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# Biventricular implantable cardioverter-defibrillator device placement in patients with hostile tricuspid valve anatomy: two case reports and review of the literature

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## Aims

Right ventricular (RV) lead placement can be contraindicated in patients after tricuspid valve (TV) surgery. Placement of the implantable cardiac-defibrillator (ICD) lead in the middle cardiac vein (MCV) can be a viable option in these patients who have an indication for biventricular (BiV) ICD. We aim to describe the case of two patients with MCV lead placement and provide a comprehensive review of patients with complex TV pathology and indications for RV lead placement.

## Methods and results

We describe the cases of two patients with TV pathology unsuitable for the standard transvenous or surgical RV lead placement and undergoing BiV ICD implantation. Their characteristics, procedure, and outcomes are summarized. The BiV ICD was successfully placed with the RV lead positioned in the MCV in both patients. The procedures had no complications and were well-tolerated. On follow-up, both patients had appropriate tachytherapy with no readmissions for heart failure or worsening of cardiac function.

## Conclusion

Right ventricular lead placement of BiV ICD in the MCV can be an excellent alternative in patients with significant TV pathology and poor surgical candidacy.

## Keywords

Tricuspid valve • Middle cardiac vein • Biventricular implantable cardioverter-defibrillator

## Introduction

Implantable cardiac-defibrillators (ICDs) are indicated for primary prevention in patients at high risk for ventricular tachycardia (VT) or ventricular fibrillation (VF). They are also indicated for secondary prevention of sudden cardiac death (SCD) in patients with prior sustained VT/VF.<sup>1</sup> Patients with heart failure, severely reduced left ventricular (LV) function [ejection fraction (EF) < 35%], and wide QRS on 12-lead electrocardiogram [ECG; QRS complex > 120 ms for left bundle branch block and > 150 ms for right bundle branch block

(RBBB)] may benefit from cardiac resynchronization therapy (CRT) as well as from the tachytherapy provided by ICDs and they usually receive biventricular (BiV) ICD as part of their heart failure therapy.<sup>2,3</sup>

Lead placement of the defibrillator coil near the right ventricular (RV) apex is the recommended position for the RV ICD lead.<sup>4</sup> This becomes increasingly complicated in patients with tricuspid valve (TV) pathology, such as patients with a mechanical TV. For these patients, surgical epicardial system placement becomes the conventional approach if their surgical risks permit. The implantation

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### What's new?

- Endovascular placement of biventricular implantable cardiac-defibrillator system might be still indicated in patients with tricuspid valve (TV)-related contraindication due to no other alternatives at this point.
- Implantable cardiac-defibrillator lead implantation through the middle cardiac vein is a safe and adequate alternative for patients with TV pathology precluding the traditional transvenous right ventricular lead implantation and not a candidate for the surgical or subcutaneous option.

of dual-chamber ICD devices using the middle cardiac vein (MCV) for six patients who were considered high risk for cardiac surgery had been previously described.<sup>5</sup> These patients had the defibrillator coil placed in the MCV, and bipolar leads for sensing/pacing purposes were placed in one of the coronary sinus branches.

Our literature review to date reveals scarce data describing transvenous implantation of BiV ICD using the MCV in patients with complex TV pathology who are poor surgical candidates for epicardial placement. We describe the case of two patients with BiV ICD implantation with the utilization of that ICD lead placed in the MCV for both pace and sense function.

