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ELECTROPHYSIOLOGY

CASE REPORT: CLINICAL CASE

S-ICD Implantation in Secondary Prevention in a Young Patient With Recent Surgically Repaired Pectus Excavatum

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ABSTRACT

We report a case of successful implantation of a subcutaneous implantable cardioverter-defibrillator in a young patient with severe pectus excavatum presenting with out-of-hospital ventricular fibrillation arrest who was recently surgically repaired with a MIRPE-Nuss procedure. No complications in lead positioning were observed, and the device was tested to determine that it functioned properly. (J Am Coll Cardiol Case Rep 2024;29:102231) © 2024 The Authors. Published by Elsevier on behalf of the American College of Cardiology Foundation. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

HISTORY OF PRESENTATION

A 16-year-old previously healthy boy suddenly collapsed while resting at a mountain hut after skiing and was immediately successful resuscitated by emergency personnel. Ventricular fibrillation (VF) was detected and treated through automated external defibrillator with the delivery of 2 shocks (**Figures 1A and 1B**) and a prompt return of spontaneous circulation. After initial evaluation at a nearby hospital, he was referred to our tertiary cardiac center.

LEARNING OBJECTIVES

- To evaluate patients with severe PE and ventricular arrhythmias.
- To assess feasibility of S-ICD treatment following PE surgical correction with intrathoracic metal bars.

PAST MEDICAL HISTORY

Physical examination on admission showed a deformity of the anterior thoracic cage consistent with pectus excavatum (PE), but he denied any previous cardiopulmonary symptoms, family history of sudden cardiac arrest (SCA) or any abuse.

DIFFERENTIAL DIAGNOSIS

The patient was admitted to our intensive care unit without any neurological sequelae and underwent several investigations to determine the cause of SCA (**Figure 2**).

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ABBREVIATIONS AND ACRONYMS

HI = Haller index

MIRPE = minimally invasive pectus excavatum repair

PE = pectus excavatum

SCA = sudden cardiac arrest

S-ICD = subcutaneous implantable cardioverter-defibrillator

VF = ventricular fibrillation

VT = ventricular tachycardia

INVESTIGATIONS

His initial post-resuscitation electrocardiogram (ECG) showed sinus rhythm, with a rSr′ pattern in the anterior chest leads and negative T waves in the inferior and anterior chest leads (III, aVF, V_2, and V_3) that were not present in previous ECG as previously (Figures 1A and 1C) and disappeared during the following hospital stay (Figure 1D).

Chest computed tomography and cine cardiac magnetic resonance imaging confirmed a severe PE and a relevant cardiac compression of the right ventricle (especially of right ventricle outflow tract), but no signs of delayed enhancement or other structural heart abnormalities were found (Figures 2 and 3).

