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Rare case of single left coronary artery in a Japanese cadaver

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ABSTRACT

A single left coronary artery with a single orifice in the left aortic sinus was observed during anatomical practice in an 81-year-old male Japanese cadaver. The single left coronary artery bifurcated into the anterior interventricular branch (IVa) and circumflex (CXa) branches. The IVa descended into the anterior interventricular sulcus to supply the apex of the heart, leaving a branch that traversed the upper part of the infundibulum to supply the anterior upper region of the right ventricle. The CXa curved leftward in the atrioventricular sulcus to reach the posterior surface, after which it continued to emerge into the anterior surface. The vascular running pattern showed that CXa directly supplied blood to the upper right ventricle (but not the conus branch), with three branches connected to the apex. The atrial arteries showed no anomalous distribution patterns. These findings are useful during surgical procedures, including

cardiac catheterization.

Key words: cadaver, single coronary artery, left coronary artery, anatomical variant, circumflex

INTRODUCTION

The left and right coronary arteries from the ascending arterial sinus are the only arteries supplying the entire heart with blood; therefore, they are among the most important arteries in the human body. Coronary artery constriction can cause ischemic cardiac dis-eases. In the typical arterial ramification and lining course, the right coronary artery branches from the right Valsalva sinus of the ascending aorta and the left coronary artery branches from the left Valsalva sinus of the ascending aorta. The typical right coronary artery has a posterior interventricular branch (the right posterior descending artery). A typical left coronary artery has two main branches: the anterior interventricular branch (left anterior descending artery) and the circumflex branch (left circumflex artery). Various unusual ramification patterns have been reported in clinical data from angiographs and cadaver studies of coronary arteries in cardiac ischemic disease. In unusually reported ramification patterns, a single coronary artery is a rare congenital anomaly in which only one coronary artery arises from the aortic trunk from a single coronary ostium and supplies the entire heart [16].

However, a single coronary artery is thought to be a rare cardiovascular malformation discovered accidentally at autopsy [2]. Recently, unusual vascular running of a single coronary artery has been considered one of the pathogeneses of complicated heart disease [7]. Furthermore, recent cases of single coronary arteries with angina, myocardial infarction, and sudden death have been reported [5, 20, 22]. Because the treatment of complications of a single coronary artery often involves catheterization and surgical approaches, it is crucial to study the detailed vascular running of the single coronary arteries. Although there are many reports on angiography [1, 17, 20], there are few reports on cadaver dissection [11]. We report a case of a single left coronary artery found during gross anatomy practice at the Tokai University School of Medicine, including a vascular running and embryologic discussion.

CASE REPORT

This case was found in the cadaver of an 81-year-old Japanese man (number: 1971, cause of death: heart failure) which was used for gross anatomy practice at Tokai

University School of Medicine in 2017. Branches with an external diameter leaguer than 2 mm were counted. Digital caliper, thread and ruler were used for measurements. No pathological findings were observed in the heart. This study complied with the guidelines of the Japanese Association of Anatomists. A cadaver designated for education and research (Tokai Daigaku Kentai No Kai) was used in this study. Written informed consent was obtained from the ante-mortem of the Tokai Daigaku Kentai No Kai.

The left coronary artery had a single orifice in the left sinus (Figure 1a). The orifice had an interior diameter of 4.6 mm (equal to the interior diameter of the blood vessel) and was located at the level of the rim of the left aortic sinus (sinotubular junction). No holes or pits were found in the hypoplastic right coronary artery on the aortic wall.

At a distance of 10 mm from the origin, the left single coronary artery, 8 mm in external diameter at the root, bifurcated into the anterior interventricular branch (IVa, 4.8 mm in external diameter) and circumflex (CXa, 5.1 mm in external diameter) branch (Figure 1b).

At its origin, the IVa branched into small twigs to the wall of the pulmonary trunk, the upper surface of the ventricles around the base of the pulmonary trunk, and between the pulmonary trunk and the aorta. Subsequently, the IVa branched into eight main branches to the left and three main branches to the right while running in the anterior interventricular groove (Figure 1b–e). Eventually, the IVa reached the apex (Figure 1b–e).

