

IMPLANTATION OF AN ICD AND DFT TESTING IN PATIENT WITH PERSISTENT LEFT SUPERIOR VENA CAVA

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Aim. The implantable cardioverter-defibrillator [ICD] has been proven to reduce the risk of sudden cardiac death through the termination of ventricular fibrillation and life-threatening ventricular tachycardia. The simplest measure of defibrillation effectiveness is the DFT, defined as the lowest delivered shock strength required to defibrillate. Improved technology and use of ICDs for primary prevention have led some to question the need for either defibrillation testing or any assessment of defibrillation efficacy after implantation. Experts disagree about optimal testing because data are insufficient to define the trade-off between accuracy and risk of testing. However there are specific cases in which DFT is necessary.

Material and methods. Authors describe the case of a patient with persistent left *vena cava*, a rare congenital anomaly, with no clinical importance which is usually accidentally revealed during the implantation of pacemaker or when placing a central vascular catheter. However, it represents a major problem and challenge for positioning of the standard pacemaker electrodes.

Results. After a successful implantation via unconventional anatomic path authors carried out DFT testing to check that the device is functioning appropriately.

Conclusion. Persistent left *vena cava* should not represent a contraindication for implantation of complex pacemaker systems such as ICD and DFT testing is advisable in this cases.

Keywords: implantable cardioverter-defibrillator, defibrillation threshold testing, persistent left *superior vena cava*.

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ICD — implantable cardioverter defibrillator, DFT — defibrillation effectiveness testing, VF — ventricular fibrillation, VT — ventricular tachycardia, PLVCS — persistent left *superior vena cava*, VCS — *vena cava superior*, LVEF — Left ventricular ejection fraction, CRP — C-reactive protein, ESR — erythrocyte sedimentation rate, CRT — cardiac resynchronization therapy.

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ИМПЛАНТАЦИЯ ИКД И ТЕСТИРОВАНИЕ ДЕФИБРИЛЛЯТОРА У ПАЦИЕНТА С ПЕРСИСТИРУЮЩЕЙ ЛЕВОЙ ВЕРХНЕЙ ПОЛОЙ ВЕНОЙ

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Цель. Доказано, что имплантируемый кардиовертер-дефибриллятор (ИКД) уменьшает риск внезапной сердечной смерти, снижает частоту фибрилляции желудочков и опасной для жизни желудочковой тахикардии. Самой простой мерой оценки эффективности дефибрилляции является тестирование, определяющее наименьшую ударную силу, которая требуется, чтобы дефибриллировать. Совершенствование технологии и использование ИКД для первичной профилактики привели некоторых к сомнению в необходимости дефибрилляции, либо испытаний или оценки эффективности дефибрилляции после имплантации. Эксперты разошлись во мнениях об оптимальном тестировании, поскольку данных недостаточно, чтобы определить компромисс между точностью и риском тестирования. Однако существуют особые случаи, в которых тестирование необходимо.

Материал и методы. Авторы описывают случай пациента с персистирующей левой верхней полой вены, редкой врожденной аномалией, при отсутствии клинических данных, которые обычно случайно выявляются во время имплантации кардиостимулятора или при размещении центрального сосудистого катетера. Тем не менее, поражение представляет серьезную проблему и требует позиционирования стандартных электродов кардиостимулятора.

Результаты. После успешной имплантации через нетрадиционные анатомические пути авторами проведено тестирование, чтобы проверить, что устройство функционирует должным образом.

Заключение. Персистирующая левая полая вена не является противопоказанием для имплантации ИКД, в этом случае желательно тестирование.

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Ключевые слова: имплантация кардиовертера-дефибриллятора, дефибрилляция, порог тестирования, персистирующая левая верхняя полая вена.

