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Anatomical variations of coronary circulation and the outcome of acute coronary syndromes: A brief review

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Abstract. Coronary circulation is one site in the human body where many variations are encountered. In addition to well-known risk factors, there are certain anatomical variations that might increase the risk of acute coronary syndromes and determine the outcome of it. Therefore, these variations have a prognostic significance. However, most of the time, a variation in coronary circulation is an incidental finding during an intervention. As such, there is little interest in looking at them from a screening point of view and the majority of the people are unaware of it until an incident strikes. Since screening for them is not routine practice, detection during procedures is helpful in order to make alterations in the routine management for the betterment of the patients. In this review, three such common anatomical variations in coronary circulation; left dominance, variants of left anterior descending artery and myocardial bridging are discussed from an anatomical point of view. All three of them have made individuals more prone to develop deleterious effects following acute coronary syndrome.

Keywords. Coronary dominance, left anterior descending artery, myocardial bridge, acute coronary syndrome

INTRODUCTION

The heart is supplied by two coronary arteries; the right and the left. The right coronary artery (RCA) originates from the anterior aortic sinus and the left coronary artery (LCA) originates from the left posterior aortic sinus of the ascending aorta (1). The RCA descends between the infundibulum and the right auricle and runs in the coronary sulcus to meet the inferior border of the heart. It gives off a right marginal branch that runs towards the apex, before turning on to the posterior aspect of the heart, where it crosses the crux of the heart and gives origin to the posterior descending artery (PDA), before terminating in the posterior part of the coronary sulcus by anastomosing with the circumflex branch of the left coronary artery (1). PDA runs in the posterior interventricular groove supplying the posteroinferior part of the interventricular septum including the atrioventricular node and bundle. Branches of RCA supply the right atrium, ventricle and a variable part of the left heart chambers and the interventricular septum. In the majority of the hearts, the LCA is larger in calibre than the RCA (2). It runs between the pulmonary trunk and the left auricle and emerges into the atrioventricular groove. Apart from smaller branches given off during the course, it divides into its two major branches left anterior descending (LAD) and circumflex branches. LAD supplies the adjacent parts of the two ventricles and the anteroinferior part of the interventricular septum while the circumflex branch curves back to the posterior part of the interventricular groove terminating left of the crux in most hearts (1). LAD is the largest calibre vessel in the coronary circulation and therefore when it is obstructed the outcome is unfavourable nick-naming it “widow-maker heart attack” (3). LCA supplies a larger amount of myocardial tissue, which includes almost the entire left ventricle and atrium, and most of the interventricular septum except in right dominant hearts where RCA supplies a variable amount of the left ventricular wall. However, irrespective of the state of dominance, the left coronary artery supplies a greater volume of the heart muscle (1).

Anastomoses between right and left coronary arteries are copious during the foetal life but they become less prominent towards adulthood (1). Anastomoses may become prominent later in life providing collateral circulation in case of chronic hypoxia encountered in coronary artery disease (4). Coronary circulation is a common site of obstruction. Acute coronary syndromes occur as a result of blockage of a segment of the coronary artery mostly due to atherosclerosis. The outcome varies

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depending on the location and extent of the block. Apart from well-known risk factors, certain anatomical variations in the coronary circulation seem to determine the prognosis of acute coronary syndromes. Therefore, it is worth studying these variations in order to understand the prognostic significance of such normal variations and also to take precautions to minimize the consequences as much as possible.

The commonly encountered such variations include left dominance, variants LAD and myocardial bridging (MB).

CORONARY DOMINANCE

Dominance is determined by the coronary artery that gives origin to the PDA which supplies the posterior part of the interventricular septum and part of the posterolateral wall of the left ventricle. In the majority of hearts, it is given off by the right coronary artery; making the individual right dominant. The remaining hearts are either left dominant or co-dominant. In left-dominant hearts, PDA is given off by the circumflex branch of the left coronary and in co-dominant hearts it is replaced by a network of vessels formed by both right and left coronary arteries (5).

Approximately 70-80% of the hearts in a population are right dominant whereas the remaining have more or less equal weightage as either left dominant or co-dominant (6). Dominance has an important role to play in myocardial perfusion, not only because the area supplied by main branches changes with the dominance pattern, but also because the volume of blood carried by major vessels changes as a result. Researchers have shown that coronary blood flow in the left circumflex artery was significantly higher in left-dominant or balanced circulation compared to right-dominant circulation whereas flow in the right coronary artery was significantly lower in left-dominant or balanced circulation (7). These changes in volume and area of distribution had made certain groups of individuals more vulnerable to acute coronary syndrome and the subsequent outcomes.

