

# Study of Third Coronary Artery in Adult Human Cadaveric Hearts

MANISHA RANDHIR DHOBAL<sup>1</sup>, MEDHA GIRISH PURANIK<sup>2</sup>, NITIN RADHAKISHAN MUDIRAJ<sup>3</sup>, UTTAMA UMESH JOSHI<sup>4</sup>

## ABSTRACT

**Introduction:** Third coronary artery (TCA) is a direct branch arising from the anterior aortic sinus (right aortic sinus) which supplies right ventricular outflow tract. It is found frequently and may be an important source for collateral coronary blood flow through a vascular anastomotic bridge (circle of Vieussens) between the right and left coronary systems.

**Aim:** To evaluate the gross anatomy of third coronary artery in terms of their number, origin, extent and distribution.

**Materials and Methods:** After an ethical approval, 150 formalin fixed adult human cadaveric hearts were collected from Department of Anatomy, BVDU Medical College and Hospital, Sangli and Pune over the period of six years. The careful dissection

was carried out to note details about third coronary artery and data was analysed using SPSS computer software.

**Results:** The TCA was present in 32% of the heart specimens. In 42 hearts (28%) single TCA and in 6 hearts (4%) double TCA were noted. It was found to be variably distributed to conus arteriosus, anterior wall of the right ventricle, interventricular septum and the apex of the heart. TCA was larger than right coronary artery in 8 hearts and later ended at inferior border of heart. Myocardial bridge was noted over large third coronary artery in one specimen.

**Conclusion:** TCA is present frequently. It anastomoses with branches of left anterior descending artery (LADA) and contributes to apical and septal perfusion. Hence role of TCA should always be considered during diagnostic and therapeutic interventions.

**Keywords:** Circle of vieussens, Collateral circulation, Conus arteriosus, Interventricular septum, Right conus artery

## INTRODUCTION

Usually there are two coronary arteries, right and left. Sometimes supernumerary arteries may arise from the anterior aortic sinus. Commonest among them is the third coronary artery. A third coronary artery (TCA) has been defined as a direct branch from the anterior aortic sinus (Right coronary sinus) that contributes to the vascularization of the infundibulum (conus arteriosus) of the right ventricle [1]. Different terms are used in the literature for describing this coronary artery like supernumerary right coronary artery, infundibular artery, right Vieussens artery, Arteria accessoria, or adipose artery [2-4].

The TCA often anastomoses with the branch of the left anterior descending branch (LADA) and forms Vieussens' arterial ring. This ring represents a significant path of collateral blood stream under conditions of coronary insufficiency [1,5-8].

These branches do open up in some cardiac pathology to provide collateral perfusion. They have been shown to improve with age [8]. The incidence of TCA is quiet common but standard approaches for coronary angiographies fail to visualize the TCA in many cases [9].

Hence, sound knowledge about the presence and distribution of TCA is needed for accurate interpretation of coronary angiograms, assessment of severity of coronary insufficiency and appropriate planning of myocardial revascularization [10]. The present study has been done to note the incidence, extent and distribution of TCA.

## MATERIALS AND METHODS

- After an ethical approval, 150 formalin fixed adult human cadaveric hearts were collected from Department of Anatomy, BVDU Medical College and Hospital, Sangli and Pune over the period of six years. The hearts having gross congenital anomalies were excluded. Epicardium and fat was removed in piecemeal. The right, left and third coronary arteries were dissected meticulously from origin to their termination.

Ascending aorta was transversely sectioned approximately 1cm above the aortic leaflets. Then the aorta was longitudinally opened at the level of posterior aortic sinus (non-coronary sinus) to visualize the details of ostia.

