

ORIGINAL ARTICLE

VARIANT CORONARY ARTERY AMONG CADAVERIC HEARTS IN ETHIOPIA

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ABSTRACT

Introduction: Coronary artery variation/anomaly is defined as a coronary artery with abnormal origin, course, termination or anomalies of intrinsic coronary arterial anatomy. Thorough, sound and complete knowledge of the magnitude of a variant coronary artery is important for correct interpretation of angiography findings mainly during cardiac surgery.

Objective: The aim of the study was to identify a variant coronary artery among cadaver hearts in Ethiopia.

Methods: A descriptive, laboratory-based, observational study was conducted. A total of thirty cadaver hearts were obtained from the Department of Anatomy in different medical schools of Ethiopia.

Result: The median arteries were identified in 43.3% of the specimens. The myocardial bridge was found in three (10%) of the hearts of the median arteries. The presence of myocardial bridge was significantly associated with median artery (p -value <0.05). The conus artery or third coronary artery arose separately from right aortic sinus and nourished the proximal outflow part of the right ventricle in 6.7% of the hearts. In most hearts (66.7%), the sino-atrial nodal artery originated from the right coronary artery. The right coronary artery was dominant in 63.3%, while the left coronary artery was dominant in 23.3%, and in the remainder these arteries were codominant.

Conclusion: This study identified important coronary artery variation among Ethiopian cadaver hearts. Further investigation should be conducted on live individuals using imaging modalities.

Keywords: Anatomical variation, Cadaver, Coronary artery, Heart.

INTRODUCTION

The heart receives an arterial supply for its myocardium and epicardium from the right and left coronary arteries. The endocardium and subendocardial tissues of the heart are nourished by diffusion or microvasculature directly from the chambers of the heart (1).

The right coronary artery (RCA) originates from the anterior right coronary sinus slightly inferior to the origin of the left coronary artery (LCA). The RCA passes posteriorly to the right of the pulmonary artery and traverses in the right atrioventricular groove to the posterior interventricular septum. The RCA gives off the conus branch in around 50% of the people; in the remaining the conus artery may arise directly from the right coronary sinus(2). Next, the RCA gives rise to the sinoatrial node artery, many right ventricular branches, the marginal branch and finally divides into the posterior interventricular artery (PIVA) and posterior left ventricular branches in a right dominant anatomy (2, 3).

The left coronary artery (LCA) originates from the left coronary sinus and passes to the left of and posterior to the pulmonary trunk. Usually, it bifurcates into the anterior interventricular artery (AIVA) and left circumflex (LCx) arteries. Sometimes, the LCA trifurcates into the AIVA and LCx arteries and the median artery.

The AIVA artery passes to the left of the pulmonary trunk and passes through the anterior interventricular groove toward the apex. It gives off the diagonal branches to the anterior free wall of the left ventricle and the septal branches to the anterior interventricular septum. The LCx artery passes over the left atrioventricular groove and gives rise to marginal branches and posterior left ventricular branches in a left dominant anatomy (2-4).

The dominance of the coronary arterial system is defined based on the origin of the posterior interventricular artery which typically supplies the inferior portion of the interventricular septum. In right dominance (about 85% of individuals), the right coronary artery crosses to the posterior interventricular groove and give rise to a posterior interventricular artery. In left dominance (7-8%) the left circumflex artery crosses the interventricular groove and give rise to the posterior interventricular artery. The remaining cases are named as codominance (7-8%) by which the inferior interventricular septum is perfused not by the posterior interventricular artery but by branches from distal RCA and LCx (1, 2).

The term “normal coronary anatomy” refers to the structures that are habitually observed. The term “anomaly” or infrequent variation is used for variations that occur in less than 1% of the general population (5).

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However, authors used different criteria for classifying coronary artery into normal or variant. In this research, we used some minimal criteria adapted from Texas Heart Institute.

The coronary arteries should have the following criteria to be considered as normal coronary arteries: 1) dual aortic and separate origins from the right and left coronary ostia; 2) the course of the right coronary artery follows the right atrioventricular groove and that of the left coronary artery follows the left atrioventricular groove and anterior interventricular

groove; 3) the posterior interventricular branch originates from either the right or left coronary arteries; 4) the left main coronary artery (left main trunk) bifurcates into the anterior interventricular and left circumflex branches; 5) the major coronary branches flow epicardially and their branches terminate at the myocardial capillary level (6) (Fig 1). Failure to distinguish between normal and anomalous structures may lead to misinterpretations and disastrous complications during heart surgery.