In the branch to the left of the IVa, passing 10 mm from the origin of the IVa and CXa branches, the IVa gave off the first branch to the left, the first left branch running to the anterior wall of the upper left ventricle, equivalent to the first diagonal branch (D1) of the coronary artery segment classification by the American Heart Association (AHA classification) [4]. A second branch was released to the left 18 mm after the first branch, bifurcated into two, and moved to the anterior wall of the lower left ventricle and apex, equivalent to the second diagonal branch (D2) of the AHA classification [4]. The third branch was released to the left 8 mm after the second branch, and moved to the apex. The fourth, fifth, sixth, seventh, and eighth branches were released to the left 35, 30, 12, 11, and 20 mm from each previous branch, respectively, and moved to the anterior wall of the lower left ventricle and apex (Figure 1b–e).

In the branch to the right of the IVa, passing 50 mm from the origin of the IVa

and CXa branches, the IVa gave off the first branch to the right, the first right branch, equivalent to the conus branch of the AHA classification [4] running to the anterior upper region of the right ventricle. A second branch was released to the left 36 mm after the first branch, equivalent to the right ventricular branch of the AHA classification [4], and ex-tended to the anterior wall of the central part of the right ventricle. A third branch was re-leased 72 mm from the second branch and went to the apex (Figure 1b–e).

The CXa curved left around the atrioventricular sulcus beneath the left auricle to reach the posterior surface, coursed to the right across the crux of the heart, and passed under the opening of the inferior vena cava, running the right ventricle below the right auricle. During its course, the CXa gave off 13 main branches downward to the surface of the right and left ventricles, three of which reached the apex (Figure 1b–g). Branches down-ward of the CXa passed 0.2 mm from the origin of the IVa and CXa branches. The CXa gave off the first branch downward, running to the anterior wall of the upper left ventricle. The second branch was released downward 10 mm after the first branch, branched into two, and moved to the anterior wall of the upper left ventricle, equivalent to the obtuse marginal branch of the AHA classification [4]. The third branch was released downward 20 mm after the second branch and went to the upper left ventricle wall. The fourth and fifth branches were released downward 0.8 and 0.5 mm after each previous branch, respectively, and went to the apex. The sixth and seventh branches were released down-ward 0.2 and 20 mm after each previous branch, respectively, and went to the left ventricle wall. The third to seventh branches correspond to the posterior lateral branches of the AHA classification [4]. An eighth branch was released downward 18 mm after the seventh branch and moved to the apex, equivalent to the posterior descending branch of the AHA classification [4]. The ninth branch was released downward 10 mm after the eighth branch and moved to the upper left ventricle wall. The tenth branch was released down-ward 0.6 mm after the ninth branch and went to the upper right ventricle wall, equivalent to the right ventricular branch of the AHA classification [4]. The eleventh, twelfth, and thirteenth branches were released downward 0.8, 40, and 15 mm from each previous branch, respectively, and moved to the upper right ventricular wall (Figure 1b,d–f). At a distance of 15 mm from the thirteenth branch, it bifurcated into a branch toward the pulmonary artery and atrium (Figure 1f). The branch toward the atrium ran 36 mm between the aorta and right auricle, branching to the wall of the left and right atrium (Figure 1f). The thick branch leading to the right atrium, which is equivalent to the sinus node branch of the

AHA classification [4], ended at the wall near the superior vena cava (Figure 1f).

The CXa branched into two main branches in the left atrium. One branch was near the third branch going downward (left ventricular wall) from the CXa (Figure 1b) and the second was the final branch of the CXa (Figure 1f). The CXa branched into 2–5 main branches to the right atrium. One branch was near the twelfth branch running downward (right ventricular wall) from the CXa (Figure 1f), and the second branch was the final branch of the CXa (Figure 1g). In addition, the third to fifth branches diverged toward the inferior vena cava ostium. Some of these were equivalent to the atrioventricular branch of the AHA classification [4] (Figure 1g).

DISCUSSION

Coronary artery anomalies are mainly reported by observations on angiographs. In the present study, a single left coronary artery was observed in the Japanese cadaver. The vascular running of IVa and CXa branching from the left single coronary artery was dissected in detail in this study. Single coronary artery is a rare congenital anomaly in which only one coronary artery arises from the aortic trunk of a single coronary orifice supplying the entire heart [16]. Coronary artery anomalies are not frequently observed during routine cardiac catheterization, and the incidence of anomalous coronary arteries reportedly ranges from approximately 0.2% to 1.6% in patients undergoing coronary angiography and 0.3% in autopsies [1, 20, 21]. A single coronary artery constitutes approximately 2–4% of all coronary anomalies, and isolated single coronary arteries occur in approximately 0.024–0.066% of the population [1, 6, 13, 20]. The incidence of left and right single coronary arteries is approximately 1.8% and 1.5% of all coronary anomalies, respectively, and is approximately 0.02% of the population [20].

