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Tricuspid Valve Function After Add-On Pacing/Sensing Lead vs ICD Lead Implantation for Failed IS-1/DF-1 ICD Leads: A Single-Center Experience

ABSTRACT

Background: The development or progression of tricuspid regurgitation (TR) following the implantation of cardiac implantable electronic devices (CIED) represents a significant concern. Although the link between transvalvular lead placement and TR is well established, the patient-related and lead-related factors that predispose patients to develop TR remain unclear. This study aimed to evaluate the effect of additional pacing/sensing leads (PSL) or implantable cardioverter defibrillator (ICD) leads on tricuspid valve function in patients with lead failure.

Methods: In this retrospective, single-center, case-control study, all ICD implantation patients, in cases performed by one of these authors, presenting with lead failure were screened. The degree of TR on pre- and post-procedural echocardiograms of patients who underwent additional PSL or ICD lead implantation is compared.

Results: The study comprised a total of 52 patients; 28 patients received PSL, and 24 patients received ICD electrodes. A non-significant increase in the degree of TR was observed in patients who underwent new ICD lead implantation ($P = .059$). The degree of TR observed in patients who underwent new PSL implantation was found to be comparable to the pre-procedure levels ($P = .180$). However, no statistically significant differences were observed between the 2 groups with respect to change in TR degree ($P = .123$).

Conclusion: This study is the first analysis comparing the effect of ICD electrode addition with PSL addition without lead extraction on right ventricular and tricuspid valve function in patients with lead failure. This study provides the first comparative analysis of PSL versus ICD lead addition in patients with lead failure. The findings suggest that additional leads, whether PSL or ICD, do not significantly worsen tricuspid valve function. The addition of PSL to the IS-1/DF-1 ICD lead with standard high-voltage leads may be a viable treatment option, as it yields similar results to a new ICD lead implantation in terms of right heart function.

Keywords: Implantable cardioverter defibrillator, lead failure, tricuspid regurgitation

ORIGINAL INVESTIGATION

INTRODUCTION

The implantation of cardiac implantable electronic devices (CIEDs), including permanent pacemakers, implantable cardiac defibrillators (ICDs), and cardiac resynchronization therapy (CRTs), has increased significantly in recent years.[1] The development or progression of tricuspid valve dysfunction after implantation of CIED represents a significant concern.[2] Following CIED implantation, tricuspid valve dysfunction is more commonly associated with tricuspid regurgitation (TR) and less commonly associated with tricuspid stenosis. The crossing of CIED electrodes over the tricuspid valve can result in the development of acute or chronic TR for a few reasons, including valve impingement, inflammation, and fibrosis of subvalvular structures and valve surfaces, damage to the right ventricular wall, leading to systolic dysfunction, and electrode-induced endocarditis.[3-5] The number, thickness, stiffness, and course of the electrodes placed across the valve are factors that affect the likelihood of valve damage or dysfunction occurring during and after electrode placement.[1,3,6] While the link between transvalvular lead placement and TR is well established, further research is required to elucidate the

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underlying conditions that predispose patients to develop associated and electrode-induced TR.

There are also studies showing more TR development with ICD lead than with pacemaker lead.[3,7] The ICD lead comprises a flexible silicone cylinder that can be coated with 1 or more copolymer materials to accommodate multiple conductors. Of particular significance is the inclusion of at least 1 distal right ventricle (RV) shock coil, which adds weight and stiffness to the transvalvular apparatus. In comparison, the pacemaker leads are typically thinner and lack a shock coil. These differences in size and material composition may influence the development of lead-related TR.[8]

To the knowledge, no study has investigated the effect of additional lead placement in the RV and the type of lead on tricuspid dysfunction. The study's objective was to investigate the effect of increasing the number of leads passing through the tricuspid valve and the type of lead on tricuspid valve dysfunction.

METHODS

Study Design and Patient Selection

This retrospective, single-center, case-control study was conducted in accordance with the Declaration of Helsinki and received approval from the Local Ethics Committee (Approval date: 05/05/2025, decision number: İ04-358-25). Each participant provided informed consent. Artificial intelligence assisted technologies were not used in the production of this study.

