

Third coronary artery a Boon to the Heart – Cadaveric study VS Coronary angiogram.

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ABSTRACT

Introduction: Understanding the anatomy and its variations of coronary arteries forms the base for coronary artery disease diagnosis and planning of surgeries.

Aim: The relation between outer diameter of right conus artery in cadaveric hearts and coronary angiograms, the relation between the diameter of right conus artery with and without the presence of long branches in both cadaveric hearts and coronary angiograms.

Materials and Methods :

150 embalmed cadaveric hearts received from various south Indian states, which were preserved in various colleges of Tamilnadu and Pondicherry was used in this study. 150 coronary angiograms of patients from various south Indian states. Methods adopted was Dissection method and Coronary angiogram were utilized for the study .

RESULTS: Out of 150 cadaveric heart and 150 coronary angiogram , the outer diameter of right conus artery arising from right coronary artery in cadaver and in angiograms was compared the resulted p value is less than 0.0001 which is considered to be extremely statistically significant. The number of long branches and short branches are studied with regard to the diameter of right conus artery. Pearson's correlation coefficient was 0.1716 which is positive.

CONCLUSION: The diameter of right conus artery in the cadaveric study differs with the angiographic study. The diameter of right conus artery is more when having a long branch.

KEY WORDS: Right conus artery, Third coronary artery, Right coronary artery, coronary angiogram.

1.INTRODUCTION :

One fifth of the heart disease is coronary heart disease which is caused by partial or complete obstruction of coronary arteries. This obstruction is caused by deposition of cholesterol in the walls of arteries known as plaque thus reducing the blood flow to the heart.

To compensate the reduction in blood flow collateral arteries play an important role. One of the major collateral arteries supplying the heart is right conus artery which is the first branch

of right coronary artery. It is also known as conus arteriosus, preinfundibular artery, right veussens artery, arteria accessoria or adipose artery(1) (Rebecca A B Burton et al 2012).

The right conus arteries sometimes get occluded by atherosclerosis. When this happens, a selective angiogram should be done on right conus artery especially when conus artery arises as a separate origin. So awareness of right conus artery its diameter and distribution plays a significant role in evaluation of coronary insufficiency which helps in proper planning of myocardium revascularization surgery.

The presence of difference in the coronary artery vasculature leads to sudden death of the individual due to over physical exhaustion. Thus the variations gains importance clinically. So it is mandatory to study the variations of conus coronary artery in management of coronary artery disease. The degree of coronary atherosclerosis can be predicted by the knowledge of coronary anatomy. Stenosis of coronary arteries was expressed in approximate percentages than a correct value which may lead to errors in actual stenosis in diffuse diseased artery angiographically. Thus the knowledge of dimension of healthy coronary artery is essential to find the correct stenosis value(2) B.G Brown,E Bolson et al 1977.

2.OBJECTIVES :

- The relation between outer diameter of right conus artery in cadaveric hearts and coronary angiograms.
- The relation between the diameter of right conus artery with and without the presence of long branches in both cadaveric hearts and angiograms.

3.Materials and Methods :

150 embalmed cadaveric hearts received from various south Indian states, which were preserved in various colleges of Tamilnadu and Pondicherry was used in this study. 150 coronary angiograms of patients from various south Indian states were collected . **Materials used** were Dissection instruments and vernier caliper **Methods adopted** was Dissection method and Coronary angiogram were utilized for the study. The right coronary artery arising from the aorta opposite the origin of the left coronary artery is noted. The epicardial layer and fat from right coronary artery was removed by retracting the right auricle laterally using forceps and scissors. The space between the right auricle and atria ventricular groove or sulcus was palpated and proximal part of right coronary artery was exposed. Then superficial portion of right coronary artery was traced towards the right side of diaphragmatic surface by the careful dissection using lens to protect its branches. Micro dissection was done to identify the right conus artery, right marginal artery and sinu nodal artery. The sinu nodal artery originated from the proximal part of right coronary artery which traverses to the right atrium at the junction of superior vena cava and right auricle. Then it enters the sinu node. The right conus artery was traced in proximal part of right coronary artery which passes to the left around right ventricle near the sub pulmonary infundibulum. Then the right marginal branch was traced near the diaphragmatic surface of the heart, which supplies the inferior border of right ventricle. Then the right coronary artery continues posteriorly through the atrio ventricular groove or post right coronary sulcus and it then travels through the posterior interventricular groove where it gets terminated as posterior

