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CASE REPORT
Arrhythmias / Electrophysiology

Riata lead failure manifests as electrical storm with lead parameters showing unique postural variations: a case report

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Background Riata implantable cardioverter-defibrillator (ICD) leads are prone to a unique type of mechanical lead failure causing conductor externalization (CE) which may be complicated by a delayed-onset electrical lead failure (ELF).

Case summary A 60-year-old male with symptomatic, severe ischaemic cardiomyopathy, and atrial fibrillation following a prior anterior wall myocardial infarction received a dual-chamber ICD with 7F-RiataST ventricular lead as a primary prevention strategy against sudden cardiac death in 2008. In 2017, a pulse generator replacement was performed for elective replacement indicator status. At that time, CE was noted in the ventricular lead but the electrical lead parameters were normal, hence lead replacement was decided against and the patient was closely followed up thereafter. Four years later, the patient presented with multiple ICD shocks within 48 h. Implantable cardioverter-defibrillator interrogation showed noise on the ventricular electrogram (EGM) channel that was detected as ventricular fibrillation (VF) episodes, triggering inappropriate ICD therapy (five ICD detected VF events within 24 h triggering three antitachycardia pacing therapies and one shock). Lead impedance and R-wave amplitude were within normal range in supine position but dramatically worsened in sitting posture. A new ventricular lead was implanted and the old lead abandoned. The patient has not experienced any device therapy in the follow-up period.

Discussion An electrically inert CE of Riata ICD leads needs close follow-up because an ELF may occur even after several years. A careful analysis of EGMs including postural changes in lead parameters can aid in detection and better characterization of underlying electrical dysfunction following CE.

Keywords Inappropriate shock • Conductor externalization • Impedance • Noise • Electrical lead failure • Case report

ESC Curriculum 5.10 Implantable cardioverter defibrillators • 5.6 Ventricular arrhythmia

Learning points

- Patients with Riata implantable cardioverter-defibrillator lead should receive close follow-up for anticipated mechanical and electrical lead dysfunction.
- There is a lack of correlation between conductor externalization and electrical lead failure in Riata leads.
- Electrical parameters of a Riata lead with externalized conductors may show prominent postural variations, even when resting supine parameters are within normal range.

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Introduction

Riata/ST leads are susceptible to structural failure following a unique inside-out abrasion of conductor cables through the silicone insulation. This leads to conductor externalization (CE) in 14–34% of cases.[1,2] Conductor externalization may be accompanied by a concurrent or delayed occurrence of electrical lead failure (ELF) in 2–6% of cases.[3] Electrical lead failure may manifest as electrical noise leading to inappropriate implantable cardioverter-defibrillator (ICD) shocks or a failure of pacing/sensing functions.[4]

This case report describes a patient presenting with multiple inappropriate ICD shocks delivered in response to electrical noise [sensed as ventricular fibrillation (VF)] on a RiataST ICD ventricular lead. Conductor externalization of this lead was detected 4 years back but had remained electrically silent till the time of current presentation. Various lead parameters showed a unique postural variation, which has not yet been documented with Riata ICD leads.

Timeline

Year 2008	Patient with symptomatic, severe left ventricular dysfunction following a prior anterior wall myocardial infarction received dual-chamber dual-coil implantable cardioverter-defibrillator (ICD) implant (employing a RiataST 7F ventricular lead) as a primary prevention strategy for sudden cardiac death.
Year 2017	(1) Conductor externalization (CE) detected at the time of pulse generator replacement for elective replacement indicator status. (2) CE was not complicated by electrical lead failure (ELF) hence, lead replacement was not performed and patient was closely followed up.
December 2020	During the scheduled bi-annual visit, ICD interrogation suggested normal pacing and sensing parameters of atrial and ventricular leads.
May 2021 Day 1	(1) Patient presents with history of receiving two ICD shocks and is admitted for further evaluation. (2) ICD interrogation suggests noise artefacts being detected as ventricular fibrillation episodes. (3) Pacing threshold is raised but lead impedance and sensed R-wave amplitude are found to be within normal range on interrogation. (4) Pacing threshold, lead impedance, and sensed R-wave amplitude worsen dramatically after assuming sitting posture.
Day 3	Patient receives a new ventricular lead implant. The old dual-coil lead is abandoned after capping.
Day 7	Patient is discharged.
9 weeks follow-up	Patient feels well with satisfactory wound healing, new lead has normal parameters and no ICD therapy has been delivered.

