

# Variation in the Number and Location of Coronary Ostia – A Cadaveric Study

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## Abstract

**Objective:** Find out the pattern of anatomical variations in the number and location of coronary ostia in Pakistani population.

**Patients and Methods:** It was a descriptive type of study and was conducted in the department of Anatomy, Army Medical College, in collaboration with various medical colleges of Rawalpindi and Peshawar, Combined Military Hospital and Military Hospital Rawalpindi during 2011. The study was conducted on thirty heart specimens obtained from routine autopsies and dissection cadavers.

**Results:** In 29 out of 30 hearts, there was single ostium in each aortic sinus for each coronary artery but in one of them, an accessory ostium was present as well in right coronary ostium (RCO) which gave origin to right conus artery. RCO was situated at the level of sinutubular junction (STJ) in 8 (27%) cases; above STJ in 3 (10%) cases and below STJ in 19 (63%) cases. Left coronary ostium (LCO) was located at STJ in 8 (26.7%) cases; above in 1 (3.3%) cases and below in 21 (70%) cases.

**Conclusion:** The coronary ostial location at or below STJ is present in majority of cases, however the frequency of the number of coronary ostia and their locations vary among different populations as reported in this study on Pakistani population.

**Key words:** Coronary artery, Ostium, Cardiac surgery.

## Introduction

Coronary arteries are known for their variation in origin, number of branches and distribution, rather there is “variation in the variation of coronary arteries” in different populations. Knowledge of these variations is indispensable in the management of patients with ischemic heart diseases. There are geographical differences in the coronary artery variations, which may have a genetic basis and sound knowledge of these variations in coronary anatomy is vital to a cardiac physician and surgeon during management of a cardiac patient. Lack of knowledge of these variations may create serious problems in cardiac catheterization, or coronary artery bypass

surgery. Moreover, some of these variations are incompatible with life and/or can lead to sudden death<sup>1-2</sup> and hence their knowledge can provide a promising clue to a forensic pathologist in diagnosing cause of death.

Myocardium is supplied by right and left coronary arteries which may vary in origin, distribution, number of branches and size. The coronary arteries and their branches may arise as a common trunk, or both arise through separate ostia from same or different aortic sinus (es). In some cases, there is a single coronary ostium and either right coronary artery (RCA) or left main coronary artery (LMCA) is

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**Contribution of Authors:** Dr. Qazi Waheedullah conceived the idea; study designed and analyzed the data. Nazish Waheed, Shemaila Saleem and Khadijah Qamar cooperated with him in his work

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absent and the single coronary artery may be larger than usual. Very rarely, an extra coronary artery arises from the pulmonary artery. Occasionally, both RCA and LMCA arise from the pulmonary trunk, either singly or in combination which is incompatible with life. There may be three or even four independent coronary arteries arising through separate ostia which are, generally, quite small.<sup>2</sup>

Over the past few years, several researches from Asia and western countries, on the basis of catheter angiographies, have described differing prevalence of coronary artery variants and anomalies in different populations ranging from 0.0004% in Japanese population<sup>3</sup> to 1.1% in European population<sup>4</sup> and even 6% in Turkish population<sup>5</sup>. Adequate interpretation of results of coronary angiography crucially relies on good anatomical knowledge of the heart and coronary arteries, which includes knowledge of the coronary segments and normal anatomical variants.<sup>6</sup> Knowledge of such variations is mandatory in determining areas related to arterial occlusive disease, in hemodynamic procedures, in handling heart trauma, in diagnosing cause of death in some cases of sudden death, for their implications for heart surgery, and finally in terms of academic value.<sup>7-9</sup>

The data available on variations in the anatomy of coronary arteries is mostly that of the West.<sup>4,10-12</sup> Available literature reveals that very few studies have been carried out on anatomical variations of coronary arteries in Asian population.<sup>4,13</sup> The few available studies reveal varying results with regard to anatomical variation of coronary arteries and most of them are based on angiographies. The present study was designed to look for the pattern of variation of coronary ostia in Pakistani population using cadaveric hearts of local population.

