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CASE REPORT
Other

Proposed treatment algorithm for cardiac device-related subclavian vein stenosis: a case series

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Background Subclavian vein obstruction may occur in patients with pacemaker leads, which may make the implantation of new pacemaker leads difficult.

Case summary We report two cases in which upgrading to cardiac resynchronization therapy pacemaker was challenging due to total central vein occlusion. In the first case, a 78-year-old woman with permanent pacemaker implantation, 5 years ago, was successfully treated by balloon venoplasty. In the second case, balloon venoplasty was unsuccessful in a 46-year-old woman who has received twice single-chamber implantable cardioverter-defibrillator, 12 years and 5 years ago, due to vessel crowding, so a contralateral side puncture, along with a tunnel technique, was performed to solve this problem.

Discussion Cardiac implantable electronic device-related subclavian vein stenosis can present a challenge to common cardiac resynchronization therapy device upgrades in the absence of appropriate techniques.

Keywords Case series • Subclavian vein obstruction • Pacemaker • Upgrade surgery

Learning points

- Carefully inspect venography before the procedure is important, especially presence of previous cardiac implantable electronic device.
- If stenosis exists, balloon angioplasty, previous leads extraction, or contralateral implantation can be an option.
- Following proposed treatment algorithm, implanting physicians can manage implantation logically.

Introduction

Venous complications of cardiac implantable electronic devices rarely cause immediate clinical problems; however, a fraction of patients develops severe stenosis or occlusion of the deep veins of an upper extremity.[1] It was reported that subclavian vein obstruction in patients with pacemaker leads is not uncommon, occurring in 13–35% of patients.[2] When upgrading a pacemaker system to a cardiac resynchronization therapy pacemaker (CRT-P) or cardiac resynchronization therapy defibrillator (CRT-D), such obstructions can make the implantation of new pacemaker leads difficult.

Herein, we report two cases in which upgrading to CRT-P was challenging due to total central vein occlusion. In the first case, a 78-year-old woman was successfully treated by balloon venoplasty. In the second case, balloon venoplasty was unsuccessful in a 46-year-old woman due to vessel crowding, so a contralateral side puncture, along with a tunnel technique, was performed to solve this problem.

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Timeline

Case no. 1	
May 2014	Diagnosed complete atrioventricular node block and received implantation of a permanent pacemaker with DDD mode (Biotronik)
January 2018	Complaints of dyspnoea on exertion
	Physical examination: crackles heard over the lung bases and bilateral lower extremity pitting oedema
	electrocardiogram (ECG): sinus rhythm with left bundle branch block (LBBB) pattern
	Transthoracic echocardiography: reduced left ventricular ejection fraction (LVEF) of 24%
January 2018 to July 2018	Symptoms of heart failure progressed under optimal medication control
July 2018	Performed cardiac resynchronization therapy (CRT) upgrade due to symptomatic heart failure in sinus rhythm with a QRS duration ≥150 ms, LBBB QRS morphology and with LVEF ≤35% despite optimal medication
Follow-up	Classified as Class I according to the New York Heart Association system
	ECG: sinus rhythm with narrow QRS
	Transthoracic echocardiography: preserved LVEF of 62%
Case no. 2	
November 2007	Received single-chamber implantable cardioverter-defibrillator (ICD) due to history of dilated cardiomyopathy with a reduced LVEF of 30% and sustained ventricular tachycardia
June 2014	Implanted second ICD lead after the first dysfunction
December 2014	Implanted a third right ventricular lead for sensing and pacing of the second device failed
December 2014 to	Symptoms of heart failure progressed under optimal medication control
November 2018	ECG: sinus rhythm with LBBB pattern
	Transthoracic echocardiography: reduced LVEF of 20%
November 2018	Performed CRT upgrade with right atrium lead (Medtronic) from the right side, tunnelling to the left pocket of the previous ICD
Follow-up	Classified as Class I according to the New York Heart Association system
	ECG: sinus rhythm with narrow QRS
	Transthoracic echocardiography: improved LVEF of 40%

Case presentation

Illustrative case no. 1

A 78-year-old woman with congestive heart failure with left ventricular ejection fraction (LVEF): 40% was diagnosed with complete atrioventricular node block after implantation of a permanent pacemaker in DDD mode (Biotronik) on 6 May 2014. There was no other past medical history in this patient. She presented with dyspnoea on exertion that had been occurring for 1 year. The physical examination revealed third heart sound, bilateral rales, and peripheral oedema, and the chest X-ray revealed bilateral pulmonary oedema. Heart failure with a reduced EF of 24% was noted and designated as Class III according to the New York Heart Association system. She was administered with optimal medication for heart failure (Ramipril 10 mg bid, Carvedilol 25 mg bid, Spironolactone 50 mg od, and Furosemide 40 mg od). A 12-lead electrocardiogram (ECG) showed a ventricular pacing rhythm with QRS duration >150 ms. To remedy this problem, she was admitted for a CRT upgrade.

