



Pacemaker leads as a potential source of problems in patients who might need a central venous access port

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Background: Lead-dependent venous occlusion may impede the insertion of a central venous access device (CVAD). The aim of this retrospective, cohort study was to assess the chance of implantation of CVAD in patients with cardiac implantable electronic devices (CIEDs).

Methods: We reviewed and analyzed 3,075 venograms of patients with CIEDs undergoing transvenous lead extraction (TLE) between June 2008 and July 2021. Relationship between venous patency and the chance of CVAD placement was estimated.

Results: In 2,318 (75.38%) patients, venography showed no potential obstacles to venous port implantation on the ipsilateral side. In patients with leads on the left side, significant narrowing more often affected the subclavian vein than the brachiocephalic vein [1,595 (55.29%) vs. 830 (28.63%), respectively] or the superior vena cava (SVC) [21 (0.73%) cases]. Furthermore, the subclavian and brachiocephalic veins on the opposite side were also narrowed [35 (2.35%) and 27 (1.24%), respectively]. The chances of port insertion were assessed as easy on CIED side or opposite side in 2,318 (75.38%) and 2,291 (97.91%) patients, respectively, as difficult insertion/questionable performance in 246 (8.00%) and 22 (0.94%) patients and doubtful or impossible insertion/questionable performance in 511 (16.62%)/27 (1.15%) patients with CIED.

Conclusions: (I) Varying degrees of lead-dependent venous obstruction (LDVO) is a frequent finding in patients with CIEDs; (II) the major thoracic veins on the opposite side of the chest may also be significantly narrowed; (III) venography should be considered before attempted CVAD insertion in patients with long lead dwell times or in patients after CIED removal, including planned contralateral port placement.

Keywords: Endocardial leads; venography; lead-related venous obstruction; venous port implantation; venous port complications

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Introduction

Over 3 million cardiovascular implantable electronic devices (CIEDs) are implanted annually in the United States, and nearly as many central vascular access devices (CVADs) are used each year (1,2). Lead-dependent venous obstruction (LDVO) is common in CIED patients (3-10). LDVO is usually asymptomatic, but it may prevent the placement of a venous port or interfere with its proper functioning. CVADs is a significant medical advance providing important benefits in the management of cancer and kidney patients (10-15). Insertion of a CVAD may interfere with the existing CIED and cause complications. So far, no detailed analysis of the location and degree of venous obstruction in patients with CIED has been performed, especially in terms of the chance of implantation and long-term normal functioning of CVAD.

This study aimed to describe obstruction of the major veins of the thorax, location and range of LDVO in relation to the device side and to examine the chances of success using different venous port approaches (cephalic, subclavian, brachiocephalic and jugular) in relation to lead location. We present this article in accordance with the STROBE reporting checklist (available at <https://cdt.amegroups.com/article/view/10.21037/cdt-23-104/rc>).

Methods

Design of the study

This is a cohort study in which a retrospective analysis of

the population of patients undergoing transvenous lead extraction (TLE) between June 2008 and July 2021 was performed. Subsequent patients undergoing TLE in three centers in Poland were included in the study: in Lublin, Zamość and Radom. In all centers, the TLE procedure was performed by one key operator. The only criterion for exclusion from the study was contraindication to venography. Patients with renal failure, contrast allergy, lack of an available peripheral vein, or presence of an arteriovenous fistula were excluded from the study. The flow diagram of the patients undergoing the study is presented in *Figure 1*.

Study population

We reviewed and analyzed retrospectively data from 3,075 patients who had a venogram routinely performed before TLE. All information about patients and procedures was entered into a computer database on an ongoing basis.

Venographic data collection

Venography was performed usually on the implant side because there was no medical indication for additional contrast dose. However, due to collateral flow, an evaluation of veins on the opposite side was possible in some patients. The volume of 20–40 mL of high-quality contrast medium (350 g iodine/mL) was administered using a forearm placed venous catheter, and venous blood flow through the arm, neck and thoracic veins was recorded in an anteroposterior view as described previously (8,9).

All the venograms were reviewed retrospectively by our TLE team consisting of an experienced cardiothoracic surgeon, cardiologist and anesthesiologist, all with more than 30 years of experience in central vein catheterization for different goals.

