Use of a defibrillation coil in the coronary sinus to reduce ventricular defibrillation threshold

SUJATHA KESAVAN, MICHAEL A JAMES

Introduction

Although the majority of implantable cardioverter defibrillator (ICD) implants occur without complication, high defibrillation threshold (DFT) can occasionally be a problem. The usual resolution to this problem is to include a subcutaneous electrode in the defibrillation circuit.[1] Use of the subcutaneous array, however, is unpopular as extensive subcutaneous dissection is time-consuming, uncomfortable for the patient and provides another focus for infection.[1,2] We report the use of the coronary sinus for the placement of a second defibrillation shock coil in a patient with an unacceptably high DFT, which was successfully reduced.

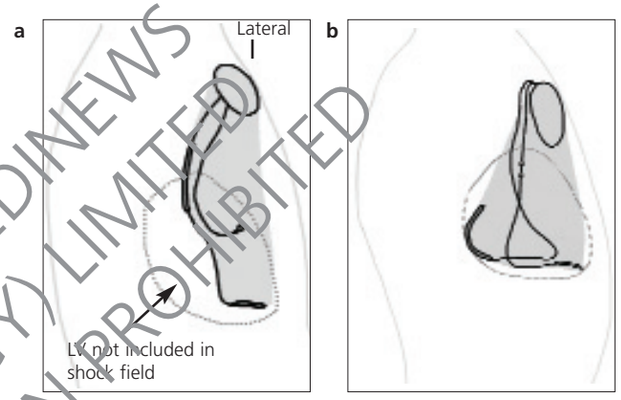
Br J Cardiol 2007;**14**:111–15

Analysis of the shock vectors involved in a standard ICD implant make it surprising that the procedure is so successful so often (figure 1a). In a standard implant, all the shocking electrodes are distributed in a very anterior plane and energy is not specifically directed either posteriorly or laterally, which means that the left ventricle is relatively protected from the defibrillation shock – the opposite to what is wanted. Theoretically, by positioning one of the shock coils in the coronary sinus, the shock field would be drawn posteriorly through the left ventricular (LV) septum and incorporate a much larger proportion of the left ventricle (figure 1b).

This approach was first considered over 10 years ago and sporadic cases have been reported.[3,4] Yet, despite the good results obtained, it appears to remain an unrecognised management option and, surprisingly, the idea seems to have fallen into disuse. This may have been due to concerns over the long-term safety of defibrillation coils in the coronary sinus but now the safety of long-term placement of shock coils in the coronary sinus is well established from atrial cardioversion devices,[5] this approach seems more feasible. It could be argued that atrial defibrillation does not prove the safety of ventricular defibrillation because the energy delivered for atrial cardioversion is often much lower but this is not always the case. It is often necessary to use high-energy shocks (30 J) to achieve atrial cardioversion and the limited autopsy reports from cases with chronically implanted ventricular defibrillation coils in the coronary sinus have also failed to find any evidence of harm.[6]

Department of Cardiology, Taunton & Somerset Hospital, Musgrove Park, Taunton, Somerset, TA1 5DA.
Sujatha Kesavan, Research Fellow/Honorary Lecturer in Cardiology
Michael Antony James, Consultant Cardiologist
Correspondence to: Dr M James
(E-mail: Michael.james@tst.nhs.uk)

Figure 1. Diagrammatic representation of an ICD implant configuration (lateral view), showing **a**: a standard ICD implant configuration compared with **b**: the modified coronary sinus configuration and the wider inclusion of the entire myocardium, especially the left ventricle (LV), in the shock field



