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Transcatheter electrosurgical septotomy technique for chronic postdissection aortic aneurysms

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ABSTRACT

Aortic dissection often results in chronic aneurysmal degeneration due to progressive false lumen expansion. Thoracic endovascular aortic repair and other techniques of vessel incorporation such as fenestrated-branched or parallel grafts have been increasingly used to treat chronic postdissection aneurysms. True lumen compression or a vessel origin from the false lumen can present considerable technical challenges. In these cases, the limited true lumen space can result in inadequate stent graft expansion or restrict the ability to reposition the device or manipulate catheters. Reentrance techniques can be used selectively to assist with target vessel catheterization. Transcatheter electrosurgical septotomy is a novel technique that has evolved from the cardiology experience with transseptal or transcatheter aortic valve procedures. This technique has been applied in select patients with chronic dissection to create a proximal or distal landing zone, disrupt the septum in patients with an excessively compressed true lumen, or connect the true and false lumen in patients with vessels that have separate origins. In the present report, we summarize the indications and technical pitfalls of transcatheter electrosurgical septotomy in patients treated by endovascular repair for chronic postdissection aortic aneurysms. (J Vasc Surg Cases Innov Tech 2024;10:101402.)

Keywords: Aortic aneurysm; Dissection; Endovascular aortic repair; Fenestration; Transcatheter electrosurgical septotomy

Aortic dissection is the most common aortic catastrophe with a potential risk of acute complications such as rupture or end-organ malperfusion.[1] Among patients who survive the initial phase, progressive aneurysmal degeneration occurs often due to false lumen pressurization and expansion.[2] A variety of early anatomic surrogates have been used to predict the risk of aneurysmal degeneration, including the diameter of the aorta, false lumen, and entry tear.[3] Although medical therapy remains the mainstream treatment of uncomplicated dissections, patients with high-risk features can be considered for early endovascular repair.[4] Patients with chronic postdissection descending thoracic and thoracoabdominal aortic aneurysms (TAAAs) are considered for thoracic endovascular aortic repair (TEVAR), with or without false lumen occlusion.[5] Those with larger aneurysms involving the thoracoabdominal aorta require hybrid or total endovascular techniques for complete aneurysm exclusion. In these patients, fenestrated-branched endovascular repair (FB-EVAR) has been increasingly used, with low mortality and morbidity.[6-9] Excessive compression of the true lumen or vessel originating from the false lumen represents a technical challenge due to limited space for stent graft expansion and catheter manipulations and the frequent need for reentrance techniques to successfully incorporate the target vessel. Transcatheter electrosurgical septotomy was originally used to divide aortic valve leaflets before transcatheter aortic valve replacement to prevent coronary artery obstruction[10] but later was applied as an adjunctive technique in patients with chronic postdissection aneurysms.[11,12] We describe the clinical applications, technical pitfalls, and limitations of transcatheter electrosurgical septotomy for four different indications among patients with subacute or chronic postdissection aneurysms. All the patients provided written informed consent for the report of their case details and imaging studies.

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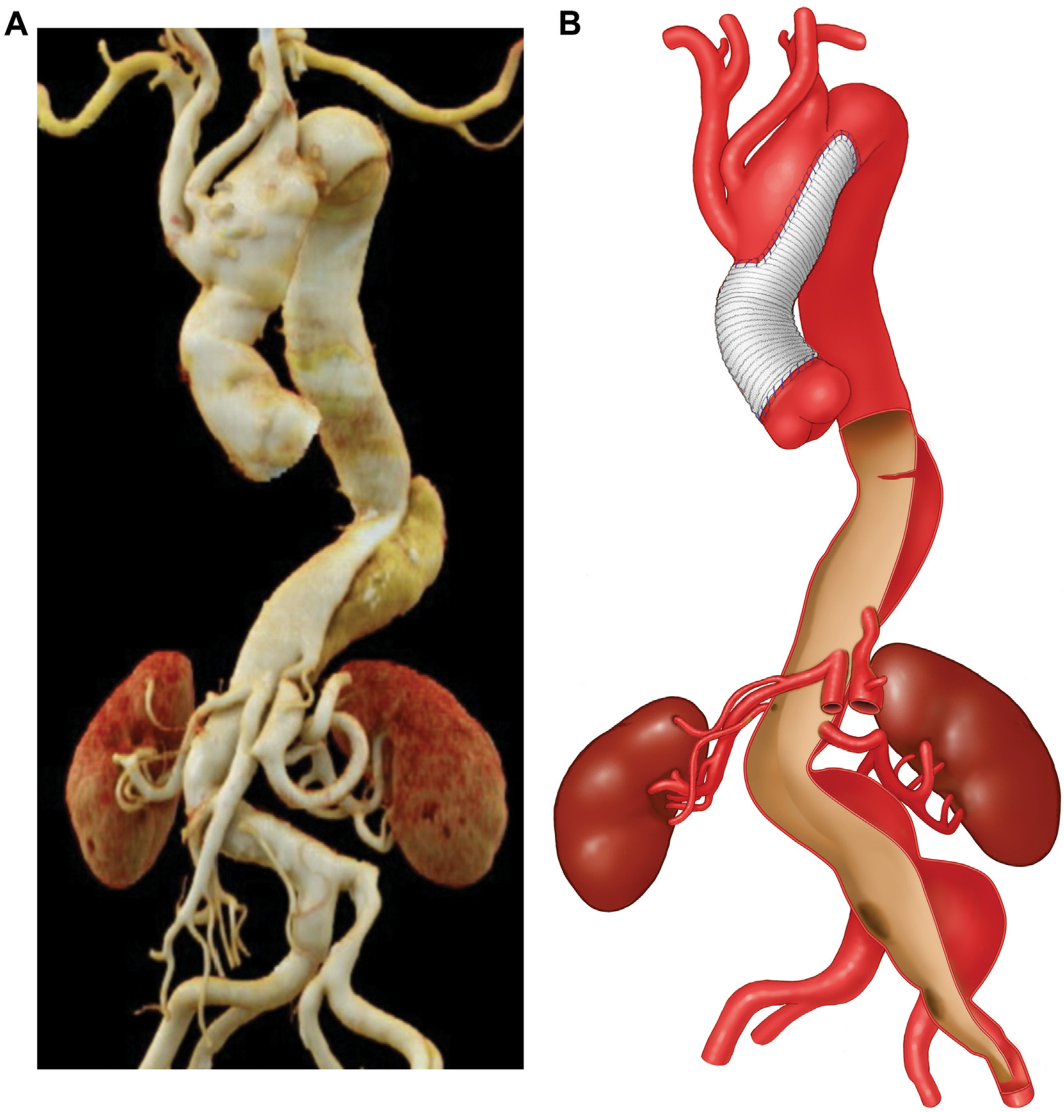

Fig 1. A, Computed tomography angiography (*CTA*) of chronic postdissection extent III thoracoabdominal aortic aneurysm (*TAAA*) with a large left common iliac artery aneurysm. **B,** Illustration demonstrating location of residual proximal entry tear, small enlargement of the distal thoracic aorta (3.8 cm), with a normal, tortuous infrarenal aortic sealing zone (2.5 cm), and compression of the true lumen in the iliac arteries.