Venographic data analysis

Venous patency, in the plane projection, was assessed on a 5-point scale from normal flow to complete venous occlusion. The degree of narrowing of all visible/dyed veins was determined as patent (no stenosis in an in-plane view), mild obstruction (<30% stenosis), moderate obstruction (30–60% narrowing), severe obstruction (>60% stenosis), and total obstruction (100%) of subclavian, brachiocephalic veins and superior vena cava (SVC). Despite ipsilateral contrast injection, the new regional collateral veins and

Highlight box

Key findings

- Insertion of the venous port in patients with cardiac implantable electronic devices (CIEDs) can be difficult due to venous occlusion on both the side of the implanted CIED and the contralateral side, therefore the initial assessment of venous flow is very important.

What is known and what is new?

- Lead-dependent venous occlusion is a frequent finding in patients with CIEDs and is usually asymptomatic.
- The main thoracic veins on the opposite side to the intracardial leads may also be severely narrowed, which can be challenging in patients requiring vascular ports and dialysis fistulas.

What is the implication, and what should change now?

- Attempting to introduce a venous port in patients with endocardial leads requires prior venography. It also seems recommended to perform it in the case of implantation of the port on the side of the chest opposite to the leads.

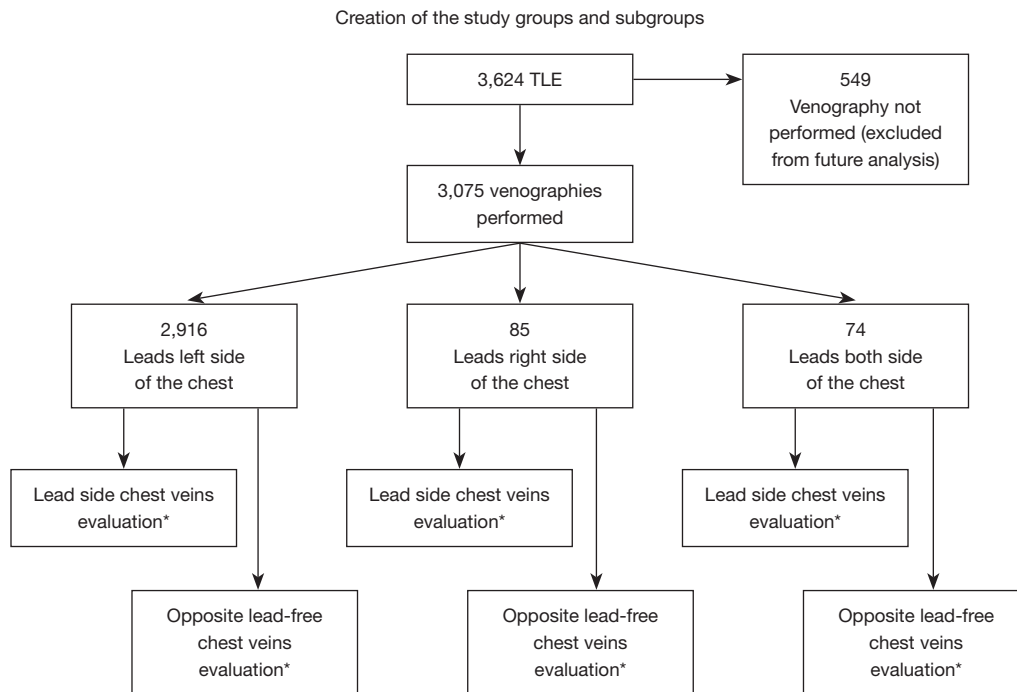


Figure 1 Flow chart of the study group. *, incomplete venogram of the evaluated vein was excluded from the evaluation (lack of information). TLE, transvenous lead extraction.

significant collateral flow via the neck veins enabled an evaluation of the brachiocephalic vein on the opposite side of the chest in some patients. In patients without collateral circulation and without contralateral leads there was no reason to suspect venous obstruction, if they had not previously undergone removal of leads, ports, and dialysis catheters on that side of the chest, as the risk of underestimating obstruction incidence was low.

