Successful Recanalization of a Longstanding Complete Left Subclavian Vein Occlusion by Radiofrequency Perforation with Use of a Radiofrequency Guide Wire

Mark O. Baerlocher, MD, Murray R. Asch, MD, FRCPC, and Andy Myers, MD, FRCPC

Treatment with radiofrequency (RF) energy can be used to ablate or perforate tissues. The latter involves lower power, higher voltage, and much shorter treatment time, and it is thought to induce much less collateral tissue damage. To date, RF perforation has been successfully used for various cardiac interventions; however, to our knowledge, there has not been a report of its use for peripheral vascular disease. This report describes the successful recanalization of a longstanding occlusion of a left subclavian vein in a 73-year-old woman with polycystic kidney disease and end-stage renal disease undergoing chronic hemodialysis treatment via an upper-extremity arteriovenous fistula. Multiple previous attempts at mechanical recanalization were unsuccessful. Recanalization was achieved by RF perforation with use of a PowerWire RF guide wire.

J Vasc Interv Radiol 2006; 17:1703–1706

Abbreviation: RF = radiofrequency

THE use of radiofrequency (RF) energy is well established in the treatment of various cardiac conduction anomalies, such as in the ablation of myocardial arrhythmogenic foci (1). To date, the majority of literature published on this technology has referred to RF ablation. However, there is a separate and distinct phenomenon of RF perforation.

In RF ablation and RF perforation, an alternating electrical current is used to produce thermal energy that destroys cells: tissue coagulates at 49°C, protein denatures at 60°C, tissue desiccates at 70°C, and intracellular water vaporizes and cell membranes rupture at 100°C (2). The primary distinction is in the speed at which this is done: RF perforation uses a higher voltage of current and lower power and involves a much abbreviated heating time. The result is near-instantaneous vaporization of target cells in contact with the transducer, with a lessening of collateral damage to surrounding tissues (3). In addition, because of the high frequency of the current, treatments do not stimulate nervous or muscular tissues.

In this report, we describe the use of RF perforation to successfully recanalize a chronic and resistant left subclavian vein occlusion.

CASE REPORT

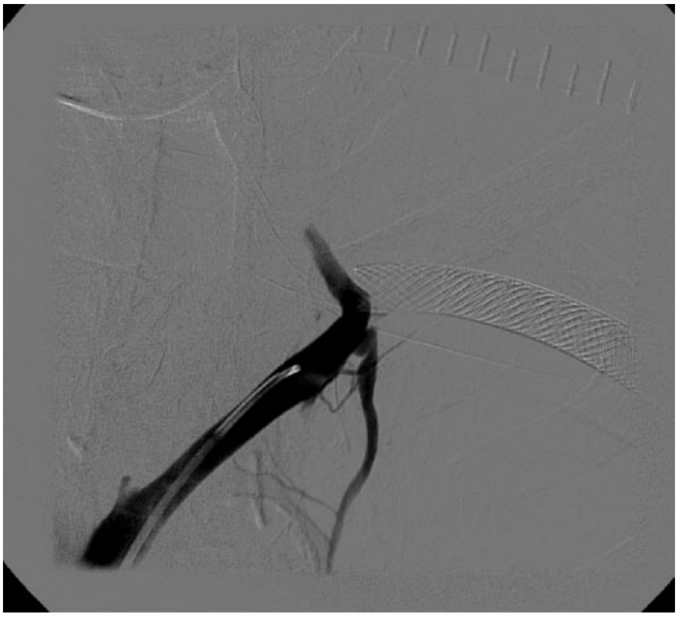
Institutional review board approval is not required at our center for a case report of this type. A 73-year-old woman with end-stage renal disease secondary to polycystic kidney disease was referred to our department for attempted recanalization of a longstanding occlusion of her left subclavian vein.

