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Original Article

Anatomy Section

Coronary Arteries and their Variations: A Retrospective Study at a Tertiary Care Centre in Tamil Nadu, India

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ABSTRACT

Introduction: Anatomic variations in coronary circulation are commonly identified during dissection and angiographic procedures. The right and left coronary arteries, which supply blood to the heart, originate from the corresponding aortic sinuses. Occlusion of the coronary artery can lead to heart ischaemia, resulting in myocardial infarction and death. Understanding such variations is crucial for cardiac catheterisation, coronary artery bypass surgery, and the identification of fistulous communication, dissection, and rupture of the coronary artery.

Aim: To identify the branching pattern of coronary arteries, their origin, dominance in the heart, and variations in angiographic images.

Materials and Methods: The present retrospective cross-sectional study analysed 100 angiographic pictures collected from the Cardiology Department at PSG Institute of Medical Sciences and Research, Coimbatore, Tamil Nadu, India, between November 2017 and April 2018. The data were analysed from March 2022 to June 2022 to determine the origin, branching pattern, and variations of the coronary arteries. The coronary arteries and their branches were carefully traced and followed to their termination, and normal and variant anatomy were analysed. Descriptive statistics were used, and the results were expressed in frequency and percentage.

Results: A total of 100 patients presented with chest pain/dyspnoea and underwent diagnostic coronary artery catheterisation in the PSG Cardiology Department. Among them, 75% were males and 25% were females, with ages ranging from 14 to 82 years (mean age of 48 years). The dominant form of coronary circulation was found to be right dominance (42%), followed by co-dominance (30%). In one study, a higher origin of the right coronary artery from the ascending aorta was observed. An anomalous vessel arising from the right coronary artery was identified in an angiogram. Separate origins of the circumflex artery and left anterior descending artery from the left coronary artery were observed in another angiogram. Fistulous communications were found in two angiograms: one between the pulmonary artery and the diagonal branch of the left anterior descending artery, and the other between the right coronary artery and the septal branch of the left anterior descending artery. Additionally, two other studies identified dissection and spontaneous rupture of the coronary artery.

Conclusion: Identifying anomalous vessels and recognising other variations are crucial for appropriate intervention, treatment, and improved outcomes. Angiography can help identify and treat variations in the course and branching pattern of the coronary artery as early as possible to avoid complications.

Keywords: Anomalous, Aorta, Branching pattern, Development, Fistula and stenosis

INTRODUCTION

The right and left coronary arteries originate from the corresponding aortic sinuses. The right coronary artery initially passes anteriorly and to the right, between the right auricle and pulmonary trunk, and then descends to the inferior cardiac border, reaching the crux. It terminates by anastomosing with the circumflex branch of the left coronary artery [1]. The artery is divided into segments as follows: the first segment extends from its origin to the inferior border of the heart, giving rise to numerous ventricular and atrial branches. One of the ventricular branches is the right conus artery, which supplies the infundibulum of the pulmonary trunk. The Sinoatrial (SA) nodal artery is an atrial branch that arises from the right coronary artery in 65% of cases and from the circumflex branch of the left coronary artery in 35% of cases. The second segment extends from the inferior border to the crux and gives rise to the right marginal artery and the posterior interventricular branch. Thus, the right coronary artery supplies the right atrium, right ventricle, part of the atrioventricular septum, and part of the left ventricle [2].

The left coronary artery passes between the pulmonary trunk and the left auricle, where it bifurcates into the left anterior descending and circumflex arteries. It supplies a larger volume (60%) of the myocardium. The left anterior descending artery runs in the left anterior interventricular groove and terminates by anastomosing with the posterior interventricular artery. The circumflex artery runs in the posterior atrioventricular groove and terminates by anastomosing with the right coronary artery. The origin of the posterior interventricular artery determines coronary dominance [2].

The prevalence of congenital coronary artery anomalies is 5-6% [3,4]. Anomalous or abnormal is used to define any variant form observed in less than 1% of the general population. Seven categories of coronary artery anomalies have been described, including anomalous pulmonary artery origins of coronary arteries, anomalous aortic origins of coronary arteries, congenital atresia of the left coronary artery, coronary artery fistula, coronary artery bridgings, coronary aneurysms, and coronary stenosis [3].

