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ORIGINAL ARTICLE

Coronary computed tomography angiography findings in young adults

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ABSTRACT

Objective: Various clinically significant cardiovascular anomalies of coronary arteries that are not associated with atherosclerosis have been previously described. This study aimed to evaluate coronary anomalies or variations on coronary computed tomography angiography (CCTA) images in patients aged under 40 years and to compare them with clinical findings, thereby contributing to the literature.

Material and Methods: Patients under 40 years who underwent CCTA with current clinical indications between 2015 and 2018 were included in the study. The scans were performed using a 128-slice CT device and electrocardiography triggering in different phases. During the examination, 35%–75% of phases were frequently evaluated although the percentage varied according to the heart rate. Outlet, course, internal structure and termination anabolites, and pathologies, as well as anatomical dominance of coronary arteries, were evaluated. However, unlike this classification, myocardial bridges (MBs) were specified as variations. Coronary artery disease reporting and data system (CAD-RADS) was used to standardize stenosis rates in the walls of coronary arteries and their lumen.

Results: Of the 927 CCTAs taken over a 3-year period, 188 belonged to patients under 40 years. The study included 156 men and 32 women with a mean age of 34.99±4.78 years. In the comparison between the patients with and without chest pain in terms of the presence of CAD-RADS 1 and above, a statistically significant higher rate of CAD was found in the group with chest pain ($p<0.05$). Abnormal cardiac findings and variations were detected in 103 patients (55%), including 16 with multiple abnormalities. Of these 103 patients, 49 (26%) had MBs.

Conclusion: Considering the presence of anomalies and variations in young adults with cardiac complaints, the reasons for the ambiguous symptoms may become clear with the use of noninvasive methods, such as CCTA. Thus, cardiovascular anomalies that may cause serious and acute events in the future, including sudden death can be detected in advance, allowing early interventions to be undertaken.

Keywords: Angiography, coronary, tomography, young adults.

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INTRODUCTION

Due to the stressful pace of life in the current age, coronary artery disease (CAD) continues to be the primary cause of death worldwide.[1] In addition to congenital heart diseases, CAD is generally considered a problem in the elderly population. However, the prevalence of CAD and risk factors associated with CAD in young adults have not been studied in detail.[2] It is important to effectively evaluate the risk groups of coronary artery patients and select the appropriate examination method to diagnose and manage the treatment process. Invasive and noninvasive methods can be used in the diagnosis of these patients, with the latter being recommended in moderate-risk patients with stable chest pain with a 10%–20% of likelihood to experience a severe cardiac attack within 10 years.[3] However, in addition to these cases, coronary artery anomalies and variations are also encountered in young patients with subjective and atypical cardiac complaints. Sudden cardiac arrest and death can also occur in individuals without any known clinical complaints.[3]

Coronary computed tomography angiography (CCTA), one of the noninvasive methods, is an examination that can visualize the wall properties and anatomical structure of coronary arteries. CCTA is an important imaging method that can be used to evaluate cardiac morphology, function, and myocardial perfusion, as well as coronary arteries. It has been proven that CCTA has diagnostic accuracy similar to invasive conventional coronary angiography in detecting CAD.[4,5] Furthermore, various clinically significant cardiovascular anomalies of coronary arteries that are not associated with atherosclerosis have been previously described.[6] In recent years, with the rapid development of computed tomography technology, the radiation dose has been further decreased, and the image quality has increased. This low dose advantage has paved the way for the use of CCTA among younger patients with atypical and intense subjective complaints, as well as medium-risk patients.

Identifying non-atherosclerotic anomalies or variations of coronary arteries and determining their hemodynamic effects and clinical outcomes play an important role in protecting the patient from current risks and guiding the treatment approach. Villa et al.[7] classified congenital coronary artery anomalies as those causing ischemia, those presenting without ischemia, and those with rare ischemia. Although congenital coronary artery anomalies are rare, ischemia-causing types have been reported as the second most common cause of sudden cardiac death in young athletes.

The aim of this study was to evaluate the coronary anomalies or variations in CCTA images in patients under 40 years of age and to compare the data with the current literature. Using this noninvasive modality can allow for early interventions to be performed by detecting cases in which serious and acute events may occur in the future.

MATERIAL AND METHODS

This study was approved by the ethics committee of Recep Tayyip Erdogan University Faculty of Medicine (approval date: October 24, 2018, number 2018/139). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Patients under 40 years who underwent CCTA with current clinical indications between 2015 and 2018 were included in the study. Patients under the age of 18 years and those who had a previous history of coronary bypass surgery were excluded from the study.

