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Review

Arrhythmia management after device removal

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ABSTRACT

Arrhythmic management is needed after removal of cardiac implantable electronic devices (CIEDs). Patients completely dependent on CIEDs need temporary device back-up until new CIEDs are implanted. Various methods are available for device back-up, and the appropriate management varies among patients. The duration from CIED removal to implantation of a new CIED also differs among patients. Temporary pacing is needed for patients with bradycardia, a wearable cardioverter defibrillator (WCD) or catheter ablation is needed for patients with tachyarrhythmia, and sequential pacing is needed for patients dependent on cardiac resynchronization therapy. The present review focuses on arrhythmic management after CIED removal.

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1. Introduction

Cardiac implantable electronic devices (CIEDs) have become increasingly important in cardiac disease management worldwide. In fact, pacemakers, implantable cardioverter defibrillators (ICDs), and cardiac resynchronization therapy (CRT) have been used and developed since the 1960s. With the increase in the number of patients with CIEDs, the number of the CIED-related complications, including infection, has also been increasing. From 1996 to 2003, the rates of hospitalization for CIED infection reportedly increased faster than the rates of CIED implantation [1]. In patients with CIED infection, complete removal of all hardware, regardless of location (subcutaneous, transvenous, or epicardial), is the recommended treatment [2]. Various tools (traction devices, mechanical sheaths, laser sheaths, electrosurgical sheaths, rotating threaded tip sheath, and telescoping sheaths) and methods (femoral approach, internal jugular approach, and a hybrid method with both, transvenous and surgical methods) have been developed for lead removal, and favorable results have been reported [3,4]. However, data to determine the optimal duration of antimicrobial therapy for CIED infection are limited. Further, data on appropriate management after CIED removal are also not available, although management of arrhythmic support after CIED removal is needed until a new CIED is implanted. In the present review, we focus on arrhythmic management from CIED removal to implantation of a new CIED.

2. Before lead extraction

Before a CIED can be removed, the consequences of removal need to be ascertained. Patients' dependence on pacemakers, the risk of tachyarrhythmia, and requirement of CRT must be determined, and the strategy for antiarrhythmic management should be determined on the basis of these investigations.

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3. Patients completely dependent on pacing

CIED removal is associated with some problems. Therefore, whether the patient definitely needs a new CIED needs to be determined first. Second, until the new CIED is implanted, temporary pacing should be set up, especially in patients completely dependent on a pacemaker, using tools such as passive fixation leads, active fixation leads, and epicardial leads.

In their prospective, controlled study, Braun et al. [5] reported that transvenous pacing with active fixation is safe and is associated with a significantly lower rate of pacing-related adverse events than the standard technique of transvenous pacing using a passive external pacing catheter. Forty-nine patients with systemic infection and hemodynamic-relevant bradyarrhythmia were temporarily paced using either a conventional pacing wire/catheter ($n=26$, reference group) or a permanent bipolar active pacing lead, which was placed transcutaneously in the right ventricle and connected to an external pacing generator ($n=23$, external lead group). The sensing values in the two groups were almost identical, but the median pacing threshold was significantly higher in the reference group (1.0 V vs. 0.6 V, $P<0.05$). Within comparable durations of pacing (median: 8.2 vs. 7.7 days), there were 24 pacing-related adverse events (including dislocation, resuscitation due to severe bradycardia, and local infection) in the reference group but only one in the external lead group ($P<0.01$). None of these complications resulted in cardiac death. The reference group showed very high complication rates, mainly lead dislocation. Active fixation of temporary leads was only introduced in Japan in 2013. Moreover, a 2-week gap is generally observed between CIED removal and new CIED implantation in patients with pocket infection and a 4–6-week gap in patients with systemic infection. Patients with passively fixed temporary leads have a high risk of complications. Therefore, especially in patients completely dependent on pacing, permanent active fixation of leads permitting bipolar stimulation has been used for temporary pacing (Fig. 1). Recently, temporary active fixation of leads became available in Japan (Fig. 2) (TUA, OSYPKA AG, Germany).