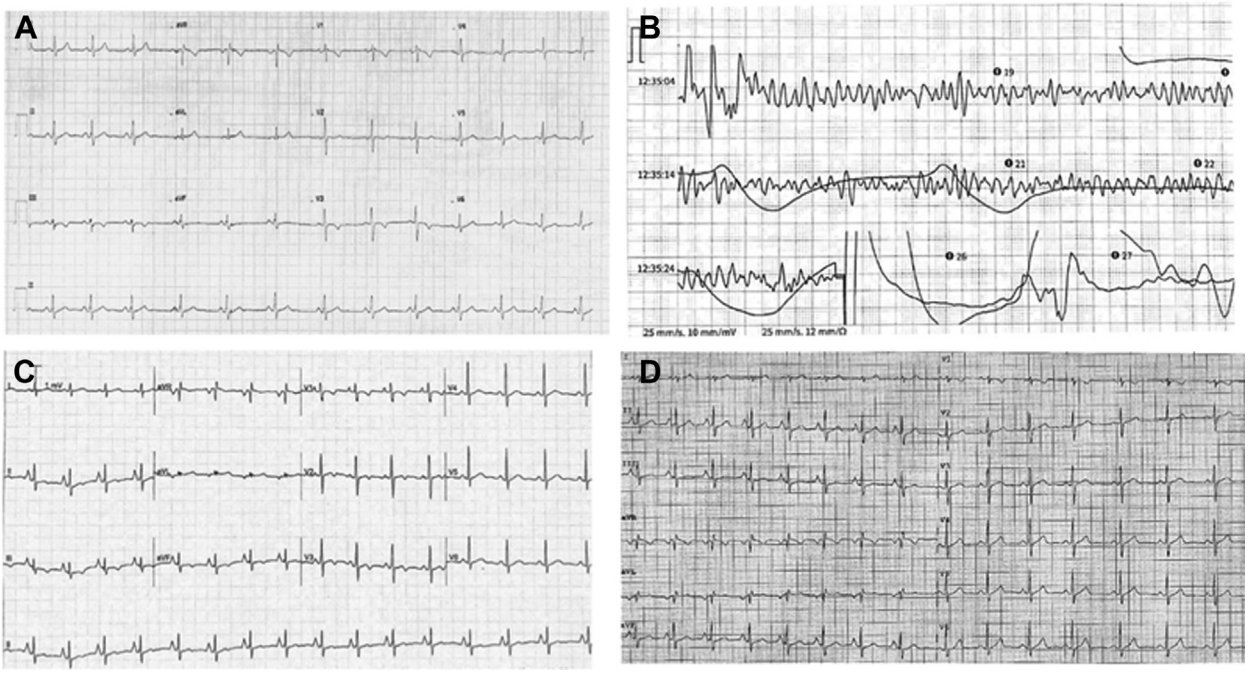
MANAGEMENT

Following extensive work-up, a clear reversible cause of SCA was not identified, and we hypothesized that the right ventricular compression resulting from PE could be related to the arrhythmic event. Considering its severity (Haller index [HI] = 5; cardiac compression index = 2.30) (Figure 4), a surgical repair of PE was performed using the minimally invasive pectus excavatum repair (MIRPE)-Nuss technique[1] (Figures 5A and 5B) with the placement of 2 intrathoracic support bars that forcefully pushed the sternum and the defect anterior.

However, given the unpredictability of a VF recurrence, a subcutaneous implantable cardioverter-defibrillator (S-ICD) was scheduled to be implanted 11 days after the repair.

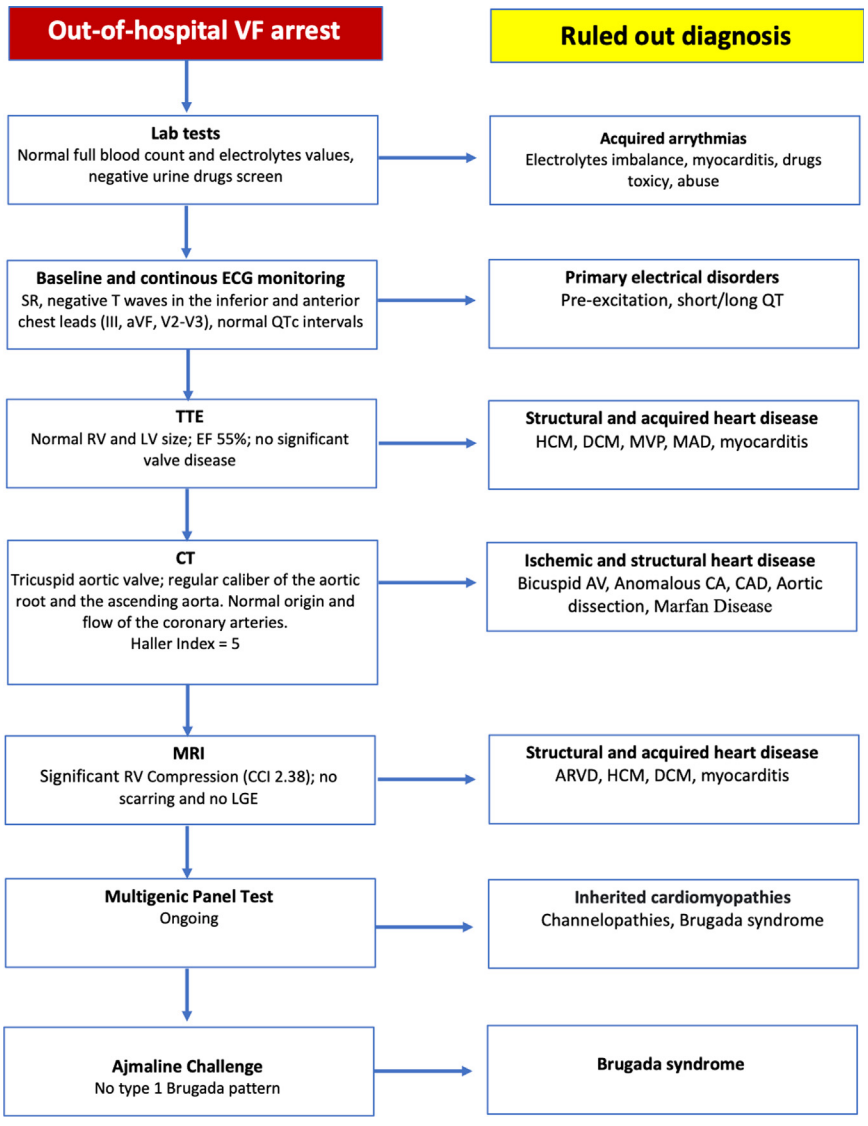
Preimplantation evaluation comprised electrocardiographic screening that confirmed the adequacy of the primary and the alternative vector in the left parasternal position and a technical assessment of the possible interferences of the metal bars with a correct device functioning. Signal detection during sinus rhythm or ventricular tachycardia (VT)/VF and shock delivery could be affected by the proximity between the ICD system and the bars, leading to inappropriate therapies. Following a standardized approach with ultrasound-guided serratus anterior plane block and parasternal block combined with the intermuscular 2-incision technique,[2] the defibrillation lead was

