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Prevalence of Congenital Coronary Artery Anomalies of Korean Men Detected by Coronary Computed Tomography

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Background and Objectives: It has been demonstrated that the anomalous origin of coronary arteries (AOCA) are generally asymptomatic and rare diseases. However, some cases can cause severe life threatening events. To detect these anomalies, coronary angiographies and autopsies were used to detect coronary artery anomalies, but these procedures have limitations because of their invasiveness. The new device, Multidetector Computed Tomography (MDCT), now replaces the method of choice for detecting coronary anomalies. The prevalence of these anomalies in Korea has not been studied yet. This present analysis attempted to determine the prevalence of AOCA in Korean men by MDCT.

Subjects and Methods: 1582 Korean male police officers underwent coronary MDCT for their health screening voluntarily. After reconstruction of CT images, we could confirm coronary artery anomalies.

Results: The prevalence of AOCA in Korean men was 1.14% (18 out of 1582 cases). The most common abnormality (11 cases, 0.70%) was the origin of the coronary artery. Anomalies of the coronary artery end point were observed in 5 cases (0.32%). The anomalous location of coronary ostium on the aortic root was observed in 1 case (0.06%). An anomalous collateral vessel was observed in 1 case (0.06%).

Conclusion: The prevalence of coronary artery anomalies in Korean men was 1.14%. Coronary CT is a safe and noninvasive modality for detecting coronary anomalies. **(Korean Circ J 2013;43:7-12)**

KEY WORDS: Coronary vessel anomalies; Multidetector computed tomography; Prevalence.

Introduction

The occurrence of coronary artery abnormalities in the general population is reported to be approximately 0.2% to 1.3% based on the adult population.[1)] These anomalies are usually not symptomatic and have no clinical significance. However, certain types of coronary artery abnormalities were related to sudden death, particularly in young athletes. According to the report of the Sudden Death Committee of the American Heart Association, approximately 19% of sudden death in athletes may be related to these anomalies.[2)] Other studies also report that sudden cardiac death due to coronary anomalies, especially those which course between the root of the aorta and the pulmonary artery (range from 19% to 33% in healthy young individuals).[3)4)] Coronary angiography and autopsy were used to detect coronary artery anomalies, but these procedures have limitations because of their invasiveness. The new device, Multidetector Computed Tomography (MDCT), now replaces the method of choice for detecting coronary anomalies. Our research aimed to find out the prevalence of rare congenital coronary vessel anomalies in Korean men with 128-slice MDCT.

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• The authors have no financial conflicts of interest.

Subjects and Methods

Study population

Institutional review board approval was obtained for this retrospective study, and informed consent was waived. We searched our

database which was performed from November 28, 2010 to June 3, 2011. A health screening program was done on 1582 Korean male police officers (age range of 27 to 60 years, mean age: 49.7±6.01 years). They underwent 128-slice coronary CT angiography voluntarily in this period.

Scan protocol and image reconstruction

Scanning was performed using a MDCT (Somatom Definition AS+, Siemens AG, Medical Solutions, Forchheim, Germany) with 128-slice scanner. The scan field extended from the carina to the diaphragm. The imaging parameters were: detector collimation of 128×0.60 mm, tube voltage of 120 kV, Max mA range of 800 mA, gantry rotation time was 300 ms, pitch of 0.3, slice thickness of 0.75 mm and 0.5 mm reconstruction interval. A single breath-hold of approximately 8-10 seconds completed the examination.

All patients were hospitalized and reviewed their medical history and drug hypersensitivity. General laboratory tests and imaging studies such as electrocardiography (ECG) and chest X-rays were performed. Before undergoing MDCT, we checked their heart rates and when the pulse rate was more than 65 beat per minute, patients took 100 mg of an oral beta-blocker (metoprolol tartrate, Betaloc; Yuhan, Seoul, Korea). All patients took nitroglycerin sublingually just before examination.