Epicardial leads are feasible for cases in which open chest surgery is required. These leads carry a very low risk of percutaneous infection and lead dysfunction for a couple of weeks.

No clinical trial data are available for determining the optimal duration of antimicrobial therapy for CIED infection. However, therapy for 10–14 days after device removal is considered reasonable when CIED infection is limited to the pocket site, while at least 2–4 weeks of parenteral therapy after extraction of the infected device is recommended for patients with bloodstream infection [6].

Only one study has reported simultaneous contralateral (side-to-side) replacement of an infected CIED [7]. A one-stage exchange was performed in 68 consecutive patients over a 14-year period by a single cardiologist, and dual-chamber devices were used in two-thirds of these patients. Clinical presentations included device erosion (41%), cellulitis or abscess (35%), and endocarditis (24%). Fifty-nine patients (87%) were followed up for more than 1 year, and 9 patients were lost to follow-up at 1–10 months after the one-stage contralateral device exchange, with no newly identified CIED infections. Additional experience with one-stage contralateral device exchange is needed before it can be recommended for routine use.

The duration between CIED removal and re-implantation may vary among cases. We encountered two cases of early re-implantation. In the first case, the patient had CIED infection on both sides, and open chest surgery was needed to remove all CIEDs. An epicardial system was simultaneously implanted when the CIEDs were removed (Fig. 3). No re-infection was noted in the 2–year follow-up period. In the other case, early re-implantation was performed because the patient experienced dementia and restlessness 3 days after CIED removal. In this case as well, no re-infection was noted in the 2-year follow-up period.

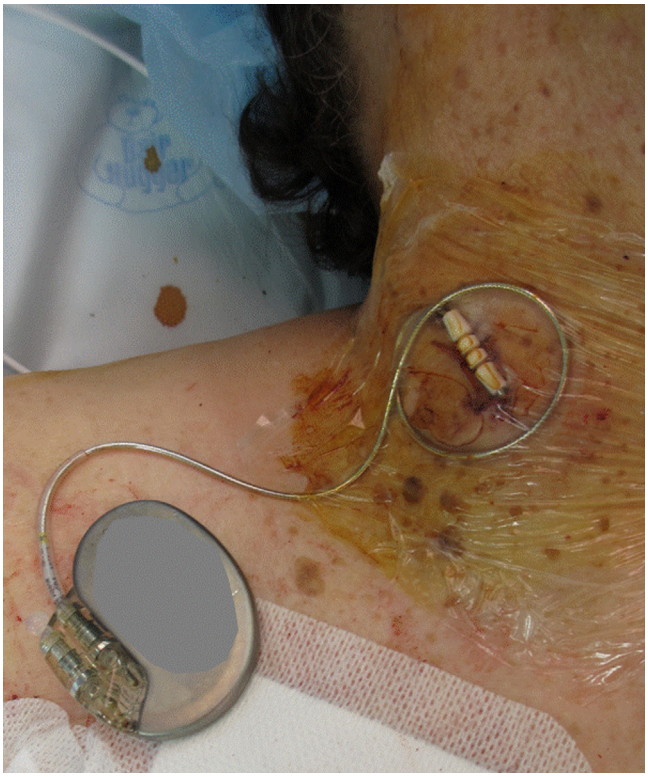

Fig. 1. Temporary pacing using a permanent active fixation lead. A permanent active fixation pacemaker lead was implanted. The electrode was connected to a generator.

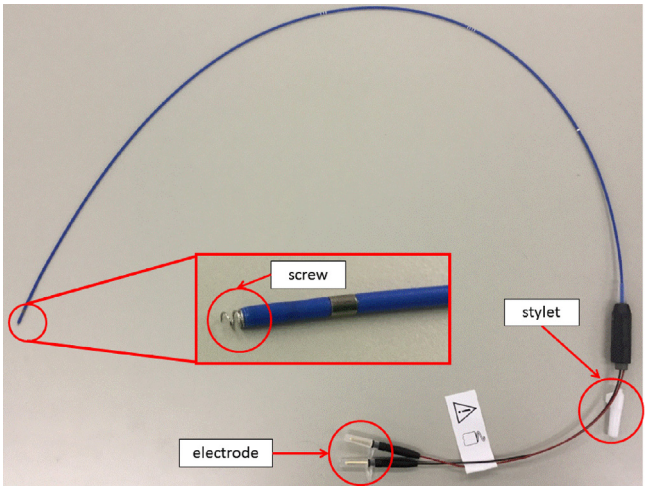

Fig. 2. Temporary active fixation lead.