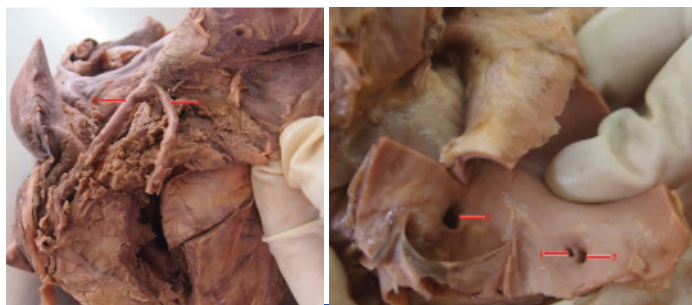
- Following observations were noted in relation to TCA:
  - Origin,
  - Course and extent,
  - Distribution,
  - Diameter of TCA if it is larger than right coronary artery,
  - Presence of myocardial bridge.
- The most representative specimens were photographed.

## RESULTS

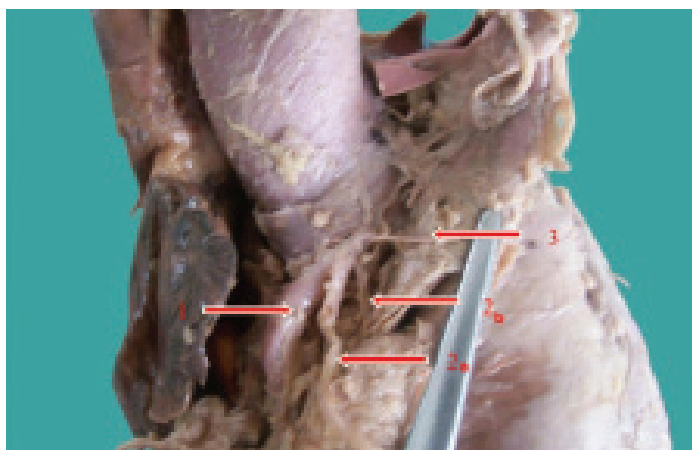
In present study, total incidence of TCA 32% (48 hearts). In 42 hearts (28%) single third coronary artery [Table/Fig-1a&b] and in 6 hearts (4%) double third coronary [Table/Fig-2,3] arteries were noted. The ostia of third coronary arteries were in front of and to the left side of that of the right coronary artery in all cases. [Table/Fig-4] shows details about ostia in anterior aortic sinus. In 2 cases, four ostia were found, one for right coronary artery, two for third coronary arteries and one for vasa vasorum of pulmonary trunk [Table/Fig-5].

TCA was found to be variably distributed to conus arteriosus, anterior wall of the right ventricle, interventricular septum and the apex of the heart. [Table/Fig-6] shows extent and distribution of TCA.

Third coronary artery (TCA) was larger than right coronary artery (RCA) in 8 heart specimens (5.33%) [Table/Fig-7]. In all these cases right coronary artery (RCA) terminated at inferior border of heart and entire diaphragmatic surface was supplied by branches of left coronary artery. In 6 of these hearts, TCA extended up to inferior border of heart supplying anterior surface of right ventricle, interventricular septum apart from infundibulum [Table/Fig-7]. In



**[Table/Fig-1]:** [a] Showing single third coronary artery (1) and right coronary artery (2) arising from ascending aorta. [b] Showing ostium of third coronary artery (1) and right coronary artery (2) from anterior aortic sinus. Left posterior aortic sinus (3) having ostium of left coronary artery is also seen



**[Table/Fig-2]:** Origin of four arteries from anterior aortic sinus, right coronary artery (1), two third coronary arteries (2a and 2b) and vasa vasorum to pulmonary trunk (3)