Electrocardiography-gated CT examinations consisted of the following three phases: 75 mL of Prosure (iopromide 300 mg/mL, LG LIFE SCIENCE, Seoul, Korea), 9 mL of Prosure with 1.5 mL/sec and 21 mL of normal saline with 3.5 mL/sec were injected simultaneously, and normal saline flushing was done after Prosure injection. Injections in all phases were administrated into an antecubital vein via an 18-gauge catheter. ECG pulsing for radiation dose reduction was applied to all participants. Data reconstruction with the ECG signal was synchronized via a retrospective gating technique. The software automatically selected the optimal systolic and diastolic data according to the lowest motion velocity of each coronary vessel with the following parameters: a detector collimation thickness of 0.60 mm, reconstruction images from the contrast-enhanced CT scan with a slice thickness of 0.75 mm, a reconstruction increment of 0.5 mm, and usage of an advanced smoothing algorithm kernel (B26f). The dose-length product (DLP, measured in milligraycentimeters) was checked as an indicator of radiation exposure. An approximation of the effective radiation dose of Coronary Computed Tomography Angiography (CCTA) was calculated by multiplying DLP by a conversion coefficient for the chest and coronary arteries {k=0.014 mSv/(mGy×cm)}.[5]

Image reformation and analysis

All reconstructed images were transferred to a dedicated workstation (4D Workstream, Siemens AG, Medical Solutions, Forchheim, Germany) equipped with dedicated cardiac post-processing software (syngo Circulation, Siemens AG, Medical Solutions, Forchheim, Germany). Image post-processing was performed using techniques of maximum intensity projection, multiplanar reformation, and volume rendering for the optimal phase data. Out of 1582 cases, the limited evaluations were 26 cases and suboptimal evaluations were 4 cases. Most of them were due to motion artifact but there is no difficulty in detecting coronary artery anatomy.

Statistical analysis

Continuous variables are shown as mean±standard deviation, and compared by Student's t-test. Categorical variables are defined as number of subjects and percentages and analyzed by a chi-square test. The Statistical Package for the Social Sciences (SPSS) statistical software (SPSS 12.0KO for Windows, Inc., Chicago, IL, USA) was used for all statistical calculations. $p<0.05$ were considered statistically significant.

Results

The baseline characteristics of the participants are listed in Table 1. There was no significant difference between two groups with respect to age and the incidence of hypertension, diabetes, dyslipidemia, smoking history or family history of coronary artery disease.

The overall incidence of coronary artery anomalies was 1.14% (18 out of 1582 participants). The most common anomaly was an ab-

Table 1. Baseline characteristics of study subjects

	Male police officers without coronary artery anomaly (n=1564)	Male police officers with coronary artery anomaly (n=18)	p
Age (years)*	49.7±6.01	50.2±6.04	0.867
Diabetes (%)	222 (14.2)	3 (16.7)	0.733
Hypertension (%)	858 (54.9)	12 (66.7)	0.352
Dyslipidemia (%)	651 (41.6)	10 (55.6)	0.242
Family history of coronary artery disease (%)	376 (24.0)	9 (50.0)	0.054
Smoker/Ex-smoker (%)	607 (38.8)	4 (22.2)	0.223

