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CASE REPORT

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Cardiac resynchronization therapy defibrillator upgrade with the atrial and left ventricular leads introduction through the persistent left superior vena cava facilitated by the balloon angioplasty

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Abstract

The persistent left superior vena cava is the systemic venous system malformation observed in 0.1–0.5% of the general population. It can result in many obstacles in pacemaker implantation.

The report presents a case of a 62-year-old male patient who underwent an upgrade of his implantable cardioverter-defibrillator to a cardiac resynchronization therapy defibrillator. The patient initially had a one--chamber cardioverter-defibrillator implanted in 2014. Due to advanced symptomatic dilated cardiomyopathy co-existing with significant nonspecific intraventricular conduction delay, the patient was qualified for a device upgrade in 2023, i.e. implantation of additional atrial and left ventricular electrodes. The obstruction in the brachiocephalic vein and the presence of the persistent left superior vena cava were revealed in the course of the procedure. The result was a successful upgrade to cardiac resynchronization therapy defibrillator with the combination of the defibrillation right ventricular lead implanted originally through the right superior vena cava and the atrial and left ventricular electrodes implanted through the persistent left superior vena cava.

The presented case describes the acceptable approach in the course of implantable cardioverter-defibrillator upgrade to cardiac resynchronization therapy defibrillator in the case of the persistent left superior vena cava and the brachiocephalic vein obstruction.

Keywords: cardiac resynchronization therapy; persistent left superior vena cava; venous malformation; electrotherapy

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Introduction

Cardiac implantable electronic device implantations are usually performed transvenously. The typical access is the subclavian or axillary vein that enables reaching the right heart through the superior vena cava. The persistent left superior vena cava is the systemic venous system malformation observed in up to 0.5% of the general population [1]. In 80–90% of cases, it coexists with the right superior vena cava [2]. The presence of the persistent left superior vena cava is usually asymptomatic and it is diagnosed incidentally, e.g. during venography. There is evidence that this anomaly correlated with atrial fibrillation onset [3]. The

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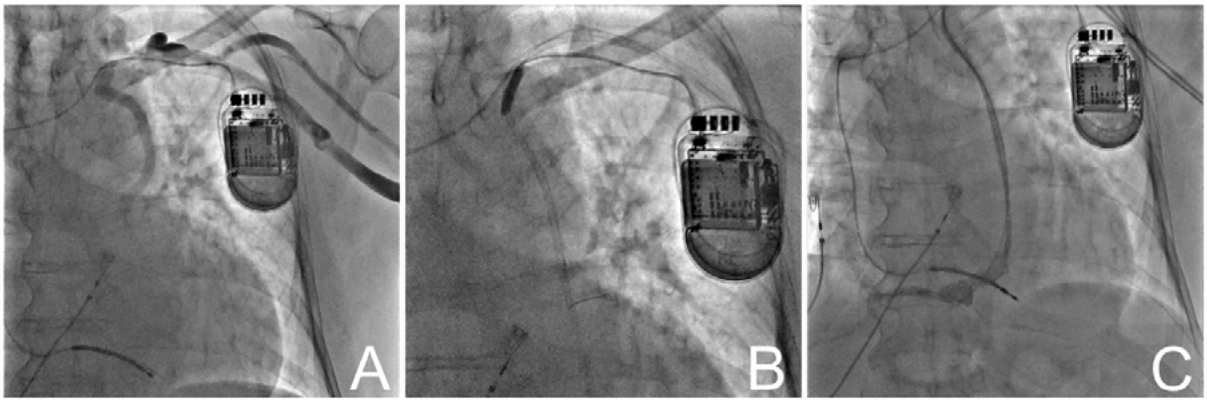

Figure 1. A. Venography of the left subclavian vein revealing persistent left superior vena cava; **B.** Angioplasty of the persistent left superior vena cava; **C.** Venography of the coronary sinus

presence of the persistent left superior vena cava may result in many difficulties in pacemaker implantation due to the unfavourable angle of entering the heart chambers [4]. There are numerous reported cases of pacemaker implantations through the persistent left superior vena cava [5–7], including the cardiac resynchronization therapy upgrade [8, 9] and the left bundle branch pacing [10, 11]. However, no cases have been found describing atrial and left ventricular leads introduced through persistent left superior vena cava co-existing with right ventricular lead through right superior vena cava.

