Alternative Access for Transcatheter Aortic Valve Replacement: A Comprehensive Review

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A Comprehensive Review

Marvin H. Eng, MD\textsuperscript{a,}\textsuperscript{*}, Mohammed Qintar, MD, MSc\textsuperscript{b}, Dmitrios Apostolou, MD\textsuperscript{c}, William W. O’Neill, MD\textsuperscript{d}

KEYWORDS
- TAVR • Transcarotid • Transcaval • Transaxillary • Antegrade • Direct apical • Direct aortic
- Alternative access

KEY POINTS
- Alternative access is used in a minority of cases and is associated with higher rates of morbidity and mortality because of patient and technical factors.
- Transthoracic access is associated with higher rates of mortality and postprocedure atrial fibrillation.
- A myriad of choices is available, but centers should focus on 1 to 2 techniques to optimize proficiency in alternative access.
- Transaxillary access is popular and widely used but associated with higher rates of stroke as compared with other alternative access techniques.

INTRODUCTION
Transcatheter aortic valve replacement (TAVR) has rapidly become the treatment of choice as an alternative to surgical aortic valve replacement in patients at high, intermediate, and low procedural risk patients.\textsuperscript{1–3} Iterative advances in technology results in increasingly lower profile sheaths, enabling broad use of transfemoral access. Despite these improvements, alternative access is still recommended in up to 21% of patients\textsuperscript{4} because of iliofemoral disease, tortuosity, severe calcification, aneurysms, mural thrombus, or previous vascular surgery, hence the continued need for alternative access to avoid vascular complications and their associated morbidity and mortality.\textsuperscript{5,6} Recently, an analysis of TAVR procedures from 2015 to 2017 revealed that 15.3% of cases used alternative access, and an inverse relationship between operator volume and 30-day mortality was seen in the transcatheter valve therapy (TVT) registry.\textsuperscript{7} Given the 19.45% relative reduction of 30-day mortality between the highest and lowest volume operators, expertise is a major determinant of outcomes.\textsuperscript{7} The differential in knowledge and experience prompts this comprehensive review of the technique and outcomes of the following nonfemoral artery alternative access routes: antegrade, transapical (TA), transaortic (TAo),

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\textsuperscript{c}Division of Cardiothoracic Surgery, Department of Surgery, Henry Ford Health System, 2799 West Grand Boulevard, Detroit, MI 48202, USA; \textsuperscript{d}Division of Cardiology, Center for Structural Heart Disease, Henry Ford Health System, 2799 West Grand Boulevard, Detroit, MI 48202, USA
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suprasternal, transaxillary (TAX), transcarotid (TC), and transcaval (TCav) access (Fig. 1).

ANTEGRADE (TRANSSEPTAL) ACCESS

The progenitor balloon expandable valve required using a 24F sheath, but a retrograde delivery catheter had not yet been designed; therefore, first-in-man TAVR used antegrade, transseptal access (Fig. 2). The initial description of TAVR was a 6-patient series of transseptal antegrade transcatheter heart valve (THV) delivery by Dr Alain Cribier and colleagues in 2004. The procedure was successful in 5 patients, but mitral valve injury prevented the widespread adoption of the technique; TAVR did not disseminate until the engineering of a retrograde delivery system. This technique is seldom used, there are few with the expertise to use antegrade access, and despite venous access for the large-bore sheath, major bleeding occurred in nearly half of the small series.12

TRANSTHORACIC (APICAL [TRANSAPICAL] AND DIRECT AORTIC [TRANSAORTIC]) ACCESS

First-generation Sapien valve (Edwards Lifesciences, Irvine, CA, USA) delivery systems required 22 to 24F sheaths for transfemoral access, and transthoracic alternative access were commonly used.

