

Elevated Defibrillation Threshold: Are Defibrillation Vectors Important?

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SUMMARY

The evaluation of the defibrillation threshold (DFT) is common after the implantation of implantable cardioverter defibrillator (ICD) devices. The goal of this standard of care is to achieve successful defibrillation of ventricular fibrillation. In patients with elevated defibrillation thresholds, alternative techniques are required to correct the situation. We describe a case in which an uncommon strategy was used to improve DFT after failed defibrillation. A 78-year old man with a history of dilated cardiomyopathy was referred to the electrophysiology laboratory to have an ICD implanted as primary prevention strategy. During the procedure, the ICD failed to defibrillate the patient even after the lead was placed in different areas of the right ventricle and after optimizing the shock wave. A defibrillation lead was implanted in the azygous vein, and the shock vector was directed towards the posterior axis; a successful defibrillation was thus achieved.

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Key words > Defibrillators, Implantable - Azygous Vein

Abbreviations > ICD Implantable cardioverter defibrillator | DFT Defibrillation threshold

BACKGROUND

The evaluation of the defibrillation threshold (DFT) is a common practice after the implantation of implantable cardioverter defibrillator (ICD) devices. The standard practice is to obtain a successful defibrillation with a defibrillation safety margin of at least 10 Joules below the total energy the device is able to deliver or multiple ventricular fibrillation inductions with subsequent conversion successes using shock energies below the 10 Joules safety margin. If this goal is not achieved, several strategies can be employed to correct this situation: changing the ICD lead position, optimizing the shock waveform or placing an additional hardware. (1-5) We describe a case in which an uncommon strategy was used to improve DFT after failed defibrillation.

CLINICAL CASE

A 78-year old man with a history of dilated cardiomyopathy was referred to the electrophysiology laboratory to have an ICD implanted as primary prevention. He had a history of non-ischemic dilated cardiomyopathy with an ejection fraction of 30%, hypertension, permanent atrial fibrillation and chronic obstructive pulmonary disease (weight 57.6 kg, BMI 19.88).

During the implantation, the pectoral muscle was exposed after the initial incision due to the reduced amount of subcutaneous tissue. The procedure included implantation of a Saint Jude Medical CURRENT VR ICD in a subpectoral pocket and fixation of a DURATA 7120-58 cm defibrillation lead

in the interventricular septum. We usually place the lead in this position in an empirical attempt to achieve an earlier depolarization of the conduction system similar to the physiologic conduction pattern. Finally, DFT were tested (Table 1). The device failed to defibrillate the patient despite having used maximum energy, optimized the shock waveform and changed the position of the ventricular lead in two different areas of the right ventricular apex. The patient required external cardioversion. The impedance of the defibrillation shocks was never higher than 35 ohms before and after having optimized the shock waveform. As the patient received multiple shocks, the decision to modify the hardware in a second time was taken.

The patient remained stable after the initial procedure and was taken to the electrophysiology laboratory 48 hours later. As the ventricular lead had been finally positioned in the right ventricular apex and the resistance to the shocks (evaluated by the impedance) was constantly appropriate, we decided to direct the defibrillation vector to the posterior wall. The implantation of a subcutaneous lead was not an adequate option in this patient due to the reduced amount of subcutaneous tissue. For this reason, we implanted a coil in the azygous vein. The subpectoral pocket was opened and the lead was disconnected from the ICD. A new access of the extrathoracic portion of the left subclavian vein was performed over the first rib. A 6 Fr introducer was inserted to serve as access platform. The azygous vein was selectively cannulated in the posterior wall of the superior vena cava using a KMP catheter (Cook Inc., Indiana,

Induction	Anode	Cathode	Result
1	RV coil	SVC Can-coil	15, 20 and 30 J, failure, external rescue (36 ohms)
2	RV coil	SVC Can-coil	20 J, success (29 ohms)
3	RV coil	SVC Can-coil	20 J, failure; 30 J, success (30 ohms)
4	RV coil	SVC Can-coil	20 and 30 J, failure, external rescue (30 ohms)
Cable repositioned in the RV apex			
5	RV coil	SVC Can-coil	20 and 30 J, failed, external rescue (33 ohms)
6	RV coil	Can	20 and 30 J, failure (47 ohms)
Cable repositioned in the apical septum			
7	RV coil	SVC Can-coil	30 J, failed, external rescue (33 ohms)
ICD replaced by other device that uses more energy			
8	RV coil	SVC Can-coil	36 J, failure, external rescue (33 ohms)

RV: Right ventricular. SVC: Superior vena cava. (*): Optimization of shock waveform. J: Joules.

Table 1. Defibrillation thresholds after the first procedure

USA) and a GLIDEWIRE hydrophilic guide wire (Terumo Corp., Tokyo, Japan) (Figure 1, panel A). A venogram of the azygous vein was performed using the KMP catheter to confirm the correct position of the catheter (Figure 1, panel B). The guide wire was then replaced by an Amplatz Super Stiff guide wire (Cook Inc., Indiana, USA) and the KMP catheter by a 9 Fr introducer. A single 58-cm defibrillation lead Medtronic 6937 was advanced along the azygous vein and positioned in the retrocardiac space (Figure 1, panel C). The defibrillation lead was then connected to the lead connector port of the ICD superior vena cava lead which was covered and abandoned in the subpectoral pocket below the ICD. Defibrillation thresholds were tested with successful cardioversion in three consecutive inductions: two with maximum energy and the third with type II conversion and a defibrillation safety margin of 5 Joules (Table 2). The patient did not present complications and was discharged on the following day.

