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Clinical significance of prevalence of coronary arteries in cadavers from Bihar region

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Abstract
Coronary arteries are the largest vasa vasorum of the heart, the heart develops from the fusion of two primitive endothelial tubes, which represent the ventral aorta. The right coronary artery arises from the right coronary sinus (anterior aortic sinus) of the ascending aorta and the left coronary artery arises from the left posterior aortic sinus of the ascending aorta. Ostia of the coronary arteries are located in the center of the corresponding aortic sinuses. Malformations of the position of the ostia and origin of coronary arteries lead to high risk of sudden death.
Based on above findings the present study was planned to evaluate the coronary arteries in human cadavers. The present study was planned in Department of Anatomy, J.L.N.M.C. Bhagalpur, Bihar, India. Total 30 cases of the heart specimens were obtained from the cadavers in the Dept. of Anatomy.
The present study on branching pattern and distribution of coronary arteries, shows some difference with respect to the results from the available literatures. The data generated from the present study concludes that knowledge about the variations of coronary arteries is helpful for cardiologists and radiologists in performing various procedures like coronary angiogram, coronary angioplasty, and bypass grafting surgeries etc.

Keywords: coronary artery, dominance, right dominant, left dominant, balanced, etc

Introduction
The coronary arteries are the blood vessels (arteries) of coronary circulation, which transports oxygenated blood to the substance of the heart. The heart requires a continuous supply of oxygen to function and survive, much like any other tissue or organ of the body [1].
The coronary arteries wrap around the entire heart. The two main branches are the left coronary artery (LCA) and right coronary artery (RCA). The arteries can additionally be categorized based on the area of the heart they provide circulation for. These categories are called epicardial (above the epicardium, or the outermost tissue of the heart) and microvascular (close to the endocardium, or the innermost tissue of the heart) [2].
Reduced function of the coronary arteries can lead to decreased flow of oxygen and nutrients to the heart. Not only does this affect supply to the heart muscle itself, but it also can affect the ability of the heart to pump blood throughout the body. Therefore, any disorder or disease of the coronary arteries can have a serious impacts on health, possibly leading to angina, a heart attack, and even death [3].
The coronary arteries are mainly composed of the left and right coronary arteries, both of which give off several branches as shown in the 'Coronary artery flow' figure.

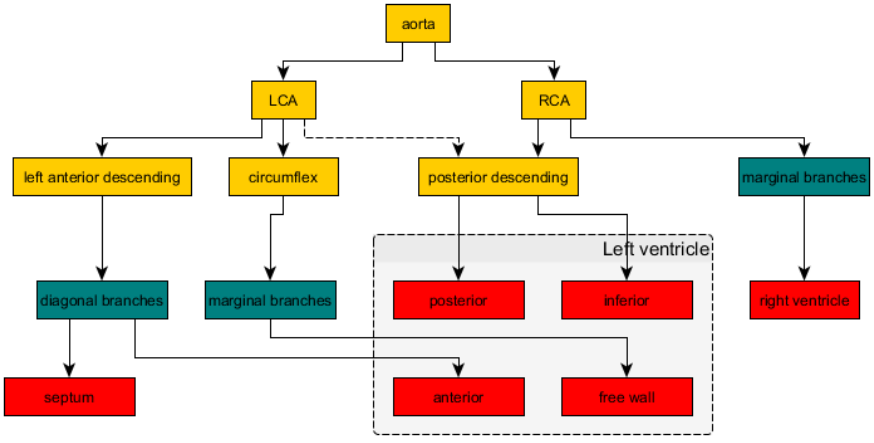

Fig 1

Coronary artery flow
- Left coronary artery (LCA): Left anterior descending artery; Left circumflex artery Posterior descending artery; Ramus or intermediate artery;
- Right coronary artery (RCA): Right marginal artery & Posterior descending artery

The left coronary artery (LCA) arises from the aorta within the left cusp of the aortic valve and feeds blood to the left

side of the heart. It branches into two arteries, the left anterior descending and the left circumflex. The left anterior descending artery perfuses the interventricular septum and anterior wall of the left ventricle. The left circumflex artery perfuses the left ventricular free wall. In approximately 33% of individuals, the left coronary artery gives rise to the posterior descending artery [4] which perfuses the posterior and inferior walls of the left ventricle. Sometimes a third branch is formed at the fork between left anterior descending and left circumflex arteries known as a ramus or intermediate artery [5].