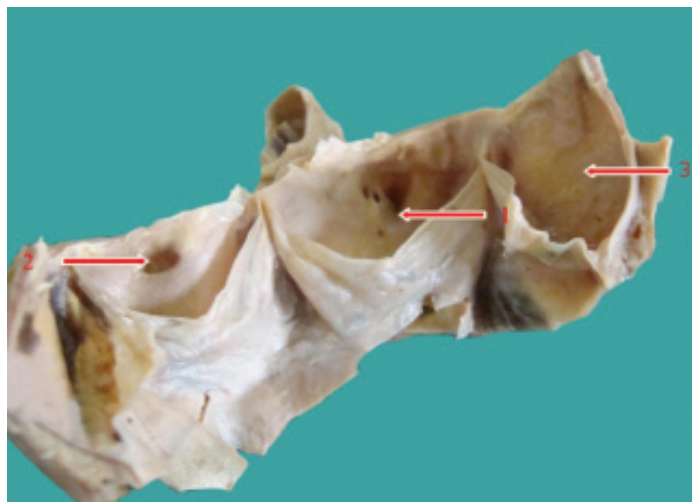


**[Table/Fig-3]:** Two third coronary arteries (arrows) extending up to the anterior wall of right ventricle

Ostia of anterior aortic sinus	No. of Hearts	Percentage
Single ostium shared for origin of RCA and third coronary artery (TCA)	3	2
Double ostium, one for RCA and other for TCA	39	26
Double ostium, one for RCA and other shared by 2 TCAs	1	0.67
3 Ostia, one for RCA and two separate ostia for 2 TCAs	3	2
4 Ostia, one for RCA, two for 2 TCA and one for vasa vasorum of pulmonary trunk [Table/Fig-5]	2	1.33

RCA- Right coronary artery  
TCA-Third coronary artery

**[Table/Fig-4]:** Showing variations in ostia of anterior aortic sinus



**[Table/Fig-5]:** Showing anterior aortic sinus (1) with 4 Ostia, one for right coronary artery, two for two TCA and one for pulmonary trunk. Left posterior aortic sinus (2) having ostium of left coronary artery and non coronary right posterior aortic sinus (3) is also seen

Extent of the artery	Distribution	Number of cases	Percentage
Ends over right ventricular outflow tract (infundibulum)	Infundibulum/conus arteriosus	24	16
Extends up to middle of the anterior wall of right ventricle [Table/Fig-3]	Supplies infundibulum with part of anterior wall of right ventricle	16	10.66
TCA larger than RCA extending up to inferior border of heart [Table/Fig-7]	Supplies infundibulum with anterior wall of right ventricle and interventricular septum	6	4%
TCA larger than RCA and ending by anastomosing with anterior interventricular branch of left coronary at apex of the heart [Table/Fig-8]	supplies infundibulum with anterior wall of right ventricle, interventricular septum and part of left ventricle near apex	2	1.33

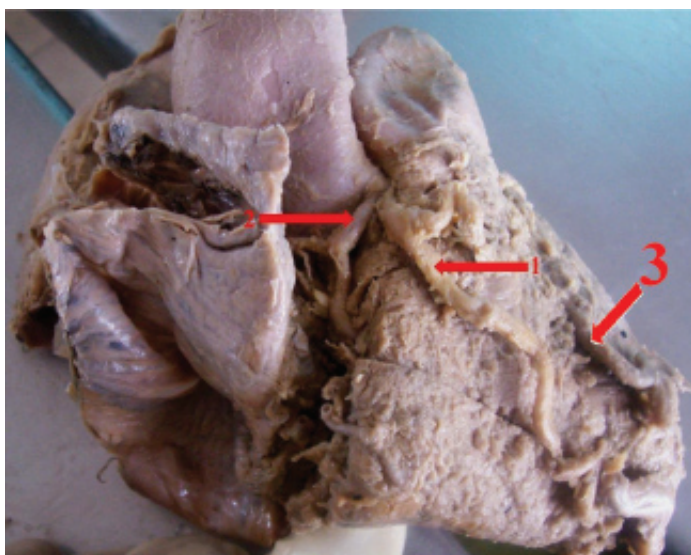
**[Table/Fig-6]:** Showing extent and distribution of third coronary artery