Evaluation of the chance of CVAD insertion and proper function

There are several equivalent techniques for introducing venous ports, depending on the operator's preferences and routines in the facility. It is possible to introduce the port through the cephalic vein and puncture of the axillary, subclavian, brachiocephalic and jugular veins. When evaluating the venograms, we considered all possible access routes. An occlusion of the axillary vein alone did not preclude the possibility of introducing the port via other routes. Therefore, the results of the assessment of the axillary and cephalic veins were omitted in the tables. An obstruction of the subclavian vein did not preclude

the possibility of introducing the port by puncture of the jugular vein or, ultimately, the brachiocephalic vein. An obstruction of the brachiocephalic vein basically prevented port insertion, whereas in cases of moderate or severe obstruction, the chances of port insertion were assessed as difficult or doubtful. Similarly, in the case of SVC obstruction, due to its larger diameter, the assessment was more tolerant. On the other hand, severe stenosis or occlusion of the SVC was classified as inability to introduce the port despite sufficient patency of the remaining veins.

Ethical statement

The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the ethics committee board of Regional Chamber of Physicians in Lublin (No. 288/2018/KB/VII) and informed consent was taken from all the patients.

Statistical analysis

Due to non parametric distribution continuous variables were expressed as median and interquartile range (IQR)

Table 1 Demographic, clinical and procedural data of study population

All patients' characteristics (n=3,075)	Values
Patient's age during TLE (years)	69.00 (17.00)
Sex (male patients)	1,874 (60.94)
Underlying disease (IHD, MI)	1,770 (57.56)
LVEF (%)	54.00 (25.00)
Renal failure (any)	607 (19.74)
Charlson comorbidity index (points)	4.00 (4.00)
System's infection	616 (20.03)
Non-infective indications (lead failure/ replacement, upgrading, overmuch of leads)	2,459 (79.97)
Kind of CIED: pacemaker (any)	2,133 (69.37)
Kind of CIED: ICD (VVI, DDD)	704 (22.89)
Kind of CIED: CRT-D	238 (7.74)
Dwell time of the oldest one lead in the patient before TLE (months)	85.91 (87.00)
Cumulative dwell time of leads before TLE (years)	12.17 (14.67)
Completed venography—chest side	
Left chest side	2,916 (94.83)
Right chest side	85 (2.76)
Both chest side	74 (2.41)
Chest side of lead's location	
Left chest side	2,916 (94.83)
Right chest side	85 (2.76)
Both chest sides	74 (2.41)
Venous obstruction (the maximal degree in the patient, any location)	
Lack of obstruction	547 (17.79)
Small obstruction	613 (19.93)
Moderate obstruction	637 (20.72)
Severe obstruction	608 (19.77)
Total obstruction (occlusion)	670 (21.79)

Data are presented as count (%) or median (IQR). TLE, transvenous lead extraction; IHD, ischemic heart disease; MI, myocardial infarction; LVEF, left ventricle ejection fraction; CIED, cardiac implantable electronic device; ICD, implantable cardioverter-defibrillator; VVI, ventricular pacemaker; DDD, dual chamber pacemaker; CRT-D, cardiac resynchronization therapy with high voltage lead; IQR, interquartile range.

categorical variables were reported as numbers and percentages and were compared using the Pearson's Chi-square test. P value <0.05 was considered statistically significant.

Statistical analysis was performed with Statistica 13.3 (TIBCO Software Inc.).

Results

The study group consisted of 3,075 patients, average age 66.85 years (60.94 women) having a wide variety of CIEDs: pacemakers (PM), implantable cardioverter-defibrillator (ICD) and implantable cardiac defibrillators with ventricular resynchronization [cardiac resynchronization therapy with high voltage lead (CRT-D)]. The average implant duration was 6.17 years. Infectious complications were observed in 616 (20.03%) of patients. The leads were usually placed on the left side of the chest in 2,916 (94.83%) of patients; leads on the right or both sides were rare (2.76% and 2.41%, respectively). Severe or total venous obstruction was observed in 1,278 (41.56%) of individuals (*Table 1*).

Table 2 summarizes the difficulty and possible complications of central venous port insertion in patients with CIEDs assessed by two experienced specialists. Future function of the port was evaluated based on possible port tip location at the junction of the SVC and the right atrium (± 2 cm) and the dynamics of collateral venous flow.

It is important to remember that the contralateral side does not always mean the "lead-free side" because 74 of the 3,075 patients (2.41%) had abandoned leads on the opposite side of the chest. The table shows that the chances of port insertion were estimated as easy on CIED side/opposite side in 2,318 (75.38%)/2,291 (97.91%), difficult insertion/questionable performance in 246 (8.00%)/22 (0.94%) and doubtful or impossible insertion/questionable performance in 511 (16.62%)/27 (1.15%) of patients with CIEDs.