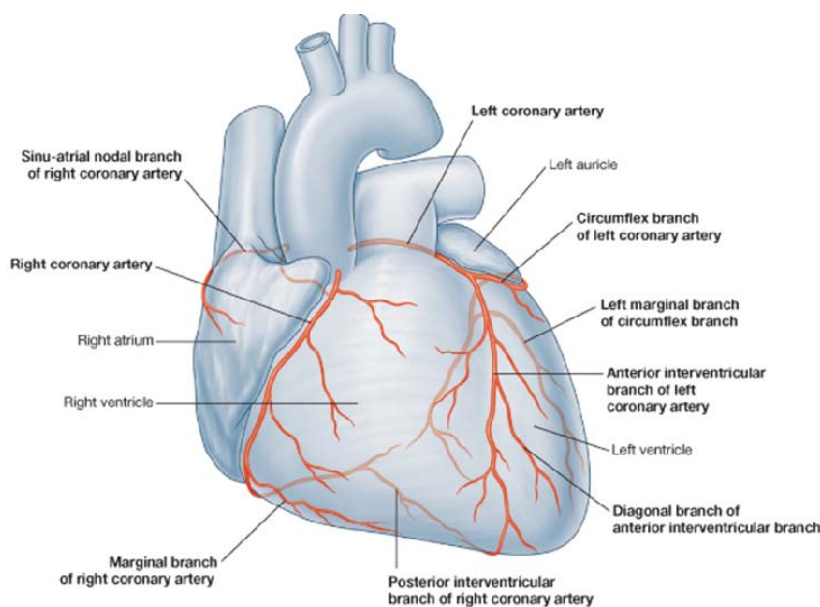


Figure 1: figurative representation of normal coronary artery and its branches. (adapted from Drake R et al, 2009(7)).

A coronary artery anomaly is defined as a coronary artery with abnormal origin, course, termination or as an anomaly of intrinsic coronary arterial anatomy(8). Such anomalies are seen in 0.3% to 1.3% of patients undergoing diagnostic coronary angiography, in 1% of routine autopsies, and in 4% to 15% of young individuals who experience sudden death (9).

Many authors have stated that some of the coronary artery variations are considered as normal variant or minor anomalies. In spite of this, there are hemodynamically significant anomalies. These include: anomalous origin of the coronary artery from the opposite sinus with a course between the aorta and pulmonary artery, anomalous origin of the coronary artery from the pulmonary artery, myocardial bridging, and coronary artery fistula (10-12).

Complete knowledge of the magnitude of a variant or anomalous coronary artery is important for those who undergo diagnosis and intervention for cardiac diseases.

There are numerous studies from developed countries on the prevalence and the pattern of variant coronary arteries. However, epidemiological data on this issue originating from developing countries is limited, and in Ethiopia totally neglected. Therefore, this study is aimed to assess the magnitude of variant coronary arteries.

MATERIALS AND METHODS

A descriptive, laboratory-based, observational study design was conducted with the aim of identifying the prevalence of variant coronary arteries. A total of thirty (30) cadaver heart specimens used in this study were collected from the Department of Anatomy from different medical schools in Ethiopia. The study was approved by the ethical review committee of Wollo University prior to data collection. The specimens were collected irrespective of religion, age, and medical diagnosis. Any heart which was considered to be traumatized by injury or subject to a pathological process was excluded from the study.

Each heart was preserved by an embalming fluid (10% formalin, phenol solution, and glycerin). The epicardial and subepicardial adipose tissues were removed and the root of both right and left coronary arteries was investigated.

Each coronary artery was examined for their branches, pathway, and area of distribution. The origin of the conus branch was identified. For the purpose of determining coronary arterial dominance, the artery that supplied the posterior interventricular sulcus was investigated. The number of hearts with median artery and its origin was also investigated. Dye was injected through the left coronary orifice in order to visualize the median artery and myocardial bridge. A transverse section of the ascending aorta was made 2 cm above the sino-tubular junction in order to visualize the coronary sinuses and ostium.