Transapical

First described by Lichtenstein and colleagues, TA access begins with a limited thoracotomy, and apical exposure is followed by horizontal mattress pledgeted suture placement surrounding the intended area of access, typically lateral to the true apex (Fig. 3). After puncturing with an 18-gauge needle, most operators take the approach of minimizing sheath exchanges in the heart. Following apical puncture, the apex is cannulated with a small sheath and then exchanged for a stiff wire in the descending aorta. After the large delivery sheath (24–33F Ascendra or Acendra II, Edwards Lifesciences, Irvine, CA) is placed over the stiff wire, valve delivery ensues (see Fig. 3). Hemostasis is achieved by first lowering the blood pressure using rapid pacing, sheath withdrawal, and pledget tightening with care not to overtension the sutures. A chest tube is left in place, and the thoracotomy is closed. Avoid systemic hypertension and undue stress to the repaired apex with antihypertensive medications if necessary. Apical tissue integrity is sometimes unpredictable, and cases have been aborted because of degeneration of apical tissue architecture or copious apical adiposity causing ambiguity during pledget placement.

During the PARTNER I trial, 42% of patients underwent TA access and experienced an increased rates of in-hospital death, renal failure, bleeding, and longer lengths of stay relative to transfemoral procedures. Moreover, data show that TA access was associated with increased myocardial injury compared with other access routes. Patients with chronic lung disease are easily compromised by apical exposure because of thoracic pain and the presence of a chest tube. Moreover, patients with chronic...
obstructive pulmonary disease have longer post-procedural ventilation times when treated via TA relative to TF TAVR, indicating that TA should be avoided in such individuals.\(^{15}\) The use of apical access declined in the PARTNER II trial to 8.5%, and a newer, smaller-caliber delivery sheath (Ascendra II 24F) was introduced at this time.\(^{2}\) Although technology improved, thoracic access (both TA and TAo) was still associated with increased death, stroke, vascular complications, and new atrial fibrillation (Table 1). Currently, the Sapien 3/Ultra balloon expandable valves (Edwards Lifesciences, Irvine, CA) use the Certitube delivery system (Edwards Lifesciences, Irvine, CA) that has an internal diameter of 18 to 21F depending on the valve size used.

After concerns with myocardial injury and comfort with limited sternotomy or aortic cannulation, TAo access was developed by Bapat and colleagues.\(^{16}\) TAo access is feasible so long as the aorta is not excessively calcified and there is at least 6.5 to 7 cm of length between the proposed entry side and the aortic annulus to allow for valve preparation. Aortic access is achieved using J-sternotomy or right lateral thoracotomy, depending on the position of the aorta (Fig. 4). After placing pledgeted sutures at the access site, direct puncture is performed with an 18-gauge needle (see Fig. 4). A small sheath should be inserted to facilitate crossing the stenotic aortic valve and exchanged for a stiff wire that enables large-sheath delivery. Following THV implantation, the pledgeted sutures are tightened for hemostatic control and the thorax closed in the usual fashion.

Some surgeons prefer TAo over TA access because of less surgical site pain, minimal myocardial injury, and freedom from concerns about apical tissue integrity. Rare complications of dissections or intramural hematomas occur, and convalescence is still prolonged.\(^{17}\) The use of TAo access in the PARTNER II trial was only 3.05%,\(^{2}\) and US registry data show that TAo is associated with an 8% in-hospital mortality, 40% rate of renal failure with the minority of patients able to be discharged home (see Table 1).

Intuitively, thoracic invasion for THV implantation is less preferred. Tsuyoshi Kaneko and colleagues\(^{18}\) give credence to this notion by showing higher rates of mortality, blood transfusion, atrial fibrillation, and intensive care unit length of stay when using transthoracic access. Moreover, new-onset atrial fibrillation is significantly increased in thoracic access, especially TA, compared with any extrathoracic access.\(^{19}\) As such, transthoracic access is declining, and TA/TAo access accounts for less than 2.8% of all Sapien TAVR cases in the US TVT registry between 2015 and 2018.\(^{20}\)