The scans were performed using a 128-slice (General Electric Discovery CT750 HD) CT device in different phases with electrocardiography (ECG) triggering. In our study regime, all patients received an oral β-adrenergic receptor blocker 12 h before the examination. The patients whose heart rate did not fall below 70 beats/min prior to the examination were administered a β-adrenergic receptor blocker orally 1 h before the examination or intravenously just before the examination after obtaining routine clinical approval. A prospective or retrospective ECG triggering method was chosen during the examination according to the patient's heart rate and the presence of extra beats.

Regions of interest were determined in the aorta visualized with the bolus tracking technique, and the scan was started automatically when the contrast material density reached 300 HU. Scanning was carried out in craniocaudal direction from the carina to the heart's basal. A total of 80–120 mL of nonionic contrast material was administered at a rate of 3–5 mL/s, followed by 40 mL of isotonic solution at a rate of 2.5 mL/s, using 17-gauge granules and an automatic injector through the antecubital vein. The scan protocol of the images obtained during a single breath-hold was as follows: rotation time, 0.3 s; tube rotation, 120 kV and 160 mA s; and scan range, 12 cm. The following electrocardiographic pulsing was adapted automatically according to the simulated heart rate for a maximum tube current within the RR interval. The images were reconstructed at 20 different RR positions in 5% increments (0% to 95% RR) at the same z-position. During the examination, 35%–75% of phases were frequently evaluated although the percentage varied according to the heart rate.

Reconstructions were created from the axial source images from an optimized RR interval to minimize motion artifacts in coronary arteries. Multiplanar reconstruction, curved, maximum intensity projection, and 3D volume images were created from transverse thin sections. The CCTA images of all patients were evaluated by a radiologist with a national cardiovascular competency certificate. Outlet, course, internal structure, and termination anomalies, as well as anatomical dominance of coronary arteries, were evaluated. Most of the coronary anomalies found were based on the classification of Angelini,[8] but we considered myocardial bridges (MBs) as variations, as described by Tsai et al.[2] The CAD-reporting and data system (CAD-RADS) was used to standardize the plaques on the coronary artery walls.[9] According to the maximum stenosis area in the vessel lumen, CAD-RADS 0 was defined as a stenosis area of 0%, i.e., no CAD; CAD- RADS 1 if there was a plaque that could cause stenosis at a rate of 1%–24%; CAD-RADS 2 if there was a plaque that could cause minimal stenosis at a rate of 24%–49%; CAD-RADS 3 if there was a plaque that could cause moderate stenosis at a rate of 50%–69%; CAD-RADS 4A if there was severe stenosis in a single vessel or two vessels at a rate of 70%–99%; CAD-RADS 4B if there was a plaque that could cause 70%–99% stenosis in three vessels or ≥50% stenosis in the left main coronary artery (LMCA); and CAD-RADS 5 if there was total stenosis. Coronary arteries that could not be evaluated segmentally or totally due to artifacts were reported as CAD-RADS N. Taking the diameters and lengths of coronary arteries specified in the literature as reference, the coronary arteries were noted as larger than normal (ectatic) or thin in width and shorter than normal in length.[10,11]

Table 1: Indications for undergoing coronary computed tomography angiography in the sample

Indication	n
Chest pain	149
Family history	14
Palpitations	12
Essential hypertension	6
Shortness of breath	6
Arm numbness	1
Total	188

Table 2: Coronary anomalies detected by coronary computed tomography angiography in the sample

Anomaly	n
Coronary hypoplasia	10
Interarterial course of RCA	4
Coronary ectasia	5
Short LMCA	2
Total	21

RCA: Right coronary artery; LMCA: Left main coronary artery.

RESULTS

Of the 927 CCTAs taken from 2015 to 2018, 188 belonged to patients under 40 years of age. The study included 156 men and 32 women, and the mean age was calculated as 34.99±4.78 years. The indications for referring the patients to the radiology clinic for CCTA imaging are summarized in Table 1. There were 20 asymptomatic patients who underwent CCTA due to family history or essential hypertension.

According to coronary artery wall pathologies, there were 44 patients (23%) with CAD-RADS 1–3. Four of these patients were asymptomatic with a family history indication. High-grade stenosis, CAD-RADS 4A, was observed in only 2 patients (1%). The remaining asymptomatic cases were reported as CAD-RADS 0. In the comparison between the patients with and without chest pain in terms of the presence of CAD (CAD-RADS 1 and above), a statistically significantly higher rate of CAD was found in the group with chest pain ($p<0.05$).