4. Patients with high risk of tachyarrhythmia

Patients with high-energy CIEDs are more likely to develop an infection than patients with a pacemaker [6]. Patients with a high risk of tachyarrhythmia should be temporarily managed using tools such as wearable cardioverter defibrillators (WCDs) and catheter ablation.

Healy et al. [8] reported on the cost effectiveness of using WCDs (Fig. 4) during the waiting period after infected CIED removal. The

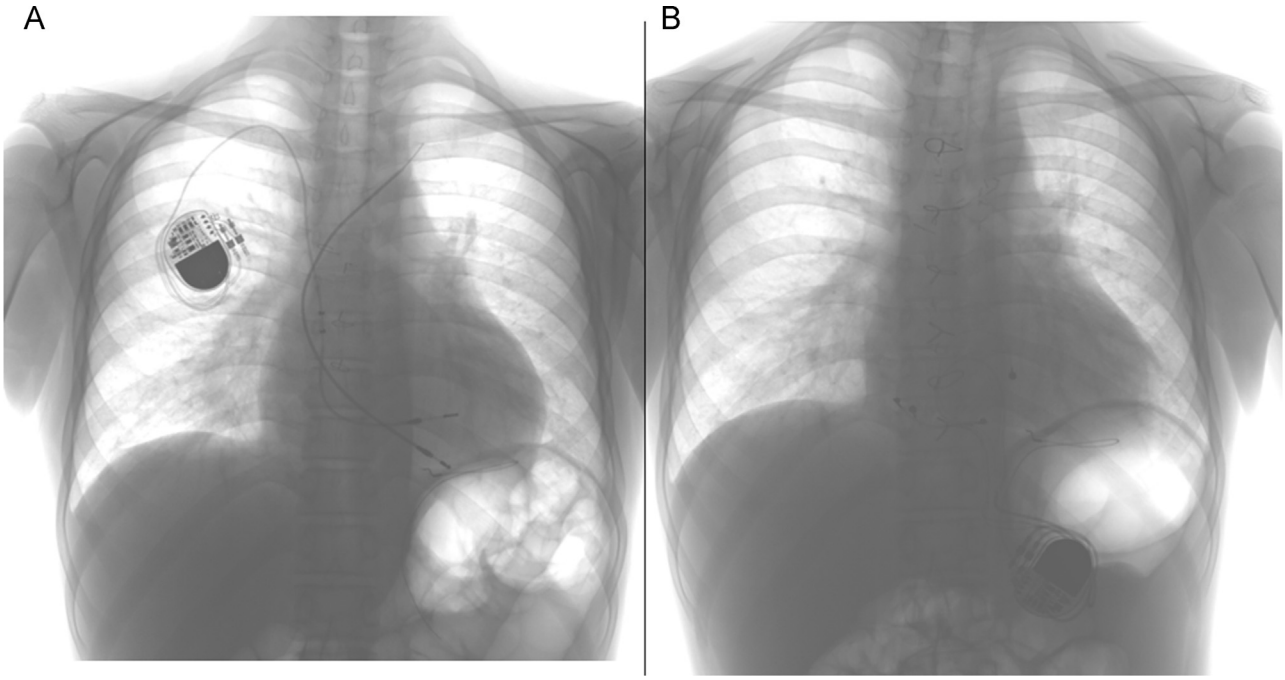

Fig. 3. Epicardial lead implantation. (A) Before removal of the CIED. (B) A new pacemaker with an epicardial lead was simultaneously implanted during open chest surgery for removal of the infected pacemaker.