interventricular artery in most cases. Digital Vernier Caliper is used to measure the diameter with accuracy to hundredth of a millimeter. The caliper consists of two graduated scales, a main scale like a ruler and a second scale the vernier, which slides parallel to the main scale. The Vernier scale consists of quadrants with the primary scale in half degrees. This scale was thirty one and one half degrees in length and divided into three equal parts. Each part was one half a degree plus one minute. The study uses a digital vernier caliper which has an electronic display that displays the diameter measurement in millimeters or inches .



Figure 1: Digital vernier caliper

The outer diameter of right conus artery was studied at the proximal part with the help of 0.01 mm sensitive digital vernier caliper.

The coronary angiograms of patients, who had undergone this procedure for various reasons, were utilized in this study

Diameter Measurement in Coronary angiogram:-

The images taken by the imaging camera is recorded by a computer. It is then analysed using “quantitative coronary analysis plus” (QCAP) software for measuring diameter and branches of right conus artery (Fig 2). The conus artery was best viewed in left anterior oblique view with 35° angulation.

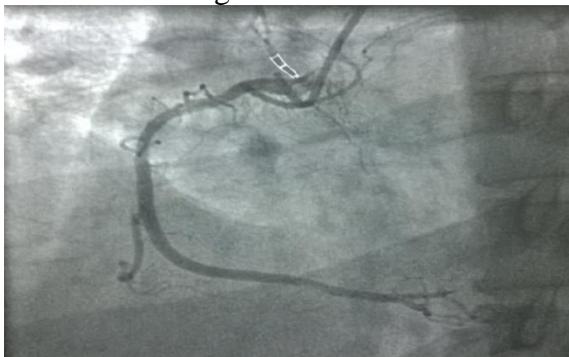


Figure 2: Diameter of right conus artery in coronary angiogram

CADAVERIC STUDY

INCLUSION CRITERIA:

Heart specimens in which conus artery is clearly seen.

EXCLUSION CRITERIA:

Pathologic heart

Putrefied heart

Hearts in which conus artery was not clearly seen.

ANGIOGRAPHIC STUDY:

INCLUSION CRITERIA:

Patient aged 35 to 70 years of both sexes.

EXCLUSION CRITERIA:-

Patient aged less than 35 and greater than 70 years of age

Patients presented with

Atrial fibrillation (permanent or persistent)

Frequent cardiac extrasystoles

Hyperthyreosis (allergy to non-ionic contrast agents)

Implanted pacemaker.

Data was recorded, tabulated and analyzed using computer software statistical package of social sciences (SPSS).

