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

Jeffrey S. Arkles, MD, FHRS,* Prakash Goutham Suryanarayana, MD, FHRS,* Mouhannad Sadek, MD, FHRS,† Joshua M. Cooper, MD, FHRS,‡ David S. Frankel, MD, FHRS,* Fermin C. Garcia, MD, FHRS,* Jay Giri, MD, MPH,§ Robert D. Schaller, DO, FHRS*

From the *Section of Cardiac Electrophysiology, Cardiovascular Division, Department of Medicine, Hospital of the University of Pennsylvania, Philadelphia, Pennsylvania, †Arrhythmia Service, Division of Cardiology, Department of Medicine, The Ottawa Hospital, Ottawa, Ontario, Canada, ‡Electrophysiology Section, Division of Cardiology, Temple University Health System, Philadelphia, Pennsylvania, and §Section of Interventional Cardiology, Cardiovascular Division, Department of Medicine, Hospital of the University of Pennsylvania, Philadelphia, Pennsylvania.

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

(Heart Rhythm O2 2020;1:21–26) © 2020 Heart Rhythm Society. Published by Elsevier Inc. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

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...
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.

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 venous access was acquired via the ipsilateral axillary vein categorized as peripheral (axillary or subclavian), central requiring the body, or for inclusion of their anonymized medical information in research studies.

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. 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 performed, systemic anticoagulation was withheld 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. 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 performed, 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.
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, coronary sinus lead placement via snaring of the distal end of the wire within the heart or vascular system, recanalization of central venous occlusions in dialysis patients, and percutaneous arterial aortic interventions. 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.

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. 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. 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. However, depending on the location of the stenosis, this technique may increase the risk of pneumothorax and decrease lead longevity.

### Discussion
Venous stenosis is a common finding during lead replacement or upgrade procedures. 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. 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
performed, but it has generally been limited to elderly patients and remains unappealing because of unknown lead longevity and possible patient discomfort.\textsuperscript{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.\textsuperscript{30} TLE has also been described in this scenario\textsuperscript{31,32} 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\textsuperscript{31} and entirely subcutaneous ICDs\textsuperscript{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.

References
1. Poole JE, Gleva MJ, Mela T, et al. Complication rates associated with pacemaker or implantable cardioverter-defibrillator generator replacements and upgrade procedures: results from the REPLACE registry. Circulation 2010;122:1553–1561.
2. Morani G, Bolzan B, Valsecchi S, Morosato M, Ribichini FL. Chronic venous obstruction during cardiac device revision: incidence, predictors and efficacy of percutaneous techniques to overcome the stenosis. Heart Rhythm 2020;17:258–264.
3. Kawamura I, Hojo R, Fukamizu S. A case of pacemaker implantation in the patient with duplication of the left innominate vein: a case report. Springerplus 2016;5:515.
4. Canonico S, Gallo C, Paolizzo G, et al. Prevalence of varicose veins in an Italian elderly population. Angiology 1998;49:129–135.
5. Del Corso L, Moruzzo D, Conte B, et al. Tortuosity, kinking, and coiling of the carotid artery: expression of atherosclerosis or aging? Angiology 1998;49:361–371.
6. Garcia Guerrero JJ, Fernandez de la Concha Castaneda J, Dobladlo Calatrava M, Redondo Mendez A, Lazaro Medrano M, Merchant Herrera A. Transfemoral access when superior venous approach is not feasible equally successful of permanent pacemaker implantation. Ten-year series. Pacing Clin Electrophysiol 2017;40:638–643.
7. Ellestad MH, Caso R, Greenberg PS. Permanent pacemaker implantation using the femoral vein: a preliminary report. Pacing Clin Electrophysiol 1980;3:418–423.
8. Mathur G, Stables RH, Heaven D, Ingram A, Sutton R. Permanent pacemaker implantation via the femoral vein: an alternative in cases with contraindications to the pectoral approach. Europace 2001;3:56–59.
9. Pinski SI, Belaskis AJ. Defibrillator implantation via the iliaca vein. Pacing Clin Electrophysiol 2000;23:1315–1317.
10. Schaller RD, Sadek MM, Cooper JM. Simultaneous lead traction from above and below: a novel technique to reduce the risk of superior vena cava injury during transvenous lead extraction. Heart Rhythm 2018;15:1655–1663.
11. Costa R, Scavanacca M, da Silva KR, Martinelli Filho M, Carrillo R. Novel approach to epicardial pacemaker implantation in patients with limited venous access. Heart Rhythm 2013;10:1646–1652.
12. Jaroszewski DE, Altemose GT, Scott LR, et al. Nontraditional surgical approaches for implantation of pacemaker and cardioverter defibrillator systems in patients with limited venous access. Ann Thorac Surg 2009;88:112–116.
13. Lathje L, Zabel M, Seegers J, Zenker D, Vollmann D. Acute and long-term feasibility of contralateral transvenous lead placement with subcutaneous, pre-sternal tunnelling in patients with chronically implanted rhythm devices. Europace 2011;13:1004–1008.
14. Fischer A, Love B, Hansalia R, Mehta D. Transfemoral snaring and stabilization of pacemaker and defibrillator leads to maintain vascular access during lead extraction. Pacing Clin Electrophysiol 2009;32:336–339.
15. Worley SJ, Gohn DC, Pulliam RW, Raffsnyder MA, Ebersole BI, Tuzi J. Subclavian venoplasty by the implanting physicians in 373 patients over 11 years. Heart Rhythm 2011;8:526–533.
16. Marcial JM, Worley SJ. Venous system interventions for device implantation. Card Electrophysiol Clin 2018;10:163–177.
17. Worley SJ. Implant venoplasty: dilatation of subclavian and coronary veins to facilitate device implantation: indications, frequency, methods, and complications. J Cardiovasc Electrophysiol 2008;19:1004–1007.
18. Rogers DP, Lambiase PD, Chow AW. Successful coronary sinus lead replacement despite total venous occlusion using femoral pull through, two operator counter-traction and subclavian venoplasty. J Interv Card Electrophysiol 2007;19:69–71.
19. Worley SJ, Gohn DC, Pulliam RW. Goose neck snare for LV lead placement in difficult venous anatomy. Pacing Clin Electrophysiol 2009;32:1577–1581.