FIGURE 1 ECG Tracings



(A) Before ventricular fibrillation arrest. (B) Ventricular fibrillation recorded by automated external defibrillator with shock delivery. (C) Immediately after sudden cardiac arrest. (D) Electrocardiogram (ECG) during hospital stay (disappearance of negative T waves).

FIGURE 2 Diagnostic Work-Up



Diagnostic work-up performed in order to rule out differential diagnosis of cardiac arrest. ARVC = arrhythmogenic right ventricular cardiomyopathy; AV = aortic valve; CA = cardiac arrest; CAD = coronary artery disease; CCI = cardiac compression index; CT = computed tomography; DCM = dilated cardiomyopathy; ECG = electrocardiograph; EF = ejection fraction; HCM = hypertrophic cardiomyopathy; LGE = late gadolinium enhancement; LV = left ventricular; MAD = mitro-annular disjunction; MRI = magnetic resonance imaging; MVP = mitral valve prolapse; RV = right ventricle/ventricular; SR = sinus rhythm; TTE = transthoracic echocardiography; VF = ventricular fibrillation.

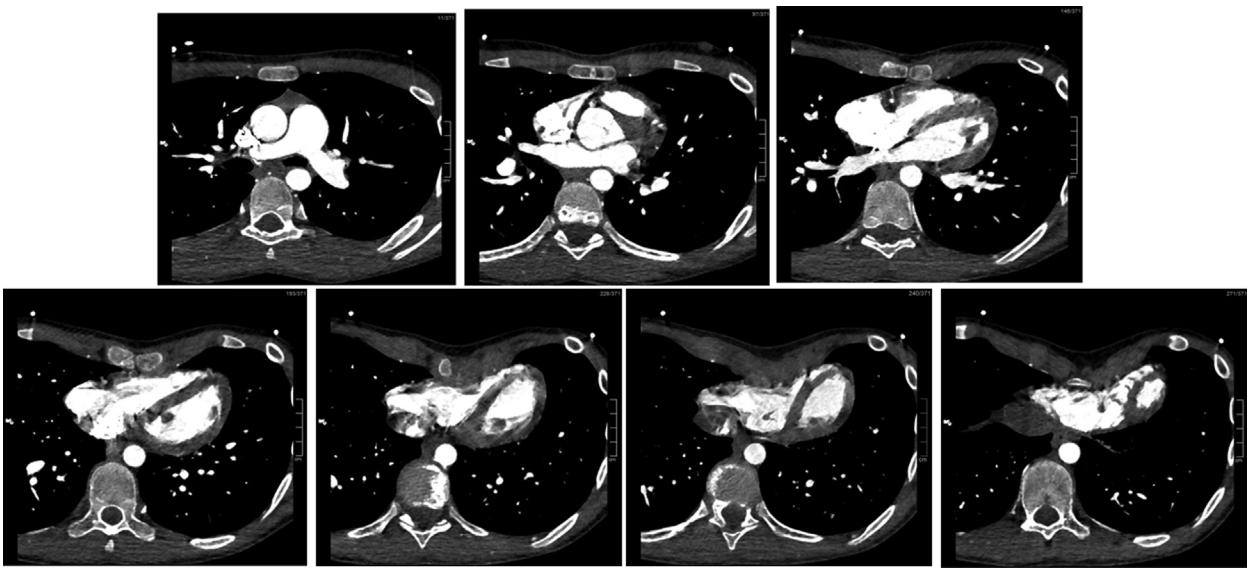
successfully placed in left parasternal line avoiding the proximity to the sternal bars recently implanted (Figure 5C).