The prevalence of all coronary anomalies is 0.23% in autopsies and ranges between 0.3 and 12% in angiographic studies [5]. Coronary artery anomalies are frequently identified during coronary angiographic studies. Anomalies were reported to have an angiographic incidence of 1.3% in the study conducted by Yamanaka O and Hobbs RE [6]. A coronary artery fistula is an abnormal termination of a coronary artery into a cardiac chamber, systemic vein, or the pulmonary artery. It has an incidence of 0.1-0.2% in patients undergoing catheter coronary angiography and 0.33-0.35% in patients undergoing computed tomographic angiography. It constitutes approximately 15% of Common Carotid Artery (CCA) [6].

Variations of the coronary arteries have been reported in many cadaveric and angiographic studies [6-34]. The present cadaveric study conducted in 2016 showed that the branching pattern of the left coronary artery is not limited to bifurcation and trifurcation; it can also exhibit tetrafurcation and pentafurcation [35]. The present study serves as a follow-up to that previous study. Cadaveric studies can help identify various anomalies and provide valuable knowledge to cardiologists and cardiothoracic surgeons. Coronary angiography, a noninvasive procedure, has become the technique of choice for visualising the coronary system. It allows cardiologists and cardiothoracic surgeons to identify anomalies and intervene accordingly.

The introduction of selective coronary angiography has provided a way to visualise the normal coronary arterial pattern and any variations in the arterial pattern [7]. Despite the availability of modern revascularisation techniques and coronary bypass surgeries, knowledge about the coronary arterial pattern and its variations remains important for cardiologists and cardiothoracic surgeons in order to improve prognosis. Therefore, the objective of present study was to investigate the pattern of angiographic coronary artery anatomy, origin, course, and dominance of the heart. Authors aimed to identify variations in the branching pattern of coronary arteries and the frequency of coronary artery anomalies and compare them with previous studies.

MATERIALS AND METHODS

This is a retrospective cross-sectional study and collected angiogram pictures from the Cardiology Department at PSG Institute of Medical Sciences and Research, Coimbatore, Tamil Nadu, India, between November 2017 and April 2018. The data were analysed from March 2022 to June 2022 to determine the origin, branching pattern, and variations of the coronary arteries. Ethical clearance was obtained from the Institutional Ethics Committee (Project no. 15/205).

Inclusion criteria: The study included patients with coronary artery anomalies, dissection, and rupture of the artery.

Exclusion criteria: Patients with coronary artery disease were excluded from the study.

Study Procedure

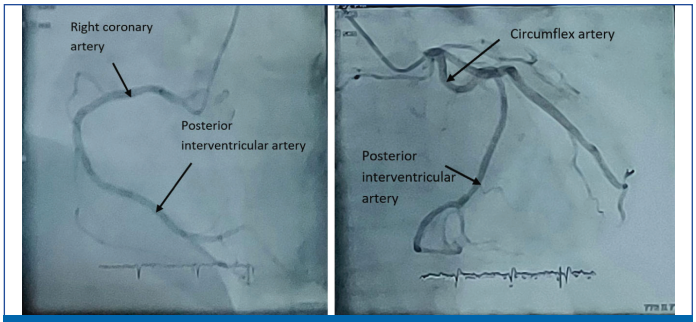
A total of 100 patients presenting with chest pain/dyspnoea were included in the study. Angiogram pictures and patient details, such as age and gender, were collected. These patients underwent diagnostic coronary artery catheterisation in the PSG Cardiology Department, and the coronary angiographic interpretation was performed by both a cardiologist and a radiologist. Anonymisation of the data was performed. The collected data were listed, recorded, and analysed from March 2022 to June 2022. The dominance of the heart was determined by the origin of the posterior interventricular artery. Authors identified and documented the origin, branching pattern, and anatomical variants of the coronary arteries (including coronary dominance, origin of the SA nodal artery, ramus intermedius), anomalous vessels from the right coronary artery, separate origin of the circumflex and left descending artery, fistulas, ruptures, dissections, and abnormal origin of the right coronary artery. The termination of the left coronary artery was categorised as bifurcation, trifurcation, or quadrifurcation based on the number of branches arising from the trunk of the left coronary artery.