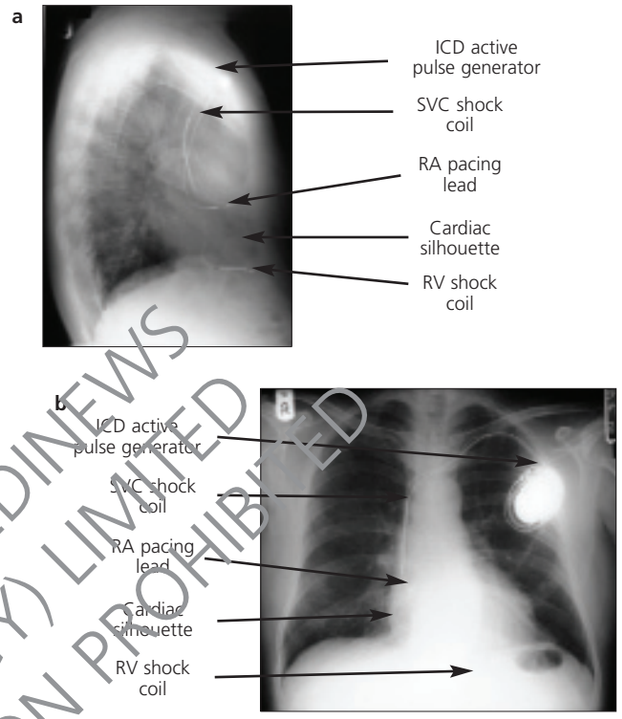
Case report

A 75-year-old woman presented with a spontaneous episode of syncopal ventricular tachycardia (VT). She had a long history of hypertension and had presented to another hospital three months previously with an episode of atrial flutter. On this occasion she suffered a sudden syncopal episode without prior symptoms. An ambulance was called and she was found semi-conscious in VT. She was cardioverted by the ambulance crew and brought to our hospital. There were no evident reversible causes for her arrhythmia. There were no acute ECG changes on admission, she was not receiving any pro-arrhythmic drugs and her electrolytes were normal. Her troponin I level was marginally elevated at 0.1 µg/L (normal < 0.03), which was felt to be consistent with her VT arrest. Her chest X-ray demonstrated cardiomegaly. Further investigation by echocardiography revealed poor LV function and significant mitral regurgitation due to a prolapsed anterior mitral valve leaflet. Coronary

angiography was performed, which confirmed poor LV function with moderate mitral regurgitation and significant left main stem disease. She was referred for urgent coronary artery bypass grafting and mitral valve repair. VT stimulation was performed three weeks after surgery, which confirmed persistent inducible VT. We proceeded to an ICD implant but, unfortunately, the first attempt was abandoned due to near total occlusion of her left brachiocephalic vein. A repeat procedure was planned from the right-sided approach.

The difficulties on the left side led us to implant a VDD ICD system to minimise the number of electrodes required. A Biotronik Kainox® ICD lead with a Deikos ICD generator was implanted. The system comprises a single pass electrode with a right ventricular (RV) pace/sense tip and ring poles, RV shock coil and two floating right atrial (RA) electrodes on the body of the lead for RA sensing, all incorporated into a single lead. The device provides four times amplification of the RA signal for better sensing, which has been demonstrated to work effectively.[7] The system is also capable of accepting a separate superior vena cava (SVC) shock coil, if required, to improve DFT. Excellent pacing characteristics were obtained with a ventricular threshold of 0.3 V, an R wave of 16 mV and an augmented A wave of 2.6–3.4 mV. Despite this, the DFT was not satisfactory and defibrillation failed in both normal and reversed polarity modes, at 25 J (maximum output of device 30 J). An SVC electrode was not helpful but rather than resorting to a subcutaneous array, we decided to try positioning the SVC coil in the coronary sinus. This proved immediately successful, with a reduction in the DFT to < 10 J.

Figure 2. Chest X rays, **a**: lateral and **b**: PA projection, from a patient with a standard ICD implant configuration. This shows how all active shock elements of the device are situated anteriorly in the chest, with no energy delivered in a postero-lateral direction



Key: ICD = implantable cardioverter defibrillator; SVC = superior vena cava; RA = right atrium; RV = right ventricle

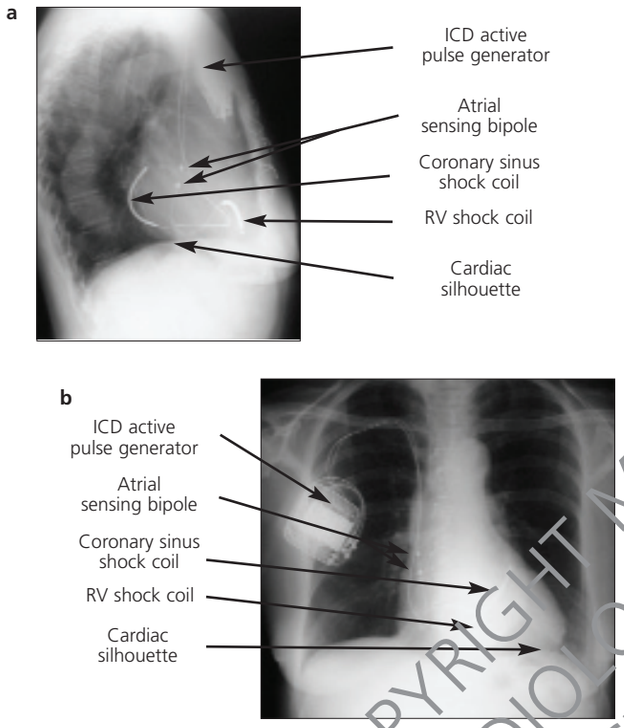
Discussion

Right-sided implants are always a concern because, intuitively, the active can is in the wrong place and the shock field is directed even further away from the left ventricle than usual. As a result, it has been reported that defibrillation thresholds can be higher in right-sided implants.[8] None-the-less, successful right-sided implants have been reported[9] and experience has demonstrated that the SVC coil adds very little to the success of the implant since the SVC electrode is right in the line of the can to the right ventricular coil vector.[10] The lack of efficacy in positioning a shock coil in the SVC makes it sensible to seek an alternative site for its placement, and the coronary sinus is easily accessible during a standard implant. It is commonly cannulated for LV pacing and experience has shown that it is usually easy to cannulate the coronary sinus itself (if not the LV veins). This adds little to the procedure time – in this case, cannulation of the sinus took no more than five minutes and added less than 90 seconds to fluoroscopy time. Although we did not have a dedicated CS coil available on the day, dedicated coronary sinus shock coils are available with an active fixation mechanism that has been demonstrated to provide good long-term stability,[5] which makes this approach even more attractive. In this case we had to redeploy the SVC shock coil to the coronary sinus, which demonstrates that, in an emergency, when a dedicated coil is not available this does not need to prevent the use of the coronary sinus. In this particular patient, the coil has been stable for over two years.

