New Application of FFRCT in Clinical Practice: Evaluation of Interarterial Anomalous Coronary Course

Fábio Bordin Trindade,[1] Thamara Carvalho Morais,[1,2] Roberto Nery Dantas Junior,[1,2] Roberto Vitor Almeida Torres,[1,2] Clarice Santos Parreira Soares,[1] José Rodrigues Parga Filho[1,2]

Hospital Sírio-Libanês,[1] São Paulo, SP – Brazil

Instituto do Coração da Faculdade de Medicina, Universidade de São Paulo (InCor/FMUSP),[2] São Paulo, SP – Brazil

A 58-year-old male patient, who worked as an airline pilot, sought emergency cardiology care due to palpitations and ill-defined chest discomfort, which had onset at rest 1 hour before admission, without irradiation or associated symptoms. He had personal history of diabetes mellitus, obesity, generalized anxiety disorder, and a mild COVID-19 episode 3 months prior (not requiring hospitalization), in addition to family history of early coronary artery disease (his father had an infarction at 40 years of age). Physical examination showed no relevant alterations. The electrocardiogram showed only sinus tachycardia and nonspecific ventricular repolarization changes. Serial troponin testing was performed, and all results were within normal limits. Echocardiogram showed preserved left ventricular ejection fraction (71%), absence of alterations in segmental contractility, and discreet diastolic dysfunction (altered relaxation). Following the institutional chest pain protocol, the patient was referred for computed tomography angiography (CTA) of the coronary arteries, which showed right coronary artery with an anomalous origin in the left coronary sinus and an interarterial (suprapulmonary) course, with significant luminal reduction (> 50%) in the ostium and proximal segment (Figure 1). After the diagnostic finding, the patient was recruited in a research protocol for evaluation of myocardial ischemia by tomography by means of non-invasive quantification of the myocardial fractional flow reserve (FFRCT). Software based on artificial intelligence (cFFR, version 3.0.0) available on a research platform (Syngovia Frontier Platform, Siemens Healthineers) was used. The calculation of FFRCT demonstrated ischemia in the right coronary artery territory (Figure 2; FFRCT 0.63 [reference values: FFRCT ≤ 0.75 = indicates ischemia; between 0.76 and 0.80 = borderline zone; > 0.80 = excludes ischemia]).[1] The patient continued investigation with coronary angiography with invasive FFR (iFFR), which confirmed flow limitation in the anomalous right coronary artery (Figure 3A; iFFR 0.68 [reference values: iFFR ≤ 0.8 indicates ischemia; > 0.8 excludes ischemia]).[2] At that moment, treatment with drug-eluting stent implantation was chosen (Figure 3B), with good angiographic results and no complications. After 6 months, the patient was asymptomatic, with no recurrence of symptoms.

Keywords

Fractional Flow Reserve, Myocardial; Congenital Abnormalities; Tomography, X-Ray Computed; Myocardial Ischemia; Machine Learning.

Mailing Address: Fábio Bordin Trindade •
Hospital Sírio-Libânes. Rua Adma Jafet, 115. CEP: 01308-050. Bela Vista. São Paulo, SP – Brazil
E-mail: fabio.trindade@hsl.org.br
Manuscript received November 8, 2022; revised manuscript February 16, 2023; accepted February 17, 2023
Editor responsible for the review: Leonardo Sara da Silva

DOI: https://doi.org/10.36660/abcimg.2023361i

Discussion

Anomalous origin and course of coronary arteries are rare congenital heart diseases, affecting less than 1% of the general population.[3,4] Anomalous coronary origin with an interarterial (suprapulmonary) course is characterized by the course of the coronary artery between the ascending aorta and the pulmonary artery trunk, most commonly involving the right coronary artery.[3,5] Most individuals are asymptomatic, but, among symptomatic patients, chest pain and dyspnea on exertion are the most prevalent complaints. There is also an increase in rates of arrhythmia, sudden death, and acute myocardial infarction.[4,6] Sudden death is the main complication of this anatomical variant, occurring in approximately 30% of patients.[3,4,6] In these cases, the narrowing and stretching of the anomalous ostium, mainly during physical exercise and in stressful situations, with consequent reduction in coronary flow, is the substrate for potentially fatal ischemic alterations.[3,4,6] Since electrocardiogram, in most cases, does not reveal ischemic alterations, diagnosis is generally made through an incidental finding on imaging exams.[4] These exams are of great importance, especially coronary CTA, which, in addition to being a non-invasive exam with high negative predictive value, allows detailed anatomical visualization (angle of the origin, presence of intramural trajectory in the aorta, degree of ostial/proximal luminal reduction) and the correct classification in relation to the pulmonary valve plane (suprapulmonary versus subpulmonary).[2,6,7]