## Methods

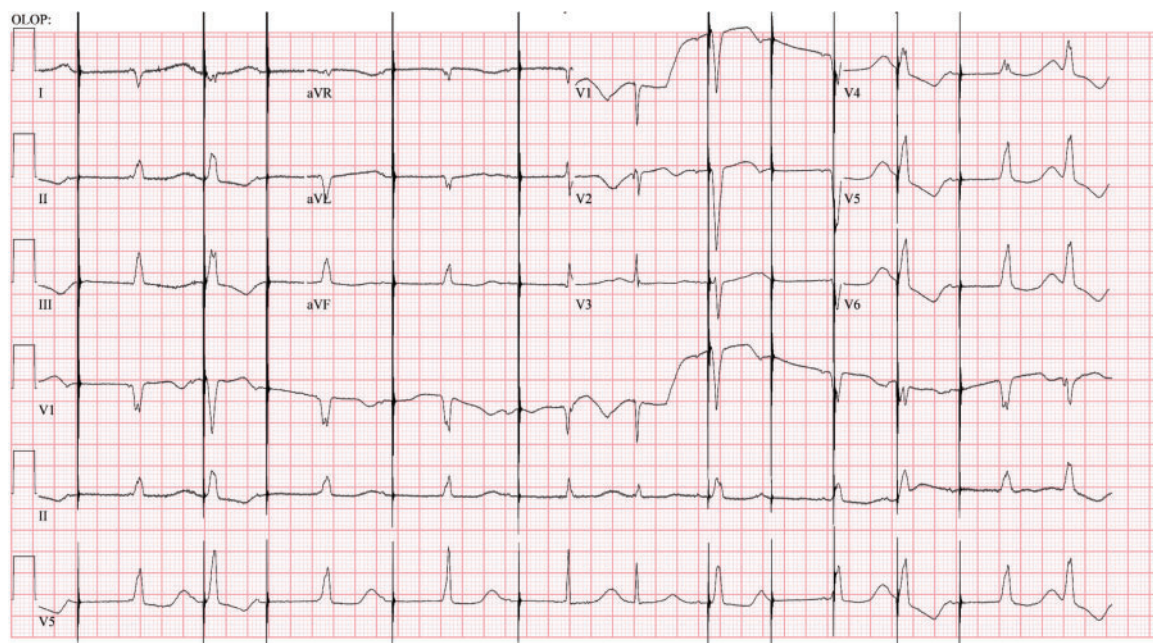
Two patients at two institutions were evaluated and deemed candidates for BiV ICD implantation. Both patients had significant TV pathology

preventing ICD lead placement through the TV and were also deemed high risk for surgical epicardial lead placement.

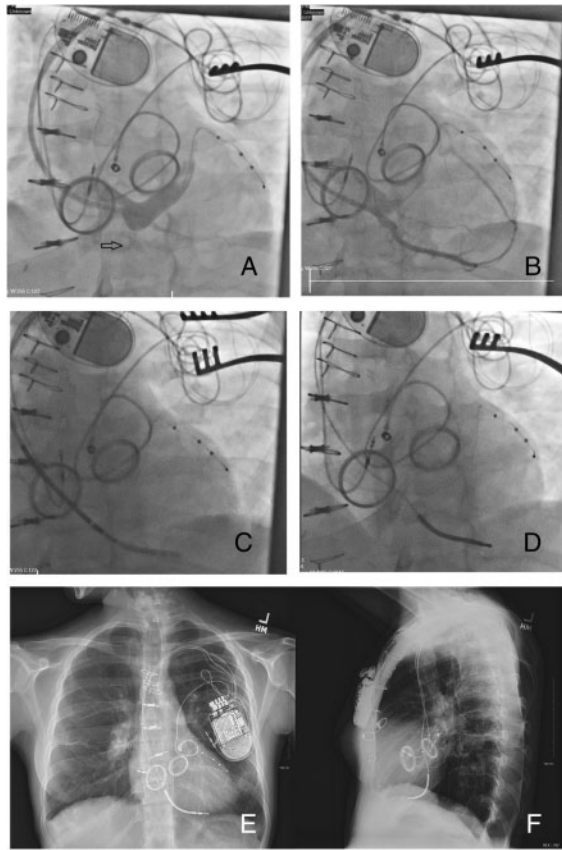
The first patient is a 24-year-old woman who was found to have methicillin-resistant *Staphylococcus aureus* endocarditis of both mitral and TVs. She underwent mechanical replacement of both tricuspid and mitral valves. At the time of surgery, her course was complicated by complete heart block and subsequent placement of a dual-chamber permanent pacemaker. The right ventricular lead was placed epicardially; the right atrial lead was later implanted endocardially using an active fixation lead.

