Cardiovasc Intervent Radiol (2011) 34:1296–1302
DOI 10.1007/s00270-011-0110-5

TECHNICAL NOTE

A Novel Fenestration Technique for Abdominal Aortic Dissection Membranes Using a Combination of a Needle Re-entry Catheter and the "Cheese-wire" Technique

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Received: 1 November 2010 / Accepted: 10 January 2011 / Published online: 9 February 2011

Abstract

Purpose This study was designed to demonstrate the applicability of a combined needle-based re-entry catheter and "cheese-wire" technique for fenestration of abdominal aortic dissection membranes.

Methods Four male patients (mean age: 65 years) with acute complicated aortic type B dissections were treated at our institution by fenestrating the abdominal aortic dissection membrane using a hybrid technique. This technique combined an initial membrane puncture with a needle-based re-entry catheter using a transfemoral approach. A guidewire was passed through the re-entry catheter and across the membrane. Using a contralateral transfemoral access, this guidewire was then snared, creating a through-and-through wire access. The membrane was then fenestrated using the cheese-wire maneuver.

Results We successfully performed: (a) membrane puncture; (b) guidewire passage; (c) guidewire snaring; and (d) cheese-wire maneuver in all four cases. After this maneuver, decompression of the false lumen and acceptable arterial inflow into the true lumen was observed in all cases. The dependent visceral arteries were reperfused. In one case, portions of the fenestrated membrane occluded the common iliac artery, which was immediately and successfully stented. In another case, long-standing intestinal hypoperfusion before the fenestration resulted in reperfusion-related shock and intraoperative death of the patient.

Conclusions The described hybrid approach for fenestration of dissection membranes is technically feasible and may be established as a therapeutic method in cases with a complicated type B dissection.

Keywords Complicated type B dissection · Needle-based catheter · Fenestration · Cheese-wire

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Introduction

In recent years, endovascular treatment of aortic dissection has become a valuable alternative to surgical treatment, especially in cases with complicated type B dissections. Complications, such as hypoperfusion of celiacomesenteric, renal, or iliacofemoral arteries, often are related to true lumen compression and/or extension of the dissection membrane into the hypoperfused artery. A general consensus regarding the management of such complications has been established [1].

Specifically, aortic stent-grafting for proximal entry site closure and/or widening of the compressed true lumen have been described, thereby resulting in reduced inflow into the false lumen and re-extension of the true lumen. Furthermore, abdominal aortic fenestration has been shown to allow for decompression of the false lumen, again resulting in re-extension and better perfusion of the true lumen. This endovascular fenestration technique was originally described in 1990 [2]. Since then, the fenestration procedure has evolved and different devices have been applied, including large-bore curved cannulas as used for transjugular intrahepatic portosystemic shunt needles (e.g., Rösch–Ushida, Ring sets; Cook, Bloomington, IN). Different imaging modalities and targeting approaches have been applied for guidance, including fluoroscopy, with or without loop snares or catheters serving as a target, and even intravascular ultrasound, allowing for more precise depiction of true and false lumen [3, 4].

In recent years, re-entry catheters have been introduced to the market. These catheters have been shown to allow for perforation into the true lumen following subintimal recanalization in patients with peripheral arterial occlusive disease [5–7]. In single reports, usage of such needle re-entry catheter for membrane perforation has been shown, which may be followed by balloon dilatation of the fenestrated membrane [8, 9]. Even more recently, a single report described the usage of a “cheese-wire” technique for stent positioning after subintimal dissection and aortic re-entry [10]. To the best of our knowledge, this technique, allowing for through-and-through femoral–femoral guidewire control, was never described in combination with needle catheter perforation of aortic dissection membranes.

In this case series, we have applied both concepts, thereby allowing for membrane puncture and extension of the perforation by bilateral pull-down of the snared “cheese-wire.”

This new technique may be beneficial in cases that do not require urgent management and do not allow for an open operation or in cases with nonsacrificable visceral arteries branching from true or false lumen.