Finally, all findings from the hearts were photographed, coded and entered to Epi-info 7. The data were analyzed by using SPSS version 20 statistical software. A p-value <0.05 was considered statistically significant. Descriptive statistics were applied and the results are presented in text, tables, and figures.

RESULTS

A total of 30 cadaveric hearts (23 males and seven females) were investigated in this study. All specimens had both right and left coronary arteries and the three aortic sinuses (anterior, right and left). The right and left coronary arteries arose from the right and left aortic sinuses respectively (Fig.2).

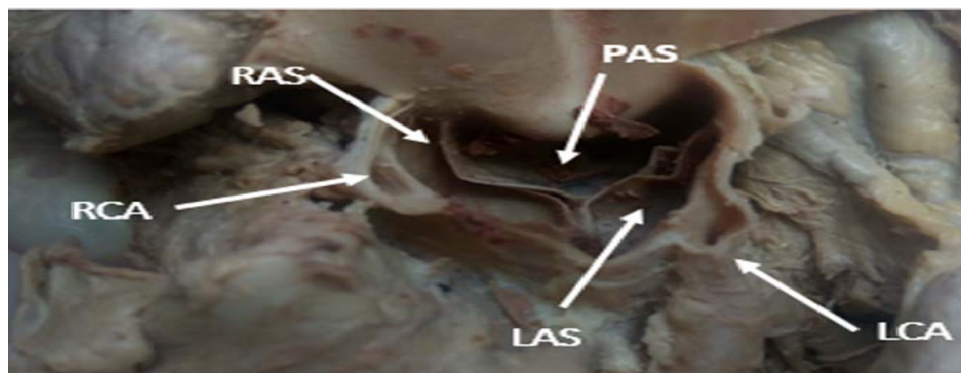


Figure 2: A photograph of transversely sectioned ascending aorta (male) showing the three aortic sinuses and the two coronary ostia. RAS: right aortic sinus; LAS: left aortic sinus; PAS: posterior aortic sinus; RCA: right coronary artery; LCA: left coronary artery.

Table 1: The common type of coronary artery variations seen in this study.

Type of variation	Sex		Frequency % N=30
	Female	Male	
Myocardial bridge	0	3	3(10%)
Median artery	3	10	13(43.3%)
Conus artery arose from right coronary artery	6	20	26(87.7)
Conus artery arose from right coronary sinus	1	3	4(13.3%)
SA nodal artery arose from RCA	4	16	20 (66.7%)
SA nodal artery arose from LCA	3	7	10 (33.3%)

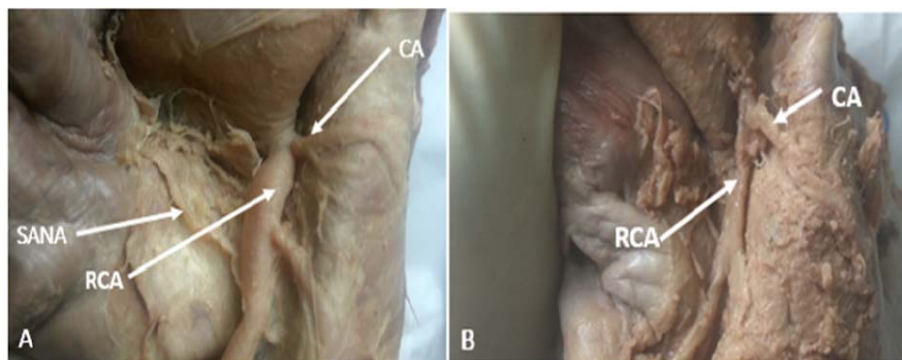


Figure 3: Photograph shows (A) the conus artery arises from right coronary sinus and SA nodal artery arising from right coronary artery, and (B) the conus artery originating from right coronary sinus. RCA: right coronary artery; SANA: SA nodal artery; CA: conus artery.

The SA nodal artery arose from RCA in 66.7% of the hearts. In the remaining hearts (33.3%) the SA nodal artery originated from the LCA. More distally, the RCA gave rise to marginal branch in all hearts and posterior interventricular artery (PIVA) in 63.3% (Fig 6). In 23.3% of the hearts the PIVA originated from the left circumflex branch of LCA.

