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Original Research Article

Arterial vascularization of the interventricular septum: morphological & radiological study

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Abstract: The arterial supply of the interventricular septum was studied by macroscopic and radiological examination after injecting radio-opaque material in 50 human hearts. During macroscopic study many intercoronary anastomoses were found in different regions of heart though they were short in length, small in caliber and thin walled. At radiological examination, the small septal arteries arising from the posterior interventricular artery and large septal arteries from the anterior interventricular artery were observed. The secondary branches from the main septal arteries displayed diverse patterns on the right and left sides of the septum. During radiological study, it was also recognized that the short septal rami from the posterior descending artery were distributed over the posterior or inferior one-third of the septum except its apical zone while the anterior descending artery through its septal branches supplied the ventral two-thirds of the septum and whole of the apical portion. Straight intercoronary anastomotic vessels were clearly discernible within the interventricular septum during radiological examination**.**
Keywords: Interventricular septum, human heart, radiological examination, coronary arteries, collateral circulation.

INTRODUCTION

Throughout life the heart requires nonstop supply of oxygen and nutrition. As if to mirror this crucial importance, the coronary arteries originate from the most proximal part of aorta. The main arteries branch repeatedly on epicardial surface, then the finer branches emerge and proceed almost perpendicularly towards the subendocardial region. Due to this arrangement when the ventricles contract these vessels are occluded, so the myocardium itself receives nutrition during diastole. [1]

Cardiovascular diseases are the world's largest killers, claiming 17.5 million lives a year [2]. Cardiovascular diseases are responsible for about 10% DALYs (Disability-adjusted life years) lost in low and middle income countries and 25% in high income countries [3]. Lately cardiovascular diseases are increasing in developing nations as a result of increasing longevity, urbanization and lifestyle changes [4].

Cardiac ischemia represents a mismatch in coronary arterial supply and myocardial demand. The vast majority of ischemic heart diseases are due to atherosclerosis – deposition of cholesterol in the subintimal layer of a branch of coronary artery causing partial occlusion of the lumen. Acute myocardial infarction typically results from complete occlusion of the coronary artery. The zone of myocardium supplied by that affected artery rapidly stops functioning. [5]

The younger patients more likely suffer from infract than angina due to lack of collateral circulation. These collaterals grow well particularly in the old who have suffered from partial occlusion of coronary artery for a long time. [6] If the collaterals are very well developed, total blocking of even a rather moderately big branch of coronary artery may be tolerated well. In man the collaterals are most commonly occur in the muscular interventricular septum and in the interatrial septum [7]. However racial differences in the distribution of coronary collateral vessels also exist [8].

Vessels supplying the interventricular septum also provide branches to the atrio-ventricular node and bundle. So, study of the arterial supply of the interventricular septum is very important as maintenance of normal cardiac conduction depends on the blood supply to its conductive system and cardiac surgeries involving the interventricular septum requires familiarity with its vascular anatomy. Another important aspect is to uncover the fact regarding the collateral vessels which is very important to reduce cardiac mortality [9].

Population based studies are always important to have adequate idea regarding the minute changes of the pattern of the arterial supply to the interventricular septum in specific population and that study should also be recent to detect any adjustments due the altered life style or changes in the external environment, which is very true in developing countries.

MATERIALS AND METHODS

In this cadaveric study 50 human hearts (age range 20 – 40 years) were collected within 12 hours of death from the mortuary of our institutions-. Higher age group subjects were avoided to eliminate any possibility of atherosclerotic changes.

Hearts without any macroscopic abnormality were cut from the cadaver with retaining the proximal 4cm of the major vessels. Hearts were thoroughly cleaned of the blood clots. The coronary arteries were cannulated through the aortic sinuses with polythene tubes of proper caliber and then a ligature passed around the coronary arteries close to their origin to fix those cannulae within the proximal part of coronary arteries. The coronary arteries were irrigated scrupulously with warm physiologic saline to flush out even any small clot by putting cannula into their lumina.

Two bottles containing 95% w/v suspension of micro fined barium sulphate with added glycerin were connected to the outer ends of these cannulae. Glycerin prevents leakage of water from the radio-opaque dye into the tissues. These two bottles were also connected with an aneroid manometer containing pressure bulb by a Y-joint. The pressure of injection was set at 140mm of Hg to avoid rupture of small vessels and at the same time to maintain a good penetration of the dye into the small vessels.

