ABSTRACT: AIMS AND OBJECTIVES: Coronary artery disease is bound to become major killer disease in our country, especially in Kerala. Considering this scenario, a sound knowledge about the anatomical details and prevalence of the supernumerary coronary artery - the “third coronary artery” is essential for interventional cardiologists, cardiovascular surgeons and anatomists. STUDY SETTINGS AND DESIGN: A prospective study was done on human hearts in the Department of Anatomy, Government Medical College, Thiruvananthapuram, Kerala. MATERIALS AND METHODS: Fifty human hearts were dissected manually to trace the coronary arteries giving special emphasis to the third coronary artery (TCA). The prevalence, distribution, gender difference and anastomotic potential of TCA were studied. Data was tabulated and analyzed. RESULTS AND ANALYSIS: Present work showed 28% prevalence for TCA. Tabulated data was analyzed using “Chi-Square test” to detect its prevalence in males and females which were 29.4% and 25% respectively. The ostium of TCA was at the same level and to the left of the ostium of RCA in 98% hearts. The termination of TCA as a single trunk or two branches were noticed. CONCLUSION: The prevalence of TCA varies widely in different populations irrespective of gender. Even though there may be variations in the position of TCA ostium, it is commonly located at the same level and to the left of the RCA ostium. It may terminate as a single trunk or bifurcated vessel. But it distributes anteriorly over the lower part of pulmonary conus and upper part of right ventricle. KEYWORDS: Third coronary artery (TCA), right coronary artery (RCA), conus artery, prevalence, gender.

INTRODUCTION: The right and left coronary arteries arise from the ascending aorta in its anterior and left posterior aortic sinuses. The levels of coronary ostia are variable: they are usually at or above the cuspal margins. The calibre of coronary arteries, both main stems and larger branches based on the measurements of arterial casts or angiograms ranged between 1.5 and 5.5mm for coronary arteries at their origin.

After originating from the right coronary sinus, RCA passes forwards and to the right between the right auricle and pulmonary trunk. Then it descends in the right atrio-ventricular groove and winds round the right border of heart to reach the crux of heart on the posterior surface. The course of RCA is divided into two segments. The first segment extends from its origin to the right border of heart and the second segment extends from the right border to the crux of heart. The branches of RCA supply right atrium and the ventricles.

The first branch is the arteria coni arteriosi or conus artery. It arises separately from the anterior aortic sinus in 36% of individuals. This is sometimes termed a “third coronary artery”. It commonly anastomoses with a similar branch from left coronary to form annulus of Vieusßen’s, a tenuous anastomotic circle over the pulmonary trunk. The functional value of such anastomoses varies, but they appear to become more effective in slowly progressive pathological conditions.

Most observations that have been made on corrosion casts suggest that the anastomotic vessels are relatively straight in normal hearts, but much coiled in hearts that have been subject to coronary
The enormous number of coronary care units in our country is a pointer to the fact that more and more patients are being admitted due to coronary artery disease. In this background present study is aimed at providing a comprehensive understanding about the prevalence, distribution, gender difference and anastomotic potential of supernumerary coronary artery – “the third coronary artery” in Keralite population.

**MATERIALS AND METHODS:** With permission obtained from Human Ethical Committee, this study was conducted in the Department of Anatomy, Govt. Medical College, Thiruvananthapuram, Kerala over a period of three years. All available human hearts were studied whereas a few hearts with severely damaged vessels excluded. A total of fifty hearts were included in the study group. Thirty four hearts belonged to male sex and sixteen belonged to female sex.

After removing the epicardium and subepicardial fat manually, each coronary artery was traced from its origin to the termination. The origin, course and main branches of RCA were studied in detail, giving emphasis to the conus artery/ third coronary artery. The proximal part of ascending aorta was opened to visualise the separate ostium of TCA and its relation with RCA ostium. The conus artery/ TCA was traced distally to visualise its branches and presence of Vieuissen’s anastomotic circle.

