Case Report

Scrimmage with 'Coronary Sinus Muscle Bridge': case series and clinical implications

***Mahdi Moeini* [1], *Mohammadreza Dehghani* [1,*]**

[1] Department of Cardiology, Seyyed-al-Shohada Educational Heart Hospital, Urmia University of Medical Sciences, Urmia, Iran

*** Corresponding Author:**
Address: Seyyed-O-Shohada Heart Center, 17 Shahrivar Aven, Urmia, Iran. **Postal code:** 5718748983; **Email:** mr.dehghani@umsu.ac.ir

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Abstract

Objectives: The coronary sinus (CS) plays a key role in cardiac electrophysiology, including cardiac resynchronization therapy (CRT) and ablation of arrhythmias such as left-sided accessory pathways, premature ventricular complexes (PVCs), and atrial fibrillation (AF). Some procedures cannot be performed without CS access, requiring alternative approaches when cannulation fails. CS cannulation can be difficult and, rarely, unsuccessful. Known causes include anatomical abnormalities such as atresia, diverticulum, anomalous ostial location, and fixed stenosis at the ostium or along the vessel course. Here, we present three cases of difficult CS cannulation due to dynamic obstruction - a novel anatomical variant.

Methods: We describe three consecutive patients referred for CRT-D implantation in whom CS cannulation or lead advancement was unexpectedly difficult. In each case, standard CS sheath and catheter techniques were used via subclavian venous access. When resistance to catheter or lead advancement was encountered, contrast venography (with balloon occlusion in select cases) was performed to delineate CS anatomy across the cardiac cycle, and catheter/lead manipulation timed to the non-systolic phase was used to overcome the obstruction.

Results: In all three patients, venography revealed dynamic narrowing of the CS main trunk or a branch during ventricular systole, with resolution of the compression during diastole - a pattern consistent with an underlying muscle bridge rather than a fixed structural lesion. Case 1 showed severe systolic compression of the CS main trunk at the posterolateral branch takeoff; Case 2 showed a similar constriction in the mid-CS body; Case 3 showed compression confined to the distal lateral branch. Despite these dynamic obstructions, successful CS lead placement was achieved in all three patients using gentle catheter manipulation and advancement timed to diastole, without need for alternative pacing approaches.

Conclusions: Dynamic, systole-phase compression of the coronary sinus or its branches - attributable to an epicardial-to-intramyocardial muscle bridge - represents a previously underrecognized and reversible cause of CS cannulation difficulty, distinct from fixed anatomical anomalies. Recognition of this pattern on cine-venography, combined with balloon-occlusion imaging and diastole-timed catheter advancement, allows most cases to be managed successfully without abandoning the CS approach.

Keywords: Coronary sinus; Muscle Bridge; Cardiac resynchronization therapy; Lead placement; Dynamic obstruction; Venography

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Introduction

The coronary sinus (CS) is one of the most important structures in cardiac electrophysiology. Coronary sinus (CS) plays a critical role in patients requiring cardiac resynchronization therapy (CRT) and in various arrhythmia ablations, such as left accessory pathways, premature ventricular complexes (PVC), or atrial fibrillation (AF) (1-4). Failure to achieve coronary venous system access represents one of the most common causes of unsuccessful CRT implantation, with an incidence of up to 4% (5-8). In some cases, the procedures are not possible without access to this important structure, so alternative methods must be used. Cannulating this structure can be challenging and, in rare cases, can lead to procedure failure. Problems that may arise during cannulation include anatomical abnormalities of the CS, such as atresia (9), diverticulum (10), improper ostial positioning (11), and fixed stenosis at the entrance or along the vessel's course (12). In this study, we examine three cases of cannulation difficulties caused by dynamic obstructions in the CS, which are a novel anatomical variation.

