Wire countertraction for sheath placement through stenotic and tortuous veins: The "body flossing" technique

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BACKGROUND Innominate vein stenosis and venous tortuosity are common findings during cardiac implantable electronic device upgrades or replacements and present a challenge to the implanting physician. Various techniques have been described to facilitate lead placement, including serial dilation, balloon venoplasty, and percutaneous access medial to the stenosis, each with its own benefits and risks.

OBJECTIVE The purpose of this study was to assess the feasibility, safety, and efficacy of the wire countertraction ("body flossing") technique to facilitate sheath placement through tortuous and stenotic vessels.

METHODS Patients undergoing cardiac implantable electronic device procedures requiring the body flossing technique due to inability to place vascular sheaths over the wire through stenoses or tortuosity were retrospectively analyzed. Clinical characteristics, procedural equipment, and outcomes were analyzed.

RESULTS Simultaneous countertraction was successful in all attempted cases, including 8 patients with stenoses and 2 with tortuosity. In 2 of the stenosis cases, venoplasty had previously failed. No complications occurred.

CONCLUSION Simultaneous countertraction (body flossing) is an effective tool to overcome venous stenosis and tortuosity that are amenable to wire advancement but not to vascular sheaths. It seems to be a safe and effective alternative to other techniques used in these scenarios.

KEYWORDS Extraction; Implantable cardioverter–defibrillator; Permanent pacemaker; Simultaneous traction; Snaring; Venous occlusion

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Introduction

Addition or replacement of transvenous permanent pacemaker (PPM) and implantable cardioverter–defibrillator (ICD) leads to an existing cardiac implantable electronic device (CIED) system is common in clinical practice.[1] Venous stenosis is frequently encountered during subsequent procedures and presents a challenge due to the inability to advance sheaths past the narrowed segment.[2] Tortuous venous anatomy, prevalent in elderly patients, poses similar challenges.[3–5]

Several strategies have been described to manage venous stenosis and tortuosity that preclude sheath insertion, including percutaneous puncture beyond the site of stenosis, femoral-based device implantation access,[6–10] surgical epicardial systems,[11,12] use of the contralateral side with or without tunneling back to the existing pocket,[13] transvenous lead extraction (TLE) to "core out" the dense fibrous luminal narrowing,[14] and balloon venoplasty.[15–17] These techniques often are effective, but they have inherent limitations and disadvantages.

Simultaneous 2-point traction facilitated by snaring the distal end of the wire from an inferior or contralateral access point ("body flossing" technique) is an effective strategy to

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KEY FINDINGS

- Venous stenosis and tortuosity are common findings during cardiac implantable electronic device procedures. Traditional strategies to overcome these scenarios can prove insufficient.
- Wire countertraction, or the "body flossing" technique, is a safe and effective practice to increase the rail strength of the wire. This enhanced rail facilitates sheath placement through vessels that typically would not accommodate them.
- Wire countertraction can be performed quickly and easily by physicians having minimal experience with percutaneous snaring but does necessitate a second operator.

overcome many of the obstacles of vascular stenosis and tortuosity. This technique, which requires a second operator, consists of firm countertraction of the distal wire from a separate site to match that of the primary operator working within the pocket environment. This technique results in enhanced rail strength and has been described in limited case reports,[18] during coronary sinus lead implantation,[19] and in percutaneous arterial interventions.[20] This article describes use of the body flossing technique in a series of patients as an alternative strategy during CIED lead implantation scenarios in which sheath placement was limited by severe venous stenosis or tortuosity.

Methods

From 2014 to 2017, all patients undergoing CIED procedures requiring the body flossing technique due to inability to place vascular sheaths over the wire through stenoses or tortuosity were retrospectively identified. Per institutional guidelines, all patients provided written informed consent for the procedure and for inclusion of their anonymized medical information in research studies.