Case presentation

A 60-year-old hypertensive male with a history of prior anterior wall myocardial infarction, dyspnoea (New York Heart Association Class II), paroxysmal atrial fibrillation with fast ventricular rate, sinus rhythm, and a reduced left ventricular ejection fraction (EF = 25%), received a dual-chamber dual double-coil ICD [using RiataST (St. Jude) 7F ventricular lead] implant in 2008 as a primary prevention strategy for sudden cardiac death. He received oral antiplatelets, anticoagulants, betablockers, and antihypertensives for next 9 years and never had any ventricular tachycardia (VT) or VF episodes requiring ICD therapy. His lead parameters were documented during annual ICD interrogations and were always found to be within normal range.

In 2017, the patient received a pulse generator replacement (PGR) for elective replacement indicator status. During the procedure, externalization of conductor elements of the ventricular lead was detected distal to the superior vena cava (SVC) coil (*Figure 1*, left panel). At this stage, electrical parameters of R-wave amplitude, capture threshold, and lead impedance were all within normal range and there were no noise artefacts on ventricular electrogram (EGM) (*Table 1*).

Since isolated CE in Riata leads has been shown to only poorly correlate with subsequent electrical lead dysfunction,[4] thus, it was decided to complete the PGR without lead replacement. The patient remained under close biannual follow-up after PGR for any subsequent lead malfunction. The ICD was programmed in two-zone configuration with VT zone at 171/min and VF zone at 214/min.

During the next 4 years, patient did not require any ICD therapy and his lead parameters monitored on a 6 monthly basis, remained within normal range. Lead parameters during his last scheduled visit in December 2020 are shown in *Table 1*.

A month before his next scheduled visit, i.e. in May 2021, the patient presented with complaint of having received two ICD shocks in the last 48 h. His haemodynamics at presentation were within normal range and 12-lead electrocardiogram (ECG) did not show any acute ischaemic changes or arrhythmia. His vital signs at presentation were within normal range and 12-lead ECG did not show any acute ischaemic changes or arrhythmia.

An ICD interrogation in the emergency room showed 12 VF episodes over the last 6 days. In the previous last 24 h, there were five

such VF episodes; three of these episodes received antitachycardia pacing (ATP) therapy and one episode received 30 J biphasic shock (*Figure 2*). This fulfilled the criteria of an electrical storm.[5]

A careful study of EGMs suggested a normal atrial lead trace but a non-cyclic, non-physiological, high amplitude, high frequency signal was noted on ventricular EGM. This noise artefact with rate falling in VF zone had triggered the inappropriate ICD therapies (*Figure 3*). An impedance trend graph showed an abrupt and variable increase in impedance values over last 7 days (*Figure 2*).

In the supine lying down position, the ventricular pacing capture threshold was raised (3.0 V @ 0.5 ms). But unexpectedly, the lead impedance and sensed R-wave amplitude were found to be within normal range (*Table 1*).

To address the discrepancy between the recent high impedance values in trend graph (*Figure 2*) and the normal value recorded in supine posture (*Table 1*, *Figure 4*, left panel), we performed lead interrogation in the sitting position. The ventricular pacing threshold, lead impedance and R-wave amplitude worsened dramatically in sitting posture while atrial lead parameters remained unchanged (*Table 1*, *Figure 4*, right panel).