Materials and Methods

Fenestration procedures were performed at our institution under fluoroscopic guidance in collaboration and in consensus between vascular surgery and interventional radiology staff in an integrated multimodality sterile suite [11].

In all patients, 5,000 IU of heparin were given intraarterially after transfemoral sheath placement.

Case 1

A 60-year-old male patient with acute thoracico-abdominal type B dissection clinically presented with acute ischemia of the right leg but was otherwise symptom-free (Fig. 1). Initial CT angiography (CTA) documented the full extent of the dissection membrane and especially the subtotal collapse of the true lumen.

On CTA, no stenoses were noted along the pelvic arteries or along the visceral arteries. The patient was referred for fenestration of the abdominal aortic dissection membrane.

In the multimodality sterile suite, under sterile precautions and after local anesthesia to the skin, a bilateral retrograde puncture of the common femoral artery was performed using 18-gauge needles; 6-French sheaths were inserted. Through the right-sided access a nonselective catheter (4-French, Omni-Flush, 65 cm; Angiodynamics, Queensbury, NY) was advanced in the subtotally collapsed true lumen, which was confirmed by angiography also depicting the origin of the celiac trunk, superior mesenteric artery and right renal artery. Left-sided advancement of a nonselective catheter (4-French Pigtail, 100 cm; Cook, Bloomington, IN) led to positioning within the larger false lumen, with angiography confirming patency of the left renal artery branching from the false lumen. Via the right-sided access the needle re-entry Outback catheter (Cordis, Miami, FL) was inserted over the compatible 0.014 inch guidewire (NiT-Vu, 300 cm; Angiodynamics) to the level of the narrowest portion of the true lumen. The catheter was then configured with the needle-outlet pointing toward the false lumen (L-configuration) and single-pass perforation was performed. The wire was then passed into the false lumen and the catheter was removed.

Through the left-sided access, a 15 mm gooseneck snare (Amplatz Goose Neck; ev3, Plymouth, MN) was inserted, and the 0.014 inch wire was snared and pulled into and out of the left-sided 6-French sheath. Having obtained through-and-through guidewire control, the initially needle created button-hole in the dissection membrane was enlarged, hopefully slitting it by simultaneous bilateral pull-down maneuver of the wire up to one vertebra (or approximately 3 cm) above the bifurcation.

Control angiography documented better expansion and perfusion of the true lumen. Because a small membrane was noted in projection onto the origin of the right common iliac artery, adjunctive placement of a stent (12 mm/40 mm, SMART Stent; Cordis Europe, Roden, Netherlands) was performed. Immediately, the patient’s ischemic symptoms of the right leg resolved.

Case 2

A 69-year-old male patient presented 1 month after operative repair of thoracico-abdominal type A dissection by ascending aortic reconstruction (Fig. 2). Within the postoperative course, the patient developed bilateral claudication (Fontaine stage 2b). Initial CTA documented high-grade compression of the infrarenal true aortic lumen with the dissection membrane extending into the left common iliac artery. As described above, again using percutaneous bilateral transfemoral retrograde accesses, outback maneuver was performed, thereby perforating the membrane. Having inserted a 65 cm 4-French vertebral catheter (Glidecath, Terumo Europe, Leuven, Belgium), this wire was exchanged for an 0.018 inch wire (V18; Angiodynamics) and a 5-French Sos Omni 3 80 cm (Angiodynamics) was passed