The relation between the prevalence of TCA and gender was studied. Necessary photographs were taken. Data was collected, tabulated and analyzed. Statistical analysis using “Chi- Square test (X²)” was done under the guidance of a biostatistician. The statistical significance or probability was expressed as ‘P value’. Appropriate tables and Bar charts (vertical bars) were prepared in both male and female hearts.

**RESULTS AND ANALYSIS:** Out of fifty hearts studied 14 hearts (28%) had separate origin of conus branch from right anterior aortic sinus (third coronary artery), very close to the origin of RCA (Figure 1). All these TCAs were short vessels which immediately after their origin supplied anteriorly over the lower part of pulmonary conus and upper part of right ventricle. In these hearts ostium of TCA was located at the same level and to the left of the ostium of RCA. In one heart (2%) the ostium of TCA was located above and to the left of the opening of RCA.

The TCA was seen as single vessel in 49 hearts (98%), where as in one heart (2%) it immediately divided into two branches both supplying the lower part of pulmonary conus and upper part of right ventricle (Figure 2). Both conus branch of RCA and TCA had subepicardial course without any myocardial bridges. The gender difference in the prevalence of TCA was studied in detail. The TCA was present in 29.4% of male hearts and 25% of female hearts (table 1, figure 3). Present study did not show any statistically significant relation between the prevalence of TCA and gender.

**DISCUSSION:** Infundibular (or conal) branch was used to designate branches that serve the anterior free wall of the right ventricular outflow tract (grossly the 3- to 5-cm segment of myocardial territory below the pulmonary valve). These branches may have direct independent aortic origin.²

Banchi³ called the conus artery “the adipose artery” and noticed its separate origin from right coronary sinus in 33% of hearts. Schlesinger et al⁴ used the term “third coronary artery” and reported its separate origin in 50% of human hearts. They concluded that the incidence of occlusions in the conus artery was much lower than in the main coronary artery trunks, but was similar to that in the primary branches of coronary artery trunks. The conus artery serves as a source of anastomotic blood.
supply directly from the aorta to other vessels of the heart when these vessels are narrowed or occluded. The dissection study done by Lujinovic et al on supernumerary coronary arteries arising from ascending aorta showed a prevalence of 32% for the direct origin of conus artery from aorta. According to their opinion, the most suitable term for this artery is "the third coronary artery "in order to differentiate it clearly from the conus branch of the right coronary artery. In their study the radius of the orifice of TCA and its distance from the orifice of RCA were 1-2 mm and 2-4 mm respectively. They documented a case in which, the third coronary artery divided into two branches, one of which went to pulmonary conus, while the other was very long and descended along the front side of the right ventricle. Their other observation was the origin of two supernumerary coronary arteries from the right aortic sinus.

A very high prevalence of 68% for the direct origin of conus artery from aorta was documented by Fazliogullari et al in a study conducted in Turkish cadaver hearts. Present work showed 28% prevalence for TCA. Comparative figures given in table 2 show wide variation in the prevalence of TCA in different population.

Whatever be the prevalence, the distribution of TCA is constant over the sternocostal surface of heart. The TCA represents a significant way of collateral circulation, as it anastomoses with the anterior interventricular branch of left coronary artery. Ballesteros et al reported 25.8% prevalence for third coronary artery, out of which 13% reached inferior ventricular surface and the remaining 87% supplied superior and middle ventricular surface.

The TCA may pass forward and to left on the sternocostal surface of the right ventricle up to the apex of heart where it anastomoses with left anterior descending artery giving small ventricular branches to the right and left ventricles during its course. Olabu et al noticed three types of origin of TCA depending on the number of orifices: 1º - common orifice with the RCA; 2º - single orifice separate from that of the RCA; and 3º - two (multiple) orifices. They reported 35.1% prevalence for the TCA. In their study most of the TCAs were epicardial in their entire length except three which showed myocardial bridges. The three types of termination of TCAs as per their study were as single trunk, bifurcation and trifurcation. They noticed the crucial anastomoses between the terminal part of TCA with the left anterior descending artery and posterior descending artery. In the present study, myocardial bridges were not identified in the course of TCA. All TCAs showed subepicardial course. In this study group one heart (2%) exhibited the division of TCA into two branches both supplying the upper part of sternocostal surface of heart.

