



## Morphological and morphometric parameters of coronary arteries in human foetal hearts

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### Abstract:

**Introduction:** Heart is a hollow muscular organ composed primarily of cardiac muscle tissue that continuously contracts and relaxes. Heart receives blood from right and left coronary arteries. **Materials and Methods:** In the present study 50 hearts from aborted fetuses (13 – 36 wks of gestational age) were collected. The fetuses were categorized in to two groups of 13 -24 weeks (Group I) and 25- 36 weeks (Group II) gestational age range. The heart specimens were observed for origin, course and branching pattern of coronary arteries, segment – wise lengths of coronary arteries, coronary dominance, presence of third coronary artery and myocardial bridges. The mean lengths of coronary arteries were compared between 1st, 2nd and 3rd segments. **Results:** There is a significant increase in the lengths of 1st, 2nd and 3rd segments from group-I to group-II. The posterior interventricular artery was arising from right coronary artery in 56%, left coronary artery in 8% and from both arteries in 6%. The frequency of occurrence of third coronary or right conus artery arising separately from anterior aortic sinus is 2%. Myocardial bridges are present in 9 hearts and among these 4 bridges are observed in the course of right coronary artery and 5 bridges on left anterior descending branch. **Conclusion:** The data presented in this study provide potentially useful information for the preoperative evaluation of the newborn and may have clinical implication in sudden fetal death.

**Key words:** Coronary artery; Dominance; Foetuses; Heart; Myocardial bridges

## Introduction

Cardiovascular system is the first major system to function in the embryo. The primordium of heart and vascular system appear in the middle of third week of embryonic life; but the heart actually starts functioning at the beginning of fourth week [1]. Since then it undergoes rhythmic and regular contractions and relaxations.

The heart is supplied by two coronary arteries viz right and left. Branches of coronary arteries vary in their origin, number, size and area of distribution [2]. Knowledge of normal anatomy, variant anatomy and anomalies of coronary circulation are vital for the management of congenital and acquired heart diseases. Congenital, inflammatory, metabolic and degenerative diseases may involve coronary circulation [2]. Enhanced understanding of detailed cardiac anatomy of coronary artery branching pattern, coronary dominance, presence of myocardial bridges, variations in vascular supply of heart are required for cardiac surgeons and radiologists to improve operative outcome in coronary heart disease [2,3].

A myocardial bridge is a segment of epicardial artery that has an intramural course within the myocardium [4-6]. Study of myocardial bridges over coronary arteries provide potentially useful information for the preoperative evaluation of the new-born and may have clinical implication in sudden fetal death [7].

Importance of detailed study of coronary arteries is emphasized by the fact that a high incidence of coronary anomalies had been observed in young victims of sudden death as compared to adults [8].

The present study on foetal coronary arteries in local aborted foetal population was under taken to understand the coronary vascular patterns in foetuses that were not available in the literature.

## Materials and Methods

A total of 50 dead aborted foetuses of 13 to 36 weeks gestational age and both sexes obtained from the Government Maternity Hospital, Tirupati with relevant obstetric records and preserved in the Department of Anatomy S.V. Medical College, Tirupati were utilized for this study. Among them 23 were male and 27 were female foetuses.

The heart specimens were collected from the foetuses by opening the thoracic cavity and were preserved in 10% formalin. Origin, course and branching pattern of coronary arteries were observed in each specimen. The coronary vessels were traced from their origin at the aortic root to their apparent distal termination by manual dissection using fine needle. The lengths of right and left coronary arteries were measured by dividing each artery into three segments. The 1<sup>st</sup> segment of right coronary artery is the distance from its origin from aortic sinus to the origin of right conus artery (Fig.1). The 2<sup>nd</sup> segment of right coronary is from the origin of right conus artery to origin of right marginal artery (Fig.1). The 3<sup>rd</sup> segment of right coronary artery is from the origin of right marginal artery to termination of right coronary artery (Fig.2). For the left coronary artery the 1<sup>st</sup> segment is from its origin from the ostium to the origin of left circumflex artery (Fig.3). The 2<sup>nd</sup> segment of left coronary artery is from the origin of left circumflex to the origin of left marginal artery (Fig.3) and the 3<sup>rd</sup> segment is from the origin of left marginal to termination of left coronary artery (Fig.4).