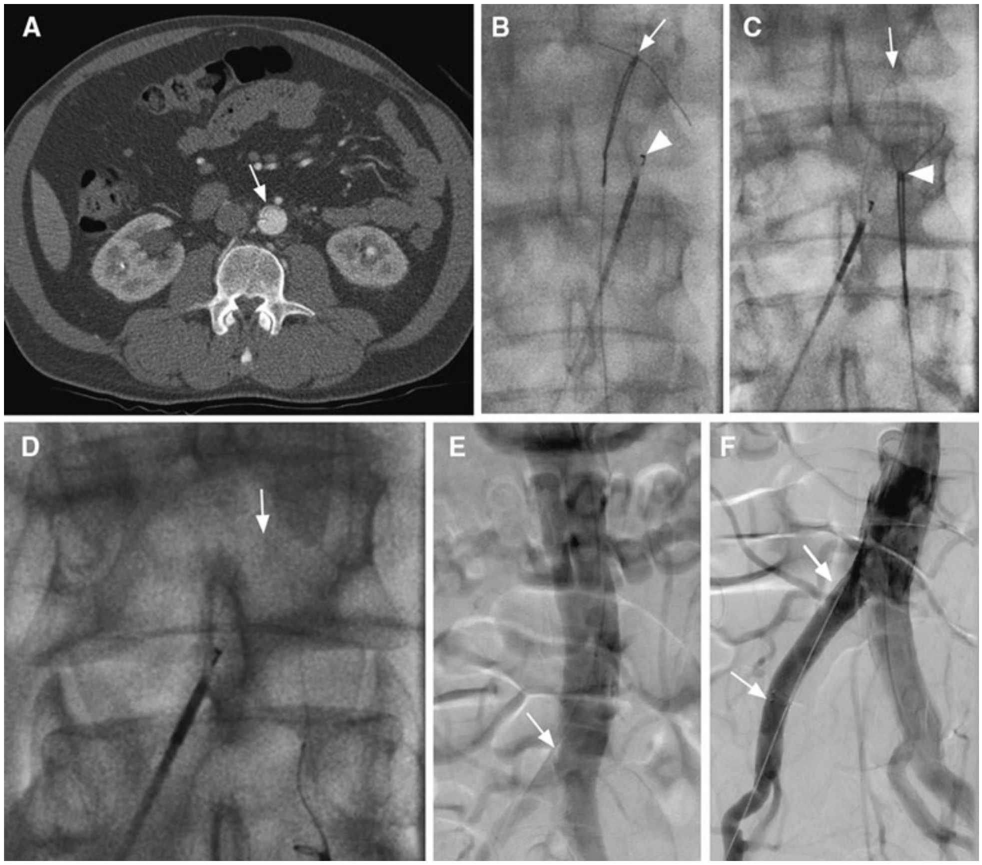

Fig. 1 Sixty year old male patient with acute thoracico-abdominal type B dissection, clinically presented with acute ischemia of the right leg. CTA (**A**) demonstrates a severely compressed true lumen within the infrarenal abdominal aorta (*arrow*). The dissection membrane was then perforated (**B**) using a combination of outback catheter (*arrowhead*) and 0.014-inch wire, the latter being snared through a contralateral transfemoral approach (*arrow*). Using the snared wire (arrowhead in **C**) cheese-wire pull-down (*arrows*) was sequentially performed (**C** and **D**). Angiography documented good perfusion of the true lumen, but a small dissection membrane extending into the right common iliac artery was noted (*arrow* in **E**). This was successfully stented (*arrows* in **F**) so that immediately the patient's ischemic symptoms of the right leg resolved

over this 0.018 inch wire across the membrane. The SOS catheter and 0.018 inch wire were then snared (15 mm Amplatz Goose Neck; ev3) and again by bilateral pull-down dissection, the flap was retracted and hopefully a slit was created.

During the postinterventional course, moderate claudication remained so that, after 5 days, stenting of the infrarenal aortic stenosis had to be performed using a 24/45 mm stent (Wall Stent; Boston Scientific, Natick, MA). Dilatation using a 20/40 mm balloon (Maxi Balloon; Cordis Europe, Roden, Netherlands) gave a good postoperative result without further evidence of claudication (ankle–brachial index left: 1.24, right: 1.39).