After the ascertainment of an electrical lead dysfunction, the ICD ATP/shock function was turned off. Following this, pre-procedure

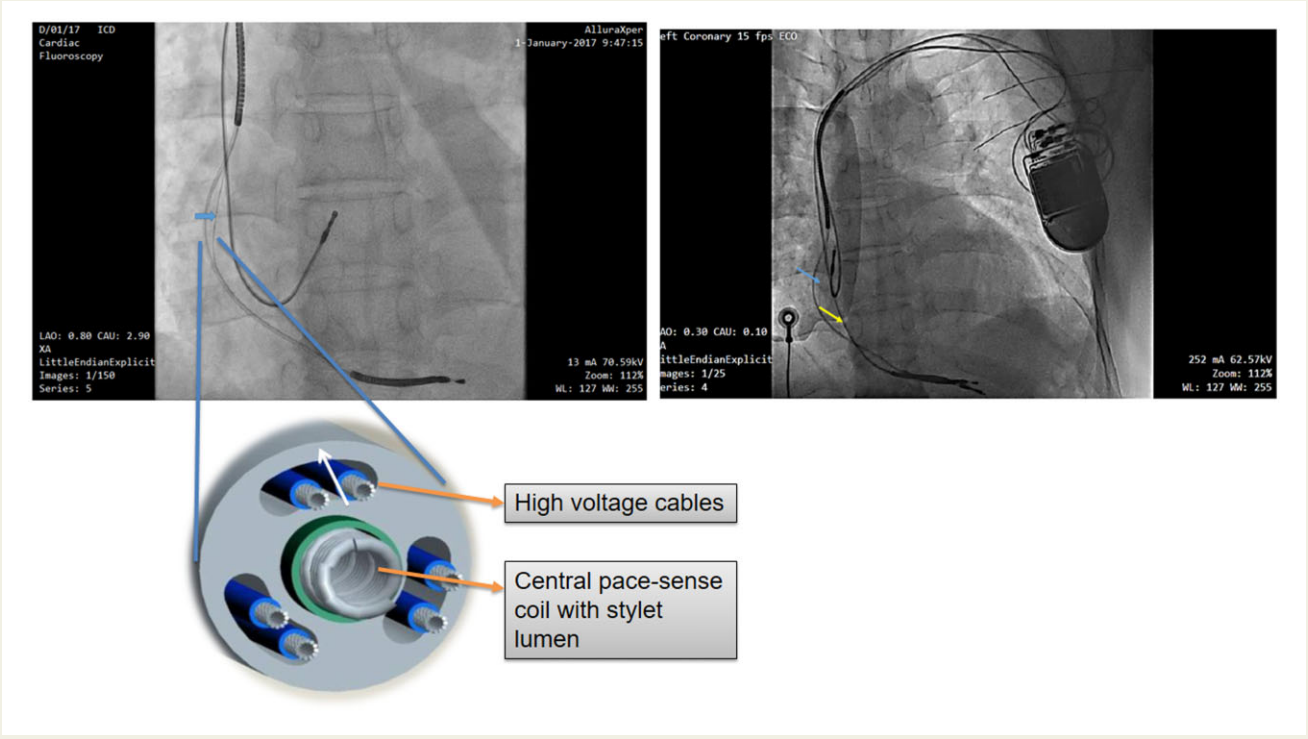


Figure 1 *Left panel*: Fluoroscopic image during pulse generator replacement in 2017 showing conductor externalization of ventricular lead (blue arrow). *Inset image*: Cross-section of silicone Riata dual-coil lead. The high-voltage cables are coated in ethylene-tetrafluoroethylene, which are shown in blue, and the central coil pace-sense conductor with a stylet lumen is encased in a tube of polytetrafluoroethylene, which is shown in green. White arrow indicates location and direction of inside-out abrasion. *Right panel*: Fluoroscopy after implantation of new ventricular lead (yellow arrow). The old lead with CE (blue arrow) was left *in situ*.