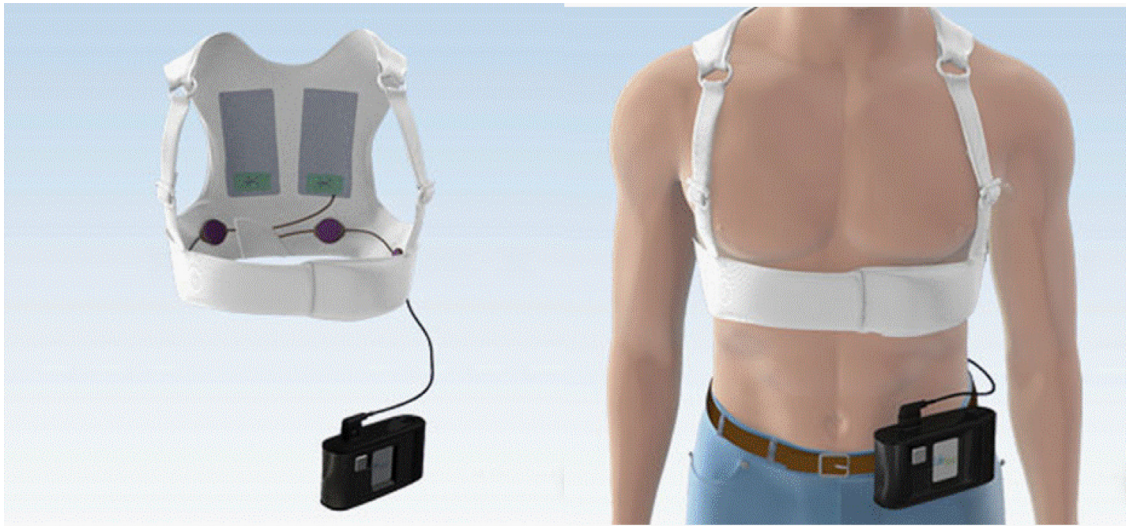

Fig. 4. Wearable cardioverter defibrillator.

incremental cost effectiveness of WCDs was $20,300 per life-year or $26,436 per quality-adjusted life-year (QALY) as compared to discharge to home without a WCD. Discharge to a skilled nursing facility and in-hospital monitoring resulted in higher costs and poorer clinical outcomes. The incremental cost-effectiveness ratio was as low as $15,392/QALY if the WCDs successfully terminated 95% of sudden cardiac arrest (SCA) events and exceeded the $50,000/QALY willingness-to-pay threshold if their efficacy was $<69\%$. Use of WCDs remained cost effective, assuming a 2-month SCA risk of 5.6%, as long as the time to reimplantation was at least 2 weeks.

Tanawuttiwat et al. [9] conducted a retrospective study on all WCD patients who underwent ICD removal because of cardiac device infections at two referral centers. Ninety-seven patients were included in their study. The median duration of antibiotic use was 14.7 days. The median daily WCD use was 20 h/day and the median duration of use was 21 days. A total of three patients received WCD shocks. Two patients had four episodes of sustained ventricular tachycardia (VT), which were successfully terminated by the WCD. A third patient received two inappropriate treatments because of oversensitivity of the signal artifact. Three patients experienced sudden death outside the hospital while not wearing the device. Five patients died while hospitalized. This previous study concluded that the WCD can prevent sudden cardiac death until ICD reimplantation is possible in patients from whom the CIED has been removed because of CIED infection. In Japan, because most patients with CIED infection are not discharged until a new CIED is implanted and are monitored by a telemetry device, the rate of sudden death during the waiting period is low. However, WCD seems to be safer than only monitoring, even when the patients are hospitalized.