As shown in *Figure 1A*, venography demonstrated total vessel occlusion, with azygos vein collateral drainage with the previous two leads. We punctured as far as the occlusion site and inserted a 0.035-in Terumo wire (Terumo Corporation, Tokyo, Japan), but could not move the wire past the lesion, even after switching to a V18 control wire (Boston Scientific, Boston, MA, USA), because the wire was not stiff enough. We then inserted a 5-Fr short sheath (Terumo) and performed balloon venoplasty using a Mustang balloon (6.0/40 mm, Boston Scientific). A stiffer guidewire (Terumo) was used simultaneously to advance an 8-Fr long sheath past the lesion under the support of a 9-Fr short sheath. The left ventricular (LV) lead (Medtronic, Dublin, Ireland) was implanted without difficulty. The total fluoroscopy time was 40 min, and total procedure time was 110 min. The ECG showed a narrow QRS pattern with duration of 88 min. The patient was discharged without incident, and a 3-month follow-up echocardiogram showed preserved LVEF of 62% and sinus rhythm with narrow QRS in an ECG. At a routine pacemaker programming visit, the condition of the leads was stable and all parameters were normal. The patient's symptoms had also improved.

Illustrative case no. 2

A 46-year-old woman had a history of dilated cardiomyopathy with a reduced LVEF of 30% and sustained ventricular tachycardia. The baseline ECG had a narrow QRS complex. She had received a single-chamber implantable cardioverter-defibrillator (ICD) through the left subclavian vein in 2007, and a second ICD lead (Medtronic) in

