INTRODUCTION

Congenitally corrected transposition of the great artery (ccTGA) is a rare congenital anomaly, accounting for 0.05% of congenital heart malformations (1). Most patients have associated cardiac anomalies, including ventricular septal defects, pulmonary stenosis, and systemic atrioventricular (AV) valve, conduction abnormality, and coronary anomalies (2). The identification of the coronary artery anatomy is essential in the preoperative evaluation for optimal surgical outcome (3) and can be evaluated using cardiac computed tomography (CT). Here, we describe a 51-year-old woman who had ccTGA with a new type of coronary artery anomaly detected on cardiac CT. This study was approved by the Institutional Review Board of our hospital. The requirement for patient informed consent was waived because of the retrospective nature of the study.

CASE REPORT

A 51-year-old woman presented with nonspecific chest pain. The electrocardiogram (ECG) showed complete AV block with junctional bradycardia. Echocardiography showed that the aorta was located anterior to and left of the pulmonary artery. The left-sided AV valve was closer to the apex than was the right-sided AV valve, and there was a moderator band in the left-sided ventricle. The ejection fraction of the left-sided ventricle was preserved (50%). Moderate left-sided AV valve regurgitation, mild to moderate aortic valve regurgitation, and mild pulmonary regurgitation were also seen.

Subsequently, retrospective ECG-gated CT angiography was performed using a 64-slice CT scanner (Somatom Definition, Siemens Healthcare, Forchheim, Germany) and a standard protocol with a collimation of 64 × 0.6 mm, gantry rotation time of 0.33 ms, and pitch of 0.31. The tube voltage was 120 kVp, with a
tube current of 336 mA and ECG-dependent tube current modulation (60–80% RR-interval). Scan delay times between the start of contrast injection and scanning were determined using the test bolus technique. After a 10 mL intravenous injection of iopamidol (Pamiray 370; 370 mg iodine/mL, Dongkook Pharma, Seoul, Korea) followed by 20 min of saline at 5 mL/s, optimal delay times were determined by automatic evaluation of contrast enhancement in the ascending aorta. Contrast-enhanced cardiac CT was performed using the triple phase injection method (60 mL iopamidol followed by 30 mL 30% blended iopamidol with saline and 20 mL saline at 5 mL/s). The dose-length product for the scan was 638 mGy·cm, with an estimated effective radiation dose of 8.9 mSv. For image analysis, traditional axial images and all the other available techniques (multiplanar reconstructions, curved multiplanar reformation, maximum intensity projection and 3D volume rendering images) were used. Cardiac CT angiography showed similar findings to those of echocardiography (Fig. 1A-C) and revealed an unusual coronary artery pattern (Fig. 1D, E). The aorta was anterior and to the left of the pulmonary artery. The anterior right sinus had two

Fig. 1. An unreported type of coronary artery anomaly in congenitally corrected transposition of great arteries.
A. Axial CT image shows the aorta anterior to and left of the pulmonary trunk, suggestive of levo-transposition of the great vessels.
B. Axial CT image shows that the left-sided AV valve (black arrowhead) lies closer to the apex than does the right-sided AV valve (white arrowhead). A moderator band (arrow) and prominent trabeculation are seen in the left-sided ventricle.
C. The three-chamber view of the left-sided ventricle shows a tricuspid-aortic fibrous discontinuity (black arrow) caused by the presence of the right ventricular infundibulum (left). The three-chamber view of the right-sided ventricle shows mitral-pulmonary fibrous continuity (right).
Ao = aorta, AV = atrioventricular, CT = computed tomography, LA = left atrium, LV = morphological left ventricle, PA = pulmonary artery, RA = right atrium, RV = morphological right ventricle
ostia. The anterior descending and circumflex arteries arose from the first ostium. The circumflex artery coursed in the right AV groove, and the anterior descending artery coursed in the anterior or interventricular groove. The right ventricular artery arose from the second ostium in the anterior right sinus. It coursed in the left AV groove around the back of the pulmonary artery and sup-

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D. Oblique axial MIP and 3D VR images show coronary arteries arising from three separate coronary ostia. A stair-step artifact (*) resulting from the irregular heart rhythm in the proximal segment of the circumflex artery arising from the anterior right sinus is also seen. The aortic valve has three cusps, which are located to the left anteriorly, right anteriorly, and posteriorly. The right ventricular branch (white arrowhead), which runs along the wall on the morphological right ventricle, originates from the anterior left sinus. The circumflex and anterior descending arteries arise from one ostium (black arrow) of the anterior right sinus. The right ventricular artery (white arrow) originates from the other ostium of the anterior right sinus. Another right ventricular branch (black arrowhead) originates from the posterior sinus.