*Data are means±standard deviations

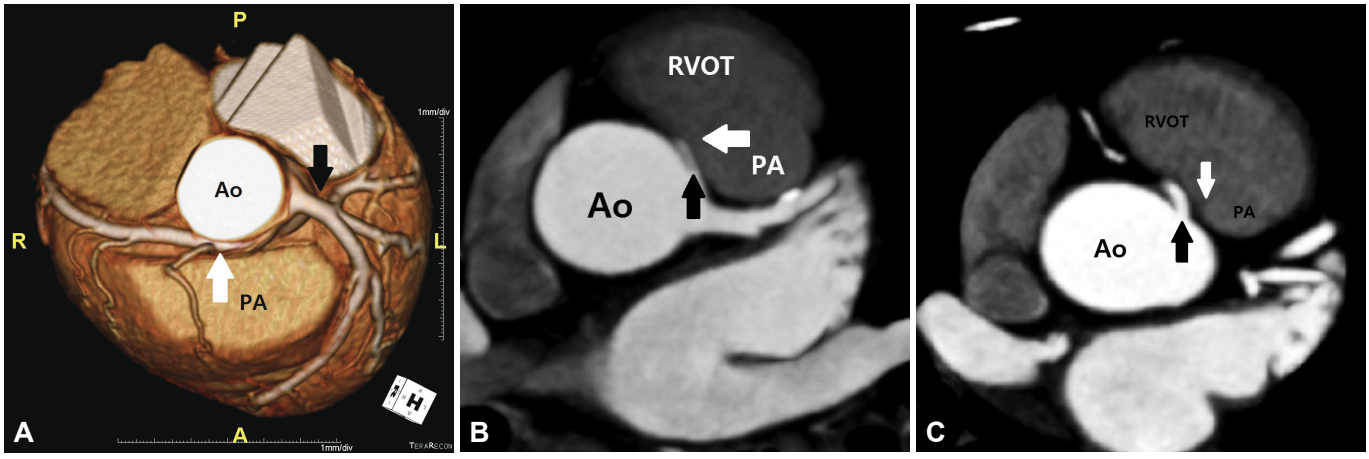

Fig. 1. Anomalous origin of right coronary artery. A: volume-rendered CT image shows RCA (white arrow) and LCA (black arrow) arising from the left coronary sinus. RCA with a course between Ao and PA. B: CT image shows high interarterial course. An anomalous RCA ostium (black arrow) from the left coronary sinus is located between the Ao and the RVOT above the pulmonary valve (white arrow). C: CT image shows low interarterial course. An anomalous RCA ostium (black arrow) from the left coronary sinus is located between the Ao and the RVOT below the pulmonary valve (white arrow). RCA: right coronary artery, LCA: left main coronary artery, Ao: aorta, PA: pulmonary artery, RVOT: right ventricular outflow tract.

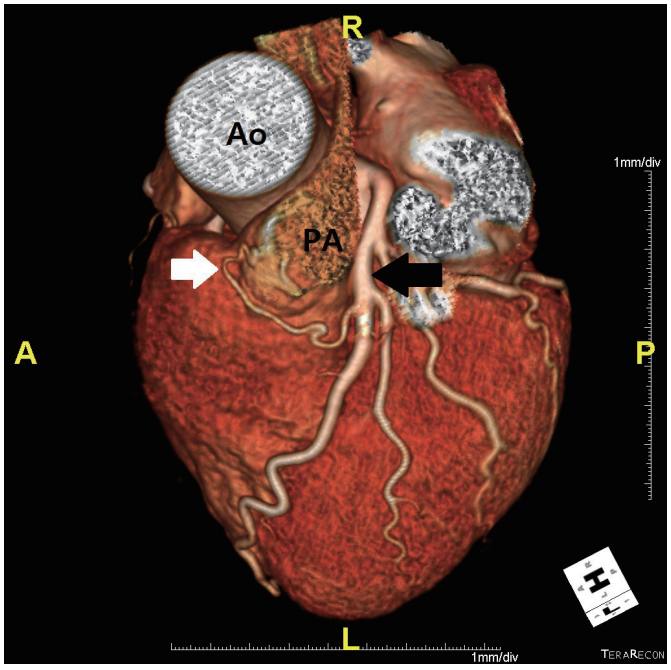

Fig. 2. Fistula between proximal LAD and pulmonary trunk. Volume rendered CT image shows fistula (white arrow) between proximal LAD (black arrow) and pulmonary artery. LAD: left anterior descending coronary artery, Ao: aorta, PA: pulmonary artery.

normal origin of the coronary ostium arising from an opposite or non-coronary sinus (n=11, 0.70%), and 7 out of 11 cases of abnormal origin were in the right coronary artery (RCA) arising from the left coronary sinus (0.44%) (Fig. 1). All of them were of an interarterial type, which the RCA runs between the pulmonary artery and the aorta. The second most common anomaly was fistulas from RCA, left coronary artery, or infundibular artery to the main pulmonary trunk and appeared in 5 cases (0.32%) (Fig. 2). An anomalous location of coronary ostium on the aortic root was detected in only one person (0.06%) (Fig. 3). An anomalous collateral vessel which is connecting proximal RCA and proximal LAD, was observed in 1 case (0.06%). The classification of coronary anomalies and their prevalence was presented according to anatomical criteria of origin, course, intrinsic anatomy, termination, and collateral vessels (Table 2).

