Combining an subcutaneous ICD and a pacemaker with abdominal device location and bipolar epicardial left ventricular lead: first-in-man approach

Christopher Gemein[1]*, Morsi Haj[2], and Jörn Schmitt[1]

[1]Medizinische Klinik I, Kardiologie und Angiologie, Universitätsklinikum der Justus-Liebig-Universität Giessen, Giessen, Germany and [2]Klinik für Herz-, Kinderherz- und Gefäßchirurgie, Universitätsklinikum der Justus-Liebig-Universität Giessen, Giessen, Germany

* Corresponding author. Tel: +49 641 985 42101; fax: +49 641 985 42109. *E-mail address*: christopher.gemein@innere.med.uni-giessen.de

Introduction

ICD therapy is established for patients as primary or secondary prophylaxis of sudden cardiac death (SCD). Some patients may also present bradycardia and therefore are in need for additional pacing. However, patients with device infections or subclavian vein occlusion might not be eligible for transvenous lead placement.

Case report

We describe the case of a 78-year-old man with survived SCD, ischaemic cardiomyopathy, and secondary prophylactic two-chamber ICD implantation in 1998. Between 1998 and 2008, the patient needed several lead and device replacements/revisions via both the right and left subclavian veins due to right ventricular (RV) lead malfunction, device infections, and battery depletions. Over time, RV pacing requirement increased to 100% due to complete atrio-ventricular (AV) block without escape rhythm while permanent atrial fibrillation emerged and ejection fraction decreased to 35%. In 2014, the patient was admitted to hospital with inadequate ICD shocks due to RV lead fracture causing noise in the sensing circuit of the lead and also an increase in shock impedance. Transvenous lead explantation was