**SUPRASTERNAL ACCESS**

In 2018, Codner and colleagues\(^{21}\) described suprasternal access using the dedicated Aegis...
metallic frame (Aegis Surgical, Dublin, Ireland). Using a 3-cm transverse incision superior to the sternal notch, blunt dissection is performed to expose the plane between the brachiocephalic artery and innominate vein. The Aegis device optimized exposure and illumination to facilitate insertion of purse-string sutures by way of thoracic port instruments. Once prepared, the brachiocephalic artery is accessed with a pericardiocentesis needle to enable eventual exchange for a delivery sheath. Postvalve implantation, a long knot-tying instrument achieves hemostasis. The published data consist of 11 patients with earlier ambulation and shorter hospitalizations that propensity matched TA or TAo. Further studies are needed on this access route to determine generalizability of suprasternal access.

<table>
<thead>
<tr>
<th></th>
<th>Antegrade Transaortic</th>
<th>Transapical</th>
<th>Surgical Axillary</th>
<th>Percutaneous Axillary</th>
<th>Transcarotid</th>
<th>Transcaval</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-hospital mortality, %</td>
<td>0</td>
<td>8.1</td>
<td>7.4</td>
<td>4.3</td>
<td>3.4</td>
<td>2.5</td>
</tr>
<tr>
<td>Longer-term mortality</td>
<td>22% 6 mo</td>
<td>19% 1 y</td>
<td>9% 30 d</td>
<td>2.9% 30 d</td>
<td>5.4% 30 d</td>
<td>4.3% 30 d</td>
</tr>
<tr>
<td>Major bleeding, %</td>
<td>44.4</td>
<td>5.0</td>
<td>7.2</td>
<td>NA</td>
<td>0.5</td>
<td>0.1</td>
</tr>
<tr>
<td>Acute kidney injury, %</td>
<td>22.2</td>
<td>39.6</td>
<td>NA</td>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stroke, %</td>
<td>0</td>
<td>2.5</td>
<td>2.8</td>
<td>3</td>
<td>6.1</td>
<td>4.2</td>
</tr>
<tr>
<td>Vascular complications, %</td>
<td>33.3</td>
<td>0.5</td>
<td>3.8</td>
<td>2</td>
<td>2.5</td>
<td>1.5</td>
</tr>
</tbody>
</table>

**Abbreviation:** N/A, not applicable.

**TRANSAXILLARY ACCESS**

TAx access has long been used as an alternative access for TAVR, beginning with surgical exposure for sheath insertion, and it has now evolved to complete percutaneous access and hemostasis. Initially disseminated as an alternative access for Medtronic Corevalve implantation, it has become the dominant alternative access in the United States. Advantages of axillary access is the relative lack of atherosclerosis compared with femoral vessels, accessibility, and extrathoracic location. The medial section of the subclavian artery is thinner with a higher proportion of elastic fibers compared with the femoral artery, causing concern that the artery may be fragile. Another caveat is the proximity of the brachial plexus to the vessel and potential for

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**Table 1**

<table>
<thead>
<tr>
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**Abbreviation:** N/A, not applicable.
compromising the upper extremity via peripheral nerve injury or distal embolism.\textsuperscript{23}

The axillary artery is divided into 3 segments (Fig. 5), with the most proximal section between the lateral margin of the first rib and medial border of the pectoralis minor muscle. The second segment is deep to the pectoralis minor muscle, whereas the third segment is between the lateral border of the pectoralis minor and inferior border of the teres major muscle. Computed tomographic analysis shows that the axillary artery is usually on average 1.5 mm smaller than the corresponding lower-extremity vessels.\textsuperscript{24} Occasionally, a pacemaker or implantable cardioverter defibrillator encroaches on the deltopectoral groove, crowding the access point. In addition, large-bore axillary access should be avoided in the presence of an ipsilateral patent mammary graft to prevent ischemia during cannulation.