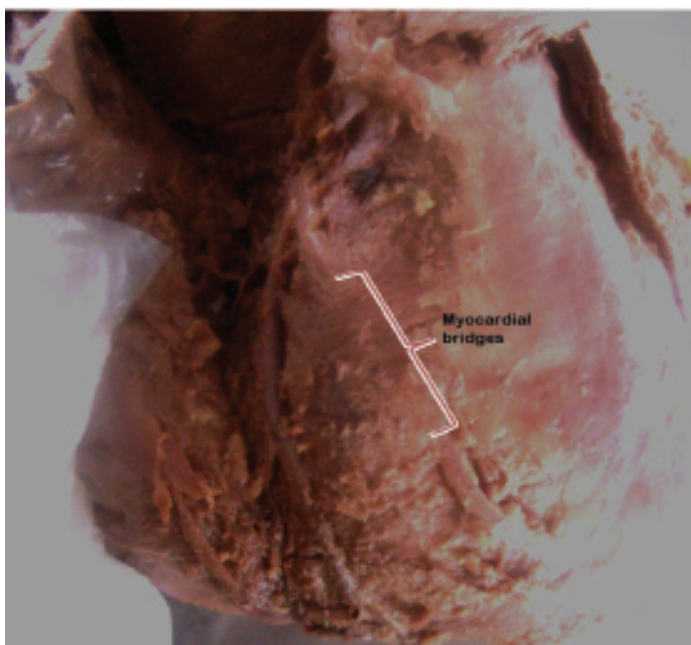
**[Table/Fig-7]:** Third coronary artery (1) is larger than right coronary artery (2) and extending up to inferior border of heart

remaining 2 of these hearts, TCA ran epicardially towards apex over sternocostal surface and terminated by anastomosing with left anterior descending artery (LADA) at apex of heart [Table/Fig-8]. The external diameter of these large arteries was ranging from 2mm to 3.5 mm. Myocardial bridge was noted over large third coronary artery in one specimen [Table/Fig-9].





**[Table/Fig-8]:** Third coronary artery (1) larger than right coronary artery (2). Third coronary artery ends by anastomosing with anterior interventricular branch (3) of left coronary artery at apex of heart



**[Table/Fig-9]:** Myocardial bridge over large third coronary artery

## DISCUSSION

Supernumerary coronary artery which arises independently from the right aortic sinus and passes through subepicardial adipose tissue of pulmonary conus and anterior aspect of the right ventricle is called third coronary artery (TCA). Schlesinger et al., for the first time reported TCA in detail [1]. Although it supplies infundibulum of right ventricle, this artery may supply variable part of the anterior wall of the right ventricle and interventricular septum [11-14].

Wide variation in the prevalence of this artery reported by various authors suggests ethnic variability which may have genetic basis or it could be due to inability to selectively cannulate TCA on conventional angiography [1,2,4,9,14].

Higher incidence of TCA was noted in subjects older than two years [6,15]. Edwards BS and group (1981) gave three potential explanations for the same –

Firstly, a failure of identification of conus artery arising from the aorta in small specimens from fetal and infantile subjects; Secondly, a progressive age related increase in the caliber of the aorta, resulting in moulding of structures, so that a conus artery arising initially from the proximal segment of RCA is carried into the aorta; and Thirdly, postnatal budding of the conus artery from the aorta.

Miyazaki & Kato also supported third view and reported that pathological hearts had a higher incidence of multiple orifices in addition to their wider ostia [15].

Olabu described three types of third coronary artery (TCA) depending upon the number of orifices as –

- 1<sup>o</sup>- TCA having common orifice with RCA;
- 2<sup>o</sup>- Single orifice of TCA separate from that of RCA;
- 3<sup>o</sup>- Two or multiple orifices for TCA [14].

The separate orifices for the TCA and RCA had been explained by insufficient unification of these vessels, during their growth towards ascending aorta [16,17].

According to this classification, 1<sup>o</sup> type of origin was found in 3 hearts, 2<sup>o</sup> type in 40 hearts and 3<sup>o</sup> type in 5 hearts in present study.

TCA may be an important source of collateral blood flow through the vascular anastomotic bridge (circle of Vieussens) between the right and left coronary systems [1,5-8]. Also the cases with anastomosis of the TCA with left anterior descending artery (anterior interventricular branch), diagonal branch, circumflex artery as well as with the branches of the right coronary artery (RCA) are described in various studies [9,18-20].

Some authors reported that TCA may also supply the conducting system [14,21]. Therefore dysfunction of the TCA may have an important role in right ventricular outflow tract (RVOT) arrhythmogenesis [21].