Routine preprocedural peripheral venography was performed in all cases using 20 cc of nonionic radiocontrast (Visipaque, GE Healthcare, Chicago, IL), followed by 20 cc of saline (Figures 1A and 1F). Venography was performed via a 18-gauge intravenous catheter placed in an ipsilateral superficial antecubital vein. If a stenosis was present, it was categorized as peripheral (axillary or subclavian), central (innominate or superior vena cava), or both. Percutaneous venous access was acquired via the ipsilateral axillary vein based on fluoroscopic guidance when feasible, typically with an angled hydrophilic 0.035-inch wire (HiWire; Cook Medical, Bloomington, IN). If possible, wires were upgraded through a 4F hydrophilic sheath (AVANTI; Cordis, Santa Clara, CA) to those with extra support, typically, a 0.035-inch extrastiff Amplatz wire (Cook Medical), and the distal tip was advanced to the inferior vena cava (IVC) or pulmonary artery for maximal support. If the venous system was occluded, the patient underwent TLE, followed by placement of a similar wire through the sheath conduit to maintain vascular access. If TLE was to be performed, systemic anticoagulation was held for 2 days before the procedure. If TLE was not performed, anticoagulation management was left to the discretion of the operator. Attempts were made to cross the stenotic or tortuous segment using the traditional method, with venous sheaths that would support lead placement (Figures 1B and 1G, and Supplementary Video 1). If unsuccessful, serial dilation with progressively larger sheaths was attempted. Balloon venoplasty was used at the operator's discretion. If a sheath still could not be advanced beyond the stenosed or tortuous segment, simultaneous wire countertraction was performed by first obtaining right-sided, ultrasound-guided femoral venous access with placement of a 7F venous sheath. A 20-mm Amplatz Goose Neck Snare (Medtronic Inc, Minneapolis, MN) was used to snare the distal end of the wire within the right atrium or IVC (Figures 1C and 1H, and Supplementary Video 2). Countertraction was maintained from below while the sheath was advanced past the troublesome region (Figures 1D and 1I, and Supplementary Video 3). The operator attempted to match the degree of traction from below with that from above, applying sufficient force to maintain the location of the snare fluoroscopically. If the wire could not be percutaneously stabilized from below during simultaneous traction due to its hydrophilic coating, the snare was used to pull the wire through the sheath and outside of the body, where it was secured with forceps and manual countertraction was used. Once the sheath tip was safely across the stenotic or tortuous venous portion, the snare was released from the wire and removed from the body. If the wire was secured outside of the body with forceps, the wire was removed via the femoral vein to maintain a sterile pocket environment. Additionally, femoral catheters were covered by a sterile drape, and all operators rescrubbed before moving from a femoral to a chest location. If the patient required more than 1 additional lead, the sheath was double-wired, and all steps were repeated for each wire. Routine lead placement was then performed (Figures 1E and 1J).

Results

Baseline demographic and clinical patient characteristics are listed in Table 1. The body flossing technique was successfully performed in 10 consecutive patients by multiple primary operators, allowing addition of 11 transvenous leads (5 ICD, 6 PPM). No attempted cases of body flossing resulted in failure of lead placement. Mean patient age was 70.7 ± 8.1 years, with an average of 2.7 ± 0.8 pre-existing leads *in situ.* The average chronic lead dwell time was 12.0 ± 5.4 years. Four patients (40%) were receiving chronic systemic anticoagulation (warfarin) at the time of the procedure, with an international normalized ratio between 1.2 and 1.8. In the 3 patients (30%) in whom TLE was required, a sheath conduit (two 12F and one 14F; GlideLight; Philips