The coronary dominance is analysed based on the origin of posterior interventricular artery. If it is arising from right coronary artery it is marked as right dominance (Fig.2), if it is from the left coronary it is marked as left dominance (Fig.4) and if it is originating from both it is designated as balanced dominance (Fig.5). Presence of third coronary artery and myocardial bridges were observed in each specimen. The foetuses were divided in to two gestational age groups of 13-24 weeks (Group I) and 25-36 weeks (Group II). The results were compared and statistically analysed. The mean lengths of coronary artery were compared between 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> segments.

## Results

Origin, course and branching pattern of coronary arteries were observed in each specimen. In the present study the origin of right and left coronary arteries are as per text-book description. The length of 1<sup>st</sup> segment of right coronary artery was in the range of 1.0 mm to 15.0 mm. The length of 1<sup>st</sup> segment of left coronary artery was in the range of 3.0 mm to 11.0 mm. The range of length of 2<sup>nd</sup> segment of right coronary artery varied between 2.0

**Table 1: Mean length of Coronary arteries according to gestational age and sex**

S. no	Gestation al age	Sex	No. of foetus es	1st segment (mm)		2 <sup>nd</sup> segment (mm)		3 <sup>rd</sup> segment (mm)	
				Right	Left	Right	Left	Right	Left
1	13-24 weeks	Male	9	2.55	4.0	5.77	8.44	10.33	8.88
		Female	13	2.15	4.84	5.76	10.23	12.07	9.92
2	25-36 weeks	Male	14	4.64	5.71	6.28	13.78	15.85	13.4
		Female	14	3.28	5.42	7.92	11.85	16.78	12.5

**Table 2: Posterior interventricular artery**

Origin of posterior interventricular artery	Frequency
From the right	28
From the left	19
From both right and left	3
Total	50

**Table 3: Frequency of occurrence of third Coronary Artery**

OCCURRENCE	FREQUENCY
Present	1
Absent	49
Total	50

**Table 4: Comparison of percentage incidence of coronary dominance**

Authors	Right Dominance	Left Dominance	Balanced
Schelesinger [9]	48%	18%	34%
James [10]	90%	10%	-
Cavalcanti [11]	69.09%	11.82%	19.09%
Bezbaruah [12]	76%	20%	4%
Kalpana [2]	89%	11%	-
Hirak Das [3]	70%	18.57%	11.43%
Present study, 2013	56%	38%	6%

**Table 5: Presence of 3<sup>rd</sup> coronary artery reported in the literature on different populations**

Author	Population	Incidence
Miyazaki& Kato [15]	Japanese	36.8%
Ivan&Milica [16]	Bulgarians	34.8%
Von Ludinghausen & Ohmachi [17]	Germans	7.1%
Kurjia et al., [18]	Iraqi	8%
Kalpana, [2]	Indians	24%
Turner & Navratnam [19]	English	15.8%
Present, 2013	Indians	2%

mm to 13.0 mm and the same for left coronary artery was in the range of 6.0mm to 20mm. The length of 3<sup>rd</sup> segment is in the range of 6mm to 26mm on right side and 2 mm to 24 mm on the left side.

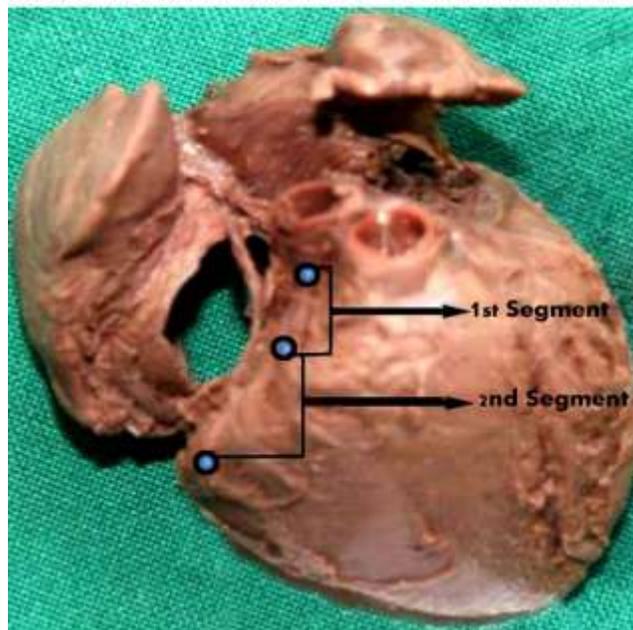
The mean segment-wise length of coronary arteries in male and female foetuses for right and left coronary arteries in the two gestational age groups (I and II) were represented in Table.1. When mean length of each segment is compared between right and left arteries the mean lengths of 1<sup>st</sup> and 2<sup>nd</sup> segments are greater for left coronary artery when compared to right in both sexes and in both groups where as for third segment it is greater for right coronary artery (Table.1) in both sexes and groups. When compared sex-wise the 1<sup>st</sup> segment length in males is more than that of females. 2<sup>nd</sup> segment lengths are almost equal in both sexes and 3<sup>rd</sup> segment length is higher in females on right side in group I. In group I the values were higher on left side in females for all the segments. In the group II all the values were higher in males except the right 2<sup>nd</sup> and 3<sup>rd</sup> segments that were more in females. In both sexes with increase in gestational age the mean length also increased in all the segments and in both arteries.

