An incidental encounter of a rare high take-off right coronary artery
A case report

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Abstract
Rationale: High take-off of the coronary arteries is a rare cardiac anatomic anomaly, which may occur independently or with other congenital heart defects. In the clinical setting, it is noteworthy as a cause of sudden cardiac death. Further, it is vital to identify such anomalies to avoid intraoperative catastrophes in surgeries for congenital heart defects.

Patient concerns: A II/6 systolic heart murmur on physical examination was incidentally found in a 9-year-old boy; he was confirmed to have a secundum-type atrial septal defect on echocardiography. He was referred to our institution for elective surgery.

Diagnoses: The preoperative echocardiogram confirmed the presence of an atrial septal defect, and during the surgical procedure, a high take-off right coronary artery was found.

Interventions: The atrial septal defect was closed surgically, and care was taken to avoid clamping the anomalous right coronary artery when placing the aortic cross-clamp.

Outcomes: Postoperative echocardiogram verified the presence of the high take-off right coronary artery and a satisfactory repair of the atrial septal defect. The postoperative course was uneventful, and the patient was discharged on postoperative day 5.

Lessons: This case suggests that it is critical to perform echocardiography to assess the anatomy of the coronary arteries, especially in pediatric cardiac patients. In addition, multi-detector computed tomography may be considered if appropriate. Care should be taken to assess the coronary anatomy for anomalies during interventional therapy or surgery, especially in congenital cases.

Abbreviations: MDCT = multi-detector computed tomography, RCA = right coronary artery.

Keywords: anomalous origin, cardiac surgery, high take-off, right coronary artery

1. Introduction
A high take-off right coronary artery (RCA) not arising from the right sinus of Valsalva is rare. The main concern with a high take-off RCA is decreased coronary perfusion. This can lead to myocardial ischemia, which is usually more pronounced during physical exertion. In children, symptoms are often insidious and present as incidental findings on imaging modalities or during cardiac surgery for another indication. Surgery may be considered in symptomatic patients. In cases in which a high take-off RCA is found incidentally, care should be taken to avoid clamping or occluding the coronary artery during interventional therapy or surgery.

Herein, we report the case of a 9-year-old boy with a high take-off RCA in association with a secundum atrial septal defect. The anomalous take-off of the RCA was incidentally discovered during surgery. A postoperative echocardiogram confirmed the presence of the anomaly and revealed a normal left coronary artery anatomy.

2. Case presentation
A 9-year-old boy was admitted to our hospital for a secundum atrial septal defect repair. Generally, the boy was asymptomatic. It was not until 1 month before the procedure that a II/6 systolic heart murmur at the left sternal border at intercostal spaces 2–4 was found. A fixed S2 split was also found on physical examination. Echocardiography confirmed the diagnosis. Ethics approval and consent to participate for this retrospective clinical case report were waived by the ethics committee of our institution.

In the operating theater, a band-like (Fig. 1) bulge, which coursed downwards from high within the ascending aorta to the point where the RCA was expected to originate, was found.

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Distal to that was a normal RCA route and distribution. As there was no intraoperative echocardiography for a “simple” case as in this study, this associated anomaly could not be diagnosed clearly. The surgeons suspected that this anomaly was a high take-off RCA and avoided cross-clamping the “band” by cannulating the arterial cannula immediately proximal to the take-off of the innominate artery to allow application of the aortic cross-clamp just above the level of the “band.” Cardiac arrest was achieved uneventfully with cold crystalloid cardioplegia. The electrocardiogram showed no ST segment or T wave changes throughout the surgery. The defect was routinely repaired using an autologous pericardium patch with continuous running sutures. Cardiac function was restored after releasing the aortic cross-clamp, with no evidence of ischemic insults.

The postoperative course was uneventful, and the patient was discharged on postoperative day 5. Postoperative echocardiogram confirmed the high take-off of the RCA with a partial intramural course (Fig. 2). The distance between the origin of the RCA and the aortic annulus was measured using echocardiography at 2 cm. The Doppler showed an acute-angled flow immediately after the orifice of the RCA (Fig. 3). However, the left coronary artery was shown to have a normal take-off height (Fig. 4).

3. Discussion

An anomalous origin and high take-off of the RCA are uncommon. The reported incidence is 0.019% to 0.17%. Often, it is only found during the course of surgery or autopsy. In adolescents and adults, the main concern with a high take-off of the RCA is decreased coronary perfusion, which could cause myocardial ischemia and angina, syncope, or sudden death even in

Figure 1. In-operation view of the high take-off of the RCA. Dotted line: course of the RCA. AAo = ascending aorta, PA = pulmonary artery, RA = right atrium, RCA = right coronary artery, RV = right ventricle.

Figure 2. Parasternal long-axis view showing a high take-off of the RCA with a partial intramural course. Arrow: ostium of the RCA, arrow head: level where a normal RCA takes off. RCA = right coronary artery.

