Coronary sinus diverticulum: importance, function, and treatment

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Abstract

The importance of venous structure in the heart is usually overshadowed by that of the arterial system. Coronary sinus is a part of cardiac venous apparatus and connects left atria to the right atria. Other than having role in physiological contractions of both atria, it contributes substantially to cardiac electrical conduction system. Due to unique placement and connections of the CS, it has become growing interest in clinical cardiology. It is used in cardiac resynchronization therapy with biventricular pacing, left-sided catheter ablation of arrhythmias and administration of retrograde cardioplegia in cardiac surgery. In some individuals, CS is presented with anatomical variants. CS diverticulum is a congenital outpouching that provides muscular connection between atria and ventricle. This connection provides a suitable substrate for occurrence of arrhythmias, which even results in life-threatening events such as sudden cardiac death. Early diagnosis leads to treatment with ablation techniques which ultimately eliminates origins of arrhythmias.

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Abstract

The importance of venous structure in the heart is usually overshadowed by that of the arterial system. Coronary sinus is a part of cardiac venous apparatus and connects left atria to the right atria. Other than having role in physiological contractions of both atria, it contributes substantially to cardiac electrical conduction system. Due to unique placement and connections of the CS, it has become growing interest in clinical cardiology. It is used in cardiac resynchronization therapy with biventricular pacing, left-sided catheter ablation of arrhythmias and administration of retrograde cardioplegia in cardiac surgery. In some individuals, CS is presented with anatomical variants. CS diverticulum is a congenital outpouching that provides muscular connection between atria and ventricle. This connection provides a suitable substrate for occurrence of arrhythmias, which even results in life-threatening events such as sudden cardiac death. Early diagnosis leads to treatment with ablation techniques which ultimately eliminates origins of arrhythmias.

Keywords: coronary sinus diverticulum; arrhythmia; ablation

Introduction

Coronary sinus (CS) anomalies such as diverticulum, persistent left superior vena cava or CS ostium dilatation are predominantly found in patients with accessory pathway-related tachycardias (1). Earlier studies have reported diverticulum of proximal CS in 7-11% of patients with posteroseptal accessory pathways (2). In this review, a literature appraisal was performed regarding importance, function, and ablation of CS diverticulum.

CS

Several cardiac procedures like targeted drug delivery, stem cell therapy as well as mapping and ablation of arrhythmias make use of CS (3). By a multipurpose catheter and injection of contrast in LAO and RAO views, CS anatomy was delineated. In the case of difficulty with catheter to cannulate, a deflectable sheath is employed (4). The average length ranges from 45 to 63mm. Different size of ostium ranges (4*5 to 9*16mm) have also been reported (5).

CS drains 60% of cardiac venous blood into the right atrium. In addition to the largest cardiac venous structure, it is an interatrial connection (6). However, unlike the veins, it has myocardial tissue which is the remnant of left atrial muscles (7). Although CS has been regarded as a venous structure for a long time but recently it was clarified its crucial role in the pathophysiology of atrial tachyarrhythmia (8-10).

The most common atrial arrhythmia in humans is atrial fibrillation (AF). Although pulmonary veins are closely associated to AF pathogenesis, it seems that ablation of these veins is not enough for disappearance of persistent AF. Additional reentry mechanism, probably by the involvement of CS was proposed (6). Muscular sleeve, which is around the proximal 25-50mm of the CS length, connects the two atria (11). Arrhythmia most likely emerges from these connections (12). Also, it was shown that CS has the capability for spontaneous depolarization and slow conduction, an indicator of intrinsic automaticity (13-15). Thereby, spontaneous firing of the cells in the CS is in charge for triggering, maintenance, and recurrence of AF (12, 16, 17). Accordingly, ablation of CS together with pulmonary vein resulted in long term improvement through decreasing the recurrences (18).

CS diverticulum

Variation in CS anatomy in terms of position, length, and diameter was seen among individuals (19). CS anomalies are, but not limited to, enlargement, absence, atresia of right ostium, and hypoplasia (6). These anomalies may affect cardiac hemodynamics, which leads to clinical manifestations and requiring prompt diagnosis and treatment. However, some others are clinically occult without any obvious symptoms. They all have the potential to increase morbidity and mortality after certain surgical procedures. Moreover, electrophysiological characteristics of the CS are influenced by the existence of these anomalies (20, 21).

CS diverticulum is a one of such anomalies. It is a CS congenital outpouching with a distinct neck that extends behind the left ventricle (22, 23). In most cases, diverticula were seen as a saccular dilatation and sometimes it is a fusiform dilatation. In some patients, its sac was bilobed. Contractility is its inherent characteristic (4). Diverticula are commonly found at the inferior aspect of the CS at its junction with the middle cardiac vein, 0 to 18mm away from the CS ostium. The neck of the CS diverticulum is 5 to 10-mm wide, opens into the CS and is proximal to the midcardiac vein (24). The orifice of the diverticula ranges between 2.6 to 15mm. The smallest and largest surface area was 0.73cm^2 and 6.45cm^2, respectively. The mean diameter of the CS was 7.05mm ± 1.90. Thus, CS could be dilated up to 11mm at measuring 3cm proximal to the CS ostium (25, 26). (Fig. 1)

Central parts of cardiac conduction system including atrioventricular node and the His bundle are in the septal area. Approximately, one third of accessory pathways (APs) are located at this complex anatomic region. These pathways frequently have short refractory periods that predispose to rapid ventricular response during atrial fibrillation, thus increasing the risk of sudden death (24).