Forty-nine (2.09%) of cases with complete venographic information, obstruction of the great veins precluded implantation of a central port on the contralateral side of the chest due to previous patient history (*Table 2*).

Table 3 shows patency of the major veins of the thorax (right and left subclavian veins, brachiocephalic veins and SVC) according to lead location. Data shows that if leads were located on the left side (most typical location), a significant narrowing was more common in the subclavian than in brachiocephalic vein [1,595 (55.29%) vs. 830 (28.63%)] or SVC [21 (0.73%)]. The narrowing of left

Table 2 Estimation of venous port insertion possibility via subclavian, brachiocephalic or jugular vein ipsilateral and contralateral to the CIED side, and its future proper function

Chances of port insertion and its future proper function	Rating of big chest veins—CIED side (pts with complete information)		Rating of big chest veins—opposite to CIED side (pts with complete information)		Pearson's χ^2 P
	Patients	%	Patients	%	
Possible/easy	2,318	75.38	2,291	97.91	<0.001
Difficult insertion, performance questionable	246	8.00	22	0.94	
Doubtful or impossible insertion, performance questionable	511	16.62	27	1.15	
All patients	3,075	100.0	2,340	100.0	

CIED, cardiac implantable electronic device; pts, patients.

subclavian and brachiocephalic veins on the opposite lead-free side was also observed [35 (2.35%) and 27 (1.24%)].

If leads were located on the right side (much less typical location), a significant narrowing of the subclavian and brachiocephalic vein was less frequent [18 (26.09%), and 10 (13.51%) of cases, respectively]. Also, the right subclavian vein was narrowed more frequently than the right brachiocephalic vein. In patients with right-sided lead system, stenosis of the subclavian and brachiocephalic veins on the opposite lead-free side was unexpectedly common [26 (31.71%) and 16 (19.04%) of cases, respectively]. This seemingly strange phenomenon can be explained by the patient's history (previous presence of leads or catheters).

Leads on both sides created more complex conditions for venous port placement. Right-sided veins (subclavian and brachiocephalic) were affected slightly less frequently [20 (40.84%) and 21 (34.43%) of cases, respectively] than those on the left side of the chest [45 (64.29%) and 38 (38.36%) of cases, respectively] in this group. Furthermore, SVC was narrowed in 3 (4.11%) of patients with bilateral chest lead location (*Table 3*).

Discussion

Occlusion of the main thoracic veins is a well-known complication in patients with CIED. The incidence of venous obstruction is as high as 30–45%, with an average incidence of mild stenosis between 10% and 40%, moderate stenosis between 6% and 50%, and severe stenosis/total occlusion between 3% and 22% (2-9). This study supports evidence from previous observations. Maximum obstruction was related to lead location and vein involvement. One of the important factors contributing to the development of venous obstruction in patients with CIEDs is inflammation.

CIED-related infections increase the risk of venous obstruction. It could be an example of a defence mechanism by which the flow of pus into the circulatory system is blocked. Our observations indicate that this is a permanent and even progressive phenomenon, which is not reversed by lead removal (9).

Lead-dependent venous occlusion makes it difficult to implant a new lead and insert the lead for temporary pacing. Electrocardiologists are very aware of this problem (2-9), however, this aspect of venous obstruction is less known among vascular surgeons and anesthesiologists. Ipsilateral central venous catheters should also be avoided as the presence of two systems (CVAD or dialysis catheter and CIED) in the same vein may increase the risk of co-infection between devices (15-20).

Our subjective grading of venous stenosis in the context of central line insertion has practical implications. In our opinion, mild and moderate narrowing should not interfere with future implantation of the venous port and its proper function.

In the case of moderate or severe stenosis of the distal section of the left brachiocephalic vein or at the confluence with the SVC, it is often possible to insert a hydrophilic guidewire and a long introducer (usually of the peel-away type). Such procedures may need fluoroscopic control for proper catheter navigation, avoidance of perforation or prevention of catheter placement in low-flow collateral veins.

Temporary or permanent PM leads will function properly despite venous obstruction, whereas venous ports need free blood flow around the distal port end for proper function. Long-term catheter function may depend on external compression from electrodes or fibrous tissue, or insufficient caliber of the vein with the positioned tip.