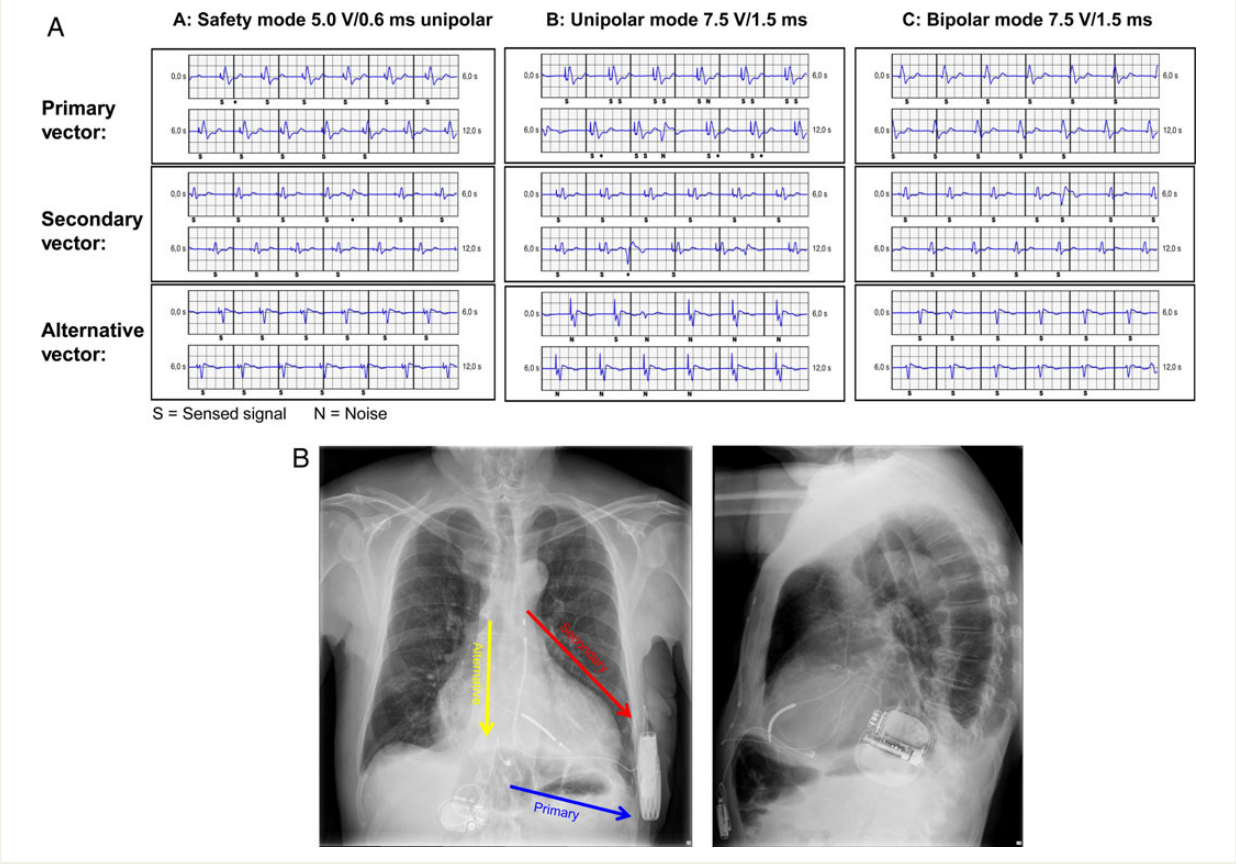

Figure 1 (*A*) IEGM recordings of the three possible S-ICD vectors in combination with either pacing in the pacemaker's safety mode (5.0 V/0.6 ms; unipolar) and unipolar or bipolar pacing with maximum output (7.5 V/1.5 ms). Note the pacing artefacts recorded during unipolar pacing with maximum output in two of the three possible vectors, while no artefacts were seen under the other pacing conditions. (*B*) Fluoroscopic image of the patient's chest after VVI pacemaker and S-ICD placement in anteriorposterior and lateral views.

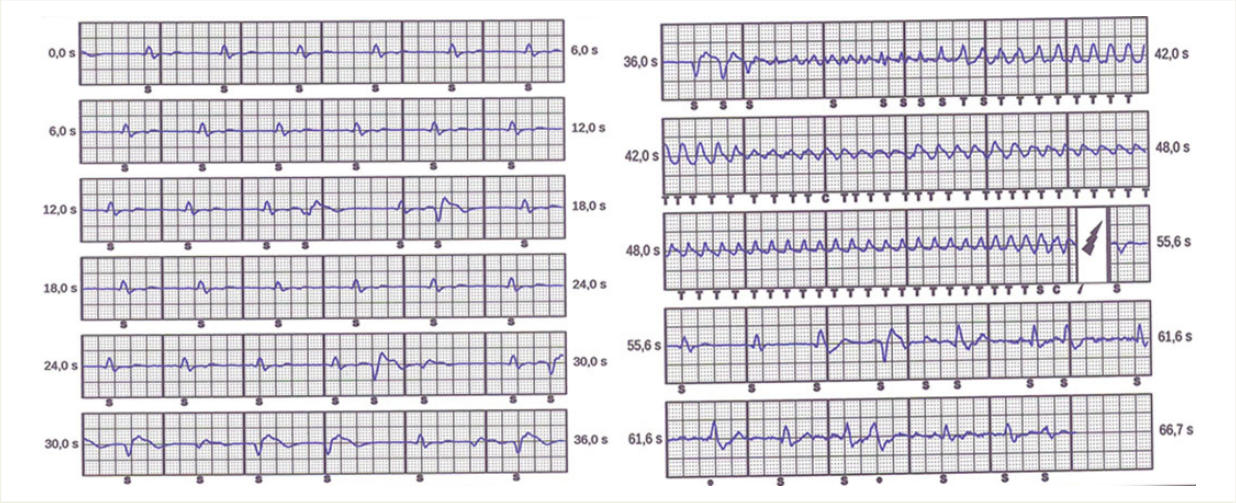

Figure 2 Subcutaneous ICD tracings of the VF episode which was adequately detected and terminated by the S-ICD while the episode was not sensed by the VVI pacemaker and bipolar stimulation was continued. Of note, bipolar epimyocardial pacing does not evoke significant pacing artefacts neither during paced rhythm nor during ongoing VF.