After completion of the injection procedure cannulae were disconnected from bottles. Care was taken to avoid introduction of air bubbles at any stage of the procedure. Another knot was given around the proximal part of the coronary arteries, just after slowly removing the cannulae, to prevent spilling over of the dye. Hearts were then transferred to 10% formalin solution and kept there for 4 weeks.

Fig-1: A] Barium sulphate within coronary artery branches (blue arrows); B] Cut interventricular septum (held in forceps) with part of right and left ventricular free wall

Then macroscopic study was done by dissecting out the coronary arteries and their branches into the interventricular septum. For radiological examination skiagrams of the interventricular septae were obtained after hearts were cut by two different methods (Group A & B). In Group A the interventricular septae were isolated (Figure- 1) by cutting the right and left ventricular free wall to prevent overlapping from the ventricular wall arterial skiagrams. In Group B slice of interventricular septae along with the ventricles were obtained by cutting through the ventricles to reveal the arterial pattern within the substance of the interventricular septum.

OBSERVATION

Macroscopic study

The coronary arteries and their branches over the epicardial surface were easily identified due to their white colour (Figure- 1) as they contained barium sulphate. Two coronary arteries were seen to arise from the root of the aorta and coursing subepicardially largely hidden by fat. At intervals they were plunged slightly into the musculature of the heart.