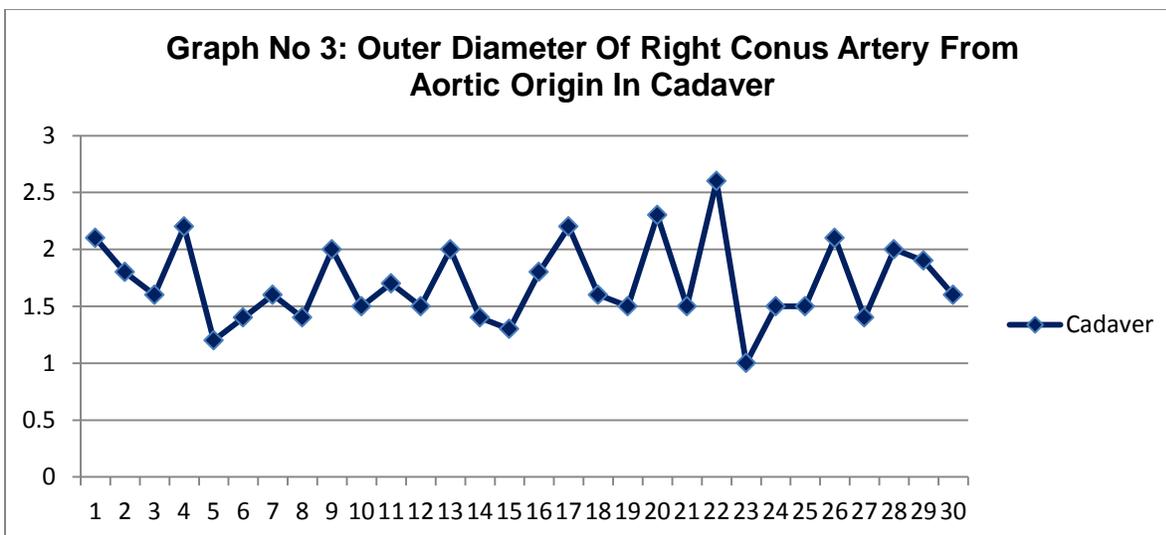
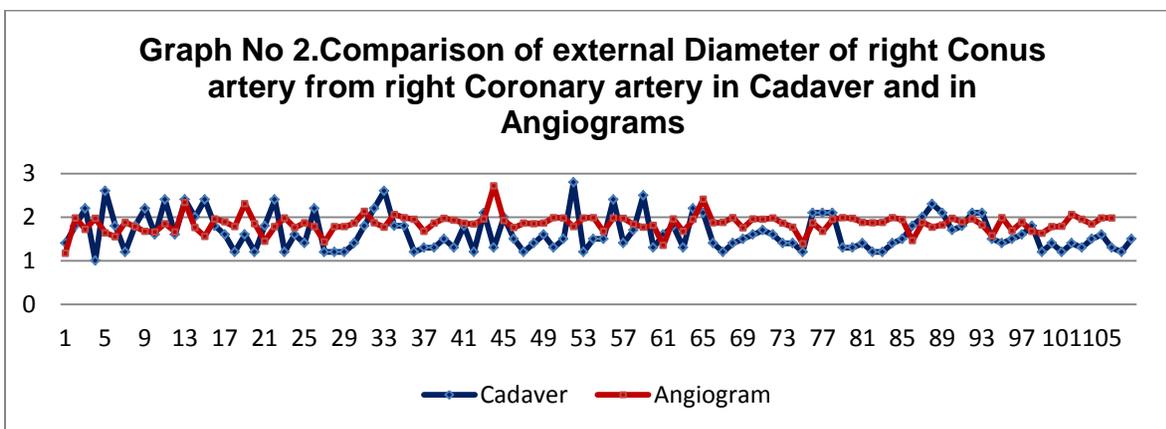
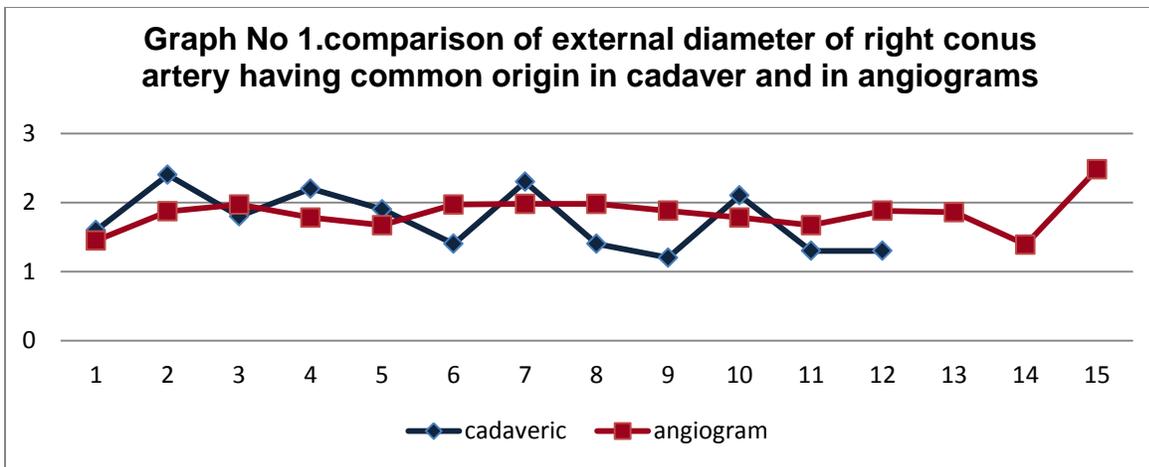
STATISTICS USED: Statistical significance was determined with help of Student unpaired t-test, Percentage calculation and Pearson's correlation coefficient.