Case 3

A 70-year-old male patient suffering from coronary-artery disease underwent aorto-coronary bypass surgery resulting in iatrogenic type A dissection, necessitating operative hemi-arch reconstruction (Fig. 3). Within the postoperative course (postoperative day 1), the patient developed acidosis and arterial hypotension, lasting for several hours. At that point, CTA documented additional extension of the dissection membrane into the abdominal aorta with subtotal collapse of the true lumen by the pressurized false lumen. In addition, the superior mesenteric artery was not perfused in the proximal 20 mm, with the celiac trunk being patent and perfused through the false lumen. Using percutaneous bilateral transfemoral retrograde accesses, outback maneuver was performed, puncturing from the true lumen into the widely patent false lumen.

In this case, over the passed 0.014 guidewire (NiT-Vu, 300 cm; Angiodynamics) and after removal of the outback catheter, a 4-French 65 cm vertebral catheter (Glidecath, Terumo Europe, Leuven, Belgium) was inserted with the tip being positioned in the false lumen. The wire was exchanged for a 0.018 inch wire (V18; Angiodynamics).

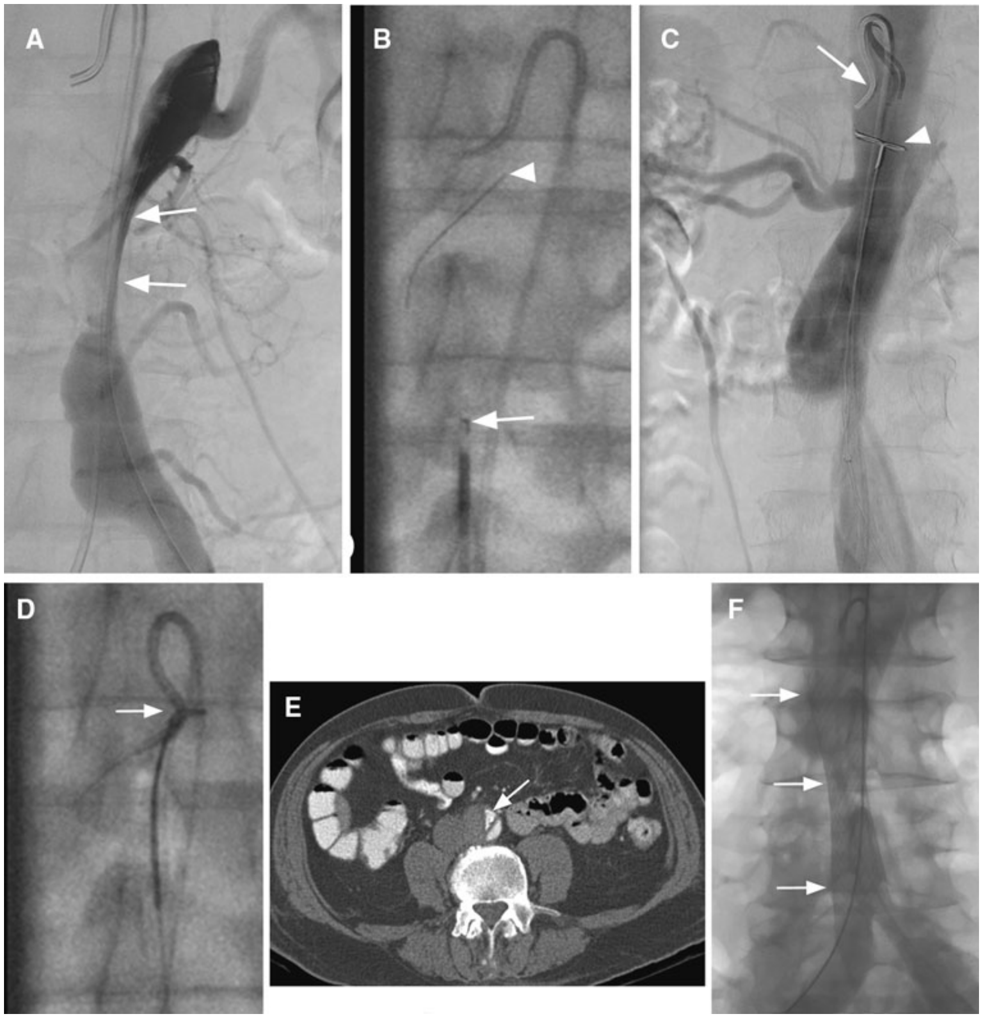

Fig. 2 Sixty nine year old male patient 1 month after operative repair of thoracico-abdominal type A dissection by ascending aortic reconstruction developed bilateral claudication. Angiography (*arrows* in **A**) documented high-grade compression of the true lumen. Using percutaneous bilateral transfemoral retrograde accesses, outback catheter (*arrow* in **B**) was used to perforate the membrane and pass a 0.014-inch wire into the false lumen (*arrowhead* in **B**). Consecutively a 5-French Sos Omni 3 catheter (*arrow* in **C**) was passed across