TOPICS IN REVIEW

Left ventricular pacing through coronary sinus after tricuspid valve replacement: A case report and review of the literature

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In patients with a mechanical tricuspid prosthetic valve, the transvenous position of a ventricular lead through the coronary sinus (CS) is a good alternative option to right ventricular or epicardial lead implantation. In cardiac resynchronization therapy, pacing the left ventricular lateral wall was considered the best site for the CS lead. However, for patients without a left bundle branch block, the best position of CS leads remains controversial. Here, we present a case of placing CS lead in the anterior interventricular vein. Measurements at implantation and 2 years' follow-up reported low pacing thresholds with good sensing thresholds. The electrocardiograph showed narrow QRS complexes (120 ms) and follow-up echocardiography at 2 years presented left ventricular ejection fraction 58.9%.

KEYWORDS Left ventricular pacing; Prosthetic tricuspid valve; Coronary sinus; Anterior interventricular vein; QRS complex

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Introduction

In clinical practice, right ventricular pacing through a transvenous lead is routine owing to its safety and relative ease of implantation. Nevertheless, in patients with mechanical tricuspid prosthesis, right ventricular lead implantation is associated with the potential risk of lead damage and tricuspid valve malfunction.[1] Epicardial lead implantation through sternotomy or thoracotomy could be used for patients with a mechanical tricuspid valve. However, epicardial leads may be associated with higher pacing thresholds and lower reliability. Moreover, for patients after cardiac surgery, epicardial lead placement is difficult and even dangerous due to dense adhesions around the ventricles.[2,3] Paravalvular lead placement is another procedure of choice but is often performed in patients with preexisting ventricular pacemakers who need tricuspid valve replacement.[4] Permanent His bundle pacing from the right atrium has been performed in several patients with prosthetic tricuspid valve.[5,6] Although the QRS complex is narrow during para-Hisian pacing, the pacing threshold is high, and the long-term stability of His bundle capture from the right atrium is uncertain. In selected patients, implantation of leadless pacemaker in mechanical tricuspid valve may be considered as a last resort.[7] However, catheter entrapment along the edge of the coaptation line is possible, which raises a significant safety concern.

A promising alternative option is the transvenous position of ventricular leads through the coronary sinus (CS). Intentional coronary sinus lead placement was first introduced by Anagnostopoulos and colleagues[8] as a new approach in patients with tricuspid mechanical prostheses. With the development of cardiac resynchronization therapy, left ventricular (LV) pacing through CS has been more feasible. Lead stability has been a concern due to a lack of active fixation with CS leads. Collected data suggest that this approach could be safely performed with low rates of lead dislodgment in patients with cardiac resynchronization therapy.[1,2]

Most of the CS leads were positioned on the surface of the LV lateral wall due to satisfactory sensing amplitude, capture threshold, and impedance.[1] For cardiac resynchronization therapy, CS leads placed at the LV lateral wall were considered the optimal position. However, for patients without a left bundle branch block (LBBB) morphology, the best position of CS leads remains unclear. Here, we present a case in which CS lead was placed in the anterior interventricular vein.

Case presentation

A 58-year-old woman with a history of rheumatic heart disease underwent tricuspid and mitral valve replacement with mechanical prostheses. Eight years after the surgery, she presented with dizziness. Electrocardiography (ECG) showed

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KEY FINDINGS

- This is the first review to summarize the available articles regarding permanent pacing through the coronary sinus in patients with tricuspid prosthesis.
- Left ventricular pacing through the coronary sinus in patients with tricuspid prosthesis is feasible and reliable.
- The anterior interventricular vein maybe a good choice for ventricular pacing in patients with mechanical tricuspid valve replacement to achieve early septal activation and minimize the risk of diaphragmatic stimulation and lead dislodgement.