In 2 hearts, TCA was larger than right coronary artery and ran epicardially towards apex over sternocostal surface and terminated by anastomosing with left anterior descending artery (LADA) at apex of heart. Similar finding was also reported by Gupta et al., and Olabu et al., [4,14] The clinical importance of these arteries is that diagnostic tests carried out for LADA occlusion may fail to detect any ischemic change in anterior wall acute myocardial infarction since anterior wall and interventricular septum is protected by a large TCA in addition to septal branches of left anterior descending artery (LADA), hence giving a false better report [22]. This variant should also be kept in mind during surgical interventions involving manipulation of the infundibulum or anterior wall of right ventricle (right ventriculotomy) done for repair of ventricular septal defect or pulmonary stenosis, especially when it is partially hidden by an intramyocardial pathway [23].

Levin et al., performed coronary angiography in 508 adult patients and revealed that in 80.5% the conus artery was well visualized on the RCA angiogram, but that in 19.5% it was not adequately visualized due to injection of contrast distal to its origin. In the latter patients, the presence of conus-LAD or conus-RCA collaterals might therefore go undetected. So for planning medical and surgical treatment, attempts are made to visualize the conus artery adequately for judging distal filling via collateral circulation whenever the LAD or RCA is obstructed. But trying to catheterize the TCA selectively is time consuming and somewhat dangerous, because the ostium is small and is usually totally occluded by the entry of the catheter tip [9].

As TCA is an important link for collateral circulation between right and left coronary system, this congenital variance can be considered safe, benign and advantageous for the individuals having it. From medico-legal point of view, having a third coronary is not a bane rather is a boon as it may help in establishment of partial identity of an individual if ante mortem records of third coronary is available [24]. Hence, adequate knowledge of TCA is important not only for the Anatomists but also for the cardiologists, interventional radiologists and forensic medicine experts.

## CONCLUSION

Third coronary artery is present frequently. It anastomoses with branches of left anterior descending artery (LADA) and contributes

to apical and septal perfusion. Hence role of third coronary artery should always be considered during diagnostic and therapeutic interventions. Possibility of large third coronary and myocardial bridges over it should be thought of during various surgical procedures to avoid damage.