All ICD-implanted patients who presented with pacing/sensing component failure between 2010 and 2024 were screened for inclusion in the study. The flow chart for patient inclusion in the study is shown in Figure 1. Pacing/sensing failure was defined as intermittent or constant pacing impedance rise above manufacturer specified threshold, increase in pacing threshold > 5 mV, R wave drop < 4 mV, or oversensing (not caused by electromagnetic interference or T wave oversensing). If patients were to be included in the PSL arm, the high-voltage circuit of the faulty electrode had to be intact (defined by shock coil impedances within the ranges specified by the manufacturer and the absence of faulty cardioversion/defibrillation). Patients who underwent electrode revision based on the manufacturer's recommendation and patients with LF due to a loose connector screw were excluded from the study. Patients who underwent PSL implantation for other indications (such as His or left bundle branch pacing) were not included in the study.

Patients with IS-1/DF-1 ICD leads with intact high-voltage conductors were included in the new PSL implantation group. Patients undergoing PSL implantation for other indications (such as His or left bundle pacing) were not included. In patients with DF4 connectors, a new ICD lead was added, and the old lead was capped.

Patients with baseline or follow-up transthoracic echocardiography (TTE) of insufficient quality for TR evaluation were excluded. Patients who underwent lead extraction were not included in the study. Three patients were lost during follow-up, and 1 patient was excluded from the study because lead extraction was performed due to axillary vein occlusion.

Implantation Procedure

All patients were taken to the electrophysiology laboratory in a fasting state. The procedures were performed under conscious sedation by a total of 3 different electrophysiologists. Patency of the venous system was confirmed by venography. The appropriate lead (PSL and ICD lead) was advanced to the RV and implanted according to current guidelines. If appropriate indications were available, additional coronary sinus and/or right atrial leads were implanted. In the study group, the IS-1 pin of the old ICD cable was switched off, while the DF-1 high-voltage connectors were reconnected to the appropriate sites on the ICD generator. The PSL pin was connected to the IS-1 connection slot on the generator. In patients with DF4 lead, the old DF4 lead was switched off and the new lead was connected to the system. If coronary sinus or atrial leads were implanted or the old device had an end-of-service warning, the generator was replaced or upgraded for CRT, as appropriate. The device was then fixed in the generator pocket, and the pocket was closed with sutures. Post-implantation fluoroscopic recordings of patients with PSL or ICD leads are shown in Video 1 and 2. The device was interrogated, and electrical parameters (threshold, pacing impedance, sensing) were checked. Patients were removed from the laboratory if all measurements were within the specified range.

Echocardiographic Studies

The primary outcome parameter was TR severity at follow-up. Two-dimensional, color flow, continuous pulse-wave, and tissue Doppler TTE were performed using a Vivid E9 imaging system (GE Medical Systems, Chicago, USA). Measurements were obtained in the standard manner recommended by the American Society of Echocardiography. Tricuspid regurgitation evaluation was based on the regurgitant jet area in the right atrium and the size of the vena contracta by color Doppler in the apical 4-chamber view. Mitral regurgitation evaluation was based on the color flow jet area in the left atrium and vena contracta by color Doppler. The degree of atrioventricular valve regurgitation was divided into 4 categories: None TR/MR; mild TR/MR (small, narrow, central jet

HIGHLIGHTS

- The valvular consequences of separate transvalvular shock and left bundle area pacing (LBAP) leads remain unclear, and an additional RV lead may further increase the risk of tricuspid regurgitation in the LBAP era.
- Our findings indicate that additional leads, whether pacing/sensing leads or implantable cardioverter defibrillator, do not significantly worsen tricuspid valve function.
- In patients with normal high-voltage IS-1/DF-1 ICD leads, PSL supplementation appears to be a viable alternative, providing comparable right heart functional outcomes to new ICD lead implantation.