Operators should aim to access the distal end of the first segment or proximal second segment

![Fig. 5. Axillary artery anatomy relevant to transcatheter access. Angiogram of the axillary artery, its 3 divisions and side branches.](image)

![Fig. 6. Percutaneous axillary access for TAVR. (A) Combined use of fluoroscopic subtraction to outline the vessel and ultrasound (asterisk) to access the axillary artery using a 21-gauge needle and 0.018” wire (arrow). (B) “Pre-close” of the axillary artery using a Proglide Perclose (triangle) (Abbott Vascular, Santa Clara, CA). (C) Exchange for a 14F E-Sheath (dagger) (Edwards Lifesciences, Irvine, CA) over a stiff wire. (D) Balloon tamponade (double dagger) of the vessel postsheath removal and tightening of the Perclose sutures. (E) Completion angiogram showing no evidence of dissection or extravasation.](image)
at a shallow angle to avoid sheath kinking (Fig. 6). The left axillary artery is more commonly used. Take care to avoid damaging the subclavian artery, as surgical rescue of this vessel requires a sternotomy. In preparation for large-bore TAVR access, the authors’ center routinely prepares the ipsilateral radial artery with a 7F sheath and a 0.014 to 0.018 wire for endovascular management and rescue. Using a combination of fluoroscopy and ultrasound, the axillary artery is punctured and dilated, and Proglide sutures are implanted in typical fashion before large-sheath insertion (see Fig. 6). Balloon tamponade between sheath exchanges minimizes blood loss, and the large-bore sheath should be inserted over a stiff wire. External compression against the second rib is feasible to maintain hemostasis in the case an ipsilateral peripheral arterial access is unavailable. Following THV implantation, balloon tamponade prevents bleeding and facilitates hemostasis. Tightening of the Perclose sutures accompanied by short duration balloon tamponade should be sufficient for hemostasis. Given the torsion encountered by the axillary artery, flexible self-expanding or balloon expandable covered stents (VBX; Gore Medical, Flagstaff, AZ, USA) should be used for rescue; the latter in particular is advantageous because of its large range and ability to fit through a 7F sheath.

Fig. 7. TC TAVR. (A) Surgical exposure of the carotid artery (arrow). (B) Insertion of a 9F sheath in the carotid artery using the Seldinger technique (triangle). (C) Crossing the aortic valve using a JR4 catheter (dagger). (D) Exchanging for a 14F E-sheath (double dagger). (E) Delivery of a 26-mm Edwards Sapien 3 Ultra valve. (F) Completion angiography of the left carotid access site demonstrating no dissection or extravasation.

Fig. 8. Pathophysiology of an iatrogenic aortic-caval fistula. (A) Intuitively, most would believe that patients should exsanguinate (red arrows) from a rent in the aorta. (B) Because a breach is present in both the aorta and vena cava and the interstitial pressure of the retroperitoneal space exceeds the venous pressure, blood preferentially shunts from the aorta to the vena cava (straight red arrows). Permission received from Springer Publishing.
Endograft implantation at minimum
Rationale: for possible endograft insertion
Objective: Select preferred iliofemoral access

Example: 18F sheath for Medtronic Evolut R
≥7 mm
14 to 16F e-sheath for Edwards Sapien 3 ≥7.6 to 8.6 mm

Objective: Identify high-risk anatomy for caval-aortic traversal and large sheath insertion
Rationale: Several extravascular and intravascular anatomic variations have been identified that jeopardize safe traversal

Interposed structures: Arterial branches, interposed bowel, and major veins (eg, renal) cannot be traversed for obvious reasons

Pedunculated atheroma: Pedunculated aortic atheroma may embolize during catheter or closure device manipulation

Abdominal aneurysms: Ectasia and aneurysms are not contraindications, but the large size of the aorta may makes endovascular bailout challenging

Dissections: Chronic dissections can extend with large-bore sheath insertion and should be avoided

Leftward aorta: Aortas with a cephalad leftward trajectory may result in a tangential trajectory if a sheath is inserted and in leftward translation of the abdominal aorta while crossing. 20° leftward aortas should be avoided

Prior device implants: IVC filters, polyester aortic grafts, and even pacemakers have impeded TCav access. Although crossing an aortic graft is possible, it should be performed in experienced centers.