TECHNIQUE

The technique is described in detail in the Supplementary Video 1. Endovascular repair was performed under general anesthesia in a hybrid operating room with fixed imaging using the Allia IGS 7 system (GE Healthcare, Buc, France) and advanced applications, including onlay fusion and high-definition cone beam computed tomography (CBCT). Percutaneous access with the preclosure technique was performed in standard fashion. Access to the true and false lumens was confirmed by intravascular ultrasound (IVUS). Septotomy was indicated as an adjunct to endovascular repair in a minority of patients with subacute or chronic dissections and was avoided in the acute phase. The indications were (1) creation of a proximal and/or distal landing zone within aortic segments that were involved by dissection but had minimal or no enlargement to limit the extent of aortic coverage; (2) elimination of compressed true lumen to facilitate stent graft expansion and catheter manipulation; and (3) communication of true and false lumens to facilitate target vessel incorporation during FB-EVAR when the vessels have separate luminal origins.

Case 1: creation of proximal landing zone in dissected segment. A 79-year-old woman with a history of hypertension, hyperlipidemia, and chronic obstructive pulmonary disease presented with an enlarging 5-cm left common iliac artery aneurysm. The patient had a prior hemi-arch repair for DeBakey type I aortic dissection. Computed tomography angiography (CTA) showed chronic dissection with mild enlargement of the

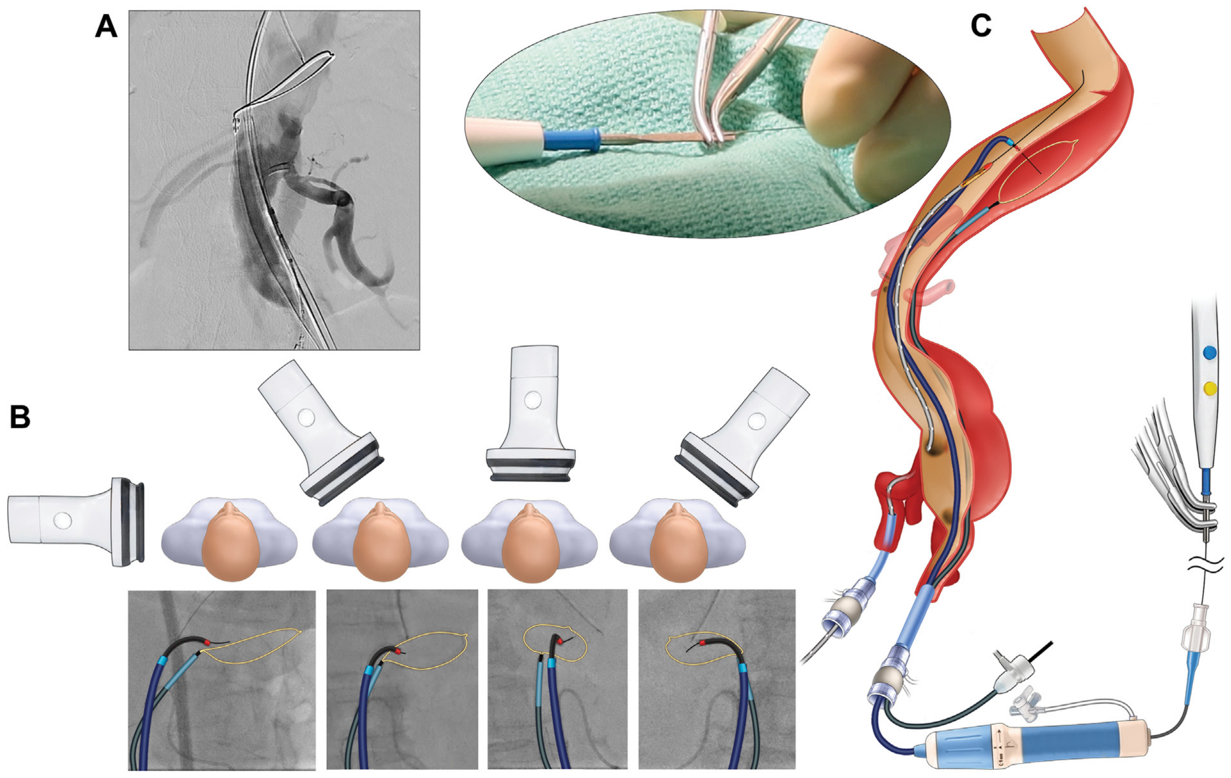

Fig 2. **A,** A 6F steerable sheath is positioned in the true lumen opposite to a snare, which is positioned into the false lumen. **B,** Confirmation of orientation in multiple views should be performed before traversing the septum. **C,** The 0.018-in. guidewire is denuded from its coating and connected to the cautery on the cut mode, with gentle forward movement of the guidewire allowing for safe passage across the lamella and snaring.

descending thoracic aorta (3.8 cm) and a normal aortic diameter at the level of the renal arteries (2.5 cm). The chronic dissection flap extended into the left common and external iliac arteries with significant true lumen compression (Fig 1). Transcatheter electrosurgical septotomy of the infrarenal aorta and iliac arteries was planned to facilitate infrarenal endovascular aortic aneurysm repair with left internal iliac preservation using an iliac branch endoprosthesis.

The procedure was performed using a bilateral percutaneous approach with a preclosure technique. Access was established into the true and false lumens and confirmed by IVUS. A 20F DrySeal sheath (W.L. Gore & Associates) was advanced via the left femoral approach. A 6F Oscor steerable guiding sheath was positioned initially below the renal arteries. However, due to excessive angulation, the sheath was moved upward to the level of the celiac axis (CA). A 35-mm Amplatz goose neck snare kit (ev3 Inc) was advanced via the left femoral sheath into the false lumen and opened opposite to the steerable sheath to facilitate orientation during guidewire crossing the dissection septum. The orientation between the steerable sheath and snare was confirmed under fluoroscopy in the anteroposterior, lateral, and oblique views (Fig 2, *A* and *B*). Once the orientation was optimized, a 90-cm NaviCross 0.018-in. catheter (Terumo Medical Corp) and 300-cm Astato 0.018-in. hydrophilic guidewire (Asahi Intecc USA Inc) were prepared by removing the guidewire coating and connecting the guidewire to the electrocautery. With the electrocautery set on cut mode at 80 W, the guidewire was gently advanced across the dissection membrane without difficulty and promptly snared (Fig 2, *C*). The through-and-through guidewire was retracted, along with the NaviCross catheter to allow for creation of a 5-mm trapeze-shaped area and was denuded from the coating and readvanced into position (Fig 3). A second NaviCross catheter was advanced via the other end of the Astato guidewire to protect structures from thermal injury, allowing only the 5-mm trapeze segment to be exposed (Fig 4, *A*). The Astato guidewire was again reconnected to the electrocautery, and septotomy was performed, extending to the distal end of the septum membrane in the external iliac artery (Fig 4, *B*). The septotomy was guided by fluoroscopy and confirmed with IVUS. Infrarenal endovascular aortic aneurysm repair was performed in standard fashion using a Gore Excluder Conformable stent graft (W.L. Gore & Associates) with bilateral iliac limb extensions. Due to the short distance between the renal artery and left iliac bifurcation, a 20-mm flared iliac