STATISTICAL ANALYSIS

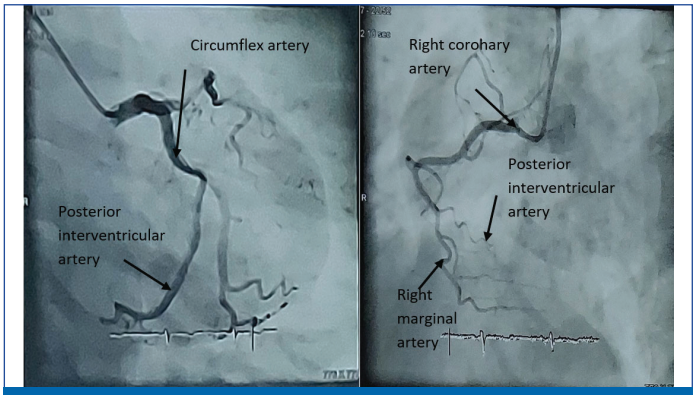
Descriptive statistics were used to analyse the data, and the results were expressed in frequency and percentage. Since there was no comparison in the study, statistical tests and software were not used.

RESULTS

A total of 100 patients presented with chest pain/dyspnoea and underwent diagnostic coronary artery catheterisation in the PSG Cardiology Department. Among them, 75% were males and 25% were females, with ages ranging from 14 to 82 years (mean age of 48 years). Electrocardiograms and echocardiograms were found to be normal, except for one patient who had a coronary artery dissection (identified by echocardiography). The posterior interventricular artery originated from the right coronary artery (right dominance) in 42% of cases, and the posterior interventricular artery originated from both the right coronary artery and the circumflex artery (co-dominance) was the next most common finding [Table/Fig-1-5].



[Table/Fig-1]: Shows right dominance.
[Table/Fig-2]: Shows left dominance. (Images from left to right)

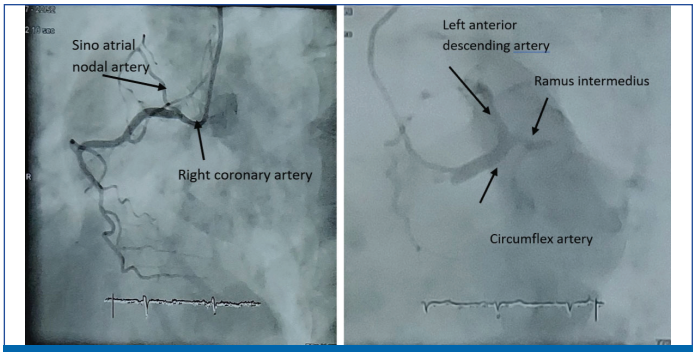


[Table/Fig-3,4]: Shows co-dominance. (Images from left to right)

Anatomic variants	Numbers (%)
1. Dominance	
Right	42 (42%)
Left	28 (28%)
Co-dominance	30 (30%)
2. Sinoatrial nodal artery	
From right coronary artery	70 (70%)
From circumflex artery	30 (30%)
With a separate ostium	Nil
3. Ramus intermedius	57 (57%)

[Table/Fig-5]: Prevalence of anatomic variants of the coronary arteries, numbers (%).

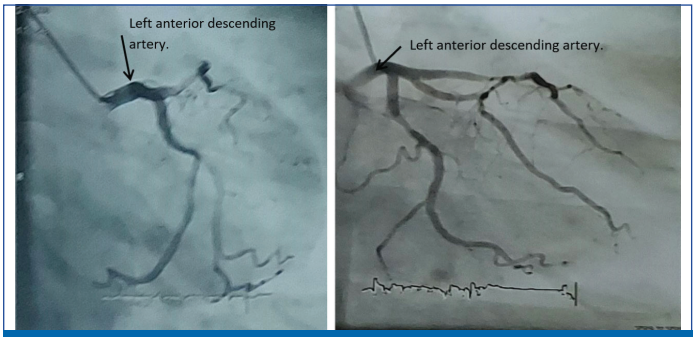
Sinoatrial nodal artery originated from right coronary artery in 70% angiograms [Table/Fig-5,6]. Ramus intermedius was found in (57%) angiograms [Table/Fig-5,7]. Left coronary artery branching pattern was found to be more bifurcating (56%) than trifurcation and quadrifurcation [Table/Fig-8-10].