The artery that gives rise to the posterior interventricular branch determines the “dominance of circulation” (Table.2). The origin of posterior interventricular artery from right coronary artery indicated “right dominance” in 28 specimens (Fig.2) and from the left circumflex artery indicated “left dominance” in 19 specimens (Fig.4), and from both right and left coronary arteries indicated “Balanced Dominance” in 3 specimens (Fig.5).

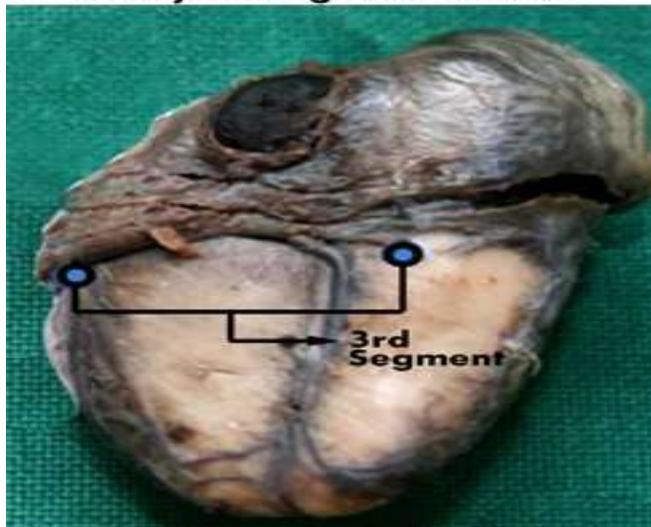
Correlation between 3<sup>rd</sup> segment length and coronary dominance are compared among the 19 cases of left dominance. In 4 specimens (21%) of left dominance the length of 3<sup>rd</sup> segment on left side is more than that of right side. A similar comparison in 28 cases of right dominance hearts indicated that the length of 3<sup>rd</sup> segment of right coronary artery is more in 19 specimens (68%). Among the three cases of balanced dominance the length of 3<sup>rd</sup> segment on right side is more in two cases when compared to left side.

The right conus artery was seen arising separately from the anterior aortic sinus as third coronary artery (Fig.6) in one specimen (2%) i.e. male with 25 weeks gestational age (table 3). In 50 foetal hearts nine hearts presented myocardial bridges of one in each with a total of nine myocardial bridges (18%). Four myocardial bridges were seen on right coronary artery (Fig.7) and five on left anterior descending branch of left coronary artery (Fig.8).

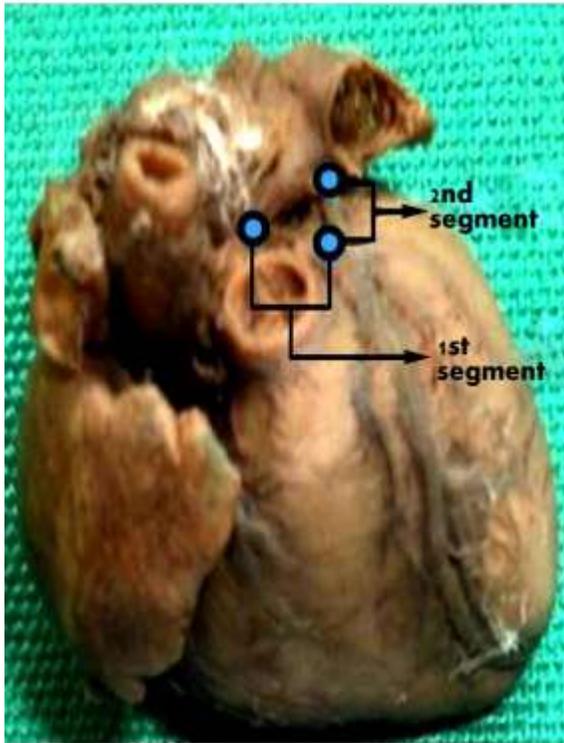
**Fig:1 Course of the RCA according to segments wise 1st and 2nd segments of Right coronary artery.**