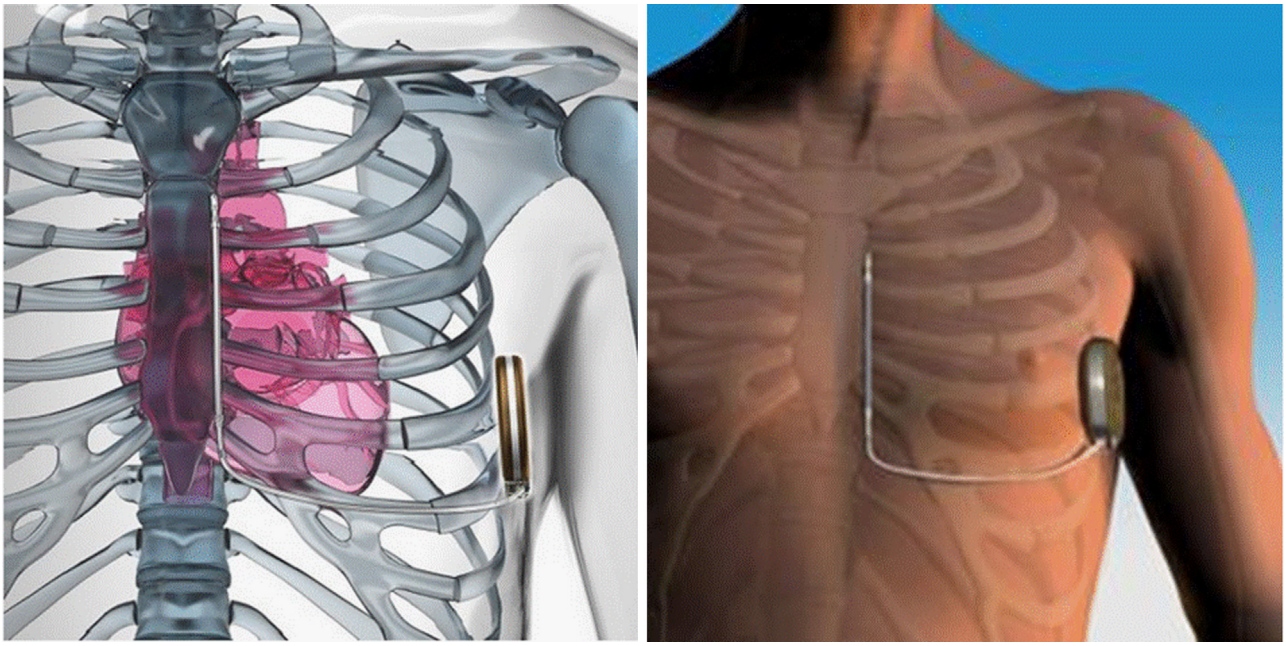

Fig. 5. Totally subcutaneous implantable cardioverter defibrillator.

