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## Cardiac

# Transseptal course of anomalous left main coronary artery originating from single right coronary orifice presenting as unstable angina

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### ABSTRACT

Transseptal course of coronary artery has often been described as a benign entity; however, this report and literature analysis provides growing evidence of high risk of serious cardiovascular events in this anomaly. We present a case of unstable angina in a patient with anomalous common origin of left and right coronary arteries from a single coronary ostium at the right sinus of Valsalva, with subsequent transseptal course of the left main artery, review of relevant literature, and discussion of possible management options.

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## Introduction

Anomalous origin of coronary artery from the opposite sinus is present in approximately 0.2%–2.0% of the population. Right-sided origin of the left circumflex artery is considered most common anomaly followed by left origin of the right coronary artery. To reach its myocardial territory, a coronary artery may take different routes such as the prepulmonic, interarterial, transseptal, or retroaortic courses. Prepulmonic and retroaortic

courses are usually asymptomatic and have been shown not to be clinically significant. The interarterial variant where a coronary vessel courses between aorta and main pulmonary artery is well accepted as “malignant” and may cause sudden or exercise-related cardiac death. The transseptal course (also named intraseptal, intramyocardial, or tunneled coronary artery) has been described as benign in several recent review articles; however, analysis of the literature reveals that 26% of patients with this coronary course developed serious cardiac events.

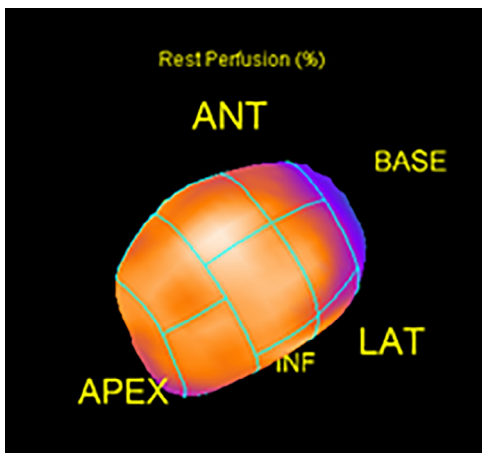
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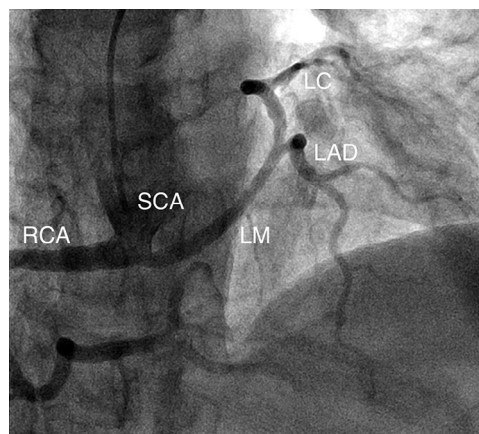
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**Fig. 1 – No perfusion abnormalities at rest. Stress portion of the heart scintigraphy was not performed due to severe ongoing chest pain. ANT, anterior; INF, inferior; LAT, lateral.**



**Fig. 2 – Cardiac catheterization demonstrates a single coronary artery (SCA) arising from right coronary sinus and giving rise to right coronary artery (RCA) with subsequent usual course in right atrioventricular groove and left main artery (LM) passing through the septal myocardium and giving origin left anterior descending (LAD) arteries and to left circumflex (LC).**

## Case report

A 62-year-old African American woman with medical history of hypertension, dyslipidemia, diabetes mellitus type 2 diagnosed 13 years ago, hypothyroidism, asthma, degenerative joint disease, obesity, and tobacco use (quit smoking 23 years ago) was undergoing a dobutamine nuclear stress test for evaluation of intermittent left precordial chest pain. She had noticed insidious exertional chest pain for 6 months with increasing frequency over the last few weeks. The pain radiated to her back, neck, left jaw, and left arm. Patient's family history was significant for her mother's myocardial infarction at age 43.