During her stay in the long-term acute rehab facility, she was noted to have episodes of polymorphic VT in the setting of loss of RV lead capture from rise in the pacing threshold (Figure 1). QTc was noted to be mildly prolonged which was attributed to both bradycardia and treatment with fluoroquinolone. She was deemed to be a poor candidate for implantation of new epicardial RV lead. Therefore, the dual-chamber pacemaker system was upgraded to BiV pacemaker with implantation of a quadripolar lead in the anterolateral branch of the coronary sinus for pacing. The quadripolar lead was chosen to allow multiple choices for pacing in this young patient with limited pacing options in the future. The sensing function of the epicardial RV lead was adequate with no evidence for noise.

Two weeks later, she suffered another cardiac arrest (VF) while at the rehabilitation facility. Her electrocardiogram showed significant prolongation of QTc with no clear aetiology. Implantable cardiac-defibrillator implantation was necessary. Thoracotomy was deemed to be a high-risk procedure and the patient failed subcutaneous ICD screening. A single-coil DF4 ICD lead with active fixation (St Jude Medical) was then implanted in the MCV (Figure 2A–F). The helix was not extended. The ICD lead provided adequate sensing and pacing function. Sensing and tachytherapy pacing were programmed through the ICD lead. However, pacing for the bradytherapy was mainly done through the previously implanted quadripolar lead (mono-LV pacing) due to multiple excellent options and preserved LV function. The leads were connected to BiV ICD pulse generator. Defibrillation was successful at 15J. The patient



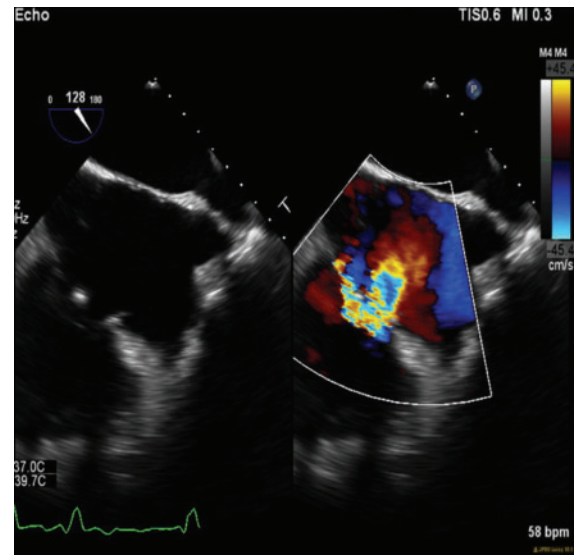
**Figure 1** EKG demonstrating rise in threshold and loss of capture leading to cardiac arrest.



**Figure 2** (A) Access to the coronary sinus was obtained using a guiding sheath (CPS Direct™ SLII 115). The arrow is pointed to the middle cardiac vein. (B) An inner catheter with a small injection of contrast helped to guide a Glide wire to the middle cardiac vein. (C) The delivery sheath was advanced deep into the middle cardiac vein over the guiding wire. (D) A single-coil DF4 ICD lead with active fixation (SJM 7122Q) was then placed in the middle cardiac vein. (E) Chest X-ray, posterior-anterior view showing MCV lead placement of the ICD. (F) Chest X-ray, lateral view showing MCV lead placement of the ICD. ICD, implantable cardiac-defibrillator. MCV, middle cardiac vein.

tolerated the procedure well. Of note, genetic testing revealed a mutation in *KCNQ* (long QT-1 syndrome).

The second patient was a 75-year-old man with a history of paroxysmal atrial fibrillation and coronary artery bypass graft surgery with concomitant bioprosthetic mitral and TV replacements. He has severe valvular and peri-valvular regurgitation of his bioprosthetic TV (Figure 3). He has had multiple admissions for heart failure with rapid progressive worsening BiV function (last EF 25%). He also required blood transfusions for haemolytic anaemia likely related to his TV pathology. His ECG was remarkable for significant first-degree atrioventricular block with a very wide RBBB (Figure 4). A heart catheterization revealed patent grafts with no indication for coronary revascularization. Given the patient's significant tricuspid valvopathy epicardial BiV ICD system placement was considered. He was found to be a poor candidate for repeat thoracotomy and a transvenous BiV ICD system approach was pursued. There was serious concern that placement of the lead in the RV would worsen his



**Figure 3** Transoesophageal echocardiogram revealing bioprosthetic tricuspid valve with severe valvular and peri-valvular regurgitation.

valvular or perivalvular regurgitation. For this reason, it was elected to place the RV ICD lead in the MCV, and the helix was extended (Figure 5A and B). The procedure was well-tolerated and without any complications. Defibrillation was successful at 20J and the patient was on amiodarone.