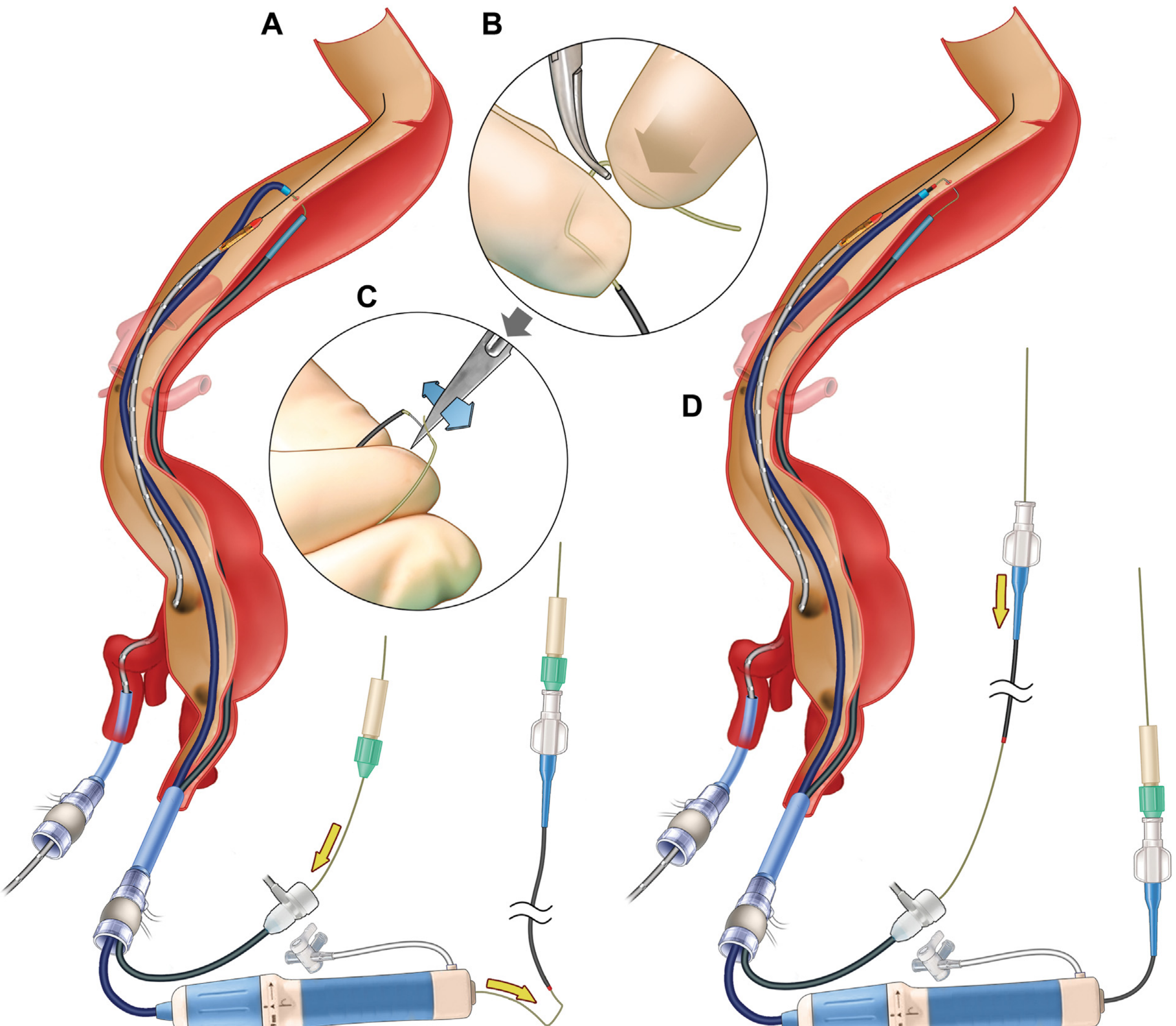

Fig 3. A, The through-and-through wire is pulled backward. **B,** A segment of the wire is bent in a trapeze shape. **C,** The coating is denuded circumferentially using a knife. **D,** The wire with the trapeze bent segment is readvanced into position, and a catheter is placed in the other end to protect tissue from thermal injury.

limb was deployed in the left common iliac artery, followed by placement of the Gore iliac branch endoprosthesis (W.L. Gore & Associates). Following deployment of the iliac branch endoprosthesis , an 8.5F Oscor steerable sheath with a locking 0.014-in. guidewire was used for selective catheterization of the iliac branch portal and left internal iliac artery. The repair was extended into the left internal iliac artery using a Gore Viabahn VBX balloon-expandable endoprosthesis (W.L. Gore & Associates; Fig 5). Due to concern for partial coverage of the left renal artery by the proximal edge of the stent graft, a VBX stent graft was deployed in the proximal left renal artery. The landing zones and attachment sites were dilated using an aortic Gore Molding & Occlusion Balloon (W.L. Gore & Associates). Rotational digital subtraction abdominal aortography and bilateral pelvic angiography with CBCT demonstrated successful septotomy and aneurysm sac exclusion with no evidence of an endoleak. Follow-up CTA at 3 months demonstrated aneurysm exclusion with complete false lumen thrombosis in the treated segment, no evidence of a type I or III endoleak, and patent renal, mesenteric, and internal iliac arteries.

Case 2: creation of a distal landing zone in the dissected segment. A 49-year-old male patient with a history of hypertension, hypercholesterolemia, gout, and cerebrovascular accident presented with subacute B3-5 aortic dissection with progressive enlargement following initial medical therapy (Fig 6, *A*). TEVAR was performed using a Gore TAG thoracic branch endoprosthesis (TBE; WL Gore & Associates, Inc) with a retrograde branch for left subclavian artery (LSA), extended by a Gore TAG conformable thoracic stent graft (WL Gore & Associates, Inc) from zone 2 to 5 using distal thoracic