Table 1 Lead parameters during ICD interrogation

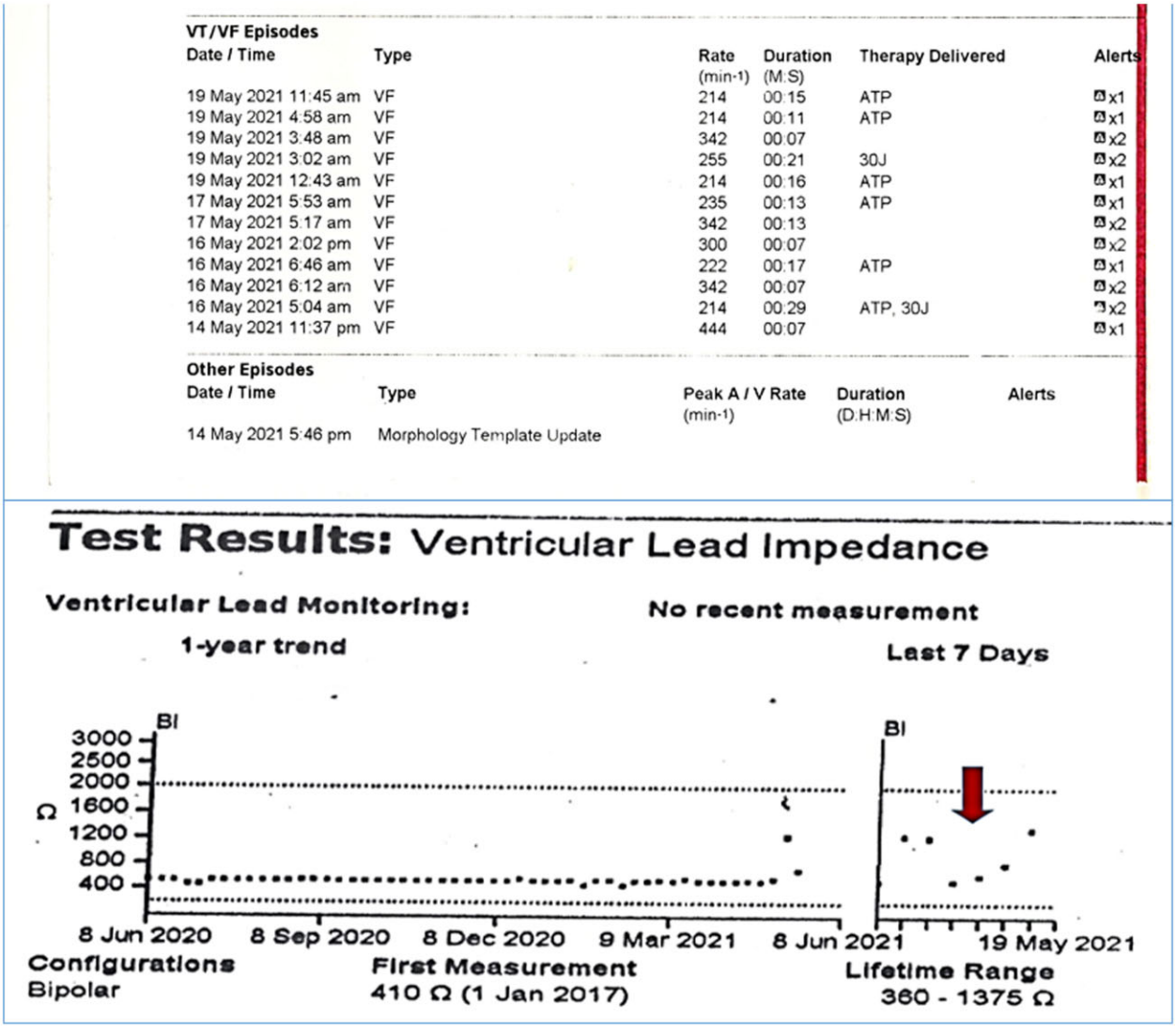
Lead parameters	Year 2017	Year 2020	Year 2021	
			supine	sitting
Capture threshold-atrial lead (pulse width = 0.5 ms)	0.5 V	0.6 V	0.75 V	0.75 V
Capture threshold-ventricular lead (pulse width = 0.5 ms)	0.8 V	0.9 V	3 V	7 V
Lead impedance	544 Ω	560 Ω	580 Ω	1575 Ω
Sensed R-wave amplitude	10.1 mV	9.8 mV	9.7 mV	6.3 mV

assessment including documentation of left subclavian vein patency by contrast venography was done and subsequently, the patient received a new ventricular lead (Durata™ ICD St. Jude) implantation on Day 3. Due to the anticipated risks and technical challenges involved in extracting an ageing dual-coil ventricular lead, the old Riata lead was capped and abandoned (*Figure 1*).

