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The prevalence of coronary artery anomalies in adults: studied with computed tomography coronary angiography

Prevalenca koronarnih anomalija kod odraslih: ispitivanje kompjuterizovanom tomografskom koronarnom angiografijom

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Abstract

Background/Aim. Coronary artery anomalies are an uncommon but important cause of chest pain, and in some cases of hemodynamically significant abnormalities, sudden cardiac death. The aim of the research was to establish the prevalence of the coronary arteries anomalies in our population. **Methods.** The study group included 1,562 patients (810 men, 752 women, average age 64.3 ± 12.0 years; range 32–80 years) who were scheduled for 64-slice computed tomography (MSCT), which enables detailed visualization of coronary arteries and heart anatomy. All examinations were made due to suspicion (atypical chest pain, angina equivalent symptoms or multiple risk factors for cardiovascular disease) or assumption of progression of coronary artery disease. **Results.** From January 2010 till December 2014 a total number of 1,562 patients were sent for evaluation of coronary arteries. The coronary anomalies were found in 45 (2.88%) patients. The most frequent coronary anomaly seen in our population group was absence of left main trunk with the separate origin of the left anterior descending artery (LAD) and left circumflex artery (LCx) originating from a left coronary sinus (LCS). This was found in 12 patients (an incidence of 0.77% or 26.7% of all coronary anomalies). Anomalous location of coronary ostium outside normal aortic sinuses in our study was present as right coronary artery (RCA) that arises from left anterior sinus in 5 (0.32%) patients and left coronary artery from non-coronary sinus in two (0.13%) patients. **Conclusion.** Knowledge of anomalies of the coronary arteries and their recognition on the multislice computed tomography is of great importance for the further planning of a possible therapeutic treatment. Coronary anomalies that are considered insignificant will require no further therapeutic treatment. But the detection of malignant coronary anomalies will certainly save many lives.

Key words:
coronary vessels; adult; abnormalities; coronary angiography; prevalence.

Apstrakt

Uvod/Cilj. Anomalije koronarnih arterija su redak, ali važan uzrok bola u grudnom košu tako da, u nekim slučajevima, hemodinamski značajne abnormalnosti mogu da izazovu iznenadnu srčanu smrt. Cilj istraživanja bio je da se utvrdi prevalencija anomalija koronarnih arterija u našoj populaciji. **Metode.** Istraživanje je uključilo 1 562 bolesnika (810 muškaraca, 752 žene, prosečne starosti 64,3 ± 12,0 godina, raspon 32–80 godine) koji su pregledani na 64-slajsnoj kompjuterizovanoj tomografiji (MSCT). Pregled na ovom apartu omogućuje detaljnu vizualizaciju koronarnih arterija i srčane anatomije. MSCT pregledi su obavljeni na bolesnicima zbog sumnje na postojanje koronarne bolesti (atipični bol u grudima, angina pektoris ili više faktora rizika od kardiovaskularnih bolesti), kao i moguće progresije bolesti koronarnih arterija. **Rezultati.** Od januara 2010. do decembra 2014. godine pregledano je ukupno 1 562 bolesnika za procenu starenja koronarnih arterija. Incidenca srčanih anomalija je bila zastupljena kod 45 bolesnika (2,88%). Koronarna anomalija koja je bila najzastupljenija u našoj studiji je bilo odsustvo glavnog stabla leve koronarne arterije sa odvojenim ishodištima leve descedentne arterije (LAD) i leve cirkumfleksne arterije (LCX) iz levog koronarnog sinusa (LCS). Pronađena je kod 12 bolesnika (učestalost od 0,77%, odnosno 26,7% svih srčanih anomalija). U našoj studiji anomalije ishodišta koronarnih arterija van normalnog koronarnog sinusa manifestovale su se kao anomalno ishodište desne koronarne arterije (RCA) iz levog koronarnog sinusa kod 5 (0,32%) bolesnika i leve koronarne arterije iz nekoronarnog sinusa kod dva (0,13%) bolesnika. **Zaključak.** Poznavanje anomalija koronarnih arterija i njihova vizualizacija na višerednoj kompjuterizovanoj tomografiji od velike je važnosti za dalje planiranje mogućeg terapijskog tretmana. Koronarne anomalije koje se smatraju beznačajnim neće zahtevati dalji terapijski tretman. Ali, otkrivanje hemodinamski značajnih koronarnih anomalija sigurno će spasiti mnoge živote.

