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CASE REPORT
Electrophysiology

Isolated subcutaneous implantable cardioverter-defibrillator generator displacement causing inappropriate shocks despite preserved lead tip and coil position: a case report

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Background Subcutaneous implantable cardioverter-defibrillators (S-ICDs) are increasingly used in patients without a pacing indication, and may reduce venous complications, endocarditis and extraction morbidity. Subcutaneous implantable cardioverter-defibrillator displacements may be less obvious than their transvenous counterparts.

Case summary A 59-year-old man was found to have dilated cardiomyopathy associated with heavy alcohol intake following investigation for a stroke. Despite 2 years of alcohol cessation and optimal drug therapy, his ejection fraction remained severely impaired, and he received an S-ICD using the manufacturer recommended screening and implant method, and by an experienced operator. Ten months later, inappropriate shocks were delivered despite optimal programming. Device displacement was demonstrated by lateral chest radiography on the second instance of inappropriate therapy. On the first admission, a lateral film was not performed, and simple device programming was undertaken which failed to prevent the second occurrence. The patient requested an explant; as ventricular function had improved following initiation of sacubutril/valsartan, the clinical team opted to remove the device.

Discussion Careful inspection of lateral chest films and review of device indication are needed to reduce the risk of inappropriate shocks. This is the first description of inappropriate device activity following lone generator displacement—lead displacement is well described.

Keywords Implantable cardioverter-defibrillator • Dilated cardiomyopathy • Primary prevention • Inappropriate shock • Radiography • Case report

ESC Curriculum 8.5 Primary prevention • 5.10 Implantable cardioverter-defibrillators

Learning points

- To know that displacement of any implantable cardiac device component can lead to malfunction and understand that standard antero-posterior chest radiography may be insufficient to assess device position.
- To recognize that patient attitudes and indications for implantable cardioverter-defibrillator therapy are dynamic and should be reassessed at clinically significant junctures in a patient journey.

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Introduction

Subcutaneous implantable cardioverter-defibrillators (S-ICDs) are a growing technology in patients at risk of sudden arrhythmic death but without a pacing indication. The lack of transvenous leads reduces the risk of future access problems, device-related endocarditis and extraction complications.[1] Like transvenous devices, performance can be affected by displacement but clinicians may be less attuned to important generator position changes than more appreciated lead displacements. This case report highlights the importance of careful chest radiograph interpretation especially of the lateral film.

Timeline

Time	Event
Presentation	Diagnosis with dilated cardiomyopathy
24 months	Subcutaneous implantable cardioverter-defibrillator (S-ICD) implanted
34 months	Inappropriate shock from lead noise—chest radiograph deemed normal and device programming altered.
35 months	Inappropriate shock and discovery of generator rotation. As his left ventricular function had improved, a decision was taken between patient and clinician to leave the device disabled.
50 months	Explant of S-ICD. Up to date echocardiography confirmed ejection fraction 40–45%.

Case summary

We present the case of a 59-year-old gentleman who received inappropriate shocks from an S-ICD. Our patient was diagnosed with dilated cardiomyopathy following investigation of a fully recovered left partial anterior circulation stroke. He works as an artist and cares for young children. At diagnosis he consumed 50–60 units of ethanol weekly. He had mild exercise intolerance but cardiac examination was normal.

Following his stroke, this gentleman received prompt thrombolytics and high dose aspirin, making a full neurological recovery. He had right knee arthritis and a 20 pack year smoking history.

Twenty-four hour continuous electrocardiogram showed sinus rhythm with paroxysmal atrial bigeminy and occasional ventricular ectopy. Computerized tomography coronary angiogram, carotid doppler ultrasound and chest radiograph were normal. Thyroid function, erythrocyte sedimentation, coagulation, autoantibody, syphilis and human immunodeficiency virus blood tests were normal. Vitamin B12 deficiency was identified and treated.

Cardiac magnetic resonance imaging demonstrated severe biventricular impairment (left ventricular ejection fraction [LVEF] 14%, right ventricular ejection fraction [RVEF] 28%) without myocardial oedema. Delayed Gadolinium enhancement was noted in the septal mid-wall, and near-transmurally in the inferolateral left ventricle. Mild aortic, tricuspid, mitral and pulmonic regurgitation were noted. He was established on ramipril 10 mg o.d., eplerenone 25 mg o.d., bisoprolol 7.5 mg o.d. Despite optimized heart failure medications and alcohol cessation, this gentleman's ventricular function failed to significantly improve over a 2 year period. He was referred to our centre for consideration of primary prevention, implantable cardioverter-defibrillator (ICD) implantation. Electrocardiogram demonstrated narrow QRS (117 ms) with Q waves in leads III and augmented vector foot [aVF].