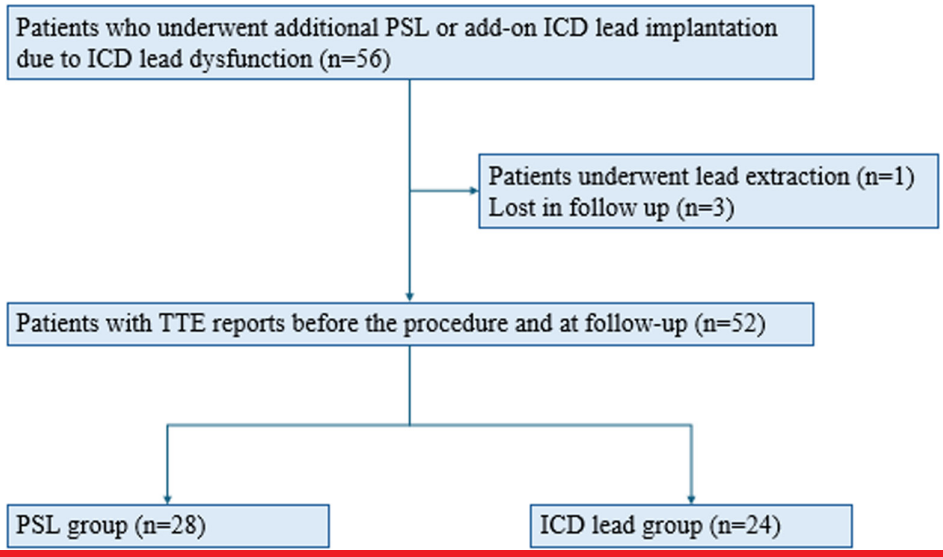

Figure 1. Patient inclusion flowchart for the study.

area; vena contracta < 3 mm); moderate TR/MR (moderate central jet area; vena contracta 3-7 mm); severe TR/MR (large central jet or jet compressing the eccentric wall of variable size; vena contracta > 7 mm). The transtricuspid pressure gradient was measured by continuous wave Doppler of the regurgitant tricuspid jet in the apical 4-chamber view. The right ventricular systolic pressure was calculated as the sum of the maximal transtricuspid pressure gradient and an estimate of the right atrial pressure based on inferior vena cava dimension and collapsibility.

The echocardiographic imaging and analysis, as well as the follow-up, were performed by cardiology residents, specialists, and professors.

Clinical Follow-Up and Data Collection

All patients underwent predetermined clinical follow-up: after echocardiographic evaluation before and after the procedure, routine annual follow-up was planned unless the clinical condition required more frequent visits. Echocardiographic reports of the patients were retrospectively reviewed. The echocardiographic evaluations of the patients before and after the procedure were analyzed.

Statistical Analysis

A Statistical Package for Social Sciences (SPSS Inc., Chicago, IL) version 26 was used for statistical analysis. The normal distribution of continuous variables was assessed using the Kolmogorov–Smirnov test. Categorical variables are expressed as frequencies (%). Differences between categorical variables were analyzed using the χ^2 test with Yates continuity correction or the Fisher's exact test, as appropriate. Continuous variables were presented as means ± SD for normally distributed data and compared using the Student's t-test, while non-normally distributed data were expressed as medians and interquartile ranges (IQR) and compared using the Mann–Whitney *U*-test. The Wilcoxon signed-rank test was used for the comparison of paired non-normally distributed continuous variables. A *P*-value of <.05 was considered statistically significant. The marginal homogeneity test was applied to compare the degree of TR before and after the lead implantation procedure.

RESULTS

Patient Characteristics

A total of 52 patients were included in the study. A new pace sense lead was implanted in 28 patients, and a new ICD lead was implanted in 24 patients. Most of the patients in both groups were male. The median echocardiographic follow-up time (months) after intervention was similar in PSL and ICD groups (respectively; 14 (IQR: 28) vs. ICD group: 13.5 (IQR: 17) $P = .92$). There was no significant difference between groups regarding types; other basic features and baseline echocardiographic parameters are listed in Table 1. Information regarding implanted patients is also provided in Table 1. No statistically significant difference was found between the degree of tricuspid valve regurgitation and the diameter of the tricuspid regurgitant jet in the vena contracta before the procedure (respectively; $P = .055$ and $P = .613$). Patients' right heart function and systolic pulmonary artery pressures obtained by echocardiography were also similar.