Lipton et al. classified cases of a single coronary artery into three groups (Groups I, II, and III) and further divided them into nine types according to branch variations of the coronary artery [13]. They used “R” or “L” to indicate whether the orifice is located in the right or left sinus of Valsalva. The present case was of the L-I type (Figure 1h). The L-I type indicates a left single coronary artery originating from the left Valsalva sinus, which has an IVa and continues in the interventricular groove, similar to the left CXa. In other words, the L-I type occurs when the right coronary artery is congenitally absent and the CXa is markedly dominant. Reportedly, 40% of single coronary artery anomalies are associated with congenital heart diseases such as tetralogy of Fallot, transposition of the great arteries, persistent truncus arteriosus,

pulmonary atresia, coronary arteriovenous fistula, and bicuspid aortic valve [3, 16]. Moreover, a single coronary artery is considered a potential cause of sudden death and severe heart disease such as myocardial ischemia [8, 10, 14, 15, 19]. Therefore, catheterization and surgical interventions are important in single coronary artery cases. Further, it is necessary to determine which blood vessels run through a single coronary artery.

Most reports on a single left coronary artery involve angiographic observations [1, 17, 20]. The branches of the IVa and CXa are unclear in the angiographic reports. Thus, a cadaver study is useful for observing the branches of the IVa and CXa. In this case, the blood sup-ply area of the right coronary artery other than the conus branch was supplemented with the CXa branches. The acute marginal branch was not confirmed. Koizumi et al. [11] re-ported a single left coronary artery (conus branch) in a Japanese female cadaver; the branch to the upper surface of the right ventricle was the conus branch branching from the IVa, and only one branch from the CXa to the apex was observed [11]. However, in our case, the final branch from the CXa went to the upper surface of the right ventricle, and the conus branch ran only along the upper anterior wall of the right ventricle. In addition, three branches reached the apex of the CXa in our case. Thus, there were two differences compared with the case reported by Koizumi et al.'. These two vascular runs are characteristic of the present case. This information is useful as supplementary information for cardiac surgery and catheter treatment.

The embryology of a single coronary artery is not well understood. During normal coronary artery development, sinusoids develop from blood islands in the epicardium and anastomose with each other to form a capillary network. Subsequently, the capillary network repeats developmental arterial remodeling and creates a communication path with the coronary artery originating from the Valsalva sinus is created [12, 18]. According to reports on a single coronary artery, the proximal anlage of the absent coronary artery fails to develop, and the capillary network on the heart wall loses its connection with the aorta to obtain new flow by anastomoses between the distal portion of the absent coronary artery and the normal coronary artery [11, 16]. When the sprouting of the right aortic sinus fails to develop or form a connection with the capillary plexuses, a single left coronary artery can be embryologically understood.

This case showed two known characteristics from the rare cases of single left coronary artery. However, few cases of single left coronary artery have been reported, and a detailed examination of the vascular anatomy has not been performed. Therefore,

the discussion of the morphology and embryology of the left coronary artery is limited. For future cardiac treatment, reports of single left coronary artery need to be examined in detail with regard to vascular running.

CONCLUSIONS

A single left coronary artery was observed in the cadaver of an 81-year-old Japanese man. New information indicates that in a single left coronary artery, CXa, not the conus branch, directly supplies blood to the upper right ventricle and sends three branches to the apex. This information helps in catheterization and surgical approaches.