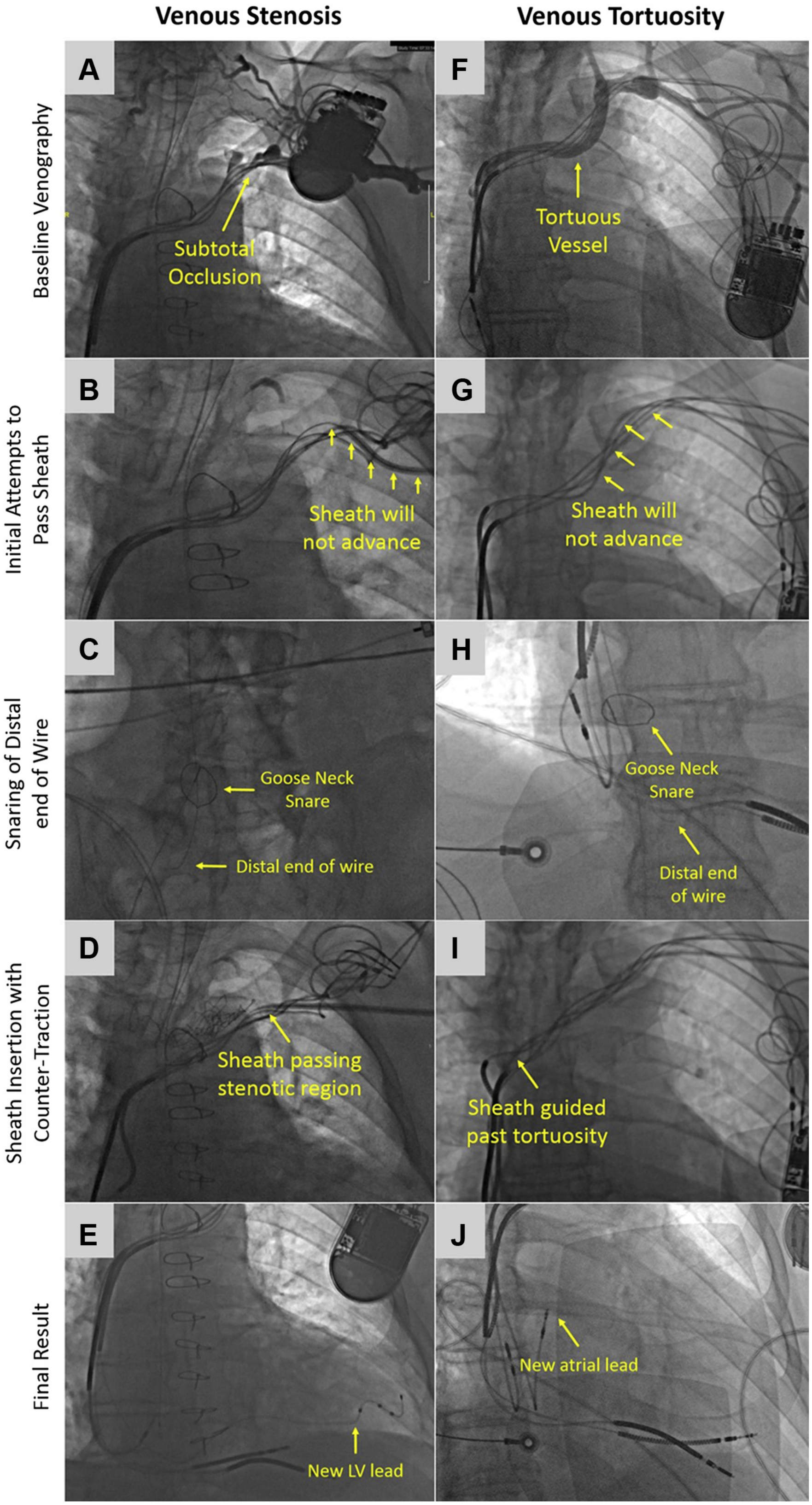

Figure 1 **Left:** Simultaneous countertraction ("body flossing") for venous stenosis. **A:** Peripheral venography showing a subclavian vein subtotal occlusion. **B:** Buckling of sheath as it will not track over the wire through the stenosis. **C:** Snaring of the distal end of the wire in the inferior vena cava. **D:** Sheath passes the stenotic region during simultaneous countertraction on the wire. **E:** Final system showing a new left ventricular lead. **Right:** Simultaneous countertraction (body flossing) for venous tortuosity. **F:** Peripheral venography showing innominate vein tortuosity. **G:** Buckling of sheath as it will not track over the wire through the tortuosity. **H:** Snaring of the distal end of the wire in the right atrium. **I:** Sheath passes the tortuous region during simultaneous countertraction on the wire. **J:** Final system showing a new right atrial lead.