The main trunk LCA bifurcated into the anterior interventricular artery (AIVA) and left circumflex in 56.7% of hearts, trifurcated into one median artery in addition to the AIVA and left circumflex artery in 26.3%, and quadrifurcated into AIVA, left circumflex and two median arteries in 16.7% of the specimens (Fig 4).

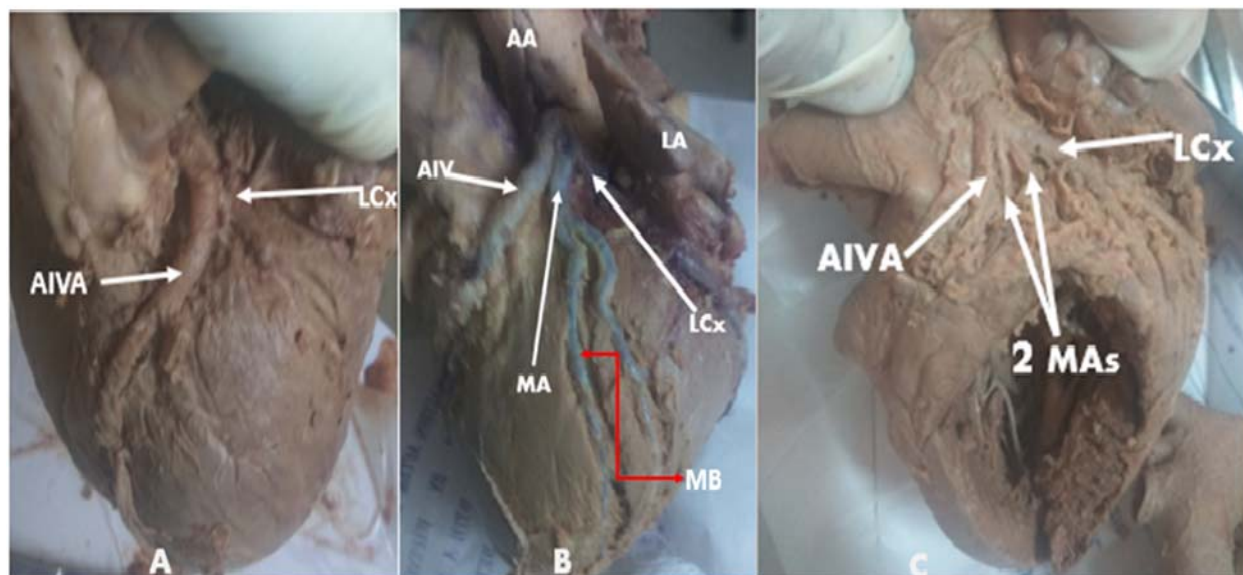


Figure 4: Photograph shows branches of left coronary artery. (A) Bifurcation, (B) Trifurcation and muscle fibers form myocardial bridge removed (red z line), (C) Quadrifurcation. AIVA: anterior interventricular artery; LCx: left circumflex; MA or MAs (plural): median artery or arteries; MB: myocardial bridge; AA: Ascending aorta; LA: Left auricle.

In all hearts, the AIVA arose from LCA under left auricle and passed in the anterior interventricular groove towards the apex of the heart. This is observed in Figure 4B where the AIVA originated from the LCA under the left auricle flap, and in Figure 4A where it passes through the anterior interventricular groove.

The median artery or ramus intermedius was found in 43.3% of the specimens. One median artery (26.3% of hearts) and two median arteries (16.7%) arose from the main trunk of the LCA. Most of the median arteries, eleven of thirteen were small as compared to the other two usual branches, whereas the remaining two median arteries were comparable in size with the AIVA and left circumflex branch (Fig 4C).

One of the median arteries arose singly from the LCA main trunk and then bifurcate, pass through the cardiac muscle fibers forming a bridge over it and reach to the apex of left ventricle unlike

the other which mostly terminated to the proximal segment of the left ventricle (Fig 4B). All the median arteries were distributed to the anterior surface of the left ventricle (Fig 4).