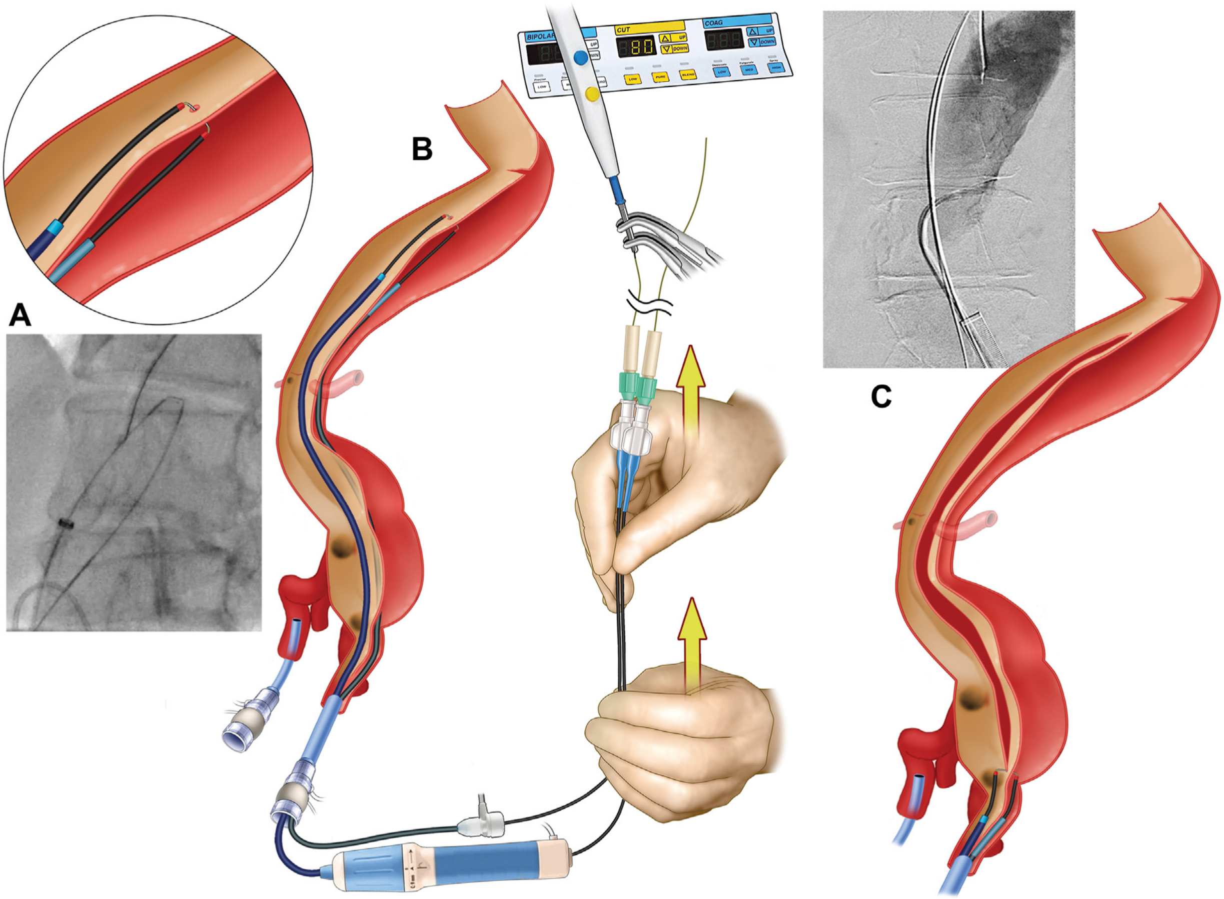

Fig 4. Once both hydrophilic catheters and the denuded trapeze-shaped guidewire are in position across the septum **(A)**, the guidewire is connected to the cautery on the cut mode at 80 W **(B)** and gently pulled down to shear the dissection flap in the desired segment **(C)**.

transcatheter electrosurgical septotomy to create a single aortic lumen and optimize the distal seal.

A bilateral percutaneous femoral approach with a preclosure technique and left radial access was established using duplex ultrasound guidance. The TBE was successfully deployed in the true lumen, followed by placement of the side branch extension into the LSA. Access into the true and false lumens was confirmed with IVUS. Using the same technique described for case 1, transcatheter electrosurgical septotomy was performed from the distal edge of the TBE device to the distal reentrance of the dissection membrane at the level of the CA (Fig 6, *B*). The TEVAR was extended to zone 5 using a Gore TAG conformable thoracic stent graft stent graft. CBCT scans with and without contrast enhancement were analyzed in the axial, coronal, and sagittal views and revealed successful dissection and aneurysm exclusion, a patent LSA, and no evidence of a type I or III endoleak (Fig 6, *C*). CTA at 4 months showed no evidence of an endoleak and complete false lumen exclusion.

Case 3: communication of true and false lumens to facilitate multibranch stent graft expansion and vessel catheterization. A 70-year-old male patient presented with a 7.3-cm extent II chronic postdissection TAAA and bilateral common iliac artery aneurysms (Fig 7, *A* and *B*). The patient had undergone prior total arch repair with the elephant trunk technique and first-stage TEVAR. A second-stage procedure was planned using an off-the-shelf Zenith t-Branch thoracoabdominal endovascular graft (Cook Medical Inc) and a bilateral Zenith branch endovascular graft-iliac bifurcation device (Cook Medical Inc) via a total transfemoral approach. CTA showed all renal and mesenteric arteries originating from a compressed lumen with an average inner diameter of 18 mm. An electrosurgical septotomy extending from the thoracic stent graft to the infrarenal aortic segment was planned to facilitate expansion of the directional branches and selective catheterization of the target vessels via a total femoral approach. Bilateral percutaneous femoral access using the preclosure technique