Objective: Identify vascular structures at risk during closure of possible endograft rescue
Rationale: The crossing site should be at least 15 mm away from the aortoiliac bifurcation and renal arteries. Important vessels, including accessory renal arteries and lumbar collaterals, in patients with important iliac disease should be noted, as endograft implantation will compromise these branches

Objective: Select preferred iliofemoral access for possible endograft insertion
Rationale: Endograft implantation at minimum requires a vessel that accepts a 12F access.

Should femoral arterial access be inadequate, then the patient will require appropriate risk:benefit counseling if operators decide to proceed

Objective: Perform measurements for equipment selection and corresponding bony landmarks for crossing plan
Rationale: Once a safe traversal point has been determined, measurements for selecting a snare, guide, and bail-out equipment

Key findings include the following:
- Crossing site(s) and correlating lumbar spinal level for crossing
- Distance from femoral vein puncture site to crossing site
- Distance from aortoiliac bifurcation
- Distance from renal arteries
- Abdominal aorta size at the crossing, 30 mm cephalad and 30 mm caudal

Aortocaval distance does not appear to be important

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TAx access has catapulted to the most frequently used alternative access in the United States due to high rates of technical success and its extrathoracic nature. Retrospective studies have shown similar procedural outcomes between TF and TAx routes,22,26 but most of these data originate from self-expanding valves and include the surgical cutdown technique. A single-center study reporting balloon-expandable platforms using TAx access reported 100 cases of complete percutaneous access with favorable outcomes.27 Analysis of the US TVT showed that TAx access has been used in 2% of Sapien TAVR cases.20 The device success rate was 97.3% and was accompanied by a major vascular complication rate of 2.5%. Propensity-matched analysis demonstrated that TAx access has lower 30-day mortality, shorter intensive care unit and hospital length of stay, but a higher stroke rate (6.1% TAx vs 3.1% transthoracic) compared with trans-thoracic alternative access (see Table 1). More recently, a 75-patient prospective registry using ACURATE-Neo valves (Boston Scientific, Natick, MA, USA) observed a high rate of complete percutaneous access (90.5%) and conscious sedation (95.2%).28 Need for bail-out stenting and surgical vascular repair were 9.3% and 4%, respectively, and only 1 (1.3%) cerebral vascular event was reported.
Right axillary access is feasible, and additional technical challenges are encountered. No data exist for whether the right or left axillary artery is better for access, but the left more closely resembles the haptics of transfemoral access, and achieving coaxial alignment is easier. Medtronic recommends against using Evolut (Medtronic, St. Paul, MN, USA) valves via the right axillary artery in root angles greater than 30°, whereas Sapien valves can be delivered but with some technical modifications. Notably, inserting the sheath tip beyond the aortic valve to predilate, passively exposing the valve/delivery system in the ascending aorta and flexing the Commander delivery system (Edwards Lifesciences) away from the aortic valve will improve coaxial alignment.

**TRANSCAROTID ACCESS**

Superficial location, sturdy constitution, and deep surgical experience with the carotid artery increased its profile as a safe access for TAVR (Fig. 7). Achieved through surgical carotid exposure and establishing proximal and distal control of the vessel with tourniquets, the vessel is usually accessed near the level of the thyroid cartilage. After small sheath insertion, the stenotic aortic valve is crossed and exchanged for a stiff wire, allowing large-bore sheath exchange (see Fig. 7). Following THV implantation, the sheath is withdrawn, and hemostatic control is maintained by tightening the tourniquets. Meanwhile, surgical repair of the arteriotomy can be performed in standard fashion. Initial series of TC access used a vascular shunt to maintain