Gender difference in the prevalence of TCA was studied by many workers. As in earlier studies, the present study also did not reveal any significance in the prevalence of TCA in males and females. Comparative figures are given in table 3.

Three patterns of origin of right conus artery as documented by Udaya Sankari et al are aortic origin, common origin with RCA and origin from RCA. More than half (53%) of their study population had the conus branch from RCA and the remaining 47% had this branch originating from aorta separately or in common with RCA. Their study reported almost an equal prevalence for aortic and common origin. The angulation of conus artery with the aortic origin was obtuse whereas the right coronary artery had an acute angled takeoff from aorta.

Miyazaki and Kato classified the orientation of third coronary artery orifice into 3 types: 10, 9 and 8 o’clock and reported a higher incidence of multiple TCAs in pathological hearts than normal hearts. According to their opinion the TCA develops and contributes to the collateral circulation after
birth. The more frequent prevalence of TCA in adult hearts than in fetal hearts, shows the possibility of its development after birth. The 9 o’ clock position of TCA ostium was later reported by Padmalatha et al in a study conducted in thirty dissected hearts. Augustin et al showed the importance of third coronary artery in providing collateral circulation in patients with left coronary artery occlusion. Collateral circulation is a key factor in the pathophysiology of coronary artery disease. The symptoms and prognosis among coronary patients depend on the quality of collateral circulation. Anatomical studies on the distribution of coronary arteries on nonhuman primates were done by Nikolic et al. According to them the orifice of TCA was at the same level as that of RCA and 0.2 mm in front of it. The ostium of TCA may be to the left of and superior to the ostium of RCA as reported by Stankovic and Jesic.

The most common position of TCA ostium in present study is at the same level and to the left of the ostium of RCA. The ostium of TCA need not be at the same level because 2% hearts showed the TCA ostium superior and to the left of the ostium of RCA. The frequency of occurrence of Vieussen’s anastomotic ring is more with the conus branch of RCA than with the TCA and the presence of supernumerary coronary arteries may reduce the anastomotic potential of RCA.

High-resolution magnetic resonance imaging study done by Burton et al reports the presence of TCA as common finding in rabbits and human hearts. Medico legal importance of TCA was pointed out by Gouda et al as it might help in establishment of partial identity of an individual if ante mortem record of third coronary artery was available.

CONCLUSION: The prevalence of TCA shows wide variation in different populations. The present study shows a prevalence of 28% for TCA. The prevalence of TCA in males and females is 29.4% and 25% respectively. This shows the absence of statistically significant relation between the prevalence of TCA and gender. Even though there may be variations in the position of TCA ostium, it is commonly located at the same level and to the left of the ostium of RCA.

TCA has a subepicardial course and it distributes anteriorly over the lower part of pulmonary conus and upper part of right ventricle. It may terminate as single trunk or two branches. Further studies using invasive techniques are needed to evaluate the anastomotic potential of TCA and its role in providing collateral circulation in coronary artery disease.

REFERENCES:


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<tr>
<td></td>
<td>Number</td>
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<tr>
<td>Male (34)</td>
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<tr>
<td>Female (16)</td>
<td>4</td>
<td>25%</td>
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Table 1: Prevalence of TCA in males and females. $X^2 = 0.105, p$ value = 0.746

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Table 2: Prevalence of TCA as reported in the literature

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<td>52%</td>
<td>48%</td>
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<td>Ballesteros et al⁷</td>
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<td>17.5%</td>
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<tr>
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Figure 1: Anterior view of heart showing TCA

Abbreviations: TCA – third coronary artery, RCA – right coronary artery, LAD – left anterior descending artery.

Figure 2: Anterior view of heart showing bifurcation of TCA
Figure 3: Bar chart showing the prevalence of TCA in males and females.