Ten percent (10%) of the coronary artery branches passed through the myocardium forming myocardial bridge, meaning the main artery passed through a tunnel forming cardiac muscle fibers. All such arteries were median arteries (Fig 4B), and this association reached statistical significance (p value= 0.037).

Based on which coronary artery gave rise to the posterior interventricular branch, coronary arterial dominance was also investigated. Right dominance accounted for most of the specimen (63.3%), while left dominant and codominance contributed for 23.3% and 13.3% respectively (Fig 5).

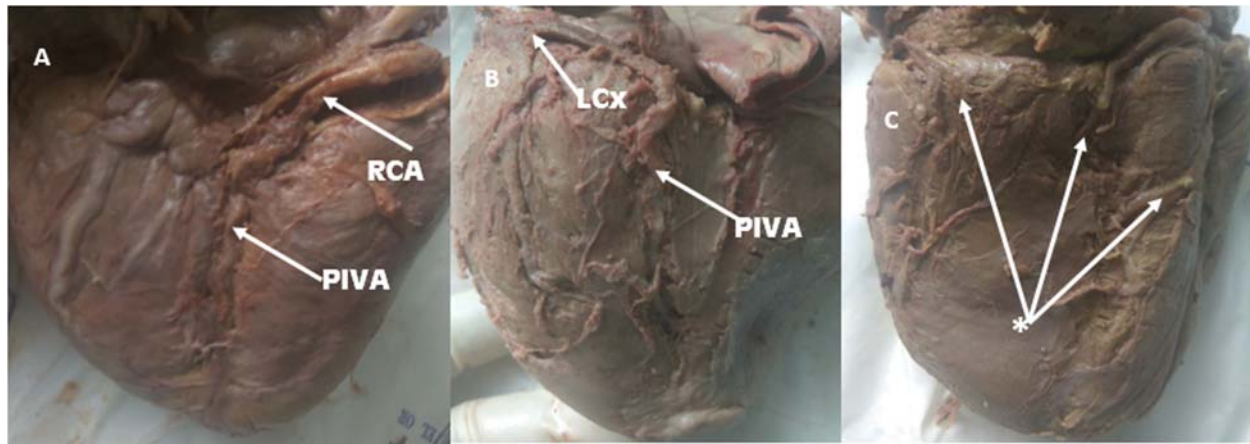


Figure 5: Photographs show coronary arterial dominance. (A): right dominant; (B): left dominant; (C): co-dominant. RCA: right coronary artery; LCx: left circumflex; PIVA: posterior interventricular artery; Asterisk (*): branches from both RCA & LCA.

DISCUSSION

Coronary arteries have long been investigated by anatomist and clinicians. However, the definition of “normal” and “abnormal” coronary artery is still equivocal. The consensus is that the majority of hearts have left and right coronary arteries, with some hearts having additional artery (13).

Coronary arteries can vary in their origin, distribution, number, and size. The nature of variation may be minor or major, a normal variant or a hemodynamically significant anomaly. These variations are studied by gross anatomic inspection, injecting corrosive chemicals or by radiography (5).

The knowledge of the existence of variant or anomalous coronary arteries is important to correctly interpret angiographic findings. During open-heart surgery, it is very difficult to cannulate vessels which arise from the anomalous ostia. While performing coronary arteriography and angiography, a preliminary aortic root injection of the dye must be given to locate the exact number of orifices and coronary arteries, so that fatal outcomes can be prevented. In addition, variants with particular hemodynamic significance have potential clinical implications (5). For example, an abnormal origin of a coronary artery from the pulmonary trunk or pulmonary artery has a chance to cause: myocardial infarction, mitral insufficiency, congestive heart failure and death in early infancy (14, 15). Reversed aortic sinus origin of coronary arteries is associated with cardiac ischemia and sudden death. Myocardial bridges are also reported to cause myocardial ischemia, infarction, stunning, left ventricular dysfunction, life threatening arrhythmias, exercise-induced tachycardia and sudden cardiac death (16, 17).

Understanding and diagnosing coronary artery variations is very critical in planning the treatment and interpretation of findings of cardiovascular diseases, especially for patients undergoing coronary arteriography, coronary interventions and cardiac surgery(18). Some investigators even suggest coronary artery variations like right coronary dominance are associated with the severity of coronary artery disease (19).