During the dobutamine infusion, she developed severe 9-10/10 left-sided chest pain with radiation to her left arm. At peak dobutamine infusion, she achieved a heart rate of 142 bpm with a systolic blood pressure of 201 mm Hg. Electrocardiography (EKG) tracing obtained during the dobutamine infusion demonstrated sinus rhythm with 1-mm horizontal ST depression in leads II, III, aVF, and V4-V6, concerning ischemia in the inferior and anterolateral leads. Administration of sublingual nitroglycerin sprays and total 4 mg of metoprolol IV did not provide relief of her chest pain. The stress portion of her heart scintigraphy was not performed (Fig. 1) due to the ongoing chest pain and she was transferred to the emergency department (ED).

On physical examination in the ED, the patient was afebrile and was not in respiratory distress. Auscultation revealed a regular cardiac rate and rhythm without audible murmurs and the lungs were also demonstrated to be clear. Physical examination of the extremities showed no clubbing, cyanosis, or edema. Pertinent laboratory analysis showed white blood cells 6.6 thou/ $\mu$ L (normal 4.5-11 thou/ $\mu$ L), hemoglobin 12.4 g/dL (normal 12-16 g/dL), hematocrit 37.8% (normal 36%-46%), platelets 362 thou/ $\mu$ L (150-450 thou/ $\mu$ L), creatinine 1.1 mg/dL (normal 0.6-1.2 mg/dL), decreased magnesium 1.5 mg/dL

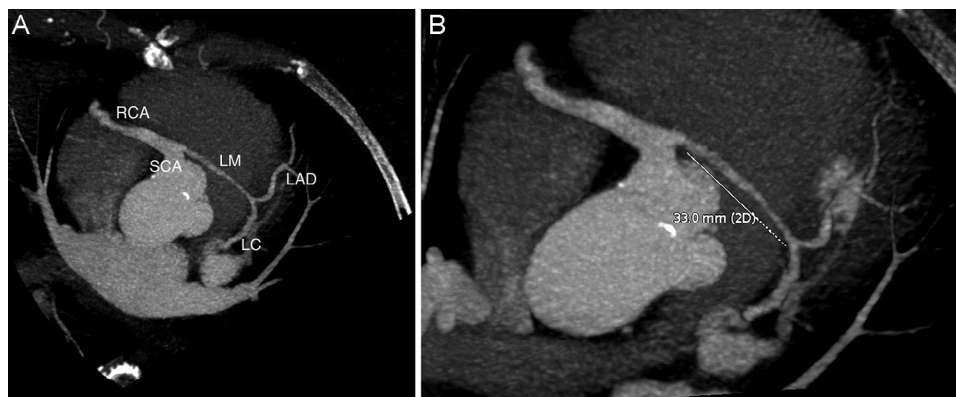
(normal 1.8-2.4 mg/dL), total creatinine kinase 103 U/L (normal 14-180 U/L), troponin T < 0.01 ng/mL (normal < 0.04 ng/mL), and pro-BNP 67.16 pg/mL (normal 80-247 pg/mL). Chest radiograph was unremarkable.

In the ED, the patient received 2 mg of IV morphine sulfate and an additional 5 mg of metoprolol IV, 2 g of magnesium sulfate IV. After this treatment, her chest pain completely resolved 45 minutes after arrival to the ED. EKG obtained after treatment demonstrated that her ST segments had returned to baseline.

Subsequent cardiac catheterization showed a single coronary ostium arising from the right coronary cusp with a single trunk supplying the right (RCA) and left main coronary arteries (LMCA). The LM took a transseptal course and gave rise to the left circumflex (LCA) and left anterior descending (LAD) arteries. The RCA followed a typical course in the right atrioventricular groove and gave rise to the posterior descending and left posterolateral branches (Fig. 2). There was no significant coronary disease with only short segment 20% stenosis of proximal circumflex artery (not shown). Left ventriculogram showed hyperdynamic left ventricular function with ejection fraction of 70%-75%.

Coronary computed tomography angiography (CTA) then was performed to confirm that there was a single coronary artery that arose from the right sinus of Valsalva and which supplied an LM artery that followed a transseptal course before it bifurcated into the LAD and LCA within the septal myocardium (Fig. 3). According to Lipton and Yamanaka-Hobbs classification, this comprises an RII-S type variant [1].