Recent studies have demonstrated that coronary CTA is an accurate test for identifying myocardial ischemia through FFRCT, when compared to invasive measurement (iFFR) by coronary angiography.[1,2,7,8] The detection of ischemia in coronary CTA is of great importance in decision-making, mainly in plaques considered moderate (50% to 69% luminal reduction) or when there is diagnostic doubt, reducing the number of unnecessary referrals to coronary angiography in cases without ischemia on FFRct.[1,2,8] Due to the excellent accuracy between

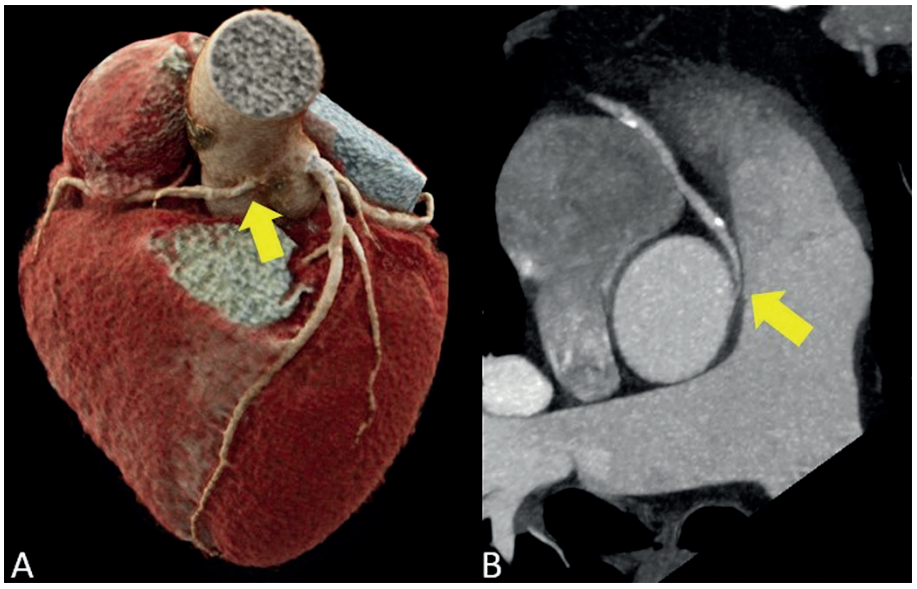

Figure 1 – *Three-dimensional reconstruction of the coronary tree with origin of the anomalous right coronary artery (arrow) in the left coronary sinus and interarterial course (A); two-dimensional curved planar reconstruction of the anomalous right coronary artery (arrow) with significant luminal reduction (> 50%) of the ostium and proximal segment (B).*