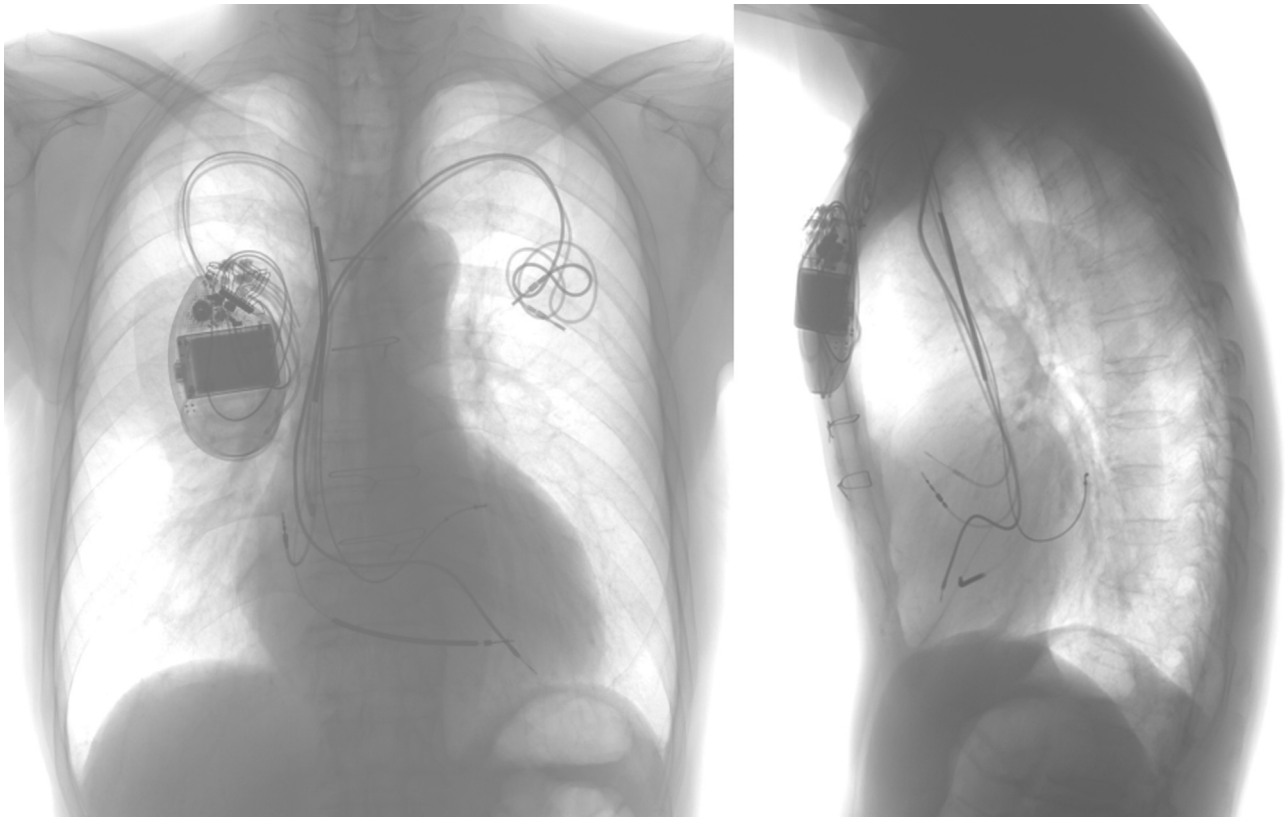

Fig. 6. Before removal of the CIED. The old pacemaker leads were implanted from left side, and a new CRT-D was implanted from the right.

Total subcutaneous implantable cardioverter defibrillators (S-ICDs) (Fig. 5) are reportedly as safe and effective as transvenous ICD systems [10]. S-ICDs are beneficial because they carry no risk of vascular injury, have a low risk of systemic infection, and have no need for fluoroscopy. Although S-ICDs are not a temporary system, they may be suitable for early reimplantation in patients at a high risk of tachyarrhythmia.

We encountered one case of successful ablation before removal of an infected CRT-D. The patient was a 72-year-old woman with complete AV block, sustained VT, and cardiac sarcoidosis. The VT was controlled using amiodarone and pilsicainide, but a VT storm occurred after pilsicainide was withdrawn. Because the LV ejection fraction was less than 30%, ablation was attempted before pilsicainide was restarted. The VT was finally eliminated

by catheter ablation, and it did not recur after implantation of a new CIED. Thus, catheter ablation may be another useful method for managing tachyarrhythmia during the waiting period.