4.RESULTS :

1.Outer diameter of right conus artery with respect to its origin in cadaveric hearts (Table No 1).

Pattern of origin	Outer diameter mean value(mm)	Range
From Right coronary artery	1.64 ± 0.40	1mm to 2.8mm
From common ostium	1.74 ± 0.43	1.2mm to 2.4mm
From aortic	1.70 ± 0.36	1mm to 2.6mm

In cadaveric study outer diameter of right conus artery ranged with minimum of 1mm to maximum of 2.8mm (Table no 1). The outer diameter of right conus artery is interpreted with its pattern of origin. When the right conus artery arose from right coronary artery its diameter ranged from 1mm to 2.8 mm with an average of 1.64mm. When right conus artery had a common with right coronary artery its diameter ranged from 1.2mm to 2.4mm with an average of 1.74mm. When third coronary artery is present (aortic origin) its diameter ranged from 1mm to 2.6mm with an average of 1.7mm.



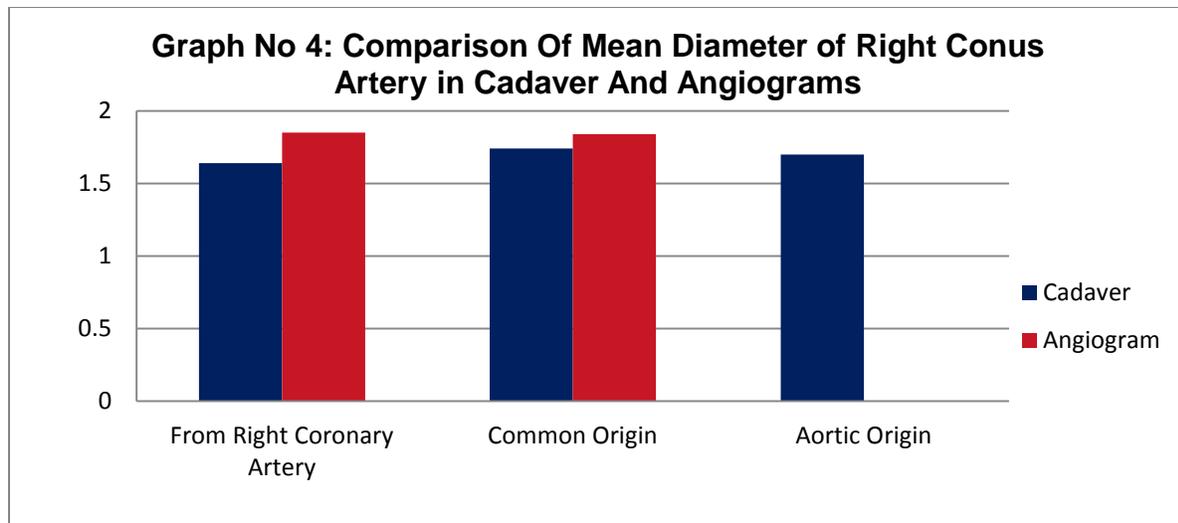


Table 2: Outer diameter of right conus artery with respect to its origin in coronary angiograms

Pattern of origin	Outer diameter mean value value(mm)	Range
From right coronary artery	1.85 ± 0.21	1.17mm to 2.72mm
From common origin	1.84 ± 0.25	1.39mm to 2.48mm

In angiographic study outer diameter of right conus artery were measured in 121 hearts which ranged with minimum of 1.17 mm to maximum of 2.72 mm with a mean diameter of 1.85 mm (Table 2). The remaining 29 hearts which could not be traced had aortic origin. The conus artery when arising from right coronary artery the diameter ranged from 1.7mm to 2.72mm with a mean of 1.85mm. When conus artery arose from common ostium along with right coronary artery ie having a common origin the diameter of right conus artery ranged from 1.39mm to 2.48mm with an average of 1.84 mm (Table 2).