E. Axial MIP and 3D VR images show the right ventricular artery arising from the anterior right sinus traveling along the left AV groove with a retropulmonary course (white arrow).

al = anterior left sinus, ar = anterior right sinus, CT = computed tomography, LA = left atrium, LV = morphological left ventricle, MIP = maximum intensity projection, p = posterior sinus, PA = pulmonary artery, RA = right atrium, RV = morphological right ventricle, 3D VR = 3D dimensional volume-rendered
plied the morphological right ventricle. The anterior left sinus had a single ostium giving rise to a right ventricular branch, which ran along the wall of the morphological right ventricle. Finally, the right ventricular artery from the posterior sinus travelled along the left AV groove. These are illustrated in Fig. 2.

The patient was diagnosed with ccTGA with a coronary artery anomaly. She is currently being followed regularly for the development of heart failure.

**DISCUSSION**

ccTGA is an unusual cardiac malformation with AV and ventriculoarterial (VA) discordance. AV discordance means that the morphological left atrium discharges blood into the morphological right ventricle, and the morphological right atrium drains into the morphological left ventricle. VA discordance means that the morphological right ventricle connects to the aorta, and the morphological left ventricle connects to the pulmonary artery. This double discordance results in physiologically correct circulation, with the morphological left ventricle supplying the pulmonary circulation, and the morphological right ventricle supporting the systemic circulation (1).

Most patients have associated cardiac anomalies, including ventricular septal defects in 70% of patients, pulmonary stenosis in approximately 40%, systemic AV valve abnormalities in up to 90%, coronary anomalies in 45%, and complete heart block in 30% (2, 4, 5). The natural history of a patient with ccTGA is variable, and the prognosis depends on AV conduction, arrhythmias, structural abnormalities, and the degree of hemodynamic disturbance (6). It is important to identify any associated coronary artery anomalies if surgery, particularly a double switch operation, is considered (7).

In this report, the left and right ventricular arteries are defined by the ventricle they supply, and the circumflex artery is that which runs in the left AV groove. The anterior descending artery is that which follows the interventricular septum (4). A universal, systemic, descriptive classification for coronary arteries and great vessel anatomy is required to allow accurate description and rapid communication of the pattern of abnormalities between radiologist, cardiologist, and surgeons. Although several classification schemes for coronary artery anomalies have been developed, no uniform classification is widely used because they are based on relatively small sample sizes and cannot be applied to variable congenital heart disease (8). Recently, Sithamparanathan et al. (8) suggested a new classification of great vessel and coronary artery anatomy in transposition and other coronary anomalies using cardiac CT. It includes both descriptive classification for clinical purpose and an alphanumeric classification for taxonomy and research. This simple, universal codex allows delineation of the coronary anatomy, anatomical relationship of the aorta to the pulmonary artery, as well as application to all congenital heart disease patients. It also

![Fig. 2. Diagrams of the coronary anatomy showing our case and typical ccTGA. Dashed lines represent variably present branches. ccTGA = congenitally corrected transposition of the great arteries](image-url)
provides the prognostic information by description about inter-arterial malignant course and the number of coronary ostia in each aortic sinus. However this new classification needs to be clinically validated in the near future. Therefore, the manner in which we described our CT findings is partially adapted from previous reports (4, 8, 9).

Our patient had ccTGA combined with a coronary artery anomaly detected on cardiac CT. Ismat et al. (4) reported several coronary anomalies in 10 ccTGA patients and described the typical orientation of the coronary arteries (Fig. 2). Typically, the right ventricular artery arises from the posterior sinus, and the anterior descending and circumflex arteries branch from a common left ventricular coronary artery from the anterior right sinus. Compared with this typical type, our patient had two additional ostia located in the right and anterior left sinuses. The first additional coronary artery was a right ventricular branch from the anterior left sinus, and the second additional coronary artery was a right ventricular artery with a retropulmonary course originating from the anterior right sinus. Chiu et al. (10) classified the coronary artery types in ccTGA into five patterns according to similarities in the epicardial configuration at the base of the heart. However, our patient did not concord with any of these five patterns.

We report an unreported coronary artery anomaly in a ccTGA patient. Knowledge of this coronary artery anomaly is a prerequisite for surgical correction, and cardiac CT is useful for detecting combined coronary artery anomalies.

Acknowledgments

This work was supported by a 2015 Clinical Research Grant from Pusan National University Hospital.

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선천성 수정 대혈관 전위 환자에서 새롭게 보고된 관상동맥 변이

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선천성 수정 대혈관 전위 환자의 45%에서 관상동맥 변이를 동반하고 있으며, 심장 수술을 시행하기 전에 이러한 관상동맥 변이를 찾는 것은 중요하다. 우리는 선천성 수정 대혈관 전위가 있는 51세 여자 환자에서 발견된 관상동맥 변이를 보고하고자 하며, 이는 이전 문헌에서는 보고되지 않았던 종류의 변이이다.

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