[Table/Fig-6]: Shows sinoatrial nodal artery from right coronary artery.
[Table/Fig-7]: Shows ramus intermedius. (Images from left to right)

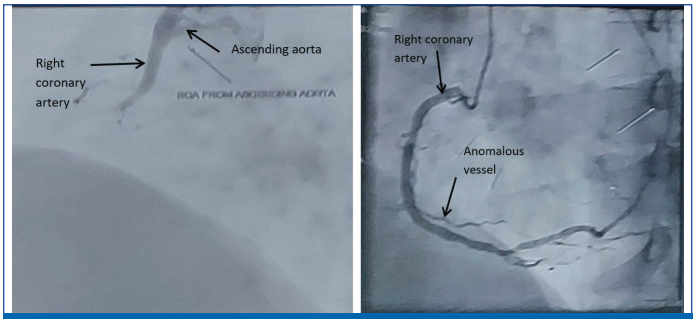
Branching pattern of left coronary artery	Males (n=75)	%	Females (n=25)	n (%)	Total number	Total percentage
Bifurcation	44	58	12	48	56	56
Trifurcation	25	33	9	36	34	34
Quadrifurcation	6	8	4	16	10	10

[Table/Fig-8]: Branching pattern of left coronary artery.

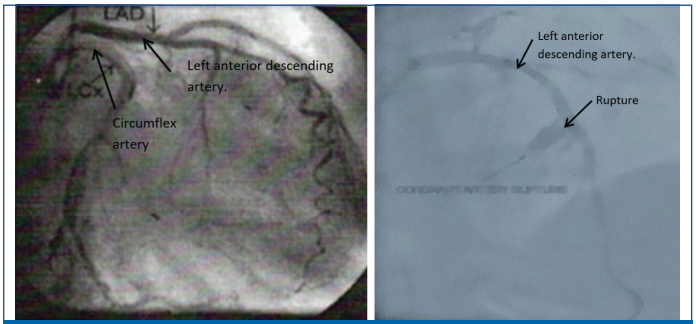


[Table/Fig-9]: Shows bifurcation of left anterior descending artery. **[Table/Fig-10]:** Shows trifurcation of left anterior descending artery. (Images from left to right)

Eight patients were found to have abnormalities. Among them, five were male and three were female. The abnormalities included higher origin of the right coronary artery from the ascending aorta [Table/Fig-11], anomalous origin of a vessel from the posterolateral branch of the right coronary artery [Table/Fig-12], separate origin of the circumflex artery and left anterior descending artery [Table/Fig-13], spontaneous rupture of a coronary artery [Table/Fig-14] and fistula between the pulmonary artery and diagonal branch of the left anterior descending artery [Table/Fig-15]. The three female patients had a posterior origin of right coronary artery [Table/Fig-16], dissection of coronary artery [Table/Fig-17,18] and fistula between right coronary artery, coronary artery dissection and septal branch of left anterior descending artery [Table/Fig-19] and a fistula between the right coronary artery and the septal branch of the left anterior descending artery.



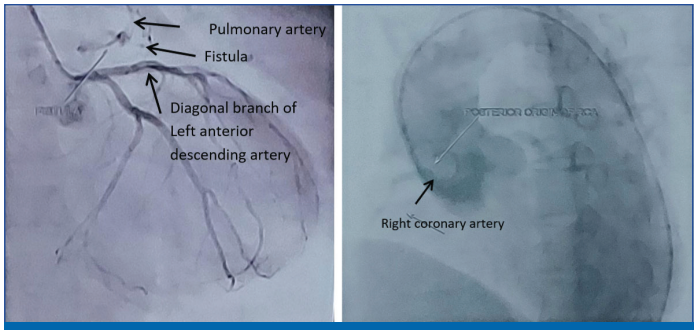
[Table/Fig-11]: Shows right coronary artery from ascending aorta as higher origin. **[Table/Fig-12]:** Shows anomalous vessel from right coronary artery. (Images from left to right)



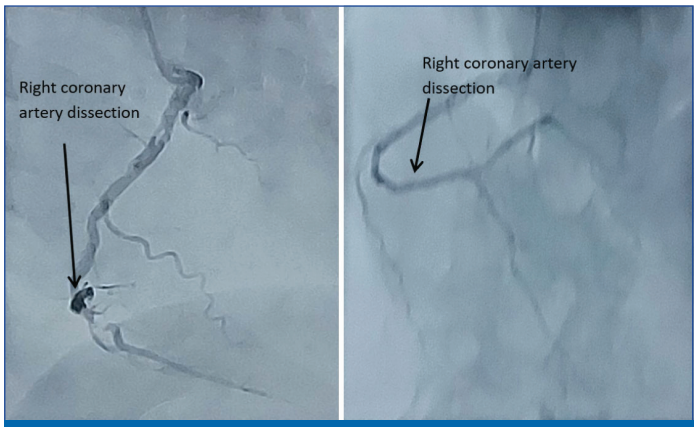
[Table/Fig-13]: Shows separate origin of circumflex and left anterior descending artery. **[Table/Fig-14]:** Shows spontaneous rupture of coronary artery. (Images from left to right)

