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Anatomic Study Of Kugel's Artery Using Luminal Cast Technique

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ABSTRACT

Introduction: the Kugel's artery or "arteria anastomotica auricularis magna" was first described by Kugel in 1927. The Kugel's artery commonly arises from the left coronary artery and traverses in the Interatrial septum to form an anastomotic circle with the right coronary artery. The use of the Luminal cast technique to study the Kugel's artery has not been found in the previous literature hence we opine that this was the first time we have used the low-cost silicon luminal casts to study the Kugel's artery.

Aims & Objectives: we aim to determine the existence and mean diameter of the Kugel's artery among the Mysore population of Karnataka state, India using a low-cost innovative luminal cast technique.

Materials and Methods: in the present study 110 adult human cadaveric hearts (90 males & 20 females) were utilized from JSS Medical College and Mysore Medical College mortuaries, for 3 years after obtaining the Institutional ethical clearance. The silicon material was injected into each coronary artery and the cast was removed. The existence and pattern of the Kugel's artery were observed in each of the luminal casts obtained.

Result: The Kugel's artery was found in 25 arterial casts (22.7% of cases) out of 110 hearts. The mean diameter of the Kugel's artery was 3.48 ± 0.75mm.

Conclusion: knowledge of the existence of Kugel's artery will help the cardiologist & cardiac surgeons to evaluate and plan treatment of patients with valvulitis and commissural lesions of the heart among the Mysore population.

Keywords: Anastomotic artery; Arterial casts; Collateral circulation; Coronary artery; Kugel's artery".

Introduction

The Heart or the myocardium is supplied by the Right and Left Coronary arteries (large Vasa Vasorum of the ascending aorta), anatomically they are not end arteries but functionally they behave as the end arteries. The origin of the right and left coronary arteries is from the aortic sinus of Valsalva, the right arises from the anterior aortic sinus and the left from the left posterior aortic sinus, the right posterior aortic sinus is devoid of any orifice hence, known as a non-coronary sinus. The margin between the aortic dilatation and the aortic tube is known as the sinutubular junction, this is represented by a well-defined circumferential supravalvular ridge and the coronary Ostia normally opens near this ridge[1]. The right coronary artery gives the posterior descending branch to supply the interventricular septum and ventricular walls, its right marginal branch supplies the right atrium and right ventricular walls. The left coronary artery gives the left anterior descending artery which gives several diagonal branches to supply the septum and ventricular walls, the circumflex branch, and its left marginal branches go to supply the left atrium and left ventricular walls[1].

The Kugel's artery or "arteria anastomotica auricularis magna" was first described by Kugel in 1927. The Kugel's artery commonly arises from the left coronary artery and traverses in the Interatrial septum to form an anastomotic circle with the right coronary artery. Studies on atrial rami are very few in literature and the existence of Kugel's artery itself has been a controversy. M.A.Kugel was the first one to observe a constant branch arising from the circumflex artery and named it "arteria anastomotica auricularis magna" due to its large caliber. The other variations that he observed were that arising from the right coronary artery /its branches or the AV nodal arteries[2].

Vasudeva Reddy and Lokanadham referred to it as a small communication branch between the left circumflex and right coronary artery[3]. James TN & McAlpin WA were not accepting the existence of such an artery instead they described it as the small atrial branch that arose either from the Left circumflex or right coronary artery or from both. Their study was not regarding the frequency of this artery, but they did describe this anastomotic circle as Kugel's artery[4,5].

Finding the existence of such an artery is of utmost importance as it might get damaged during mitral valvular surgeries or ablation procedures done for

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treating arrhythmias; this can happen if the Kugel's artery arises as a branch from SA nodal artery or as an accessory branch to the AV node[6].

Determination of the existence of Kugel's artery has been studied by various previous authors using different modalities like angiographic studies & dissection method, our study is unique in that we used a newer innovative low-cost luminal cast technique wherein silicon is being used to develop the arterial cast. We aimed to determine the existence, course & mean diameter of Kugel's artery among the Mysore population of Karnataka state using a low-cost innovative silicon luminal cast technique.

Materials and Methods

This study was carried out at JSS Medical College after taking Ethical clearance from the JSS Ethical Committee of JSSAHER. A total of 110 human hearts were freshly collected from the mortuary of Forensic departments of JSS Medical College & Mysore Medical College & Research Centre, Mysore for the duration of 2 years (2017-2019).

Exclusion criteria: Hearts belonging to patients with a history of injury, cardiac interventions, scarring due to myocardial infarction & cardiomegaly were not utilized for this study.

Inclusion criteria: Fresh normal hearts with intact Aortic roots & blood vessels were utilized for this study.

Each specimen was immediately washed thoroughly in running tap water to remove all the blood clots & debris from the major vessels of the heart. The aortic trunk was incised vertically and the three aortic sinuses were identified along with their coronary Ostia. A cannula was inserted into each ostium & tied firmly to the trunk; the nozzle of the silicon gun was attached to the cannula & the cartridge was adjusted and the silicon material was slowly injected into each ostium. The heart was then immersed in acid for 24hours until the cardiac tissue got corroded completely. All the cardiac debris was removed & the silicon cast was carefully separated & dried under sunlight for 2-3days. The arterial pattern was then carefully studied, the existence and pattern of Kugel's artery were noted and its course was defined, morphometric measurements were taken using vernier calipers, and all the data was collected & statistically evaluated.

Results

In our study 110, human hearts were utilized, 90 males & 20 female hearts. Out of 110 hearts, the Kugel's artery was found in 25 arterial casts (22.7% of cases). It was seen arising from the proximal segment of the left circumflex artery, it had a larger diameter compared to the other atrial branches from the circumflex artery. The mean diameter of the Kugel's artery was 4.48 ± 0.75mm. After emerging from the initial part of the circumflex artery it was seen as the first branch of the circumflex artery & taking a long course and had the largest diameter, it first passes in front of the left auricle and left atrium to pierce the inter-atrial septum, finally ending at the region of the crux by anastomosing with the branches arising from the right coronary artery (Refer figures 1).