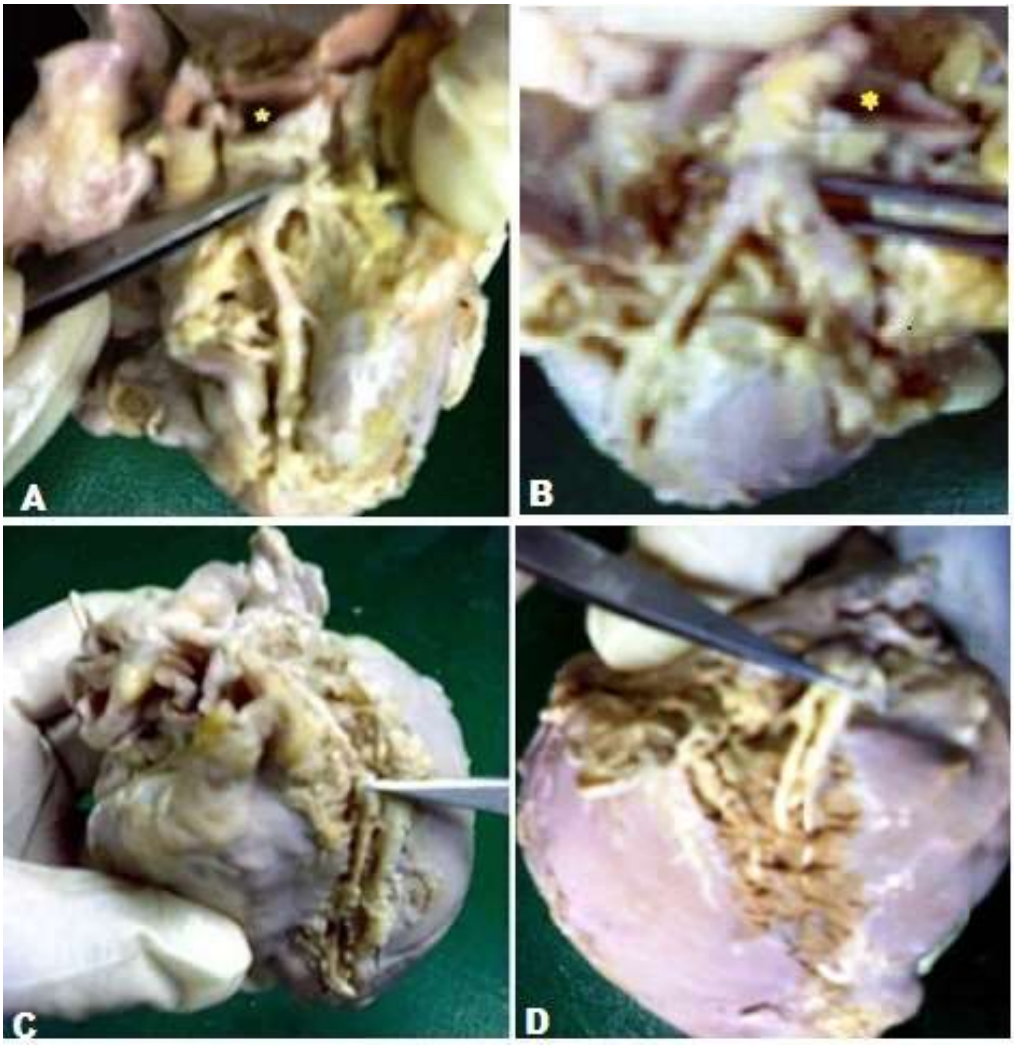

Fig-2: A] Right coronary artery (held in forceps) arising from the anterior aortic sinus; B] Left coronary artery (lifted by forceps) arising from the left posterior aortic sinus (yellow star indicating cut stump of ascending aorta); C] Anterior interventricular artery (held in forceps); D] Multiple posterior interventricular branches (held in forceps).

The left coronary artery was found to arise from the left posterior aortic sinus (Figure - 2) and gave off circumflex and anterior interventricular branch. The right coronary artery was found to arise from the anterior aortic sinus (Figure - 2) and usually gave off 1-3 posterior interventricular branches though sometimes none. The posterior interventricular artery was singular in 37 specimens (74%), among these only in two specimens (4%) the posterior interventricular artery was a continuation of the circumflex branch of left coronary artery (left dominance). In the rest 13 specimens (26%) two or three posterior interventricular branches were seen (Figure - 2), among these only one specimen (2%) showed that one of the posterior interventricular branches was the continuation of the circumflex artery (balanced type). Therefore in overall 47 specimens (94%) right dominance was detected. When multiple posterior interventricular branches existed their branches were small and sparse.

The anterior interventricular arteries descended apical-ward along the anterior interventricular groove, sometimes deeply embedded in or crossed by bridges of myocardial tissue. From the apex they turned round into the posterior interventricular groove (Figure - 2) and after passing about caudal $^{1}/_{3}^{rd}$ of the groove they met with the terminal twigs of the posterior interventricular branches present in the posterior interventricular groove directed towards the apex. The anterior interventricular artery produced 4 to 7 long septal branches along its course. The anterior septal branches leave the anterior interventricular artery almost perpendicularly and pass back and down in the septum, assume a course close to the endocardium on the right side of the septum, usually supplying its ventral two-thirds. Small posterior septal branches from the same source supplied the posterior one-third of the septum for a variable distance from the cardiac apex. Rest of the posterior $^{1}/_{3}^{rd}$ of the septum except its apex was supplied by the septal branches of the posterior interventricular artery. These septal branches were shorter than the branches from the

anterior descending artery but they were many in number.

Many extramural anastomoses were observed at the crux, interventricular grooves, near the apex, interatrial grooves and at the anterior aspect of the right ventricle. Though they were very short in length, small in caliber and thin walled.

Radiological study

Group A: (Figure - 3)

The parent trunk of the anterior descending artery was very clearly visualized in its entire extent and its septal rami were seen to run through the septum giving off branches. The septal branches of the anterior descending artery were more or less clearly visualized. They were long and almost straight, directed downward and backward. The first septal ramus was very much long and supplied greater area of the septum than the other septal rami. They gave off secondary branches to supply approximately the anterior two-thirds of the septum plus the whole of the apical portion. The septal branches of the posterior descending artery were far shorter and they supplied the posterior one-third of the septum except near the apex. At the junctional region of the territory of both the descending artery were found to have lower number of vascular marking in respect to other area of the septum. Many anastomotic vessels were clearly evident, connecting the septal branches of both the descending arteries. The anastomotic vessels were straight without having any remarkable tortuous course.

Group B: : (Figure - 4)

The septal rami from the anterior descending artery ran slightly on the right and gave off branches that supply the right and left sides of the septum. The secondary branches were more on the left side of the septum and they were disposed perpendicular to the endocardial surface; those on the right side of the septum ran parallel to the endocardial surface and some of the branches supplied the papillary muscles as well.