DISCUSSION

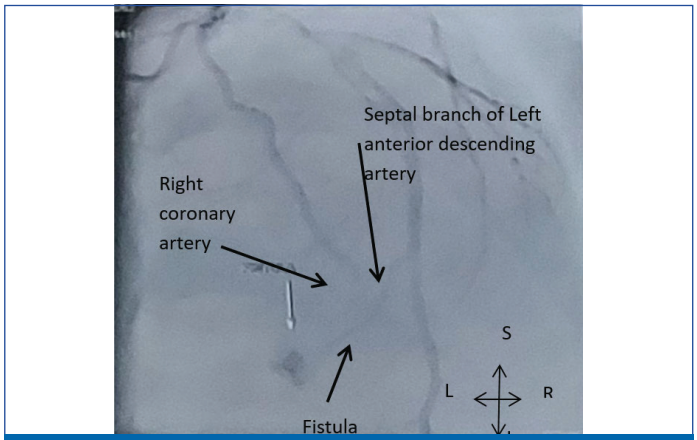
During the 3rd week of embryogenesis, the cardiac area develops from the splanchnopleuric mesoderm. The coronary arteries normally arise from the appropriate differentiation of pluripotent cells. Anomalies



[Table/Fig-15]: Shows fistula between pulmonary artery and diagonal branch of left anterior descending artery. **[Table/Fig-16]:** Shows posterior origin of right coronary artery. (Images from left to right)



[Table/Fig-17,18]: Shows coronary artery dissection. (Images from left to right)



[Table/Fig-19]: Shows fistula between right coronary artery and septal branch of left anterior descending artery.

of the coronary circulation can occur due to disruptions in the normal differentiation and specialisation of the heart tube. Variability in coronary artery anatomy is observed even in normal individuals. Anomalies can involve the origin, course, branching pattern, and termination of the coronary arteries. The dominance is determined by the origin of the posterior interventricular artery, which can arise from the right coronary artery, the circumflex artery, or both. The origin of the posterior interventricular artery is based on a study by James TN [9]. Angina, myocardial infarction, and even death may occur depending on the stenosis of the dominant artery. In coronary artery bypass surgeries, any variation in dominance plays a significant role. In the coronary artery bypass grafting procedure, precise knowledge of the patient's specific coronary artery is crucial. This is because the surgeon must identify which vessels are suitable to receive the distal anastomosis of the venous graft. For occlusion of the right or left coronary artery, the posterior descending artery may be a suitable choice based on its patency. The venous conduit is sutured into the portion of the right coronary artery that is distal to the occlusion [10].

An abnormal vessel arising from the posterolateral branch of the right coronary artery was found in an angiogram. This was not reported in studies conducted by previous authors.

The left anterior descending artery has two groups of branches: septal branches and diagonal branches. The number of branches can vary. Obtuse marginal arteries, diagonal arteries, and ramus intermedius have complementary roles to each other. When one is absent or small in caliber, the other branch supplies its territory [11]. Separate origins of the left anterior descending artery and circumflex artery from the left coronary sinus of Valsalva with an absent left main trunk were observed. The angiographic incidence of the anomalous circumflex artery was observed to be 0.6% to 1.1% [12]. In autopsy studies, the incidence of the anomalous circumflex artery was found to be 0.2% to 0.8% [12]. To prevent the risk of infarction or sudden death, special surgical procedures might be needed when an anomalous circumflex artery is observed during valvular replacement surgery.

