

Transcaval Aortic Valve Replacement

A step-by-step guide, including how to manage transcaval-specific complications.

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The novel and innovative transcaval approach has been developed to bypass suboptimal iliofemoral anatomy while avoiding the invasiveness and morbidity associated with other alternative access options in transcatheter aortic valve replacement (TAVR).¹⁻⁴ This article details the transcaval technique in TAVR.

WHY I DO IT

The transfemoral approach remains the preferred and default access strategy in contemporary TAVR. However, despite refinements in design and deliverability over the last decade, there remains a minority of patients with small or diseased iliofemoral arteries who are not eligible for transfemoral TAVR.^{5,6} Transthoracic access is largely obsolete in contemporary TAVR practice due to unacceptably high complication rates. Initial data on alternative extrathoracic access (transcarotid, subclavian, transaxillary) suggest that these approaches are safe and feasible in this population; however, some require surgical cutdown, increase operator radiation exposure, and may be associated with higher stroke rates.^{7,8} The transcaval approach utilizes the transfemoral vein to offer a nonsurgical, fully percutaneous option that retains transfemoral ergonomics in limiting operator radiation exposure for patients who are ineligible for conventional transfemoral TAVR (Table 1).^{1-4,9-11}

ANATOMY

Contrast-enhanced multidetector CT (MDCT) planning is essential to ensure procedural success and plan bailout strategies. First, a target entry point for the caval-aortic tract is identified. The target must be free of calcium on the rightward side of the abdominal aortic wall, and ideally at least 15 mm below the lowest renal artery and 15 mm above the aorto-iliac bifurcation (Figure 1). The target crossing location is defined relative to key bony landmarks, specifically the verte-

brae and iliac crests, that can then be used to “coregister” the target on fluoroscopy in the cath lab. Patency and typical takeoff of the celiac and superior mesenteric arteries must be confirmed in case the inferior mesenteric artery is jeopardized. Finally, the aorta is sized in advanced to plan bailout strategies with aortic balloon tamponade and/or covered stent deployment in the event of closure device failure.

MATERIALS

Specific equipment are required for transcaval access and closure:

- Two Perclose ProGlides (Abbott)
- 0.014-inch Atrato XS 20 wire (Asahi Intecc USA, Inc.)
- 135-cm, 0.014-inch Finecross MG coronary microguide catheter (Terumo Interventional Systems) or equivalent 0.014-inch microcatheter
- 90-cm, 0.035-inch NaviCross support catheter (Terumo Interventional Systems) or equivalent 0.035-inch microcatheter
- 100-cm, 6-F JR4 guiding catheter
- 7-F renal, 55-cm-length renal double curve or internal mammary guiding catheter
- Amplatz GooseNeck snare (Medtronic) sized by MDCT
- 0.035-inch Lunderquist Extra-Stiff guidewire (Cook Medical)
- 8.5-F Agilis NXT SML Curl sheath (Abbott) or equivalent deflectable/steerable sheath
- 0/8 Amplatz Duct Occluder 1 (Abbott)
- 0.014-inch workhorse coronary wire (eg, balance middle weight)
- 7-F, 45° TorqVue delivery kit, specifically device loader and cable (Abbott)
- Balloons for aortic tamponade and covered stents for bailout

TABLE 1. SUMMARY OF PUBLISHED DATA ON TRANSCAVAL TAVR

			In-Hospital			1 Year		
Study	N	TAVR Success (%)	Mortality (%)	VARC-2 Major Vascular Complications	VARC-2 Life-Threatening Bleeding	Mortality	VARC-2 Major Vascular Complications	VARC-2 Life-Threatening Bleeding
Greenbaum et al, 2014 ²	19	17/19 (89.5%)	1/19 (5.3%)	7/19 (36.8%)	3/19 (15.8%)	–	–	–
Greenbaum et al, 2017 ^{1*}	100	99/100 (99.0%)	4/100 (4.0%)	13/100 (13.0%)	7/100 (7.0%)	–	–	–
Paone et al, 2018 ⁹	58		2/58 (3.4%)	1/58 (1.7%)	–	–	–	–
Lederman et al, 2019 ^{4*}	100	99/100 (99.0%)	4/100 (4.0%)	13/100 (13.0%)	7/100 (7.0%)	29/100 (29.0%)	13/100 (13.0%)	7/100 (7.0%)
Long et al, 2020 ¹⁰	22	22/22 (100.0%)	1/22 (4.5%)	0/22 (0.0%)	0/22 (0.0%)	1/16 (6.3%)	0/16 (0.0%)	1/16 (6.3%)
Sanders et al, 2021 ¹¹	79	77/79 (97.5%)	1/79 (%)	1/79 (%)	–	–	–	–
Total	278	215/220 (97.7%)	9/278 (3.2%)	22/278 (7.9%)	10/141 (7.1%)	30/116 (25.9%)	13/116 (11.2%)	8/116 (6.9%)

*Both studies represent the same population of patients.