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Introduction, materials and methods

The implantable cardioverter-defibrillator (ICD) has been proven to reduce the risk of sudden cardiac death through the termination of ventricular fibrillation (VF) and life-threatening ventricular tachycardia (VT). Defibrillation threshold (DFT) testing has traditionally been an integral component of ICD implantation [1]. Electrical shocks delivered by ICDs arise from the

discharge of the capacitors through the heart via the high energy electrodes. The main determinant of success of defibrillation is the magnitude of the electric field generated across the heart. Although the magnitude may be very hard to determine because of its dependence on numerous factors, it is usually proportional to the spatial derivative of the voltage. The simplest measure of defibrillation effectiveness is the DFT, defined as the lowest delivered



Figure 1. Venography showing the left caval vein.

shock strength required to defibrillate. The DFT is often determined in a step-down manner, in which shocks of progressively lower intensity are delivered, after VF is induced, and the lowest successful shock strength is defined as the DFT. The step down DFT is a convenient measurement to obtain during implantation and generally correlates with a probability of success of approximately 70%-80%. Historically, a safety margin (a margin between the DFT and the maximum output of the ICD) of 10 J was considered as a minimal implantation criteria. 30-35 J outputs are for most devices, and 20-25 J has been considered the maximum acceptable DFT [2].

Improved technology and use of ICDs for primary prevention have led some to question the need for either defibrillation testing or any assessment of defibrillation efficacy after ICD implantation. Experts disagree about optimal testing because data are insufficient to define the trade-off between accuracy and risk of testing. Overall, sensing and detection issues require induction of VF in about 5% of ICD recipients, testing defibrillation efficacy is required in 20% to 40%, and testing is contraindicated in about 5% because of conditions such as left atrial appendage thrombus, inadequate anesthesia, and inadequate external rescue support [2]. Currently, assessing defibrillation efficacy at implantation is the legal standard of practice and the recommendation of the Heart Rhythm Society [3]. Despite that DFT is not done routinely in majority of cases. Accordingly, findings from the large SIMPLE study demonstrate that those patients who received ICDs without defibrillation testing did as well as those who underwent the standard defibrillation testing at the time of implantation.

Defibrillation testing is typically performed at the completion of the implant procedure, often before or during closure of the ICD pocket. Number of defibrillation testing protocols has been used in the past. Presently it is more common to ensure a repeated successful defibrillation 10 J or more below the maximum output of the device or at least once 15–20 J or more below the maximum output of the device. This testing protocol does not determine the actual defibrillation threshold but does establish defibrillation efficacy [2, 3].

Persistent left *superior vena cava* (PLVCS) represents a rare congenital vascular defect of the venous system, and is usually discovered accidentally. In the early phase of embryogenesis, the venous system is bilateral — meaning that

there are bilateral primitive venous vessels. An anomaly in this phase of embryogenesis is characterized by the existence of bilateral venous system. Usually, besides PLSVC, the right *vena cava superior* (VCS) is also present, with communication between them through the variable *vena inominata*, which can be absent in 70% of cases [4]. In 65% of patients, the right VCS is small in diameter [5]. The overall incidence of PLSVC is 0.3% to 0.5% in general population, 4% of which have other congenital defects [5, 6]. The incidence is similar in patients that need pacemaker therapy, and is 0.47% [7]. The presence of only PLVCS occurs in 1% of patients [8-10]. In relation to the way of the inflow of PLVCS in the heart, there are few anatomic variants:

- PLVCS flowing through the dilated coronary sinus into the right atrium, this variation occurs in over 90% of cases. It can be isolated or associated with other abnormalities of the cardiovascular system.
- Other variations include inflow of PLVCS in the left atrium in two ways:
 - PLVCS empties into the coronary sinus, which has a defect in the wall and communicating with the left atrium;
 - PLVCS flows directly into the roof of the left atrium between the left upper pulmonary vein and the left auricle. This anomaly is always associated with other heart anomalies [6, 7].

Case report

Patient M. B., male, 26 years old, was complaining of dyspnea, fatigue, swelling of the legs. Three months prior to admission he was treated in the regional hospital for infectious syndrome accompanied by symptoms of heart failure due to consequent myocarditis. Left ventricular ejection fraction (LVEF) was then 30%.

Patient was admitted to Clinical Centre Nis due to worsening of heart failure and malignant dysrhythmia on the ECG in the form of VT. Echocardiography showed a dilated left ventricle (63x51 mm) with LVEF of 28%. Routine laboratory parameters were in referent values, including erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP). Twenty-four hours ambulatory ECG monitoring showed frequent ventricular premature beats, individual, polymorphic, as well as ventricular couplets and VT. Since the patient had left bundle branch block, authors decided to implant an ICD device.