Post-procedure echocardiographic and electrical parameters of patients are presented in Table 2. There was no significant difference in ejection fraction between groups after the procedure. No differences were detected between the groups in terms of mitral regurgitation grades and mitral valve regurgitant jet vena contracta diameter. Similarly, tricuspid valve regurgitation grade and tricuspid valve regurgitant jet vena contracta diameter were similar between the 2 groups after the procedure. No differences were detected between the groups in the other echocardiographic findings evaluated in patients. Median R wave at the end of the procedure was similar between the 2 groups (10 (IQR: 9.0), 14 (IQR: 12.0), $P = .194$). Median pacing impedances and shock impedances were also similar.

Baseline and post-implantation echocardiographic parameters are summarized in Table 3. In the PSL group, there were

Table 1. Baseline Demographic and Echocardiographic Characteristics

		Total n (%)	PSL Group n = 28 (%)	ICD Lead Group n = 24 (%)	*P*
Etiology	Ischemic	32	18 (64.3)	14 (58.3)	.87[a]
	Non-ischemic	20	10 (35.7)	10 (41.7)	
Sex	Female	10 (19.2)	5 (17.9)	5 (20.8)	1.00 [b]
	Male	42 (80.8)	23 (82.1)	19 (79.2)	
Age (years)		62.8 ± 11.7	65.5 ± 11.4	59.79 ± 11.4	.08[c]
ICD type					.32[b]
VR-ICD		20 (38.5)	10 (35.7)	10 (41.7)	
DR- ICD		14 (26.9)	6 (21.4)	8 (33.3)	
BIV-ICD		18 (34.6)	12 (42.9)	6 (25.0)	
CRT upgrade		1	1	0	
Primary prophylaxis		38 (73.1)	24 (85.7)	14 (58.3)	.057[a]
Secondary prophylaxis		14 (26.9)	4 (14.3)	10 (41.7)	
Follow-up duration, -months		48 (IQR: 24)	48 (IQR: 24)	48 (IQR: 34)	.87[d]
Follow-up echocardiography time after procedure (month)		14 (IQR: 18)	14 (IQR: 28)	13.5 (IQR: 17)	.92[d]
Indication for lead revision					
Impedance rise/pacing threshold rise/R wave decrease		37 (72.5)	18 (66.7)	19 (79.2)	
Oversensing		28 (53.8)	15 (53.6)	13 (54.2)	
Implanted leads					
Pacing/sensing leads					
Medtronic 5076			18 (64.2)	–	
Boston scientific INGEVITY			5 (17.8)	–	
Biotronik solia S60			3 (10.7)	–	
SJM tendril			2 (7.1)	–	
Defibrillation leads					
Medtronic 6947			–	16 (66.6)	
Boston scientific endotak			–	7 (29.1)	
SJM durata			–	1 (4.1)	
Ejection fraction (%)		35 (IQR: 5)	35 (IQR: 6)	30 (IQR: 5)	.68[d]
Baseline MR					.971[b]
None		3 (5.8)	2 (7.1)	1 (4.1)	
Mild (VC < 3.0 mm)		17 (32.7)	8 (28.6)	9 (37.5)	
Moderate (VC = 3.0-6.9 mm)		23 (44.2)	13 (46.4)	10 (41.6)	
Severe (VC ≥ 7.0 mm)		9 (17.3)	5 (17.8)	4 (16.6)	
Vena contracta of MR (mm)		3.50 (IQR: 2.25)	3.50 (IQR: 2.25)	3.55 (IQR: 2.5)	.84[d]
Baseline TR					.055[b]
None		3 (5.8)	0 (0)	3 (12.5)	
Mild (VC < 3.0 mm)		28 (57.7)	15 (53.6)	15 (62.5)	
Moderate (VC = 3.0-6.9 mm)		18 (30.8)	11 (39.3)	5 (20.8)	
Severe (VC ≥ 7.0 mm)		3 (5.8)	2 (7.1)	1 (4.2)	
Vena contracta of TR (mm)		2.55 (IQR: 2.65)	2.55 (IQR: 2.85)	2.55 (IQR: 1.88)	.613[d]
Pre-implantation sPAP (mmHg)		38 (IQR: 15)	38 (IQR: 15)	37.5 (IQR: 12)	.10[d]
TR vmax (m/sec)		3.18 (IQR: 1.1)	3.20 (IQR: 1.2)	3.15 (IQR: 1.0)	.14[d]
TAPSE (mm)		20 (IQR: 4)	20.0 (IQR: 4)	20.5 (IQR: 5)	.87[d]
TAPSE/sPAP		0.47 (IQR: 0.08)	0.45 (IQR: 0.09)	0.50 (IQR: 0.08)	.68[d]