The details of most coronary anomalies found in our study were based on the classification of Angelini[8] In 2 patients, the right coronary artery (RCA) originated from the left coronary sinus and had an interartery course (Fig. 1). There were a further two cases, in which the RCA originated from the posterior of the sinus with a narrow angle and was obstructed in the interarterial area, which is not evaluated in the classification mentioned above. Table 2 presents the coronary artery anomalies detected in the sample. As an example, all coronary arteries of a patient were ectatic (Fig. 2). Abnormal cardiac findings and variations were detected in 103 patients (55%), including 16 with multiple abnormalities. Of these 103 patients, 49 (26%) were found to have MBs. Among cardiac pathologies of extracoronary artery origin were diverticula (n=3, 1%; 2 atrial and 1 septal) and pericardial effusion (n=1, 0.5%). Another variation evaluated as an MB in this study was the atrial transition of the RCA revealed by the atrial loop image.

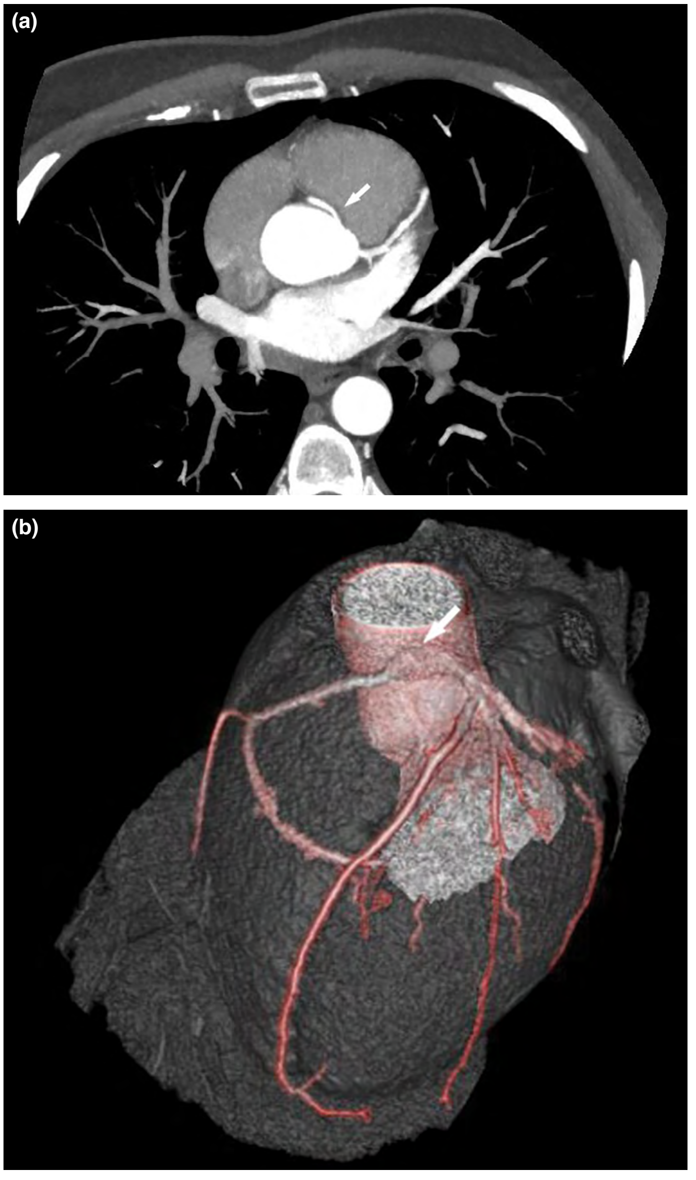

Figure 1: CCTA performed on a 31-year-old male patient. Axial maximum intensity projection images **(a)** and three-dimensional images **(b)** show that the RCA originates from the left coronary sinus and is obstructed between the pulmonary artery and aorta (arrows).

Apart from these, 1 patient had a long LMCA with an acute angulation and tortuous course. According to the dominance of coronary artery irrigation areas, right dominance was observed in 138 patients (73.4%), left dominance in 21 (11.1%), and codominance in 30 (16.0%). Two of the RCAs obstructed in the intermedial area had right dominance and 2 had codominance.