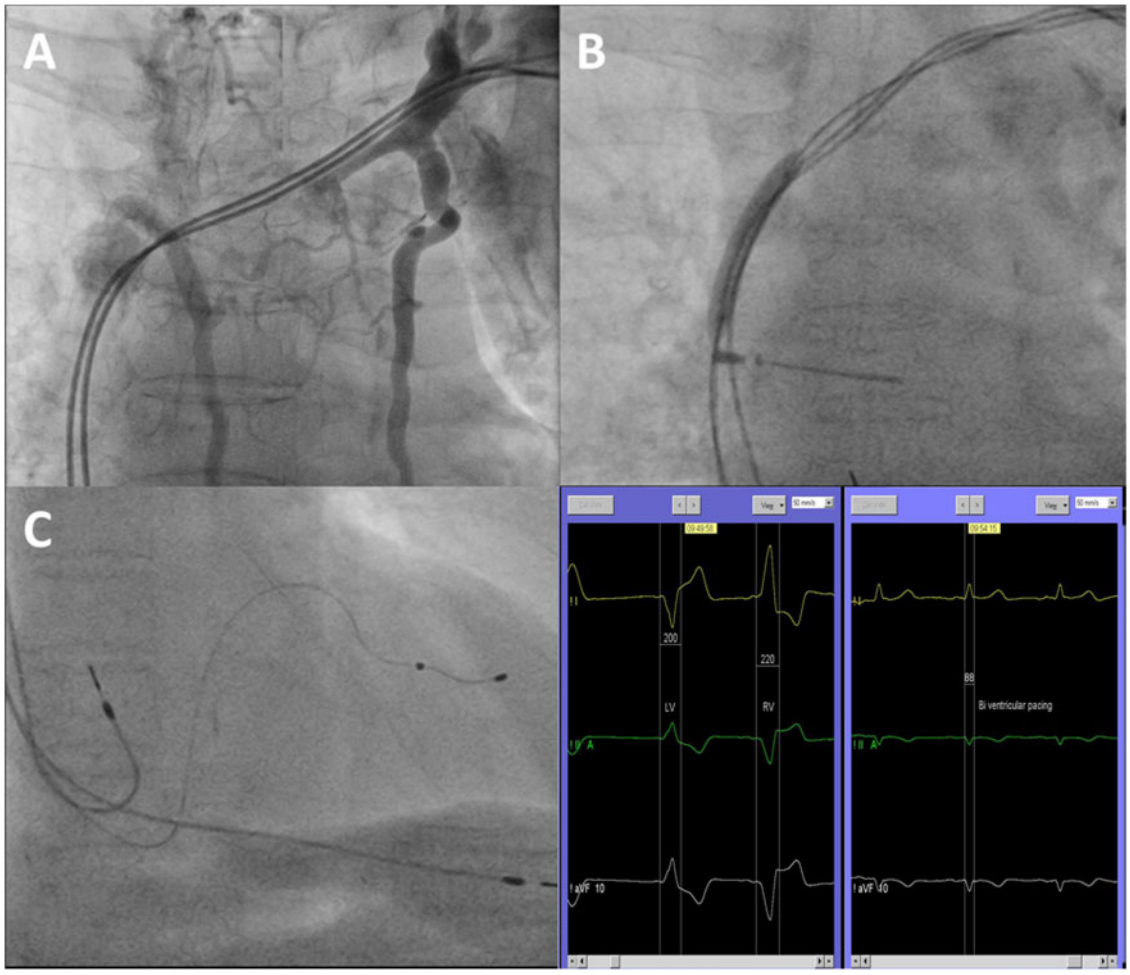

Figure 1 (A) Venography demonstrating total occlusion with azygos vein collateral drainage with the previous two leads. (*B*) Balloon venoplasty performed using a Mustang balloon (6.0/40 mm). (*C*) Implantation of left ventricular lead. (*D*) Bedside electrocardiogram immediately showed narrow QRS pattern.

2014 after the first failed. When sensing and pacing of the second device failed, we implanted a third right ventricular lead. The QRS complex remained narrow after first and second implantation.

Despite the optimal medical care (Valsartan 160 mg bid, Carvedilol 25 mg bid, Spironolactone 50 mg od, and Furosemide 40 mg bid), her LV systolic function deteriorated to EF 20%. The 12-lead ECG showed a wide QRS duration of 168 min and a typical left bundle branch block pattern. There's no other past medical history except heart failure. We decided to upgrade her ICD to CRT-D. Venography demonstrated subclavian vein stenosis with collateral drainage to the internal jugular vein with the previous leads (*Figure 2A*). We successfully cannulated the coronary sinus ostium and implanted a bipolar LV lead (Medtronic).

Unfortunately, the right atrium (RA) lead could not pass through the limited space of the left subclavian vein (*Figure 2B and C*), even after successful balloon angioplasty using a Terumo 0.035 wire and a Mustang balloon (4.0/60 mm). The patient refused both replacement of the device with an implant on the contralateral side and extraction of the previous leads due to health insurance coverage issues. Instead, we successfully implanted the RA lead (Medtronic) via incision in the right side and tunnelling to the left pocket of the previous ICD using fluoroscopic guidance. The total fluoroscopy time was 30 min, and the total procedure time was 180 min. A post-procedure chest X-ray confirmed good lead position and no pneumothorax (*Figure 2D*).

The patient was discharged and showed improved LV function, with EF increasing to 40% 6 months later and sinus rhythm with narrow QRS. A routine pacemaker programming visit showed that the condition of the leads was stable and all parameters were normal. The patient's symptoms have also improved.

Discussion

Subclavian vein stenosis/occlusion is a known complication following transvenous cardiac implantable electronic device (CIED) insertion. In case no. 1, venography revealed total subclavian vein occlusion

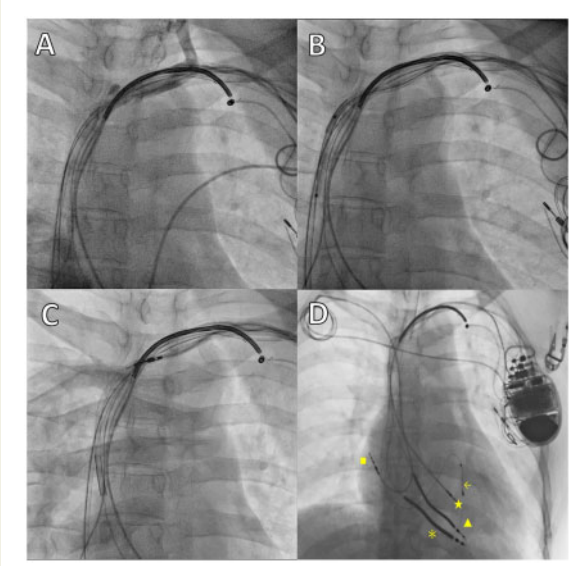

Figure 2 (A) Venography demonstrated subclavian vein stenosis with collateral drainage to internal jugular vein with previous leads. (*B*) Balloon anchoring technique performed using a Mustang balloon (6.0/40 mm) and long sheath to bypass the stenosis site. (*C*) Although the sheath could bypass the lesion, the right atrium lead could not pass due to occupied vessel. (*D*) Intra-procedure fluoroscopy shows the functional implantable cardioverter-defibrillator lead (*), previous implantable cardioverter-defibrillator lead (▲), left ventricular lead (←), right ventricular lead (★), and right atrium lead (■).

with azygos vein collateral drainage with the previous two leads. Careful inspection revealed a tapering stump. In case no. 2, venography demonstrated subclavian vein stenosis with collateral drainage to the internal jugular vein with the previous leads. Only a small volume of blood continued to flow, underscoring the importance of avoiding crowding of the subclavian vein.