Ključne reči:
koronarni krvni sudovi; odrasle osobe; anomalije; angiografija koronarnih arterija; prevalenca.

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Introduction

Coronary artery anomalies are defined as an abnormality of the origin, direction, and coronary artery bifurcations. This definition of anomalies of the coronary arteries is incomplete, as we still do not have any recommendations for the diagnosis and treatment of these anomalies. The biggest obstacle to solving this problem is a great variety of clinical presentations (from completely silent to those that can lead to sudden cardiac death), as well as an incomplete understanding of the pathophysiology of these disorders.

The most widely accepted attitude about these anomalies was given by Angelini [1–3] that they "can be considered a normal variation of each coronary artery that has a frequency of > 1% in the general population".

It is enough to ask ourselves whether anatomical variation that does not cause any functional impairment, which is seen very rarely, such as, for example, the separate origin of the circumflex branch of the left coronary artery, deserves to be classified as a coronary anomaly or not.

Methods

The study group included 1,562 patients (810 men, 752 women, average age 64.3 ± 12.0 years; range 32–80 years) which were scheduled for multislice computed tomography (MSCT) which enables detailed visualization of coronary arteries and heart anatomy. They were referred to the Department of Radiology of the Clinical Center Niš, Serbia. Exclusion criteria were patients with previous allergic reaction to iodinated contrast, pregnant women, heart rate irregularity and renal insufficiency (creatinine ≥ 1.5 mg/dL).

Examinations were performed using a Multi-Slice Computed Tomography Toshiba Aquilion 64 system (Toshiba Medical Systems, Japan), with a rotation time of 0.33 seconds and a collimation of 64 × 0.5 mm. The tube current was 120 kV, at 300 mA. Field of view (FOV) was 140–180 mm.

Nonionic contrast material was applied in the cubital vein in the amount of 80 to 90 mL and a flow rate of 4.0–5.0 mL/s (Iopromide/Ultravist® 370, Bayer HealthCare Pharmaceutical, Germany). A 50 mL bolus of normal saline was given after administering the contrast material. In a software, we used automatic peak enhancement detection in the descending aorta with the timing of the bolus using a threshold of +180 Hounsfield Units. Data acquisition was performed during a breath hold of approximately 8 to 10 seconds. Patients with heart rate > 70 bpm received 100 mg of metoprolol *per os* 1 h prior to examination.

Electrocardiography (ECG) was performed simultaneously with retrospective gating of the data, during the examination. Reconstruction was performed at 75% of the RR interval, with a slice thickness of 0.5 mm. The ECG was edited manually when the heart rate was irregular. Post-processing and evaluation were done on a workstation (Vitrea 1, Vital Images, USA), where all images were transferred.

All data were analyzed with post-processing tools such as multiplanar reconstructions (MPR), curved MPR (cMPR), maximum intensity projections (MIP) and volume rendering (VR) to three-dimensionally image of the complex anatomy of the coronary artery tree. Anomalies of origin and course, intrinsic coronary anomalies (myocardial bridging, aneurysms) and termination anomalies (fistulas) were checked.

Results

From January 2010 till December 2014 a total number of 1,562 patients were sent for evaluation of coronary arteries. Coronary anomalies were found in 45 (2.88%) patients. There were normal findings of the heart in 515 patients (32.97%). The other patients (64.15%) had coronary artery disease, stenting of coronary arteries or bypass operation (Table 1).

The most frequent coronary anomaly seen in our population group was absence of left main trunk with the separate origin of the left anterior descending artery (LAD) and left circumflex artery (LCx) originating from a left coronary sinus (LCS). This was found in 12 patients (an incidence of 0.77% or 26.7% of all coronary anomalies) (Figure 1).

In 10 (0.64%) patients intramural coronary artery (muscular bridge) was found, which most commonly involved proximal LAD (Figure 2).

Anomalous location of coronary ostium within the aortic root or near proper aortic sinus of Valsalva was found high in 7 (0.45%) patients and low in 3 (0.19%) patients (Figures 3 and 4).