Figure 3. Doppler image showing an acute-angled flow immediately off the orifice of the right coronary artery (arrow).

Figure 4. Normal take-off of the left coronary artery (arrow).
the absence of atherosclerosis. The symptoms associated are typically more pronounced with physical exertion.[2,4–7] In children, this anomaly is usually insidious and presents as an incidental finding in imaging modalities or during cardiac surgery.

The sites and courses of the anomalous RCA suggest the relative risk that it carries.[8,9] If it courses between the aorta and the right ventricular outflow tract, it is likely to lead to ischemia or infarction due to compression of the artery.[10]

The long course of the RCA, originating from the tubular portion of the aorta, creates an acute angle at the origin. In addition, the ostium may sometimes have a slit-like shape. Both anomalies are clinically significant and may impair myocardial perfusion.

A high take-off RCA also has implications for surgical procedures. While performing a procedure on a patient with such an anomaly, the anatomical variation increases the technical challenges, such as the unsuccessful induction of cardiac arrest by cardioplegia.[11] There is also the risk of unexpected injury to the anomalous RCA.

For symptomatic patients, the anomaly can be corrected surgically using a saphenous vein graft or reimplantation of the RCA into the correct sinus in adults. In pediatric patients, an isolated high take-off RCA is rarely symptomatic. Usually, it is found during preoperative workups for associated congenital heart defect correction or during the surgery. In our case, we did not surgically treat the high take-off. Close attention should be paid to the patient, and regular follow-up is warranted.

As mentioned above, high take-off RCAs are rare, as they are easily misdiagnosed or completely missed. Some authors suggest performing multi-detector computed tomography (MDCT) for accurate diagnosis, especially in adult patients.[10] However, for a pediatric patient who presents with no symptoms related to high take-off RCAs, the adverse effects of radiation exposure outweigh the benefits of MDCT in this setting. In this case, although it was missed preoperatively under echocardiogram, we showed that it was feasible to demonstrate the origin and course of an anomalous coronary artery under echocardiography. Use of the correct settings and a thorough understanding of the associated ultrasound physics are crucial for obtaining quality images.[11] We suggest that in a pediatric hospital staffed with cardiologists or sonographers with sufficient experience in congenital cardiac defects, it is feasible to use this modality to assess the coronary anatomy. Other congenital conditions such as transposition of the great arteries and anomalous left coronary artery from the pulmonary artery could also be identified. However, this demands sonographers to be experienced and meticulous. If there is a high index of suspicion of an anomaly, MDCT may then be considered for further verification. In conclusion, the anatomy of the coronary arteries should be thoroughly evaluated before cardiac surgery or interventional therapy, especially in pediatric cases. Care should be taken in congenital heart surgery with regard to the origin of the RCA. Negligence or missed diagnosis may result in injury or occlusion of the RCA.

References

[1] Tarhan A, Kehlibar T, Yilmaz M, et al. Right coronary artery with high takeoff. Ann Thorac Surg 2007;83:1867–9.
[2] Motamedi MH, Hemmat A, Kalani P, et al. High take-off of right coronary artery: an extremely rare case of RCA anomaly. J Card Surg 2009;24:343–5.
[3] Nishi H, Minou M, Tanaka H, et al. High anomalous origin of the right coronary artery associated with aortic stenosis: a word of caution. Ann Thorac Surg 2010;89:961–3.
[4] Ogino H, Miki S, Ueda Y, et al. High origin of the right coronary artery with congenital heart disease. Ann Thorac Surg 1999;67:558–9.
[5] Kashima J, Fukuda T, Suzuki T. Successful surgical repair of a ventricular septal defect and high take-off of the right coronary artery in an infant. Jpn J Thorac Cardiovasc Surg 2002;50:445–7.
[6] Kragel AH, Roberts WC. Anomalous origin of either the right or left main coronary artery from the aorta and pulmonary trunk: analysis of 32 necropsy cases. Am J Cardiol 1988;62:771–7.
[7] Alpaslan M, Onrat E. Anomalous origin of right coronary artery above the sinus of Valsalva: observation by transthoracic echocardiography. J Am Soc Echocardiogr 2002;15:264–6.
[8] Wang SP, Jao YT, Han SC. Acute coronary syndrome due to high aortocoronary junction of the right coronary artery: the value of multislice CT. Int J Cardiol 2008;123:e59–61.
[9] Zema AR, Blinder J, Sharif D, et al. Congenital coronary artery anomalies in adults: non-invasive assessment with multidetector CT. Br J Radiol 2009;82:254–61.
[10] Kadakia J, Gupta M, Budoff MJ, et al. High take-off” of the right coronary artery evaluated by coronary CT angiography. Catheter Cardiovasc Interv 2013;82:E765–8.
[11] Brown LM, Duffy CE, Mitchell C, et al. A practical guide to pediatric coronary artery imaging with echocardiography. J Am Soc Echocardiogr 2015;28:379–91.