In local anesthesia, after puncture of the left subclavian vein operator placed the electrode of the ICD Medtronic Sprint Quattro 6947, 75 cm when the existence of the left persistent left *superior vena cava* was observed (Figure 1). The electrode was placed in the outflow tract of the right ventricle with good parameters of the installation (TR 1.1, R> 9mV, Imp 1075Ω) (Figure 2).

Then the patient was sedated by anesthesiologist and operator carried out the electrophysiology test of the DFT. Authors got DFT on 15 J, with the first successful defibrillation (Figure 3).

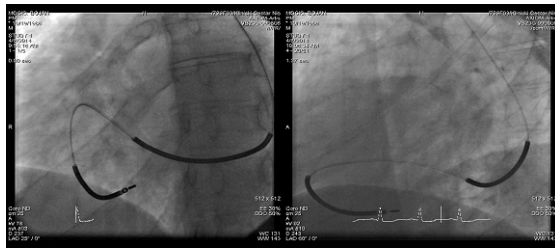


Figure 2. Placing the electrode in the outflow tract of the right ventricle through the persistent left caval vein.

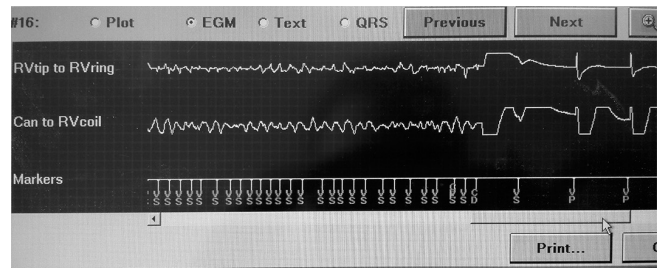


Figure 3. Successful DFT testing with 15J.

It was decided that the electrode is successfully placed in the proper position despite inadequate anatomical path. The presence of the PLVCS did not represent a problem for the successful implantation of the ICD.

Patient gave the written informed consent. All work was done according to the Declarations of Helsinki and Tokyo, and Ethical Committee of the Clinical Centre Nis.

Discussion

Primary prevention of sudden cardiac death refers to patients with myocardial disease and impaired left ventricle with decreased LVEF. Several studies have demonstrated the benefit of an implanted ICD compared to medical therapy. Reduction in LVEF below 35% increases the incidence of malignant arrhythmias not in linear but in exponential manner, so below this threshold significantly higher occurrence of life-threatening rhythm disturbances is expected. MADIT study demonstrated reduction in mortality of 54% in patients with LVEF <35%, and an implanted ICD due to ischemic heart disease. MUSTT study which included patients with decreased LVEF <35% shown that in the group of patients with an ICD reduction in the mortality rate due to arrhythmia was 75% and overall reduction in mortality was 60%. SCD-HEFT study compared the effects of an ICD with antiarrhythmic drug-amiodarone. Patients with an ICD had reduced mortality by 23%. MADIT II study evaluated the benefit of prophylactic ICD implantation in patients with coronary artery disease and LVEF <30%. The patients with an ICD had a mortality reduction of 31% compared to a

group of patients with a conventional therapy [11, 12]. That was the reason why authors decided to place an ICD pacemaker to theirs' patient.

PLVCS is a congenital anomaly with no clinical importance and is usually accidentally revealed during the implantation of electrodes of the temporary or permanent pacemaker or when placing a central vascular catheter, as in authors' patient. However, PLVCS is a major problem and challenge for positioning of the standard pacemaker electrodes. As an alternative to ventricular stimulation, pacing from the coronary sinus can be used since it is readily available in these patients [13]. A particular problem, and sometimes disabling factor, occurs in patients who have indicated ICD implantation or the electrodes of the CRT-P or CRT-D system [13-15]. This was not the case with authors' patient.

DFT testing in this case was done during implantation because of the presence of the anomaly, while the DFT test is not done routinely at Clinical Centre Nis. DFT in the right ventricular outflow tract did not differ in practice from DFT with ICD system where authors placed electrodes at the apex of the right ventricle.

Conclusion

The presence of persistent left *superior vena cava* is not contraindication for a successful implantation of complex pacemaker systems such as an ICD. Defibrillation testing is advisable during at or following ICD implantation to assure the physician that the device is functioning appropriately and that it will deliver needed therapy in the future.

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