Coronary fistula formation is a direct communication between the coronary artery and the coronary sinus or one of its tributaries, such as the superior vena cava, the pulmonary artery, or veins close to the heart or lumen of any cardiac chambers [13]. The presence of new anastomoses between the vessels indicates hypoxia, anaemia, occlusive disease, and valvular disease of the heart [14]. In the present study, a fistula was found between the diagonal branch of the left anterior descending artery and the pulmonary artery in an angiogram picture. In another angiographic study, there was a fistula between the septal branch of the left anterior descending artery and the right coronary artery. High fistula flow causes the hemodynamic steal phenomenon, multiple communications, multiple terminations, and significant aneurysm formations. These effects lead to myocardial ischaemia, congestive cardiac failure, and pulmonary hypertension.

Early surgical or interventional treatment is needed because of these important clinical consequences. Clinical symptoms are based on the induced hemodynamic abnormality. If the patient is asymptomatic, treatment options include closing the fistula, either by coil embolisation or by ligation of the fistula with or without coronary artery bypass graft [30]. The most frequently reported drainage sites for coronary artery fistulas in coronary angiography studies are the right ventricle (41%), followed by the right atrium (26%) and the pulmonary artery (17%) [31].

The drainage sites of coronary artery fistulas are clinically more important than the site of origin. The fistula causes a left-to-right shunt in approximately 90% of cases and has a negative impact on hemodynamic mechanism. Most of them are asymptomatic in adults, and the severity of the left-to-right shunt determines the clinical presentation [32].

Rupture of the coronary artery was found in an angiogram in the present study. This finding was similar to the study conducted by Murti A et al., [33], in which the patient presented with spontaneous rupture of the coronary artery resulting in acute myocardial infarction. In another patient who presented with chest pain, spontaneous dissection of the coronary artery was found.

The present finding was not similar to the study conducted by Shroff G and Rajani R, [34], in which spontaneous dissection of the circumflex artery with the left anterior descending artery in a patient with dyspnea on exertion was observed. A comparison of the frequency of the left coronary artery branching pattern among various studies is presented in [Table/Fig-20] [7,12-22,35]. [Table/Fig-21] shows a comparison of various parameters (anomalies related to origin, anomalies of

Authors and year of study	Type of study	Population and number of cases	Bifurcation	Trifurcation	Quadrifurcation	Pentafurcation	One branch
Kalpana R [7], 2003	Cadaveric	Indian 100	47	40	11	1	1
Ballesteros LE et al., [12] 2008	Cadaveric	Colombian mixed race 154	52	42.2	9	_	_
Fazliogullari Z et al., [13], 2010	Cadaveric	Turkish 50	46	44	10	_	_
Bhimalli S et al., [14], 2011	Cadaveric	Indian 60	56.6	33.3	8.3	1	_
Kosar P et al., [15], 2009	64-slice CT angiography	Turkish 700	68	31	_	_	_
Cadematiri F et al., [16], 2008	64-slice CT angiography	Italian 543	78.1	21.9	_	_	_
Tomar S et al., [17], 2013	64-slice CT angiography	North Indian 50	76	24	_	_	_
Baptista CA et al., [18], 1991	Cadaveric	American 150	54.7	38.7	6.7	_	_
Reig J and Petit M [19], 2004	Autopsy	Spanish 100	62	38	_	_	_
Surucu HS et al., [20], 2004	Autopsy and Cadaveric	Turkish 40	47.5	47.5	2.5	2.5	_
Lujinovic A et al., [21], 2005	Coronary angiography	Bosnian 100	71	29	_	_	_
Lujinovic et al., [21], 2005	Cadaveric	Bosnian 20	71	29	_	_	_
Christensen KN et al., [22], 2010	64-slice CT angiography	American 105	81	19	_	_	_
Manickavasuki AK et al., [35], 2018	Cadaveric	South Indian	30	34	16	6	2
Present study, 2022	Coronary angiography	South Indian	56	34	10	0	0

[Table/Fig-20]: A comparison of the frequency of left coronary artery branching pattern among various studies [7,12-22,35].
CT: Computed tomography

