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## Woven Coronary Artery

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### 1. Introduction

In this chapter we will discuss the woven coronary artery which is one of the most interesting coronary arterial anomalies. Although it is difficult to estimate the real incidence of coronary artery anomalies due to the difficulty in specific identification, it is approximately %0.3 - %1.3. The main reasons of underestimation of coronary artery anomalies may be that, in many individuals; don't lead to symptoms, morbidity, or mortality (Friedman & Silverman, 2010).

### 2. Woven coronary artery

Woven coronary artery is an extremely rare congenital malformation characterized by the division of epicardial coronary artery into thin channels which then reanastomose with the distal part of the abnormal coronary artery. Generally this anomalous segment of the coronary artery is limited to several centimeters long. By means of several angiographic studies it has been shown that the blood flow is completely normal in all segments of the woven coronary artery. This is a totally benign malformation which doesn't lead to any pathologic cardiac event.

Woven coronary artery was first described by Sane et al. in 1988, during the coronary angiography performed on a 55 year old woman with congestive heart failure seven years after from her aortic valve replacement and mitral valve commissurotomy (Sane, 1986). He defined this branching and reanastomosing structure as "figure 8" pattern and named this congenital anomaly as "woven coronary artery".

Approximately nine adult and only one pediatric patient with woven coronary artery have been reported since then. Most of these patients were males diagnosed accidentally at the coronary angiography performed due to chest pain, after acute myocardial infarction or due to the suspicion of left coronary artery aneurysm in Kawasaki disease. Although the pathology is mostly seen in the right coronary artery, woven structures have also been demonstrated in left coronary arteries or in circumflex artery. These are listed in Table 1.

	No: 10	Age	Gender	Previous history	Cause of coronary angiography	Coronary Angiography	Stres test	Procedure
Sane et al.	1 patient	55 Y	F	AVR + MVC	CHF	Woven RCA		
Berman Et al	1 patient							
Gregorini et al.	3 patients	60Y 62Y	M	- -	Angina pectoris Angina after AMI	Woven LCA LAD stenosis Woven LCXA	positive	- Mid LAD coronary angioplasty -
		45Y	F	-	AMI	Distal LAD plaque, Woven LCA		
Martuscelli et al.	1 patient	42 Y	M	Hypercholesterolemia	Angina	LAD stenosis Woven RCA		LAD coronary angioplasty
Kursaklıoğlu et al.	1 patient	48Y	M	No	Exertional chest pain	RCA Mid stenosis, Woven mid CX	positive	RCA stenting
Kaya et al.	1 patient	56Y		LAD coronary angioplasty	Dyspnea after AMI	Woven RCA		Medical treatment
Yıldırım et al.	1 patient	9 months	M	Kawasaki disease	Aneurysmatic LCA	Aneurysmatic LCA, Woven RCA	-	Medical treatment
Iyisoy et al.	1 patient	58Y	M	Smoking	Exertional chest pain.	Mid LAD stenosis, Woven RCA	positive	LAD stenting

AVR: aortic valve replacement, MVC: mitral valve commissurotomy, CHF: Congestive heart failure, LAD: left anterior descending artery, RCA: right coronary artery, LCA: left coronary artery, AMI: acute myocardial infarction, LCXA: Left circumflex artery

Table 1. The summary of the demographic and clinical data of the patients with woven coronary artery in the literature.

### **2.1 Embryology of coronary artery**

As there are very few number of woven coronary artery cases, the embryological development of this rare coronary artery anomaly has not been explained yet. However, there are two models of explanation for the embryologic development of normal coronary arteries. Previously it had been thought that the cells of the myocardium nourished from the blood in the ventricular cavity thicken and become close to the ventricular cavity by means of multiple trabeculations. These trabeculations then develop into sinusoids which were the forerunners of the coronary vascular system (Tomanek et al, 1996). The new model of coronary arterial development suggests that the cells of the primordial liver form a proepicardial protrusion. These cells establish the proepicardium and the epicardial cells then migrate over the surface of the heart. The epicardial cells invade the subepicardial matrix and form the coronary vascular plexus. By an undefined mechanism, probably involving multiple growth factors, the epicardial cells undergo epithelial mesenchymal transformation and form mature vessels. These small vessels on the surface of the heart fuse and grow inward to penetrate the aorta fusing with the coronary vessels. The new experimental data on the development of the coronary system suggests that beside multiple growth factors, several adhesion molecules and chemotactic factors play role in this complicated coordinated migration and transformation of cells to form coronary vessels. The presence of congenital anomalies of coronary arteries may be due to abnormalities in these signaling pathways or alterations in local factors that direct coronary vessel development. (Matherne & Lim, 2008)