Table 1 Patient characteristics

Pt no.	Age (y)	Existing leads	Oldest lead (y)	Male	Chronic anticoagulation (INR)	Stenosis location	Stenosis length (cm)	Sheath size (F)	Leads added
1	72	4	12	Yes	Yes (1.8)	N/A (tortuosity)	N/A	10	PPM
2	79	3	14	Yes	Yes (1.7)	L subclavian	1.8	7	PPM
3	61	2	10	No	No	L subclavian	3.6	7	PPM
4	75	3	12	No	No	L subclavian	4	9,7	ICD, PPM
5	79	3	25	No	Yes (1.7)	R subclavian	4.6	10	PPM
6	59	1	10	Yes	Yes (1.2)	R subclavian	1.76	9	ICD
7	75	3	8	Yes	No	N/A (tortuosity)	N/A	9	ICD
8	72	3	5	Yes	No	L subclavian	1	8	ICD
9	78	3	16	No	No	L subclavian	2.1	9	PPM
10	57	3	1	Yes	No	L axillary	3.5	8	ICD

ICD = implantable cardioverter–defibrillator; INR = international normalized ratio; L = left; N/A = not applicable; PPM = pacemaker; Pt = patient; R = right.

Healthcare, Andover, MA) was used to cross the venous occlusion. Because of residual stenosis, body flossing was required thereafter.

Stenosis that limited sheath placement was present in 8 patients. The mean occluded segment length was 2.8 ± 1.1 cm. Tortuosity limiting sheath placement was present in 2 patients and affected both the subclavian and innominate veins in both patients. Hydrophilic wires were used for crossing stenoses in all cases and were exchanged for stiff wires in 3 cases (30%). In 2 cases, venoplasty was performed before body flossing, without success. In both cases, a 6-mm diameter noncompliant balloon (POWERFLEX; Cordis) was used along the entirety of the stenosis and inflated to rated burst pressure. The average time required to snare the wire was 5.8 ± 2.9 minutes. No complications occurred during the procedures or during an average follow-up period of 30.2 months (range 17–62 months).

Discussion

Venous stenosis is a common finding during lead replacement or upgrade procedures.[2,21,22] The ability to track a sheath over a wire in a coaxial manner along an intravascular course is dependent on the strength of the wire serving as the "rail." If the rail is insufficient for the surrounding venous environment, then the progress of the sheath tip will be halted and the remaining force will result in bending of the sheath, which further diminishes its ability to progress forward. Use of stronger and/or longer wires can be helpful but ultimately has a modest effect and may prove insufficient in challenging scenarios. Capturing both ends of the wire and applying simultaneous countertraction increases the lateral stiffness of the wire, allowing force to be directed forward along the rail.[23] In this scenario of enhanced rail strength, successful sheath deployment ultimately is only dependent on the size and strength of the sheath material and the vascular environment that it is traversing.

