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Transcaval Aortic Access for Percutaneous Thoracic Aortic Aneurysm Repair: Initial Human Experience

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Abstract

Transcaval aortic access has been used for deployment of transcatheter aortic valves in patients in whom conventional arterial approaches are not feasible. The present report describes its use for thoracic endovascular aortic repair (TEVAR) in a 61-year-old man with a descending thoracic aneurysm. Transcaval access was performed in lieu of a surgical iliac conduit in view of small atherosclerotic pelvic arteries. TEVAR was successfully performed, followed by intervascular tract occlusion with the use of a ventricular septal occluder. Computed tomography 2 d later demonstrated no extravasation. At 1 mo, the aneurysm was free of endoleaks, the aortocaval tract had healed, and the patient had returned to baseline functional status.

Current thoracic endovascular aortic repair (TEVAR) requires large-bore arterial accesses ranging from 18 to 24 F, necessitating suitably large femoral and iliac arteries. A variety of techniques have been developed to circumvent small or diseased vessels, including placement of surgical or endovascular iliac conduits and direct abdominal aortic access (2). Although effective, these techniques require more invasive surgeries and are associated with greater morbidity and mortality, with postoperative major complication rates reaching 16% and mortality rates ranging from 3% to 12% in two large recent studies (1,2). Moreover, these surgical approaches may be contraindicated in some patients because of unfavorable anatomy or previous intervention (1,3). Transapical delivery for TEVAR represents an alternative approach to TEVAR as well, but it carries other current risks, including ventricular pseudoaneurysm formation and injury to other cardiac structures (4). Percutaneous transcaval aortic access has been used as a means to avoid these approaches in patients undergoing transcatheter aortic valve replacement (TAVR), a procedure with similar iliofemoral vessel diameter requirements as TEVAR (3). The technique entails transcatheter puncture of the abdominal aorta from the inferior vena cava (IVC), with tract

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closure using a nitinol occlusion device (3). Here we present the initial human experience with the use of this percutaneous approach for endovascular repair of a thoracic aortic aneurysm (TAA).

CASE REPORT

Institutional review board exemption was granted for the preparation of this case report. It complies with Health Insurance Portability and Accountability Act requirements. A 61-year-old man with a 1976 history of congenital thoracic aortic coarctation repair was found to have an asymptomatic descending TAA expanding from 4.5 cm to 5.9 cm in the repaired segment over an 18-month period. Pertinent medical history included hypertension, hyperlipidemia, obstructive sleep apnea, and 10–20 pack-year history of tobacco use.

A multidisciplinary team consisting of cardiovascular surgeons, interventional radiologists, and interventional cardiologists determined that endovascular repair would be preferable to open surgical TAA repair. The patient's < 6-mm-diameter external iliac arteries were unsuitable for introduction of the 22-F sheath required for the chosen endograft. The proximity of the caudal aorta and IVC and relative absence of mural aortic calcification suggested that the patient would prove a favorable candidate for a transcaval approach (Fig 1a). The patient was offered an open surgical common iliac artery exposure and a percutaneous transcaval approach and indicated his desire to avoid open surgery. As part of obtaining informed consent, the risks of the transcaval access, including the investigational nature of the procedure, were discussed in depth.

Procedure

A cerebrospinal fluid lumbar drain was placed to reduce the risk of spinal cord ischemia. Transcaval aortic access was performed by using previously described means (3). Under general anesthesia, the right common femoral vein and bilateral femoral arteries were accessed percutaneously. Simultaneous aortography and cavography were performed, confirming the target access sites identified on preoperative computed tomography (CT; Fig 1). After systemic heparinization, a 6-F curved guiding catheter (RDC; Boston Scientific, Marlborough, Massachusetts) was advanced from the femoral vein. A 0.014-inch guide wire (Asahi Confianza Pro 12; Abbott Vascular, Santa Clara, California) with 10 mm of its leading tip amputated was advanced through a long transitional catheter (PiggyBack; Vascular Solutions, Minneapolis, Minnesota) and support catheter (Minnie Support Catheter; Vascular Solutions, Maple Grove, Minnesota) and, together, positioned in the caudal IVC. The PiggyBack hydrophilic catheter has a 0.035-inch outer diameter and 0.014-inch inner diameter that allows conversion into 0.035-inch inner-lumen catheters, and it is typically used in the periphery. A 15-mm nitinol GooseNeck snare (Covidien, Plymouth, Minnesota) was placed at the aortic target site by a left femoral arterial approach. An electrocautery device was attached to the caval guide wire (Bovie Medical, Clearwater, Florida) and energized by using the "cut" setting at 50–70 W. Short 1–2-second bursts of energy were administered while the wire was advanced into the abdominal aorta. The wire was snared within the abdominal aorta and, together with the enclosing snare, advanced into the thoracic aorta. The transitional catheter and the support catheter followed into the thoracic aorta, after which the original wire and inner catheter were removed and exchanged