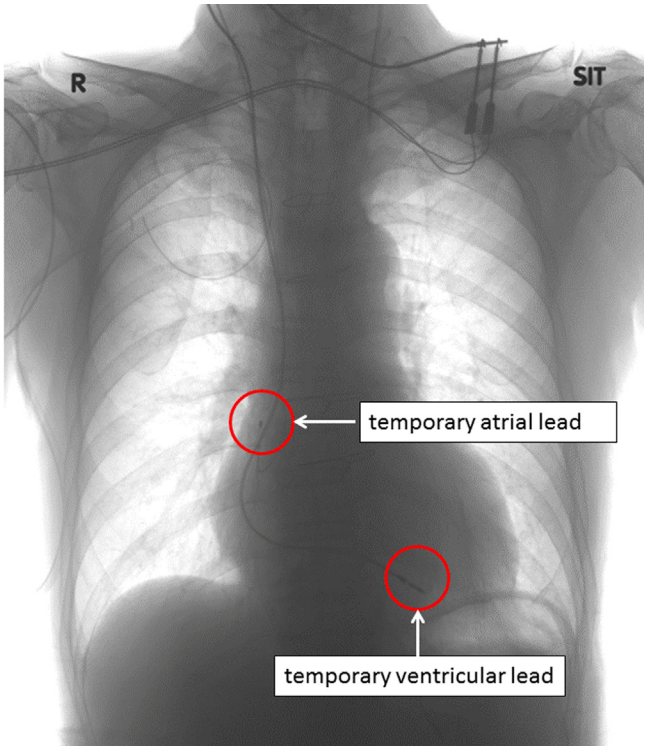

Fig. 7. Temporary DDD pacing. Temporary atrial and ventricular leads were implanted from the right jugular vein.

5. Patients dependent on CRT

In patients dependent on CRT, it is very difficult to maintain hemodynamics by using temporary VVI pacing after CIED removal. To our knowledge, no study has reported temporary CRT pacing until new CIED implantation.

We encountered two cases in which temporary sequential pacing was used during the waiting period. The first was that of a 77-year-old man who suffered from a complete AV block, sustained VT, and cardiac sarcoidosis. His pacemaker was upgraded to CRT-D (Fig. 6), and pocket infection occurred 3 years later. However, the patient was pacing dependent and responded to CRT. Before lead extraction, a hemodynamic test was performed. VVI pacing instead of CRT aggravated the hemodynamic state (cardiac index [CI] = 2.27 L min^{-1} m^{-2} in DDD with BiV pacing; 1.76 L min^{-1} m^{-2} in VVI with RV pacing). After lead extraction, temporary DDD pacing was used (Fig. 7) with intravenous catecholamine infusion. The hemodynamic state was maintained for 2 weeks, and a new CRT-D was successfully implanted after the infection disappeared. The other case was that of a 72-year-old woman with complete AV block, sustained VT, and cardiac sarcoidosis. Her pacemaker was upgraded to CRT-D at the time of mitral valve replacement, and the LV lead was an epicardial lead (Fig. 8). The patient contracted a pocket infection 4 years after CRT-D implantation. A hemodynamic test was performed before lead removal. VVI pacing instead of CRT aggravated the hemodynamic state (CI = 1.95 L min^{-1} m^{-2} in DDD with BiV pacing; 1.74 L min^{-1} m^{-2} in DDD with only RV pacing; 1.45 L min^{-1} m^{-2} in VVI with RV pacing). The lateral chest wall was opened to remove the LV epicardial lead, but because of adhesion of the left lung, the LV lead was only partially removed. Temporary epicardial atrial and LV leads were implanted. A temporary RV lead (with a permanent active fixation lead) was also implanted from the right jugular vein. DDD with Biventricular pacing could be delivered from the three leads (Fig. 9). The hemodynamic state was maintained for 2 weeks, and a new CRT-D was successfully