The S-ICD was then positioned between the serratus anterior and the latissimus dorsi muscles, as posterior as possible to the bars (Figure 5C).

At the end of the procedure, induced VF was successfully terminated by a 65 J shock (38 Ω impedance) 13 seconds after the initial detection.

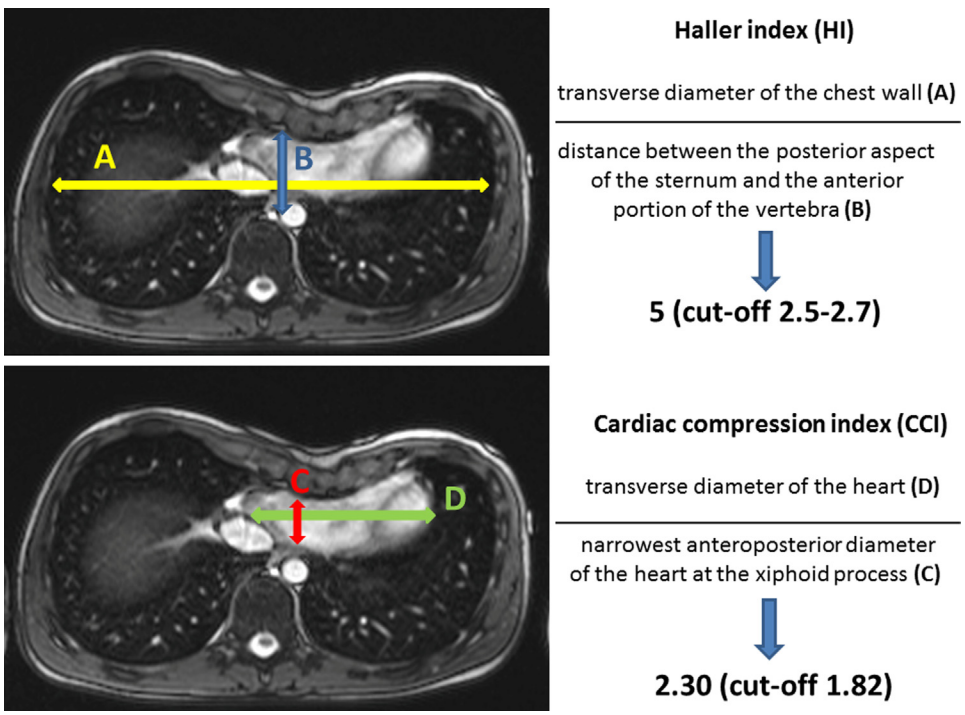
Optimal lead position was fluoroscopically confirmed in 2 projections (Figure 5C), and the device was adequately programmed.

FIGURE 3 Cardiac CT Scans



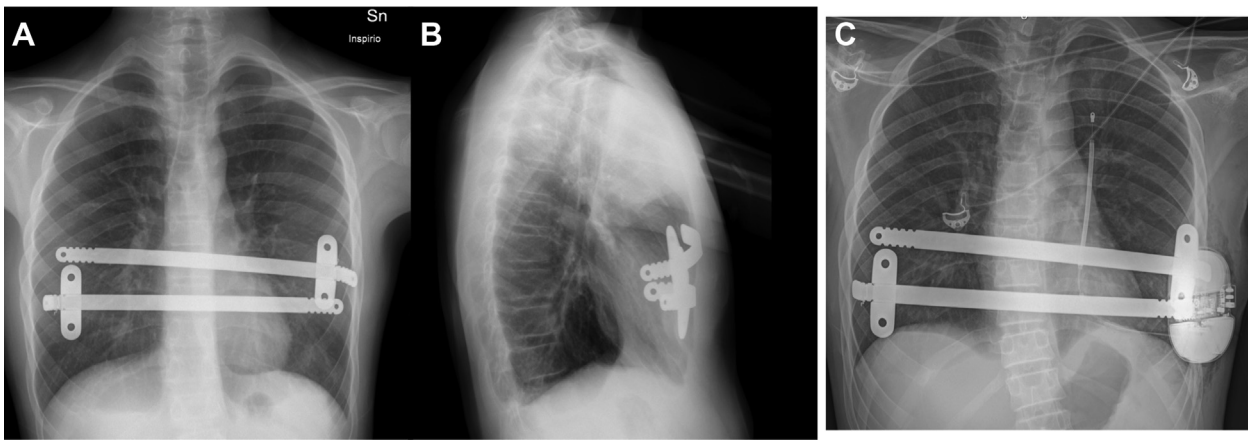
Significant RV compression at different levels. Abbreviations as in Figure 2.