## REFERENCES

- [1] Schlesinger MJ, Zoll PM, Wessler S. The conus artery: a third coronary artery. *Am Heart J*. 1949;38:823-38.
- [2] Stankovic I, Jesic M. Morphometric Characteristics of the Conal Coronary Artery. *MJM*. 2004;8:2-6.
- [3] Fiss DM. Normal coronary anatomy and anatomic variations. *Applied Radiology*. 2007;36(1) Suppl:14-26.
- [4] Gupta SK, Abraham AK, Reddy NK, Moorthy SJ. Supernumerary right coronary artery. *Clin Cardiol*. 1987;10(7):425-27.
- [5] Yamagishi M, Haze K, Tamai J, Fukami K, Beppu S, Akiyama T, et al. Visualization of isolated conus artery as a major collateral pathway in patients with total left anterior descending artery occlusion. *Cathet Cardiovasc Diagn*. 1988;15(2):95-98.
- [6] Edwards BS, Edwards WD, Edwards JE. Aortic origin of conus coronary artery. Evidence of postnatal coronary development. *Br Heart J*. 1981;45(5):555-58.
- [7] Lujinovic A, Ovcina F, Tursic A. Third coronary artery. *Bosn J Basic Med Sci*. 2008;8(3):226-29.
- [8] Tayebjee MH, Lip GY, MacFadyen RJ. Collateralization and response to obstruction of epicardial coronary artery. *QJM*. 2004;97(5):259-72.
- [9] Levin DC, Beckmann CF, Garnic JD, Carey P, Bettmann MA. Frequency and clinical significance of failure to visualize the conus artery during coronary arteriography. *Circulation*. 1981;63:833-37.
- [10] Tanigawa J, Petrou M, Di Mario C. Selective injection of the conus branch should always be attempted if no collateral filling visualizes a chronically occluded left anterior descending coronary artery. *Int J Cardiol*. 2007;115(126):126-27.
- [11] Sahni D, Jit I. Blood supply of the human interventricular septum in north-west Indians. *Indian Heart J*. 1990;42(3):161-69.
- [12] Ben-Gal T, Sclarovsky S, Herz I, Strasberg B, Zlotikamien B, Sulkes J, et al. Importance of the conal branch of the right coronary artery in patients with acute anterior wall myocardial infarction: electrocardiographic and angiographic correlation. *J Am Coll Cardiol*. 1997;29:506-11.
- [13] Von Ledinghausen M, Ohmachi N. Right superior septal artery with "normal" right coronary and ectopic "early" aortic origin: a contribution to the vascular supply of the interventricular septum in human heart. *Clin Anat*. 2001;14(5):312-19.
- [14] Olabu BO, Saidi HS, Hassanali J, Ogeng'o J. Prevalance and distribution of the third coronary artery in Kenyans. *Int J Morphol*. 2007;25:851-54.
- [15] Miyazaki M, Kato M. Third coronary artery: Its development and function. *Acta Cardiol*. 1988;43(4):449-57.
- [16] Reese DE, Mikawa, T, Bader DM. Development of the coronary vessel system. *Circ Res*. 2002;91(1):761-68.
- [17] Wada A M, Willet SG, Bader D. Coronary vessel development: a unique form of vasculogenesis. *ArteriosclerThromb Vasc Biol*. 2003;23(12):2138-45.
- [18] Sharma S, Kaul U, Rajani M. Collateral circulation to the diagonal artery from the infundibular coronary artery in obstructive coronary arterial disease. *Int J Cardiol*. 1989;25:134-36.
- [19] Kerensky RA, Franco EA, Hill JA. Antegrade filling of an occluded right coronary artery via collaterals from a separate conus artery, a previously undescribed collateral pathway. *J Invasive Cardiol*. 1995;7(7):218-20.
- [20] Mishkel GJ, Biagioni E, Stolberg H. Total occlusion of the circumflex artery with collateral supply from the conus artery. *Cathet. Cardiovasc Diagn*. 1991;23(3):194-97.
- [21] Ovcina F, Susko I, Hasanovic A. Intramural blood vessels in the AV segment of the human heart conduction system. *Med Arh*. 2002;56(5-6):251-53.
- [22] Zafir B, Zafir N, Gal TB, Adler Y, Iakobishvili Z, Rahman MA, et al. Correlation between ST elevation and Q waves on the predischARGE electrocardiogram and the extent and location of MIBI perfusion defects in anterior myocardial infarction. *Ann Noninvasive Electrocardiol*. 2004;9(2):101-12.
- [23] Trivellato M, Angelini P, Leachman RD. Variations in coronary artery anatomy: Normal versus abnormal. *Cardiovascular Diseases*. 1980;7(4):357-70.
- [24] Gouda HS, Meshri SC, Aramani SC. Third coronary artery-Boon or Bane? *J Indian Acad Forensic Med*. 2009;31(1): 971-73.

### PARTICULARS OF CONTRIBUTORS:

1. Assistant Professor, Department of Anatomy, Bharati Vidyapeeth Deemed University Medical College and Hospital, Sangli, Maharashtra, India.
2. Professor, Department of Anatomy, Bharati Vidyapeeth Deemed University Medical College and Hospital, Pune, India.
3. Professor and Head, Department of Anatomy, Bharati Vidyapeeth Deemed University Medical College and Hospital, Sangli, Maharashtra, India.
4. Associate Professor, Department of Anatomy, Bharati Vidyapeeth Deemed University Medical College and Hospital, Sangli, Maharashtra, India.

### NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:

Dr. Manisha Randhir Dhobale,  
C/o Dr. V. N. Dhobale, 25-Trimurti Housing Society, Vijaynagar, Wanlesswadi, Sangli, Maharashtra, India.  
E-mail: dr.manishadhobale@gmail.com

FINANCIAL OR OTHER COMPETING INTERESTS: None.

Date of Submission: **Apr 30, 2015**  
Date of Peer Review: **Aug 08, 2015**  
Date of Acceptance: **Sep 07, 2015**  
Date of Publishing: **Oct 01, 2015**