The patient had been receiving hemodialysis since 2001 via a left-arm arteriovenous fistula and was well known to the interventional radiology service, having been treated with multiple angioplasties and ultimately requiring stent implantation of her left subclavian vein in October 2003 for symptomatic relief of severe arm swelling and prolonged bleeding from dialysis puncture sites. The patient's symptoms improved and remained stable until January 2005, when she again began to report left arm swelling and pain. Angiography in March 2005 revealed subclavian stenosis adjacent to the leading or central margin of the stent with development of significant collateral venous circulation. After discussion with the patient, it was decided that repeat stent implantation would not be attempted, given that the patient believed her symptoms

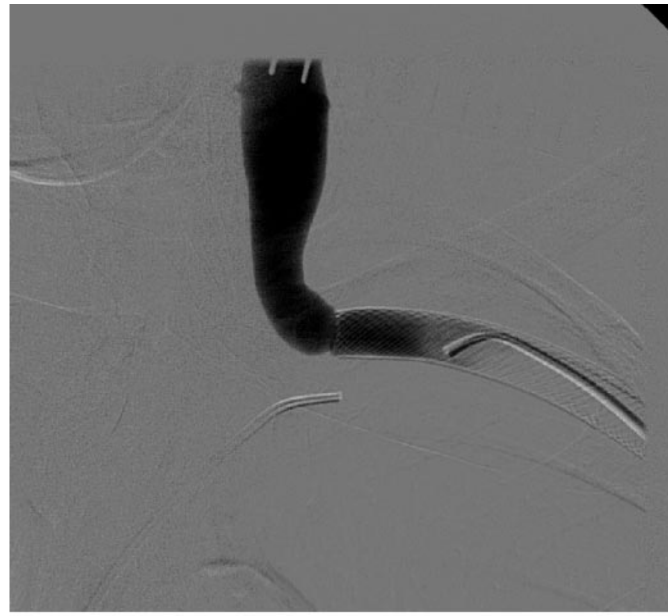
From the Department of Interventional Radiology (M.O.B.), University Health Network and Mount Sinai Hospital, University of Toronto, Toronto; and Department of Interventional Radiology (M.R.A., A.M.), Lakeridge Health Corporation, Oshawa, Ontario, Canada. Received March 23, 2006; revision requested July 4; final revision received July 6; and accepted July 12. **Address correspondence to** M.O.B., 13 Marshview Dr., Sackville, NB, Canada E4L 3B2; E-mail: mark.baerlocher@utoronto.ca

None of the authors have identified a conflict of interest.

DOI: 10.1097/01.RVI.0000243637.23923.A7



1.



2.

Figures 1, 2. **(1)** Contrast medium injection from a femoral vein approach demonstrates subclavian vein occlusion. **(2)** Contrast medium injection from a basilic vein approach demonstrates subclavian vein occlusion and retrograde blood flow up the internal jugular vein.

were tolerable and that dialysis had not been affected (arterial blood flow, 800–900 mL/min). However, the patient's symptoms worsened, and angiography in September 2005 revealed complete subclavian vein occlusion with retrograde blood flow up the left internal jugular vein. Attempted recanalization with a variety of catheters and wires was unsuccessful. Three weeks later, another attempt was made with use of a retrograde approach via the brachiocephalic vein; this attempt was also unsuccessful. The patient's symptoms continued to worsen. By February 2006, the patient reported severe soft-tissue swelling of her scalp and left arm, painful venous distention in the head, and unilateral left conductive hearing loss. Cataract surgery was canceled until her symptoms could be alleviated because the ophthalmologist was concerned regarding the degree of venous congestion. Another attempt at recanalization in February 2006 failed. On this occasion, sharp recanalization with use of the trailing end of a stiff 0.035-inch Glidewire (Terumo, Somerset, NJ) was performed. Contrast medium extravasation into the mediastinum was noted, but the patient's condition remained stable.