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**Fig. 9.** Stereotypical case of TCav access and closure. (A) Scout angiogram using DSA of the abdominal aorta in the coplanar view. (B) A 6F IM (asterisk) guide is oriented in the IVC pointed toward the abdominal aorta. A 6F JR4 guide with a 25-mm Gooseneck snare (arrow) oriented orthogonally to the coplanar angle in preparation for wire crossing. (C) The image intensifier is rotated 90° to the coplanar angle and the IM catheter trajectory into the open snare in the abdominal aorta. (D) Assembly of a coaxial, serial telescoping system composed of a 0.014" Confianza Pro 12 within a 0.014" Piggyback, all nested inside a 0.035" NAVICROSS. (E) The end of the of Confianza Pro 12 wire is clamped to an electrosurgical pencil with a hemostat. (F) With the application of 50 W of “cut” electrosurgical energy, the 0.014" wire (arrow) traverses the IVC and abdominal aortic wall to the level of the snare. (G) The 0.014" wire is captured and towed to the thoracic aorta. A 0.014" Piggyback catheter (circle) crosses into the abdominal aorta. (H) Using the Piggyback 0.014" → 0.035" wire converter enables passage of a 0.035" NAVICROSS (arrow) to facilitate delivery of a 0.035" wire from the IVC into the abdominal aorta. (I) With the support a 0.035" Lunderquist wire, a 14F Edwards Lifesciences E-sheath (arrow) is delivered to the abdominal aorta. (J) Using a small curl Agilis catheter (asterisk), an Amplatz Duct Occluder 10/8 (arrow) is deployed with the retention disc against the abdominal aortic wall. (K) Final DSA aortogram demonstrating minimal flow (type 0) across the TCav fistula. Permission received from Springer Publishing.
antegrade flow but has largely been abandoned. Current practice at the authors’ institution is contralateral carotid and circle of Willis screening for advanced atherosclerosis, but this is not a universal practice. Although traditionally TC access has been under general anesthesia, data from France suggest feasibility of TC TAVR using local and conscious sedation and noted that it was associated with lower stroke rates and less days in the hospital without compromising clinical outcomes.

Retrospective French registry data show that TC access is associated with better outcomes compared with thoracic access; lower incidence of atrial fibrillation, less bleeding, acute kidney injury, and shorter hospital length of stay. US TVT data corroborated these outcomes and observed 0.4% rate of utilization in Sapien TAVR cases (see Table 1). Compared with TAx TAVR, TC TAVR has similar mortalities, less fluoroscopy and procedure time, and numerically lower stroke rates (nonstatistically significant), making it a favorable alternative access (see Table 1).

### TRANSCAVAL ACCESS

A translational to catheterization laboratory innovation, TCav is the least conventional alternative access. First validated in an animal model, the technique of harnessing electrosurgical power to traverse the inferior vena cava (IVC) wall, retroperitoneal space, and abdominal aortic wall seems counterintuitive. At first glance, creating a vascular breach into the retroperitoneal space results in exsanguination, but because the interstitial hydrostatic pressure of the abdomen exceeds IVC pressure, arterial blood preferentially shunts into the IVC. Successful use of TCav hinges on this concept, and the IVC must serve as a sink for arterial blood (Fig. 8).

TCav access planning requires detailed analysis of the IVC/aorta to determine the crossing level, calcification, aortic size, distance from renal arteries (accessory renal arteries), distance to the iliacs, coplanar crossing angle, presence of interposed structures, and distance from the femoral vein (Box 1).