Although high DFT is not a common problem, it is not infrequent and can occur for a variety of reasons. Anti-arrhythmic drug therapy can be a cause for high DFT although that was not the case in this patient, as she was not receiving any anti-arrhythmic drugs apart from bisoprolol. In this case it was almost certainly the right-sided implant that led to the problem. The successful use of the coronary sinus for delivery of defibrillation energy to the ventricle demonstrates that it is a feasible approach to the problem of high DFT.

Other strategies for the management of high DFT, such as higher output devices or alteration in shock waveforms, all have their own drawbacks and we do not believe they are as attractive as the use of the coronary sinus. An intrinsic advantage of the coronary sinus approach is that it does actually reduce DFT, whereas a high output device commits the patient to long-term high-energy shocks with consequent effects for the patient and reduced battery life. In addition, high output devices are more expensive, bulkier to implant, and unlikely to

Figure 3. Chest X-rays, **a**: lateral and **b**: PA projection, from our patient showing a modified ICD implant configuration with a coronary sinus shock coil. The ICD is implanted on the right hand side of the chest with a shock coil in the coronary sinus. Unusually, a VDD pacing system has been employed so an atrial bipole is demonstrated rather than a separate atrial pacing lead



Key: ICD = implantable cardioverter defibrillator; RV = right ventricle

be available at the required time unless it is known in advance that DFT is going to be high. In contrast, it is much easier to carry a spare defibrillation coil 'on the shelf' in case it is needed. Programmable waveforms are available in some devices but not all companies deploy these techniques as their advantage is not proven and they do not always work, in the same way that, in this case, reversal of the shock polarity had no effect at all.

The use of the coronary sinus has logical advantages for any ICD implant. Placing a coil in the coronary sinus considerably improves the distribution of the shocking field, as demonstrated in figures 1–3, and the success of this approach demonstrates that it is not just a theoretical consideration. Although experience remains very limited, there is now accumulating evidence of a substantial benefit in DFT without long-term harm from this approach, which is not widely appreciated. We believe it is time to focus attention on the coronary sinus as a potential site for lead implantation. We would suggest that the use of the coronary sinus should always be considered when problems of high DFT present.

Although this case report concerned the use of a VDD ICD system and the particular problem of a right-sided implant, it is important to emphasise that neither a right-sided implant nor a VDD system is necessary to the success of this strategy to reduce DFT. However, the use of a VDD system is worthy of comment. Single chamber ICD systems remain quite popular because of their ease of implant and the avoidance of problems with the atrial lead, such as displacement. A single pass VDD lead retains the simplicity of a single pass electrode but offers the additional advantage of atrial sensing both for VT discrimination and physiological pacing. The atrial signal amplification system built into this device improves the likelihood of obtaining satisfactory atrial signals but, if atrial sensing proves inadequate at implant, a separate atrial lead can be added to the device.

Conflict of interest

None declared.

References

1. Trusty JA, Hayes DL, Stanton MS, Friedman PA. Factors affecting the frequency of subcutaneous lead usage in Implantable Defibrillators. *PACE* 2000;**23**:842-6.
2. Korte T, Jung W, Spehl S *et al*. Incidence of ICD lead related complications during long-term follow up. *PACE* 1995;**18**:2053-61.
3. Bardy GH, Allen RM, Johnson G, Feldman S, Greene HL, Ivey TD. Transvenous defibrillation in humans via the coronary sinus. *Circulation* 1990;**81**:1252-9.
4. Vlay SC, Bilfinger TV, Levy M, Chitkara V. Alternative locations for internal defibrillator electrodes. *PACE* 1998;**21**:1309-12.
5. Data on file. Guidant Corporation, 4100 Hamline Avenue North, St Paul, MN, USA.
6. Jones GK, Swerdlow C, Reichenbach DD *et al*. Anatomical findings in patients having had a chronically indwelling coronary sinus defibrillation lead. *PACE* 1995;**18**:2062-7.
7. Niehaus M, de Sousa M, Klein G *et al*. Chronic experiences with a single lead dual chamber implantable cardioverter defibrillator system. *Pacing Clin Electrophysiol* 2003;**10**:1937-43.
8. Friedman PA, Rasmussen MJ, Grice S, Trusty J, Glikson M, Stanton M. Defibrillation thresholds are increased by right-sided implantation of totally transvenous implantable cardioverter defibrillators. *PACE* 1999; **22**:1186-92.
9. Flaker G, Tummala R, Wilson J. Comparison of right and left-sided pectoral implantation parameters with the Jewel active can cardiodefibrillator. *PACE* 1998;**21**:447-51.
10. Personal communication. Biotronik UK, Biotronik House, Avonbury Business Park, Bicester, OX26 2UA.