## Methodology

It was a descriptive type of study of six months duration with sampling method of convenience and had been conducted in the department of Anatomy, in collaboration with Department of Pathology, Army Medical College Rawalpindi, various medical colleges of Rawalpindi/Islamabad, Peshawar, District Headquarters (DHQ) hospital, Combined Military Hospital (CMH) and Military Hospital (MH), Rawalpindi. The hearts were obtained from thirty adult male cadavers, at the time of autopsy & during routine anatomy dissection practice at Army Medical College, Rawalpindi, Foundation University Medical College, Islamic International Medical College (IIMC), Islamabad, Khyber Medical University (KMU) Institute of Medical Sciences (KIMS), Kohat and Khyber Medical College (KMC) Peshawar. The protocol for the research project was approved by a suitably constituted Ethics Committee of Army Medical College Rawalpindi and the study conformed to the provisions of the Declaration of Helsinki in 1995 (as revised in Edinburgh 2000). For our sample, we selected adult male cadavers irrespective of age and excluded cases involving direct trauma to the heart or any evidence of cardiac surgery.<sup>14-16</sup>

In order to collect specimen, cadaver was put in the supine position on the autopsy/dissection table. Thoracic cavity was opened according to the method described in Cunningham's manual of Practical Anatomy.<sup>17</sup> Fibrous Pericardium was incised through H-shaped incision in order to approach and thereby take out the heart from thoracic cavity (Figure 1). The position and number of coronary ostia and the origin of RCA & LMCA were noted by removing the anterior wall of the right ventricle; the interventricular septum



**Figure 1: Steps involved in taking out of heart from cadaver through thoracotomy**

& aorta (between the right semilunar and posterior valvulae) were cut longitudinally.<sup>18</sup> Observations were recorded with photographs taken with Nikon Coolpix 10 megapixel digital Camera with 3 optical zoom.

**Statistical Analysis of The Data:** Data were analyzed by using ‘Statistical Package for Social Sciences’ (SPSS) windows version 18. Descriptive statistics were used to describe the data. Mean and Standard deviation (SD) were calculated for quantitative variables. Frequencies along with percentages were calculated for qualitative variables.

## Results

**Origin of Right Coronary Artery (RCA):** Heart specimens from thirty cadavers were observed for origin of coronary arteries. In 29 out of 30 cases, there was a single ostium for each coronary artery in each sinus (Figure. 2), whereas in one of them, an accessory ostium was present as well in left coronary sinus of Valsalva (LSV) which gave origin to left conus artery (Figure. 3). With reference to sinutubular junction (STJ), majority of cases had their coronary ostial location below STJ. (Table 1).



**Figure 2: Single ostium in RSV for right coronary artery**

**Origin of Left Main Coronary Artery (LMCA):** On examination of the LMCA, we noted that it branched out of the left anterior aortic sinus and was related to the left side of aorta in all of the cases. The position of

ostia was noted at three positions with respect to STJ. 1 (3.3 %) subject had left coronary ostium (LCO) above STJ; 8 (26.7 %) had LCO below STJ, whereas 21 (70%) had their LCO below the STJ (Table 1).

In all cases, the RCA and LMCA originated through single ostia.



**Figure 3: An accessory ostium in LSV for left conus artery and a single ostium in RSV for right coronary artery**

Location of ostium	Right coronary ostium	Left coronary ostium
AboveSTJ	3 (10 %)	1 (3.3%)
AtSTJ	8 (26.7%)	8 (26.7%)
BelowSTJ	19 (63.3 %)	21 (70 %)

## Discussion

Anatomical variation was defined by Shakeri *et al.*<sup>19</sup> as a normal flexibility in the topography and morphology of body structures. The exact anatomy of the myocardial blood supply system varies considerably from person to person. No two human hearts are alike regarding the picture of their coronary

arterial tree.<sup>20</sup> This points to the fact that no classical model for anatomy of coronary arteries can ever be presented. Clinicians and anatomists have been examining coronary artery variations for a long time. In particular, from the 1960s when the use of selective coronary angiography began, the number of investigations on this topic has increased. However, there is still no consensus on the normality or abnormality of coronary arteries anatomy.

According to Gray's Anatomy, the right and left coronary arteries arise from the corresponding aortic sinuses at the proximal part of the ascending aorta, just superior to the aortic valve.<sup>21</sup> RCA occasionally arises from the pulmonary trunk.<sup>2</sup> In our study, both RCA and LMCA originated from their respective aortic sinuses in all cases, as reported by Gotzilius.<sup>21</sup> Generally, there is only one ostium in the aortic sinus from which the RCA originates; however, more than one ostium is sometimes observed. It has been reported that the conus branch originates from this accessory ostium; in this case, the conus branch is called the third coronary artery.<sup>21</sup> In our study, only one case showed accessory ostium in LSV from which the left conus artery originated (Figure. 3).