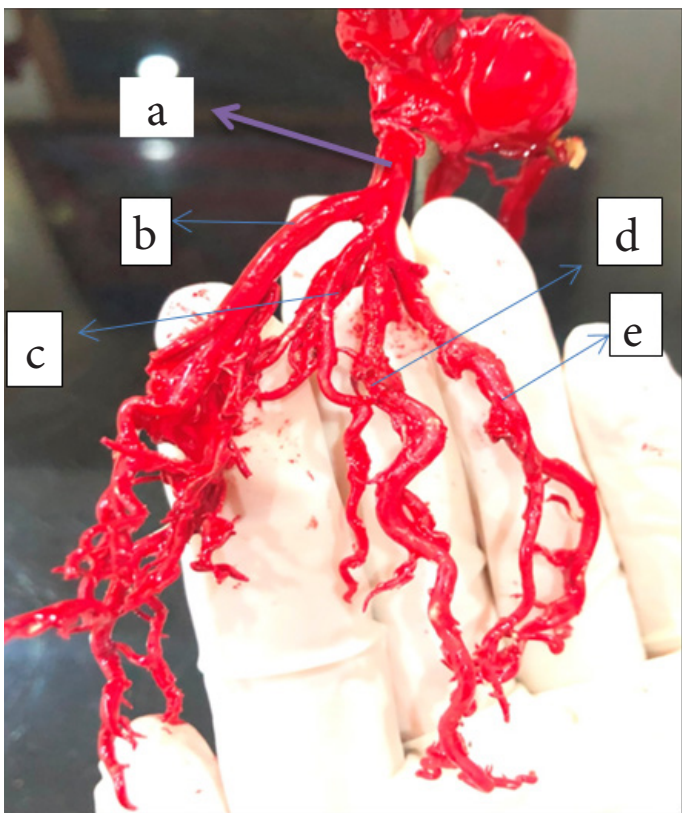

Figure 1. Left coronary artery showing kugel's artery.
[a: LCA trunk; b: anterior descending branch; c: 2 diagonal branches/Median artery; d: Kugel's artery; e: circumflex branch].

Discussion

Gray's textbook of Anatomy describes the Kugel's artery as a constant branch arising from the circumflex artery which traverses into the interatrial septum to form a direct anastomosis with the right coronary artery[7].

Divya Prakash *et al* in their angiographic study of the SA nodal & AV nodal arteries observed that the SA node was supplied by Kugel's artery[8].

In many of the previous studies on coronary arteries, it has been observed that inter and intra-coronary anastomoses tend to become larger in hearts-whenever there's a stenotic lesion. Moreover, the interventional cardiologist must be aware of the origin and course of Kugel's artery when they perform procedures involving inter-atrial septum, biventricular pacemaker insertion, and surgical procedures involving the aortic root (Refer to Table 1).

Table 1. Comparison of the incidence of kugel's artery with other studies.

Authors	Population	Technique	Percentage
Christos *et al*[9] (2004)	Texas	Angiography	6
Kumari *et al*[10] (2017)	South Kerala	Dissection	20
Manimegalai *et al*[11] (2018)	Salem, Tamil Nadu	Dissection	25
Our present study	Mysuru, Karnataka	Luminal silicon cast	22.7

Thomas NJ in his study on Kugel's artery described the link between the anterior ventricular and posterior ventricular arteries, which form a collateral circulation to the ventricles & serve as an accessory supply to the AV node[12].

The Kugel's artery may supply the aortic cusp of the mitral valve occasionally. Any surgical approach to the mitral valve and sub-valvular structures can lead to damage to a sinoatrial artery leading to cardiac arrhythmias[13]. Kugel's artery was found forming a coronary arteriovenous fistula with the coronary sinus in a 71year old female patient with mitral valve regurgitation; its course was identified by multislice computed tomography [14]. Kugel's artery is very difficult to demonstrate in a cadaveric heart and angiographic studies, percentages as low as 3.6% and 6% with severe atherosclerotic heart disease, have been reported in 3 coronary angiographic studies[15,16,17], percentages as high as 40% and 66% have been reported by cadaveric studies [2] such a discrepancy may be due to the difficult course of the anomalous artery. Hence, we can infer that the use of a luminal cast can help identify the existence and course of the anomalous arteries.

Many cardiologists agree that the existence of such an anomalous artery is a benign and asymptomatic event but few suggest that its retro-aortic course between the aorta and pulmonary artery may predispose to ischemia or atherosclerosis[18]. It's very crucial for the radiologists doing angiography to identify the existence and course of such anomalous coronary arteries for easy diagnosis with non-invasive coronary imaging techniques like multi-detector computed tomography[19] and cardiac magnetic resonance imaging[20]. The limitation of the present study was that the number of female hearts was less compared to the male hearts. Further studies can be done by using more number of female hearts.

Conclusion

The caliber of Kugel's artery in our study was large enough to perfectly function as collateral circulation whenever an atrial arterial occlusion has occurred. Hence, it acts as an important potential anastomotic channel. Knowledge of the existence of Kugel's artery will help the cardiologist & cardiac surgeons to evaluate and plan treatment of patients with valvulitis and commissural lesions of the heart among the Mysore population. Silicon casts are a boon to the anatomy researchers & academicians who would like to study the vascular patterns of various viscera in detail as it has many advantages over the resins which are commonly used. Such an innovative technique can be adopted by future researchers in anatomical studies.

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