**Figure:2 3<sup>rd</sup> segment of right coronary artery and right dominance.**



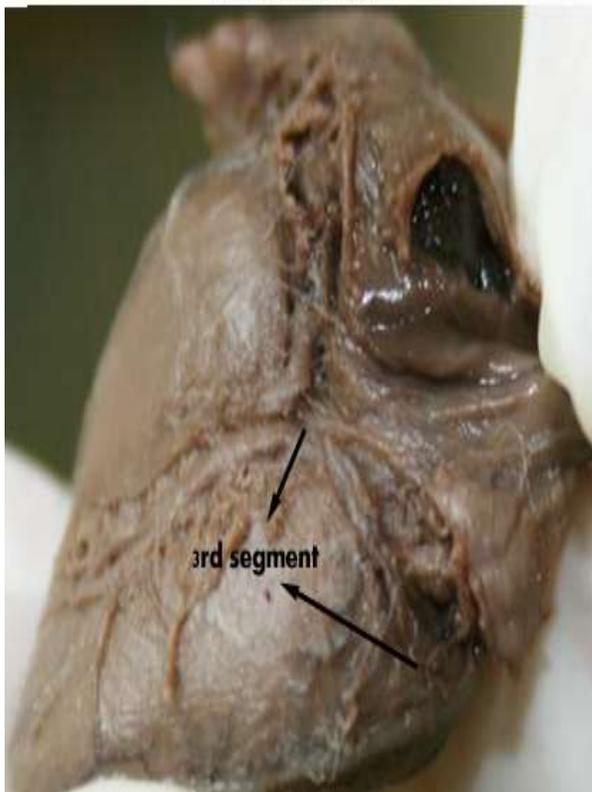
**Fig.3 Course of the LCA according to 1st & 2nd segments wise.**



**Fig.5 Balanced Dominance**

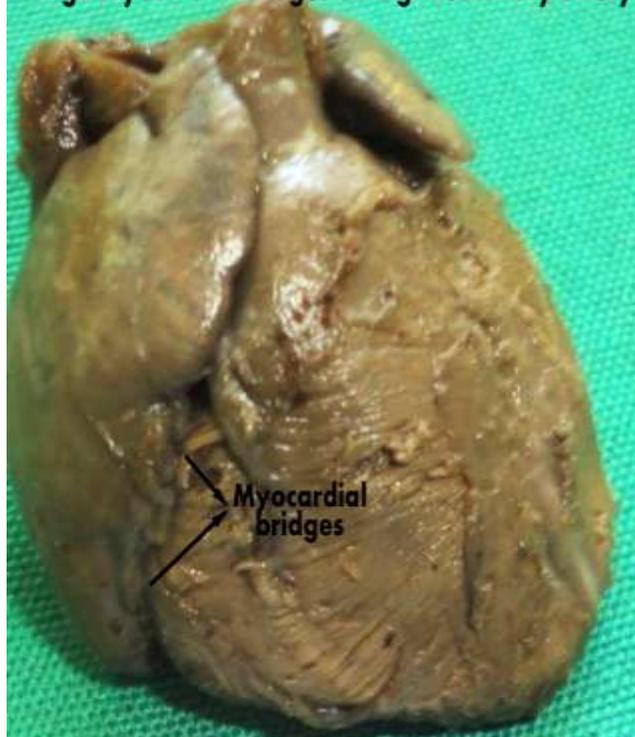
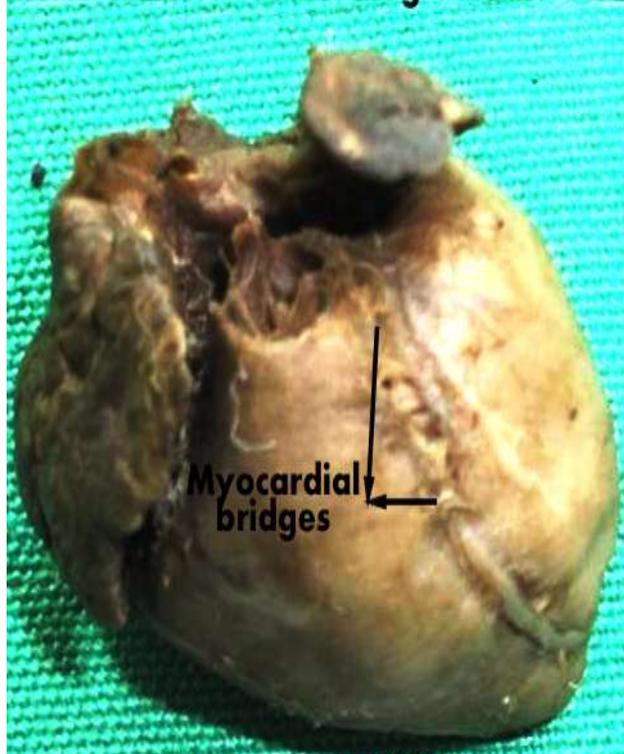