Case report

We present a case of a 62-year-old man who underwent upgrading his implantable cardioverter--defibrillator to a cardiac resynchronization therapy defibrillator. The patient was diagnosed with dilated cardiomyopathy, and he had a one-chamber implantable cardioverter-defibrillator implanted in 2014 as the primary prevention of sudden cardiac death. There were no adverse events or anatomical anomalies reported in the course of the first implantation. In 2023, due to symptomatic (NYHA III) low ejection fraction (LVEF 24%) co-existing with significant nonspecific intraventricular conduction delay (QRS 160ms), the patient was qualified for a cardiac implantable electronic device upgrade to cardiac resynchronization therapy, i.e. implantation of additional atrial and left ventricular electrodes. The venography performed in the course of the upgrade procedure confirmed the obstruction in the brachiocephalic vein, which was the consequence of thrombosis due to the hitherto presence of a lead in the venous system, however, it simultaneously revealed the presence of the persistent left superior vena cava (Fig. 1A). It is suggested that obstruction in the brachiocephalic vein promoted the blood flow through the persistent left superior vena cava, which was unnoticed during the first procedure when the brachiocephalic vein was unobstructed. The persistent left superior vena cava was however stenosed at the point of the inlet. That is why, the balloon angioplasty (NC 5.0 mm × 20 mm) was performed to restore full blood flow through the persistent left superior vena (Fig. 1B). This way coronary sinus was visualized in venography (Fig. 1C).

The persistent left superior vena was then used to introduce the atrial lead into the right atrium (Fig. 2 A). The atrial electrode was implanted on the free right atrial wall instead of the atrial appendage which is caused by a different angle of introducing the lead into the atrium which resulted in acceptable stimulation parameters (3.3 V at 0.5 ms) [7]. Then the left ventricular lead was introduced. The first location in the lateral vein was not optimal due to insufficient pacing parameters (Fig. 2B) so the left ventricular lead was inserted into the intermedia vein where the pacing parameters were acceptable (LV2-LV4 2.7 V at 1.5 ms) (Fig. 2C).

The location of the leads remained stable in the control X-ray before the discharge (Fig. 3). The stimulation parameters at the discharge were also acceptable (atrial: 2,75 V at 0,5 ms; right ventricle: 2,5 V at 0,5 ms; left ventricle: 3,5 V at 1,4 ms).

Discussion

There are three main types of central venous system according to classification by Schummer et al.: I — normal anatomy; II — only persistent left superior vena cava; and III — coexisting right and persistent left superior vena cava — with connection (IIIa) or without connection (IIIb) [12]. The persistent left superior vena cava is the most common systemic venous system malformation. On the other hand, it is observed only in 0.1–0.5% of the general population [1]. Moreover, type

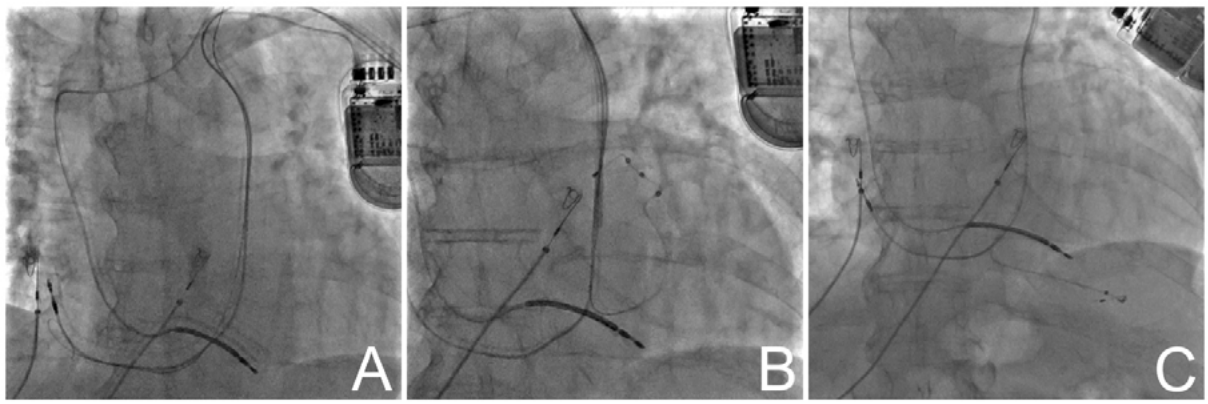

Figure 2. A. The position of atrial lead; **B.** Left ventricular lead; **C.** Repositioned left ventricular lead