Interventions for subclavian and central vein stenosis have been described by Marcial and Worley,[3] and Buiten *et al.*[4] reviewed use of a lead extraction tool and its complications. However, no optimal step-by-step intervention strategy has been reported yet. *Figure 3* presents our proposed treatment algorithm for performing venous intervention combined with new lead implantation. The first step is to reduce the risk of damage to any ipsilateral arteriovenous fistula, if the patient undergoes regular haemodialysis. Central venous stenosis is a frequently encountered problem among dialysis patients. The frequent punctures needed for dialysis also increase the risk of infection. If we implanted leads on the same side of haemodialysis site, there is significant risk of losing the vascular access of haemodialysis. The second step is the routine performance of peripheral venography and careful inspection of the venogram under digital subtraction angiography. If visible flow remains (which means visible blood flow back to RA), the vessel can be directly wired and dilated through the introduction of a large sheath or balloon venoplasty. Advancing the long sheath to bypass the stenotic lesion is critical. A balloon anchoring technique may improve the ease of advancement, as demonstrated in case no. 2. Stenting may be another option if the vessel easily recoils and leads can be extracted totally. The Heart Rhythm Society expert consensus on transvenous lead extraction suggests CIED lead removal should be prior to stent deployment at sites of lead-induced venous stenosis to avoid entrapment of the CIED leads.[5]

In cases involving total occlusion as indicated by venography (which is defined by 100% occlusion at subclavian vein or axillary vein, sometimes accompanied with collateral veins), we were still able to use an anterograde approach using strong support (5-Fr sheath or 5-Fr Judkins right catheter). We recommend using an 18-in wire to find micro-channels, especially in cases with a tapering stump (as in case no. 1). After passing the lesion and performing venoplasty, we preferred using a 5-Fr Judkins right catheter in place of the stiff wire for further advancement of the long sheath. The retrograde approach from femoral vein to open the occlusion is also the option. It would also be prudent to evaluate the risk and benefits of extracting if the leads were mobile within the fibrous adhesions, we extracted the lead and performed venoplasty. Any subsequent stenting should be performed after leads are extracted.

If all of the above methods have failed, the contralateral approach combined with pre-sternal tunnelling is another option, as described in case no. 2. The disadvantages of the tunnel technique include the need for general anaesthesia and the requirement of a longer lead, which is not available in some countries. If all these methods fail, implantation at the opposite or epicardial lead can be also considered. Finally, abandoned CIED leads create a challenging decision-making process when considering extraction. Heart Rhythm Society expert consensus statement suggests several indications.[6] The risks of abandonment include venous stenosis, lead-lead interaction, and infection. The sum of the diameter of leads may result in venous stenosis.[7] Clinically significant thromboembolic events related to transvenous leads occur with a low incidence, and no study has directly linked abandoned leads to venous thrombosis.[6] The reasonable maximum number of leads depends on patient's age, with 3–4 leads in the young patient and 5 leads in the older patient.[8] The potential risk of electrical interference between abandoned leads and functional leads is not supported by published research studies, and the exact incidence is unknown. It rarely causes oversensing although leads can rub together causing an insulation break.[5,6] The correlation between the infection rate and abandoned leads has failed to demonstrate an increased risk of device-related infection, but the evidence is limited by small sample size and short follow-up periods.[5] In addition, patients with CIED infections and previously abandoned leads have distinguishing characteristics in terms of presentation, pathogen, and need for more specialized tools for extraction.[9] To sum up, only those patients in whom the benefits of lead removal outweigh the risks receive leads extraction. It is important to consider the duration the lead has been implanted, the fragility of each particular lead, life expectancy of patients and the experience of operators.[6]

Our hospital is a tertiary university hospital with four qualified electrophysiology cardiologists. Annually, our hospital performs about 300 permanent pacemaker implantations, 30 ICDs, and 20 CRT-Ds. A prospective study and registry of these cases are needed to further explore the best strategy for addressing this problem.