#### Performing Transcaval Access

First, proper patient consent for alternative access and all necessary equipment for crossing, closure, and bailout should be assembled (Fig. 9). Attach the electrosurgical pad with care not to be close to any metallic implants (eg, hip replacement). Choose the largest femoral artery for access in case of the need for endovascular bailout. After vascular access, anticoagulate with a goal of activated clotting time of greater than 250 seconds. Perform a scout abdominal aortogram under digital subtraction angiography (DSA) at ~32 cm

<table>
<thead>
<tr>
<th>Box 2</th>
<th>Equipment for transcaval access, closure, and bleeding management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transcaval access</td>
<td></td>
</tr>
<tr>
<td>● Electrosurgical unit and pen (Bovie)</td>
<td></td>
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<tr>
<td>● 6F Judkins right guide</td>
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<tr>
<td>● Amplatz Gooseneck snares (~5 mm larger abdominal aortic diameter; Medtronic) (example: 20 mm diameter, use a 25-mm snare) (Medtronic, St Paul, MN)</td>
<td></td>
</tr>
<tr>
<td>● 6 to 7F Renal Double Curve-1 guide catheter or 6 to 7F IM guide catheter (renal length)</td>
<td></td>
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<tr>
<td>● 0.014” microcatheters:</td>
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<tr>
<td>● 0.014” Finecross 135 cm (Terumo, Ann Arbor, MI, USA)</td>
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<tr>
<td>● 0.014” Piggyback 120 or 150 cm (Teleflex Medical, Morrisville, NC, USA)</td>
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<tr>
<td>● 0.014” Advance Microballoon 150 cm (Cook Medical, Bloomington, IN, USA)</td>
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<tr>
<td>● 0.035” catheters:</td>
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<tr>
<td>● 0.035” CXI catheter 90 cm (Cook Medical)</td>
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<tr>
<td>● 0.035” NAVICROSS catheter 90 cm (Terumo, Ann Arbor, MI, USA)</td>
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<tr>
<td>● 0.035” Lunderquist Wire (Cook Medical, Bloomington, IN)</td>
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<tr>
<td>● 0.014” crossing wires</td>
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<tr>
<td>● 0.014” Astato XS 20 wire 300 cm (Asahi Intecc, Tustin, CA, USA)</td>
<td></td>
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<tr>
<td>● 0.014” Confianza Pro 12 300 cm (Asahi Intecc)</td>
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<tr>
<td>Transcaval closure:</td>
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<tr>
<td>● Small curl Agilis (Abbott Structural, Santa Clara, CA)</td>
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<tr>
<td>● Amplatz Duct Occluder I 8/6 mm or 10/8 mm (Abbott Structural)</td>
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<tr>
<td>● 0.014” Balance Middle Weight 300 cm</td>
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<td>Bleeding complication rescue:</td>
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</tr>
<tr>
<td>● Reliant Aortic Occlusion Balloon (Medtronic)</td>
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<tr>
<td>● Coda Aortic Occlusion Balloon (Cook Medical)</td>
<td></td>
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<tr>
<td>● 14 to 28 × 45 mm Endologix Ovation IX iliac Limb Extender stents (Endologix, Irvine, CA)</td>
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magnification using the coplanar angle preidentified. Afterward, exchange the pigtail catheter for a 6F JR4 guiding catheter and position a single-loop snare (Amplatz Gooseneck; Medtronic) in the abdominal aorta at the proposed crossing point, oriented toward the IVC. Next, the crossing catheter, usually a 6 to 7F Renal Double Curve or renal length internal mammary (IM) catheter is aimed at the snare at the corresponding lumbar spinous level in the IVC. Prepare a 0.014” Aastato 20 wire, 0.014” microcatheter, and 0.035” braided catheter as a serial telescoping crossing system. After crossing the system assembly, clamp the 0.014” wire to the electrosurgical pencil and confirm coaxial trajectory of the wire to the snare center using orthogonal projections (see Fig. 8). Once confirmed, advance the wire while applying a short burst of 50 W of electrosurgical cutting, halting when the wire approximates the snare location. Close the snare around the wire and drag the 0.014” wire cephalad to the thoracic descending aorta. Using the countertraction of the captured wire, advance the 0.014” catheter and 0.035” catheter in a telescoping fashion. Release the snared 0.014” wire to exchange for the 0.035” Lunderquist wire. Finally, exchange the small venous sheath for the large-bore sheath under high-resolution radiography to ensure smooth passage and scrutinize for sheath splaying.