atrial fibrillation with frequent episodes of long R-R interval and an incomplete right bundle branch block with QRS duration 100 ms, which indicated permanent pacemaker implantation. Echocardiography revealed a LV ejection fraction of 61.8%, and the anticipated percentage of ventricular pacing was around 20% to 30%. The patient was prepared to place a transvenous pacing system through the left axillary vein. A preshaped long sheath (6250VIC Attain Command; Medtronic) was introduced into the coronary sinus, and venography was performed to show the detailed anatomy of the coronary veins. A bipolar endocardial pacing lead (Attain Ability 4196; Medtronic) was implanted in the lateral vein; nevertheless, the lead was dislocated when the pacemaker was placed in the subfascial pocket. A second attempt was made to place the lead in the anterior interventricular vein (Figure 1). Measurements at implantation reported a pacing threshold of 0.5 V at 0.40 ms, an R-wave sensing potential of 10.1 mV, and an impedance of 890 Ω. ECG showed that QRS complexes were around 120 ms (Figure 2). The lead was secured and connected to a single-chamber pacemaker (ADSR01; Medtronic). A quadripolar lead was considered when bipolar leads failed to be placed in an appropriate place because quadripolar leads were only suitable for cardiac resynchronization devices, which were far more expensive than either a single- or dual-chamber pacemaker in China. On day 2 after the implantation, the ventricular pacing threshold was 0.625 V at 0.4 ms, the R-wave sensing potential was 16 to >22.4 mV, and the lead impedance was 876 Ω. Sensing and pacing thresholds were stable during the 2-year follow-up. The pacemaker was programmed in VVI mode at a back-up rate of 40 beats/min. Echocardiography demonstrated preserved cardiac function with an ejection fraction of 56.8% at 1-year follow-up and 58.9% at 2-year follow-up.

Discussion

Intentional LV pacing through the coronary sinus was first described in 1969 in patients after tricuspid valve replacement to avoid cartilage resection and thoracotomy.[8] In the 1990s, biventricular pacing with CS lead pacing in the LV emerged as a nonpharmacologic management of heart failure.[9]

Studies regarding permanent LV pacing through the coronary sinus are summarized in Table 1. The anterior interventricular vein (AIV), anterolateral vein (ALV), lateral vein (LaV), posterior lateral vein (PLV), middle cardiac vein (MCV), posterior vein (PV), and great cardiac vein (GCV) had been targeted in case reports to place the LV leads in patients with tricuspid valve surgery. One study retrospectively analyzed 23 patients with tricuspid valve surgery/disease

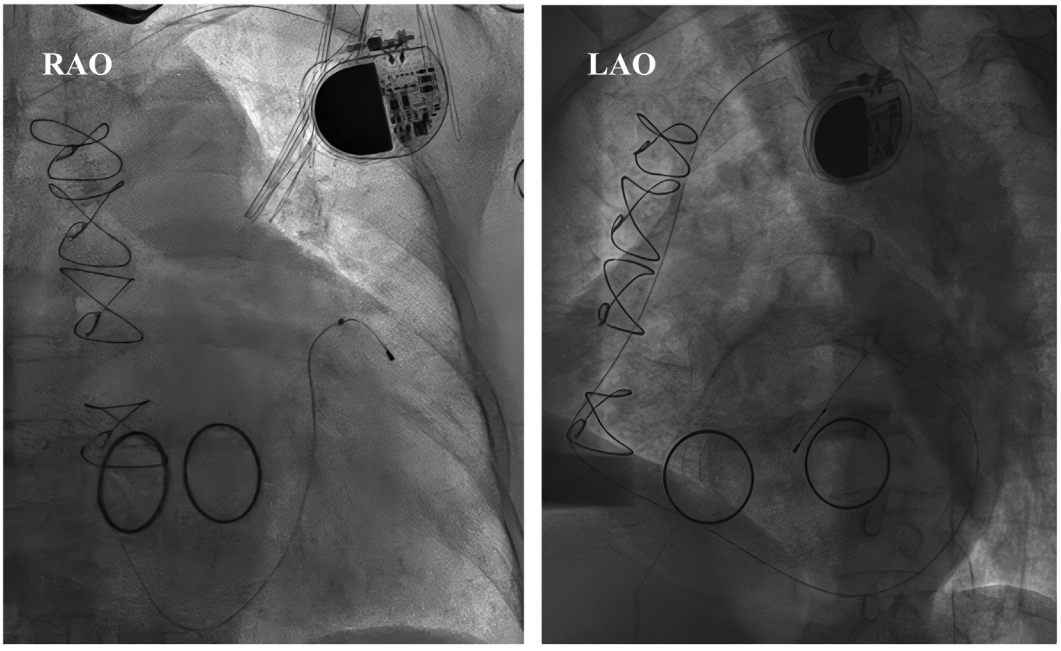

Figure 1 A single coronary sinus lead was implanted in the anterior interventricular vein. LAO = left anterior oblique; RAO = right anterior oblique.