During her subsequent hospitalization, the patient continued to have intermittent severe chest pain, which was not responsive to IV heparin and IV nitroglycerin. Two days after her presentation in the nuclear medicine department, she underwent coronary artery bypass grafting with the left internal

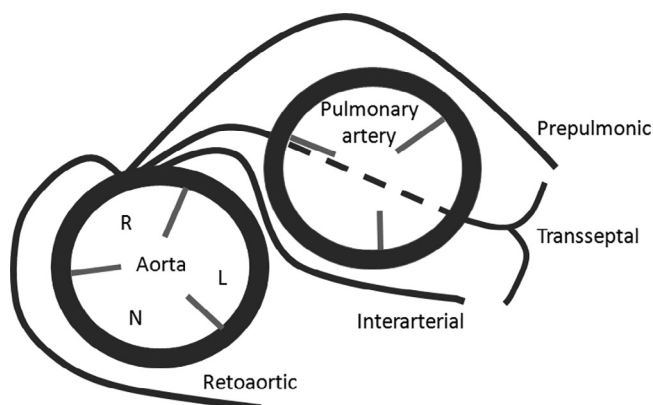


**Fig. 3 – Single coronary artery (SCA) arising from right coronary sinus and giving rise to right coronary (RCA) and left main (LM) arteries. LM passes through septal myocardium and gives rise to left anterior descending (LAD) and left circumflex (LC) arteries. RCA has a typical course within the right atrioventricular groove (A). Intramyocardial portion of LM measures 33 mm (B).**

mammary artery to LAD and a reverse saphenous vein graft to obtuse marginal branch. After surgery, the patient reported complete resolution of her chest pain and remained pain-free during subsequent clinical follow-up.

## Discussion

Among variants of anomalous coronary artery origins from the contralateral sinus of Valsalva, right-sided origin of LC and left-sided RCA are the most common anomalies [2,3] (Table 1). Single coronary artery with only 1 coronary ostium is considered extremely rare with reported incidence of 0.0024%-0.044% of the population [4,5]. Including this case, there are 5 reported cases of right single coronary artery with subsequent transseptal course of LM [6-9]. Also, it is important to note that overall a single coronary artery in 60% of cases is an isolated finding, but in 40% of cases, it is associated with additional cardiac anomalies such as tetralogy of Fallot, truncus arteriosus, and transposition of great vessels [10,11].



**Fig. 4 – Four possible courses of anomalous left main coronary artery arising from right coronary sinus.**

For most variants of aberrant coronary origin, clinical significance and potential complications depend on the course that the ectopic artery takes to reach its perfusion territory. Of the numerous described courses of the coronary arteries as they relate to the ascending aorta and pulmonary artery (Table 2 and Fig. 4), the transseptal and interarterial courses are the two most clinically significant. The anomalous vessel passes through the septal muscle inferior to the plane of the pulmonic valve in the transseptal variant, whereas the anomalous vessel courses at the level of pulmonic valve in the interarterial variant [12]. Lipton [5] and Yamanaka-Hobbs [1] classifications exist for the single coronary artery anomaly with the aim of defining the risks of developing significant cardiac events in patients carrying these abnormalities (Table 3). In 126,595 patients undergoing coronary angiography, the transseptal variant was most common in patients with the ectopic right-sided origin of the left coronary artery and right-sided single coronary RII and RIII types, whereas ectopic left origin of RCA and LII single coronary was most common in patients with the interarterial variant [1].

Several recent review articles have described transseptal LM or LAD course as benign [13]. Transseptal course was postulated to have the same risk factors for development of myocardial ischemia as does myocardial bridging which is a very frequent finding on coronary CT [14,15]. However, review of the reported cases of transseptal variant, as well as our case, shows that the transseptal variant is a high-risk variant.

In myocardial bridging, the current literature suggests that clinical significance may be related to length, depth, and degree of systolic compression of involved segment [16]. Reported length of the symptomatic intramyocardial course ranged from 10 to 55 mm and the depth from 4 to 16 mm; however, a minority of the articles contain this numeric information [17,18]. There are case reports showing that even with the extreme degree of myocardial tunneling, a patient may be asymptomatic [15]. In our patient, the length of the intramyocardial segment was 33 mm and the maximal thickness of myocardium above the tunneled vessel was 1 mm. Further research