The right coronary artery (RCA) originates within the right cusp of the aortic valve. It travels down the right coronary sulcus, towards the crux of the heart. The RCA primarily branches into the right marginal arteries, and, in 67% of individuals, gives place to the posterior descending artery [4]. The right marginal arteries perfuse the right ventricle and the posterior descending artery perfuses the left ventricular posterior and inferior walls.

There is also the conus artery, which is only present in about 45 percent of the human population, and which provides collateral blood flow to the heart when the left anterior descending artery is occluded [6, 7].

Narrowing of the arteries can be caused by a process known as atherosclerosis (most common), arteriosclerosis, or arteriolosclerosis. This occurs when plaques (made up of deposits of cholesterol and other substances) build up over time in the walls of the arteries. Coronary artery disease (CAD) or ischemic heart disease (IHD) are the terms used to describe narrowing of the coronary arteries [8].

As the disease progresses, plaque build-up can partially block blood flow to the heart muscle. Without enough blood supply (ischemia), the heart is unable to work properly, especially under increased stress. Stable angina is chest pain on exertion that improves with rest. Unstable angina is chest pain that can occur at rest, feels more severe, and/or last longer than stable angina. It is caused by more severe narrowing of the arteries [9]. A heart attack results from a sudden plaque rupture and formation of a thrombus (blood clot) that completely blocks blood flow to a portion of the heart leading to tissue death (infarct). CAD can also result in heart failure or arrhythmias. Heart failure is caused by chronic oxygen deprivation due to reduced blood flow, which weakens the heart over time. Arrhythmias are caused by inadequate blood supply to the heart that interferes with the heart's electric impulses. The coronary arteries can constrict as a response to various stimuli, mostly chemical. This is known as a coronary reflex. There is also a rare condition known as spontaneous coronary artery dissection, in which the wall of one of the coronary arteries tears, causing severe pain. Unlike CAD, spontaneous coronary artery dissection is not due to plaque build-up in arteries, and tends to occur in younger individuals, including women who have recently given birth or men who do intense exercise [10].

Coronary artery disease (CAD), also known as ischemic heart disease (IHD), involves the reduction of blood flow to the heart muscle due to build-up of plaque in the arteries of the heart. It is the most common of the cardiovascular diseases. Types include stable angina, unstable angina, myocardial infarction, and sudden cardiac death. A common symptom is chest pain or discomfort which may travel into the shoulder, arm, back, neck, or jaw. Occasionally it may feel like heartburn. Usually symptoms occur with exercise or emotional stress, last less than a few minutes, and improve with rest. Shortness of breath may also occur and sometimes no symptoms are present. In many cases, the first sign is a heart attack. Other complications include heart failure or an abnormal heartbeat [11].

Risk factors include high blood pressure, smoking, diabetes, lack of exercise, obesity, high blood cholesterol, poor diet, depression, and excessive alcohol. A number of tests may help with diagnoses including: electrocardiogram, cardiac stress testing, coronary computed tomographic angiography, and coronary angiogram, among others. Ways to reduce CAD risk include eating a healthy diet, regularly exercising, maintaining a healthy weight, and not smoking. Medications for diabetes, high cholesterol, or high blood pressure are sometimes used. There is limited evidence for screening people who are at low risk and do not have symptoms. Treatment involves the same measures as prevention. Additional medications such as antiplatelets (including aspirin), beta blockers, or nitroglycerin may be recommended. Procedures such as percutaneous coronary intervention (PCI) or coronary artery bypass surgery (CABG) may be used in severe disease. In those with stable CAD it is unclear if PCI or CABG in addition to the other treatments improves life expectancy or decreases heart attack risk [12].

Limitation of blood flow to the heart causes ischemia (cell starvation secondary to a lack of oxygen) of the heart's muscle cells. The heart's muscle cells may die from lack of oxygen and this is called a myocardial infarction (commonly referred to as a heart attack). It leads to damage, death, and eventual scarring of the heart muscle without regrowth of heart muscle cells. Chronic high-grade narrowing of the coronary arteries can induce transient ischemia which leads to the induction of a ventricular arrhythmia, which may terminate into a dangerous heart rhythm known as ventricular fibrillation, which often leads to death [13].