MBs had right dominance in 32 patients (65.3%), codominance in 11 (22.44%), and left dominance in 6 (1.22%).

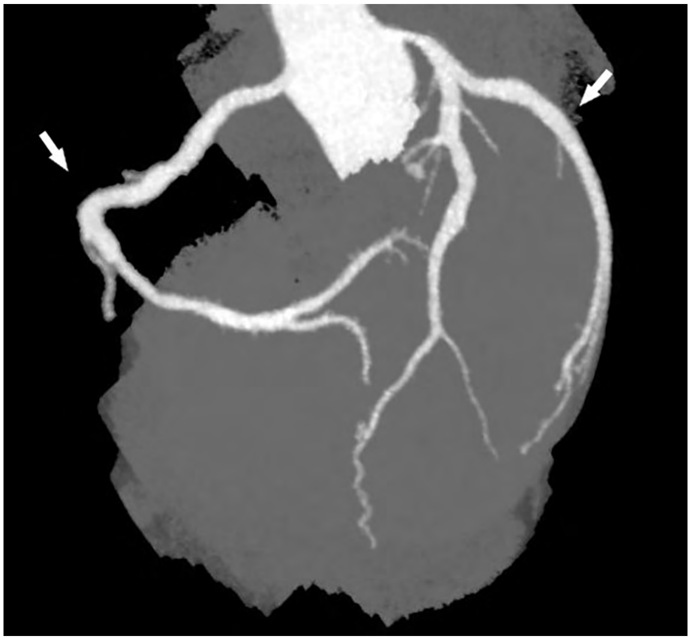

Figure 2: CCTA images of a 37-year-old male patient presenting with chest pain. All coronary arteries are seen to be ectatic in this image, which demonstrates conventional angiography obtained with CCTA post-processing (arrows).

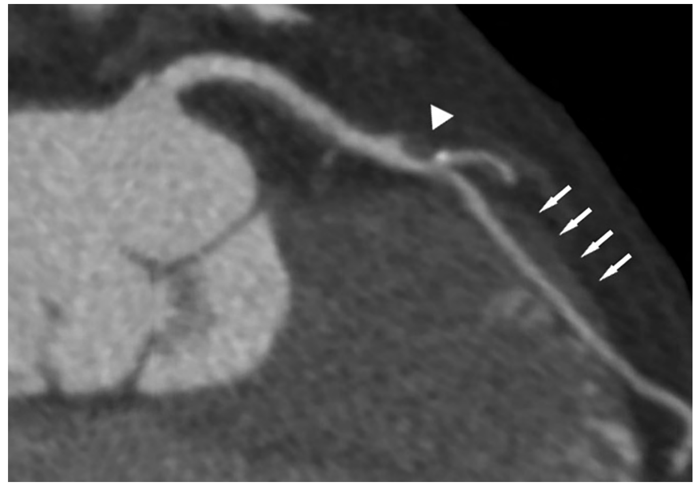

Figure 3: CCTA images of a 31-year-old male patient. left anterior descending artery has an intramuscular course (arrow) and there is plaque formation (arrowhead) immediately proximal to the intramuscular segment.

DISCUSSION

Literature data indicate that the prevalence of CAD is lower in adults under 40 years. In this study conducted with CCTA in a population under 40 years, we determined the prevalence of cardiovascular pathologies as 55%. This finding is similar to the results of Tsai et al.,[2] who also evaluated CCTA images in a young population. Of the patients included in the current study, 23% had CAD, 26% had MBs, and 11% had coronary anomalies. Our study is important in terms of presenting the number of patients in a population under 40 years in comparison with the literature. Contrary to the study of Tsai et al.,[2] the prevalence of CAD in our patients with chest pain was statistically significantly higher than those without this complaint. This may be due to the number of symptomatic patients and the total number of patients being higher in our study than in the previous research or the differences in the demographic features of the sample. These results suggest that the possibility of CAD should not be overlooked in patients aged under 40 years, and associated symptoms should be evaluated carefully. One possible reason for the high prevalence rates we determined may be the high diagnostic performance of the latest-generation computed tomography angiography devices, especially due to the rapid technological developments in recent years. There is still a need for comprehensive comparative studies in different populations using different imaging methods for the evaluation of cardiovascular diseases. The data in the literature indicate that 80% of myocardial infarction in young adults is caused by CAD; however, it has been reported that only 3% of all CAD patients are young adults.[12] In our study, the prevalence of CAD was determined to be 25%, and only a few had high-grade stenosis. This suggests that most patients remain undiagnosed with ambiguous symptoms until severe CAD develops at later ages. Similarly, in another study conducted with CCTA, the prevalence of CAD was found to be high in young adults.[13]