Similarly, in the context of venous tortuosity, a wire with unilateral traction may prove insufficient to allow tracking of a sheath down a meandering venous system. Hydrophilic wires, which frequently can navigate these tortuous segments, typically do not provide sufficient support to allow a sheath to track over them. Alternatively, stiffer wires prove challenging to negotiate through the tortuous segment. Exchanging one for the other via a low-profile sheath is a helpful but occasionally limited strategy. Increasing rail strength via simultaneous countertraction is a novel solution in these circumstances and has been described in a multitude of clinical scenarios, including venous sheath placement,[18] coronary sinus lead placement via snaring of the distal end of the wire within the heart or vascular system,[19] recanalization of central venous occlusions in dialysis patients,[24] and percutaneous arterial aortic interventions.[8] A similar concept has been described during TLE procedures, in which simultaneous countertraction was shown to stabilize rail tension at all points along the lead in an effort to avoid a noncoaxial orientation and vascular damage.[10]

Several other techniques have been described to facilitate sheath placement in the setting of venous stenosis, including balloon venoplasty, by way of circumferential dilation of the stenosed segment.[15–17] Although effective, this technique has limitations, including the cost of successively larger balloons, lack of familiarity of balloon-based vascular interventions by electrophysiologists, and possible dissections and perforations of the deep veins.[25] In our series, the body flossing technique was successful in 2 cases after balloon venoplasty had failed. Additionally, venoplasty is not helpful for cases of venous tortuosity, which requires enhanced rail stability along the entirety of the wire rather than focal dilation.

When venous stenosis or occlusion seems to prevent transvenous lead implantation from the superior approach, use of several other implantation strategies has been reported. Placement of leads via more central venous access has been proposed, with the goal of puncturing the venous system medial to the stenotic region, and sometimes a supraclavicular access strategy is used.[26–29] However, depending on the location of the stenosis, this technique may increase the risk of pneumothorax and decrease lead longevity.[24,25] CIED placement by way of the femoral vein also has been performed, but it has generally been limited to elderly patients and remains unappealing because of unknown lead longevity and possible patient discomfort.[6–9] Surgical epicardial lead placement is a consideration but is generally reserved for patients with no vascular access options or unacceptably high risk of endovascular infection due to the invasive nature of the procedure, unpredictable pacing lead longevity, and crinkling associated with epicardial defibrillator patches.[30] TLE has also been described in this scenario[14] but typically is used in the setting of complete venous occlusions that cannot be traversed with a wire because of the added cost and resources required and the small but real risks of extraction sheath utilization. Lastly, leadless PPMs[31] and entirely subcutaneous ICDs[32] have recently been introduced but currently have limited indications.

Simultaneous countertraction is an appealing technique but has inherent challenges, including the need for single-point femoral access traditionally not used during CIED implantation. Occasionally, this may be required intraoperatively when it is inconvenient to prepare this region. Efforts should be made to maintain the sterility of the chest during femoral access in order to avoid pocket contamination. Additionally, simultaneous countertraction requires the presence of a second operator, and the primary operator must have a basic understanding of percutaneous snaring. However, snaring of a wire with a free end within the right atrium or IVC can be easily accomplished, even by operators with limited experience.

Study limitations

This is a small, single-center, observational, nonrandomized study, which limits the conclusions that can be drawn. A large assortment of sheaths and wires of variable sizes and strengths are currently available for CIED procedures. It is possible that these alternative types of traditional tools could have resulted in success without the need for simultaneous countertraction. TLE typically results in successful subsequent sheath placement but in our study was found to be insufficient in 3 patients due to residual stenosis. It is our practice to use the appropriately sized extraction sheath for the lead that is being removed in order to maintain safety. However, it is possible that use of a larger-diameter extraction sheath could have facilitated sheath placement. Similarly, venoplasty with balloons of different sizes could have resulted in success. Lastly, femoral snaring was performed from the right femoral vein. Although it is possible that the results could have been different using another access point, we do not believe this to be likely.

Conclusion

Simultaneous countertraction (body flossing) is an effective tool to overcome venous stenosis and tortuosity amenable to wires but not to vascular sheaths. It can be performed efficiently and safely, including intraprocedurally, without the need for advanced planning and with minimal procedural adaptations and tools readily available in the electrophysiology laboratory. It seems to be a useful addition to the arsenal of the implanting physician.

Appendix

Supplementary data

Supplementary data associated with this article can be found in the online version at https://doi.org/10.1016/j.hroo.2020.01.001.

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