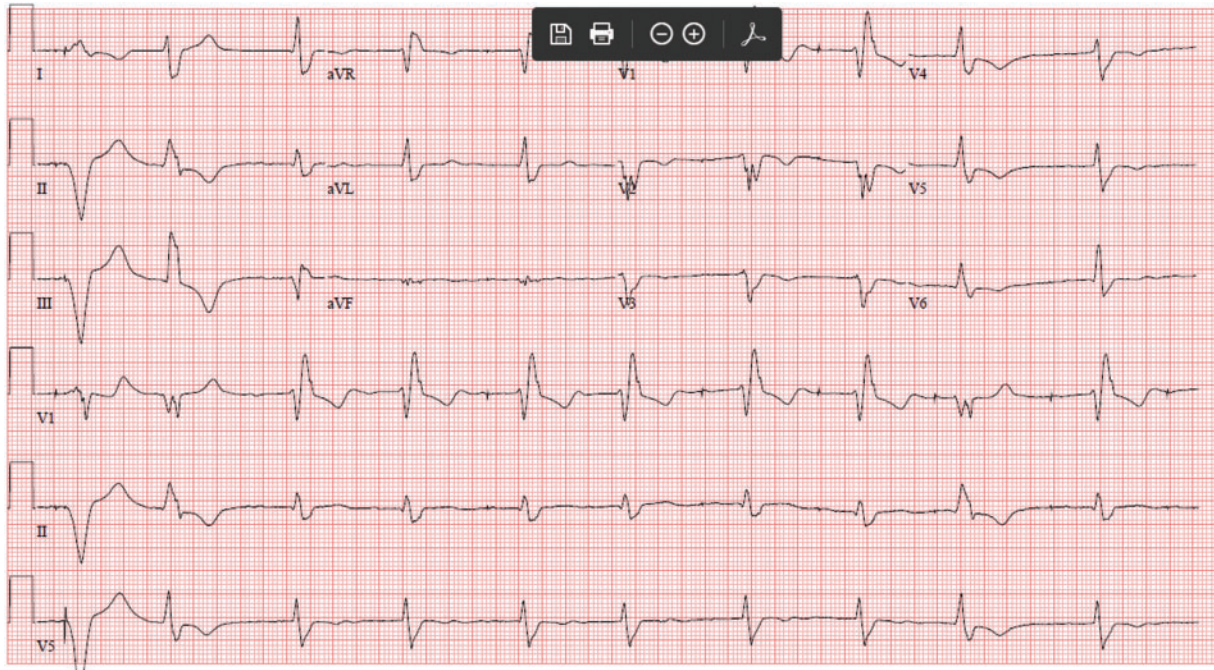
## Results

Both procedures were successful and performed in the electrophysiology lab under moderate sedation and local anaesthesia. There were no peri-procedural complications. On follow-up, there was no lead dislodgement or worsening ventricular function. Both leads in the MCV have acceptable sensing, impedance, and pacing thresholds (Table 1).