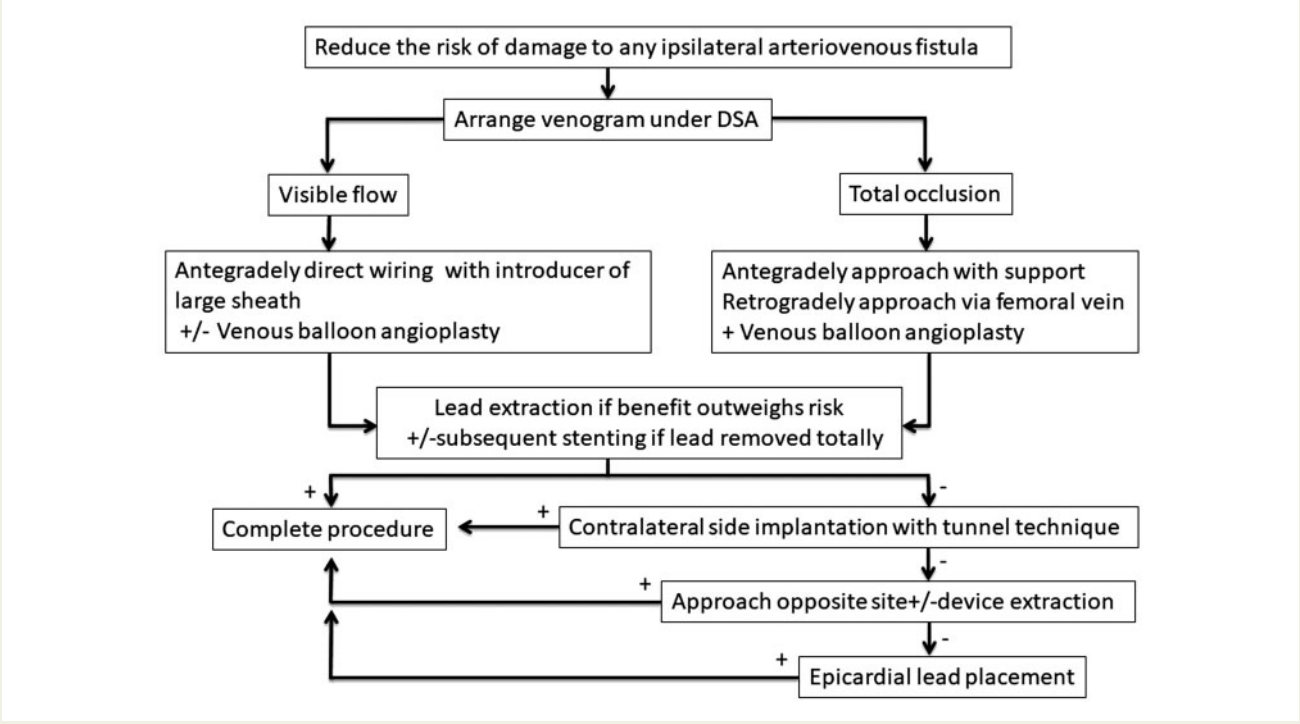

Figure 3 Treatment algorithm for cardiac device-related subclavian vein stenosis. The first step is to reduce the risk of damage to any ipsilateral ateriovenous fistula, if the patient undergoes regular haemodialysis. Routine performance of peripheral venography and careful inspection of the venogram under digital subtraction angiography. Visible blood flow can be solved by direct wiring with introducer of large sheath or balloon angioplasty. Total occlusion can be approached either antegradely or retrogradely from femoral vein. The benefits and risks of previous leads extraction should always been considered. The subsequent stenting should be performed after leads extraction. If all of the above failed, contralateral side implantation with tunnel technique would be considered. Other side of approaching, like creating new pocket on contralateral side or epicardial lead placement may also be option if all of the above failed. +, success; -, failure.

Conclusion

Cardiac implantable electronic device-related subclavian vein stenosis can present a challenge to common CRT device upgrades in the absence of appropriate techniques. Here, we describe successful upgrades in two patients with total subclavian vein occlusion. The first case was resolved by balloon venoplasty and the second case was resolved using a contralateral approach combined with pre-sternal tunnelling. In addition, a suggested algorithm for approaching such cases was presented in a stepwise manner.

Lead author biography

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Supplementary material

Supplementary material is available at *European Heart Journal - Case Reports* online.

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Slide sets: A fully edited slide set detailing this case and suitable for local presentation is available online as Supplementary data.

Consent: The author/s confirm that written consent for submission and publication of this case report including image(s) and associated text has been obtained from the patient in line with COPE guidance.

Conflict of interest: none declared.

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