Azygos Lead Implantation in a Patient with High Defibrillation Thresholds

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Implantable cardioverter-defibrillators (ICDs) are the cornerstone therapy for terminating life-threatening ventricular arrhythmias, which are a common cause of sudden cardiac death.[1]

Routine defibrillation threshold (DFT) testing is somewhat controversial. There are several causes of elevated DFTs necessitating testing, which include patient-specific factors (ie, metabolic abnormalities, ischemic heart disease), implant-related issues, device type, medications, electrolytes, sympathetic tone, and antiarrhythmic medications.[2,3] In the rare occurrence that an individual has an elevated DFT, it poses a challenge on the effectiveness of therapy delivered by an ICD.[4]

One method of DFT testing involves inducing repeated episodes of ventricular fibrillation (VF) followed by detection and defibrillation from the ICD to determine the lowest amount of energy required to successfully terminate VF.[4] Various techniques can be used to test a patient's DFT. The single energy success technique induces VF, and a shock with a 10J safety margin is repeated 2-3 times.[5] A step-down method uses serial VF induction with graded energy shocks until they fail to defibrillate the myocardium.[5] Due to the influence of many factors on a patient's DFT, a 10J safety margin is often used between the lowest successful defibrillation energy and the maximum device output.[3]

Patients with high DFTs often die of sudden cardiac death due to unsuccessful defibrillation.[3] We describe a rare case of a patient with high DFTs who underwent a series of lead revisions and ultimately received an azygos lead implantation to enhance the efficacy of defibrillation. In addition, we briefly review various causes of elevated DFTs as well as the different options available to patients when encountering elevated defibrillation thresholds.

Case Presentation

A 52-year-old male with a history of dilated cardiomyopathy (ejection fraction of 15%), New York Heart Association class II, and chronic congestive heart failure presented with multiple episodes of symptomatic nonsustained ventricular tachycardia (VT)/fibrillation. Mexiletine was initiated to suppress the VT/VF, but the patient still had unacceptably high DFTs (>30J, the maximal energy delivered by the device) regardless of the shocking vector configuration, including the elimination of the superior vena cava (SVC) coil and changing the shocking vector polarity. The patient wore an external wearable defibrillator while being weaned off mexiletine (which can increase DFTs). The patient was scheduled for repeat DFT testing with potential ICD revision if necessary. DFT testing was performed and failed to defibrillate the patient at 30J and 35J, requiring an external rescue defibrillation at 360J to sinus rhythm.

The patient subsequently underwent an ICD revision with the addition of an azygos vein lead the same day. To access the azygos vein, a JR5 catheter was placed via the axillary venous approach and used to find the ostium, which was located lateral and slightly posterior from the brachiocephalic/SVC junction. The azygos vein ostium was identified with small injections of iodinated contrast dye and the use of an angled Terumo wire. Once the wire was inserted down the azygos vein, a long sheath was then advanced over the wire, allowing easy placement of a new azygos coil (Model 6937A, Medtronic). The patient's existing SVC coil was disconnected from the ICD, capped off, and replaced by the new azygos lead. The new lead was attached to a high-energy ICD along with the old right ventricular ICD lead. Figure 1 shows the new high-energy ICD and azygos lead following implantation. The patient underwent repeat DFT testing, which demonstrated successful termination of VF to sinus rhythm with 40J using a shocking vector from the right ventricular coil to the azygos coil and a new 40J output pulse generator (Cobalt VR Model DVPB3D1, Medtronic).

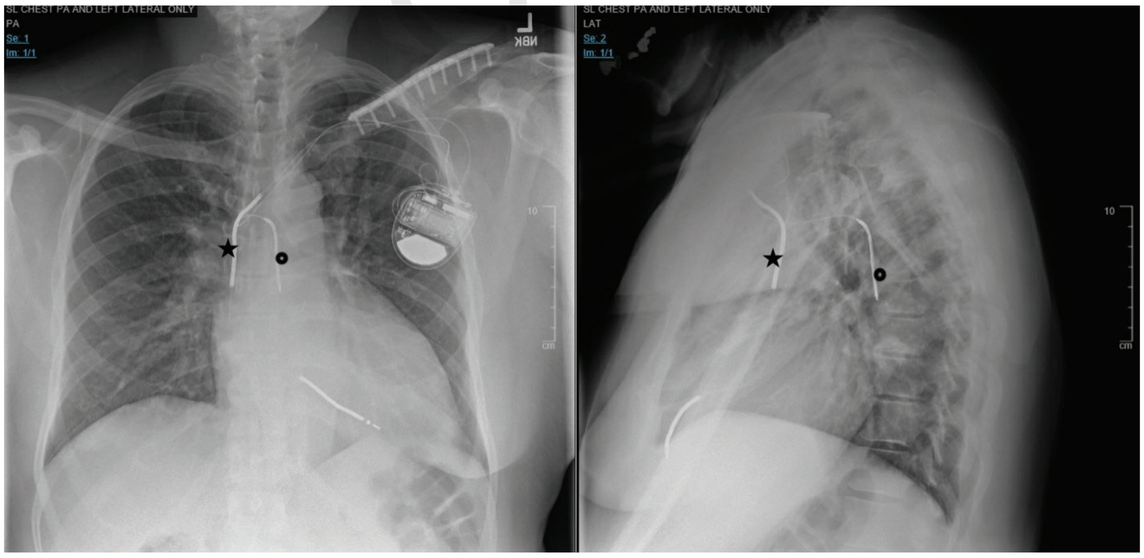

Figure 1. Posterior/anterior (PA) and left lateral chest radiographs following implantation of a posterior azygos lead (star) and ICD via the axillary venous approach. The superior vena cava coil (circle) was unplugged from the ICD, thereby removing it from the potential shocking vector.