**Fig.4 3rd segment of left coronary artery and left dominance**



**Fig.6 Direct origin of Right Conus artery from aorta**



**Fig.7 Myocardial bridges on Right Coronary artery****Fig.8 Myocardial bridges on Left anterior descending branch**

## Discussion

In the literature no study was available on coronary artery pattern in fetuses. Hence the present study on foetal heart parameters has to be compared with that of adult hearts for morphological parameters and is the first to be reported on morphometric parameters.

In the present study the mean lengths of right and left coronary arteries were recorded for 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> segments each and were compared. With increase in gestational age there is increase in the length of each segment of both right and left coronary arteries in both sexes. All segments are longer on left side than right side except 3<sup>rd</sup> segment where the length is more on right side.

The values for left coronary artery are more on left side when compared to right side for 1<sup>st</sup> and 2<sup>nd</sup> segments and vice-versa for 3<sup>rd</sup> segment in both male and female fetuses and in group I and II. The mean values for each segment presented sexual differences with a higher value in females for certain segments of one artery and for males in certain segments of another artery. In female fetuses a left sided predominance in group I and a right predominance in group II were observed.

The percentage incidence of dominance based on the origin of posterior interventricular branch was 56%, 38% and 6% respectively for right, left and balanced dominance. The percentage incidence of dominance observed in the present study was compared with that cited in the literature in adult population (Table.4) as no literature was available in foetal population [2,3,9-12]. It is less than that reported by various authors in literature in adult population excepting that of Schelesinger [9]. The percentage incidence for left dominance is higher in the present study when compared to that reported in literature. Percentage incidence of balanced dominance is much less when compared to that reported in literature except for that of Bezbaruah [12].

When percentage incidence of relationship between long 3<sup>rd</sup> coronary segment and coronary dominance was calculated a 21 % correlation for left dominance and 68% correlation for right dominance were observed. Among the three cases of balanced dominance the length of 3<sup>rd</sup> segment on right side is more in two cases when compared to left side. This type of comparative studies was not reported in the literature. The right conus artery was present in all the specimens. In one male fetus of 25 weeks gestational age the right conus artery arose from the anterior aortic sinus from a separate ostium as third

coronary artery. According to Reesse et.al. [13] and Wada et.al. [14] separate orifice for third coronary artery and right conus artery is due to insufficient unification of these two vessels during their growth towards the ascending aorta. The frequency of occurrence of 3<sup>rd</sup> coronary or right conus artery arising separately from the anterior aortic sinus is 2% in the present study. When the percentage obtained in the present study is compared with that reported in the literature the percentage is very less in the local South Indian fetal population. The values reported in the literature were on adult hearts (table 5).

In the present study among 50 hearts only 9 hearts presented one myocardial bridge each with a percentage incidence of 18%. The only study reported in literature on this aspect was that of Yusuf Ozgur Cakmak et.al [7] who reported 26 bridges in 39 hearts with a percentage incidence of 66.7% which is higher than that observed in the present study. This variation could be due to population difference. Among these 4 are in the course of right coronary artery and 5 bridges on the left anterior descending branch. Yusuf Ozgur Cakmak [7] reported higher number of myocardial bridges (13nos) on left anterior descending branch, than on diagonal artery (8 nos) and on posterior descending artery (5 nos).

## Conclusion

The present study on morphology and morphometry of fetal coronary arteries forms a basis for undertaking more elaborate studies on fetal hearts for understanding the variations in coronary vascular pattern and congenital anomalies of fetal heart.

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