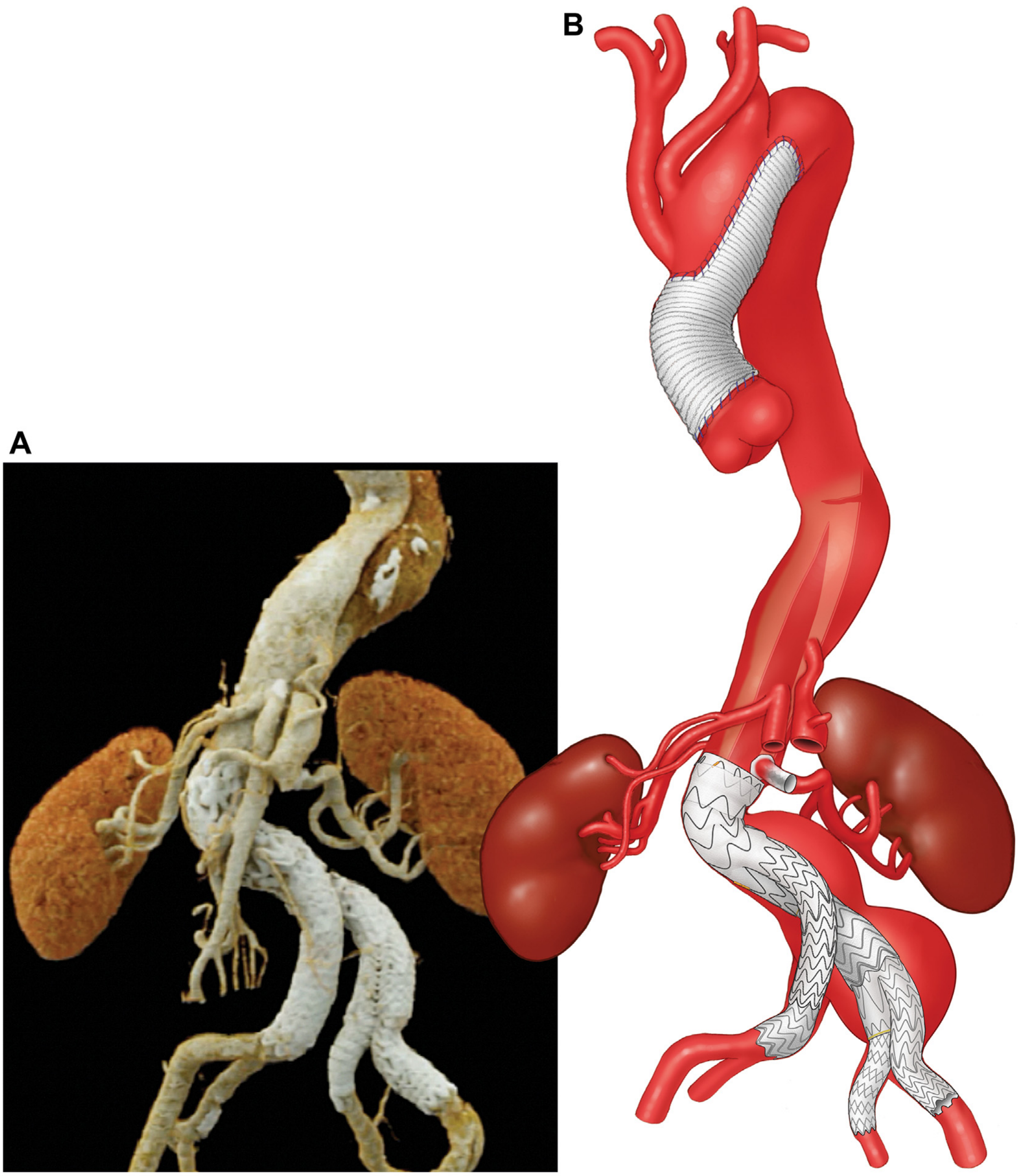

Fig 5. A, Computed tomography angiography (*CTA*) of infrarenal endovascular aortic repair shows successful exclusion of the infrarenal aortic and iliac aneurysm with preservation of flow into the renal and mesenteric vessels and no evidence of a type I or III endoleak. **B,** Illustration demonstrating placement of the left renal stent due to partial coverage and left iliac branch endoprosthesis.

was obtained in standard fashion, with true lumen access confirmed by IVUS. Transcatheter electrosurgical septotomy of the chronic dissection flap was performed using the technique previously described, starting from the distal edge of the thoracic stent graft in zone 5 to the infrarenal aortic segment (Fig 7, *C*). A t-Branch multibranch stent graft was deployed with each directional branch proximal to the intended target vessel. All four directional branches were extended into the target vessels using the total transfemoral approach with a steerable sheath without technical difficulties. Finally, the procedure was completed by the placement of a distal bifurcated device and bilateral Zenith branch endovascular graft-iliac bifurcation devices, also performed using the total transfemoral technique with a steerable sheath (Fig 7, *D*). CBCT revealed no evidence of a type I or III endoleak and widely patent branches. The total fluoroscopy time was 85 minutes. The patient recovered without complications and was discharged on postoperative day 3. CTA at 2 months showed widely

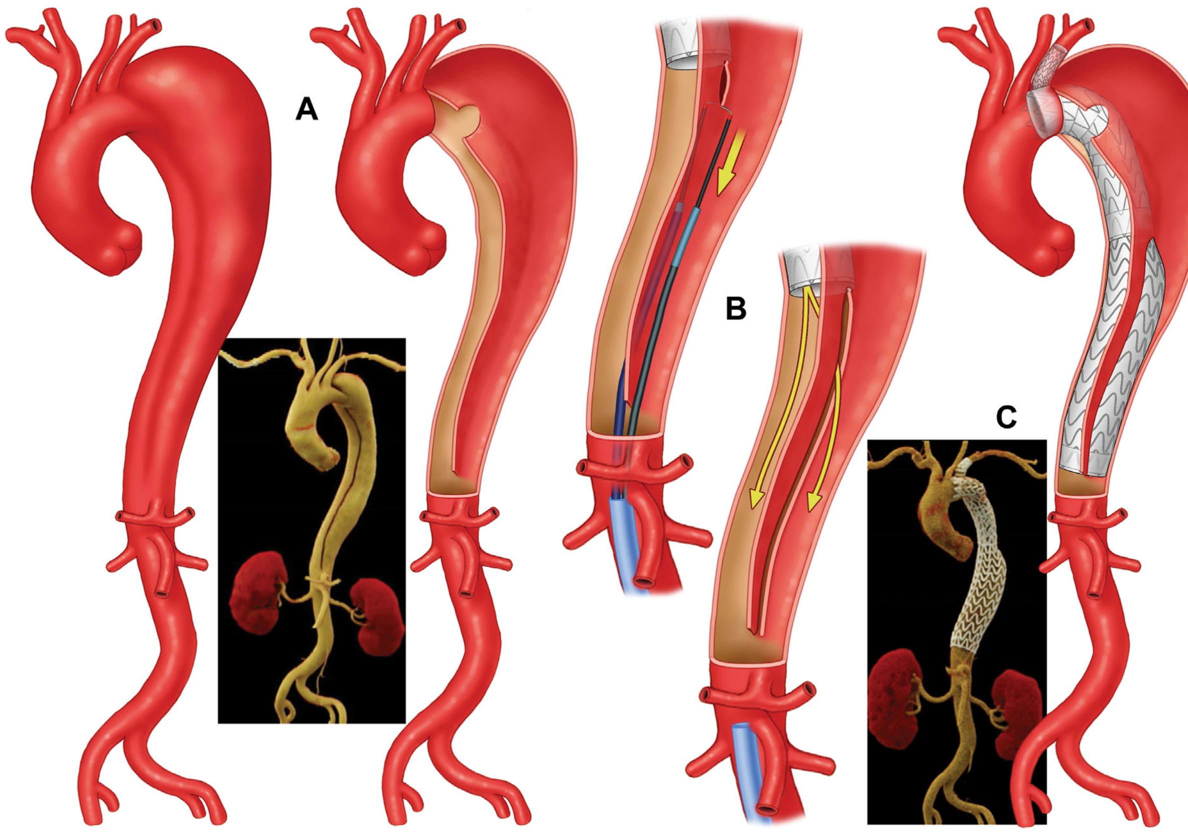

Fig 6. A, Illustration and preoperative computed tomography angiography (*CTA*) demonstrating a type B3-5 subacute aortic dissection with enlargement of the proximal thoracic aorta. Note the large proximal entry tear and extension of the dissection flap to the distal thoracic aorta just proximal to the origin of the celiac axis (*CA*). **B,** Following placement of a thoracic stent graft with a retrograde left subclavian branch, transcatheter electrosurgical septotomy was performed to connect the true and false lumens and optimize the distal landing zone. **C,** Postoperative CTA and illustration depicting successful aneurysm exclusion.

patent renal, mesenteric, and internal iliac branches, no evidence of a type I or III endoleak, and a persistent type II endoleak (Fig 7, *E*).