Parameters	Kosar P et al., [15] study (700 angiogram, Turkey, 2009)	Altaii FG et al., [23] study (500 angiogram, Damascus, 2010)	Kulkarni J and Mehta L, [24] study (107 angiogram, North India, 2012)	Mahani MG and Agarwal PP, [25] study (2011)	Diwan y et al., [26] study (1130 angiogram, North India, 2017)	Graidis C et al., [27] study (2572 angiogram, Greece, 2015)	Altin C et al., [28] study (5548 angiogram, 2015)	Tharwat M et al., [29] study (4246 angiogram, 2014)	Present study (100 angiogram, Tamil Nadu, 2018)
Anomalies related to origin Sinu-atrial nodal artery	79%	--	--	60%	--	--	--	--	70%
Abnormal origin of right coronary artery	0.5%	1%	--	--	0.09%	0.35%	1.2%	15.65%	2%
C. Anomalous vessel from right coronary artery	--	0.02%	--	--	--	--	--	--	1%
Anomalies of termination (Fistula)	--	0.02%	--	0.002%	0.09%	0.15%	0.3%	7.82%	2%
Anomalies related to branching pattern commonest branching pattern of left coronary artery	Bifurcation (68%)	--	Bifurcation	Bifurcation	--	--	--	--	Bifurcation (56%)

Separate origin of left anterior descending artery and circumflex artery	0.4%	--	2.8%	--	0.27%	0.58%	--	--	1%
Ramus Intermedius	31%	--	11.5%	--	--	--	--	--	57%
Right coronary dominance	76%	77%	--	85%	--	--	81.6%	63.02%	42%

[Table/Fig-21]: Comparison of various parameters- Anomalies related to origin, anomalies of termination, anomalies related to branching pattern and right coronary dominance with previous authors [15,23-29].

termination, anomalies related to branching pattern, and right coronary dominance) with previous studies [15,23-29].

Limitation(s)

The study was performed over a short period with a small sample size. If, the study were planned for a longer period, the results might vary.

CONCLUSION(S)

In the present study, females who underwent cardiac catheterisation showed normal coronary artery anatomy compared to males. The majority of the hearts were right-dominant, and the bifurcation of the left coronary artery was found to be the most common in the present study. The incidence of coronary artery anomalies was approximately 8% in present study. Congenital anomalies of the coronary artery are a significant cause of chest pain and sudden cardiac death. The findings of the present study will be beneficial in making a correct diagnosis and treating the patients accordingly.