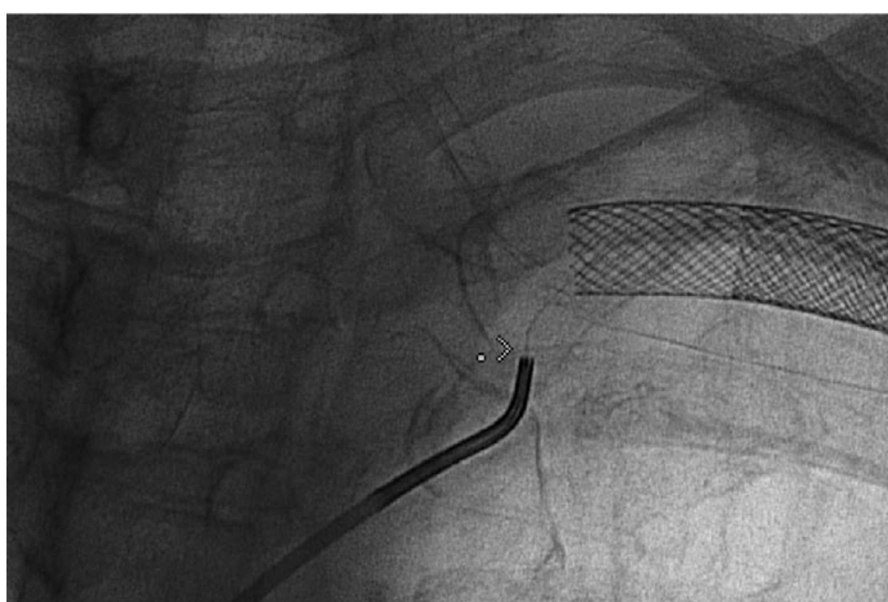
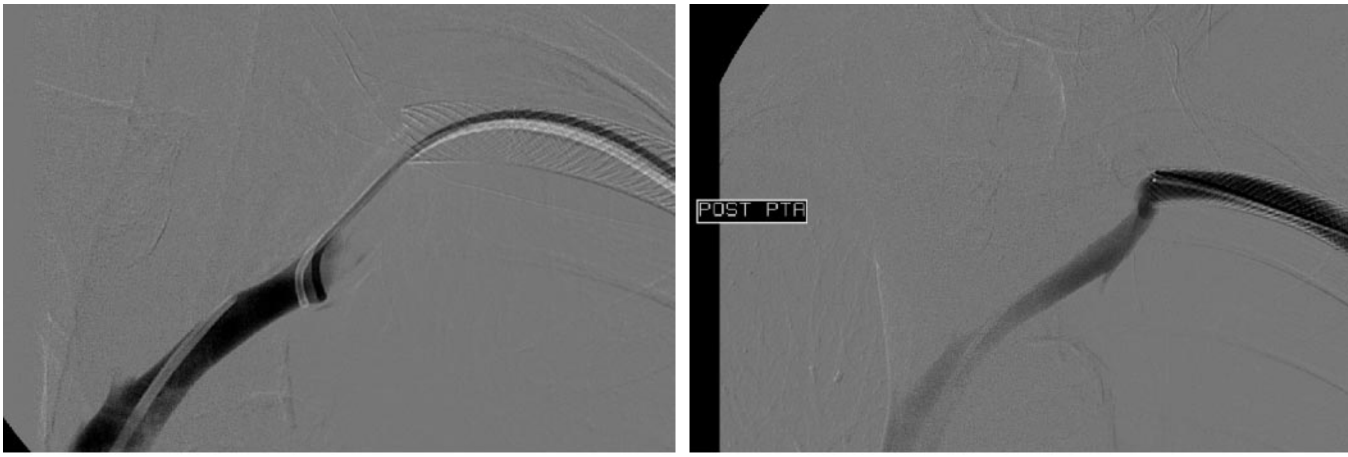


Figure 3. Image showing the tip (arrow) of the PowerWire having traversed the subclavian vein occlusion in contact with the transfemoral brachiocephalic vein catheter.