not successful. After removing the lead from the surrounding venous tissue by an extraction device (Cook Medical, Evolution Shortie), the RV lead disrupted proximally during retraction and another transvenous approach was not possible due to venous occlusion. In this SCD secondary prophylactic pacemaker-dependent patient, an subcutaneous ICD (S-ICD) with parasternal placed subcutaneous shock lead but without pacing ability was implanted in combination with an abdominally positioned epicardial (bipolar on left ventricle) pacemaker. First, the implantation of the epicardial lead was performed from a subxiphoidal approach. After having stable pacing conditions for several days, implantation of the S-ICD was done in a second procedure. Placement of both leads in anatomical neighbourhood was feasible without lead contact or damage (*Figure 1B*, anterior–posterior and lateral views). However, our main concern in combining the two devices was oversensing of pacing artefacts by the S-ICD or undersensing/inhibition because of concomitant pacing during ventricular tachycardia/ventricular fibrillation (VF) by the S-ICD and thus withholding shock therapy. In the chosen pacemaker and S-ICD lead positions, no interaction or oversense of potential pacemaker artefacts between the S-ICD detection algorithm and bipolar pacing with maximum output (7.5 V/1.5 ms) was observed as no bipolar pacing artefacts were detected. Unipolar pacing with maximum output evoked noise in two of three possible S-ICD detection vectors, while no interaction was observed using the safety programme of the chosen pacemaker (unipolar stimulation at 5 V/0.6 ms in VVI mode) (*Figure 1A*). Defibrillation threshold tests were performed with adequate detection and termination of induced VF by the S-ICD, while no interaction with the implanted pacemaker which also detected the induced VF episodes or switching to the pacemaker's unipolar safety mode after S-ICD shock delivery occurred.

In July 2015, regular device interrogation revealed a VF episode, which was adequately detected and terminated by the S-ICD, while the episode was not sensed and displayed in the device storage by the VVI pacemaker. Undersensing of the VF episode by the pacemaker in contrast to the induced episodes during defibrillation threshold testing might be caused by the initially programmed algorithm for automatic sensitivity adjustment. As a consequence, a fixed pacemaker sensitivity was programmed after this episode. However, the undersensing of this VF episode and missing of unipolar pacing artefacts in the S-ICD tracings during the VF episode (*Figure 2*) implicate that bipolar stimulation must have been continued. Of note, bipolar epimyocardial pacing does not evoke significant pacing artefacts in the S-ICD tracings in this pacemaker-dependent patient without escape rhythm during ongoing VF as well as initially shown for paced rhythm during cross testing of both devices (compare *Figure 1A*). By that, it could be demonstrated in a spontaneous VF episode that bipolar pacing due to pacemaker undersensing at ongoing VF did not affect the sensing capabilities of the S-ICD in our specific case.

Discussion

Most of these patients with ICD and pacing indication can be provided with common transvenous systems.[1] They have the advantage that pacing and defibrillation functions are combined in one device, and the underlying algorithms work together without any disturbing influence. However, in cases with venous obstruction or in patients with prosthetic tricuspid valves, there is a lack of established alternatives. During the past few years, the S-ICD has found its way into routine clinical practice, but this device does not have any pacing opportunities. The main concern in combining S-ICD systems and pacemakers is oversensing of pacing artefacts leading to inappropriate shocks or undersensing of a VF episode at ongoing pacemaker stimulation and therefore withholding shock therapy. Kuschyk *el al.*[2] are the first to describe the combination of an S-ICD with other implantable electronic devices like pacemakers and devices for cardiac contractility modulation or vagus nerve stimulation. After cross testing and careful device programming, no inappropriate shocks were reported during a mean follow-up period of up to 17 months. In the present case also a careful cross

testing was performed even during induced VF. In this context, it is essential to find an adequate device programming enabling high reliability at the lowest risk for device interactions. Therefore, it may also be necessary to test various lead positions and change detection vectors of the S-ICD to avoid oversensing. In addition, it could be demonstrated in this specific case that even ongoing bipolar stimulation does not affect the sensing algorithm of the S-ICD. Nevertheless, long-term data in such patients are lacking, and thus this approach still remains experimental.

Conclusion

Combination of an S-ICD and a pacemaker with bipolar leads is feasible and may be an option for patients in need for ventricular pacemaker stimulation and ICD therapy with contraindication for transvenous lead placement. Nevertheless, long-term and prospective randomized data in such patients are lacking, and this approach should be limited to patients without any other reliable option.

Conflict of interest: none declared.

References

1. Tracy CM, Epstein AE, Darbar D, Dimarco JP, Dunbar SD, Estes NA 3rd *et al.* 2012 ACCF/AHA/HRS Focused Update of the 2008 Guidelines for Device-Based Therapy of Cardiac Rhythm Abnormalities: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines. *J Am Coll Cardiol* 2012;**60**:1297–313.
2. Kuschyk J, Stach K, Tülümen E, Rudic B, Liebe V, Schimpf R *et al.* Subcutaneous implantable cardioverter-defibrillator: first single-center experience with other cardiac implantable electronic devices. *Heart Rhythm* 2015;**12**:2230–8.