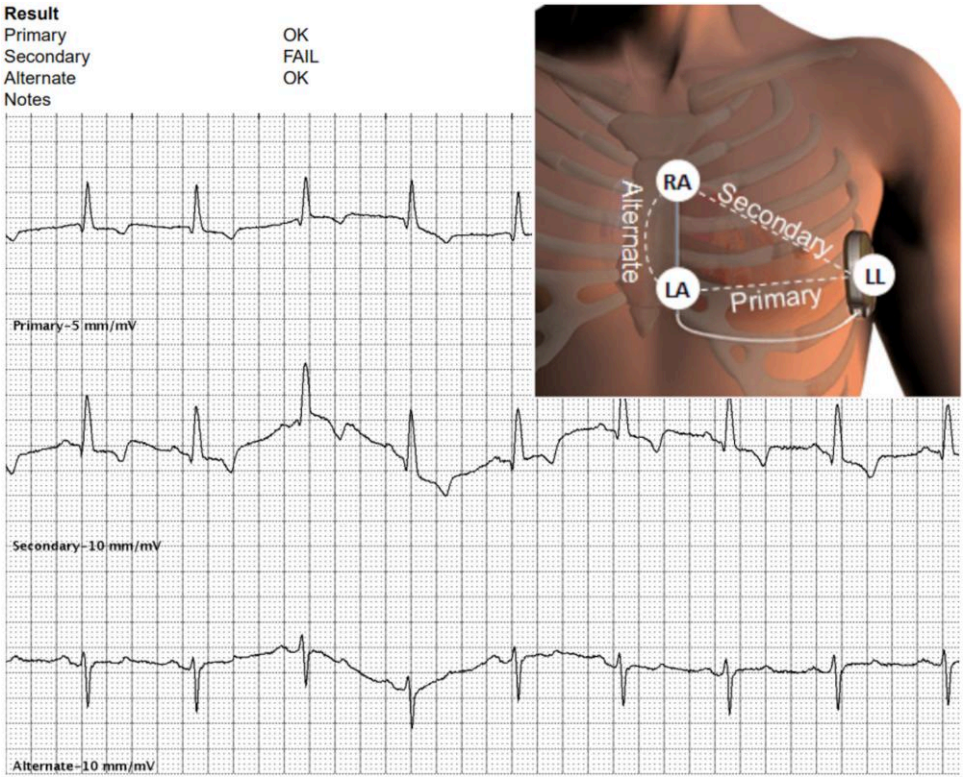


Figure 1 Screening of vectors prior to subcutaneous implantable cardioverter-defibrillator placement. The subcutaneous implantable cardioverter-defibrillator consists of a generator implanted in the left lateral chest wall and a lead placed superficially to the sternum. There are three possible vectors to detect electrograms—two involving the generator (primary, secondary) and one involving only the lead (alternate). Prior to implantation, screening takes place to ensure these vectors will be suitable for analysis based on QRS and T wave size, stability of QRS complex morphology during postural change. In this gentleman, the secondary vector failed automated screening.