In March 2006, after an RF generator and Powerwire (Baylis Medical, Montreal, QC, Canada) were obtained by our institution, we again attempted to recanalize the left subclavian vein. Under local anesthesia and moderate sedation (100 μg fentanyl and 1 mg midazolam intravenously), the patient was prepared and draped in the appropriate fashion. The fistula was punctured in an antegrade direction. Several attempts to recanalize the occluded segment were again unsuccessful from femoral and basilic vein approaches (**Figs 1, 2**). With use of a 4-F



4. 5.

Figures 4, 5. **(4)** Contrast medium injection through the C2 Glidecath inserted through the fistula after successful RF perforation of left subclavian occlusion confirms intraluminal position within the left brachiocephalic vein. **(5)** Contrast medium injection through the fistula demonstrates restoration of antegrade flow after balloon angioplasty. After this, the patient reported partial symptomatic relief.

C2 angled Glidecath (Meditech/Boston Scientific, Natick, MA), a 0.035-inch angled PowerWire was advanced to the location of the occlusion. With a dedicated RF generator, 10 W of power was applied for 2 seconds through a 1.5-mm exposed segment at the tip of the PowerWire (**Fig 3**). The wire was seen to "jump" forward. Initially, contrast agent injection opacified a false passage adjacent to the brachiocephalic vein. The PowerWire was repositioned at the site of occlusion, and again 10 W of power was applied for 2 seconds. The wire was again seen to jump forward. Subsequent manipulation confirmed contact with the catheter positioned in the central brachiocephalic vein from the femoral approach. The Glidecath was easily advanced over the PowerWire. Contrast agent injection confirmed intraluminal placement within the brachiocephalic vein (**Fig 4**).

An 8-mm-diameter Conquest balloon (Bard Peripheral Vascular, Tempe, AZ) was then used to dilate the previously occluded segment. An 8-mm balloon was used rather than a larger one to prevent venous rupture because the patient had small veins. Contrast agent injection demonstrated the restoration of antegrade flow (**Fig 5**). A 10-mm × 49-mm Wallstent (Boston Scientific) was deployed from the subclavian vein to the mid-brachiocephalic vein, telescoping into the previously inserted stents. It was dilated with an 8-mm × 4-cm Conquest balloon, followed by a 10-mm × 4-cm balloon (Bard Peripheral Vascular). Contrast agent injection demonstrated the majority of flow being antegrade into the brachiocephalic vein, with a small amount of retrograde flow directed into the internal jugular vein (**Fig 6**).

The patient tolerated the procedure well, and there were no immediate complications. The patient reported subjective symptomatic improvement immediately after the first balloon angioplasty of the previously occluded vessel, with improved hearing and less pain. Three weeks later she successfully underwent cataract surgery and has reported continued symptomatic improvement. At the last follow-up visit 4 months after the procedure, the patient's hearing was much improved, to such an extent that she seldom required her hearing aid.

DISCUSSION

An increasing number of reports on the use of RF perforation have been published recently. In one of the earlier reports, Hausdorf et al (4) used RF perforation to "reconstruct" a right ventricular outflow tract that had become occluded secondary to muscular pulmonary atresia. Others have since similarly used the technique to reconstruct atretic pulmonary valves of various causes in neonates and infants (5–10). Justino et al (11) used the technique in the treatment of a child with congenital heart disease via the creation of a transseptal defect. There is also increasing evidence of its use for percutaneous left heart access (3,12). Therefore, to date, published reports on RF perforation have focused on its use for cardiac applications.

In the current case, transcatheter RF perforation was successfully used to treat a chronic and resistant venous occlusion. It should be mentioned that there was no concern of "jailing out" the left internal jugular vein because (i) a bare stent was used (so flow was still possible to the jugular vein) and (ii) the intent was to redirect flow through the innominate vein and reduce the retrograde flow up the jugular vein, thereby alleviating the patient's cranial and ocular symptoms.