### **2.2 Etiology of woven coronary artery**

The number of case studies published about woven coronary artery is so limited that the etiology of this rarely encountered anomaly has not been clearly understood yet. The reported cases on this anomaly are mostly adult patients. Recently a case report about an infant nine- months-old with woven coronary artery has been published (Yıldırım et al., 2010). Therefore it is now suspected that woven coronary artery may be a congenital malformation and advanced studies are needed to lighten this issue

### **2.3 Incidence of woven coronary artery**

The real incidence of woven CA is not known. The diagnosis of the patients in the literature have been made accidentally so far. A remarkably high number of woven CA cases might have been misdiagnosed as coronary artery thrombus, stenosis or dissection. It can be claimed that the frequency of this anomaly could have been higher if woven coronary artery anomaly had not been misinterpreted in this way.

## **3. Clinical features of woven coronary artery**

As mentioned above “woven coronary artery” is accepted as a benign condition. Most of the woven coronary artery patients in the literature are the cases diagnosed unexpectedly during the coronary angiography made upon acute myocardial infarction or angina pectoris. In the case report of İyisoy et al., (2010) severe stenosis in the middle segment of left anterior descending coronary artery and multiple thin channels in the right coronary artery were demonstrated during the same coronary angiography session, however stenosis

was accused to be responsible from the myocardial ischemia. Another coronary angiography performed on a patient with positive stress test by Kursaklıoğlu et al. (2006) revealed stenosis in the mid-segment of the right coronary artery and the division of arterial lumen into multiple thin channels in the mid-segment of the circumflex artery. They thought that the severe stenosis in the right coronary artery was the most possible reason of the positive stress test in this patient rather than the woven coronary anomaly. In the cases reported by Martuscelli et al. (2000), Kursaklıoğlu et al. (2006) and Yıldırım et al. (2010) no adverse coronary events occurred during 4 to 5 year follow-up periods. Repeated control coronary angiograms of the patients with coronary arterial stenting or cardiac surgery have revealed no structural change in woven coronary arteries. This finding suggests that the cause of chest pain, angina pectoris, acute myocardial infarction or positive stress test is not dependent on woven coronary artery anomaly.

#### **4. Diagnosis of woven coronary artery**

Although there is an anatomically abnormal coronary artery, the blood flow and the myocardial contraction is normal. Therefore the physical examination, laboratory findings, chest x-rays, electrocardiographic and echocardiographic investigations of the woven coronary artery patients are completely normal. The echocardiography is not helpful for the diagnosis. The gold standard for the diagnosis of woven coronary artery is coronary angiography. There is no angiographic uniform image of woven coronary arteries however the most important angiographic criteria is definite intraluminal globular filling defects in repeated angiographic views.

##### **4.1 Cardiac catheterization**

In the coronary angiography it is seen that the arterial lumen is divided into multiple thin channels at the proximal segment of affected coronary arteries or their branches; subsequently, these channels proceed distally with a slightly twisting route and then fuse again. Distal to this woven segment, the downstream blood flow is absolutely normal (Figures 1A, B and C).

During the coronary angiography division of coronary artery may be misdiagnosed as a complicated plaque with thrombus formation instead of coronary artery malformation. In addition, coronary artery stenosis, spontaneous coronary artery dissection, intracoronary thrombosis or recanalization of a thrombus may mimic this woven structure. These mimicking pathologies have lead to the misdiagnosis of woven coronary artery (Martuscelli et al., 2000; Kaya et al., 2006). However for an accurate explanation of the etiology, more detailed information about the characteristics and the development of this malformation is needed.