Table 3 The exact analysis of venograms in CIED carriers

Variables	CIED/leads left side of the chest, pts (%)						CIED/leads right side of the chest, pts (%)						Leads both side of the chest, pts (%)								
	Veins of left side of the chest (containing leads)		Vena cava superior	Veins of right (opposite) side of the chest (free of leads)		Pearson's χ^2 P		Veins of right side of the chest (containing leads)		Vena cava superior	Veins of left (opposite) side of the chest (free of leads)		Pearson's χ^2 P		Veins of right side of the chest (containing leads)		Vena cava superior	Veins of left side of the chest (containing leads too)		Pearson's χ^2 P	
	Left SC vein	Left BC vein		Right SC vein	Right BC vein	Left vs. right SC vein	Left vs. right BC vein	Right SC vein	Right BC vein		Left SC vein	Left BC vein	Right vs. left SC vein	Right vs. left BC vein	Right SC vein	Right BC vein		Left SC vein	Left BC vein	Right vs. left SC vein	Right vs. left BC vein
All patients	2,916 (100.00)	2,916 (100.00)	2,916 (100.00)	2,916 (100.00)	2,916 (100.00)	-	-	85 (100.00)	85 (100.00)	85 (100.00)	85 (100.00)	85 (100.00)	-	-	74 (100.00)	74 (100.00)	74 (100.00)	74 (100.00)	74 (100.00)	-	-
Complete information	2,885 (98.94)	2,899 (99.42)	2,882 (98.83)	1,486 (50.96)	2,183 (74.86)	<0.001	<0.001	69 (81.18)	74 (87.06)	84 (98.82)	82 (96.47)	84 (98.82)	<0.001	<0.001	49 (66.22)	61 (82.43)	73 (98.65)	70 (94.59)	73 (98.65)	<0.001	<0.001
Lack of obstruction	617 (21.39)	1,663 (57.36)	2,837 (98.44)	1,434 (96.50)	2,139 (97.98)			44 (63.77)	53 (71.62)	83 (98.81)	42 (51.22)	57 (67.86)			20 (40.82)	33 (54.10)	69 (94.52)	9 (12.86)	33 (45.21)		
Small obstruction	673 (23.33)	406 (14.00)	24 (0.83)	17 (1.14)	17 (0.78)			7 (10.14)	11 (14.86)	0 (0.00)	14 (17.07)	11 (13.10)			9 (18.37)	7 (11.48)	1 (1.37)	16 (22.86)	12 (16.44)		
Moderate obstruction	646 (22.39)	246 (8.49)	9 (0.31)	7 (0.47)	8 (0.37)			7 (10.14)	3 (4.05)	0 (0.00)	9 (10.98)	7 (8.33)			9 (18.37)	6 (9.84)	1 (1.37)	7 (10.00)	7 (9.59)		
Severe obstruction	516 (17.89)	205 (7.07)	5 (0.17)	14 (0.94)	9 (0.41)			4 (5.80)	1 (1.35)	0 (0.00)	11 (13.41)	8 (9.52)			4 (8.16)	5 (8.20)	1 (1.37)	14 (20.00)	3 (4.11)		
Total obstruction (occlusion)	433 (15.01)	379 (13.07)	7 (0.24)	14 (0.94)	10 (0.46)			7 (10.14)	6 (8.11)	1 (1.19)	6 (7.32)	1 (1.19)			7 (14.29)	10 (16.39)	1 (1.37)	24 (34.29)	18 (24.66)		
Lack of information	31 (1.06)	17 (0.58)	34 (1.17)	1,430 (49.04)	733 (25.14)	-	-	16 (18.82)	11 (12.94)	1 (1.18)	3 (3.53)	1 (1.18)	-	-	25 (33.78)	13 (17.57)	1 (1.35)	4 (5.41)	1 (1.35)	-	-

CIED, cardiac implantable electronic device; SC, subclavian; BC, brachiocephalic; pts, patients.

Drop in the blood flow caused by venous outflow obstruction leads results in drug-induced venous wall irritation, producing additional lumen narrowing and, finally, port dysfunction or vein thrombosis.

Previous reports on risk factors for LDVO demonstrated that patient age and gender had no effect on venous obstruction, but there is still controversy as to whether the number of leads (lead burden) and implant duration may contribute to LDVO (2-9).