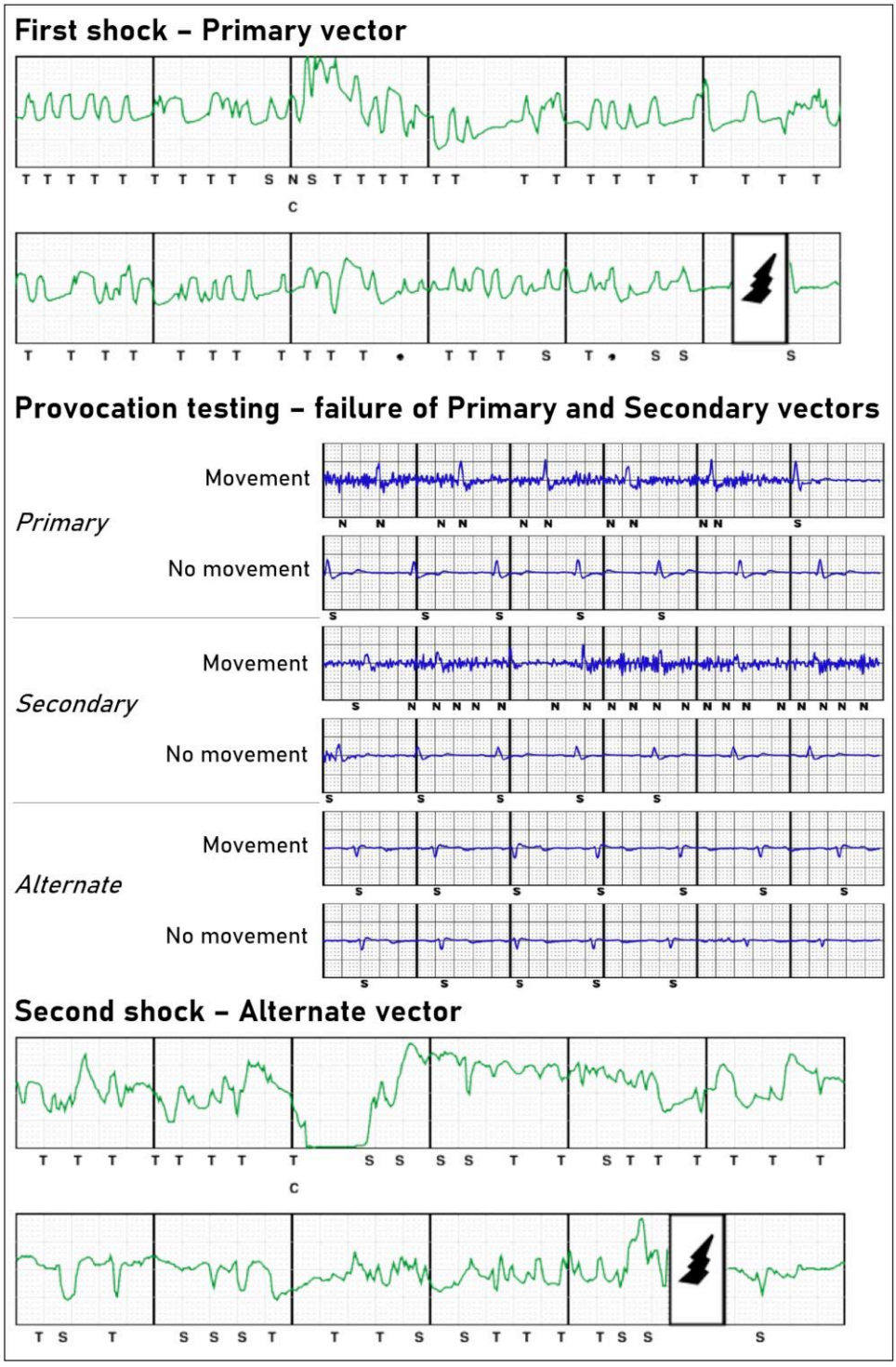


Figure 2 Traces downloaded from the device. (Top) Noise leading up to the delivery of the first inappropriate shock. This was misinterpreted by the device as ventricular fibrillation, demonstrating the importance of electrogram review before deciding appropriateness of therapy. (Middle) Provocation testing by arm movement, shown here to cause significant noise in the primary and secondary vectors but not in the alternate vector. Hence, the alternate was the chosen vector going forward. (Bottom) Despite negative provocation testing, the Alternate vector could still be affected by enough noise to trigger an inappropriate shock.