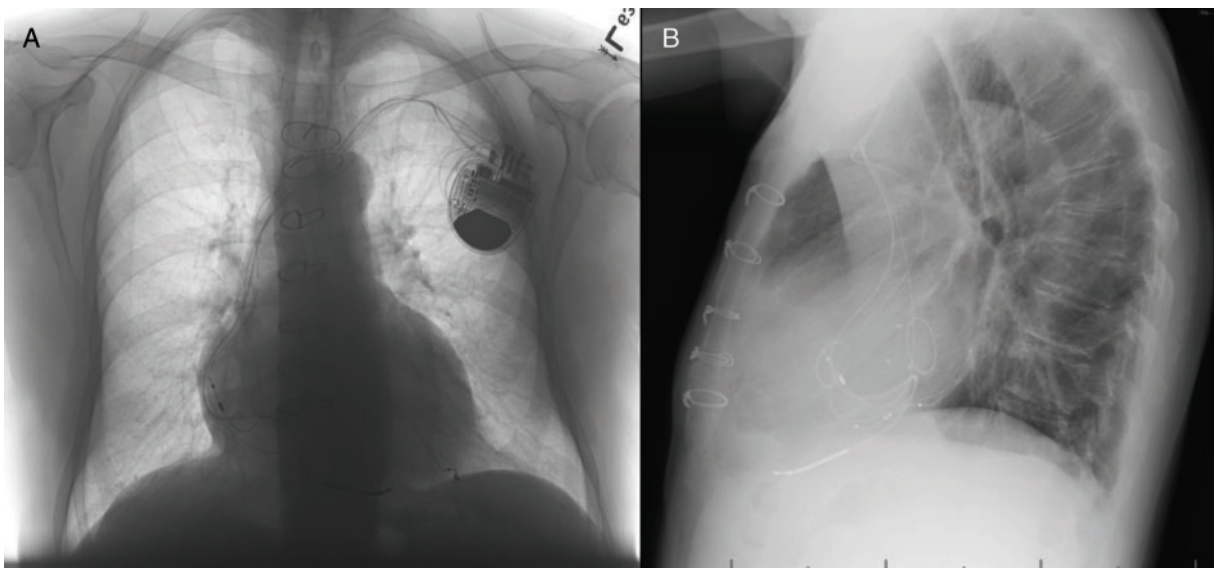
The first patient is currently 43 months post-BiV ICD implantation. She has received successful ICD shock therapy twice for VF. Her LV function continues to be normal. The second patient's clinical course has improved dramatically. He is currently 25 months post his BiV ICD implantation. His New York Heart Association Classification has improved from Class III-IV to Class II symptoms. Furthermore, he has had no heart failure-related readmissions since implantation of the BiV ICD and haemoglobin has remained stable since implantation and received appropriate, effective antitachycardia pacing.

## Discussion

Cardiac resynchronization therapy in patients with heart failure, severe LV systolic dysfunction, and wide QRS has been shown to improve functional class, improve 6-min walking distance, reduce heart failure admissions, reduce all-cause mortality, and in some instances promote reverse remodelling.<sup>6-8</sup> Many patients requiring CRT also



**Figure 4** Electrocardiogram showing the baseline prolonged PR segment and wide right bundle branch block.



**Figure 5** (A) Chest X-ray, posterior-anterior view showing MCV lead placement of the ICD. (B) Chest X-ray, lateral view showing MCV lead placement of the ICD. ICD, implantable cardiac-defibrillator. MCV, middle cardiac vein.

have indications for ICD placement.<sup>9</sup> Implantable cardiac-defibrillator is also indicated for secondary prevention of SCD in patients with prior sustained VT/VF.<sup>1</sup> Despite the benefits provided by BiV ICDs patients may have complex TV pathology (such as prior TV repair or replacement) with a relative or absolute contraindication to lead

placement through the TV. It should be completely avoided in patients with mechanical TV. A transvenous approach is preferred over the epicardial one.<sup>10</sup> A prior retrospective study showed that RV lead placement across a repaired TV was associated with recurrence of significant TV regurgitation and increase in late mortalities.<sup>11</sup>

**Table 1** Baseline and follow-up measurements of the ICD lead

	Sensing	Pacing threshold	Impedance	Shock impedance
Patient 1 at implant	5.4 mV	2 V @ 1.2 ms	2200	37
Patient 1 at follow-up	Paced	2 V @ 1.2 ms	1932	42
Patient 2 at implant	5.9 mV	2 V @ 1.2 ms	968 Ohms	68 Ohms
Patient 2 at follow-up	6.4 mV	1.5 V @ 1 ms	512 Ohms	67 Ohms

ICD, implantable cardiac-defibrillator.