Case 4: vessel origin from separate lumens and excessive true lumen compression. A 50-year-old male patient presented with an aortic arch and extent I TAAA 10 years after ascending repair for complicated DeBakey type I dissection. The initial dissection presentation was complicated by severe bilateral lower extremity ischemia requiring hip disarticulation, paraplegia, colostomy, and temporary dialysis. The patient also had a history of congestive heart failure. A two-stage repair of the arch and TAAA was planned with patient-specific three-vessel inner arch branch stent graft and a fenestrated-branched stent graft using temporary left iliac conduit access. CTA demonstrated severe compression of the true lumen, which was 10 mm in the narrowest segment, and a separate origin of the left renal artery from the false lumen. The repair was intentionally planned into the false lumen with transcatheter electrosurgical septotomy extending from the supraceliac to the infrarenal aorta to facilitate vessel catheterization (Fig 8, *A*).

The first-stage procedure was performed using a left flank retroperitoneal approach and end-to-side anastomosis of a 10-mm rifampin-soaked graft into the distal left common iliac artery. A percutaneous right axillary approach with preclosure was performed. Access into the false lumen was confirmed by IVUS. Using the left temporary conduit, a patient-specific three-vessel inner branch stent graft (Cook Medical Inc) was deployed in the zone 0 polyester graft with rapid ventricular pacing. Catheterization and stenting of the innominate artery branch were completed via the right axillary approach, and the left common carotid artery and LSA were approached via the left iliac conduit. The repair was extended distally to zone 5 intentionally into the false lumen using an Alpha thoracic stent graft (Cook Medical Inc; Fig 8, *B*). Transcatheter electrosurgical septotomy of the remaining aortic septum was performed from the distal thoracic aorta to the infrarenal aorta using a previously described technique (Fig 8, *C*). Rotational digital

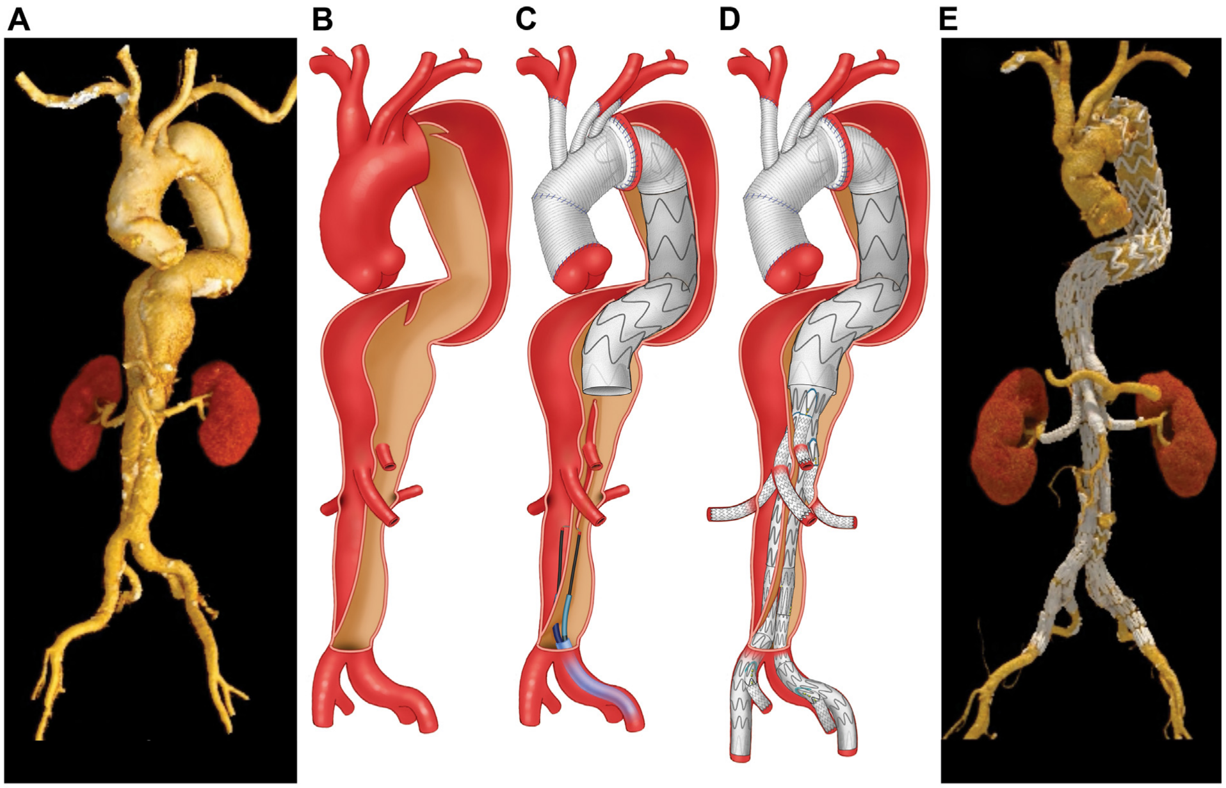

Fig 7. Preoperative computed tomography angiography (*CTA*; **A**) and illustration **(B)** of diffuse aortic enlargement involving the ascending aorta, aortic arch, and thoracoabdominal aorta. **C,** After total arch repair with the elephant trunk technique and thoracic endovascular repair, a staged completion procedure was planned with electrosurgical septotomy extending from the distal thoracic aorta to the infrarenal aorta. Illustration **(D)** and postoperative CTA **(E)** of the completed endovascular repair using a four-vessel off-the-shelf multibranched stent graft with bilateral iliac branched devices.

subtraction angiography revealed a widely patent branched arch stent graft, and renal and mesenteric arteries. The temporary conduit was oversewn and buried into the subcutaneous tissue. The patient had no complications from the aortic arch repair. A second-stage completion TAAA repair was planned 7 days after the arch repair using a patient-specific device with two directional branches for the CA and superior mesenteric artery and two renal fenestrations with preloaded catheters. The existing conduit, which was buried in the subcutaneous tissue, was dissected free via a small left groin incision. Over-the-wire thromboembolectomy of the occluded conduit was performed, followed by end-to-end anastomosis of a new 10-mm polyester graft to facilitate access. Using the iliac conduit, the fenestrated-branched stent graft was deployed into the thoracic stent graft in the false lumen. Both renal arteries were catheterized and stented using the preloaded sheaths. The directional branches were then performed using steerable sheaths via the iliac conduit (Fig 9, *A*). Final digital subtraction angiography and CBCT confirmed the patency of all renal mesenteric vessels and stent grafts, with no evidence of an endoleak (Fig 9, *B*). Follow-up at 3 months showed a shrinking aortic arch and TAAA and patent stent grafts with no evidence of a type I or III endoleak.