20. Hsu HL, Huang CM, Chen YY, Hsieh FC, Chen JS. The sandwich technique with body flossing wire to revascularize left subclavian artery in thoracic endovascular aortic repair. Ann Vasc Surg 2017;39:152–159.

21. Haghigh M, Nikoo MH, Fazelifar AF, Alizadeh A, Emkangee Z, Sadr-Ameli MA. Predictors of venous obstruction following pacemaker or implantable cardioverter-defibrillator implantation: a contrast venographic study on 100 patients admitted for generator change, lead revision, or device upgrade. Europace 2007;9:328–332.

22. Rozmus G, Daubert JP, Huang DT, Rosero S, Hall B, Francis C. Venous thrombosis and stenosis after implantation of pacemakers and defibrillators. J Interv Card Electrophysiol 2005;13:9–19.

23. Lenoir J, Cotin S, Duriez C, Neumann P. Physics-based models for catheter, guidewire and stent simulation. Stud Health Technol Inform 2006;119:305–310.

24. Huang Y, Chen B, Tan G, et al. The feasibility and safety of a through-and-through wire technique for central venous occlusion in dialysis patients. BMC Cardiovasc Disord 2016;16:250.

25. Oshima K, Takahashi T, Ishikawa S, Nagashima T, Hirai K, Morishita Y. Superior vena cava rupture caused during balloon dilation for treatment of SVC syndrome due to repetitive catheter ablation—a case report. Angiology 2006;57:247–249.

26. Antonelli D, Freedberg NA, Turgeman Y. Supraclavicular vein approach to overcoming ipsilateral chronic subclavian vein obstruction during pacemaker-ICD lead revision or upgrading. Europace 2010;12:1596–1599.

27. Brown KT, Getrajman GI. Balloon dilation of the superior vena cava (SVC) resulting in SVC rupture and pericardial tamponade: a case report and brief review. Cardiovasc Intervent Radiol 2005;28:372–376.

28. Mansour M, Altenburg A, Haage P. Successful emergency stent implantation for superior vena cava perforation during malignant stenosis venoplasty. Cardiovasc Intervent Radiol 2009;32:1312–1316.

29. Kuhn J, Klicic A, Stein E. Management of innominate vein rupture during superior vena cava angioplasty. A A Case Rep 2016;7:89–92.

30. Molina JE, Benditt DG, Adler S. Crinkling of epicardial defibrillator patches. A common and serious problem. J Thorac Cardiovasc Surg 1995;110:258–264.

31. Reynolds D, Duray GZ, Omar R, et al. A leadless intracardiac transcatheter pacing system. N Engl J Med 2016;374:533–541.

32. Bardy GH, Smith WM, Hood MA, et al. An entirely subcutaneous implantable cardioverter-defibrillator. N Engl J Med 2010;363:36–44.