[a]Yates Continuity Correction chi-square test; [b]Exact test; [c]Student *T*-Test; [d]Mann–Whitney *U*-test.TAPSE, Tricuspid Annular Plane Systolic Excursion

no statistically significant changes in vena contracta of mitral regurgitation (3.50 [IQR 2.25] vs. 3.50 [IQR 2.25], *P* = .21) or TR (2.55 [IQR 2.85] vs. 2.55 [IQR 2.15], *P* = .42). Similarly, no significant differences were observed in sPAP (38 [IQR 15] vs. 40 [IQR 15], *P* = .27), TR Vmax (3.20 [IQR 1.20] vs. 3.31 [IQR 1.20], *P* = .48), or TAPSE (20.0 [IQR 4] vs. 20.1 [IQR 4], *P* = .87) after implantation. In the ICD lead group, vena contracta of mitral regurgitation remained unchanged after implantation

Table 2. Post-procedural Echocardiographic and Electrical Parameters of Patients

	Total n (%)	PSL Group n = 28 (%)	ICD Lead Group n = 24 (%)	*P*
Ejection fraction (%)	35 (IQR: 7.5)	35 (IQR: 7.5)	30.0 (IQR: 5)	.68[c]
Follow-up MR				.581[b]
None	4 (7.6)	3 (10.7)	1 (4.1)	
Mild (VC < 3.0 mm)	15 (28.8)	7 (25.0)	10 (41.6)	
Moderate (VC = 3.0-6.9 mm)	24 (46.1)	13 (46.4)	9 (37.5)	
Severe (VC ≥ 7.0 mm)	9 (17.3)	5 (17.8)	4 (16.6)	
Vena contracta of MR (mm)	3.50 (IQR: 2.25)	3.50 (IQR: 2.25)	3.55 (IQR: 2.5)	.56[c]
Follow-up TR				.324[b]
None	3 (5.8)	0	3 (12.5)	
Mild (VC < 3.0 mm)	26 (50.0)	14 (50.0)	12 (50)	
Moderate (VC = 3.0-6.9 mm)	16 (26.9)	10 (35.7)	6 (250)	
Severe (VC ≥ 7.0 mm)	7 (13.4)	4 (14.2)	3 (12.5)	
Vena contracta of TR (mm)	2.60 (IQR: 2.45)	2.55 (IQR: 2.15)	3.0 (IQR: 2.78)	.202[c]
Post-implantation sPAP (mmHg)	37.5 (IQR: 16.5)	40.0 (IQR: 15)	35.0 (IQR: 15)	.29[c]
TR vmax (m/sec)	3.25 (IQR: 1.2)	3.31 (IQR: 1.2)	3.18 (IQR: 1.2)	.16[c]
TAPSE (mm)	20.0 (IQR:4)	20.1 (IQR: 4)	20.4 (IQR: 4)	.88[c]
TAPSE/sPAP	0.45 (IQR: 0.08)	0.42 (IQR: 0.07)	0.48 (IQR: 0.08)	.42[c]
R wave at the end of the procedure	13.0 (IQR: 11.1)	10 (IQR: 9.0)	14 (IQR: 12.0)	.194[c]
RV coil Shock impedance at the end of the procedure	51 (IQR: 14)	50 (IQR: 21)	52 (IQR: 9.0)	.744[c]
Pacing impedance at the end of the procedure	620 (IQR: 308)	660 (IQR: 224)	565 (IQR: 328)	.307[c]

[a]Yates Continuity Correction Chi-Square Test; [b]Exact test; [c]Mann–Whitney *U*-test.