DISCUSSION

Transcatheter electrosurgical septotomy is an adjunctive technique that can be used in select patients with subacute and chronic postdissection thoracic and TAAAs. The technique aims to allow repair via a single lumen, decreasing or eliminating the challenges imposed by the compressed true lumen. Because extensive dissections often involve the entire thoracoabdominal aorta with enlargement of isolated segments, this technique can also allow for limiting the extent of coverage by creating suitable landing zones within the thoracic or abdominal aorta for successful aneurysm exclusion.

Prior techniques of septotomy relied on forceful disruption of the lamella using a pull-through or “cheese-wire” technique with small profile guidewires or balloon disruption.[13-16] Although these techniques are still valid, the pull-through or “cheese wire” technique can result in the dislodgement of large portions of intima and

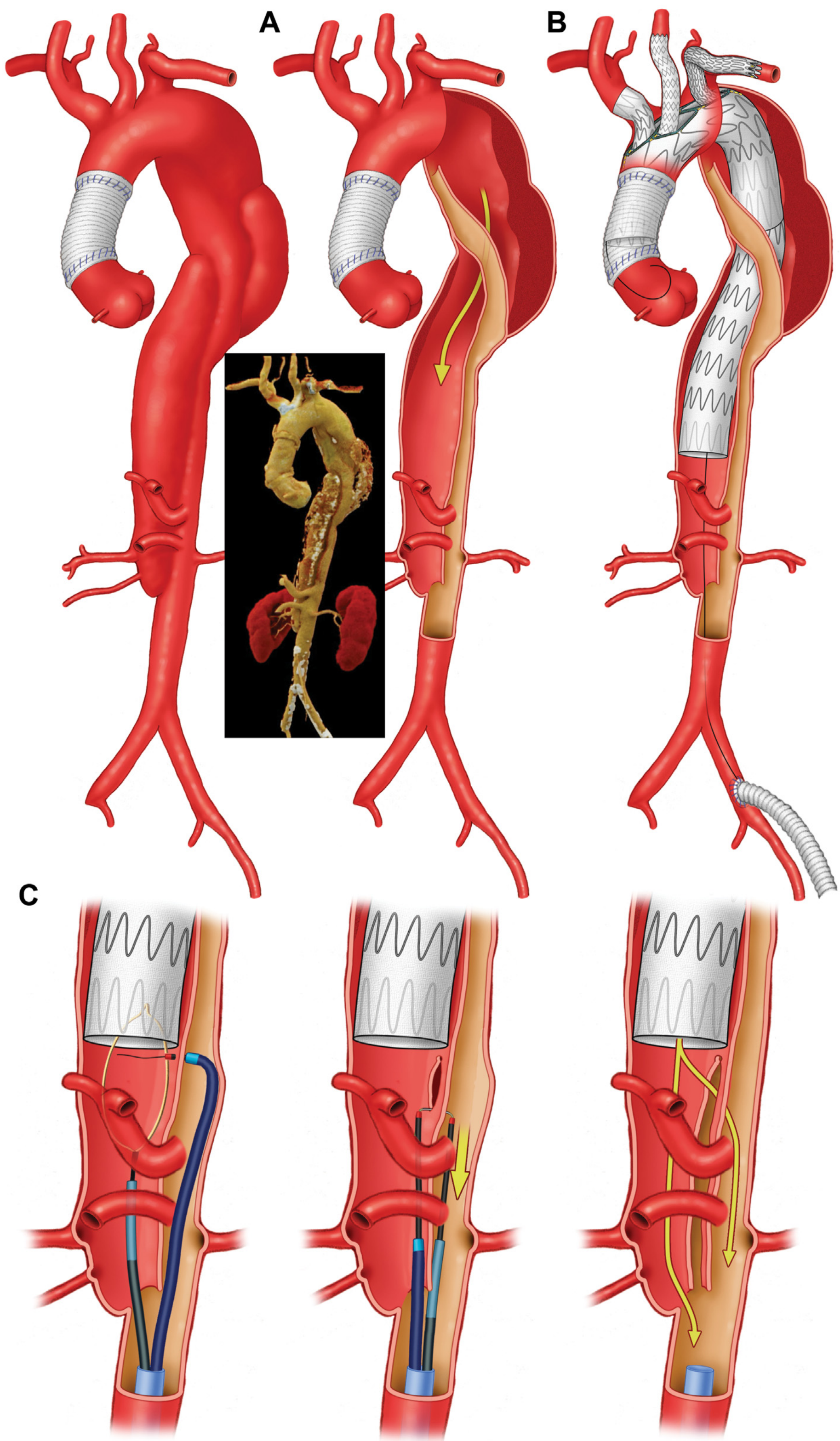

Fig 8. A, Illustration and preoperative computed tomography angiography (*CTA*) demonstrating residual arch and thoracoabdominal aortic dissection following ascending aorta repair, with severe compression of the true lumen and separate origin of the renal and mesenteric vessels. **B,** A first-stage procedure was performed with a three-vessel inner branch arch stent graft and intentional placement of the thoracic stent grafts into the false lumen. **C,** Electrosurgical septotomy was performed extending from the distal thoracic aorta to the level of the renal arteries, allowing for the development of a single lumen between.