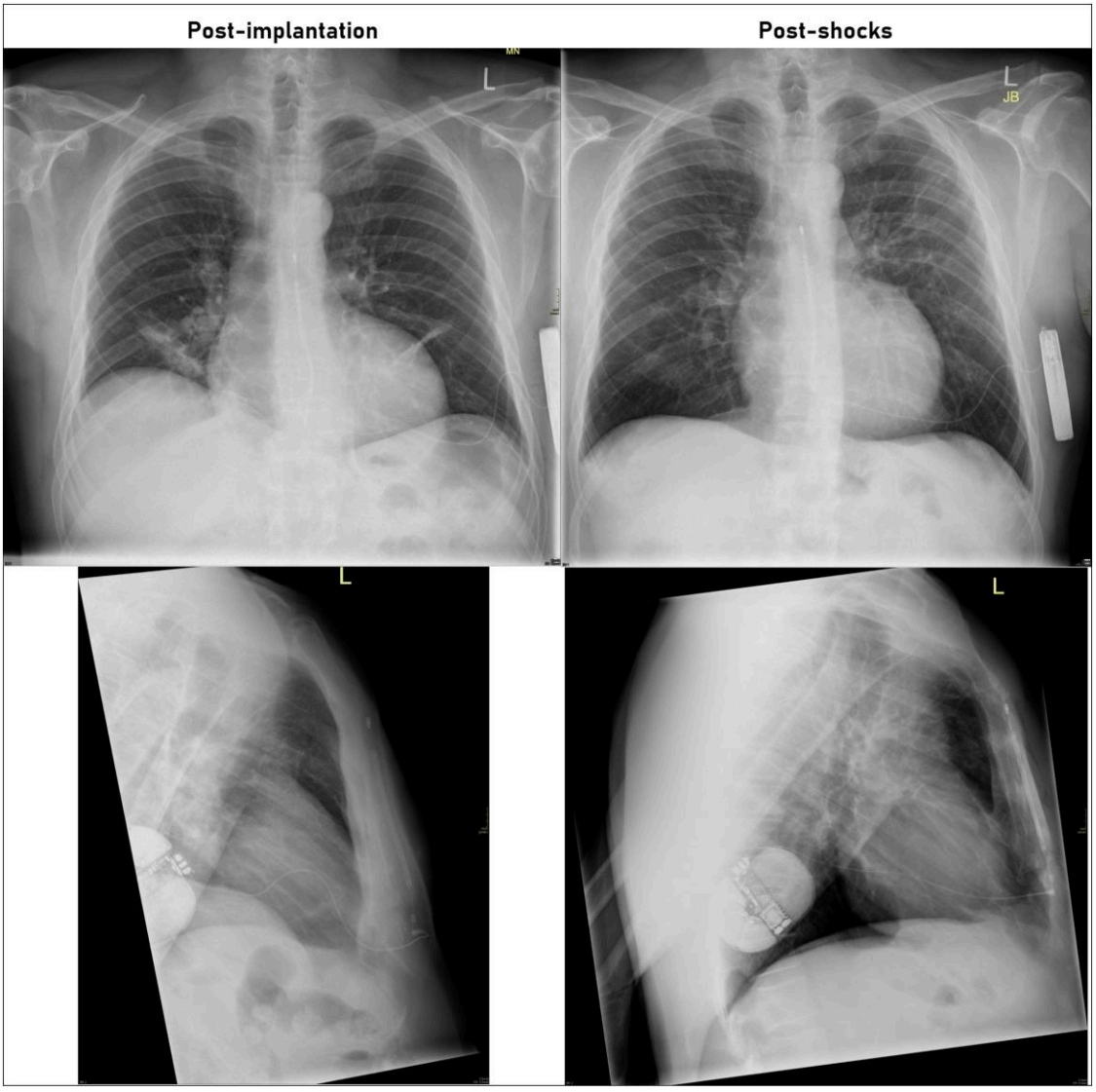


Figure 3 Radiographs of the device. (Left) Immediate post-implantation films. Neither film shows the full extent of the device. The generator header can be seen facing anteriorly and level with the posterior heart border on the lateral film. Bilateral lower zone atelectasis is seen. (Right) Films following inappropriate shocks. The postero-anterior film (top right) shows preserved lead electrode position; the change in lead slack is not immediately obvious but the projection of the lead has changed from mid-generator to high on the generator. The lateral film confirms rotation and posterior displacement of the device, with a significant reduction in lead slack. The atelectasis seen on the first films has resolved.

Echocardiography showed global left ventricular impairment with an ejection fraction of 26%. Due to anxieties about intracardiac lead placement, he was screened for a subcutaneous device. Automated device screening was reviewed by a qualified Boston Scientific representative; primary and alternate vectors were deemed satisfactory but the secondary vector failed (*Figure 1*).

A Boston Scientific Emblem™ subcutaneous generator was implanted between serratus anterior and latissimus dorsi. An Emblem™ 3501 lead was tunnelled along the superior sternal edge, as well as between xiphisternum and pocket. The device and lead were secured with silk sutures. Defibrillation testing was successful at 80 J; there were no immediate or early complications.

He received his first shock 10 months post-implantation whilst seated and using his mobile telephone. He was asymptomatic prior to shock. Device interrogation revealed significant artefact leading up to shock delivery (*Figure 2*). Movement provocation testing demonstrated myopotentials on the primary and secondary vectors but not on the alternate. The device was reprogrammed to use the alternate vector.