(3.55 [IQR 2.50] vs. 3.55 [IQR 2.50], *P* = .35). A non-significant increase in TR vena contracta was observed (2.55 [IQR 1.88] vs. 3.00 [IQR 2.78], *P* = .22). No significant changes were detected in sPAP (37.5 [IQR 12] vs. 35 [IQR 15], *P* = .36), TR Vmax (3.15 [IQR 1.00] vs. 3.18 [IQR 1.20], *P* = .62), or TAPSE (20.5 [IQR 5] vs. 20.4 [IQR 4], *P* = .88). Overall, implantation was not associated with statistically significant changes in left- or right-sided echocardiographic functional parameters in either group. Table 4 summarizes changes in the degree of tricuspid and mitral regurgitation in patients. The numbers in the table represent the number of patients. In the 4 patients who received PSL implantation, at least a 1-degree increase in TR grade was observed. In the 6 patients who received a new ICD electrode implantation, at least a 1-degree increase in TR grade was observed. The addition of PSL did not result in a statistically significant change in TR grade (*P* = .180). In the ICD lead group, a trend toward an increase in TR grade was observed; however, this did not reach statistical significance (*P* = .059). The change in TR grade (ΔTR) demonstrated minimal variation in both groups. Median ΔTR grade was 0 (IQR: 0-0.5) in the PSL group and 0 (IQR: 0-0.75) in the ICD lead group. There was no statistically significant difference in ΔTR change between groups (*P* = .123, Mann–Whitney *U*-test). Overall, neither PSL addition nor ICD lead implantation was associated with a statistically significant worsening in TR severity.

During follow-up there were no episodes signaling lead-lead interaction and no patients were diagnosed with venous obstruction or superior vena cava syndrome.

DISCUSSION

The importance of the potential pro-regurgitant effect of an additional transvalvular (RV) lead is probably even more critical in the era of left bundle area pacing (LBAP). Mounting evidence suggests that in selected patients undergoing CRT, favorable clinical outcomes may be achieved via this pacing modality.[9-11] However, the question of potential valvular

Table 3. Pre- and Post-Implantation Echocardiographic Parameters in PSL and ICD Lead Groups

	PSL Group			ICD Lead Group		
Variables	**Pre-implantation**	**Post-implantation**	***P***	**Pre-implantation**	**Post-implantation**	***P***
Vena contracta of MR (mm)	3.50 (2.25)	3.50 (2.25)	.21	3.55 (2.50)	3.55 (2.50)	.35
Vena contracta of TR (mm)	2.55 (2.85)	2.55 (2.15)	.42	2.55 (1.88)	3.00 (2.78)	.22
sPAP (mm Hg)	38 (15)	40 (15)	.27	37.5 (12)	35 (15)	.36
TR Vmax (m/s)	3.20 (1.20)	3.31 (1.20)	.48	3.15 (1.00)	3.18 (1.20)	.62
TAPSE (mm)	20.0 (4)	20.1 (4)	.87	20.5 (5)	20.4 (4)	.88

Wilcoxon signed-rank test.

Table 4. Change in the Degree of Mitral and Tricuspid Regurgitation in Patients

			Mild	Severe	*P*	ΔMR Grade (Post−Pre)	*P*
PSL group n = 28	Pre-implantation MR degree	Post-implantation MR degree					
		None	0	0	.317[a]	0 (IQR: 0.5)	.85[b]
		Mild	7	0			
		Moderate	0	0			
		Severe	0	5			
ICD lead group n = 24		None	0	0	1.00[a]	0 (IQR: 0.0)	
		Mild	8	0			
		Moderate	1	0			
		Severe	0	4			
PSL group n = 28	Pre-implantation TR degree	Post-implantation TR degree					
		None	0	0	.180[a]	0 (IQR: 0.5)	.123[b]
		Mild	13	0			
		Moderate	1	2			
		Severe	0	2			
ICD lead group n = 24		None	0	0	.059[a]	0 (IQR: 0.75)	
		Mild	11	0			
		Moderate	1	2			
		Severe	0	1			

[a]Marginal homogeneity test; [b]Mann−Whitney *U*-test.