Therefore, precise localization of these pathways is critical during ablation of APs. APs of this area are classified into anteroseptal, midseptal, and posteroseptal (27). Diverticula with posteroseptal APs were first reported in 1985 (28). This type of AP increases the incidence of inducible AF (27). Myocardial fibers of CS diverticulum establish a connection between CS coat and the ventricle, which facilitates the incidence of AP (29, 30). Close proximity of the wall and the neck of the diverticula with posteroseptal and left posterior APs endangers patients to arrhythmias and even sudden cardiac death (22, 23).

Among 480 patients with posteroseptal or left posterior AP, CS diverticula was found in only 36 (7.5%) (30). It is a rare anomaly which often diagnosed during venography and catheter ablation (31). The existence of CS diverticula is expected in the case of previous failed ablation, documented AF, when the best location for ablation is at the proximal of CS, and in specific ECG findings like polarity of the delta wave. A negative delta wave in lead II is an indicator of CS diverticulum with highest specificity and sensitivity (29, 30, 32, 33). (Fig 2.)

Treatment

Radiofrequency (RF) ablation is safe and treatment of choice for resolving septal APs (28). Percutaneous access for ablation of epicardial APs is feasible through CS cannulation. This was performed even in patients with previously failed endocardial ablation (34). Ablation of the CS eliminated focal tachyarrhythmia with CS origin (6). As CS has anatomic and electropgysiological relationship with atria, origin of multifocal tachyarrhythmia from either atria could be determined. If myocardial part of the CS is the origin, high-frequency higher-amplitude component indicates a near-field potential. Otherwise, (low-frequency lower-amplitude) shows a far-field potential (35, 36).

Epicardial and endocardial ablation of the CS increase AF cycle length and eventually leads to AF termination (8). One study reported posteroseptal AP in a patient with a history of three previous failed attempts of ablation. In such cases, open chest surgical ablation is deemed as the only remaining choice. This difficult-to-ablate AP was managed by epicardial mapping through pericardial catheter. Although, existence of high impedance due to thick epicardial fat hampered the ablation by this approach but a linear ablation within the CS targeting the earliest activation area terminated the preexcitation (37).

CS ablation is performed in patients with AF without previous pulmonary vein ablation (38). The anomalies of the CS sometimes becomes the crucial sites for successful ablation of posteroseptal pathways (1). Findings showed that CS diverticulum with APs were more prone to sudden death during AF due to acceleration of atrioventricular conduction (33). However, CS diverticulum is a well-known cause of unsuccessful AP ablation in wolff-parkinson-white syndrome. This fact underscores the necessity of identification and reporting of CS anomalies especially that of diverticula (32).

Epicardial approach and the diverticula neck are the helpful points toward a successful ablation in patients with CS diverticulum and posteroseptal APs (29, 30, 32). The success rate of ablation in the neck of the

diverticulum reaches 90% (2). After recording early retrograde atrial signal at the neck by the ablation catheter which representing CS activity, delivering controlled energy leads to elimination of APs footprints (29). However, successful ablation was also reported within the CS. In one patient with small diverticulum, ablation was done in the adjacent CS. Overall, it seems that neck of the diverticula is the site with highest rate of success for ablation (2, 4).

Posteroseptal APs are sometimes difficult to ablate due to complex anatomic arrangements (29, 39). Other than anatomic complexity, the inherent nature of diverticula with a pouch and a neck increase the intricacy of the task (39). Not only is the matter the difficulty of ablation of posteroseptal APs but also are the consequent life-threatening complications because of close proximity to the coronary arteries (39). It was reported that total occlusion of left circumflex artery during ablation inside the CS augments the risk of arrhythmias (40, 41). Even ventricular fibrillation following by sudden cardiac death was reported (40). In order to prevent complications such as perforation, formation of coagulation, excess heat, and right coronary artery stenosis during ablation procedure in the CS, some recommendations have been made like temperature control ablation, irrigated RF ablation, and cryoablation (42, 43). Low temperature RF ablation resulted in a safe and complication-free ablation (44).

Conclusion

CS diverticulum is a variant of CS. Importantly, it has been substrate of APs near epicardium. CS diverticulum with AP is a rare disorder. During an electrophysiologic study seeking for the underlying reasons of left posterior and posteroseptal APs, CS diverticulum is detected in coronary vein angiography. Treatment of choice for such patients is RF catheter ablation. The target site for ablation is typically the narrow neck of the CS diverticulum.

List of abbreviations

CS: coronary sinus; AP: accessory pathway; EPS: electrophysiologic study; RF: radiofrequency

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