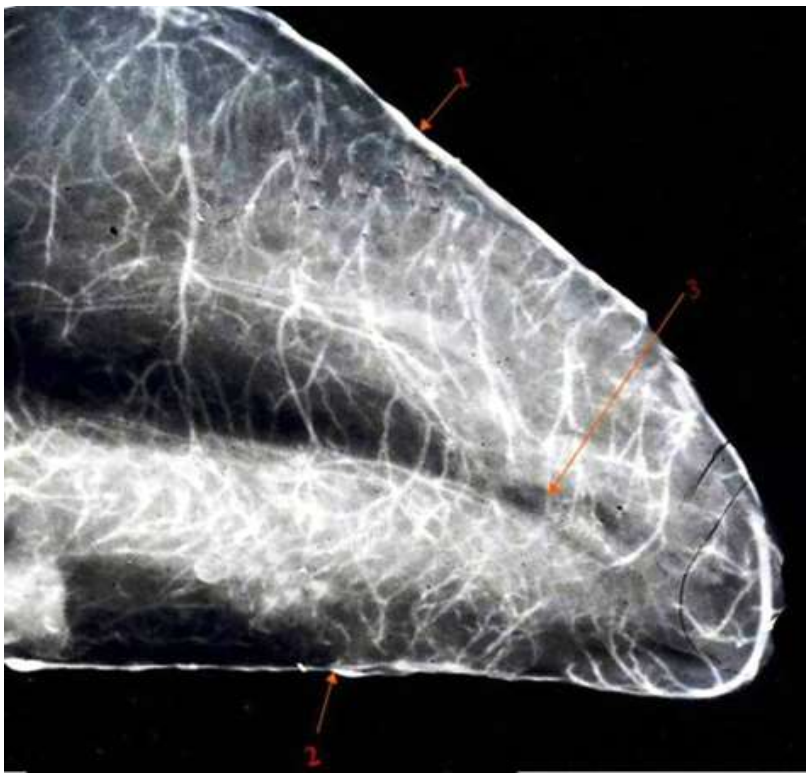

Fig-3: X-ray of isolated interventricular septum (1- Anterior interventricular artery, 2 - Posterior interventricular artery, 3 - Anastomotic vessels), Anterior septal arteries supplying ventral two-third of the septum and posterior septal arteries supplying dorsal one-third of the septum

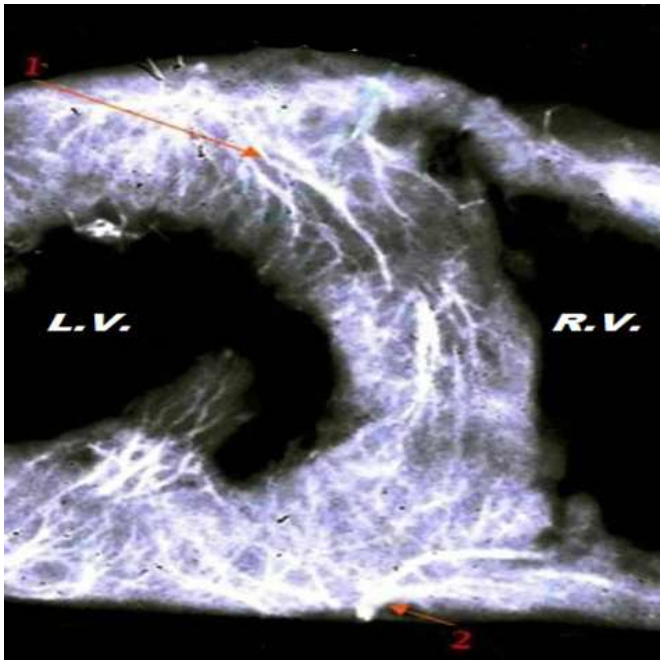

Fig-4: X-ray of section through interventricular septum (1- Septal ramus from anterior interventricular artery, 2 - Posterior interventricular artery with its septal rami), L.V. –left ventricle, R.V. – righr ventricle.