Difficulty crossing should trigger caution and prompt troubleshooting steps. First, avoid wire buckling, as spring release of a buckled wire may create a slitlike orifice that is unmatched on the caval side and increase risk for bleeding. Unexplained hemodynamic changes in the context of multiple crossing failures should prompt aorta angiography. Review that electrosurgical monopolar cutting of at least 50 W is being activated and the contact point between the coronary wire and electrosurgical pencil is clean. Several failed traversal attempts will char the wire, necessitating replacement. If a different crossing location is selected, knowledge of lumen size, interposing structures, proximity to vessels, and coplanar angles must be reassessed. The aortic wall may sometimes be resistant to catheter crossing despite wire traversal, in which case use a 2.5- to 3.0-mm noncompliant coronary balloon to facilitate traversal.

**Transcaval Access Closure**

Once the THV is implanted, reaffirm all access emergency bailout equipment is assembled (Box 2). Infuse protamine to normalize the activated clotting time and leave a 0.014” 300-cm safety wire across the tract. Advance a small curl deflectable catheter through the delivery sheath, prepare a nitinol closure device, preferably an Amplatz Duct Occluder I (ADO I; Abbott Vascular, Santa Clara, CA, USA). Withdraw the large-bore TCav sheath close to the crossing site and passively expose the ADO I, forming a “ball.” Retract the TCav sheath to the IVC and ensure the venous side is not obstructed to allow venous decompression. Finally, form a retention disc completely and deflect the catheter 90° and retract the system with sufficient tension to appose the aortic wall but avoid pulling through. Once apposed, passively expose the remainder of the device. Immediate angiography is important to recognize any bleeding early. Generally,
there are 4 patterns of closure (Fig. 10): Occluded (type 0), funneled (type I), cruciform (type II), and extravasation (type III). Types 0 to 2 can be observed without intervention, and extravasation requires intervention. Transient blood pressure drops of 10 to 15 mm Hg are typical with shunting. If hypotension persists, consider oblique views to exclude extravasation.

In the event of extravasation, rapidly exchange for an aortic occlusion balloon and tamponade the TCav tract. Occlusion of the tract for 3- to 5-minute cycles can be done several times, but if there is no improvement, then proceed with covered stent implantation. In rare occasions, patients with right ventricular cardiomyopathy can experience hemodynamic embarrassment from the inability to accommodate aortic-caval shunting. To manage extravasation or arterial-venous shunting, occlusion of the tract using a covered stent is sometimes necessary. A self-expanding covered stent 10% to 20% larger than the aortic lumen is recommended, and the stent of choice is an Ovation iX aortic limb extender stent (Endologix, Irvine, CA, USA); however, a balloon expandable stent (VBX; Gore Medical) has been successfully used as well.

The feasibility of this access was demonstrated in preclinical work on animals and subsequently performed in a series of 25 patients without femoral or another alternative access options. A larger prospective study was done and reported data on 100 patients at 17 centers with 99% successful TCav access (1 failure to cross), and 98% device success (no death or surgery bailout). The 1-year data on TCav tract closure were reported in 2019 and showed that 93% of patients had complete closure of the cavoaortic tract at 1 year.

SUMMARY

Vascular access complications continue to negatively impact patients, and alternative access remains essential to treating complex cases of valvular heart disease. The infrequent use of alternative access requires that operators concentrate their focus on developing expertise with 1 to 2 techniques or refer patients to experienced tertiary centers. Although THV evolution may eventually further reduce the need for alternative access, high prevalence of advanced age, morbid obesity, peripheral vascular disease, and earlier onset diabetes will likely preserve the need for nonfemoral access. Furthermore, the authors’ center promotes the philosophy that the best access be pursued in each individual case and not simply the most convenient. To this end, alternative access remains central to building a high-quality tertiary center for TAVR.

REFERENCES


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