Anomalous location of coronary ostium outside normal aortic sinuses in our study was present as right coronary

Table 1

Coronary artery anomalies detected in our series

Type of anomaly	Number of patients	Incidence (%)	Anomalies (%)
Absence of left main trunk – separate ostium for LAD and LCx	12	0.77	26.7
Bridging	10	0.64	22.22
High "take-off"	7	0.45	15.55
RCA from LCS	5	0.32	11.11
Low "take-off"	3	0.19	6.66
Aneurysms of coronary artery	2	0.13	4.44
LM from NCS	2	0.13	4.44
Coronary artery fistulae	2	0.13	4.44
Single coronary artery	2	0.13	4.44
Total	45	2.88	

LAD – left anterior descending; LCx – left circumflex; RCA – right coronary artery; LM – left main; LCS – left coronary sinus; NCS – non-coronary sinus.

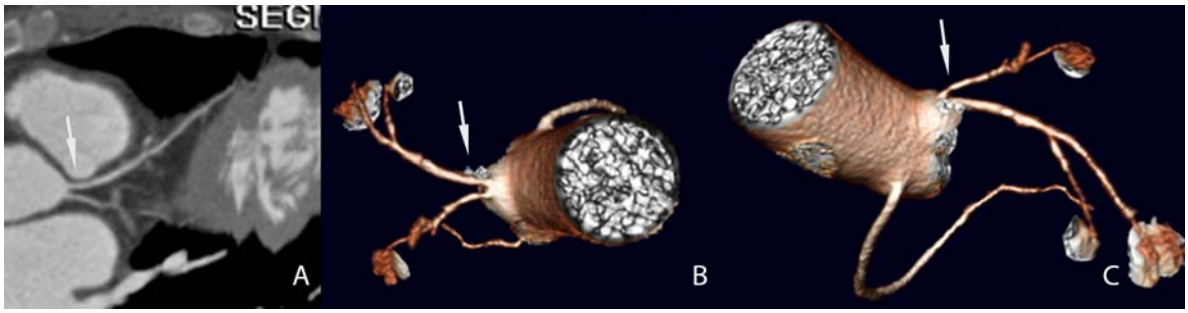

Fig. 1 – Absence of left main trunk with the separate origin of the left anterior descending artery (LAD) and left circumflex artery (LCx) originates from a left coronary sinus (LCS);
A) curved multiplanar reconstruction – MIP; B) and C) Volume rendering – VR.

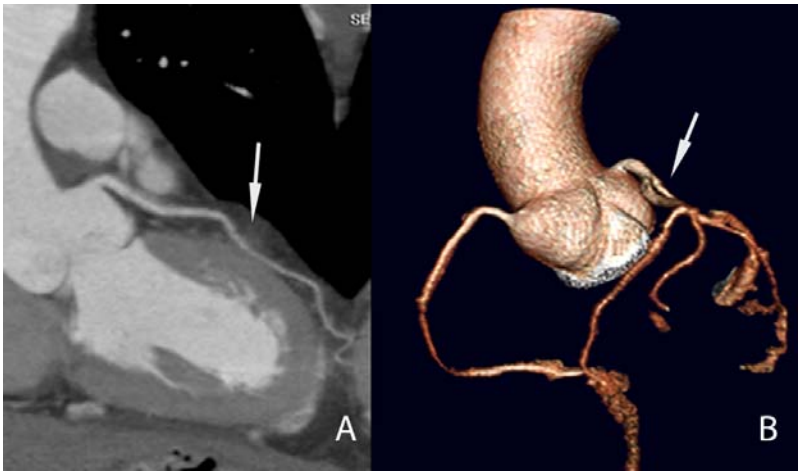

Fig. 2 – A) Maximum intensity projection (MIP), and B) 3D volume rendering show bridging of the left anterior descending.