Discussion

We explained in advance the impact of the exposure to radiation doses to those who wanted to choose MDCT as an additional health examination tool. 1582 Korean police officers agreed to undergoe MDCT voluntarily. The prevalence of coronary anomalies was 1.14%. Previous studies which were performed by invasive coronary angiography, figured 0.6-1.3% in symptomatic adults[6)7)] and those performed by MDCT figured about 1.3-2.9% (Table 3) in symptomatic adults.[8-13)] The incidence of congenital coronary artery anomalies in Korean men is similar to studies in other countries. But there is a difference between our study and previous studies. Our study enrolled participants who had been scanned for their cardiovascular health screenings, but the other studies enrolled symptomatic adults who went to hospital for evaluating their cardiac disease, and we included only male participants. So our result may represent the prevalence of coronary artery anomalies of the general male population.

Multidetector Computed Tomography may provide better images of the coronary artery anatomic course and more clinical information, compared to coronary angiography.[8)] But the increasing use of CT raises concerns about radiation exposure and the associated cancer risk.[14)] However, recent reports demonstrated that CCTA using a 128-MDCT with prospective ECG-gating provides higher image qu-

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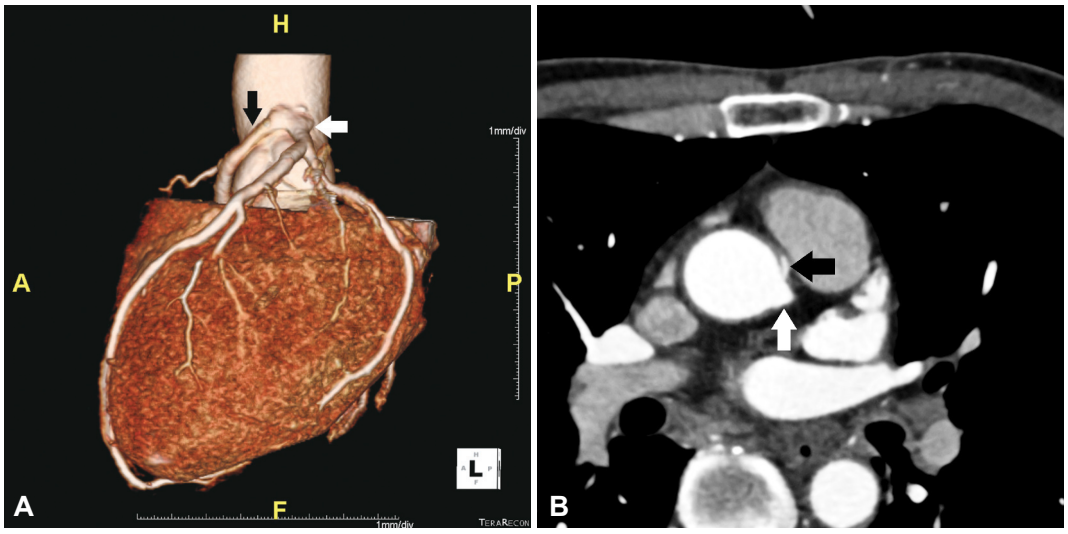

Fig. 3. Anomalous location of coronary ostium within aortic root or near proper aortic sinus of Valsalva. A: volume rendered CT image shows anormalous orgin of RCA (black arrow) and LCA (white arrow) from left noncoronary sinus (high take off). B: CT image shows RCA (black arrow) from left noncoronay sinus, interarterial course, LCA (white arrow) from left noncoronary sinus. RCA: right coronary artery, LCA: left main coronary artery.

Table 2. Prevalence of anomalous origins of the coronary artery by classification (n=1582)

Variable	Number	Percentage (%)
Anomalies of origination and course		
Absent left main trunk (split origination of LCA)		
Anomalous location of coronary ostium within aortic root or near proper aortic sinus of Valsalva		
High take off	1	0.06
Anomalous location of coronary ostium outside normal "coronary" aortic sinuses		
Anomalous origination of coronary ostium from opposite, facing "coronary" sinus		
RCA arising from left anterior sinus, with interartrial course	7	0.44
RCA arising from non-coronary sinus, with interartrial course	1	0.06
LAD arising from right coronary sinus, with interartrial course	1	0.06
Cx arising from right anterior sinus, with precardiac course	1	0.06
LCA arising from right coronary sinus, with prepulmonic course	1	0.06
Anomalies of intrinsic coronary arterial anatomy		
Anomalies of coronary termination		
Fistulas from LAD, RCA, LCA, or infundibular artery to main pulmonary trunk		
Fistula LAD-pulmonary trunk	2	0.13
Fistula D1-pulmonary trunk	1	0.06
Fistula RCA-pulmonary trunk	2	0.13
Anomalous collateral vessels	1	0.06
Total	18	1.14