The patient has been in follow-up for 9 weeks, the wound site is healing well and patient has not received any new ICD interventions and has been doing well. The new lead parameters with all lead parameters are within normal range.

Discussion

Riata/Riata ST leads have a unique hollow multilumen design that predisposes them to an 'inside-out' form of lead abrasion through breach of silicon insulation[4] (*Figure 1*, inset). This resulted in a Class I US FDA recall in 2011.[6] Conductor externalization may or may not be complicated by an ELF (defined as one of the following five: presence of non-physiological signals on ventricular EGM, pacing impedance outside the 200–2000 Ω range or a >100% increase or >50% decrease from baseline value, change in high-voltage impedance to >200 or <25 Ω, pacing threshold >5 V or >100% rise, and R-wave sensing <3 mV or >50% reduction).[4,7]



VT/VF Episodes

Date / Time	Type	Rate (min-1)	Duration (M:S)	Therapy Delivered	Alerts
19 May 2021 11:45 am	VF	214	00:15	ATP	x1
19 May 2021 4:58 am	VF	214	00:11	ATP	x1
19 May 2021 3:48 am	VF	342	00:07		x2
19 May 2021 3:02 am	VF	255	00:21	30J	x2
19 May 2021 12:43 am	VF	214	00:16	ATP	x1
17 May 2021 5:53 am	VF	235	00:13	ATP	x1
17 May 2021 5:17 am	VF	342	00:13		x2
16 May 2021 2:02 pm	VF	300	00:07		x2
16 May 2021 6:46 am	VF	222	00:17	ATP	x1
16 May 2021 6:12 am	VF	342	00:07		x2
16 May 2021 5:04 am	VF	214	00:29	ATP, 30J	x2
14 May 2021 11:37 pm	VF	444	00:07		x1

Other Episodes

Date / Time	Type	Peak A / V Rate (min-1)	Duration (D:H:M:S)	Alerts
14 May 2021 5:46 pm	Morphology Template Update			

Figure 2 *Upper panel*: Summary of ventricular arrhythmia episodes and the implantable cardioverter-defibrillator therapy delivered over last 6 days. A total of 12 shocks were aborted. *Lower panel*: Impedance trend chart of last 11 months shows abnormally high and variable impedance values for last 7 days (red arrow). Before this, the impedance values were within normal range.