for a Lunderquist guide wire (Cook, Bloomington, Indiana). A 20-F expandable vascular sheath (eSheath; Edwards Lifesciences, Irvine, California) was then passed across the intervascular tract into the aorta.

A 26-mm × 100-mm Valiant stent graft (Medtronic, Minneapolis, Minnesota) was advanced through the sheath (Fig 2) and deployed across the TAA, with planned coverage of the left subclavian artery. The latter was embolized by using seven detachable coils (Penumbra, Alameda, California), ranging from 14 mm to 20 mm in diameter and 40 cm to 60 cm in length, advanced from a left radial artery access (Fig 2). Final angiograms demonstrated a small type IA endoleak. After heparin reversal, the transcaval tract was closed by using a deflectable catheter (8.5 F, 61 cm; Agilis NxT; St. Jude Medical, St. Paul, Minnesota) loaded with an 8-mm-diameter ventricular septal closure device (AMPLATZER Muscular VSD Occluder; St. Jude Medical). Abdominal aortography demonstrated a small amount of contrast medium extravasation into the retroperitoneum together with shunting into the IVC (Fig 3) in the cruciform pattern (3). These had ceased on repeat aortography 8 minutes later without any further intervention. The femoral vein was closed with two predeployed suture-mediated closure devices (ProGlide; Abbott Vascular).

The patient was observed in the surgical intensive care unit for 2 days and showed no evidence of bleeding. His day-2 CT angiogram demonstrated that the abdominal aortic puncture site had sealed (Fig 4). The type IA endoleak persisted but resolved by the day-7 CT angiography examination (Fig 5). The patient was discharged 15 days after TEVAR, after a readmission to the surgical intensive care unit following a syncopal episode that occurred during a bowel movement and hypotension on day 7, which had prompted CT angiography. At 1-month follow-up, he was doing well, had returned to his baseline functional status, and denied left arm claudication or abdominal pain.

DISCUSSION

Between 2005 and 2007, 7,644 TEVAR procedures were performed in the United States, with an in-hospital mortality rate of 6.8%–7.3% (5). Although as many as 70% of these patients are able to undergo TEVAR with a conventional endovascular approach, many will require adjunctive surgical methods for access, particularly women, in whom the iliofemoral vasculature is smaller at baseline (2). Here we describe the first use of transcaval aortic access for the purposes of TAA repair. The approach used has been championed by Greenbaum et al (3) and Lederman et al (8) for TAVR. In the series of Greenbaum et al (3), caval–aortic accesses and closures were successful in 19 of 19 patients, with one TAVR-related mortality caused by valve embolization into the ascending aorta. Six patients experienced major vascular complications, which included hemorrhage requiring percutaneous aortic stent graft placement ($n = 2$) or necessitated conservative treatment for pseudoaneurysm ($n = 1$), focal aortic dissection ($n = 2$), and bleeding with hypotension ($n = 1$). They have demonstrated that aortocaval fistulae do not create hemodynamic collapse and are well tolerated (3). The perforation and subsequent extravasation during deployment of the closure device is mostly decompressed into the IVC, and this fistulization appears essential for prevention of large retroperitoneal hematomas (3). This was demonstrated in initial animal experiments (6), which showed that failure to close the aortocaval fistula did

not result in hemodynamic collapse or retroperitoneal hemorrhage. The presence of aortocaval fistulae is common with this technique, and Greenbaum et al (3) have described three distinct patterns of the phenomenon, which include a straight aortocaval fistula, the cruciform pattern of aortocaval fistula, and frank extravasation.