#### **5. Differential diagnosis**

In differential diagnosis of woven coronary artery the important criteria is the absence of coronary artery disease history of the patient with normal stress tests such as treadmill, echocardiography and myocardial scintigraphy. The patient with a woven coronary artery anomaly usually demonstrates normal coronary reserve during stress test.

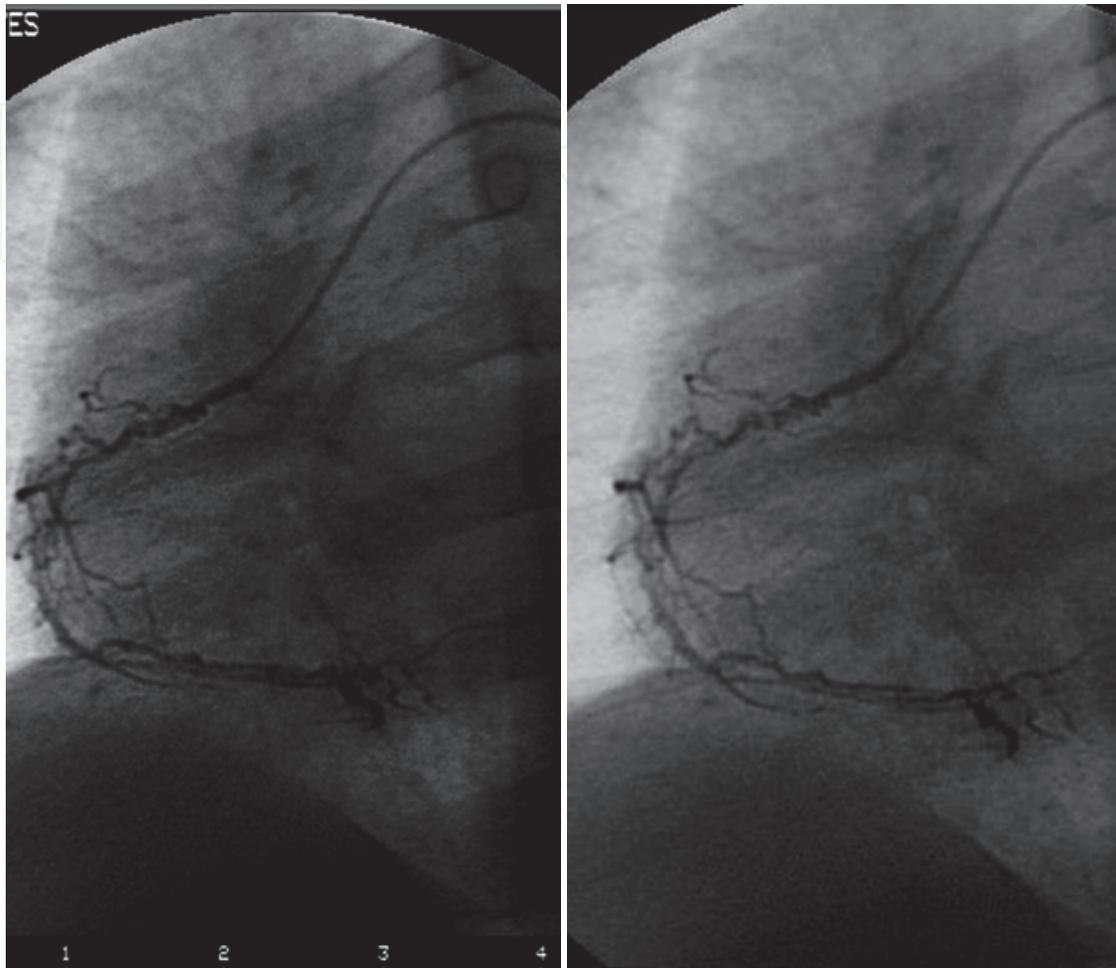


Fig. 1A. and B. Right coronary angiography showed proximal thin channels and distal reanastomosis

This is dependent on normal blood flow distal to the anomalous segment (Kursaklıoğlu et al., 2006; Yıldırım et al., 2010; İyisoy et al., 2010). In woven coronary artery anomaly, normal blood flow can be maintained distal to the anomalous segment, therefore coronary blood reserve is not disturbed with stress tests, especially myocardial perfusion imaging (İyisoy et al., 2011). Even if there is clinical evidence of myocardial infarction or angina pectoris in a patient with woven coronary artery, coronary angiography should be repeated to eliminate other coronary artery pathologies. Radiologically, the examination and the interpretation of the angiographic image are crucial to prevent misdiagnosis of the woven coronary arteries. In this coronary anomaly, although the filling is defective, flow is normal; which differentiates this structure from other pathologies such as intracoronary thrombus, stenosis or dissection.