the membrane and a gooseneck snare was contralaterally inserted (*arrowhead* in **C**). SOS catheter and 0.018-inch wire were snared and again by bilateral pull-down dissection membrane slit was created (*arrow* in **D**). Because moderate claudication remained, CTA was performed documenting better perfusion but persisting compression of the true lumen, so that after 5 days stenting and postdilatation were performed (*arrows* in **F**), resulting in acceptable true lumen extension and good postoperative result without further evidence of claudication

The 0.018 inch wire was then snared (25 mm Amplatz Goose Neck; ev3) from the contralateral side and again by bilateral pull-down (to the level of the third lumbar vertebra) and hopefully a dissection membrane slit was created. Angiography confirmed expansion of the true lumen and showed patency and reperfusion of the superior mesenteric artery. Unfortunately, due to long-standing intestinal hypoperfusion and resulting reperfusion syndrome, shock and pulseless electric activity developed within minutes. Despite extensive supportive measures through the on-site anesthesiologist and cardiopulmonary resuscitation, the patient died in the operating room.

Case 4

A 60-year-old male patient with incidentally diagnosed chronic thoracico-abdominal type B dissection presented with bilateral claudication (Fontaine stage 2b, Ankle–brachial Index at rest right: 0.89, left: 0.92). CTA documented a significantly collapsed true lumen of the infrarenal aorta.

As described in cases 1 and 2, using percutaneous bilateral transfemoral retrograde accesses, outback maneuver was performed just below the level of the right renal artery. The passed 0.014 guidewire (NiT-Vu, 300 cm; Angiodynamics) was snared (25 mm Amplatz Goose