Table 3: Statistical analysis of comparison for outer diameter of right conus artery arising from right coronary artery in cadaver and in coronary angiograms:

Statistical variants	Cadaveric	Angiogram	P value (by applying unpaired t test)
Mean	1.64	1.85	<0.0001 (Highly significant)
Standard deviation (SD)	0.40	0.21	
Standard error of mean (SEM)	±0.04	±0.02	
Number	108	106	

Students unpaired t test is used to compare outer diameter of right conus artery arising from right coronary artery in cadaver and in angiograms. The resulted p value is less than 0.0001 which is considered to be extremely statistically significant (Table 3). This shows that there is a difference in the diameter of right conus artery between cadaveric hearts and angiograms.

2.Branches of right conus artery:

Table no 4: Branches of right conus artery in cadaver and in coronary angiograms.

Methods	Long branch and short branch	Only short branch
Cadaveric study	27	123

Coronary angiogram	20	130
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In the present study out of 150 hearts only 27 (18%) hearts had long branches and 123 (82%) hearts had only short branches (Fig 18, 19 & 20). In the angiographic study 20 hearts (13.33%) showed long branches (Table 4).

Fig 3: RIGHT CONUS ARTERY HAVING THREE SHORT BRANCHES

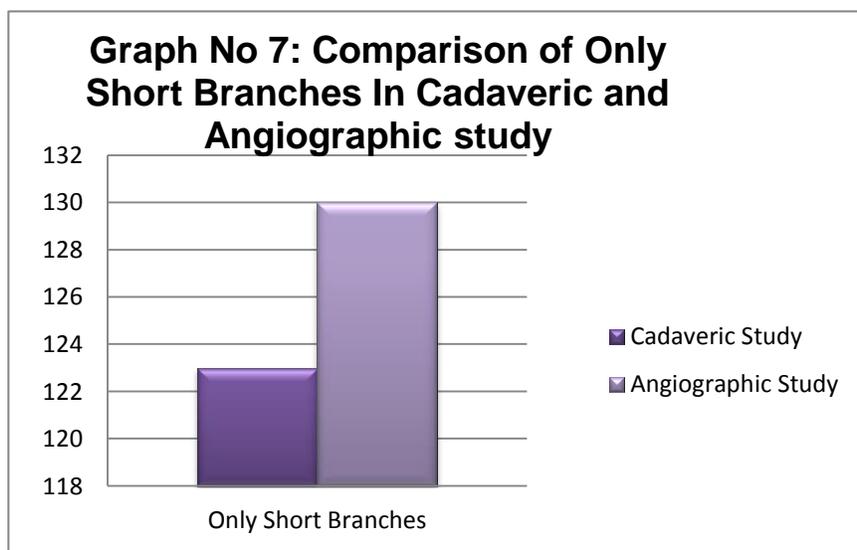
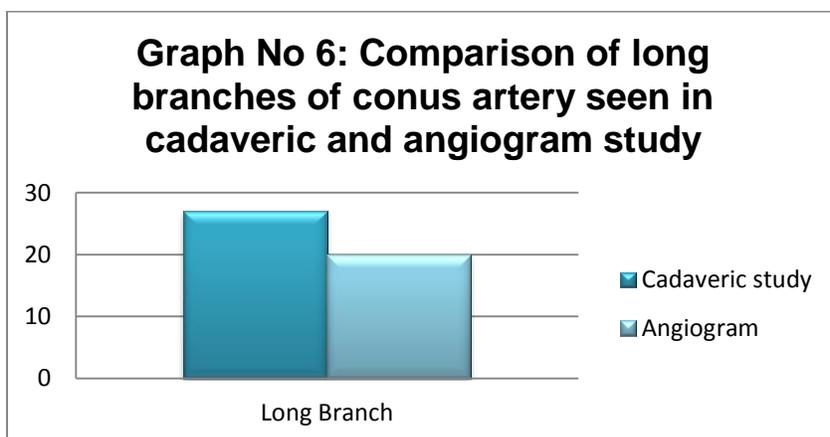
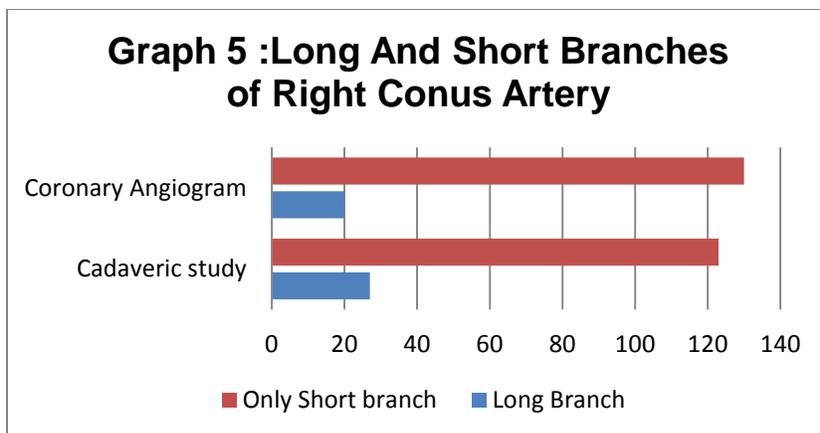


