



VARIATIONS IN THE ORIGIN OF THE CORONARY ARTERY IN BLACK AFRICAN POPULATION: A CADAVERIC STUDY IN WESTERN KENYA

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ABSTRACT

Background: The coronary arteries which originate from the right and left aortic orifices are the main blood vessels to the myocardium. Variations are anomalies which could affect the overall perfusion of the myocardium causing conditions like ischemic heart diseases leading to sudden unpredicted death. Variants can also cause confusion to cardiologists and heart surgeons leading to challenges in patient management. This study sought to determine these variations among black African population in Western Kenya by assessing the variations in origin of the coronary artery. **Methods:** A cross-sectional study design was used in the Maseno University, Uzima University and Masinde Muliro University Human anatomy laboratories. Out of a total of 89 cadavers, 72 samples were identified using Cochran's formula. Data sheets were used to capture the variables while descriptive statistics was used to calculate the frequency and percentage of the variation in the origin of the coronary arteries while Pearson's correlation test was used to analyze the relationship between the variables and variations $P \leq 0.05$ considered as significant. All ethical approval was issued via license number: NACOSTI /P/22/21905. **Results:** Dual aortic origin was the most common occurrence at 55.6% while 44.4% were variations with more than one orifice on the aortic cusps. **Conclusions:** There were variations which could be fatal during surgical procedures, but also important alternate pathway for the perfusion of the myocardium. There is need for early routine imaging of the heart for effective management and to avoid mortalities and morbidity associated with the variations.

Keywords: Origin, Cadaver, Coronary Artery, Variation.

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INTRODUCTION

The coronary arteries are the first blood vessels from the ascending aorta that supplies the muscles of the heart with oxygen and nutrients. The principal branches of coronary artery are the right coronary artery (RCA) and the left coronary artery (LCA) (Rehman *et al.*, 2011). Variations in the origin of coronary arteries are thought to be responsible for the changes in the coronary blood vessels. This changes could either be compensatory, collateral or a duplication of another vessel which could have positive or negative attributes depending on their location, distribution and function (Olabu *et al.*, 2007).

Joshi *et al.*, (2010) notes that the most common causes of coronary artery variations is the anomalous origin which is important in the clinical presentation like sudden death. These variants are the second commonest cause of sudden unpredicted death worldwide especially in the young professional athletes due to the changes they cause in the coronary blood vessels. The American heart association highlights that approximately 19% of fatal heart conditions are caused by coronary artery variations due to the differences in coronary blood flow which affects the perfusion of the myocardium (Angelini *et al.*, 2002; Gać *et al.*, 2022).

Procedures like cardiac catheterization, coronary bypass procedures done by cardiologist heart surgeons require uttermost keenness and accuracy to avoid fatal mistakes. The difference caused by these variants can have a severe effect on the perfusion of the myocardium complicating the management of heart diseases (Olabu *et al.*, 2007).

In Africa there is little literature on variations in the origin of coronary artery. However, its effects can be highly felt by the increase in cardiovascular mortality and morbidity with increased hospitalization and revascularization procedures (Khan *et al.*, 2020). A study by Olabu *et al.*, (2007) is among the few studies done in Africa and specifically in Kenya on these variations. The study asserts the prevalence of the third coronary artery and its role in the acceleration and extent of myocardial infarction (MI) in cardiac surgery but also notes its significance in the formation of collateral circulation and anastomosis.

Ogeng'o *et al.*, (2013) studied variation in luminal diameter of the left anterior

descending artery a branch of the left coronary artery and its significance as a cause of stenosis among different ethnic communities. He noted that variations were important markers in the development of atherosclerosis. Similarly, variations in the origin of the coronary arteries are important in relation to the overall perfusion of the myocardium, cardiac surgeries and coronary bypass procedures to enhance awareness and improved management to the patients among the healthcare providers. Asiki *et al.*, (2018) in the Kenya national guidelines for cardiovascular diseases notes that 25% of Kenyan population admission and 13% of deaths are due to cardiovascular diseases. There has been a steady increase in the prevalence of ischemic heart diseases in Western Kenya caused by non-communicable diseases like diabetes in the population (Chege, 2016). The aim of this study was to assess and report the variations in the origin of the coronary artery among black African population. This finding will play an important role to health providers in averting possible injuries due to mistakes.