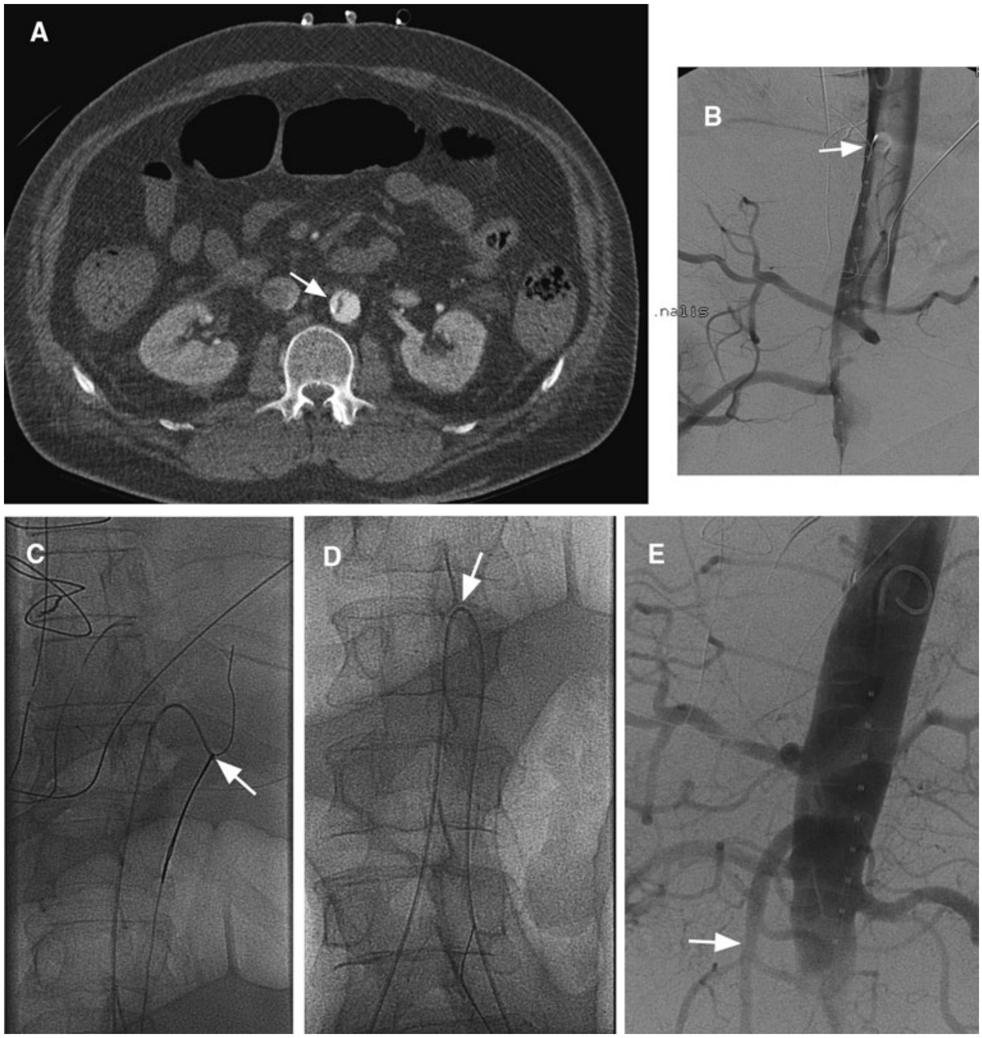

Fig. 3 Seventy year old male patient 1 day after aorto-coronary bypass surgery with iatrogenic type A dissection necessitating operative hemi-arch reconstruction. Within the postoperative course, metabolic acidosis was noted and CTA (**A**) documented extension of the dissection into the abdominal aorta with severe compression of the true lumen (*arrow* in **A**). This was confirmed by flush angiography (**B**). Using an outback catheter, the dissection membrane was perforated and the passed wire was snared (*arrow* in **C**) and pulled down using a cheese-wire technique (*arrow* in **D**). Angiography confirmed expansion of the true lumen and showed patency and reperfusion of the superior mesenteric artery (*arrow* in **E**)

Neck; ev3), and by bilateral pull-down dissection, the membrane was hopefully slit.

This was a good postinterventional result with angiographically normalized flow and diameter of the true lumen. Clinically, there was no further evidence of claudication.

Results

We successfully performed: (a) membrane puncture, (b) guidewire passage, (c) guidewire snaring, and (d) cheese-wire maneuver in all four cases. After this maneuver, acceptable arterial inflow into the true lumen was observed in all cases. The dependent visceral arteries were reperfused.

In one case, portions of the fenestrated membrane occluded the common iliac artery, which was immediately and successfully stented.

In another case, long-standing intestinal hypoperfusion before the fenestration resulted in reperfusion-related shock and intraoperative death of the patient.

In a further case, membrane fenestration did not fully resolve the bilateral claudication so additional percutaneous stenting was performed, expanding the true lumen. After this adjunctive procedure, no further evidence of claudication was present.

Having administered 5,000 IU of heparin in all cases, no thrombotic or embolic events were encountered.

Discussion

Complicated aortic dissection is a potentially life-threatening condition. Untreated mortality rates of up to 50% within 48 h are reported and, even after successful intervention, 30-day mortality rates may be as high as 25% due to pre-existing irreversible ischemia of visceral organs [1, 3, 12, 13].