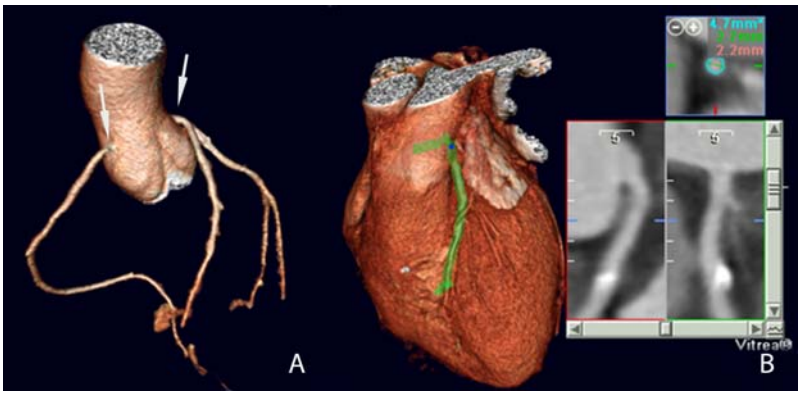

Fig. 3 – Volume-rendering images show high take-off of: A) the right, and B) left coronary arteries above the sino tubular junction.

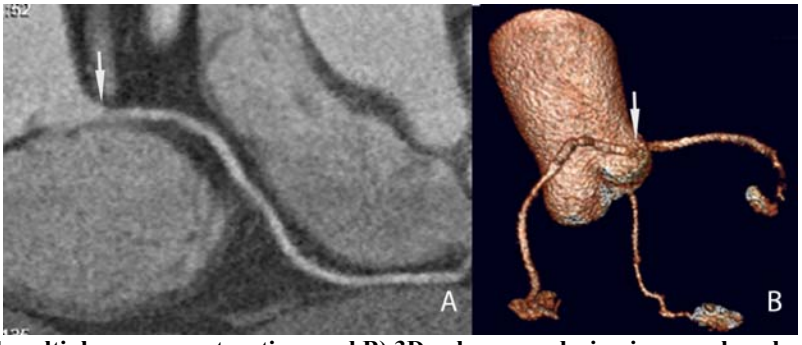

Fig. 4 – A) Curved multiplanar reconstruction, and B) 3D volume rendering images show low insertion of right coronary artery ostium.

artery (RCA) that arises from left anterior sinus in 5 (0.32%) patients and left coronary artery from non-coronary sinus in two (0.13%) patients (Figures 5 and 6).

The single coronary artery was found in two (0.13%) patients. One patient had a single coronary artery from the right coronary sinus and left coronary artery coming out of the RCA. The second one had single coronary artery from the left coronary sinus. A coronary artery fistula was found in two patients (0.13% or 4.44% of all coronary anomalies). The both of them had a fistula between the left anterior descending artery and the pulmonary artery (Figures 7–10).

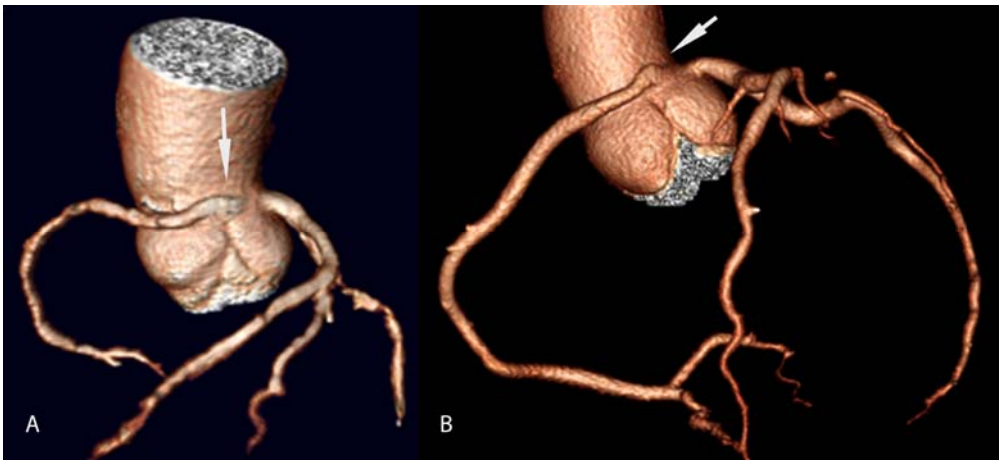

Fig. 5 – Volume-rendering images show two different patients with anomalous location of coronary ostium at improper sinus – right coronary artery arises from left coronary sinus.