dysfunction that may occur due to separate shock and LBAP leads that are both transvalvular is still unanswered. Most (but not all) studies attribute the higher incidence of TR worsening to ICD leads and the presence of multiple transvalvular (RV) leads.[3,7,12-16] In a previously published observational study, De Cock et al[6] investigated the complications of patients with 3 or more leads and suggested that the presence of more than 1 lead in the RV may increase TR. Çeliker et al[15] found no difference in the degree of TR with 1 or 2 lead implantations, whereas Al-Bawardy et al[13] also found no correlation between the number of leads and the worsening of TR.[1,15] In the study, findings suggest that additional leads, whether PSL or ICD, do not significantly worsen tricuspid valve function. When compared with the patient's preoperative echocardiogram, no statistically significant difference was found between the 2 groups in terms of TAPSE, vena contracta diameter, and changes in tricuspid valve insufficiency grade and right heart function in the postoperative echocardiogram. Although no statistically significant difference was observed in TR progression between groups, a borderline *P*-value was noted in the ICD lead group ($P = .059$), suggesting a potential trend toward greater TR worsening in this subgroup. Previous studies have suggested that ICD leads are typically thicker and less flexible than Pacemaker leads (PPM), causing more interference with TV closure or more damage to the valve.[3,7] While Kim et al[7] observed a higher prevalence of TR in patients with ICDs compared to PPMs, Leibowitz et al[14] and Al-Bawardy et al[13] reported no correlation. Patients in the groups were also similar in terms of the type of previously implanted device. Since most patients with ICDs exhibit moderate or severe left ventricular dysfunction and a predisposition to secondary (functional) TR, comparing CIED-related TR may be particularly biased in patients undergoing CRT. The strength of the study is that both PSL and ICD lead groups were compared in a relatively homogeneous population with similar left ventricular function in both groups with previous ICD implantation. It is noteworthy that the groups exhibited comparable characteristics with respect to the potential for a diminution in the evolution of secondary TR, attributable to the anticipated enhancement in left heart function in patients who have undergone implantation of a BIV-ICD.

Limitations of the Study

There was no selection bias in terms of referral of the patients for echocardiographic follow-up. However, simultaneous control echocardiographic measurements were not performed in patients after implantation is one of the limitations of the study. A total of 3 patients were excluded from the study because they did not undergo post-procedure echocardiography, and a further patient was excluded due to lead extraction performed. In order to avoid confounding the study results with tricuspid valve insufficiency due to additional valve trauma that may occur during electrode removal procedures and to evaluate the effect of multiple leads in patients, patients who underwent electrode removal procedures were not included in the study.

Although no statistically significant difference was observed in TR progression between groups, a borderline *P*-value was noted in the ICD lead group. Future prospective studies with larger patient populations and longer follow-up periods are needed to clarify whether ICD lead−associated mechanical interaction with the tricuspid valve contributes to clinically relevant TR progression.

Since the study was a retrospective observational study, the echocardiographic evaluation of the patients did not specifically include the evaluation of TV function. In routine follow-ups in the clinic, the degree of TR is mostly evaluated by measuring the regurgitation of the jet area and vena contracta with color flow imaging. This qualitative and semi-quantitative assessment may be inaccurate compared to quantitative measurements. Furthermore, the presence of an eccentric TR results in the loss of this Doppler-colored flow signal (Coanda effect) and thus underestimation of regurgitation. A prospective study including quantitative measurements such as proximal isovelocity surface area method and volumetric methods and examination of the hepatic vein flow model will provide a more objective view. 3D echocardiography may provide information on the mechanism by better characterizing the interaction between the lead and the valve or valve apparatus. The study is not mainly aimed at explaining the mechanism but provides an idea about the effect of increasing lead number and lead type on tricuspid valve function in a relatively homogeneous population.

CONCLUSION

This study provides the first comparative analysis of PSL versus ICD lead addition in patients with lead failure. The findings suggest that additional leads, whether PSL or ICD, do not significantly worsen tricuspid valve function.

Ethics Committee Approval: This study was approved by the Ethics Committee of Ankara University Faculty of Medicine (Approval date: 05/05/2025, decision number: İ04-358-25).

Informed Consent: Written informed consent was obtained from the patients who agreed to take part in the study.

Peer-review: Externally peer-reviewed.

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Declaration of Interests: The authors have no conflict of interest to declare.

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Video 1: Post-implantation fluoroscopic recordings of patients with PSL.

Video 2: Post-implantation fluoroscopic recordings of patients with ICD lead addition.

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