The levels of the coronary ostia are variable.<sup>22</sup> The RCO and LCO are normally present within the sinuses of Valsalva. In our study, RCO was situated at the level of STJ in 8 (27 %) subjects; 3 (10 %) subjects had their ostia above STJ whereas 19 (63 %) had their ostia below STJ, i.e. in most (90%) of the cases, RCO was located at or below the STJ. According to Fazliogullari *et al.*<sup>23</sup>, RCA arises at the level of STJ in 71 %, above in 19%, and below the STJ in 10% of Turkish population i.e. 81% of cases have their right ostial location at or below the STJ which supports our study. The observations by Turner and Navratnam<sup>24</sup> support our study who found that 62 of the 74 main coronary ostia lie either at or immediately below the STJ. Observations of Jatene *et al.*,<sup>25</sup> also support our findings that the RCO predominantly lie below the STJ. Some other investigators reported that the RCO was located below the STJ in 60-69% of the cases (which is supports our findings) and it was above the STJ in 22-28% of cases (which is contrary to our observations).<sup>26</sup> According to Muriago *et al.*,<sup>22</sup> the right

coronary artery arose below the STJ in 18 (78%) specimens, at the level of the STJ in two (9%) and above the junction in three (13%) cases and hence supports the observations of our study that the right ostial location in majority of cases is at or below the STJ. However, our study contradicts the observations of Valodaver *et al.*,<sup>27</sup> who reported a 44% incidence of ostia being present above STJ, while Pejkovic *et al.*,<sup>27</sup> reported a very high incidence of ostia at or above the level of the STJ (82% left and 90% right). This indicates geographical/genetic and/or ethnic differences as potential causes of such variation.

LMCA originated from its corresponding LSV in all of the cases. The LMCA occasionally arises from the pulmonary trunk and is usually associated with myocardial ischemia and death during early life. When both coronary arteries arise from the pulmonary trunk, death occurs shortly after birth.<sup>2</sup> In our study, no case with origin of LMCA from pulmonary trunk was noted since it was incompatible with life and the present study was conducted on adult population. The present study demonstrates the ostium location of LMCA above STJ in 1 (3.3 %) subject; at STJ in 8 (26.7 %) cases and below STJ in 21 (70%) cases and hence supports the observations of Govsa *et al.*,<sup>29</sup> that the most coronary orifices are located at or below the STJ. Our study also supports the observations of Banchi<sup>30</sup> that the most (66 %) of the left coronary ostia are located at or below the STJ. This study also supports the findings of Muriago *et al.*<sup>22</sup> that 78% of LCO are located at or below the STJ. These findings prove the very fact that the locations of coronary ostia at or below the STJ are the most adequate sites with regard to coronary filling, under high aortic blood pressure.

LMCA was noted to arise from the left aortic sinus behind the pulmonary trunk and emerged between left auricle and infundibulum of the right ventricle.

The incidence of coronary variations may be due to genetic and/or environmental causes. Environmental perspectives may include changes in maternal nutrition, exercise patterns, psychological stressors, health care and a multitude of other environmental factors that have altered over the centuries. Socio-environmental factors, combined with increased geographical mobility over the time to

different areas in search of better living, might have resulted in an increase in the range of variability of anatomical structures.<sup>31</sup> An example of the impact that environment can have on developing embryonic tissues can be observed in the reduction of the incidence of neural tube defects associated with increased folic acid intake.<sup>32</sup>

The present study on Pakistani population adds to the growing body of data on inter- and intra-population frequencies of coronary artery variation in the origin of coronary arteries among non-Europeans. It is remarkable that although the prevalence of various anatomical variations of coronary arteries is close to most studies, much varying values have also been reported. The frequency of coronary ostia's number and location reported in our study differ from international and even some regional studies which might be due to geographic, genetic and/or ethnic differences among various populations.

### Conclusion

The coronary ostial location at or below STJ is present in majority of cases, probably because it is the most adequate site for coronary filling. However the frequency of the number of coronary ostia and their locations in our population vary from those reported in other studies and that prevalence of different types of coronary variations are different in the different populations of the world; rather, more aptly speaking, no two human hearts are alike regarding the coronary arterial anatomy. This variety in the variation pattern of coronary arteries in different population lends support to the contention that postpartum development, along with geographic/ethnic differences (having genetic bases) may modify the anatomical pattern of coronary arteries.

**Limitations:** The sample size was small for obvious reasons involved in any human-based research like this. Moreover, it was not possible to exactly categorize the cases from different regions of Pakistan in order to give a more diverse picture. Furthermore, all cadavers studied were of males and hence gender based variation, if any, could not be studied.

**Recommendations:** Future studies should be conducted on a larger sample size – preferably categorized into gender- and region-based groups and thereby compared for coronary variations;

1. Moreover, studies might be planned such that the patients with so-called normally variant anatomy are followed for any association of variation with occurrence of coronary artery disease/coronary event;
2. As the number of non-Caucasian patients undergoing surgical treatment for ischemic or valvular heart disease increases, additional comparative data on racial, sexual, and ontogenetic variation of the coronary arteries and their aortic ostia are required to improve the care of these patients.

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