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Coronary Sinus Anatomy and its Importance-evidence based Review

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Abstract

Coronary sinus is the largest cardiac venous channel and its increasingly used during electrophysiological procedures like LV pacing, biventricular ICD lead placement and ablation. There are few other novel procedures under research including stem cell delivery in case of ischemic myocardium. Coronary sinus anatomy, its variations in tributaries and the clinical implications are discussed in this review article.

Keywords: Coronary sinus; Anatomy; Cardiac vein variations

Abbreviations

CS: Coronary Sinus; MVA: Mitral Valve Annulus; LV: Left Ventricle; SVC: Superior Vena Cava; AVNRT: Atrio: ventricular Nodal Reentry Tachycardia; GCV: Great Cardiac Vein; AIV: Anterior Interventricular Vein; MCV: Middle Cardiac Vein; PLV: Postero Lateral Vein; CRT: Cardiac Resynchronization Therapy; VT: Ventricular Tachycardia; CRT: Cardiac Resynchronization Therapy

Introduction

Coronary sinus (CS) is the largest vein of the heart. It is least explored compared to its arterial counterpart due to life saving interventional approaches through coronary artery. Most of the modern procedures in electrophysiology require deep understanding of coronary sinus and its tributaries. In this review article, I tried to explore the current evidence based approach in learning coronary venous system and their importance academically and clinically.

Basic Terminologies

The terminology used to describe the various tributary veins is the one recommended by MacAlpine [1].

The great cardiac vein (GCV): It originates, in the majority of cases, from the lower or middle third of the interventricular sulcus, courses with in it, and it then turns toward the left side of the atrioventricular groove and enters the CS at an approximately 180° angle. Its ostium coincides, in the majority of cases, with the valve of Vieussens.

The middle cardiac vein (MCV): MCV starts near apical region of the heart and runs in the posterior inter-ventricular groove and joins the coronary sinus before it reached the right atrium. MCV sometimes drains into right directly.

The posterolateral vein (PLV): Venous branches arising from the lateral and posterior aspects of the left ventricle either drain into GCV or the CS.

The left atrial oblique Marshall vein: It is a remnant of left superior vena cava (SVC). It diagonally runs on the left atrium posteriorly and joins where the GCV unites with the posterolateral vein to become CS.

Basic Anatomy

The CS is a wide channel, about 2-5.5 cm long and the orifice is 5-15 mm in diameter. The orifice has a fold of endocardial tissue called Thebesian valve. Thebesian vavle is a remnant of caudal portion of the right valve of embryonic sinoatrial orifice [2]. It is situated in the diaphragmatic part of coronary sulcus. It is covered by left atrium muscle fibers. It is dependent on the site of the drainage of the posterolateral vein (Figure 1) [2].

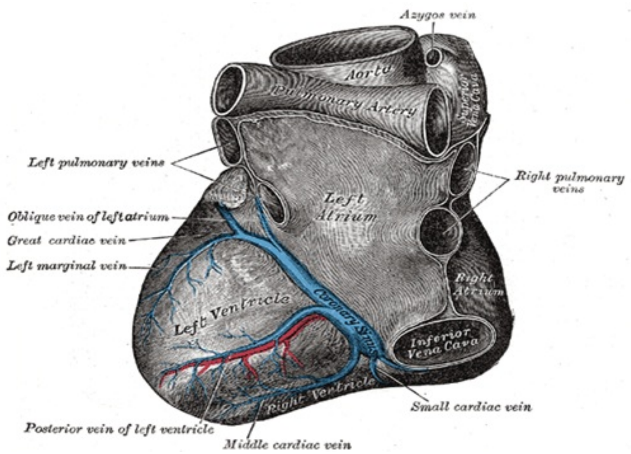

Figure 1: Schematic diagram of the heart showing coronary sinus and its tributaries.