There is some previous evidence that RF perforation may be effective years after the original occlusion occurs. For example, Fink et al (13) reported an interesting such case in which RF perforation was successfully used to reconstruct a surgically disconnected left pulmonary artery in a 7-year-old patient with transposition of the great arteries (and postarterial switch operation) 4 years after complete occlusion.

There are reports in the literature of other techniques that can be used to treat complete vascular occlusions, such as sharp recanalization (14). In the current case, we attempted some of these techniques (eg, use of a Glidewire, still Glidewire, catheter only,

Figure 6. Completion angiogram shows widely patent left subclavian vein with stent.

and trailing end of a Glidewire), none of which worked. Although RF perforation does not have greater directional control per se, the advantage is that it seems to advance relatively easily with the use of controlled energy applied in a specific direction, and the technology is thought to cause minimal local collateral damage (3).

References

1. Wood MA, Brown-Mahoney C, Kay GN, et al. Clinical outcomes after ablation and pacing therapy for atrial fibrillation: a meta-analysis. Circulation 2000; 101:1138–1144.
2. Honig WM. The mechanism of cutting in electrosurgery. IEEE Trans Biomed Eng 1975; 22:58–62.
3. Veldtman GR, Hartley A, Visram N, et al. Radiofrequency applications in congenital heart disease. Expert Rev Cardiovasc Ther 2004; 2:117–126.
4. Hausdorf G, Schulze-Neick I, Lange PE. Radiofrequency-assisted "reconstruction" of the right ventricular outflow tract in muscular pulmonary atresia with ventricular septal defect. Br Heart J 1993; 69:343–346.
5. Schneider M, Schranz D, Michel-Behnke I, et al. Transcatheter radiofrequency perforation and stent implantation for palliation of pulmonary atresia in a 3060-g infant. Cathet Cardiovasc Diagn 1995; 34:42–45.
6. Kort HW, Balzer DT. Radiofrequency perforation in the treatment of acquired left pulmonary atresia following repair of tetralogy of Fallot. Cathet Cardiovasc Intervent 2003; 60:79–81.
7. Pedra CA, Filho RM, Arrieta RS, et al. Recanalization of a discrete atretic right pulmonary artery segment with a new radiofrequency system. Cathet Cardiovasc Intervent 2003; 60:82–87.
8. Kothari SS, Sharma SK, Naik N. Radiofrequency perforation for pulmonary atresia and intact ventricular septum. Indian Heart J 2004; 56:50–53.
9. Hill SL, Mizelle KM, Vellucci SM, et al. Radiofrequency perforation and cutting balloon septoplasty of intact atrial septum in a newborn with hypoplastic left heart syndrome using transesophageal ICE probe guidance. Cathet Cardiovasc Intervent 2005; 64:214–217.
10. Javois AJ, Van Bergen AH, Cuneo BF, et al. Novel approach to the newborn with hypoplastic left heart syndrome and intact atrial septum. Cathet Cardiovasc Intervent 2005; 66:268–272.
11. Justino H, Benson LN, Nykanen DG. Transcatheter creation of an atrial septal defect using radiofrequency perforation. Cathet Cardiovasc Intervent 2001; 54:83–7.
12. Sakata Y, Feldman T. Transcatheter creation of atrial septal perforation using a radiofrequency transseptal system: novel approach as an alternative to transseptal needle puncture. Cathet Cardiovasc Intervent 2005; 64:327–332.
13. Fink C, Peuster M, Bertram H, et al. Transcatheter recanalization of the left main pulmonary artery after four years of complete occlusion. Catheter Cardiovasc Intervent 2001; 53:81–84.
14. Farrell T, Lang E, Barnhart W. Sharp recanalization of central venous occlusions J Vasc Interv Radiol 1999; 10:149–154.