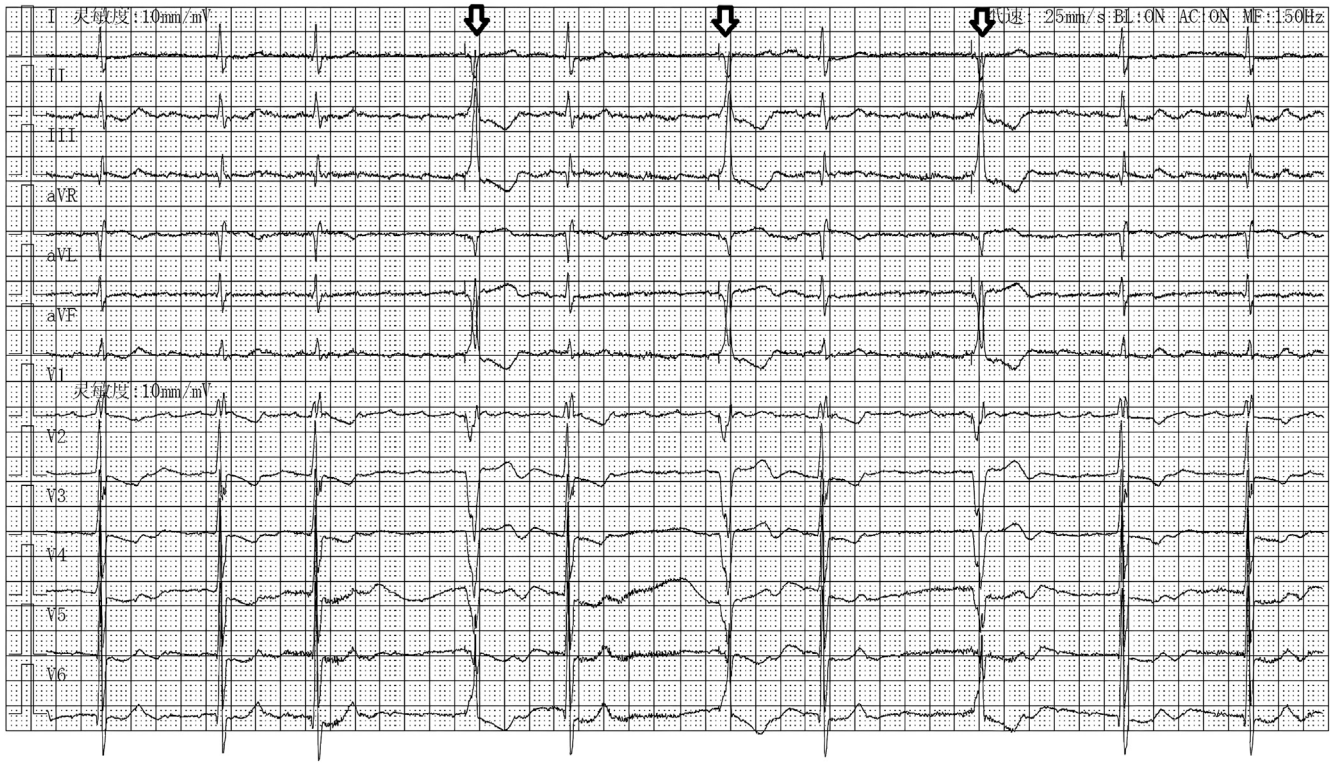

Figure 2 Outpatient follow-up electrocardiogram displaying intermittent ventricular paced rhythm with a QRS complex of about 120 ms (arrow).

