Unusual Coexistence of Type II Bovine Aortic Arch, Left Dominant Coronary Artery, and Tunneled Left Circumflex Artery in Single Donor Who Had Double CABG

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ABSTRACT

Background: Anatomy This case report presents an incidental finding in a 90-year-old male donor of the unusual coexistence of three variations: a type II bovine aortic arch, a left-dominant coronary artery, and a tunneled left circumflex artery. The donor had indicators of prior double coronary artery bypass grafts and had a listed cause of death of head injury caused by a motor vehicle accident. Many studies have shown that bovine aortic arch, coronary artery dominance, and tunneled coronary artery variants do not cause clinical symptoms but are risk factors for cardiovascular and neurological diseases. The combined presence of these risk factors around a single heart might further increase the risk of developing associated diseases requiring interventions, including coronary artery bypass grafting, as seen in this donor, to improve coronary circulation. Therefore, knowledge of such variations, which can be associated with significant life-threatening conditions, is vital for the prevention, early diagnosis, and management of the consequent diseases.

Keywords: Coronary artery; Coronary artery bypass graft; Left coronary artery dominance; Type II bovine aortic arch; Tunneled left circumflex artery

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INTRODUCTION

The aortic arch (AA) typically gives rise to three branches: the brachiocephalic trunk (BT), the left common carotid artery (LCCA), and the left subclavian artery (LSA), and, rarely, the thyroidea ima artery. However, a two-branch pattern, as in the bovine aortic arch (BAA), is a well-documented variant [1,2] and is classified as Type I or Type II BAA [2,3]. These variants are believed to be benign and do not cause clinical symptoms, but they are risk factors for cardiovascular and neurological diseases [2-7]. Such variations can also exert mechanical compression on adjacent structures, causing functional impairments of the compressed structures [8,9].

Coronary artery dominance (CAD) depends on whether the left and/or right coronary arteries (CAs) give rise to the posterior descending artery (PDA) that supplies the posterior one-third of the interventricular septum [10]. Based on this, coronary circulation can be classified as right-dominant (RCAD), left-dominant (LCAD), or codominant (balanced) types. In most cases, the PDA originates from the right CA, making the coronary circulation RCAD, which accounts for the largest share of the coronary circulation [10]. The LCAD type, in which the PDA arises from the left circumflex artery (LCiA), a branch of the LCA, is less common than the RCAD type. In contrast, the codominant type, in which the PDA arises from both right and left CAs, is even less common [10]. Although these CADs are also believed to be benign, they can be associated with adverse cardiovascular events, such as ischemic heart disease and coronary artery disease, as well as structural heart diseases and coarctation of the aorta

[11-15]. Studies have also shown that left and codominant CA circulations are associated with higher in-hospital mortality among patients undergoing percutaneous coronary intervention for acute coronary syndromes (ACSs) [15]

The CAs normally lie on the surface of the heart, in the epicardial fat of the epicardial space, between the epicardium and myocardium; hence, they are known as epicardial CAs [16]. Myocardial bridging (MB) is a variation in which a segment of an epicardial CA courses intramyocardially. A myocardial bridge is part of the myocardium overlying the artery, and the segment of the artery beneath the bridge is a tunneled coronary artery [17,18]. Though tunneling most commonly affects the LADA [18], the LCiA may also be tunneled [19, 20]. MB or a tunneled CA is a clinically benign aberration with variable incidences in imaging and autopsy studies [20,21]. However, systolic compression of the tunneled artery can cause ischemia, myocardial infarction, spasm, or malignant arrhythmias [21], as well as conduction disturbances and sudden cardiac death during increased cardiac demand [22,23].

Even though BAA, CAD, and MB are considered benign risk factors, they can be associated with diseases that require invasive or noninvasive procedures to improve coronary circulation, including coronary bypass surgery (CABG), which is a potentially life-saving procedure for severe occlusive coronary arterial disease and congenital heart diseases. CABG provides the greatest survival benefit from revascularization for patients at the highest risk of angina and ischemia [24]**.** However, CABG has its own limitations, in that ACS often occurs in patients with prior CABG [25,26]. Despite this, CABG remains pivotal in alleviating symptoms and provides a prognostic advantage for most patients [27]. Many previous studies have also noted the advantage of multiple arterial bypass grafts in reducing long-term mortality and major adverse cardiac and neurological events [28-32].

In this report, we present the coexistence of BAA, LDCA, and Tunneled LCiA in a single donor with a double CABG in a 90- year-old male donor whose listed cause of death was a head injury caused by a motor vehicle accident.

MATERIALS AND METHODS

This case report presents an incidental finding during the dissection of a 90-year-old male donor, in which an unusual combination of a type II BAA with the LCCA originating from the BCT, a LCAD giving branches to LADA, a tunneled LCiA that continued as PDA, and a double CABG, which included ascending aorta (AsA)-to-PDA and left internal thoracic (LITA)-to-LADA bypass grafts. The variant structures and the bypass grafts were carefully dissected, cleaned, and photographed. The Microsoft PowerPoint Draw application was used with red coloring to highlight these variant structures and bypass grafts in the images.

