Defibrillation threshold decrease with the supradiaphragmatic extracardiac implantable cardioverter-defibrillator implantation technique

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Despite advances in implantable cardioverter-defibrillator (ICD) technology, the optimal ICD implantation technique for pediatric patients has not yet been established. One increasingly used option is totally extracardiac implantation. However, concern exists about the high defibrillation threshold (DFT) at the moment of implantation or during follow-up. We report the case of a 3-year-old boy with repetitive syncopal idiopathic ventricular tachycardia episodes treated with ICD implantation using the extracardiac technique. Changing device position from abdominal to a supradiaphragmatic, solved unsafe elevated discharge impedance and DFT during follow-up.

Introduction
The use of implantable cardioverter-defibrillator (ICD) in the pediatric population has proven to be effective therapy in life-threatening ventricular arrhythmias. Decisions about ICD implantation are difficult because of the high incidence of device-related complications during implantation and follow-up. Optimum positioning of defibrillation electrode and device is still controversial. One increasingly used option is totally extracardiac implantation, which avoids complications related to intravascular access and intracardiac lead placement. However, the extracardiac location of the lead and device raises concern about the possible high defibrillation threshold (DFT) at the moment of implantation or during follow-up1,2.

We report the case of a 3-year-old boy with repetitive syncopal ventricular tachycardia (VT) episodes treated with ICD implantation using the extracardiac technique. Changing the device position from abdominal to a supradiaphragmatic position solved unsafe elevated discharge impedance and DFT.

Clinical case
A 3-year-old boy without familial sudden cardiac death (SCD) history presented with fever and a history of self-limited wide QRS complex tachycardia at 200 bpm at the age of 5 months. Baseline ECG in sinus rhythm showed bifascicular block and a minor elevation of ST-segment in right precordial leads. Cardiac enzymes, echocardiography, and viral serology were normal. Congenital metabolic disease was also excluded. At the age of 2 years, the patient was readmitted for syncope. The electrophysiology (EP) evaluation showed a prolonged HV interval with a non-diagnostic flecainide test for Brugada syndrome. After 7 months, patient presented again with syncope and wide-QRS complex tachycardia at 280 bpm. A new EP study was performed and a VT identical to the clinical one was induced (Figure 1). Although the VT diagnosis was unclear, an ICD implantation was indicated. As the patient weighed only 19.1 kg and was 98 cm tall, a totally extracardiac implantation technique was performed.

Figure 1 Twelve-lead ECG of the spontaneous sustained ventricular tachycardia, with left bundle branch abnormality-like, superior axis morphology at 260 bpm.
The patient was implanted with a single-chamber ICD (Virtuoso™ VR D164VWC, Medtronic Inc.). A defibrillator lead (Transvene™ 6937-35, Medtronic Inc.) was tunnelled subcutaneously from xiphoid process to the level of the sixth rib and placed in a lateral position with a subscapular orientation. A complete sternotomy was performed to access the pericardium and a bipolar steroid-eluting pacing and sensing lead (Capsure Epi 4968-25, Medtronic Inc.) was sutured to the anterior wall of the right ventricle. The ICD device was implanted as an active can in the right upper abdomen. After the implantation, the correct position of the electrode and ICD device was determined (Figure 2). Defibrillation testing was performed, with a 10 J safety margin: 25 J with 93 Ohms impedance.

After 2 years follow-up, the patient gained 6.4 kg, more than 20% of the weight at implantation, and reached a height of 117 cm. A new defibrillation test was performed and 35 J shock was unable to recover the patient from ventricular fibrillation. The ICD device was moved to the thorax in supradiaphragmal intrapleural position to improve the defibrillation vector (Figure 3). The new DFT was 25 J with an impedance of 66 Ohms.

Discussion
Owing to low incidence of SCD in patients under the age of 20 years, only a minor portion of ICD implantations is performed in this population.

Implantation of trans-venous ICDs is not recommended in infants, due to the small vein size and the diameter and length of the electrodes. Nonetheless, several implantation techniques have been applied. One is extracardiac ICD implantation. The study done by Kriebel et al.3 demonstrated that this technique is feasible, considering the defibrillation as well as the sensing and pacing threshold. On the other hand, Bauersfeld et al.4 reported that extracardiac implantation of ICD systems together with intrathoracic position of device optimizes the electrical field and results in a safe and protected device position. Both studies showed that DFT is higher with an extracardiac technique, compared with that of endocardial ICD lead implantation, but still acceptable.

With the child’s growth after the first implantation, a further DFT increase was expected because of the associated defibrillation vector change. The ICD device repositioning from the abdomen to the thorax was needed due to the unsuccessful 35 J shock during the induction test. Positioning the device in the thorax improved the defibrillation vector and decreased the impedance, obtaining an acceptable safety margin, although this case report also underlines the necessity of repeated DFT testing in these ICD patients. The position of ICD device in the thorax was safe, protected and benefited social recovery because the ICD is not visible during everyday activities. However, although no complications were observed in the present case, it would be possible to produce lung atelectasis or pleural adhesions.

Figure 2 Frontal chest roentgenogram showing the extracardiac defibrillator placement (abdominal device).

Figure 3 Frontal and lateral chest roentgenogram showing the subdiaphragmal (intrapleural) placement of the device.
Conflict of interest: none declared.

References

CASE REPORT

Unusual case of initial failure of pacemaker implantation

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Central venous obstruction sufficient to prevent primary pacemaker implantation is rare. We report on such a patient in whom removal of a very large retrosternal goitre led to subsequent procedural success.

Case report
An 86-year-old lady with a history of recurrent syncope from sick sinus syndrome was admitted for implantation of a dual-chamber pacemaker. She was right-handed. A chest radiograph showed a mediastinal mass, presumed to be due to a thyroid goitre (Figure 1A).

At the time of the procedure, the left cephalic vein could not be identified. Passage of a guide wire via the left subclavian vein was blocked beneath the clavicle. Bilateral arm venography was performed. On the right, the subclavian vein was partially occluded with a tight stenosis (Figure 1C) which only opened on abduction of the arm. There was a localized total occlusion of the left subclavian vein with multiple collaterals filling central veins proximally (Figure 1D). Angioplasty to the left subclavian vein with an 8 mm balloon was performed but on withdrawal of the balloon, the vein resumed its original appearance with occlusion, as would be expected with

Figure 1 (A) Chest radiograph in the postero-anterior projection demonstrating the mediastinal mass. (B) Computed tomography of the thorax showing the large retrosternal goitre with displacement of the trachea and oesophagus to the right. (C) Right- and (D) left-sided arm venograms showing occlusion of the subclavian veins with multiple collaterals filling central veins proximally. (E) Photo of the surgically resected thyroid tumour.

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