who received a CS ventricular pacing lead. Eight of them were placed in the LaV, 3 in the PLV, 10 in the ALV, 1 in the AIV, and 1 in the MCV. During the follow-up of 5.3 ± 2.8 years, most of the leads were functional with stable pacing and sensing parameters, only 1 being extracted for unrelated reasons.[2] Another study included 26 patients who had tricuspid valve surgery/disease and underwent pacemaker implantation through the coronary sinus. LV leads were placed in the LaV in 10 patients, in the PLV in 6 patients, in the AIV in 6 patients, and in the MCV in 4 patients. Compared with right ventricular pacing, LV pacing via the coronary veins is safe and reliable.[10] In a single-center retrospective study, 34 patients with tricuspid valve surgery/disease received LV pacing leads in the coronary veins. A total of 19 patients were implanted with single-CS leads and 15 patients with dual-CS leads. Most of the patients with a single lead employed an AIV location and none of them suffered lead migration.[11] Lead dislodgment in the PLV was reported in 1 case during attempts to remove the guiding catheter from the coronary sinus.[12] Generally speaking, LV leads positioned in the branches of coronary sinus are stable for pacing. However, for patients who are pacemaker dependent, dual-CS leads implantation for redundancy could be considered due to the risk of lead dislodgement. Other patients with baseline LV systolic dysfunction, dual-CS leads in the LaV and AIV may achieve cardiac resynchronization therapy (CRT) pacing. In our case, LV leads placed in the AIV was more stable compared with the LaV. Hence, LV pacing through CS in patients with tricuspid prosthesis is feasible and efficient, and AIV may be the first choice if available.

In patients with heart failure and LBBB, LV free wall sites were more effective for CRT than the LV anterior sites.[13] Further studies showed that LV leads positioned in the apical region were associated with increased risk for death or heart failure.[14] These results may be explained by regional differences in conduction delays, as LV depolarization in most conduction disturbances occurs early in the apex. However, in patients without underlying cardiomyopathy or LBBB, early stimulation of the anterior wall may be more physiological. The GCV and MCV had been targeted in case reports to place the single LV leads in patients with tricuspid valve disease or surgery.[15–17] ECGs of cases with pacing leads in the GCV showed right bundle branch block configuration and right axis deviation with a QRS width around 180 ms.[15] One patient with a lead placed in the mid-anterolateral location and paced QRS duration of 196 ms developed pacing-mediated cardiomyopathy with a decline of LV ejection fraction from 65% to 26% over 5 years.[2] AIV is the coronary sinus venous system branch that leaves the atrioventricular groove to travel anteriorly in the interventricular septum. The AIV is closer to the normal conduction system, thus QRS generated by LV pacing in AIV could be narrow. In our case, the pacing QRS was 120 ms and follow-up echocardiography

Table 1 Summary of articles about permanent left ventricular pacing through coronary sinus after tricuspid valve replacement

Year	Study	Number of patients	Position of coronary sinus leads							Left ventricular ejection fraction (%)			QRS complex (ms)
			AIV	ALV	LaV	PLV	MCV	PV	GCV	Baseline	Follow-up (1 y)	Follow-up (2 y)	
1970	Anagnostopoulos et al[8]	2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1983	Lee[24]	2					1	1		NA	NA	NA	NA
1994	Bai et al[15]	2							2	NA	NA	NA	180
2001	Winter et al[25]	1						1		NA	NA	NA	NA
2001	Garrigue et al[26]	1				1				NA	NA	NA	NA
2001	Altmiks et al[27]	1				1				NA	NA	NA	NA
2002	Curnis et al[28]	1			1					NA	NA	NA	NA
2002	Nguyen et al[16]	1					1			NA	NA	NA	NA
2002	Faerestrand et al[29]	2						1	1	NA	NA	NA	NA
2002	Nolasco et al[30]	1							1	NA	NA	NA	NA
2002	Hansky et al[31]	7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2003	Lord et al[32]	1						1		NA	NA	NA	NA
2004	Kerpel et al[12]	1				1				NA	NA	NA	NA
2004	Herre et al[33]	1		1						NA	NA	NA	NA
2005	Yoda et al[34]	1	1							NA	NA	NA	NA
2007	Lopez et al[35]	1								NA	NA	NA	NA
2008	Yoda et al[36]	1							1	NA	NA	NA	NA
2008	Lopez et al[37]	1			1					NA	NA	NA	NA
2009	Anselmino et al[38]	1	1							NA	NA	NA	NA
2010	Grimard et al[17]	4			2					NA	NA	NA	NA
2013	Vijayakumar et al[39]	1			1					NA	NA	NA	NA
2014	Ku et al[40]	1			1					NA	NA	NA	160
2014	Conti et al[41]	1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2016	Sideris et al[1]	17	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2016	Zipse et al[42]	1		1						NA	NA	NA	NA
2017	Zha et al[43]	4			3				1	NA	NA	NA	NA
2018	Kharod et al[44]	1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2018	Noheria et al[2]	23	1	10	8	3	1			58.0 ± 7.9	↓2.6 ± 10.5	NA	NA
2019	Li et al[10]	26	6		10	6	4			54.2 ± 9.8	NA	58.2 ± 6.9	NA
2019	Lee et al[11]	34	27		17		4	1		56 ± 13	58 ± 9	59 ± 7.2	NA
2019	Çelik et al[45]	1		1						NA	NA	NA	NA
2020	Michaelis et al[4]	27	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2020	Ikeya et al[46]	1			1					69	NA	NA	200
2020	Yolcu[47]	1			1		1			50	NA	55	160
2020	Lovev et al[48]	1				1				NA	NA	NA	NA
2023	Bazire et al[49]	1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2023	Zirille et al[50]	10	2	2		3	1	2		35–65	NA	NA	NA
2023	Grazina et al[51]	1			1					NA	NA	NA	180
2024	Santobuono et al[52]	1		1	1					NA	NA	NA	160
Relative distribution of CS branches, %			26.4	11.1	33.3	11.1	9.0	4.9	4.2				