Typically, coronary artery disease occurs when part of the smooth, elastic lining inside a coronary artery (the arteries that supply blood to the heart muscle) develops atherosclerosis. With atherosclerosis, the artery's lining becomes hardened, stiffened, and accumulates deposits of calcium, fatty lipids, and abnormal inflammatory cells – to form a plaque. Calcium phosphate (hydroxyapatite) deposits in the muscular layer of the blood vessels appear to play a significant role in stiffening the arteries and inducing the early phase of coronary arteriosclerosis. This can be seen in a so-called metastatic mechanism of calciphylaxis as it occurs in chronic kidney disease and hemodialysis (Rainer Liedtke 2008). Although these people suffer from a kidney dysfunction, almost fifty percent of them die due to coronary artery disease. Plaques can be thought of as large "pimples" that protrude into the channel of an artery, causing a partial obstruction to blood flow. People with coronary artery disease might have just one or two plaques, or might have dozens distributed throughout their coronary arteries. A more severe form is chronic total occlusion (CTO) when a coronary artery is completely obstructed for more than 3 months [14].

Cardiac syndrome X is chest pain (angina pectoris) and chest discomfort in people who do not show signs of blockages in the larger coronary arteries of their hearts when an angiogram (coronary angiogram) is being performed. The exact cause of cardiac syndrome X is unknown.

Explanations include microvascular dysfunction or epicardial atherosclerosis. For reasons that are not well understood, women are more likely than men to have it; however, hormones and other risk factors unique to women may play a role. Up to 90% of cardiovascular disease may be preventable if established risk factors are avoided. Prevention involves adequate physical exercise, decreasing obesity, treating high blood pressure, eating a healthy diet, decreasing cholesterol levels, and stopping smoking. Medications and exercise are roughly equally effective. High levels of physical activity reduce the risk of coronary artery disease by about 25% [15].

Most guidelines recommend combining these preventive strategies. A 2015 Cochrane Review found some evidence that counselling and education in an effort to bring about behavioral change might help in high risk groups. However, there was insufficient evidence to show an effect on mortality or actual cardiovascular events. In diabetes mellitus, there is little evidence that very tight blood sugar control improves cardiac risk although improved sugar control appears to decrease other problems such as kidney failure and blindness. The World Health Organization (WHO) recommends "low to moderate alcohol intake" to reduce risk of coronary artery disease while high intake increases the risk [16].

Methodology

The present study was planned in Department of Anatomy, J.L.N.M.C. Bhagalpur, Bihar, India. Total 30 cases of the heart specimens were obtained from the cadavers in the. Department of Anatomy, J.L.N.M.C. Bhagalpur

Adult Human Cadaveric heart specimens were collected and preserved in 10% formalin. The coronary arteries were traced through epicardium and subepicardial adipose tissue. The observations were made with respect to its origin, level of ostium, in relation to sinotubular junction, length of trunk of LCA, normal branching pattern, variations in branching pattern, course, dominance and presence or absence of myocardial bridge. To see the location of ostia the ascending aorta was transversely sectioned approximately 1cm above the commissure aortic leaflets. The aorta was then longitudinally opened at the level of right posterior aortic sinus which enabled to analyse the level and number of ostia with respect to sinotubular junction [19].

Results and Discussion

The branching pattern and distribution of coronary arteries have been studied by various workers in the past. Coronary artery disease is one of the most common causes of death due to changing dietary habits, sedentary habits, smoking etc, in developing countries like India. With the advancement of medical technology, the incidence of coronary angiography and coronary bypass surgeries, stunt, balloon angioplasty is also increasing. The present study was taken up with the hope that the data collected in the study may help clinician to interpret properly the findings which will lead on to its remedy.

Nowadays, with the extensive use of advanced image diagnostic techniques and the development of nonaggressive treatments, a in-depth knowledge of anatomy of the normal coronary and its variations and anomalies is important. Branches of coronary arteries may vary in origin, distribution, number and size. The name and nature of a coronary artery or a branch is defined by that vessel's distal vascularisation pattern or territory, rather than by its origin.