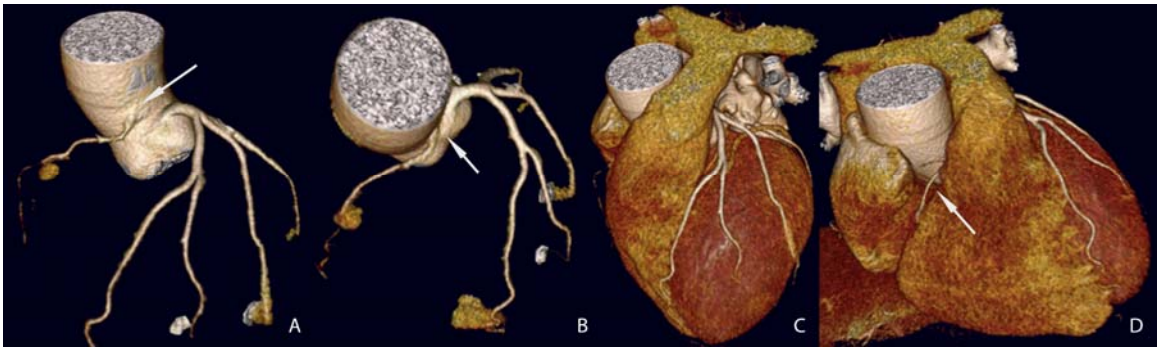

Fig. 6 – Volume rendering show right coronary artery arising from left anterior sinus, with anomalous course between aorta and pulmonary artery.

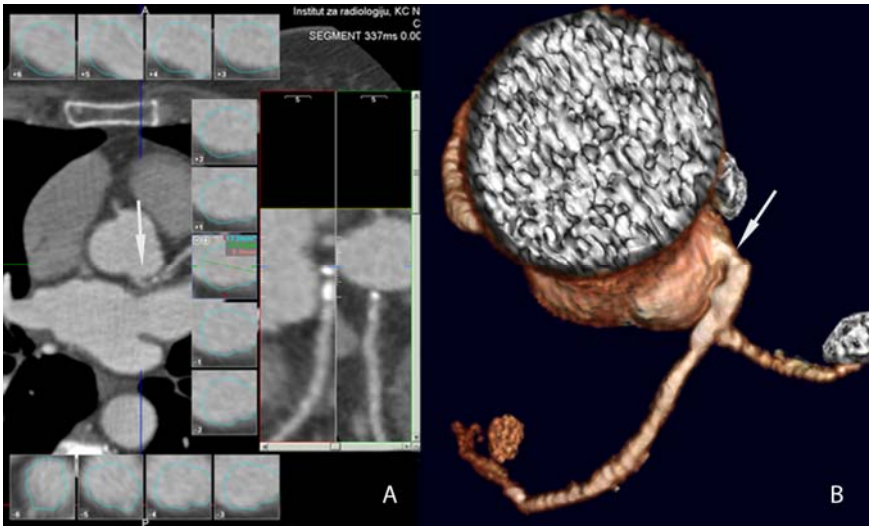

Fig. 7 – Left coronary artery arises from non-coronary sinus with angulation: A) curved multiplanar reconstruction; B) volume rendering images.

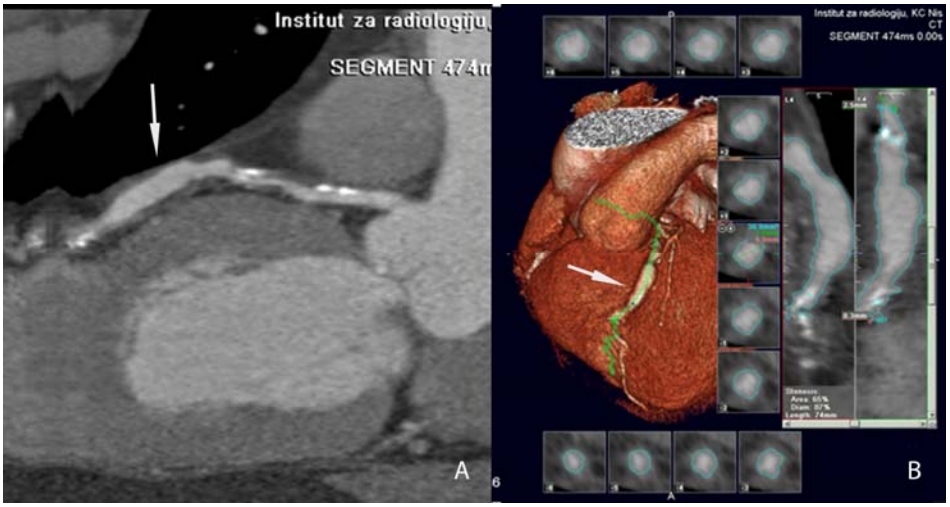

Fig. 8 – Aneurysm of left descending artery (LAD).