Coronary sinus is formed by the union of the greater cardiac vein and main posterolateral vein. Greater cardiac vein runs along the interventricular groove similar to its counterpart left anterior descending artery. GCV, also known as the anterior interventricular vein drains the anterior wall of the left ventricle and interventriuclar septum [3]. Other major tributaries entering the CS include inferior left ventricular vein and the middle cardiac vein that drain the posterior aspect of the left ventricle. Various atrial veins and vein of marshall drains atrial myocardium into the CS. At the ostium of the right atrium, the small cardiac vein drains the right atrium and the posterior and posterolateral portions of the right ventricle. The smaller cardiac veins also known as Thebesian venous network drains the inner layers of myocardium directly into the right ventricle. Their orifices are less than 0.5 mm in diameter [4].

Thebesian Veins: Significance

The Thebesian veins are believed to have two separate functions. First, they provide a route of myocardial drainage. Second, they offer an alternative route of nourishment to the myocardium. A greater number of Thebesian veins were observed in the right ventricle than in the left (P<0.05) [5-8]. Trans myocardial revascularization proves that thebesian veins play an important role in providing nutrition to the ischemic myocardium.

Relation to Mitral Annulus

The CS courses superiorly to the MVA in the majority of the patients. Multislice computed tomography may provide clinically relevant information for the selection of potential candidates for percutaneous mitral annuloplasty. Out of the total subjects of 105 patients, 71 patients (68%) had circumflex artery coursed between the CS and the MVA with a minimal distance between the CS and the circumflex artery of 1.3 ± 1.0 mm. The minimal distance between the CS and the MVA was significantly greater in patients with severe mitral regurgitation compared to patients without severe mitral regurgitation (mean 7.3 ± 3.9 mm versus 4.8 ± 2.5 mm, P<0.05) [8].

Congenital Anomalies

Weiss et al studied incidence of coronary sinus anomalies in 204 patients who as referred for electrophysiology study prospectively. Major CS anomalies were diverticulum of coronary sinus, persistence of left superior vena cava and enlargement of CS ostium. Diverticulum of coronary sinus angiographically described as cul-de-sac of the vein contour separated from CS or middle cardiac vein by neck. CS diverticulum was seen in 9 patients, out of which 8 patients had cs diverticulum in posteroseptal branch. All patients with CS diverticula had accessory pathway and requires RF ablation at the neck of the diverticula. Persistent left superior vena cava was found in 5 patients in which coronary sinus drains into right atrium, 4 had accessory pathway and 1 had AVNRT. Dilatation of coronary sinus ostium which is dilatation of CS ostium larger than diameter of 25 mm in atleast one fluoroscopic view was seen in 9 patients. Persistent left superior vena cava was present in 5 of the 9 patients, 4 of these patients had accessory pathway and 1 had AVNRT. Four patients were having CS ostium dilatation without presence of left superior vena cava, 3 of which had AVNRT and 1 had VT and dilated cardiomyopathy. These findings should not be extrapolated to general population as it is done in patients with tachyarrhtyhtmias [9].

Anatomical Variations

Randhawa et al. [10] studied coronary venous anatomy in 50 adult cadaveric hearts.10 The study includes evaluation of number of veins, their diameter and opening angles of the tributaries. Thebesian valve (TV) was present in 64% of cases and Vieussens valve was present in 60% cases. TV was seen covering more than 75% of the CS ostium in 25% of the cases. Number of identifiable tributaries lying between AIV and MCV varied from 1 - 4. Only one prominent tributary was present in 28% of the hearts. Midlateral vein was present in 58% of the hearts; they form an acute angle with CS axis in four cases. PLV (average diameter 1.62 ± 0.45 mm) was found in 72% of the cases. Their average distance is 33.4 ± 11.7 mm from coronary ostium. In three (8.33%) cases, PLV forms an acute angle with the CS. Restrictive TV covering ≥ 75% CS ostium occurs in 25% cases and the presence of single tributary is seen in 28% cases. Cannulation of CS can be impeded by the following findings in the study: Formation of acute angle of tributary with CS axis in 1/4 cases with anterolateral vein, 4/29 cases with midlateral vein, 3/36 cases with posterolateral vein, and 3/28 cases with posterior veins of the left ventricle [10].