D1: the first diagonal artery, RCA: right coronary artery, LCA: left main coronary artery, LAD: left anterior descending artery, Cx: left circumflex artery

ality with significant lower radiation doses when compared to 64-MDCT, using retrospective ECG-gating.[15] The mean effective radiation dose was 2.1±0.9 mSv for the prospective 128-MDCT group, which was significantly lower ($p<0.01$) than that for the retrospective 64-MDCT group.[14] The mean radiation doses were 350.0±149.7 mGy×cm in DLP (4.90±2.10 mSv) in our study. And the newly developed 256 slice cardiac CT angiography showed a 10% mean relative dose reduction.[16] The average radiation dose of invasive coronary angiography is about 7 mSv.[17] It means that the recently developed non-invasive MDCT is an accurate diagnostic tool for coronary anomalies with lower radiation doses.

Anomalous coronary arteries which originate from the opposite coronary sinus may follow 4 main courses: an interarterial course, a retroaortic course, a prepulmonary course, or a transseptal course.[18]

Table 3. Prevalence of congenital coronary artery anomalies that underwent multidetector computed tomography in different nations

Author	Incidence of coronary anomaly	Nation	Published year
Erol and Seker.[8]	1.96% (41 out of 2096 symptomatic adults)	Turkey	2011
Tariq et al.[9]	1.55% (14 out of 900 symptomatic adults)	Pakistan	2011
Zhang et al.[10]	1.3% (24 out of 1879 symptomatic adults)	China	2010
Fujimoto et al.[11]	1.52% (89 out of 5869 symptomatic adults)	Japan	2010
Andreini et al.[12]	2.9% (80 out of 2757 symptomatic adults)	Italy	2010
Koşar et al.[13]	2.4% (17 out of 700 symptomatic adults)	Turkey	2009

An interarterial course is clinically important and carries a high risk for sudden cardiac death in young adults.[3][4] The possible mechanism of myocardial ischaemia remain unclear, but the acute take-off angle, the slitlike ostium, compression of the RCA between the aorta and the pulmonary artery, and spasm of the anomalous RCA have been thought to be possible causes.[19] A recent study showed all types of interarterial courses are not considered clinically important, and classified anomalies into two subgroups according to the opening of the RCA ostium: the high and low interarterial course. Patients with a high interarterial course show more typical angina symptoms and major adverse cardiac events than a low interarterial course.[20] In our research, a high interarterial course was in 4 cases and a low interarterial course was in 3 cases. However, sudden cardiac death due to this anomaly is rare in asymptomatic patients, and treatment of anomalous RCA with an interarterial course is still under debate because most of them are benign with a small risk of sudden cardiac death.[21] Our participants with this anomaly had no clinically important cardiac symptoms and were followed closely in outpatient departments.

High takeoff is defined as the origin of either RCA or LCA at a point above the junctional zone between its sinus and the tubular part of the ascending aorta. High takeoff of the coronary arteries is said to pose no major clinical problems, but it can cause difficulty in catheterizing during coronary angiography.

A coronary artery fistula is an abnormal termination of the coronary arteries which are characterized by a communication between the coronary arteries and either a cardiac chamber, systemic vein, or the pulmonary artery. In the majority of cases, the fistula has a single communication and is not clinically important.

In conclusion, the prevalence of congenital coronary artery anomalies in Korean men is similar to what is reported in other populations. MDCT as a primary imaging modality for diagnosis of these anomalies provides an excellent cardiac and coronary artery anatomy. These anomalies are rare, but known to be associated with sudden cardiac death, particularly in young groups with cardiac symptoms. It is necessary to study further on the relationship between coronary artery anomaly and sudden cardiac death. Further research on the long term follow ups of the individuals who have this anomaly is mandatory.

The limitation of our research was that female participants were excluded because only 28 female underwent CT images, and the sample was too small to represent the general female population.

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