MATERIALS AND METHODS

This was a cross sectional study in which convenient sampling was used to select cadavers from three Anatomy laboratories in Western Kenya. The study adopted mixed methods to select the desired sample size. The study area was stratified into the existing 3 Universities (Maseno, Masinde Muliro and Uzima universities) according to the number of cadavers available in each laboratory. The cadavers were grouped into gender (male or female) after which the samples for each laboratory were randomly selected.

To ensure equal distribution of samples, sampling was done proportionately with the strata population by location, where the sample size per laboratory was calculated by dividing laboratory cadaver (d) by total location population (n), multiplied by the

desired sample size (m); $n = (d/N)m$. As a result, 72 cadavers were acquired as the total actual sample size using the Cochran's formula (Cochran 1967) Ahmad & Halim (2017) from a total available specimen of 89 cadavers (Table 1). The cadavers were dissected to expose the thoracic cavity.

With the help of trained laboratory technicians, the visceral pericardium was removed and the coronary artery was observed and reflected to visualize the coronary artery and its variation. The observations were recorded in a data sheet and images were taken where variations were observed. The collected data was subjected to statistical tool and descriptive statistics was used to record the incidence of variations from normal while Pearson's correlation test was used to analyze the

relationship between the variations at a $P \leq 0.05$ considered as significant. The collected data was stored and processed in confidentially and was only be used for the current research. Approval was obtained from School of Graduate Studies Scientific

review committee. Ethical review was sought from Maseno University Ethics and Review Committee (MUERC) and National commission for Science Technology and Innovation (NACOSTI) via license number: NACOSTI /P/22/21905.

RESULTS

Of the total 72 specimens, 40 hearts 55.6% had dual aortic origin, one on the right and the other on the left for the coronary arteries while 24 hearts 33.3% had an orifice in the left and 2 orifices in the right (Figure 2). Five hearts (6.9%) had an orifice in the left and 3 in the right (Table 2). Among the 40.2% (29) cases which had an orifice in the left and 2-3 in the right, 16.6% (12) of the orifices were associated to the right conus artery with 9 originating from those with an orifice in the left and 2 in the right with the remaining 3

originating from an orifice in the left and 3 in the right. The sinoatrial nodal artery had 1 of its orifice originating from the right aortic cusps with 2 openings and the other with 3 openings. The remaining 4.2% (3) hearts had orifices all the orifices on the left aortic cusps and none on the right. As a result, 55.6% of the origin were normal while the remaining 44.4% were variations.

There was no statistical significance in the variation in origin of the coronary artery at ($p=0.463$) (Table 3).

Table 1: Distribution of cadavers from the different universities

Laboratory location	Population in laboratory(d)	Selected sample (n)
Maseno University	45	37
Uzima University	24	19
Masinde Muliro University	20	16
TOTAL	89(N)	72(m)

Table 2: Variation in the origin of the coronary artery.

Origin of the coronary artery	Frequency	Percent age
Dual aortic origin	40	55.6
Orifice in the left and 2 Orifice in the right	24	33.3
Orifice in the left and 3 Orifice in the right	5	6.9
Orifices in the left aortic cusps	3	4.2
Total	72	100

Table 3: Test for significance in variation of origin of coronary artery

Chi-Square Tests		
	Value	df
Pearson Chi-Square	4.630a	5
Likelihood Ratio	4.511	5
Linear-by-Linear Association	0.162	1
N of Valid Cases	150	

DISCUSSION

In the current study, 55.6% (40) hearts had normal dual aortic origin while the remaining 44.4% (32) had variations. Among the variations, 40.2% (29) had an orifice in the left and 2-3 orifices in the right, while 3

(4.2%) had orifices in the left and none in the right (Table 2). Normally, the right and left coronary arteries originate from the right and left aortic cusps (Figure 1). This enables the principal arteries to form branches

effectively that will efficiently perfuse the myocardium at all angles (Bhele *et al.*, 2017). A study done by Khwansang & Chentanez (2018) on 95 hearts (48 males and 47 female) in Thailand found a lower number in variation at 31% which were on the left and 2-3 orifices in the right aortic cusps. The lower number of variations from the previous study may have been due omission of origin of the conus artery from the 2-3 orifices as part of the variation. The current study considered any other orifice which was not of the normal dual aortic origin to be a variant and noted that any differences from the above was bound to cause imbalance in the coronary arterial pressures (Figure 2).