DISCUSSION

The prevalence of third coronary artery is very high in certain populations, as in Japanese – 36.8 %; Kenyans – 35 %; Bulgarians – 34.8 % etc [10]. But in this study all the heart specimens had two coronary arteries and no anomalous origins of coronary arteries were noted. Posterior interventricular artery was single in 74% of the specimens and in rest 26% it was multiple. 94% of the specimens showed right dominance, 4% were left dominance and only 2% specimens showed 'balanced' type circulation. Human mostly possess right coronary predominance where the posterior interventricular artery is derived from the right coronary artery. In about 10% of hearts the right coronary artery is shorter than usual and the posterior interventricular artery is replaced by a continuation of the circumflex branch of the left coronary artery, it is known as left coronary predominance - these people are likely to be affected by coronary artery disease, because the entire ventricular septum are under the nutritional control of left coronary artery. In a 'balanced' circulation, branches of both arteries run in or near the interventricular groove. [11]

No remarkable difference in the pattern of arterial distribution of the interventricular septum was noticed during the macroscopic and radiological study in this observational study. Interventricular septum predominantly received blood supply from the anterior interventricular artery. Large septal rami after arising from the anterior interventricular artery were found close to the endocardium on the right side of the septum, probably to avoid the high pressure within the left ventricular chamber. Posterior one-third of the septum except its apex was supplied by the shorter septal branches of the posterior descending artery. These findings are very much similar to the previous observations [12]. Arterial vascularization of the interventricular septum in different animal species may have different variants. In man the anterior septal arteries are the important ones but in the equine species the posterior septal arteries are preponderant while in porcine heart anterior and posterior septal arteries share almost equally for ventricular septal vascularization [13].

The secondary branching pattern from these septal arteries varies on the two sides of the septum. Branching pattern on the left side of the septum are similar to the arterial branching pattern of the left ventricular free-wall. On the other hand, those of the right side of the septum resembles to the arterial branching pattern of the right ventricular free-wall. The contrast of arterial pattern on the two sides of the septum is probably due to the added growth of muscle mass in left ventricle than the right. This difference in the arterial pattern in the two side of the interventricular septum is one of the explanations why the interventricular septum is "functionally bilayered" as demonstrable by tissue Doppler methods [14, 15].

The right and left coronary arteries are not end arteries. Many intercoronary network anastomoses are present at a precapillary level and also between larger caliber vessels. The anastomotic vessels are generally of two types: thin, long, straight or gently curving vessels and tortuous, enlarged, cork-screw like vessels [16]. The shape of the anastomotic vessels depends mainly on whether the vessels are functioning or nonfunctioning. Corrosion cast studies have suggested

that anastomotic vessels are relatively straight in normal hearts but greatly coiled in hearts that have been subject to coronary occlusion [17]. In normal hearts they are straight, since probably very little amount of circulation is possible through them. In this study, almost in all the skiagram, anastomotic vessels were seen and they appear straight.

Extramural anastomoses were observed in the apex, interatrial and interventricular grooves, the anterior aspect of the right ventricle, crux and near the sinoatrial node [18]. Dominant locations of intercoronary collateral vessels vary with species. Dogs tend to have these collaterals mainly in the epicardial portions of the heart, while pigs show predominance in the endocardium [19]. In man most common sites are muscular interventricular septum and interatrial septum. However racial differences in the distribution of intercoronary collateral vessels may also exist [20] necessitating population specific studies. Existence of third coronary artery and its distribution to the conducting system, interventricular septum and cardic apex suggests its significant role as a source of collateral circulation [10]. In abnormal hearts with holes within the ventricular septum were found to deviate the path of the septal perforating arteries in a predictable manner. The perforating arteries that nourish the ventricular septum and the atrioventricular conductive tissues are placed at risk during operations that involve incisions in the region in the repair of congenital heart defects.

The collateral circulation through the anastomoses protects the myocardium but its development is a very slow process. After sudden complete coronary occlusion, several weeks are necessary for the development of rich anastomoses and several months intervene before their full potentiality is realized. Physical exercise which reduces the diastolic time may produce a state of relative anoxia mainly in the inner aspect of myocardium. That relative anoxia may excite the development of intercoronary anastomoses even in lower age group without having any pathological obstruction. The effective functioning of that intercoronary collateral vessel may prevent severe morbidity or even death due to the first myocardial infarction, even in young people, if adequately develops by simple measures like physical exercise. Exercise is an important life style factor that reduces cardiovascular risk.

CONCLUSION

Interventricular septum is usually supplied by both the coronary arteries. But the arterial territory of left coronary artery is much greater than right coronary artery within interventricular septum. This view is supported by both macroscopic and radiological examination. During this study many intercoronary anastomoses were found in different regions of heart which are helpful in reducing cardiac mortality and morbidity.

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