The following month, this gentleman received a further shock from his device whilst reaching for items in a high cupboard with both arms. Once again there were no preceding symptoms. Lead impedance was satisfactory at 70 Ω. Interrogation revealed myopotentials leading up the shock delivery in the Alternate vector (*Figure 2*). Boston Scientific were unable to offer further programming solutions.

Lead fracture and device displacement were considered. The implanted lead had a company advisory for fracture following 26 reports of serious injury worldwide. Displacement is a common cause for implantable device malfunction.

Chest radiograph demonstrated a satisfactory device position immediately post-implantation (*Figure 3*).

After the first shock, chest radiograph was reviewed by the consultant radiologist and Boston Scientific representative; the S-ICD was agreed to be in a 'satisfactory position' (*Figure 3*). Radiographic position was identical after the second shock.

Closer examination of all images revealed that the generator had rotated ~90° and displaced posteriorly from original position by the time of the first inappropriate shock. In contrast, the lead electrodes were undisplaced, although slack on the lateral portion of the lead had reduced.

We advised disabling therapies and admission to hospital for further investigation, but this was not acceptable to the patient because of family and working commitments. Leaving therapies enabled was also unacceptable to the patient. Fully informed, he felt that he would rather take the risk of sudden arrhythmic death than be exposed to frequent inappropriate shocks.

Clinical review revealed that following initiation of sacubutril/valsartan 97/103 mg b.d. this gentleman had become asymptomatic even on significant exertion. Echocardiography revealed an improvement in LVEF to 40%. Device interrogation showed no ventricular arrhythmia apart from isolated ectopy. As a primary prevention ICD was no longer indicated, we elected to leave the device disabled. We offered the option of extraction, with or without transvenous ICD implantation. Our patient opted for S-ICD explant without transvenous ICD insertion.

Explantation was performed without complication 15 months following the inappropriate shocks. The patient returned for review 5 months after this for review, revealing stable LVEF 40–45%. He remains asymptomatic.

Discussion

Inappropriate shocks are experienced by up to 4% of S-ICD recipients per year.[2] They are associated with increased mortality, physical and psychological pain as well as significant healthcare cost.[3] The commonest causes were cardiac signal oversensing and supraventricular tachycardia. Lead displacement occurs in <1:200 cases.[4,5] Our case is the first description of isolated generator displacement with consequent inappropriate shocks.

The standard implantation procedure includes securing the S-ICD generator with non-dissolvable suture through the device header.[6] This case demonstrates that this may be insufficient to guarantee consistent device position. The published procedure does not give a recommendation for post-implant chest radiography, but in this case the diagnosis was secured by imaging both immediately following implant and after inappropriate shocks. Whilst lead electrode macrodisplacement can be effectively assessed by posterior–anterior views, the lateral view is critical for reviewing generator position and lead tension.

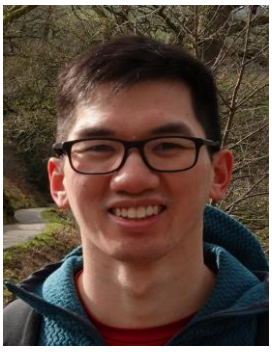
Generator position directly affects the primary and secondary vectors of a subcutaneous device. Although the alternate vector does not use the generator as an electrode, QRS amplitudes are smaller as the bulk of the ventricle is excluded. Myopotentials can therefore pose even more of a problem due to lower signal:noise ratios.

As well as pre-implantation counselling, discussion at significant junctures in a patient journey may aid informed consent for future procedures such as generator change, reprogramming or extraction. Our case illustrates the potential benefit of re-reviewing indications for ICD implantation especially following complications.

Conclusions

We describe the first case of isolated S-ICD generator displacement causing inappropriate shocks despite preserved lead electrode positions. This case underlines the need for careful chest radiography in the assessment of inappropriate shocks, as well as the need for reassessment of ICD indications especially in patients who have had a complication.

Lead author biography



Ji-Jian Chow is a cardiology registrar and research fellow at Imperial College London. His area of research is the electrophysiology of patients at risk of sudden cardiac death and is currently training in device implantation and ablation at the Hammersmith Hospital, London, United Kingdom.

Supplementary material

Supplementary material is available at *European Heart Journal – Case Reports*.

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Slide sets: A fully edited slide set detailing this case and suitable for local presentation is available online as Supplementary data.

Consent: The authors confirm that written consent for submission and publication of this case report including the images and associated text have been obtained from the patient in line with COPE guidance.

Conflict of interest: None declared.

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