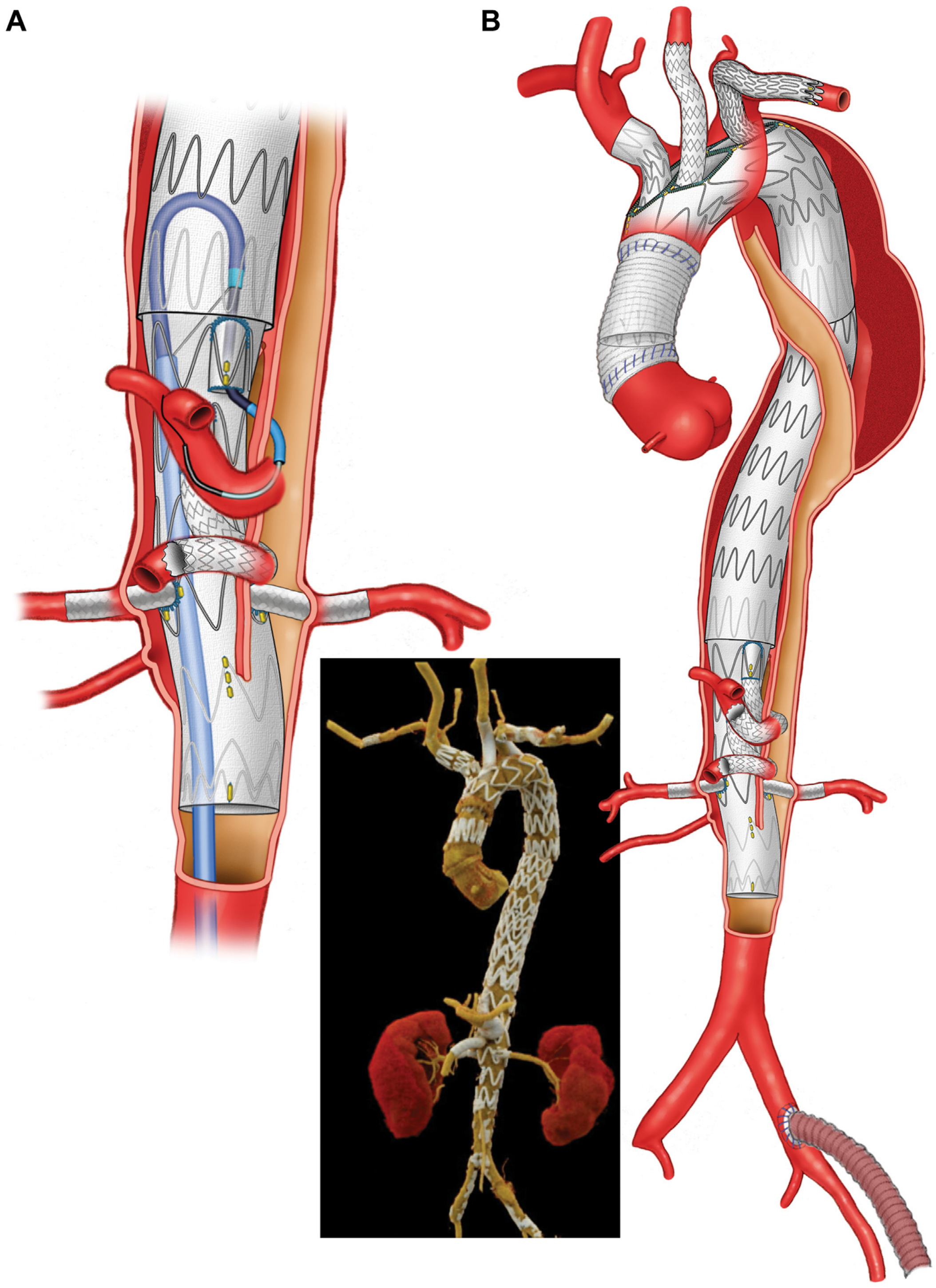

Fig 9. **A,** Completed fenestrated-branched endovascular aortic repair (*FB-EVAR*) was performed using steerable sheaths via iliac conduit for stenting of the directional branches. **B,** Postoperative computed tomography angiography (*CTA*) and illustration of the repaired arch and thoracoabdominal aortic aneurysm (*TAAA*) with patent branches and no evidence of a type I or III endoleak.

lamella, which can obliterate side branches and the aortic bifurcation.[15-17] Therefore, many operators have avoided using the "cheese-wire" septotomy.[18] In patients with chronic dissections, TEVAR with coverage of the entry tear and extension to the level of the CA has been the most frequent strategy; however, persistent false lumen flow distal to the stent graft with progressive enlargement occurs in ≤20% of patients, often requiring additional interventions.[17,19] Another potential risk is stent graft–induced new entry, which can result in a pressurized false lumen with rapid enlargement or rupture.[20] Techniques of false lumen occlusion have also been applied with favorable results.[21-24] In the acute or subacute phase, the PETTICOAT (provisional extension to induce complete attachment) technique, with or without the septum STABILISE (stent-assisted balloon-induced intimal disruption and relamination in aortic dissection repair) technique, has been described, with favorable remodeling of the aorta in almost all patients.[25] For chronic aneurysms, the Hamburg group has described the use of controlled disruption with a thoracic stent graft designed with a larger flared diameter ("knickerbocker") or, more recently, a false lumen occlusion device ("candy-plug").[21,24,26,27] The latter option has gained increasing popularity in European centers but remains investigational. Eleshra and colleague[26] reported a series of 155 patients treated for chronic postdissection thoracic aneurysms using TEVAR with a false lumen occlusion device, achieving stability or a decreased aneurysm diameter in 96%, which compares favorably to other endovascular series.

Transcatheter electrosurgical septotomy has been used in a selective manner and is not recommended for routine use. It is commonly indicated for optimizing landing zones or serving as an alternative to balloon-assisted septal disruption and the pull-through or "cheese wire" technique.[28] For these indications, septotomy has allowed limiting aortic coverage to the thoracic or abdominal segments as exemplified in cases 1 and 2. The procedure avoids or defers a more extensive repair with FB-EVAR without creating future technical challenges. It is crucial to be cautious of the risk of inadvertent pressurization of the false lumen when performing septotomy distal to a stent graft and leaving the chronic dissection flap within the abdominal segment. This scenario can be considered equivalent to a stent graft—induced new entry and should be avoided as an important pitfall. In these cases, unless there is large false lumen outflow via a reentrance, septotomy should be avoided or carried out for the entire length of the septum.

A second indication is to facilitate FB-EVAR by allowing the placement of stent grafts intentionally into the false lumen when the true lumen is excessively compressed or to connect the false and true lumens into a large space to facilitate stent graft expansion and target vessel incorporation, as depicted in cases 3 and 4. Although obliteration of one of the renal and mesenteric vessels by the lamella remains a theoretical concern, this has not been a frequent occurrence and can usually be managed with advanced endovascular techniques. In such cases, the septotomy can be performed during either the first- or second-stage procedure, provided it is done carefully to prevent pressurization of the false lumen. If there is a risk of false lumen pressurization, it is recommended to perform the septotomy in conjunction with FB-EVAR.

Successful transcatheter electrosurgical septotomy requires correct denudation of the portion of the wire that lacerates the aortic septum, careful insulation with microcatheters and a 5% dextrose flush, and higher energy settings with the generator set to cut (typically 80 W). To achieve better results and avoid traction of the septum, important technical considerations include focally denuding the inner surface of the kinked wire to increase the charge on the inner lacerating surface, the use of opposing insulating microcatheters, and flushing the field with nonconductive dextrose. The suggested mechanism for the use of 5% dextrose in water, as a nonionic solution that displaces inherently ionic blood, hinges on its capacity to elevate impedance around the guidewire electrode and diminish the dissipation of radiofrequency energy. This, in turn, facilitates a more effective and efficient delivery of energy to the tissue without warming the surrounding blood, which enables one to precisely vaporize the targeted tissue with lower power levels, reducing the formation of char, coagulation, and the risk of thromboembolism in the blood.[29]

CONCLUSIONS

Transcatheter electrosurgical septotomy is an adjunctive technique previously used in the cardiology literature for transcatheter aortic valve and electrophysiology procedures, which has been useful in facilitating endovascular repair in patients with subacute or chronic postdissection aneurysms. Increasing experience and follow-up are needed to better define the risks and benefits of this adjunctive technique for postdissection aortic aneurysm repair.

DISCLOSURES

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