Values are mean ± SD, unless otherwise indicated. A downward arrow (↓) indicates decreased compared with baseline.

AIV = anterior interventricular vein; ALV = anterolateral vein; CS = coronary sinus; GCV = great cardiac vein; LaV = lateral vein; MCV = middle cardiac vein; NA = not available; PLV = posterior lateral vein; PV = posterior vein.

presented great LV function. However, long-term follow-up in these populations is needed to demonstrate the effects of different LV pacing sites on cardiac function.

Another advantage of AIV implantation is the rare occurrence of diaphragmatic stimulation. Compared with posterior (2%) and lateral (8.4%) leads, anterior leads (0.3%) have a very low incidence of diaphragmatic interference.[18] Lee and colleagues' study[11] also showed no diaphragmatic stimulation, which is likely due to anterior LV lead implantation in the majority of the patients. Other researchers examined by gross dissection the courses of phrenic nerves in 19 cadavers and found that the left phrenic nerve located at a distance of <3 mm from the LaV in 43% of cases, and <2 mm from the GCV in 21% of cases. The left phrenic nerve runs close to the left marginal artery and the lateral or left obtuse marginal vein,[19] which is relatively far from the anterior interventricular groove where the AIV travels. Therefore, an LV lead in the AIV is less likely to stimulate the phrenic nerve.

The average infection rate of cardiac implantable electronic device (CIED) was 1% to 1.3%,[20] and the prevalence of CRT-related infection was around 4.3%.[21] However, device-related infections in patients with tricuspid prosthesis and LV pacing through the CS are not well understood. It has been reported that anticoagulation drug use and prolonged

procedure duration were correlated to CIED infection.[20] Because CS lead implantation in patients with tricuspid prosthesis is more precautious and complex, longer operation time is anticipated. Besides, patients with tricuspid prosthesis are more likely taking anticoagulation drug, thus the infection risk may be higher than other CIED patients. Regarding CS lead extraction, clinical success rate and major complication rate were not significantly different from non-CS lead extraction.[22] Patients with tricuspid prosthesis and LV leads should also be programmed to minimize ventricular pacing, especially for those with wide QRS durations. VVI mode with a lower basic pacing rate, adaptive atrioventricular delay, and pacing mode switch could be considered in selected patients.[23]

In conclusion, the AIV maybe a good choice for ventricular pacing in patients with mechanical tricuspid valve replacement to achieve early septal activation and minimize the risk of diaphragmatic stimulation and lead dislodgement. However, randomized studies are needed to verify the effects of AIV pacing on cardiac function in patients with tricuspid prosthesis.

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Patient Consent: Written consent was given by the patient for the publication of this case report.

Ethics Statement: The study was approved by our local Institutional Review Board at the Second Affiliated Hospital of Zhejiang University. The study protocol adheres to the ethical guidelines of the Declaration of Helsinki.

Data Availability: More information is available by request from the corresponding author.

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