric patients. *J Am Coll Cardiol*. 2007;50:2078-2082.
-