Lead-induced TV dysfunction may be due to obstruction, perforation, laceration, or lead entrapment.<sup>12</sup> However, worse outcomes were not seen in those with normally functioning bioprosthetic TV in another small retrospective study.<sup>13</sup> The patients in our study had bioprosthetic TVs with severe valvular and perivalvular regurgitation precluding the addition of an RV ICD lead. We demonstrate that the placement of the RV ICD lead in the MCV may be an acceptable alternative to the standard approach for patients requiring BiV ICD.

A previous case review conducted by Lopez<sup>5</sup> summarized the safety and efficacy of ICD coil placement in the MCV in six individuals as an alternative to epicardial placement via thoracotomy in patients for whom RV lead placement was not possible. Of the six individuals, four had TV replacement similar to our patients. All patients were deemed to be poor surgical candidates. None of the patients underwent BiV ICD implantation. Five of the six patients in that series received another bipolar lead to do the pace/sense portion instead of using the ICD lead (that was placed in the MCV). Four patients had the lead placed in a lateral coronary sinus branch, and one patient with Epstein anomaly had the lead placed in the atrialized portion of the RV. This was done as a safety precaution since the patient had an indication for ventricular pacing (brady/tachytherapy). Only one patient in that series had no indication for pacing and the same ICD lead was used for sensing with an acceptable threshold. The helix was not extended in the six patients in that series due to concern about perforation and effusion. They used dual-coil leads. We used single-coils ICD and we used it in the sense/pace therapy in our patients and the helix was extended in one patient with no issues. In the first patient, it was felt that extending the helix was not needed. There was a concern for possible pericardial effusion if the helix was extended due to small body habitus (<50 kg) and chronic anticoagulation (double mechanical valve) with no immediate indication for BiV pacing, while we feel it is most likely safe to extend the helix in such patients, that decision needs to be based on a case by case approach. Although dual-coil ICDs were more common until recent years, current data suggest that these are not superior to single coil ICDs. Furthermore, single-lead coils are associated with less complications including risk of lead fracture, removal, and infection, and should be considered before implantation of dual-coil ICDs.<sup>14,15</sup> DFT was successful in our two cases, as well as, all six patients mentioned in the case series by Lopez.<sup>5</sup> Similar results have been noted in prior animal studies and it should be considered that DFT testing to confirm appropriate sensing may be lower than that for the standard RV lead.<sup>16</sup>

Grimard *et al.*<sup>17</sup> described a case of a patient with TV prosthesis and permanent atrial fibrillation requiring intermittent pacing and ICD therapy. A floating coil in the inferior vena cava and a bipolar LV

lead was used. In our cases, we can use a bipolar lead in the septal position (MCV or great cardiac vein), floating coil, and DF1-IS4 system rather than an ICD in the MCV. This can be a helpful approach in patients with small MCVs. It can also provide another option for the septal pacing (i.e. the great cardiac vein) if sensing or pacing thresholds were poor in the MCV. However, it is important to minimize the number of leads in young and smaller patients like our first.

New technologies like subcutaneous ICD and His pacing were successfully used in some patients with TV disease. Subcutaneous ICD placement, which eliminates the need for lead placement across TV, can be ideal alternative for patients with TV disease if they passed the subcutaneous ICD screening, and have no indication for pacing or pacing was achieved with prior epicardial pacemaker or through LV pacing.<sup>18,19</sup> His pacing was done successfully in nine patients with TV ring.<sup>20</sup> While combining such technologies can be an excellent alternative for patients with an indication for BiV ICD they cannot be used in patients similar to ours.

To our knowledge, this is the first report in the literature of BiV ICD implantation with the utilization of that ICD lead placed in the MCV for the pace/sense function. The beneficial long-term outcomes and absence of complications are promising and provide another strategy in similar high-risk patients with no other alternatives.

## Conclusions

In patients with significant TV pathology preventing ICD lead placement in the RV, with indications for BiV ICD and poor surgical candidacy, RV lead placement in the MCV can be an excellent alternative.

**Conflict of interest:** None declared.

## Data availability

Data will be shared on reasonable request to the corresponding author.

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