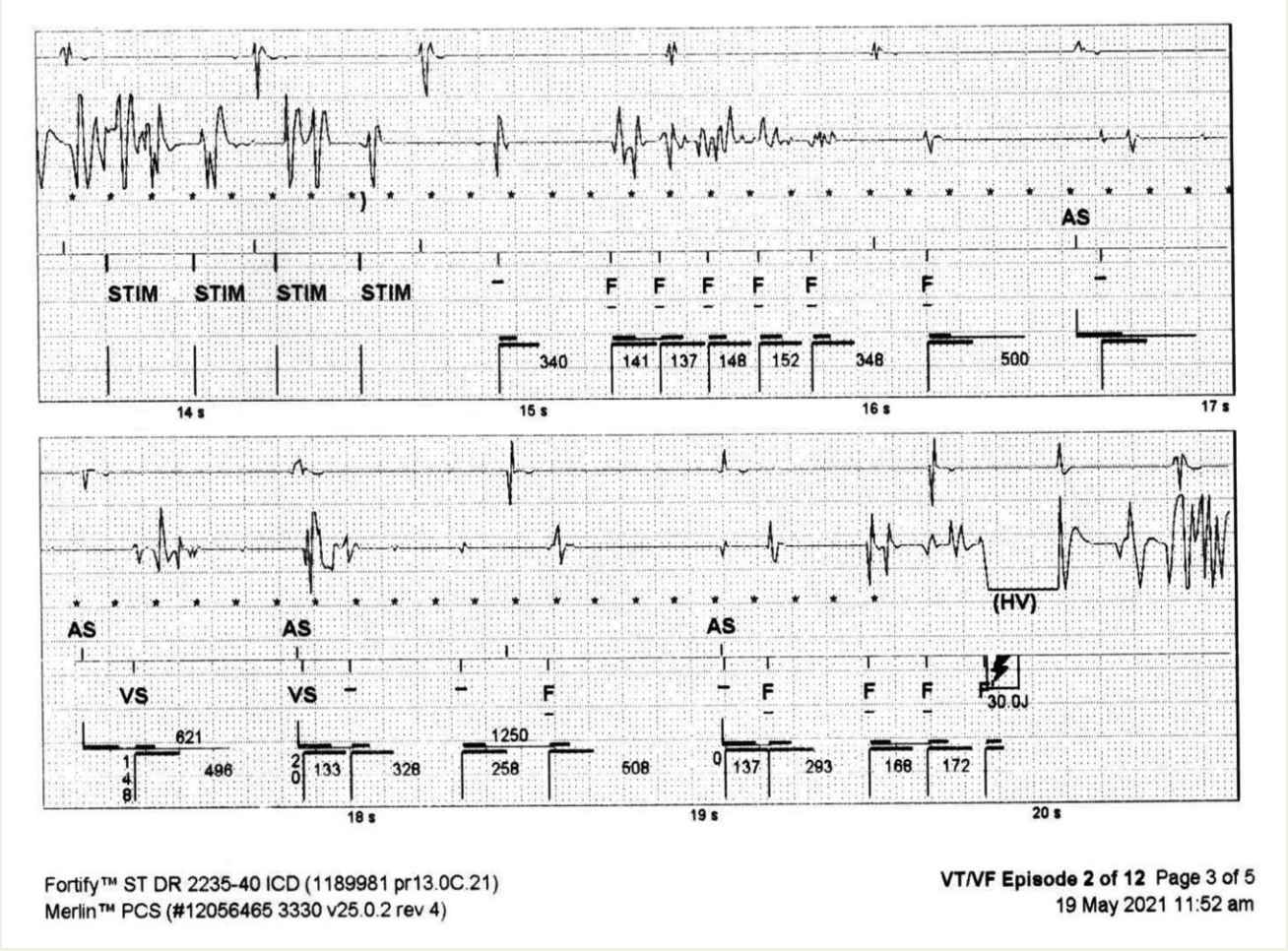


Figure 3 Electrogram recording showing high frequency, high amplitude noise signal on ventricular electrogram leading to an antitachycardia pacing therapy (shown as STIM annotation) which is then followed by 30 J high voltage shock. No noise is detected on atrial electrogram trace.

Our patient had an electrically silent CE noted at the time of PGR and it was decided to keep him under close monitoring. Such an approach of watchful monitoring has been advocated by studies showing poor correlation between CE and ELF.[4,7,8] The location of integrity breach distal to SVC coil, as seen in our case, has been described in about 14% cases of CE.[4] One of the reasons hypothesized for normal Riata lead functioning despite CE is the preservation of intact internal Ethylene tetrafluoroethylene coating of conductor cables even when the outer silicon coating has undergone erosion leading to CE.[9]

Riata lead electrical dysfunction correlates with time since implant and impaired EF is an independent predictor of ELF in these leads.[4] Our patient with ischaemic cardiomyopathy (EF—25%) developed ELF manifesting as inappropriate ICD therapy more than a decade after receiving the initial ICD implant. Noise oversensing, as seen in our case, is the commonest mode of presentation of ELF in Riata leads[7] and may lead to inappropriate ICD therapy in 15–24% of patients.[10]

The pacing and sensing parameters remained within normal range at initial evaluation in supine position (*Table 1*), while the lead impedance trend showed a sudden and abrupt rise in impedance values over the last 1 week (*Figure 2*). This prompted us to note any postural variation of these parameters. The results, shown in *Table 1*, signify the value of ICD interrogation in sitting posture in suspected cases of ELF in Riata leads with previous CE. The cause of such variation is unclear. We hypothesize that due to gravitational forces acting on the heart in sitting posture, the externalized lead components of the fixed ventricular lead are stretched which causes worsening of electrical parameters. This probably accounted for the discrepancy between impedance values in supine position and impedance trend chart.

