Anatomical and Radiological Study of the Variations of the Left Coronary Artery in Man

Thesis

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Abstract

Knowledge of the left coronary artery anatomy is of great importence to avoid misdiagnosis of coronary illness.

The present study was designed to assess the incidence of different anatomical variations of the left coronary artery and their branchies.

Keywords:

Variations- Artery- Left- Coronary- Anatomical-Radiological.

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Introduction

The anatomy of the coronary arteries has been extensivelydescribedfor at least three centuries. However, most of the reports are based on views and respectives obtained from gross specimens **(Fiss, 2007;Young et al., 2011).**

Cardiac computed tomography (CT) provides detailed information regarding the coronary arteries but its usage requires a firm understanding of basic gross anatomy of these arteries**(Tomar et al., 2013).**

Detailed description of the origin, course, branches and myocardial distribution of these arteries is vital so that these variations could be easily recognized and applied to clinical practice**(Fiss, 2007).**

The morphology of the left coronary artery has been reported to present wide variability regarding its length, caliber and the mode of branching. Its trunk divides into several ways: bifurcation into left anterior descending (LAD) and circumflex (CX) branches or trifurcation into LAD, CX and median or ramus intermedius (RI) arteries**(Beg et al., 2015)**. Tetra-and pentafurcation patterns of branching have been also mentioned**(Reig and Petit, 2004; Roy et al., 2014).**

The bifurcation pattern has been described as the most frequent one**(Chougule et al., 2014).** Recently, technical advances in computed tomography (CT) have improved image quality, diagnostic performance, and accuracy of coronary CT angiography (CCTA)**(Graidis et al., 2015)**. Dose-reduction strategies have reduced radiation dose to an acceptable level even lower than that from conventional coronary angiography

(Altin et al., 2015). Three dimensional CCTA is a noninvasive imaging modality which can effectively show complex anatomy and variations of the coronary arteries**(Erol et al., 2013).**

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Aim of the Work

This study was designed to:

1- Describe the regular anatomy of the left coronary artery in human cadaveric hearts and in 3D-CCTA images of living individuals.

2- Identify the anatomical variants of the left coronary artery and its branches in both methods of study.

3- Assess the percentage of each variant of the left coronary artery.

4- Correlate some of the variations of the left coronary artery, met in the current work, to the incidence of clinical problems reported in literature.

Review of Literature

Anatomy of the Left Coronary Artery in Man

The arterial supply of the heart is provided by the right and left coronary arteries which arise from the ascending aorta immediately above the aortic valve. The coronary arteries and their major branches are distributed over the surface of the heart, lying within the subepicardial connective tissue **(Snell et al., 2011)**.

The left coronary artery (LCA) presents a wide range of variations in its origin, length and branching pattern. These variations have anatomical, pathophysiological, diagnostic and therapeutic implications. An in-depth knowledge of these variations is of paramount importance in management of congenital and acquired heart diseases. Failure to distinguish these variations may lead to misinterpretations and disastrous complications during heart surgery **(Tomar et al., 2013).**

The coronary arteries are the first vessels that branch from the aorta, normally originating below the junction between the bulbus and the ascending aorta, i.e. at the sinotubular junction. The patency of the LCA is vital for sufficient perfusion of most of the heart. The LCA is responsible for irrigation of most of the left ventricle and also a considerable proportion of the right ventricle **(Hosapatna et al., 2013).**

The left coronary artery which is usually larger than the right one, supplies the major part of the heart including the

greater part of the left atrium and left ventricle **(Dewey and Kroft, 2009; Michael and Sherly, 2015)**.

The LCA arises from the left posterior aortic sinus. Its length is variable, although it is not usually more than a few millimeters. It lies between the pulmonary trunk and the left auricle, emerging into the anterior part of the left atrioventricular (AV) groove where it then turns to the left. On reaching the AV groove, the LCA usually divides into two main branches: the left anterior descending (LAD) and the circumflex (CX) arteries **(Beg et al., 2015).**

The LCA divides in several ways. It bifurcates into left anterior descending (LAD) and circumflex (CX) arteries or trifurcates into LAD, CX and ramus intermedius (RI) arteries. Ramus intermedius artery is also termed as intermediate branch (IMB) or ramus medianus and it arises between LAD and CX arteries. Presence of ramus intermedius artery is the most common anatomic variation observed in the left coronary system and its incidence is reported to be 33% (**Dewey and Kroft, 2009)**. The size of ramus intermedius artery varies greatly from a small vessel to a large one that gives branches **(Koşar et al., 2009)**.The bifurcation pattern is the most frequent mode of branching of the LCA **(Chougule et al., 2014).**

The LAD artery is considered, for practical purposes, as the continuation of the left main artery. It passes to the left of the pulmonary trunk, travels into the anterior interventricular groove and continues toward the apex of the heart **(Snell et al., 2011)**.