RESULTS

During the opening of the pericardial sac, two intercrossing vascular structures connecting the LITA to the LADA and the AsA to the PDA were observed (Figures 1 and 2). Further dissection of the great vessels at the base of the heart revealed that the AA gave branches only to the BCT and the left subclavian artery. The LCCA originated from the BCT within 1-2 cm of the AA, ran to the left, and ascended to the neck anteromedial to the left subclavian artery (Figures 1 and 2). The dissection of the CAs revealed that the LCA gave rise to both LADA and PDA (Figure 2). In addition, it was found that LCiA was tunneled and covered with myocardial coat from the point of its origin to the crux on the posterior surface of the heart. It exited the myocardium and continued as PDA in the posterior interventricular sulcus (Figure 2).

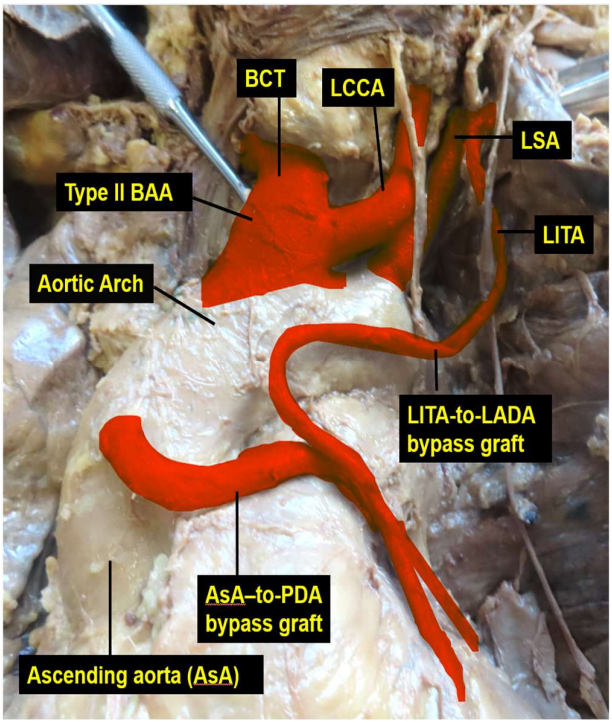

Figure 1: Intra-cadaveric view of the type II bovine aortic arch (BAA), showing the left common carotid artery (LCCA) originating from the brachiocephalic trunk (BCT). The figure also illustrates the left internal thoracic-to-left anterior descending artery (LITA-to-LADA) and a portion of the ascending aorta-to-posterior descending (AsA-to-PDA) bypass grafts.

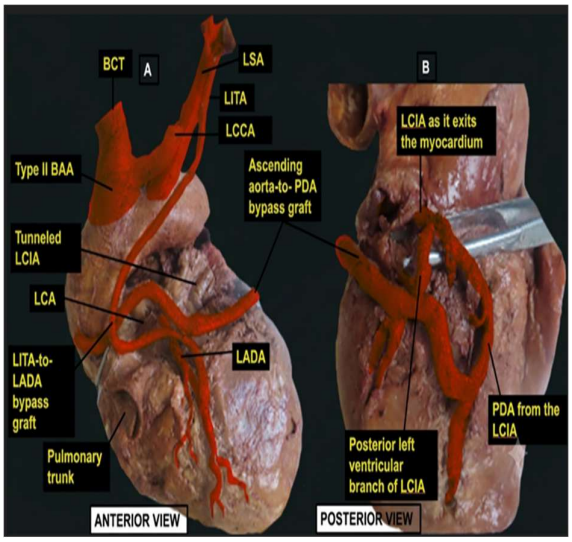

Figure 2: (A) Illustrates the type II bovine aortic arch (BAA) with the left common carotid artery (LCCA) originating from the brachiocephalic trunk (BCT), and the left dominant coronary artery (LDCA) with its branches- LADA and the tunneled LCiA. (B) shows the LCiA exiting the myocardium near the crux and continues in the posterior interventricular sulcus as the posterior descending artery (PDA). The LITA-to-LADA and AsA-to-PDA bypass grafts are also demonstrated in both A and B.