Case 1

A 66-year-old woman with ischemic cardiomyopathy was admitted to our center complaining of dizzy spells, without experiencing chest pain or new or worsening dyspnea. A 12-lead standard electrocardiogram (ECG) showed a heart rate of about 45 beats per minute and a 2:1 atrioventricular block (AVB) with a narrow QRS configuration. Echocardiography revealed severe ventricular systolic dysfunction (left ventricular ejection fraction (LVEF=35%)). Laboratory values, including cardiac enzymes and brain-type natriuretic peptide (BNP), were in the normal range. The decision to move forward with the implantation of a cardiac resynchronization therapy with defibrillator (CRT-D) was reached after considering this assessment and reviewing the patient's medications. During the procedure, a high-voltage lead was placed in the right ventricular apex, and a St. Jude CS sheath was navigated through the left subclavian vein to the right atrium. Our standard practice involved using a CS catheter to navigate the CS. Once we successfully accessed the CS ostium with the catheter, we advanced it into the main body of the coronary sinus. Meanwhile, we encountered an unexpected issue: the catheter could not be advanced further after reaching a midpoint. We tried to reposition the catheter along a different path. To resolve this, we advanced the sheath and injected a contrast agent for better visualization. As shown in Figure 1, the sheath is in the posterolateral branch, where we can see dynamic narrowing and compression of the main trunk of the coronary sinus (CS) during systole, followed by widening during ventricular diastole. A comparable constriction was also observable along the posterolateral branch. After we could not position the CS lead in the anterolateral branch, we tried the same posterolateral branch for the CS lead insertion. We placed the lead in the target branch without any challenge.

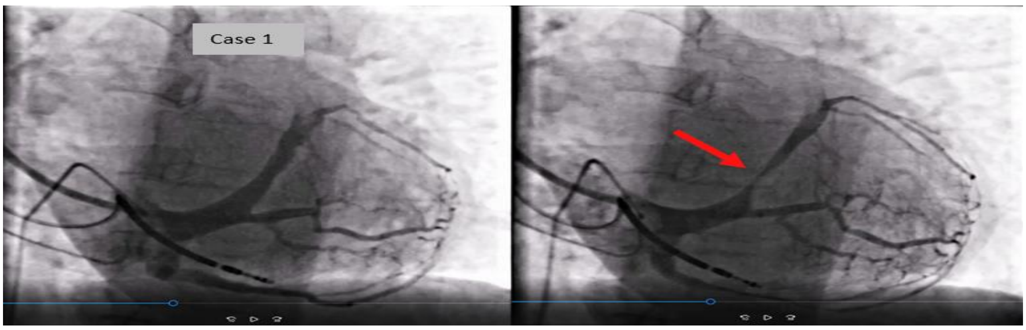

Figure1. Near-normal diameter of CS during diastole (left side) and severe compression of the main trunk after Takeoff of the posterolateral branch during systole of the cardiac cycle (right side, red arrow) (LAO view).

Case 2

A 66-year-old man was a candidate for CRT-D implantation after experiencing aborted sudden cardiac death (ASCD). His resting ECG showed a left bundle branch block (LBBB) pattern with a duration of approximately 200 milliseconds, and he had a left ventricular ejection fraction (LVEF) of

15-20%. The patient was classified as New York Heart Association functional class (NYHA FC) III and had an estimated survival of over one year. The procedure was started and progressed with outcomes similar to those observed in the first patient. To our surprise, we encountered an anatomical structure in the CS body identical to the one seen in the prior case. The CS sheath was guided into a CS branch just before the area of dynamic constriction. As in the previous case, we overcame challenges while maneuvering through this region. With a combination of gentle pulling and cautious pushing maneuvers, we navigated the CS catheter in the correct direction, allowing it to pass through the constricted segment. The CS sheath was advanced over the catheter to reach the great cardiac vein. We positioned the sheath properly, then conducted another CS angiography. We identified an appropriate CS branch in the lateral position. We successfully placed the CS lead in the lateral position, achieving satisfactory pacing and sensing parameters.

Figure 2. Severe compression of main trunk during systolic phase of cardiac cycle (red arrow)

Case 3

Another instance involved a 71-year-old female with a medical history encompassing idiopathic dilated cardiomyopathy and hypertension (HTN). She was admitted to the hospital for the elective purpose of receiving a CRT-D implant. Her functional capacity was classified as class III, and her surface ECG displayed a fairly typical LBBB with a width of 150 milliseconds. We positioned the CS sheath, then we proceeded with contrast injection and conducted CS angiography. Contrary to previous cases, we did not observe any constriction in the coronary sinus (CS) body. We identified a suitable branch in a lateral position to implant the CS lead. While closely observing the CS angiography, we noticed dynamic compression occurring near the distal segment of the chosen branch. However, we easily placed the lead in that branch. We placed the lead in the target branch with minimal manipulation.