FIG.4: R.CON.A. SHORT & LONG TERMINAL BRANCHES



FIG.5: R.CON.A. SHORT & LONG TERMINAL BRANCHES





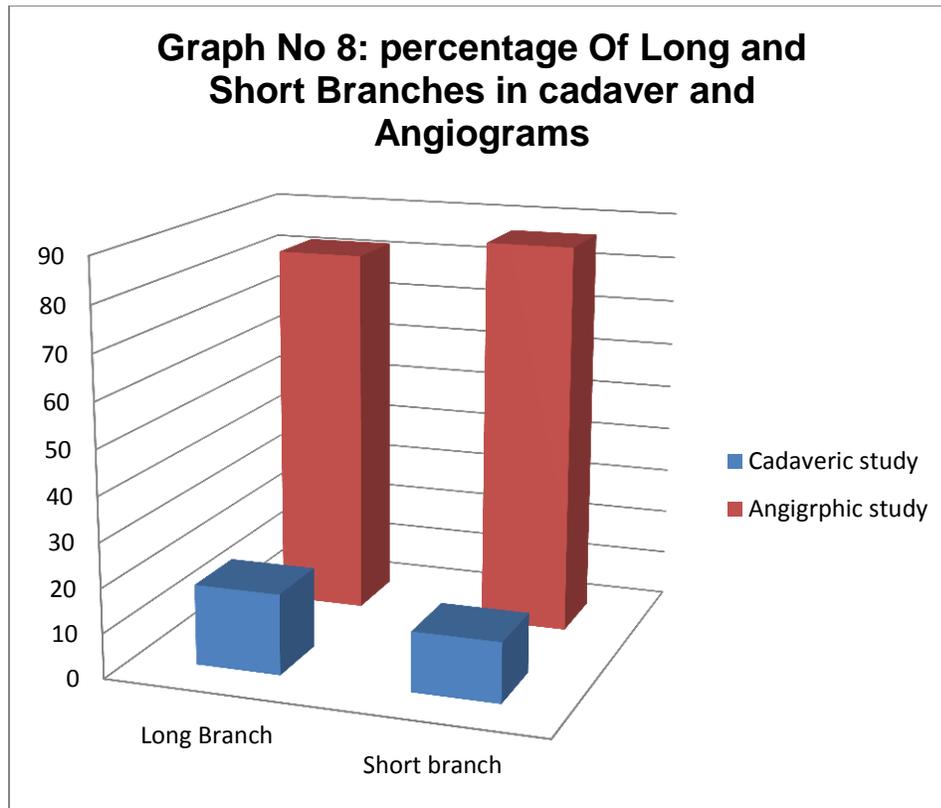


TABLE NO 4: STATISTICAL ANALYSIS TO COMPARE THE DIAMETER OF RIGHT CONUS ARTERY WITH AND WITHOUT THE PRESENCE OF LONG BRANCHES.

Mean diameter of right conus artery (mm)		Pearson's correlation coefficient
long branch present	Only short branch	
1.87	1.83	0.1716

Pearson's correlation coefficient was 0.1716 which is positive and it shows that the diameter of right conus artery is more when having Long Branch than having a short branch.