The LAD artery forms a 90° angle, often highlighted by the origin of the second diagonal branch. Surgically, this location is very important as it represents the point at which the LAD becomes amenable to bypass. How far the LAD artery extends is variable but it usually continues to the heart- apex. Occasionally, the LAD artery bifurcates into two parallel vessels which descend along the edges of the interventricular sulcus toward the heart apex. During its course, the LAD artery is often covered by superficial muscle fibers which run at right angles to the vessel creating what is known as a "myocardial bridge" **(Fiss , 2007;Young et al., 2011).**

The LAD artery gives right and left anterior ventricular, anterior septal branches, and a variable number of corresponding posterior branches. The right anterior ventricular branches are small and rarely more than one or two arteries and the right ventricle is almost wholly supplied by the right coronary artery**(Standring et al., 2008; Kim et al., 2015).**

The left ventricular branches of the LAD artery are known as the diagonal branches, because they branch from their parent vessel at acute angles and extend over the left ventricle in a diagonal fashion toward the inferior margin and apex of the heart. They run parallel to one another and are variable in number (2- 9). If a ramus intermedius artery is present, the diagonal arteries are less prominent and arise more distally. The first diagonal branch tends to be the most prominent. When the first diagonal artery is large, the other diagonal arteries tend to be small and run a shorter course.

One of the large diagonal branches may arise separately from the left coronary trunk that ends in a trifurcation pattern. This left diagonal artery is reported to be present in 33-50% of individuals, being sometimes duplicated in 20% of cases. A small left conus artery frequently leaves the LAD artery close to its beginning and anastomoses on the conus arteriosus with its counterpart from the right coronary artery and with the vasa vasora of the pulmonary artery and aorta. The anterior septal branches leave the LAD artery almost perpendicularly and pass back and down in the interventricular septum to supply its ventral two-thirds. Small posterior septal branches arise from the LAD to supply the posterior one-third of the septum at a variable distance from the cardiac apex **(Standring et al., 2008; Erol et al., 2013).**

The anterior septal perforators range in diameter from 0.5 to 1.2 mm. Their length varies from 40 to 80 mm. These arteries tend to become shorter as they approach the cardiac apex. Like the septal branches of the posterior descending artery, the anterior septal perforators travel along the right ventricular border of the interventricular septum. The anterior septal perforators mechanically immobilize the LAD fixing it to the heart, limiting its motion, and preventing buckling of the artery during systole **(Young et al., 2011).**

Clinicians divide the course of the LAD artery into three segments: proximal (from its origin to the first major septal perforator), middle (from the origin of the first septal perforator to the 90° angle at the second diagonal branch), and

distal (from the second diagonal to the artery- end) **(Erol et al., 2013)**.

Right ventricular branches of the LAD artery, when present, are usually short and they extend over the adjacent right ventricular surface to meet right ventricular branches of the right coronary artery (RCA). Occasionally a prominent branch, known as the left preinfundibular artery, arises from the proximal part of the LAD artery and courses over the superior portion of the right ventricle to meet the conus artery **(Fiss, 2007)**.

The circumflex (CX) artery arises from the LCA at almost a right angle. Its course nearly mirrors that of the RCA as it travels below the left atrial appendage, in the left AV groove around the left margin of the heart **(Standring et al., 2008).**

Occasionally, the CX artery may not course in the AV groove but rather descends over the left ventricular surface diagonally toward the apex, terminating at the midportion of the posterior interventricular groove. At its origin, the CX artery has a diameter of 1.5 to 5 mm. The degree of variability of the circumflex artery and its branches is comparable to that of the RCA. The CX artery may extend to become the posterior descending artery and supply the AV node **(Ballesteros and Ramirez, 2008).** The RCA is usually the dominant artery (60%). Coronary dominance becomes left when the posterior interventricular (posterior descending) artery arises from the circumflex branch of the LCA **(Standring et al., 2008).**

Clinicians divide the course of the CX artery into three segments: proximal (from the artery- ostium to the origin of the first major obtuse marginal branch), middle (between the first and second obtuse marginal branches), and distal (beyond the origin of the second obtuse marginal branch). According to the site of their origin, the left atrial branches of the CX artery are categorized into: left anterior, marginal, or posterior. In 40% of subjects, the sinoatrial node is supplied from an atrial branch of the CX artery. When this is the case, the sinoatrial branch travels upward along the left atrium, behind the aorta, to the anterior interatrial sulcus then it continues rightward to partially encircle the lower portion of the superior vena cava **(Fiss, 2007; Young et al., 2011).**

Anastomoses between branches of the coronary arteries, subepicardial or myocardial, and between these arteries and extracardiac arteries are of prime medical importance. Clinical experience suggests that anastomoses cannot rapidly provide collateral routes sufficient to circumvent sudden coronary obstruction, and the coronary circulation is assumed to be end-arterial. Nevertheless, it has long been established that anastomoses do occur, particularly between fine subepicardial branches, and they may increase during individual life. Analyses of coronary radiographs and resin corrosion casts, and the results of radio-opaque perfusion studies have revealed intra-and intercoronary anastomoses of coronary branches up to 100-200 μm in calibre. The most frequent sites of extramural anastomoses include the apex, the anterior aspect of the right ventricle, the posterior aspect of the left