Table 1: Termination of Right Coronary Artery

Site	Male	Female	Total
(i) Right border	1	0	1
(ii) Right border – crux	3	1	4
(iii) Crux	4	2	6
(iv) Crux- left border	11	5	16
(v) Left border	2	1	3
Total	21	9	30

Table 2: Termination of Circumflex Artery

Site	Male	Female	Total
Acute /Right Border	0	0	0
Crux-acute border	2	1	3
Crux	3	3	6
Obtuse border – crux	12	4	16
Obtuse / left border	3	2	5
Total	20	10	30

Table 3: Origin of Posterior Interventricular artery (Dominance)

Dominancepattern	Male	Female	Total
Right dominance	15	5	20
Left dominance	4	2	6
Balanced	2	2	4
Total	21	9	30

Table 4: Dominant pattern observed by various authors.

Authors	Right dominance	Left dominance	Common dominance
Kurjia *et al* [20]	46%	14%	40%
Ortale *et al* [21]	62%	12.50%	25%
Loukas *et al* [22]	55%	24%	33%
Fazligullari *et al* [23]	42%	14%	44%
Bhimalli *et al* [24]	66%	23.30%	-
Kalpana *et al* [25]	89%	11%	-
Present *et al*	67%	20%	13%

The Kalpana R (2003) reported that i.e. the Right and left coronary ostia were present at the anterior aortic and left posterior aortic sinus respectively in all the 100 specimens studied and there were no variations in the location of the ostia [26]. Study done by Subhash D Joshi *et al* on 105 embalmed heart specimens found that neither openings were detected in the pulmonary sinuses nor in the right posterior aortic sinus [27]. Study conducted by Jyoti P kulkarni *et al* revealed that in all 60 cases, the dissected right coronary artery (RCA) and left coronary artery (LCA) were found to originate from anterior aortic sinus and the left posterior aortic sinus, respectively [28]. In a dissection study on heart specimens received from medico legal autopsies and performed by Sahni and Jit *et al*, [29] revealed that anomalous origin of any coronary artery was not found in any case. Baroldi and Scomazzoni In 1967, described 36% prevalence of independent origin of right conus [30]. Similar findings also noted by Bhimalli *et al*. [31]. However, ectopic origin may have for RCA from left posterior aortic sinus. On angiographic studies 0.0008% prevalence of this ectopic origin was observed, as mentioned by Yarnanaka and Hobbs [32]. and 0.043-0.46%, as revealed by Solanki *et al*. [33]. Grag and Tiwari *et al* [34]. observed anomalous coronaries in 0.95% of individuals. Of these cases, about 90% were anomalies of origin. Harikrishnan *et al*. [35]. reported an incidence of 0.45% of anomalies of origin of coronary

artery.

Kronzon, *et al*. [36]. reported right dominance in his angiographic study of 104 participants whereas Kurjia, *et al*. [37] establishing the location and origin of the conus artery in relation to the right ventricular outlow tract radiologically prior to surgery is essential for the treatment of tetralogy of fallot. Ortale al. [38] examined dominant circulation in 40 cadaver hearts, and accepted the posterior inter ventricular branch arising from the RCA and its branches supplying at least the middle medial part of the left ventricular posterior face as right dominance (62.5%).

Major or minor congenital anomalies of the coronary arteries are present in those undergoing cardiac catheterization. Depending upon the origin, course, and termination of the anomalous vessel, certain coronary anomalies may be associated with sudden death, syncope, other congenital heart diseases, or angina syndromes, or they may be incidental findings, without adverse prognosis. Accurate recognition and documentation of coronary artery anomalies at the time of coronary angiography are essential to determine the significance of such findings and to avoid therapeutic complications [39]. Variations in coronary artery anatomy are often recognized in association with structural forms of congenital heart disease. Importantly, coronary artery anomalies are a cause of sudden death in young athletes in the absence of additional heart asbnormalities [40]. The coronary artery study in regard to the area of distribution is a matter of prime medical importance. Their physiological significance is indicated by the fact that they utilize 10% of the blood flowing through the aorta [41]. Early and correct diagnosis of anomalies that may compromise the myocardial blood supply is stressed, and possible surgical solutions are offered. Selective coronary angiography is the technique of choice for precise visualization of the coronary artery system [42].

Conclusion

The present study on branching pattern and distribution of coronary arteries shows some difference with respect to the results from the available literature. The data generated from the present study concludes that knowledge about the variations of coronary arteries is helpful for cardiologists and radiologists in performing various procedures like coronary angiogram, coronary angioplasty, and bypass grafting surgeries etc.

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