A New Road to CRT: Patent Vein of Marshall for Left Ventricular Lead Implantation

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**Introduction:** Coronary sinus anomalies, including coronary sinus ostial atresia, atypical right atrial drainage and unroofed coronary sinus, complicate implantation of a left ventricular pacemaker lead for cardiac resynchronization therapy. In many of the above CS anomalies, coronary venous return will flow retrograde through a patent vein of Marshall to the innominate vein. We report a series of cases from multiple international centers of patients with coronary sinus anomalies where a PVOM was utilized for left ventricular (LV) lead placement.

**Methods:** We reviewed the data on 20 patients where a patent vein of Marshall was identified & used to attempt LV lead placement in order to better understand: 1. Clinical circumstances that lead to the discovery of the PVOM. 2. Imaging techniques used to identify the PVOM. 3. CS anomalies were associated with a PVOM. 4. Physical characteristics of the PVOM. 5. How the PVOM was used to facilitate attempted LV lead placement. 6. Potential complications associated with using a PVOM for LV lead placement.

**Result:** Clinical Characteristics: 44% had at least one previously unsuccessful attempt at LV lead placement due to inability to find or cannulate the CS. 22% had been referred for epicardial LV leads. Imaging Techniques: The PVOM was identified by catheter manipulation & contrast injection in 72% and identified via levophase CS venography in 28%. In 2 cases prior dedicated cardiac CT did not reveal the PVOM, however in 1 case cardiac CT did demonstrate the PVOM pre-procedure. CS Anomalies & Characteristics: 33% of PVOM were associated with an unroofed CS. The average PVOM measured 5.3 mm in diameter. LV Lead Implantation: LV lead implantation was successful in 89% of cases, with implant directly down the PVOM in 80% of cases. In 1 case subclavian venoplasty was necessary prior to identification of the PVOM, and in 1 case CS venoplasty and snaring the circumference of the PVOM was necessary in order to advance the LV lead into the CS. Complications: In 1 case the patient experienced a stroke during implantation secondary to an unroofed CS.

**Conclusion:** Coronary sinus anomalies are rare congenital and iatrogenic anatomic variants that complicate implantation of a left ventricular pacemaker lead for cardiac resynchronization therapy.
Searching for, finding and utilizing a patent vein of Marshall can achieve successful lead implantation.