Discussion

Elevated DFTs can result in inadequate and unsuccessful defibrillation. Various therapeutic strategies can be employed to manage such a situation. While there is no consensus, a strategy of trial and error is usually undertaken to determine an appropriate solution. DFT testing with a 10J safety margin lower than the maximum output of the device is widely considered standard practice.[3]

There are various noninvasive and invasive therapies available to manage high DFT. Noninvasive therapies may include reprograming the vector and/or shocking waveform morphology of the device, and/or eliminating antiarrhythmic drugs that raise DFTs and utilizing alternative antiarrhythmic drugs that may lower DFTs.[6] Invasive therapies include using a high-output device, repositioning the right ventricular lead, adding a subcutaneous array, and repositioning the proximal electrode (typically SVC coil) in a two-lead system. The common therapies used to treat a patient with high DFTs are outlined in Table 1, which breaks down the maneuvers to potentially decrease defibrillation thresholds into two categories: (1) noninvasive techniques, which can be accomplished by starting or stopping certain antiarrhythmic drugs or reprogramming the device, and (2) more invasive techniques, which may require additional surgical intervention and/or the addition of another lead or subcutaneous array.[3] The initial maneuvers to lower DFTs should assure that maximal output is delivered rapidly from the ICD. In addition, changes in the shocking vector polarity and elimination of the SVC coil should be considered. Some devices can also alter the waveform of the electrical shock that is delivered from the device. If reprogramming fails to lower the DFT, a surgical revision strategy of the system should be considered. In a new implant, the RV lead can be repositioned to a more apical location, which may help facilitate defibrillation. In longstanding chronically implanted leads (eg, over two years of age) where repositioning cannot be easily achieved, the addition of either a coronary sinus or azygos vein coil or a subcutaneous array may be useful.

A subcutaneous array requires the tunneling of antennas underneath the skin, which may provide an effective change in vector to a more lateral left ventricular location. Unfortunately, there may be some discomfort from the antennas that are tunneled underneath the skin. A coronary sinus coil typically provides the ability to shock a more lateral location; however, the coronary sinus is located in a more basal location of the left ventricle and may not encompass the entire left ventricular myocardium. Alternatively, an azygos coil is placed in an embryological remnant of the vasculature, which travels in a very posterior location and can dramatically impact the shocking vector. The latter was the rationale for using this technique in our patient with severely dilated cardiomyopathy and an implanted right ventricular dual coil with an apically positioned lead.

Conclusion

Traditionally, most operators do not usually perform DFT testing, making it unclear how frequently high DFT exists in the population. Our patient's history of elevated DFTs and taking mexiletine (a medication known to increase defibrillation thresholds) prompted us to evaluate his DFT. This case demonstrates a very useful approach for improving high DFTs using an azygos vein coil. Further studies are needed to evaluate this azygos lead implantation strategy compared to other techniques on a larger scale. ■

Table 1. Non-invasive and invasive management options for a patient with a high defibrillation threshold (DFT).[3]

Noninvasive Strategies	
Management Options	**Reason for Approach**
Stopping medications that may increase DFTs (amiodarone or mexiletine); Starting medications that may decrease DFTs (sotalol and dofetilide)	A simple medication adjustment including known antiarrhythmic drugs may be the first and simplest strategy for managing high DFTs.
Removal of the SVC coil	Removal of the SVC coil may help change the shocking vector to encompass more of the left ventricle and lower DFT. This approach can be accomplished without surgical intervention by device reprogramming.
Changing polarity	Switching the distal coil from the cathode to the anode; reversing the configuration may reduce DFTs.
Invasive Strategies	
Management Options	**Reason for Approach**
Addition of a coronary sinus coil	Placement of a coil in a posterior or lateral branch of the coronary sinus may reduce DFTs.
Addition of a subcutaneous array electrode	Changes the shocking vector to a more lateral location to encompass more of the left ventricle.
Repositioning of the proximal electrode	Placement of a proximal coil in the left subclavian vein, brachiocephalic vein, or azygos vein may improve DFTs.
Usage of high-output device	A high-output device will generate more energy to defibrillate a patient.
Right ventricular lead positioning	Positioning the right ventricular lead to a more apical location may help lower DFTs.

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References

1. Bunch TJ. Who will benefit from an implantable cardioverter defibrillator? *Circ Cardiovasc Qual Outcomes.* 2019;12(8):e005995. doi: 10.1161/CIRCOUTCOMES.119.005995
2. Matassini MV, Healey JS. How to manage a high defibrillation threshold in ICD patients: and does it really matter? *Curr Treat Options Cardiovasc Med.* 2013;15:497-505. doi: 10.1007/s11936-013-0244-7
3. Mainigi SK, Callans DJ. How to manage the patient with a high defibrillation threshold. *Heart Rhythm.* 2006;3(4):492-495. doi: 10.1016/j.hrthm.2005.12.023
4. Lin EF, Dalal D, Cheng A, et al. Predictors of high defibrillation threshold in the modern era. *Pacing Clin Electrophysiol.* 2013;36(2):231-237. doi: 10.1111/pace.12039
5. Uyguanco ER, Berger A, Budzikowski AS, Gunsburg M, Kassotis J. Management of high defibrillation threshold. *Expert Rev Cardiovasc Ther.* 2008;6(9):1237-1248. doi: 10.1586/14779072.6.9.1237
6. Hohnloser SH, Dorian P, Roberts R, et al. Effect of amiodarone and sotalol on ventricular defibrillation threshold: the optimal pharmacological therapy in cardioverter defibrillator patients (OPTIC) trial. *Circulation.* 2006;114(2):104-109. doi: 10.1161/CIRCULATIONAHA.106.618421