In a study conducted by Abu-Assi et al among 767 patients with ST elevation myocardial infarction treated with primary percutaneous coronary intervention (PCI), left dominance had shown a significant association with mortality (8). In further analysis, they have found that left dominance is an independent predictor of reinfarction as well. In another study by Goldberg et al, where a large cohort of patients (27,289) with acute coronary syndrome was followed up and left dominance was found to be a significant independent predictor of higher mortality (9). Further, Iwama et al. studied a group of patients who had undergone emergency PCI due to acute total/subtotal occlusion of the unprotected left main coronary artery and divided their group into two subgroups RCA dominant and non-dominant depending on the size of the RCA. Interestingly, deaths due to all causes were significantly lower in the group with dominant RCA than in the non-dominant RCA group (10). In left dominance, left ventricular ejection fraction was found to be significantly lower than that of right dominant or co-dominant circulations at baseline; however, at 12 months of follow-up, there were no differences in left ventricular function or volumes among the different dominance groups (11). The fact that there is no difference in left ventricular function among dominance groups at 12-month follow-up indicates the importance and identifies the need for special attention. In all the above studies and in many more, left dominance played an important role in the outcome of acute coronary syndrome. Understanding the importance of left coronary circulation, particularly in the case of left dominance, current clinical practice guidelines recommend revascularization for all patients with more than 50% stenosis present in the left main coronary artery (12).

However, there were instances where controversial findings have been encountered occasionally. In a case-control study by Wang et al where 265 individuals with acute inferior MI were compared with 530 age and sex-matched controls, there was a significantly higher distribution of right dominance among the cases (13). Such findings are possible with variations in the extent of supply of the vessel concerned.

VARIANTS OF LAD

LAD supplies blood to a large part of the myocardium which includes the left ventricular wall and the interventricular septum. The amount of myocardium supplied varies depending on the anatomy of LAD. Therefore, occlusion of its proximal portion may influence the severity of acute anterior

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wall MI. Ilia et al studied a group of patients presented with acute anterior wall MI at their institution over 10 years. They divided the patients into two subgroups depending on the length of LAD; one group had LAD wrapped around the apex of the heart, whereas in the other group, LAD terminated at or before the apex of the heart. They showed that long LAD was a strong predictor of death compared to shorter in this group of patients (14). Obviously, when the extent of supply is greater, the damage is severe when there is an obstruction to the artery concerned. On the other hand, having a short, narrow LAD artery does not necessarily determine the severity of the disease if the left ventricular apex is partially or completely supplied by the PDA (15).

Interestingly, long LAD wrapped around the apex of the heart was found to be associated more with left dominance than with right dominance (11,12). It indicates that left dominance not only determines that PDA is given off by LCA but also has an impact on the anatomy of the other branches of it, mainly LAD. Moreover, according to some studies, the left coronary arterial bed seems more atherogenic than the right system (18). Since curvilinearity and bifurcations make coronary arteries more susceptible to atherosclerosis (19), it is understandable, that when both LAD and PDA are given off by the left coronary artery, increased curvilinearity and bifurcations would have made it atherogenic than the right system.

MYOCARDIAL BRIDGING

Myocardial bridge (MB) is formed when a part of a coronary artery which usually has a subepicardial route; penetrates the substance of the myocardium, taking an intramyocardial course, forming a bridge by the myocardium over that particular segment of the artery which is now called as a tunnelled artery (20). According to the depth of location in the myocardium and the anatomical arrangement of the myocardial fibres on that particular segment of the artery i.e. superficial traversing or encircling; MB could be classified into either superficial or deep (21). The pathophysiology of MB is complex since the outcome varies with the degree of hemodynamic changes produced by it. MB is usually considered a benign condition, but there are instances where the obstruction leads to considerable cardiac symptoms, causing myocardial ischemia, arrhythmia or sudden cardiac death (22). The area supplied by the particular vessel undergoes myocardial ischemia as a result of the alteration in hemodynamics, even in the absence of atherosclerosis. Though MB can occur in any epicardial vessel, it is common in LAD (23). According to a meta-analysis done by Hostiuc et al, MB was associated with major adverse cardiac events and myocardial ischemia but not with cardiac events identified by imaging techniques or exercise stress testing (24). MB is most often detected in isolated cases. There are several reported cases of MI in patients with MB detected as incidental findings (25,26). There are some interesting phenomena associated with MB. Though it is a congenital anomaly, there are rare cases where MB has disappeared following an MI (27). Detecting MB is useful in an individual like an athlete who is undergoing strenuous exercises to prevent unforeseen ischemic insult to the myocardium. Both invasive (e.g. intravascular ultrasound, coronary angiography) and non-invasive (e.g. doppler ultrasound, MRI) methods can diagnose MB with high sensitivity and specificity (21). Unlike the other two anomalies discussed above MB is a treatable anomaly.

CONCLUSIONS

Anatomical variations of the coronary circulation are not uncommon. Left dominance, variants in the left anterior descending artery and myocardial bridging had shown an interesting association with myocardial ischemia and its consequences. In the majority of instances, they make the individual more prone to an acute cardiac event and /or worsen the outcome. Though we hardly change the anatomy of the coronary circulation we are born with, the insight about the matter would make somebody's life better and in fact, might save a life.

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