Recently, multiple studies on venous port implantation (have concentrated on comparing different approaches to venous port insertion and techniques (cephalic *vs.* subclavian *vs.* jugular vein) (21-33), methods of evaluating correct tip location [external measurements only, fluoroscopy (21) or intracardiac electrocardiogram (ECG)] (21), surface catheter measurements (30) or transesophageal echocardiography (TEE) (34). Guidance for puncture of the subclavian, brachiocephalic and jugular vein is most frequently ultrasonic (25,31,34-45), rarely fluoroscopic (37,45) or venipuncture is performed without imaging (43).

There is a wide variety of studies that compare the incidence of intraoperative complications (hemothorax, hemothorax or pinch-off syndrome, pneumothorax, nerve damage, arterial puncture and hematoma, wrong tip location in the internal thoracic vein, or in the collateral circulation with subsequent severe consequences) when different safety approaches are used (21,26-31,33,35,37,43,44,46,47).

Several investigators have described periprocedural or late complications of venous port implantation (21,23,24,26,27,30,32-36,38,41,42,46,47). These include: venous thrombosis, infection, catheter-related infection, skin complications at the port site, port infection, post-operative venous access obstruction, central venous stenosis, catheter damage, port and catheter disconnection, flexion at the catheter-port interface, infusion disorders, thrombotic obstruction of the catheter or spontaneous dislocation of the port tip into the azygos or other small veins, and unexpected difficulties during removal of the port (22).

Ultrasonic control of the subclavian, brachiocephalic, or jugular vein puncture site is an easy and widely used option for patients with normal, previously untouched venous system without stenosis (48-50). Standardized protocols such as RaCeVa have been established and are widely used in hospital practice (48-50). Problems may appear when a narrowed vein segment cannot be visualized with ultrasound. In our opinion, venography is still a valuable option in patients with CIEDs. Ultrasound monitoring

perfectly shows possible sites for cannulation but may not show the dynamics of collateral flow or obstacles. In such cases the guidewire, instead of entering the SVC and right atrium can be displaced to a small thoracic vein or the left SVC (if present). The likelihood of an inappropriate guidewire path is minimal in healthy patients, but the risk grows dramatically in patients with preexisting venous stenosis or obstruction. Attempts at device insertion can result in its placement in the collateral circulation or in dissection of the obstructed vein wall. Finally, port dysfunction and severe complications can occur if the procedure is performed without fluoroscopic control.

Figures 2,3 show that insertion of a venous port may be difficult or even dangerous in spite of the unchanged lumen of the jugular, subclavian or auxiliary veins and blood flow visible in ultrasound because of stenosis or occlusion in the lower segments, inaccessible by ultrasound.

To the best of our knowledge, no one has investigated the causes of difficult or impossible port insertion, and the results of venographic imaging obtained for different indications prompted us to present the data. Especially that the risk of developing cancer should be considered in aging patients with CIED leads who may need venous port implantation.

The problem still exists and one of the reports provided an important conclusion: "*in the light of the findings, there is a need for standardized guidelines for evaluation before central venous port catheter insertion and follow-up after insertion to detect and to avoid possible complications*" (25).

The current study describes occlusion of the main thoracic veins with permanently implanted leads and, in some patients, occlusion of the main veins on the opposite side of the chest. An explanation of this phenomenon is that right-sided thoracic veins were previously used for other medical purposes, i.e., temporary pacing leads or another central venous catheter [perioperative, at intensive care unit (ICU), rarely venous port or temporary or permanent catheter for hemodialysis]. And any temporary lead or temporary catheter can cause or initiate the narrowing of the vein in which it has been placed.

It seems that an important message is the recognition of patients with CIED as candidates for the placement of a central venous port. It could also suggest that every attempt at venous port insertion in patients with CIEDs, especially on the implant side, may be safer when preceded by venography. Venography is also recommended if the contralateral side of the chest is to be used.



Figure 2 Four examples of difficult or even dangerous venous port insertion in spite of normal jugular vein lumen and blood flow detected by ultrasound. Brachiocephalic vein occlusion with collateral flow.

Study limitations

Routine pre-TLE venography was performed in all patients without contrast contraindications. Thus, analysis does not include all the patients referred for TLE. Although the analysis was carried out on data prospectively entered into the database, the study is retrospective. In most patients, venography was performed only on the side of the implant to reduce the dose of contrast. In some patients, we were able to evaluate patency of the contralateral brachiocephalic vein thanks to collateral circulation through the neck veins and opposite jugular vein, but not subclavian or auxiliary veins.