Values are n/N (%).

Abbreviations: TAVR, transcatheter aortic valve replacement; VARC-2, Valve Academic Research Consortium-2.

HOW I DO IT

Vascular Access

Performing a transcaval TAVR requires three vascular access sites: one large-bore venous access to deliver the transcatheter heart valve (usually the right femoral vein), a second venous access for transvenous pacing for the TAVR implant, and an arterial access (either left or right common femoral artery, for delivery of the snare, pigtail aortography during the TAVR implantation, and bailout aortic balloon tamponade and covered stent deployment, if necessary). The femoral vein is typically preclosed using two Perclose ProGlides. Alternatively, at the conclusion of the procedure, large-bore venous hemostasis can be achieved using a figure-of-eight suture or manual compression. Common fem-

oral arterial access is then achieved using the ultrasound-guided micropuncture technique. Once all access sites have been successfully achieved, and before achieving transcaval access, full-dose heparin is administered to achieve an activated clotting time > 250 sec.

Caval-Aortic Access

Assembling the coaxial crossing system consists of loading a 0.014-inch guidewire (Astato XS 20) inside a 0.014-inch microcatheter (Finecross), which is then loaded into a 0.035-inch braided microcatheter (NaviCross). The whole system is then loaded into a 7-F renal-length guiding catheter in the inferior vena cava (IVC) aiming for the target crossing location. Optimal position is confirmed

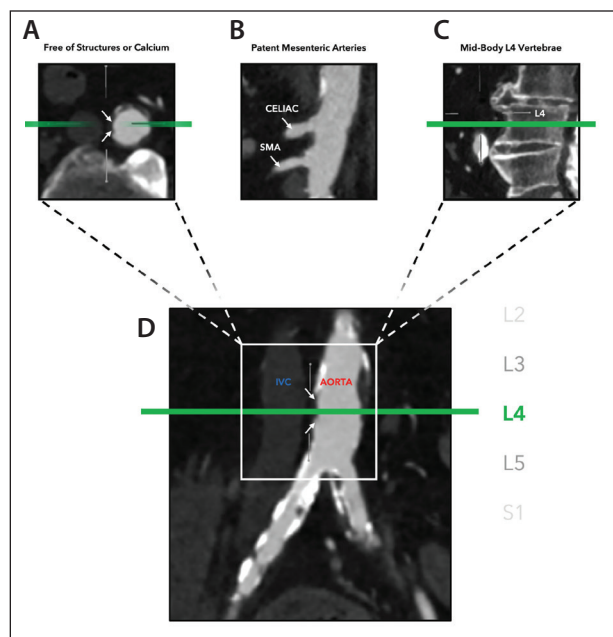


Figure 1. Transcaval TAVR planning on preprocedural CT. Transverse plane of the target caval-aortic crossing (green line), which is free of interposed structures or calcium (white arrows) (A). Sagittal plane of patent celiac and superior mesenteric arteries (white arrows) (B). Sagittal plane of the target caval-aortic crossing (green line) in the midbody of the L4 vertebrae (C). Coronal plane of the target caval-aortic crossing (green line, white arrows) in the midbody of the L4 vertebrae (D).

in orthogonal projections (defined using MDCT). The back end of the guidewire is clamped to an electrosurgery pencil set to “pure cut” mode at 50W. Care must be taken to ensure no short circuits are created by wet towels or wire loops. Through the arterial access, a 6-F JR4 guiding catheter is advanced to the target crossing location, and a GooseNeck snare is deployed to serve as a fluoroscopic bullseye. The snare is sized approximately 5 mm larger than the diameter of the abdominal aorta. The guidewire is electrified and advanced into the aorta and snared. The guidewire and snare are advanced to the aortic arch. The wire converter and microcatheter are then sequentially advanced into the aorta through the caval-aortic tract. The 0.014-inch guidewire and microcatheter are then withdrawn and exchanged for a 0.035-inch Lunderquist Extra-Stiff guidewire, over which the TAVR introducer sheath is advanced from the femoral vein into the descending aorta. The sheath should always be sutured in place to prevent inadvertent withdrawal during the TAVR portion of the procedure. TAVR is then performed in exactly the same way as with a transfemoral arterial approach.