Currently, tract closure is performed with off-label use of Food and Drug Administration–approved nitinol occlusion devices that are designed to close intracardiac defects or patent ductus arteriosus (Fig 5), which is the subject of an ongoing investigational device exemption clinical trial (ClinicalTrials.gov identifier NCT0228 0824). As this method evolves, additional technologies may be developed to facilitate closure of the aortocaval tract. The alternative methods for device delivery include surgical access and planned percutaneous iliac rupture and endovascular repair. Although common, open iliac exposure is not without risk, with a major (> 4 U) transfusion rate of 17%, need for repeat operation in 9.1% of cases, and mortality rate of 3% (1). Similarly, iliac rupture and repair has a risk of life-threatening hemorrhage, and occurs significantly more often in TEVAR cases, compared with endovascular abdominal aortic aneurysm repair (3,7).

Patients with porcelain, ie, heavily calcified, abdominal aortae should not be offered this treatment. The rigidity of the aortic walls may make creation of the aortotomy and passage of subsequent catheters more difficult. Calcification may also impede closure with the nitinol occluder device, as the intraaortic portion of the disk may become stuck to an eccentric plaque. Finally, calcification in the wall may make stent-graft deployment in the involved abdominal aorta, an important bailout option in cases of extravasation with hemodynamic compromise, difficult as a result of the inability to obtain adequate seal zones. Nevertheless, Lederman et al (8) reported a case of successful use of the transcaval technique in a patient with a polyester aortic graft. Patients with near-occlusion of the iliac vessels, in whom bailout endovascular graft placement in the abdominal aorta cannot be performed, should also be approached cautiously.

There are potential pitfalls with the transcaval approach, and this method should be reserved for patients with favorable anatomic features (9). Ideal candidates include patients with proximity between the aorta and the IVC, a calcium-free window at the intended caval–aortic crossing target, aortic luminal diameter large enough for deployment of a closure device, and absence of important interposed structures (ie, duodenum, lumbar arteries). Finally, the target zone should be at least 1 cm away from the aortic bifurcation, lowest renal artery, or left renal vein to avoid encroachment by the occluder device. Although no cases of aortic or caval thrombosis have been observed, most patients undergoing TAVR with a transcaval approach undergo anticoagulation (3). The role of anticoagulation in patients with transcaval access for TEVAR will need to be clarified in subsequent studies, as most patients do not routinely undergo anticoagulation after percutaneous thoracic stent-graft placement.

In summary, the transcaval access technique, although investigational, may prove increasingly valuable for patients with aortic pathologic processes. Careful patient selection guided by preoperative imaging is essential. Prospective studies comparing the outcomes of this procedure with the existing surgical approaches may be warranted.

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ABBREVIATIONS

IVC	inferior vena cava
TAA	thoracic aortic aneurysm
TAVR	transcatheter aortic valve replacement
TEVAR	thoracic endovascular aortic repair

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Figure 1.

(a) Volume-rendered three-dimensional reconstruction of preoperative CT angiogram demonstrates the ideal target area for puncture from the IVC into the abdominal aorta (green arrow). (b) Simultaneous aortogram and cavogram demonstrate the intended puncture site (arrow).

Figure 2.
Aortogram demonstrates the 26-mm $\times$ 100-mm Valiant stent graft being positioned within the aortic arch.

Figure 3.

Digital subtraction angiogram obtained immediately before deployment of the 8-mm ventricular septal closure device. There is an aortocaval fistula with the cruciform pattern of contrast medium extravasation, which decompresses into the IVC instead of creating a retroperitoneal hematoma (arrow). The cruciform pattern is contrast medium in the shape of a plus sign as a result of caudal and cranial retroperitoneal spread of contrast medium around the neck of the metallic closure device, associated with residual aortocaval fistula.

Figure 4.

Axial contrast-enhanced CT performed on postoperative day 7 demonstrates the ventricular septal closure device spanning the transcaval retroperitoneal tract (arrowhead) without evidence of extravasation. There is no contrast agent passage into the IVC (arrow).

Figure 5.

(a) Volume-rendered three-dimensional reconstruction of the aorta 1 week after stent-graft deployment (open arrow). The closure device (solid arrow) is seen in the distal abdominal aorta. **(b)** Volume-rendered three-dimensional reconstruction of the aorta shows the coil mass (arrowhead) with retrograde contrast enhancement of the left subclavian artery from the left vertebral artery.