**Table 1 – Frequency of variants of anomalous coronary artery origins from the contralateral sinus.**

Author, year of publication	Total number of patients	Right-sided origin of LMCA	Right-sided origin of LC	Right-sided origin LAD	Left-sided origin of RCA	Right single coronary artery	Left single coronary artery
Amado et al., 2016 [25]	53	10	16	3	19	1	
Graidis et al., 2015 [26]	60	2	6		9	1	2
Karabay et al., 2013 [27]	33		6				
Opolski et al., 2013 [2]	72	11	33	9	20		
Tariq et al., 2012 [4]	14				4	3	
Taylor et al., 1992 [23]	242	49	21	1	52	22	22
Yamanaka and Hobbs, 1990 [1]	1,461	22	467	38	136	25	31
Total		94	549	51	240	52	55

is needed to determine if these anatomic parameters play a role in development of ischemia in the transseptal course.

Among 74 patients with the transseptal course published in the literature, 19 (26%) were symptomatic. Eight of 74 patients (11%) had sudden death, 8 patients (11%) presented with myocardial ischemia, angina, or reported chest pain, 2 (2%) had palpitations or exercise-induced neurocardiogenic spells which improved after cardiac bypass, and 1 (1%) had persistent ventricular tachycardia [7–9,17–20]. The most common artery with transseptal course is the LAD, and in the majority of cases, this is associated with aberrant origin of the LMCA from the right coronary cusp [21]. Average age of symptomatic presentation was 35 years. The oldest reported patient with ischemia was 83 years old. Our patient became symptomatic at the age of 62 years, confirming that ischemia may develop at any age and is clearly not limited only to younger patients.

Many sudden cardiac death events reported in the literature related to anomalous origin of coronary artery from the opposite site occurred during exercise or immediately after exercise [22]. Taylor et al. showed that sudden or exercise-induced death more commonly occurred with right-sided single coronary (18%) vs the left (9%) [23]. The same is true with aberrant right-sided origin of the LM compared with aberrant left-sided RCA [22,23]. Stress test is frequently used to evaluate patients with an interarterial course of RCA while patients with interarterial LM are typically managed surgically [24]. Out of the 13 patients with a transseptal coronary course who had a stress test performed, 3 (25%) showed evidence of ischemia, including our patient. Therefore, it can be presumed that a stress test may potentially assist in stratifying risk of future cardiac ischemic events in patients with this anomaly. However, it is unknown at this time if a negative stress test in an asymptomatic patient with the transseptal course variant is adequate to exclude risk of future cardiac events.

## Conclusion

This case report illustrates a rare anomaly of common origin of the RCA and LM coronary arteries from a single coronary ostium at the right sinus of Valsalva with subsequent transseptal course of the LMCA. Analysis of literature reveals growing evidence of clinical significance of the transseptal course of a coronary artery in developing of myocardial ischemia, arrhythmias, and sudden or exercise-related death. The patients with this anomaly may develop symptoms at any age as also illustrated by this case report. At this point, there is insufficient evidence that negative stress test is an adequate risk stratification tool. Further research into risk stratification of transseptal coronary artery course is needed.

## Supplementary data

Supplementary data associated with this article can be found in the online version, at <https://doi.org/10.1016/j.radcr.2018.02.009>.



**Table 2 – Four possible courses of an aberrant coronary artery with its potential clinical significance.**

Coronary course	Description	Clinical significance
Prepulmonic	Artery passes anterior to the pulmonary artery	Benign, usually asymptomatic
Retroaortic	Artery passes posterior to the aorta	
Interarterial	Artery passes in between pulmonary artery and aorta (at the level of pulmonary valve)	Associated with sudden or exercise-related cardiac death [23]
Transseptal	Artery passes through the septal muscle more inferiorly below the plane of pulmonary valve	Described as benign in recent review articles [8]; however, fatal cases, arrhythmia, and myocardial ischemia have been increasingly reported

**Table 3 – Lipton classification of solitary coronary artery.**

Lipton classification	R—Solitary vessel originates from the right	L—Solitary vessel originates from the left
I	A solitary vessel follows the course of either a normal right or left coronary artery.	
II	Solitary vessel gives off a large transverse trunk (TT) that crosses at the base of the heart to reach the contralateral site	
III	SCA originates from the right with LCA and LAD arising separately from the common trunk	

LAD, left anterior descending artery; LC, left circumflex artery; SCA, single coronary artery.

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