Figure 2. Transcaval closure patterns. There are four angiographic patterns of closure: complete occlusion around the closure device (white arrow) (A); patent fistula with a tunnel around the occluder (B); patent fistula with a “cruciform” appearance (C); and extravasation (D). Reproduced with permission from Lederman RJ et al. How to perform transcaval access and closure for transcatheter aortic valve implantation. *Catheter Cardiovasc Interv.* 2015;86:1242-1254.

Caval-Aortic Closure

First, heparin is fully reversed with protamine. The aortic pigtail catheter is withdrawn to just below the transcaval crossing location. Through an 8.5-F Agilis NXT SML Curl sheath, a 10/8 Amplatzer Duct Occluder 1 is deployed by first withdrawing the TAVR sheath back into the IVC, carefully positioning the aortic disc of the occluder against the aortic wall, and then passively releasing the neck of the occluder in the aortocaval tract. A brief drop in blood pressure is commonly observed but is usually tolerated. Pressors that would raise arterial pressure to suprasystemic levels should be avoided. Digital subtraction angiography using 10 mL at 10 mL/sec is then performed. There are four angiographic patterns of closure: type 0, complete occlusion; type 1, patent fistula with a tunnel around the occluder; type 2, patent fistula with a cruciform appearance (the most common); and type 3, extravasation (Figure 2). If the patient remains hemodynamically stable with a closure pattern of 0, 1, or 2, the large-bore femoral venous access is closed using the “preclose” technique, figure-of-eight suture, or manual pressure. Figure 3 summarizes key steps of the transcaval technique.

COMPLICATIONS

Hemodynamic compromise is rare but can occur for three main reasons. The first is bleeding/extravasation, which is identified using digital subtraction angiography. This can occur if there is inadvertent withdrawal of the sheath from the aorta into the retroperitoneal space (but not into the IVC). In this case, the sheath should be further pulled back into the IVC, allowing the blood to flow from the aorta to the cava. The sheath dilator (or a new sheath if

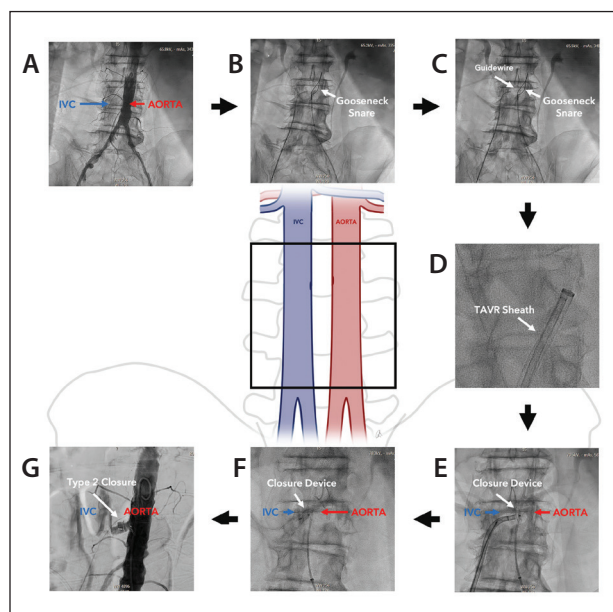


Figure 3. Transcaval technique. Abdominal aortogram (A); 7-F renal guiding catheter in the IVC and GooseNeck snare in the abdominal aorta (B); caval-aortic puncture using an electrified guidewire (C); caval-aortic crossing of the TAVR sheath (D); caval-aortic closure using a 10/8 Amplatzer (E, F); final abdominal angiogram demonstrating angiographic type 2 closure (G).

an expandable sheath is in place) can then be readvanced to the aorta, and closure can be performed as usual. If bleeding and extravasation occurs after closure, management includes volume administration (intravenous fluids or blood) and aortic balloon tamponade at the level of the occluder (for three cycles of 5 minutes without further heparin administration), which usually achieves hemostasis. If this fails, deploying a covered stent is the next step. Self-expanding covered stents are preferred because they are less traumatic and achieve better sealing around the occluder.

Second is the inability to tolerate the acute left-to-right transcaval shunt secondary to underlying cardiomyopathy or pulmonary vascular disease, although this is vanishingly rare. Balloon tamponade and/or covered stenting may be required.

Third is the usual complications related to the TAVR deployment (eg, annular rupture, left ventricular apical perforation), and they should be managed accordingly.

SUMMARY

Transcaval TAVR is a safe and effective alternative access option in patients with suboptimal iliofemoral anatomy that avoids the invasiveness and morbidity associated with other alternative access options. ■

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