The first demonstrable variation identified was the origin of the conus artery, which for most hearts represents the first branch of the RCA. However, in some other heart samples it arose from the right aortic sinus and therefore, this artery is frequently referred as the third coronary artery (20). In our study, we found a conus artery variation in 13.3% of the heart samples. This finding is consistent with results reported by Erol and Seker, Gajbeet al and Kalpana who reported that in 17%, 16% and 24%, respectively, of the cases the conus artery directly originated from right aortic sinus (21-23). Other investigators also have reported higher frequencies of the third coronary artery (conus artery) (Table 2). According to Miyazaki and Kato, variation in prevalence were explained by differences in age or physiologic growth (24).

The presence of the third coronary artery has been reported to supply blood to the interventricular septum upon occlusion of the anterior interventricular artery. This may compromise diagnostic tests to evaluate AIVA occlusion and ischemia (20, 23). In addition, it has been reported that radiological establishment of the appropriate location and origin of the conus artery in relation to the right ventricular outflow tract prior to surgical treatment of tetralogy of fallot is critical (25).

Table 2: Comparison of coronary artery variation among various research. RD: right dominant, LD; left dominant, CD: co-dominant, BF: bifurcation, TF: trifurcation, QF: quadrifurcation.

Authors	Method and number of samples	Third coronary artery %	Coronary artery dominance %			LCA branching %		
			RD	LD	CD	BF	TF	QF
Gajbe U L et al. (2008)	Dissection (30)	16						
Fazliogullari Z et al. (2010)	Dissection (50)	68	86	4	10	46	44	10
Kalpana R (2003)	Dissection (100)	24				47	40	11
Olabu BO et al. (2007)	Dissection (148)	35						
Erol C and Seker M (2012)	Angiography (2096)	17	86.6	9.6	3.8			
Grande N et al.(1982)	Dissection (710)		33.6	32.2	34.2			
Loukas M et al. (2006)	Angiography (1000)		24.4	66.6	8.7			
Kate et al. (2008)	Dissection (208)		85.1	8.8	6.1			
Ogeng'o JA (2014)						54.8	32.2	9.6
Leguerrier A et al. (1976)						65–70	20–30	5–10
The present study	Dissection (30)	13	63.3	23.3	13.3	56.7	26.7	16.7

The overall prevalence of the median arteries reported by different investigators has varied from 31% to 54% (13, 21, 23). Our finding (43.3%) was within this range. We did not find a significant relationship between sex and presence of medial arteries, a finding also consistent with the aforementioned studies.

Another controversial variation is a myocardial bridge in which the main artery passes through a tunnel-shaped bridge of cardiac muscle fibers. Its occurrence is highly variable and ranges from 5%-80% (29). The present study found 10% of hearts with a myocardial bridge; all were from median arteries, which was highly significant statistically. The association between myocardial bridges and the medial artery is support by the study of Fazliogullari Z et al (13), though they observed a higher prevalence (81.5%) than our study.

Coronary arterial dominance has different definitions according to different authors. In this study, dominance was based on the origin of the PIVA. In right dominance, the PIVA arose from the RCA, and in left dominance the PIVA arose from the LCx, and in codominance, there was no PIVA, but branches from both LCx and RCA supplied the posterior interventricular groove. The frequency in this investigation was 63.3%, 23.3% and 13.3% for right, left and codominance, respectively. This distribution is consistent with the studies of Erol and Seker and Kate et al (21, 30).

Variability in prevalence exists between the present study and other studies listed in Table 2. These differences may be related to operational definitions of dominance.

In conclusion, this study found different coronary artery variations among cadavers in Ethiopia. The variations included the presence of the median artery, a myocardial bridge and third coronary artery, arterial dominance and origin of the sino-atrial artery. These variations can have functional and clinical significance, for example, in coronary bypass surgery and angiography. Therefore, greater attention should be given for these variants during diagnostic investigations and surgical procedures. Further investigations should be conducted on the living individuals in order to clarify differences in observations by various researchers and clearly depict the association between coronary artery variation and cardiac diseases.

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Conflict of Interest:

Authors have no conflict of interest to declare.

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