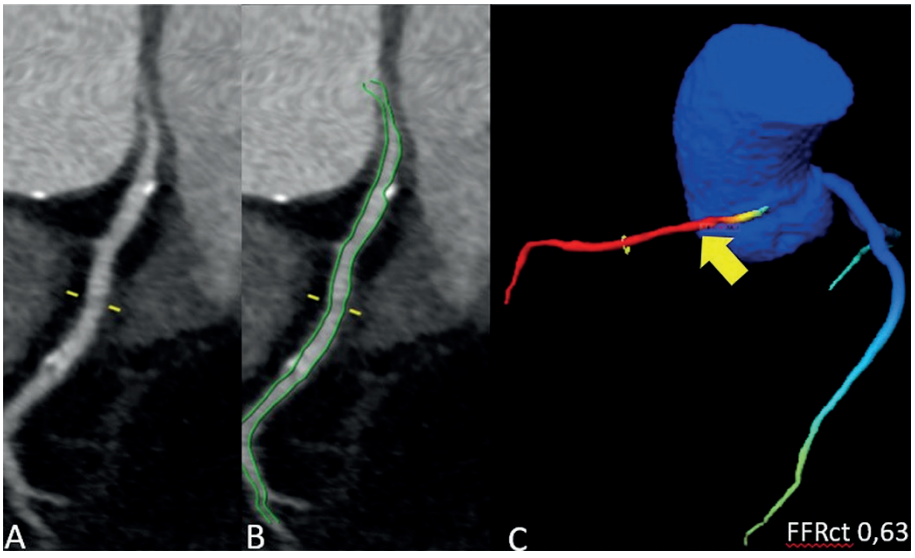

Figure 2 – *Two-dimensional curved planar reformatting (A), with delimitation of the coronary lumen (B) of the anomalous right coronary artery. Three-dimensional reconstruction with representation of FFRCT values throughout the entire coronary tree (C). FFRCT demonstrates coronary flow limitation, calculated approximately 1 cm after the luminal reduction in the ostium/proximal third of the anomalous right coronary artery (arrow).*

the methods in the analysis of a coronary tree without anomaly, the applicability of the method in the context of coronary anomaly has been extrapolated.[5,7] Our group applied the most current version of a tool for calculating FFRCT currently available only on a research platform developed by Siemens Healthineers (cFRR, version 3.0.0) in the clinical case described. This research tool is available for installation on standard configuration computers, and it uses artificial intelligence tools, with reduced processing time.[8] Currently, commercially available options require the step of sending images in DICOM format for processing in specific centers, with delivery of results at least 24 hours

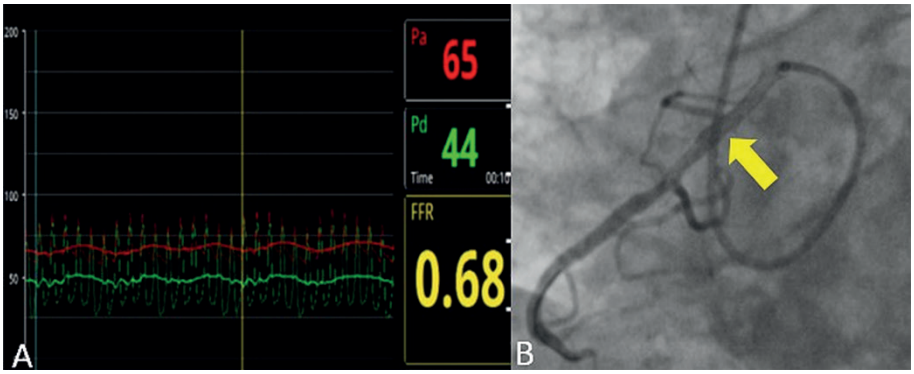

Figure 3 – *Ischemia in the right coronary artery confirmed by iFFR (reference value for ischemia ≤ 0.8) (A); invasive coronary angiography demonstrating the final result after drug-eluting stent implantation (arrow) in the proximal segment of the anomalous pathway (B).*

after the images have been sent.[1,2] The research tool used in this clinical case has advantages, such as fast processing time on standard configuration computers in the analysis room and use of tomographic images from the standard routine protocol, without requiring the addition of a specific protocol or a higher dose of radiation, without the use of stressors.[2,8] This tool, in general, has some limitations, such as difficulty in defining the coronary borders in the presence of excessive calcification, and the need for high-quality images, without movement artifacts, for adequate automatic detection of the central luminal line and the lines that delimit the coronary borders, allowing adequate calculation of FFRct.[8] It is important to emphasize that this tool distinguishes the interarterial pathways associated with ischemia, considering only the flow obstacle during rest, without estimating the risk of ischemic events associated with dynamic changes secondary to intense exercise. Use of this tool is scarce in the literature,[5] and it still does not have a robust body of evidence. Nevertheless, in the clinical case described, the FFRCT tool was applied in a context different than what is usual, where luminal reduction was not determined by coronary atheromatosis, but by ostial angulation and compression of the proximal segment of the anomalous interarterial pathway. The ischemic response was considered a parameter of poor prognosis; subsequently, the confirmatory invasive functional test (iFFR) was indicated to assist in the therapeutic decision.