We report a new hybrid technique combining needle based re-entry catheter perforation of the membrane in combination with a lately described cheese-wire technique for slit formation along the membrane [10]. During the past decade, such membrane fenestrations were performed simply using the rigid end of a guidewire or even more rigid and larger-bore devices (transjugular intrahepatic portosystemic shunt needles), potentially bearing the risk of fatal perforation. Caliber and rigidity of devices was in some studies compensated by adding intravascular ultrasound (IVUS) for procedure guidance [14]. The availability of IVUS currently limits its usage. Therefore, some groups have published case reports documenting their experience using a gracile needle-based re-entry catheter system for fenestration. These reports have combined fenestration with dilatation of the created hole using balloons [8, 9]. Some authors recommend two-step dilatation of the fenestration site using a smaller balloon (e.g., 5 mm) and then a larger balloon (e.g., 18 mm) [15]. Other groups advocate for a more gradual dilatation process, sequentially using 5, 12, and 14 mm balloons [9]. Of course, usage of such re-entry catheters should be limited to the experienced operator but was technically easily feasible within this series, especially because we were targeting from the collapsed true lumen toward the expanded false lumen. This technique makes both true and false lumen access mandatory, which can be difficult to obtain and time-consuming. Cases with a single undissected common iliac artery and those cases with false lumen re-entry into the internal iliac artery are technically challenging, because they allow only for true-lumen access by the transfemoral wire. In our cases, however, we did not encounter these problems.

Precise knowledge of the preoperative CTA findings and, especially, the geographical relationship between both lumens, allows for procedure planning, needle positioning, and safe puncture.

Theoretically unstable ulcerations and dense plaque may be visualized on those CTAs and may result in an increased risk of peripheral embolism during the procedure. However, we did not encounter these complications in the hereby presented series.

Because we did not measure intra-arterial pressures and pressure gradients during our interventions, we cannot explain the ultimate cause of true lumen narrowing in the described cases. Theoretically, this may be due to a fall in pressure within the true lumen (Bernoulli effect) or compression by the larger false lumen, especially when re-entry is not present or not effective.

The needle markers of the needle-based catheter have been proven to be well visible under fluoroscopy and allowed for determination of L- and T-configuration and successful puncture in this series. We believe that the applied cheese-wire technique may be a valuable alternative to balloon expansion of the fenestration site as it allows for single-step long-range fenestration. Snaring of the guidewire was easily feasible in all cases. In our series the sequence of membrane puncture, wire snaring, and slit creation took less than 30 min in all cases. The pull-down of the cheese-wire was performed within seconds by a single downward motion, with increasing force until the operator felt loss of resistance. However, special care was taken not to go beyond the level of the aortic bifurcation.

As a drawback, creation of this tear is not precisely controllable and may result in obstruction of branching vessels, which makes additional stenting necessary (e.g., cases 1 and 2).

For this reason, we did not apply this technique cranially to SMA and renal arteries and believe that potentially occurring stenoses and occlusions of the iliac arteries can safely be treated through the obtained bilateral transfemoral access. In all cases, we performed control-angiography after the cheese-wire maneuver. This angiography was used to search for potentially complicating stenoses and occlusions. If relevance of such stenoses should not be obvious from angiography alone, even additional intra-arterial pressures may be measured.

As shown in cases 2 and 3, the described technique can be modified by exchange of the 0.014-inch wire for thicker and stiffer wires (e.g., 0.018 inch) and by snaring a combination of wire and catheter. In theory, this creates a thicker tear within the membrane, potentially allowing for better wire control and to maximize inflow into the visceral arteries.

As a limitation of this technical note, the definitive anatomic mechanism of our cheese-wire procedure is not proven, as we do not provide necropsy results. Pull-down of the snared wire may result in creation of a longitudinal slit or in a transverse intimal tear followed by stripping and inversion of the flap.

Comparing this technique with other options, such as open perforation or flap resection or primary stenting of dissections, this new technique may be beneficial in cases that do require urgent management and do not allow for an open operation, or in cases with non-sacrificable visceral arteries branching from true or false lumen.

Conflict of interest None.

Grant information None

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