5. Discussion

1. outer diameter of right conus artery arising from right coronary artery in cadaver and in angiograms

In present study Students unpaired t test is used to compare outer diameter of right conus artery arising from right coronary artery in cadaver and in angiograms. The resulted p value is less than 0.0001 which is considered to be extremely statistically significant (Table 1). This shows that there is a difference in the diameter of right conus artery between cadaveric hearts and angiograms.

Similar studies on conus artery was conducted by(3) Valentina Nicolic, (1)Rebecca A B Burton et al, (4)Gupta et al and the results are nearly similar to the present study.

Many other studies on right coronary artery were done with less importance to right conus artery like the studies conducted by(5) Grover m hutchins et al1976,(6) Kohler et al 1981, (7)Sahini D 1989, (8)Cheemlapati Saikrishna 2006, (9)Fazliogullari Z Karabulut et al 2010,(10) A Avirmed et al 2012, (11)Gomez 2013,(12)Imad Ghanem Shukri et al 2014,and (13)Nagaraj malla Shetty et 2014.

In a study done on 55 monkeys it was reported that the external diameter of third coronary artery at its origin was 0.3mm(3) (Valentina Nicolic et al 2004) which differs with our study which may be due to species variation.

A study done on rabbit and human hearts concluded the mean diameter of third coronary artery (right conus artery) was found to be 0.27 mm and 1.26 mm in rabbit and human respectively which showed the diameter of right conus artery was considerably smaller than the right coronary artery, both in rabbit and human (1)(Rebecca A B Burton et al 2012). This study goes in hand with our study.

In the study conducted using selective catheterization and arteriography found the outer diameter of the conus artery was small with average of 0.5-2 mm. The conus artery arose as a separate vessel from right coronary sinus, nearer to the mouth of the right coronary artery (4)(Gupta et al 1987). The present study showed similar results to this study.

(6)Kohler et al 1981 found the ostial diameter with a mean on right coronary ostia is 3.83mm. (13)Nagaraj malla Shetty 2014 reported the external diameter of right coronary artery is 4.1mm and outer diameter of left coronary artery is 4.3mm.

(9)Fazliogullari Z Karabulut et al 2010 found that the outer diameter of right coronary artery was 3.32 ± 0.79 mm. The external Diameter of right coronary artery in pig's heart and the mean diameter was 3.85mm (11)(Gomez et al 2013).

Sahini D 1989 (7)studied the mean diameter of right coronary artery at its origin and found it to be 3.2 ± 0.5 mm in males and 3.2 ± 0.6 mm in females. Another study found the diameter of right coronary was 4 mm, which arises as the direct branch from the aortic sinus. It also stated the diameter of left coronary artery and it had a mean of 3mm at the proximal part (14)(Sukhendu Dutta 2014).

Imad Ghanem Shukri et al 2014(12) in their study found the diameter of coronary arteries were larger in males than females. In males the mean diameter of proximal RCA was 3.26 mm while in females it was 3.02 mm.

A study using black ink cast and silver impregnation specimens to find the diameter of the collateral branches of the right coronary artery ranged from $113.3 \pm 23.1 \mu\text{m}$ to $736 \pm 92.5 \mu\text{m}$ (Avirmed et al 2012)(10).

Grover m hutchins et al 1976 (5) in his study concluded that there was no relationship seen between coronary artery branch vessel diameter and branch angle.

Cheemlapati Saikrishna et al 2006(8) in his study found the mean diameter of proximal right coronary artery is $2.75 \pm 0.65\text{mm}$ in males and in females is $2.55 \pm 0.5\text{mm}$ which had p value 0.11. the mid of right coronary artery $2.47 \pm 0.66\text{mm}$ in males and $2.31 \pm 0.13 \text{mm}$ in females and p value obtained was 0.28. he also found that male had large coronary artery than female artery. This difference is however was not statistically significant in right coronary artery.

2.Branches of conus artery :

Similar study has been done by Antonello Musiani et al. (1995)(15), Wynn et al (2008)(16), Luis Ernesto Ballesteros (2011)(17), Gomez et al 2013(11), Manisha randhir dhobalae 2015(18).