DISCUSSION

Therapy with ICD has demonstrated to produce a significant reduction in mortality of patients at high-risk of sudden death. (6-8) However, not all the devices implanted function appropriately. The technological improvement with devices capable of delivering greater energy, better leads and programming algorithms, provide some of the tools to ensure that these devices function correctly. However, some patients require additional hardware to direct the defibrillation vector in order to achieve a successful defibrillation.

Azygous vein lead implantation is a technique with a few references in the medical bibliography. In 2004, Cesario et al. published the first series of patients with high defibrillation thresholds that were successfully treated with azygous vein lead implantation. (9) This approach was initially difficult due to the lack of previous experience, requiring guide wires via the femoral vein to guide the implant from the pectoral pocket. In fact, in one of the cases reported, the abdominal implantation generated a defibrillation vector that produced a successful defibrillation. More recently, Cooper et al. published the first retrospective review of seven consecutive patients which is still the greatest cohort ever published. (10) These authors used a technique that was similar to the one used in our case report. The average time required for azygous vein cannulation was 15 minutes, which is consistent with our experience. In our patient, this technique allowed the ICD to produce a successful defibrillation even without achieving a safety margin of 10 Joules.

In our case, the resistances to the energy delivered, evaluated by defibrillation impedance, were always within normal limits. This finding reinforces the concept that the patient's tissue resistance was not a factor responsible for the inability of the ICD to achieve a successful cardioversion. A successful cardioversion was achieved by adding a lead through the azygous vein without modifying the impedance. Thus, the favorable alignment of lead-generator vector was the main reason for the successful outcome.

In conclusion, azygous vein lead implantation is a technique that may be used in patients with elevated defibrillation thresholds in whom successful defibrillation is not possible. This approach is simple and has low risk and should be considered the first option for complex cases. The favorable alignment of lead-generator vector through the left ventricle is an important concept to consider, actually if defibrillation fails even with low impedance. Further studies are necessary to know the real value of this technique.

RESUMEN

LinUmbral de desfibrilación elevado: ¿los vectores de desfibrilación son importantes?

La evaluación del umbral de desfibrilación (UDF) es una práctica habitual en la mayoría de los implantes de cardiodesfibriladores implantables (CDI). La práctica estándar busca obtener una desfibrilación exitosa de la fibrilación ventricular. En pacientes con umbrales de desfibrilación elevados en los cuales esto no resulta posible se da inicio a una serie de maniobras tendientes a corregir la situación. En esta presentación se describe un caso en el que se recurrió a una estrategia de uso poco frecuente para mejorar resultados durante la falla del UDF.

Se trata de un paciente de 78 años, de sexo masculino, con antecedentes de miocardiopatía dilatada, que fue derivado al laboratorio de electrofisiología para el implante de un CDI para prevención primaria. Durante el procedimiento, el CDI falló en desfibrilar al paciente aun luego de haber posicionado el cable en diferentes áreas del ventrículo derecho y de haber optimizado la onda de choque. El paciente finalmente recibió el implante de un electrodo de desfibrilador en la vena ácigos, lo que permitió la reorientación del vector de desfibrilación hacia el eje posterior, con el resultado de una desfibrilación exitosa de la fibrilación ventricular por el CDI.

Palabras clave > Desfibriladores implantables - Vena ácigos

Fig. 1. Sequence of vein azygous lead implantation. **A.** Selective cannulation of the azygous vein. **B.** Venogram of the azygous vein. **C.** Lateral chest X-ray after implantation in the azygous vein.

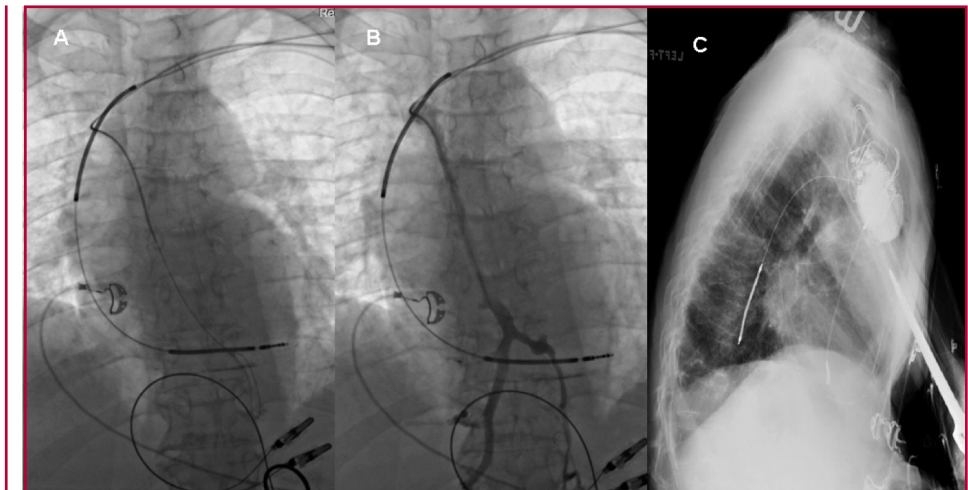


Table 2. Defibrillation thresholds after ayzgos vein lead implantation

Induction	Anode	Cathode	Results
1	RV coil	SVC Can-coil	25 J, failure; 36 J, success (30 ohms)
2	RV coil	SVC Can-coil	29 J, success (type II, 30 ohms)
3	RV coil	SVC Can-coil	36 J, success (29 ohms)

RV: Right ventricular. SVC: Superior vena cava. J: Joules.

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