REFERENCES

[1] Standring S. Heart in Gray's Anatomy: The Anatomical Basis of Clinical Practices. 42nd ed. New York: Johnson D & Collins Eds. Churchill Livingstone; 2021. pp.1089-91.
[2] Datta AK. Essentials of Human Anatomy. 8th ed. Kolkatta: Current Books International; 2008. pp.83-84.
[3] Mongiardo R. Anomalous coronary arteries- A report of 2 cases of single coronary artery. Cardiologia. 1991;36(2):143-46.
[4] Perloff JK. Coronary artery anomalies: A comprehensive approach. Circulation. 2001;103(13):e72.
[5] Amico F, Castorina S. Anatomical variations in the coronary arteries. Ital J Anat Embryol. 2001;106(2):113-17.
[6] Yamanaka O, Hobbs RE. Coronary artery anomalies in 1,26,595 patients undergoing coronary arteriography. Cathet Cardiovasc Diagn.1990;21(1):28-40.
[7] Kalpana R. A study on principal branches of coronary arteries in humans. J Anat Soc India. 2003;52(2):137-40.
[8] Fritzgerald MJ. Human embryology. Sao Paulo. Brasil: Harper & Row; 1980, p. 48.
[9] James TN. Anatomy of the coronary artery. New York: Hoeber Med Div, Harper & Row; 1961.
[10] Shahoud JS, Ambalavanan M, Tivakaran VS. Cardiac Dominance. In StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2022.
[11] Ortale JR, Filho JM, Paccola AMF. Anatomy of the lateral, diagonal and anterosuperior arterial branches of the left ventricle of the human heart. Braz J Cardiovasc Surg. 2005;20(2):149-58.
[12] Ballesteros LE, Ramirez LM. Morphological expression of the left coronary artery: A direct anatomical study. Folia Morphol. 2008;67(2):135-42.
[13] Fazliogullari Z, Karabulut AK, Unver Dogan N, Uysal II. Coronary artery variations and median artery in Turkish cadaver hearts. Singapore Med J. 2010;51(10):775-80.
[14] Bhimalli S, Dixit D, Siddhibhavi M, Shhirol VS. A study of variations in coronary arterial system in cadaveric human heart. World J Sci Tech. 2011;1(5):30-35.
[15] Kosar P, Ergun E, Ozturk C, Kosar U. Anatomic variations and anomalies of the coronary arteries: 64 slice CT angiographic appearance. Diagn Interv Radiol. 2009;15:275-83.
[16] Cadematiri F, La Grutta L, Malago R, Alberghina F, Meijboom WB, Pugliese F, et al. Prevalence of anatomical variants and coronary anomalies in 543 consecutive patients studied in 64- slice CT coronary angiography. J Euro Rad. 2008;18(4):781-91.
[17] Tomar S, Aga P, Sharma PK, Manik P, Srivastava AK. Normal & variant anatomy of left coronary artery: 64- slice CT slice multi detector computed tomography coronary angiographic depiction in north Indian Population. Int J Sci & Res Publications. 2013;3(8):01-17.
[18] Baptista CA, DiDio LJ, Prates JC. Types of division of left coronary artery and the ramus diagnalis of the human heart. Jpn Heart J.1991;32(3):323-25.
[19] Reig J, Petit M. Main trunk of the left coronary artery: Anatomic study of the parameters of clinical interest. Clinical Anatomy. 2004;17(1):06-13.
[20] Surucu HS, Karahan ST, Tanyeli E. Branching pattern of the left coronary artery and an important branch. The Median artery. Saudi Med J. 2004;25(2):177-81.
[21] Lujinovic A, Ovcina F, Voljevica A, Hasanovic A. Branching of main trunk of left coronary artery and importance of the diagonal branch in cases of coronary insufficiency. Bosn J Basic Med Sci. 2005;5(3):69-73.
[22] Kevin N, Christensen, Harris SR, Froemming AT, Brinjikji W, Araoz P, et al. Anatomic assessment of the bifurcation of the left main coronary artery using multidetector Computed Tomography. Journal of Surg & Radio Anatomy. 2010;31(10):903-09.
[23] Altaii FG, Youssef M, Takla M. Angiographic coronary artery study: Anatomy, variation and anomalies. Kasr El Alini J Surg. 2010;2(1):71-76.
[24] Kulkarini J, Mehta L. Study of angiographic anatomy of right coronary artery. IOSR J Dental & Med Sci. 2012;2(1):39-41.
[25] Mahani MG, Agarwal PP. Coronary artery anomalies on CT angiography. Appl Radiol. 2011;40(6):18-25.
[26] Diwan Y, Diwan D, Chauhan RS, Negi PC. Coronary artery anomalies in North Indian population: A conventional coronary angiography. Nat J Clin Anat. 2017;6(4):250-57.
[27] Graidis C, Dimitriadis D, Karasawidis V, Dimitriadis G. Prevalence and characteristics of coronary artery anomalies in an adult population undergoing multidetector-row computed tomography for the evaluation coronary artery disease. BMC cardiovas disorders. 2015;15:112.
[28] Altin C, Kanylimaz S, Koc S, Gursoy YC. Coronary anatomy, anatomic variations and anomalies: A retrospective coronary angiography study. Singapore Med J. 2015;56(6):339-45.
[29] Tharwat M, Ashtokhy MA, Mahfouz RA, Alshahatlbrahim A. Angiographic study of anatomical variations of coronary arteries by using diagnostic catheter. ZUMJ. 2014;20(6):826-34.
[30] Maroules CD, Adams DZ, Whiting ED, Antevil JL, Mitchell ES. Anomalous origin of the right coronary artery from the pulmonary artery. Tex Heart Inst J. 2013;40(1):106-08.
[31] Erol C, Sekar M. Coronary artery anomalies: The prevalence of origination, course, termination and anomalies of coronary arteries detected by 64-detector CT angiography. J Comput Assist Tomogr. 2011;35(5):618-24.
[32] Sundaram B, Krenic R, Patel S. Imaging of coronary artery anomalies. Radiol Clin North Am. 2010;48(4):711-27.
[33] Murthy A, Artisingh, Meizlish J. Spontaneous rupture of right coronary artery presenting as acute inferior myocardial infarction. Am J Med Case Rep. 2014;2(9):198-99.
[34] Shroff G, Rajani R. Spontaneous coronary artery dissection: An uncommon problem with a common presentation. Indian Heart J. 2003;55(6):655-57.
[35] Manickavasuki AK, Jamuna M, Hebzibah D, Nirmaladevi M, Swamicken B, Radhika K, et al. Anatomical study of left coronary artery and its variations-cadaveric study. J Clin Diag Res. 2018;12(1):AC01-AC05.

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