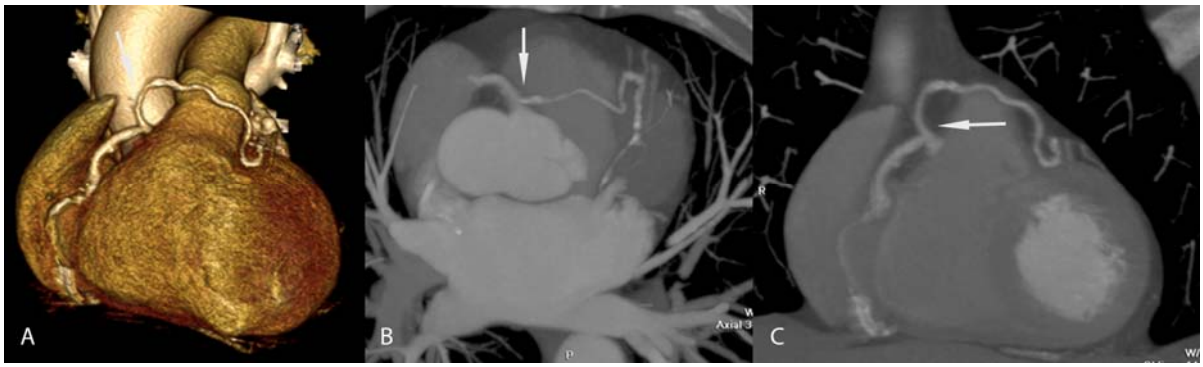

Fig. 9 – Single coronary artery arising from right coronary sinus – left descending artery (LAD) arises from the right coronary artery (RCA): A) volume rendering; B and C) multiplanar reconstruction.

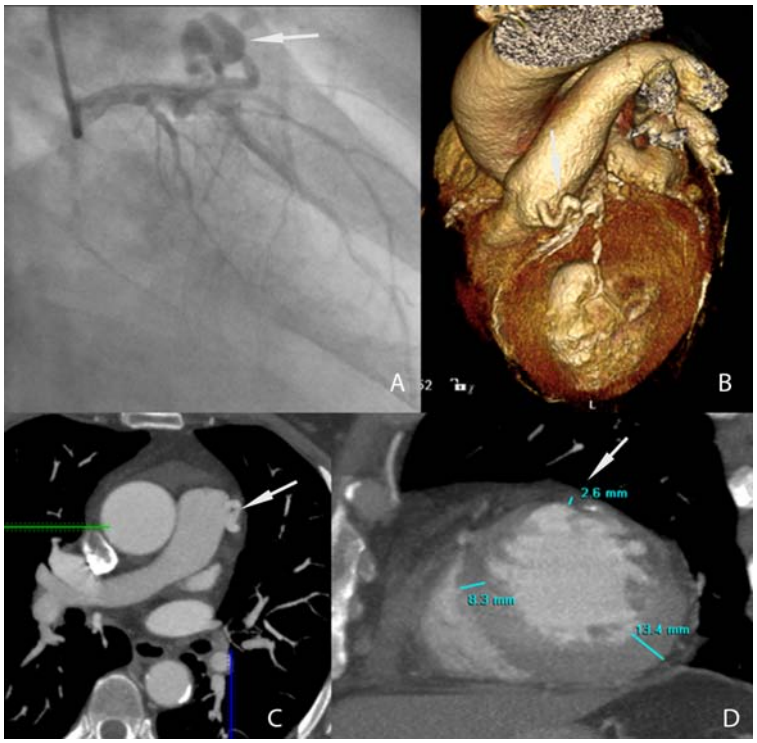

Fig. 10 – A) A fistula between the left anterior descending artery (LAD) and the pulmonary artery (PA); B) digital subtraction angiography (DSA) of LAD; C) Volume rendering show the fistula between PA and LAD; D) maximum intensity projection (MIP) axial view (short view of the heart with diameter reduction of myocard in the region of LAD vascularisation).