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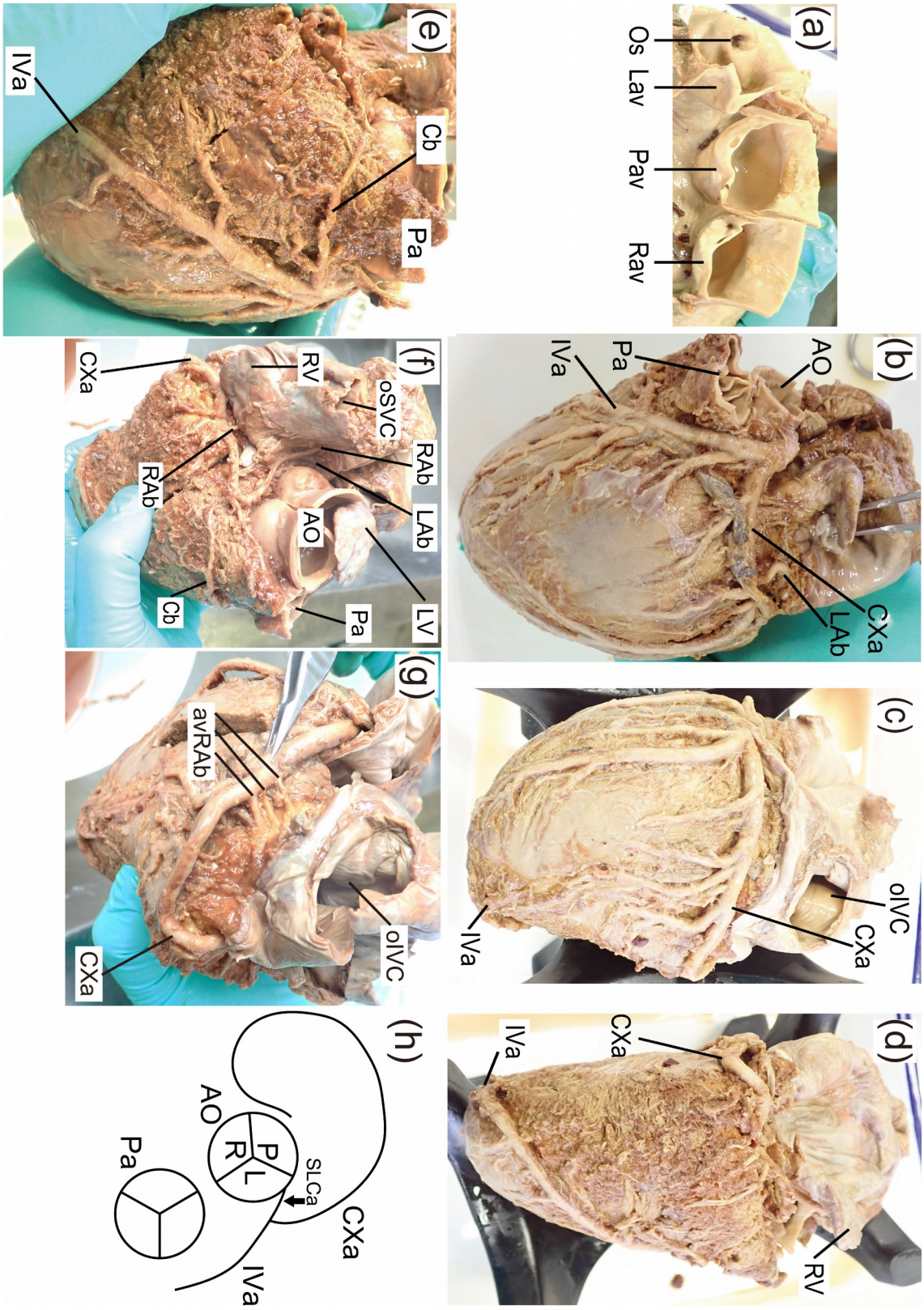

Figure 1. Single left coronary artery (SLCa) and blood vessels branching from SLCa, observed from various directions. Each panel ([a] to [g]) in the figure demonstrates each aspect. Schematic diagram representing the L1 type Lipton classification of a

single coronary artery (h). The orifice is located in the left sinus (of). Some right atrial branches (RAb) are atrioventricular branches (avRAb). AO, abdominal aorta; avRAb, atrioventricular branch; Cb, conus branch; CXa, circum-flex artery; IVa, anterior interventricular branch; L, left Valsalva sinus; LAb, left atrial branch; Lav, left aortic valve; LV, right ventricle; oIVC, opening of the inferior vena cava; Os, orifice of single left coronary artery; oSVC, opening of the superior vena cava; P, posterior aortic sinus; Pa, pulmonary artery; Pav, posterior aortic valve; R, right Valsalva sinus; Rav, right aortic valve.