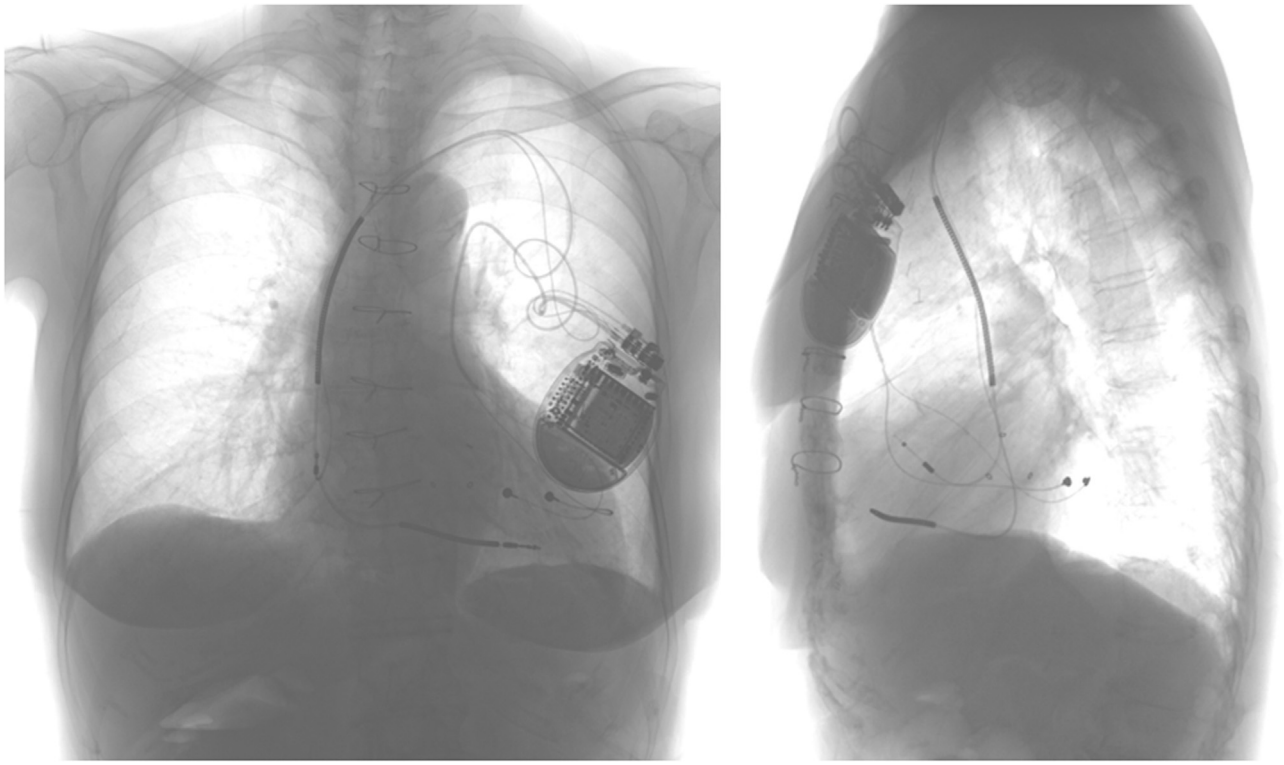

Fig. 8. Before removal of the CIED. Atrial and ICD leads were implanted transvenously. A left ventricular epicardial lead was implanted during open heart surgery.

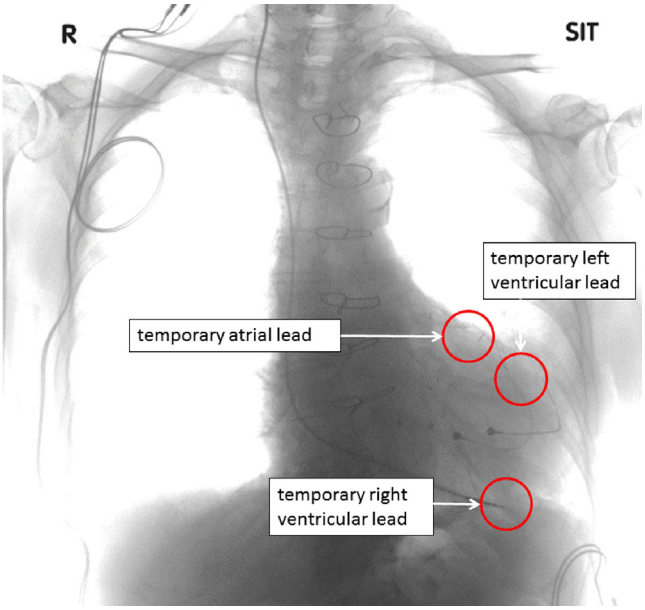

Fig. 9. Temporary DDD with biventricular pacing. Temporary epicardial atrial and left ventricular leads were implanted, while a temporary right ventricular lead was implanted transvenously.

implanted after infection disappeared. We have never used a temporary transvenous LV lead, which may be required in some cases.

6. Summary

Various methods can be used for arrhythmic management during the waiting period before new CIED implantation. The aim should be to use an appropriate method to prevent the occurrence of arrhythmic events.

Conflict of interest

The author declares no conflict of interest related to this study.

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