MBs are congenital variants of coronary arteries, in which most of the left anterior descending artery takes an intramuscular course.[8] In our study, the rate of MBs in young adults was found to be 26%, which is consistent with both the autopsy and CCTA case series published in the literature.[14] MBs are generally accepted as benign events, and although their relationship has not been clearly demonstrated, there are studies that have stated them as a cause of angina-like chest pain, coronary spasm, myocardial infarction, and even sudden cardiac death.[15] Therefore, CCTA emerges as an important noninvasive imaging method in detecting this entity in symptomatic young adults.

Identifying coronary artery variations in advance can guide invasive interventional procedures and surgical procedures and prevent complications that may occur. MBs cause stenosis in coronaries during systole while normal calibration is regained during diastole. Myocardial ischemia can be seen in patients who do not have signs of atherosclerosis in coronary arteries but have hemodynamic risk factors, such as tachycardia, coronary spasm, and hypertrophy.[16] MBs prevent atherosclerotic plaque from accumulating in the bridge segment, but contribute to the formation of stenosis in the proximal segment adjacent to the bridge (Fig. 3).[17] They increase the rate of restenosis in the stent after a percutaneous coronary intervention and constitute an important factor in the occurrence of major cardiac adverse events.[18] Left coronary artery anomalies and variations, especially the presence of an MB can lead to clinical findings.

Congenital coronary anomalies are a diverse group of congenital disorders with highly variable symptoms and pathophysiological mechanisms.[8] It has been reported that the prevalence of coronary anomalies ranges from 0.3% to 5.6%.[7] In our study, various congenital coronary anomalies were diagnosed in 8% of young adults. Although congenital coronary artery anomalies are generally rare, they are the second most common cause of sudden cardiac death among young adults and athletes, associated with anatomical features, such as abnormal course, acute angulation, and ostial abnormalities.[7] CCTA is important in terms of identifying potentially fatal coronary anomaly subtypes that may result in catastrophic events. In the current study, 4 patients presented with RCA obstructed in the interarterial area, which represents a type that can cause ischemia. In another patient, we detected acute angulation in LMCA, and although this is not clinically significant, it may result in complications in percutaneous interventions.[7] Therefore, a preprocedural CCTA performed with clinical indications may guide invasive procedures.

Our study had certain limitations. First, patient selection errors may have occurred due to the retrospective design of the study. The relatively small number of patients can also be considered among our limitations. Another important limitation is that we were unable to evaluate information about underlying cardiovascular risk factors. Finally, the definition of young adult age varies to a great extent, e.g., from >35 to >55, in different studies. In this study, we identified young adult patients as those under the age of 40 years, in line with the definitions adopted in most previous studies.[13,19] However, this situation may have limited the number of our patients and caused our findings to be interpreted differently from the literature data. Therefore, larger-scale studies are needed for a more complex analysis of the details of CAD in different age groups.

Guidelines concerning the management of coronary syndromes now recommend noninvasive functional imaging methods, such as CCTA, as the first-line diagnostic test in patients with symptoms such as chest pain, and obstructive CAD cannot be ruled out only based on a clinical evaluation.[20]

CONCLUSION

In conclusion, our study is important in terms of CAD and coronary anomalies in young adults with CBTA. We detected anomalies, variations, CAD, and cardiac pathologies of extracoronary artery origin in 55% of young adults under the age of 40 years. Clinicians should be aware of cardiac abnormalities and variations in young adults, and further studies with large series should be conducted to clarify the prevalence of cardiovascular diseases in different populations. This will result in the early identification of cases with ambiguous symptoms that may cause serious and acute events in the future, including sudden death, and thus allow early interventions to be performed.

Statement

Ethics Committee Approval: The Recep Tayyip Erdoğan University Clinical Research Ethics Committee granted approval for this study (date: 24.10.2018, number: 2018/139).

Informed Consent: Written informed consent was obtained from patients who participated in this study.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – TE; Design – TE; Supervision – TE; Materials – TE; Data Collection and/or Processing – TE, UK; Analysis and/or Interpretation – TE; Literature Search – UK; Writing – TE, UK; Critical Reviews – UK.

Conflict of Interest: The authors have no conflict of interest to declare.

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