DISCUSSION

The prevalence of BAA, in which two branches instead of the typical three arise from the AA, ranges from 1% to 41% in cadaveric and imaging studies [1]. However, according to a retrospective review of 817 serial computed tomography images, the prevalence in the US population ranged from 15% to 35% [2]. In the review study by Moorehead, PA et al. [2] and a recent case report on CT angiography findings of the aorta by Singh A et al. [3], BAA was described as a vascular aberration in which either the LCCA and the BT have a common origin from the AA (type I) or the LCCA arises from the BT (type II). Typically, BAA is benign and asymptomatic; however, it may be associated with a higher prevalence of ischemic, vascular, and neurologic complications or diseases [2,3]. Moorehead et al. [2] reported a close association between thoracic aortic dissection, thoracic aortic aneurysm, hypertension, hyperlipidemia, aortic calcification, and type II BAA. Furthermore, Singh A et al. [3] noted that patients with BAA have a substantially higher rate of hypertension and a thinner layer of tunica media, with a consequent higher risk of aortic dilation/dissection, intramural hematoma, coarctation, and stroke. The prevalence of BAA in a variety of cardiovascular and neurological disorders, such as in patients suffering embolic stroke [4,5], its hemispheric laterality [5], and its association with idiopathic pulmonary artery aneurysm with bronchial compression [6], was also well described in the literature. One study on the association between BAA and CA stenosis revealed that left-sided CA disease is more common in individuals with BAA and that this variant may be a marker of increased cerebrovascular risk [7]. Moreover, there are case reports of mechanical effects of BAA that may compress adjacent structures, such as the trachea and esophagus, leading to dyspnea, dysphonia, and dysphagia [8,9].

CAD, which depends on where the PDA originates from to supply the posterior 1/3 of the interventricular septum, is also widely studied and reported in the literature. In most cases (85.5%), the PDA arises from the RCA [10]. In comparison, the dominance pattern for the LCA and the codominant (balanced) type is only 9.7% and 4.8%, respectively. Therefore, right dominance is a typical feature of coronary circulation [10]. As described by Wu, B. et al. [11], the prevalence of left-dominant and codominant coronary circulation decreases with age, suggesting that these types may be associated with early death. CADs, though, are also accepted as benign variations; they can be associated with adverse cardiovascular events, such as ischemic heart diseases, coronary artery diseases such as calcifications, dysrhythmias, conduction diseases, and structural heart diseases such as ventricular hypertrophy and valvular involvement [11], and coarctation of the aorta [12]. The left-dominant type is strongly associated with calcified plaque in the LADA [13]. In contrast, the codominant type is associated with more right CA issues [14]. Likewise, a previous study of 207926 percutaneous coronary interventions for ACSs revealed that left-dominant and codominant coronary circulations are particularly associated with higher in-hospital mortality among patients undergoing percutaneous coronary intervention [15].

Myocardial bridging (MB) is a variation in which a segment of an epicardial coronary artery courses intramyocardially [16]. A myocardial bridge is the muscle overlying the artery, and the segment of the artery beneath the bridge is a tunneled artery [17,18]; this primarily affects the proximal and middle segments of the LADA [18]. MB (tunneled CA) is a clinically benign variation with a variable incidence of 2-7% in invasive coronary angiography, 19-22% in cardiovascular computed tomography angiography, and 45% in autopsy [19,20]; however, significant systolic compression can cause ischemia, spasm, or malignant arrhythmias [20]. In a retrospective descriptive study of 132 cases, Sylvia, MT et al. [21] found

tunneling in 28 cases (21.2%). Most of these were in LADA (86.2%), while 10% were in the RCA, and 3.2% in the LCiA. Though it seems less frequent, there are many reports regarding LCiA bridging [22,23]. Clinically, MB may be silent but may cause significant ischemia leading to myocardial infarction, conduction disturbances, and sudden cardiac death [24,25].

The diseases associated with these benign risk factors could require invasive or noninvasive interventions to improve coronary circulation, including a CABG. For severe occlusive coronary arterial disease and congenital heart diseases, CABG is a potentially life-saving procedure. According to Mery CM et al. [26], CABG provides the greatest survival benefits from revascularization for patients at the highest risk of angina and ischemia. CABG is strongly recommended for diabetics because the disease is usually diffuse, distal, progressive, and associated with sudden death [26]. However, according to Eikelboom, R et al. [27], CABG has its own limitations, in that about one-third of patients after CABG are at risk of early and late graft failure, which increases the risk of acute coronary events, and in 5-10% it also increases the risk of progression of the underlying atherosclerotic disease process, which can result in myocardial infarction, stroke, and cardiovascular death. ACS often occurs in patients with prior CABG [28]. Patients with ACS and prior CABG are, therefore, at an increased risk of acute and long-term complications [28]. Despite this, CABG remains a vital cornerstone in the alleviation of symptoms and provides a prognostic advantage for patients suffering from complex multivessel and left main coronary artery disease [29]. Moreover, many previous studies have also indicated the advantage of multiple arterial bypass grafts using radial and internal thoracic arteries in reducing long-term mortality and major adverse cardiac and cerebral effects [30-32].

CONCLUSION

As it was well documented in many studies, BAA, CAD, and MB do not cause clinical symptoms but are risk factors for cardiovascular and neurological diseases. We speculate that the unusual co-occurrence of these three risk factors in and near a single heart, as seen in this donor, probably further increases the risk of associated diseases requiring interventions, including CABG, to improve coronary circulation and quality of life. Therefore, awareness of the possibility of the coexistence of such variations as risk factors is paramount for prevention, early diagnosis, and management of associated life-threatening cardiovascular and neurovascular conditions.

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