Anatomical Studies for Clinical Implications

Gilard et al. [6] studied coronary venography on one hundred consecutive patients who were admitted for coronary angiography. Two veins that are consistently present are the middle cardiac vein (mean diameter 2.62 ± 1.26 mm) and the great cardiac vein (mean diameter 3.55 ± 1.24 mm). The left posterior vein(s) (LPV) (mean diameter 2.25 ± 1.2 mm) is variable in number (ranging from 0 to 3), in size and in angulation. The absence of LPV limits the ability to pace the left ventricle endovenously. Insertion of the lead is complicated by diameter of the vein less than 2 mm and also the angulation of the vein. The main finding of this study was the wide variations in number and size of the left posterior veins leads to difficulty in placing a lead. Coronary venous system has wider variations compared to coronary artery and the main conclusion is that it allows commercially available leads to be placed in 85% of cases atleast in one vein [6].

Noheria et al. [7] systematically examined 620 human hearts from consecutive autopsies between October 1998 and July 2003. The median length of the CS was 4 cm where it was demarcated from the most distal branch, i.e., the GCV, by the ostium of the oblique vein of left atrium (vein of Marshall) or the ligament of Marshall. Their observations were CS drained a median of 3 left atrial veins and there were no left atrial branches seen in 7% of the hearts. There was a median of 6 LV veins draining into the CS and the MCV was present in all cases. In 95% hearts, the left posterior vein originated within the first centimeter of the CS course with a common or proximate ostium with the MCV. For CRT lead placement, the mid-lateral LV was accessible from the MCV in 20%, the left posterolateral vein (PLV) in 92% or the anterior interventricular vein (AIV) in 86%. In 91% of specimens, the mid-lateral wall could be approached from at least 2 of these 3 major veins [7].

Gender Differences

Kawata et al. [11] studied gender differences in 223 consecutive patients undergoing CRT from 2003 to 2011.11 Mid-lateral or posterolateral LV wall is the optimal position for LV leads. Lateral or posterolateral CS branches were absent in more women than men (26.3% vs. 10.8%, P = 0.011). Although not statistically significant, there was a trend for women to have the LV lead placed in any basal wall or anterior wall more often than men. The reason is that short and narrow lateral branches lead to the LV lead being placed in the basal and anterior area more often, as an alternative in women [11].

There is an anatomical disadvantage in women for LV lead placement and their LV lead pacing threshold is higher compared to men. Implanting physicians should be aware of gender differences during LV lead placement in order to maximize CRT benefits. This was a retrospective analysis of consecutive patients who underwent CRT and therefore is subject to the limitations for any retrospective study. Implanting physicians should consider these gender differences during LV lead placement to ensure maximum success and increase the CRT benefits (Figure 2) [12].

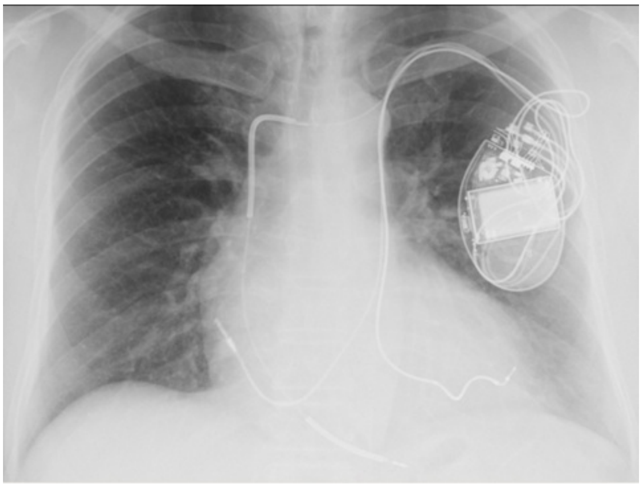

Figure 2: Radiograph with Bi-ventricular ICD- showing LV lead placement.

Conclusion

Coronary sinus still remains a potential site for advanced clinical and translational research. Further, anatomical variations and gender differences in coronary sinus and its tributaries play an important role during standard electrophysiological procedures. This article provides deep knowledge about coronary sinus and its tributaries based on multiple studies.

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Conflicts of interest

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