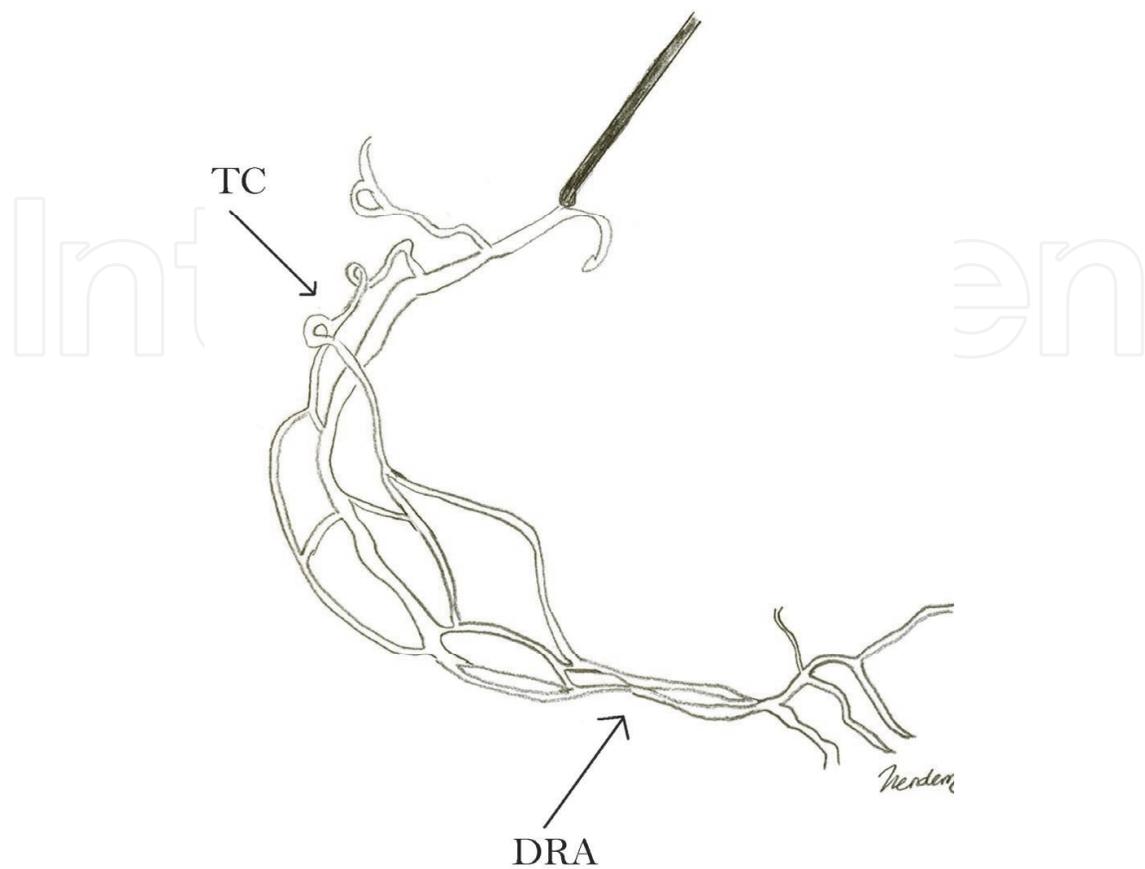


Fig. 1C. Diagram of the right woven coronary artery showing proximal thin channels (TC) and distal reanastomosis (DRA)