One of the positive aspects of the multiple variant orifice in the origin of the CA is that in cases of blockage of either of the main orifices, anastomosis from the variants could help in the perfusion of the myocardium. Notably, during surgery like cardiac catheterization and ventriculotomy the multiple orifices can cause confusion leading to injury or damage of the blood vessels (Ogeng'o *et al.*, 2013; Bhele *et al.*, 2017) (Figure 3)

Mutyal *et al.*, (2014) in his study on 60 Indian hearts found a much lower number in the variations at 13.33% (18) which were three to four orifices on the right aortic cusps. The study did not have any findings on orifices on the left aortic cusps as variants which could have led to the difference in the variations, but in the current study, three study specimens had orifices on the left aortic cusps with none in the right. This meant that blood supply to the right side of the myocardium was purely by anastomosis of the available circulation or collateral circulation from the orifices in the left.

Results of a study done by Vilallonga (2003) in Spain noted almost the same prevalence in variations of origin of the coronary artery at 40.3% (31) out of the total 211 hearts dissected, this is in line with the current

study, where the variant orifices were associated to the origin of the conus and the sinoatrial nodal artery. It was also noted that the presence of the variants could seriously jeopardize the functioning of the coronary arteries due to the alteration of different pressures that maintain coronary arterial circulation to the myocardium.

However, unlike Vilallonga's (2003) findings, there was a slight difference in specific variations where 16.6% (12) of the variations were found to be the origin of the conus artery while 2.7% (2) were from the origin of the SANA. This artery had one of its orifice originating from the right aortic cusps with 2 openings and the other with 3 openings. The conus artery and the sinoatrial nodal artery having their own orifice could be a saving effect to the heart such that in case of any damage or injury to the RCA with a patent aorta, the myocardium can be saved from myocardial infarction and ischaemia.

This is important especially with the current increase in non-communicable diseases, these variants can ensure proper perfusion after anastomosis and collateral circulation. However, they could also make management complicated during surgeries and even radiology. The success of delicate procedures like ventriculotomy highly depend on radiological features of the arteries before the surgery. In case of the multiple orifice and lack of opacification during radiology, fatal mistakes can be made during surgery leading to catheterization of the wrong artery. This could deny the heart muscles significant blood supply therefore predisposing it to multiple damages, injury and inability of the heart to compensate (Mutyal *et al.*, 2014).

Of importance to note is that the 44.4% variations in the origin of CA in the present study could have a serious circulatory effect on the myocardium which could easily predispose the heart to myocardial infarction and probably cardiac death. Khwansang &

Chentanez, (2018) therefore advises that these variations should be keenly noted when looking at the overall perfusion of the myocardium and more so during coronary angiographies and revascularization procedures. This is because they can cause confusion thus fatal mistakes.

Pearson's correlation test was used to analyze the relationship between the variables and variations $P \leq 0.05$ was not significant at ($p=0.463$). Meaning that there was no correlation between the variations in origin and the gender.

CONCLUSIONS

There were variations in the origin of coronary arteries, with most of the variant orifices occurring on the right side of the aortic cusps.

Furthermore, the variations can be beneficial or non-beneficial to the perfusion of the myocardium leading to the development of ischemic heart diseases.

Recommendations

Training of the health care providers. This is important for all the levels of healthcare provision so that they can be aware of the variations, their effect and how to manage them. Cardiologists and heart surgeons should also be continuously informed on the changes caused by these variants on the myocardium

Early routine imaging of the heart. This will note any changes that are occurring on the heart early enough and interventions can be easily put in place to avoid morbidity and mortality.

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