Treatment of coronary anomalies involves the following two strategies: conservative treatment with clinical follow-up of patients in asymptomatic cases; or invasive (surgical or percutaneous) treatment, myocardial revascularization surgery being the preferred technique in symptomatic patients under 30 years of age.[4,6,7] Percutaneous coronary intervention with drug-eluting stent implantation, as in the clinical case described, has emerged more recently as a promising alternative therapy.[4]

Conclusion

Considered a rare anatomical variation, interarterial course is a potentially fatal coronary anomaly, even in asymptomatic patients. In the case described, the novel application of FFRCT based on artificial intelligence proved to be an excellent diagnostic alternative in this anatomical context, given that it is a non-invasive method capable of detecting ischemic coronary luminal reductions in accordance with iFFR, with future potential to guide planning and decision-making in myocardial revascularization interventions.

Author Contributions

Conception and design of the research: Trindade FB; writing of the manuscript: Trindade FB, Soares CSP; critical revision of the manuscript for intellectual content: Morais TC, Dantas Júnior ND, Parga Filho JR; literature review: Trindade FB, Morais TC, Dantas Júnior ND; realization of the FFRct: Morais TC; obtaining and reconstructing 2D and 3D images: Torres RVA.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

Sources of Funding

There were no external funding sources for this study.

Study Association

This study is not associated with any thesis or dissertation work.

Ethics Approval and Consent to Participate

This article does not contain any studies with human participants or animals performed by any of the authors.

References

1. Rajiah P, Cummings KW, Williamson E, Young PM. CT Fractional Flow Reserve: A Practical Guide to Application, Interpretation, and Problem Solving. Radiographics. 2022;42(2):340-58. doi: 10.1148/rg.210097.
2. Morais TC, Assunção NA Jr, Dantas RN Jr, Silva CFGD, Paula CB, Torres RA, et al. Diagnostic Performance of a Machine Learning-Based CT-Derived FFR in Detecting Flow-Limiting Stenosis. Arq Bras Cardiol. 2021;116(6):1091-8. doi: 10.36660/abc.20190329.
3. Ferreira AFP, Rosemberg S, Oliveira DS, Araujo-Filho JAB, Nomura CH. Anomalous Origin of Coronary Arteries with an Interarterial Course: Pictorial Essay. Radiol Bras. 2019;52(3):193-7. doi: 10.1590/0100-3984.2017.0203.
4. Suryanarayana P, Lee JZ, Abidov A, Lotun K. Anomalous Right Coronary Artery: Case Series and Review of Literature. Cardiovasc Revasc Med. 2015;16(6):362-6. doi: 10.1016/j.carrev.2015.03.006.
5. Ferrag W, Scalbert F, Adjedj J, Dupouy P, Ou P, Juliard JM, et al F. Role of FFR-CT for the Evaluation of Patients with Anomalous Aortic Origin of Coronary Artery. JACC Cardiovasc Imaging. 2021;14(5):1074-6. doi: 10.1016/j.jcmg.2020.10.003.
6. Saleem S, Syed M, Elzanaty AM, Nazir S, Changal K, Gul S, et al. Interarterial Course of Anomalous Right Coronary Artery: Role of Symptoms and Surgical Outcomes. Coron Artery Dis. 2020;31(6):538-44. doi: 10.1097/MCA.0000000000000893.
7. Adjedj J, Hyafil F, Fretay XH, Dupouy P, Juliard JM, Ou P, et al. Physiological Evaluation of Anomalous Aortic Origin of a Coronary Artery Using Computed Tomography-Derived Fractional Flow Reserve. J Am Heart Assoc. 2021;10(7):e018593. doi: 10.1161/JAHA.120.018593.
8. Röther J, Moshage M, Dey D, Schwemmer C, Tröbs M, Blachutzik F, et al. Comparison of Invasively Measured FFR with FFR Derived from Coronary CT Angiography for Detection of Lesion-Specific Ischemia: Results from a PC-Based Prototype Algorithm. J Cardiovasc Comput Tomogr. 2018;12(2):101-7. doi: 10.1016/j.jcct.2018.01.012.