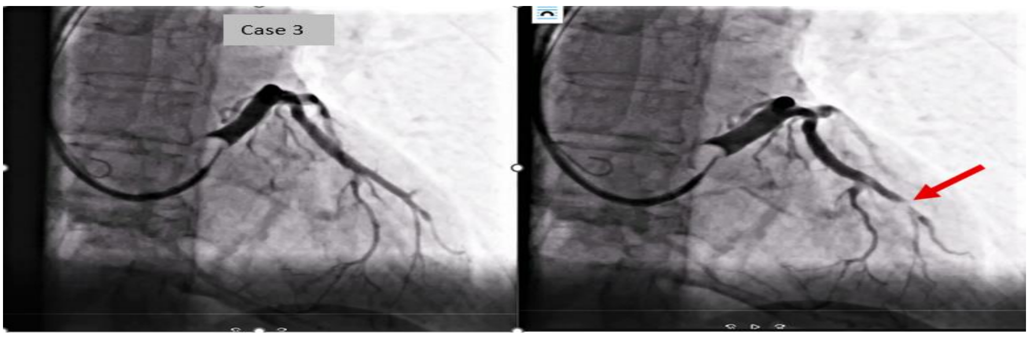

Figure 3. Severe compression of lateral branch of CS at distal part during systolic phase of cardiac Cycle (red arrow)

Discussion

The coronary sinus is the venous drainage system of the heart that drains blood from the heart's myocardium into the right atrium. It is approximately 38 millimeters long, and its maximum diameter has been reported to be around 24 millimeters. Its shape is mostly tubular in nature (12). Two important valves are usually visible in most cases (70-80%), one known as the valve of Thebesian and the other known as the valve of Vieussens. The first valve is located at the CS orifice and is mostly semilunar. It does not pose a significant issue, but in rare instances, it can cover the orifice of the CS completely in a non-fenestrated manner, making catheter manipulation challenging (12). The second valve, the valve of Vieussens, is located at the junction of the great cardiac vein (GCV) in the main body of the CS. The valve of Vieussens can complicate the cannulation of the CS and may sometimes cause the catheter or guidewire to deviate from the sinus to the vein of Marshall. The catheter insertion or lead placement may encounter challenges, which can be overcome with catheter manipulation (12). These are fixed obstructions in the pathway to the CS or its distal branches. Previous reports have suggested that transesophageal echocardiography (TEE) may be useful for guiding coronary sinus (CS) catheter placement during minimally invasive cardiac procedures and for identifying mechanical difficulties encountered during CS access (13-14). The CS is anatomically set on the epicardial surface. Therefore, to reach the right atrium, it must deviate slightly inward into the heart's interior at the end of its outflow pathway and travel a distance within the myocardium. This distance is vulnerable to compression by the myocardium during ventricular systole. Systolic compression of the posterolateral-posterior branch of the CS has been reported, particularly among elderly patients. This condition can be common and may hinder CS cannulation and dissection (11). The challenges associated with coronary sinus (CS) cannulation in the three cases were as follows: In case 1, the catheter could not be advanced smoothly, and in cases 2 and 3, the lead could not be advanced easily. To better visualize CS anatomy, we performed venography with contrast injection using a balloon. This allowed us to reveal dynamic obstructions at the locations indicated in the images. As the images show, the obstructions in the CS cannulation path in our patients do not exhibit a fixed pattern. Instead, they occur dynamically during ventricular systole. The involved areas in our patients are primarily within the main body of the CS or its branches. These regions indicate a muscle bridge (MB). These MBs create challenges during CS cannulation or placing the lead within the target vessel. However, in all three cases, we tried to overcome the issue by manipulating the catheter and advancing the catheter or lead during non-systolic periods. This allowed us to place the leads in the desired branches successfully.

Conclusion

Anatomical challenges within the CS, whether manifested as fixed or dynamic obstructions or issues with orifice positioning, can lead to complications during cardiac electrophysiological procedures. To address these problems, the findings of the present study suggest utilizing venography balloons and conducting a more thorough anatomical assessment, with catheter manipulation and advancement of the catheter or lead.

Author's contributions

The authors were the primary operators of the procedures described**.**

Conflicts of Interest

No

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Ethical statements

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