The individuals having a long branch from right conus artery, it was really a boon. The branches of conus artery was studied in pigs (Gomez et al 2013)(11). Conus artery was seen in 63.3% of the heart out of which 41% of hearts the right conus artery was found to end up at the cone. Conus artery ends at the upper third of the anterior wall of right ventricle in 19%, at the mid third in 37% and at the lower third of the anterior wall in 3% of cases. In Colombian population the right conus artery that irrigate the conus arteriosus, anterior wall also supplies the in 87% had short branch supplying superior and middle ventricular surface while 13% had long branch reaching the inferior ventricular segment Luis Ernesto Ballesteros et al(2011)(17). According to the study conducted by Manisha randhir dhobalae 2015(18) the artery that ends over the right ventricular outflow tract (infundibulum) supplied the conus arteriosus in 24 hearts (16%) and infundibulum was supplied by the artery extending to the middle of the anterior wall of right ventricle was seen in 16 hearts (10.66%). Third coronary artery supplied the inferior border of the heart in 6 hearts (4%). He stated the third coronary artery is present frequently, hence role of third coronary artery should always be considered during diagnostic and therapeutic interventions. Takumi Sumimoto et al (1992)(19) suggested when reduced coronary blood flow due to hypertrophied myocardium occurs, the long branches from the right conus artery running parallel to left anterior descending branch (LAD) upto the apex of the heart may compensate for the blood supply. In his study those long branches were seen in 20% of the heart.

The present study focuses on long and short branches seen in cadaver and coronary angiogram. A branch of conus artery running till the cone of the heart is termed short branch and the branch which runs along the anterior ventricular wall and reaching the inferior border or nearing apex is termed as long branches. In the formalin fixed hearts micro dissection was done to trace the branches of right conus artery till the end of the artery. 27 of the hearts specimen had atleast one long branches nearing the apex of the heart. Remaining 123 heart specimens had only short branches that nearing the cone of the heart. As 82% of the heart specimens had only short branches it is evident that short branches are more frequently found than the long branches. These 18% of the heart specimens which had a long branch is a boon.

The angiogram study of 150 hearts showed predominant presence of only short branches similar to the cadaveric study. 130 angiograms showed only the presence of short branches and the remaining 20 angiograms had at least one Long Branch.

In the ECG during acute myocardial infarction the ST segment elevation is seen in lead V₁. In the case study of myocardial infarction conducted by(21) Tuvia Ben Gal et al1997 concluded that the absence of ST segment elevation in lead V₁ is suggestive of presence of long conal branch supplying the interventricular septum along with the left anterior descending artery. Thus a long conal branch supplying the interventricular septum restores the blood flow acting as collateral when occlusion of the left anterior descending artery occurs. So it is a real boon for the patient who is having it.

The conus branch of the right coronary artery usually supplies the outflow tract of right ventricle. Occlusion of this conus artery occurs mostly due to iatrogenic causes during diagnostic procedures and heart surgeries. When conus artery is occluded the ECG shows Brugada syndrome like changes i.e. elevation of ST segment through lead V₁ to V₃. Brugada syndrome is known to cause lethal ventricular tachycardia. So whenever Brugada syndrome like changes seen in ECG the conus artery occlusion should also be considered. In a case report which showed ECG changes of ST segment elevation was successfully treated only by restoring the conus artery blood flow by a guide wire (20)(Masanari Umemura et al 2012).

In a case of hyper acute myocardial infarction due to occlusion of left anterior descending artery the long branch of conal artery anastomosed with the left anterior descending artery acting as a “life saving necklace” to restore circulation of the left anterior descending artery (Faith Cam).

The number of long branches and short branches are studied with regard to the diameter of right conus artery. When Long Branch is present the mean diameter of right conus artery was 1.87mm. The mean diameter of right conus artery when only the short branches are present was 1.83mm (table no 4).

From the reviewed literatures of right conus artery there are no reports comparing the branch length to the diameter of right conus artery. The present study compares the diameter of the right conus artery to its length. The length of the conus artery falls under 2 category i.e. long or short branch. The result showed that the conus artery running near to the apex is greater in diameter than the conus artery which ends near the cone of the pulmonary trunk. The Long Branch with larger diameter supplies large area of anterior wall of ventricle than the short branch having a smaller diameter.

6. CONCLUSION

- The diameter of right conus artery in the cadaveric study differs with the angiographic study.
- The diameter of right conus artery is more when having a long branch.

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