Conclusions

- (I) Varying degrees of lead-dependent venous occlusion are a common finding in patients with pacing or defibrillation leads;
- (II) Large thoracic veins on the opposite side of the chest may also be occluded in a small percentage of patients;
- (III) Patients with CIED may benefit from fluoroscopic control during venous port insertion;
- (IV) Venography should be considered before attempted CVAD insertion in patients with endocardial leads;
- (V) Venography seems to be valuable also in cases of planned contralateral port placement.

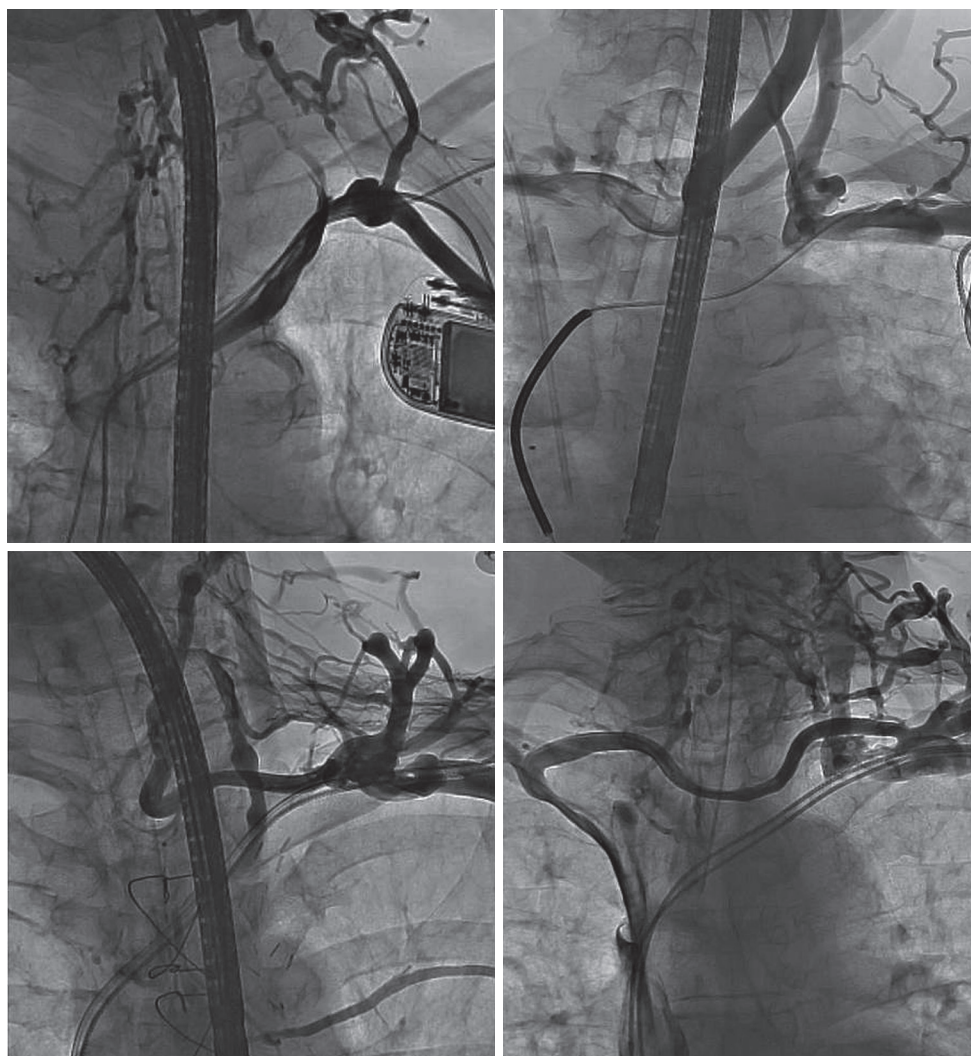


Figure 3 Four examples of potential obstacles during attempted venous port insertion, despite normal axillary or subclavian vein lumen and blood flow detected by ultrasound. Brachiocephalic vein occlusion.

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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at <https://cdt.amegroups.com/article/view/10.21037/cdt-23-104/rc>

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related

to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the ethics committee board of Regional Chamber of Physicians in Lublin (No. 288/2018/KB/VII) and informed consent was taken from all the patients.

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