FIGURE 4 HI and CCI Measured at MRI



MRI measurements: HI = 5; CCI = 2.30. HI = Haller index; other abbreviations as in Figure 2.

FIGURE 5 Chest Radiography



(A) Postero-anterior and (B) Latero-lateral projections showing the metal bars inserted with Nuss procedure. (C) After subcutaneous implantable cardioverter-defibrillator implantation.

DISCUSSION

To the best of our knowledge, this is the first experience of successful S-ICD implantation in secondary prevention in a young patient with severe PE previously (11 days) surgically repaired with MIRPE-Nuss technique.

PE is the most common anterior chest wall deformity and is generally considered a benign condition with most cases remaining completely asymptomatic.[1] Depending on its severity, a significant cardiac compression has been described, leading to structural or hemodynamic consequences that may be also proarrhythmic; however, limited data are available about these arrhythmias and very little is known on the best treatment strategy in these patients.[3-8]

Exertional and monomorphic sustained VTs associated with severe PE have been solved either with surgical correction alone or in 1 case, together with catheter ablation,[3,4] whereas only 3 cases of severe PE presenting with SCA due to VF have been previously reported.[5-7]

The impaired cardiac function resulting from decreased preload and output was advocated as a reversible cause of VF in a young patient with PE while bending forward and therefore only a modified Ravitch procedure was performed.[7] Conversely, Hamoud et al[5] opted for an implant in secondary prevention of a S-ICD in a young patient with severe PE presenting with out-of-hospital VF arrest, without PE surgical repair.[5]

Although a successful management with pectus correcting surgery alone without ICD placement has been attempted for monomorphic VT,[3] a VF recurrence at long-term follow-up in such young patients without a well-recognized structural or electrical cardiac disorder cannot be excluded even after a PE surgical repair, and ICD implantation in secondary prevention should be considered.[8]

Surgical repair is currently recommended when HI is more than 3.25 (normal 2.5-2.7) or correction index is more than 10%,[1] as well as in presence of any evidence of cardiopulmonary impairment. Our patient met the criteria (HI = 5; cardiac compression index = 2.30) (**Figure 4**) and underwent MIRPE-Nuss repair, placing pectus bars under the abnormally depressed sternum, followed by S-ICD implantation after extensive work-up without identification of a clear reversible cause of SCA.

ICDs are standard and effective treatment to prevent SCA due to ventricular arrhythmias; however, transvenous leads have been associated with both short- and long-term complications, occasionally requiring removal.[8] S-ICDs have been developed to overcome these complications, especially in young patient with long life expectancy, avoiding the need for transvenous lead and ensuring the delivery of life-saving defibrillation therapy.

Implantation of S-ICD in patients with PE has been recently reported as safe and effective;[9] however, this is the first description of such procedure in a young patient with severe PE a few days after surgical correction through MIRPE-Nuss technique.

The presence of recently inserted pectus bars aiming to repair the anatomical chest abnormalities lifting up the sternum may represent an obstacle to

the adequate positioning of the defibrillation catheter, to the correct cardiac signal detection, and to the effective shock defibrillation delivery.

Our experience demonstrated for the first time the feasibility and safety of S-ICD implantation with the intermuscular 2-incision technique even after a surgical PE repair with bars.

FOLLOW-UP

The post-operative period was uneventful, and the patient was discharged the following day post-implantation. At the 6-month follow-up, continuous remote monitoring reported no arrhythmic events.

CONCLUSIONS

S-ICD has the advantage of delivering life-saving defibrillation therapy without the need for transvenous leads and related long-term complications and, therefore, represents the preferred treatment strategy in young patients who have no pacing requirements. However, its implantation may be more challenging in patients with severe chest abnormalities treated with surgical repair because the presence of metal bars inserted under the sternum could interfere with lead positioning and device functioning.

We reported that the implantation of an S-ICD is feasible and safe even in the case of a young patient with severe PE presenting with out-of-hospital VF arrest that was surgically corrected with MIRPE-Nuss procedure.

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KEY WORDS electrophysiology, Nuss procedure, pectus excavatum, right ventricle, secondary prevention, S-ICD, sudden cardiac arrest, ventricular fibrillation