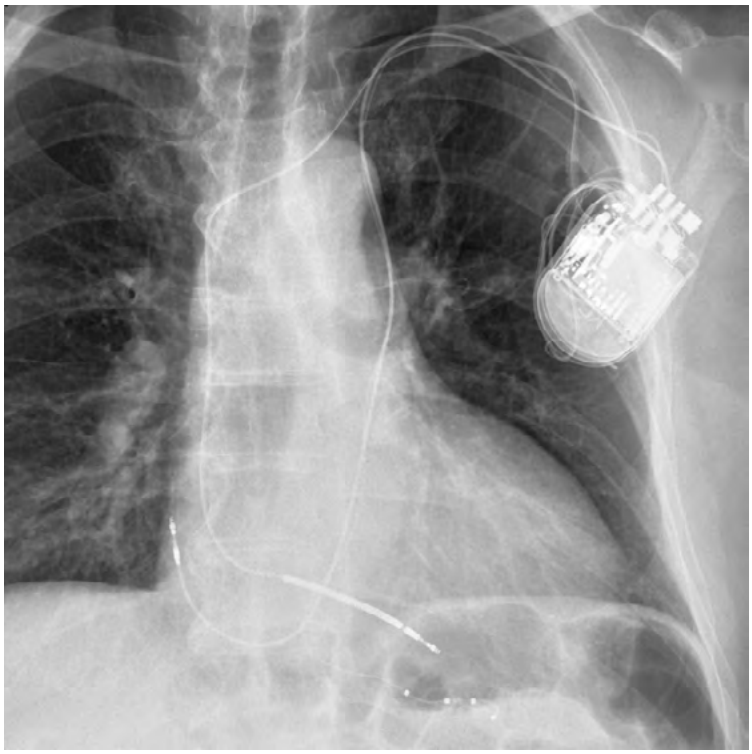

Figure 3. X-ray after procedure showing the proper location of leads

III is observed in 80–90% of the cases of the persistent left superior vena cava [2]. The persistent left superior vena cava is usually asymptomatic and its diagnosis is made incidentally during invasive procedures, e.g., pacemaker implantations. Due to different connections between veins, the presence of the persistent left superior vena cava may result in many difficulties in pacemaker implantation due to the unfavourable angles of entering the heart chambers [4]. That is why, if an atrial lead is implanted through the persistent left superior vena cava, it is usually fixed on the free right atrial wall instead of the atrial appendage [7]. In the presented case atrial lead was also positioned at the free wall. Such a location is more prone to dislocations.

There are reported cases of pacemaker implantations through the persistent left superior vena cava [5–7], including cardiac resynchronization therapy [8, 9] and the left bundle branch pacing [10]. Nonetheless, most of them are primary implantations in type II by Schummer i.e. in only persistent left superior vena cava without right superior vena cava. The persistent left superior vena cava drains to the coronary sinus in many cases, so it is used as direct access to the target point [13].

There are cases of the upgrade from a dual chamber cardioverter-defibrillator to a cardiac resynchronization defibrillator with a brachiocephalic vein and congenital coronary sinus occlusions [9, 14]. In one of the described cases, operators decided to perform balloon angioplasty of a narrow persistent left superior vena cava which communicated with coronary sinus after the congenital occlusion [9]. This way the operators were able to introduce left ventricular lead from the persistent left superior vena cava to the coronary sinus. This approach was possible as in both mentioned cases, only left ventricular leads were implanted, as the patients had already received a dual chamber cardioverter--defibrillator through the right superior vena cava.

Moreover, due to the already mentioned unfavourable access to the right atrium, atrial lead introduction and fixation are particularly difficult in this group. Two leads cardiac resynchronization therapy (only right and left ventricle stimulation) is not a common approach, however, there is a case of a cardiac resynchronization therapy defibrillator implantation through the persistent left superior vena cava without atrial lead. Nonetheless, this approach can raise concerns regarding atrial--guided pacing in patients with preserved sinus rhythm [15]. Another interesting approach is presented when unfavourable angles are dealt with by the right-sided approach [11, 13]. This access can be used in III type, when the right vena cava is present and when the right--sided implantation is a primary procedure. When the persistent left superior vena cava is directly communicating with the coronary sinus, a left-sided approach can provide access to the implantation of all the leads especially in type IIIb when the persistent left vena cava does not communicate with the brachiocephalic vein [16]. In such cases, there are suggestions that bilateral venography can be helpful in decision-making for the side and vein of the lead insertion [17]. In the presented case brachiocephalic vein occlusion disrupted communication between the right and the persistent left superior vena cava, and the presence of a right-ventricular defibrillation electrode at the left side promoted the left-side approach.

Altered topography results in atypical angles during lead introduction, which consequences in a longer time of procedure [18]. That is why the implantation procedures in patients with the persistent left superior vena cava are potentially at a higher risk of complications compared to type I morphology. This can potentially increase the risk of early complications such as bleeding or infections, as well as dislocations [19]. The number of reported cases of cardiac electronic device implantations in patients with the persistent left superior vena cava is however limited, so there are no overall statistics that summarize these complications in this group of patients or any analyses of whether the persistent left superior vena cava itself can be a potential factor for selected complications.

Conclusions

The presented procedure resulted in a successful upgrade from a one-chamber cardioverter-defibrillator to a cardiac resynchronization therapy defibrillator with implantation of both atrial and left ventricular electrodes through the persistent left superior vena cava after the balloon angioplasty of its stenosed inlet. This case shows a rare example of cardiac pacing system implantation in a patient with central venous system malformation and thrombosis of the brachiocephalic vein. The described procedure is a feasible method of implantable cardioverter-defibrillator upgrade to cardiac resynchronization therapy defibrillator in the case of the persistent left superior vena cava and the brachiocephalic vein obstruction.

Article information and declarations

Ethics statement: The principles of the Helsinki Declaration have been respected. The case report did not require an Ethics Board opinion.
Author contributions: MS, TC, JPK, PB: conceptualization; JPK: data curation; TC, MS: procedure performance; PB, MS, TC, JPK: resources; JPK: visualization; JPK: writing — original draft; JPK, PB, TC, MS: writing — review & editing.
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