## 6. Associated diseases

Up to now, woven coronary artery cases have only been reported as isolated coronary artery anomaly (Sane et al., 1988; Berman et al.1990; Gregorini et al., 1995; Martuscelli et al., 2000; Kursaklioglu et al., 2006; Kaya et al., 2006; İyisoy et al., 2010). Only in the case report of Yıldırım et al., (2010) the woven coronary artery was described as the part of a systemic disease, Kawasaki disease, in an infant patient of nine months old. In this patient, routine echocardiographic evaluation of coronary arteries revealed aneurysm of the left coronary artery, leading to an angiographic study in which a woven right coronary artery was detected coincidentally. In fact there is also a tendency for the development of thrombus in Kawasaki disease and this condition should not be confused with woven coronary artery (Yıldırım et al., 2010). For this reason, the pediatric and adult cardiologists should be aware that woven coronary artery may accompany Kawasaki Disease and they should perform coronary angiography to distinguish real thrombus from this coronary anomaly.

## 7. Treatment

Woven coronary artery is an anatomic abnormality and it doesn't disturb cardiac functions at all. Therefore it is not necessary to treat this anomaly. However other coronary artery

pathologies such as coronary artery stenosis, thrombosis, dissection or myocardial infarction should be carefully distinguished from woven coronary artery. This point is crucial to prevent misdiagnosis and treatment of woven coronary artery unnecessarily.

## 8. Conclusion

Angiographic examination of the patients with suspected coronary artery pathologies should be performed carefully to make differential diagnosis of dissection, thrombosis stenosis and woven coronary artery. The catheter angiography scenes should be evaluated repeatedly not to misinterpret the coronary artery pathologies. Such a detailed evaluation and definitive diagnosis is important to reduce the risk of unnecessary percutaneous coronary interventions, which expose the patients to several complications. Woven coronary artery does not need treatment but follow-up is required as there are only a few reports about the progress of this rare event. Advanced studies are needed on this unknown entity to demonstrate its detailed pathology. Even though this anomaly appears to be a benign coronary anomaly without any major adverse cardiovascular events, we need more data to figure out its exact natural history.

## 9. Acknowledgment

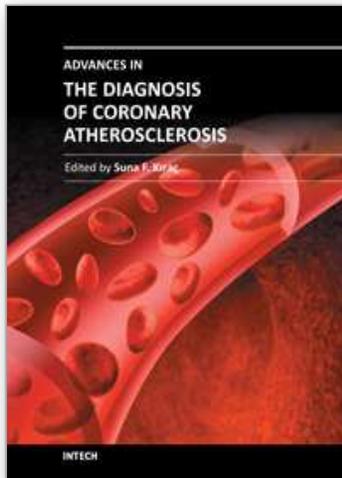
As the current collected data about the woven coronary arteries has been provided from a very limited number of cases, we believe that the embryology, pathophysiology, clinical feature and the prognosis of this rare coronary anomaly will be explained better with advanced studies.

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## **Advances in the Diagnosis of Coronary Atherosclerosis**

Edited by Prof. Suna Kirac

ISBN 978-953-307-286-9

Hard cover, 378 pages

**Publisher** InTech

**Published online** 09, November, 2011

**Published in print edition** November, 2011

Coronary artery disease (CAD) and its consequences are most important morbidity and mortality reasons in the developed and developing countries. To prevent hard end-points, early definitive diagnosis and optimum therapy play significant role. Novel advanced diagnostic tests which are biomarkers of inflammation, cell adhesion, cell activation and imaging techniques provide to get the best result in the detection and characterization of calcified or uncalcified atherosclerotic plaques. In spite of last developments in the imaging methods, coronary catheterization is still frequently performed. Following the first cardiac catheterization performed in 1844, date by date historical developments and the mechanics of cardiac catheterization techniques, risks associated with coronary angiography, and also, preventions and treatments of possible complications have been presented in this book. Other important issue is radiation exposure of patients and staff during coronary angiography and scintigraphy. Radiation dose reduction techniques, general radiation protection principles have been discussed in related chapters.

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In order to correctly reference this scholarly work, feel free to copy and paste the following:

Ayşe Yıldırım and A. Deniz Oğuz (2011). Woven Coronary Artery, *Advances in the Diagnosis of Coronary Atherosclerosis*, Prof. Suna Kirac (Ed.), ISBN: 978-953-307-286-9, InTech, Available from: <http://www.intechopen.com/books/advances-in-the-diagnosis-of-coronary-atherosclerosis/woven-coronary-artery>

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