Previous studies have suggested that removing Riata leads is more challenging than removing other ICD leads because of CE and the absence of coil backfill.[11,12] Therefore, we decided to abandon the old dual-coil ventricular lead and proceeded with a new lead implant.

To the best of our knowledge, this case report is the first to describe a postural worsening of RiataST lead parameters post-CE. This

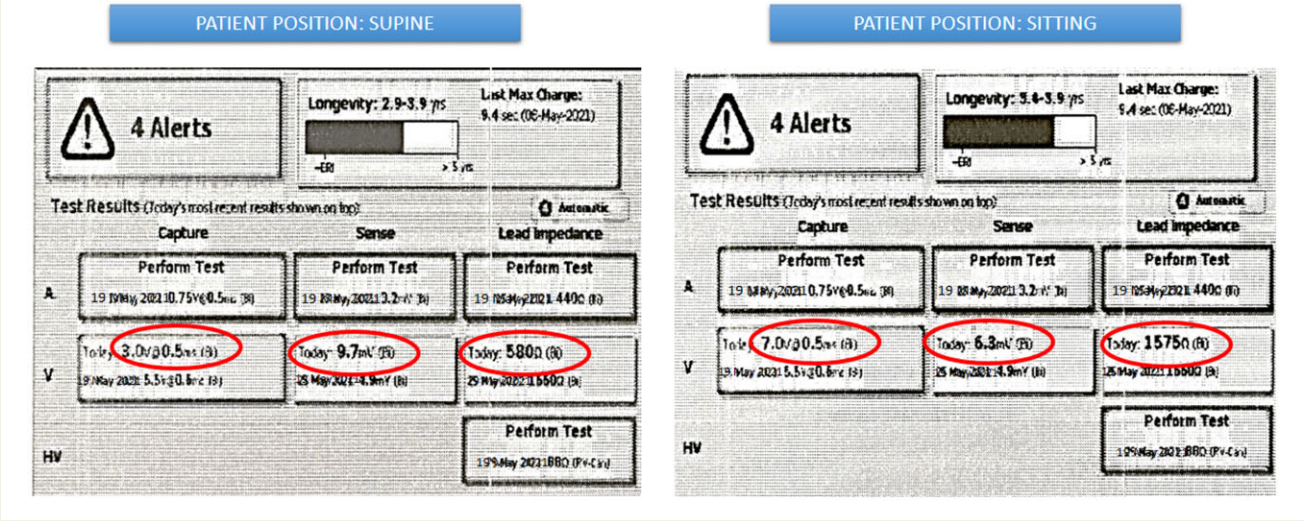


Figure 4 Implantable cardioverter-defibrillator interrogation showing dramatic change in ventricular capture threshold, lead impedance, and sensed R-wave amplitude (red ovals) with change in posture from supine to sitting.

dynamic manoeuvre during lead interrogation can unmask an underlying conduction abnormality of externalized leads and probably aid in early detection of ELF.

Conclusion

Long-term follow-up is necessary for patients with Riata ICD lead considering a delayed occurrence of CE and ELF. Frequent monitoring should follow an isolated CE and the earliest sign of an ELF should mandate lead replacement or novel lead implant. Apparently, normal lead parameters in supine position may show dynamic changes with posture change and aid in better characterization and early detection of ELF.

Lead author biography

Dr Abhimanyu Uppal is a senior resident in the Department of Cardiology in G.B. Pant Hospital, New Delhi. He has been associated with multiple national and international publications from this institute and takes keen interest in electrophysiology.

Supplementary material

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

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 images and associated text has been obtained from the patient in line with COPE guidance. Patient consent was taken in compliance with COPE guidelines.

Conflict of interest: None declared.

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