Discussion

Previously, congenital anomalies of the coronary arteries were distributed to the minor and major, depending on whether they may or may not cause relevant clinical consequences. However, as knowledge of the pathophysiology and clinical consequences of certain anomalies is often insufficient, this classification has been abandoned, and Angelini classification is increasingly being used, based on anatomical parameters (number, localization and size of the artery ostium, the angle at which they are separated, size of arteries, their flow in the proximal and medial segments, branching and termination) [1–3].

Dilemmas exist when it comes to the frequency of congenital anomalies of the coronary arteries. Earlier data from the literature indicates detection of these anomalies on autopsies and invasive coronary angiography. It has been found to occur less frequently than congenital heart disease, with an incidence about 1% of the population [4–9].

An invasive coronary angiography was traditionally used for the diagnosis of coronary anomalies [10, 11], until the appearance of the first publications in released statements in the multislice computed tomography.

On invasive angiography, it sometimes can be difficult to see a course of arteries, especially when it passes between the aorta and the pulmonary tree, thereby requiring specific projections and skillful interpretation. Three-dimensional reconstruction of coronary vessels on MSCT significantly facilitates observation of these anomalies.

Yamanaka and Hobbs [5] have published the largest invasive angiography series with 126,595 patients, and 1.3% incidence of the anomalous coronary arteries.

In our study, the incidence of coronary anomalies amounted 2.88% on MSCT angiography.

There is great diversity in the results of studies performed with multislice computed tomography. Graidis et al. [12] in their study analyzed 2,572 patients examined by MSCT and found 60 patients with coronary artery anomaly (incidence 2.33%).

In other study, anomalies were detected with the incidence of 2.5% in 44 patients out of the reviewed 1,758 [13].

Srinivasan et al. [14] assessed 1,495 patients using MSCT coronary angiography and found the prevalence to be 0.8 %.

Absence of left main trunk with the separate origin of LAD and LCx origin from a left coronary sinus in our study was found in 12 patients (an incidence of 0.77%). They are estimated to be seen in 0.5% to 8% of the population. This anomaly was the first most common anomaly in our study. Multiple arterial ostia [15] usually present no major clinical problems, but they may cause a problem during catheterization of the artery at invasive coronary angiography.

Anomalous location of coronary ostium outside normal aortic sinuses in our study was present like RCA that arises from left anterior sinus in 5 (0.32%) patients. The anomalies of the course of the coronary artery, especially when passing between the aorta and the pulmonary arteries, may be the cause of sudden cardiac death. Particularly people who are exposed to extreme physical exertion and athletes are at risk.

Coronary artery fistula is also within the anomalies that can cause serious complications in the heart or sudden cardiac death. Fistulas may occur as communication with the venous blood vessels or communication with coronary artery heart chambers. In our study, there was communication between the LAD and the pulmonary artery in two patients. One patient suffered a myocardial infarction and in the region of vascularization LAD and then the existence of fistula was discovered.

Myocardial bridging has a special place in the diagnostic examination of the coronary arteries on the MSCT. The possibility of assessing the condition of the coronary arteries in the myocardium as well as the length and depth of the segment is of particular importance. Having this information, further therapeutic treatment can be planned.

In our study muscular bridge was found in 0.64% of cases with most commonly involved LAD. There is some difference in the literature data between the prevalence of myocardial bridging at invasive angiography (0.5–2.5%) and prevalence at autopsy (15–85%) [16]. It can be explained by the fact that these patients often don't have any symptoms, so they do not undergo invasive angiography. In some patients myocardial bridging can cause angina pectoris, myocardial infarction, arrhythmias, or even death [17]. The main advantage of MSCT is the visualization of intramyocardial location of the coronary arterial segment. Relative limitation of this method is an image reconstruction using retrospective electrocardiography (ECG) gating in diastolic phase. If there is a suspicion for myocardial bridging, it is recommended to perform the ECG-gated reconstruction during the systolic phase as well as diastolic one.

Conclusion

Knowledge of the coronary artery anomalies and their recognition on the multislice computed tomography is of great importance for the further planning of a possible therapeutic treatment. Coronary anomalies that are treated as insignificant will require no further therapeutic treatment. But the detection of malignant coronary anomalies will certainly save many lives.

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