

Alternative Access and Closure Options for TAVR

Transaortic, subclavian, or axillary access can be reasonable in TAVR patients who are not candidates for the transfemoral approach.

BY COLIN BARKER, MD, AND MICHAEL J. REARDON, MD

Severe aortic stenosis is a common form of cardiac valve disease that increases with advanced age. Symptomatic severe aortic stenosis carries a high mortality rate and has no medical treatment that increases survival^{1,2} and therefore carries a class I indication for aortic valve replacement in both the United States and European guidelines.^{3,4} Unfortunately, a substantial number of patients are denied surgical aortic valve replacement due to advanced age, frailty, comorbidity, or other factors. The advent of transcatheter aortic valve replacement (TAVR) allows for a less-invasive approach that can be offered to these patients.

For patients who are considered extreme risk and not operative candidates, TAVR has shown superior survival rates compared to best medical therapy.^{1,5,6} It has also shown equivalent survival rates in high-risk patients^{7,8} and superior survival rates in randomized trials when compared to surgical aortic valve replacement.^{2,9} In these trials, transfemoral access was considered the preferred access route, and in the nonoperative PARTNER B trial, only transfemoral access was allowed. In the high-risk PARTNER A trial and both the extreme- and high-risk CoreValve pivotal trials (Medtronic), alternative access routes were allowed. For the PARTNER trial using the first-generation Sapien valve (Edwards Lifesciences), the sheath sizes needed were 22 and 24 F, and of those, only approximately 60% of cases could be done using a transfemoral approach.⁷ In the CoreValve trials, all valves were inserted using an 18-F sheath, and a transfemoral approach was used in 83% of the cases.²

Continued improvements in TAVR technology have resulted in even smaller introducer sheath sizes and an

increase in the use of the transfemoral route. However, this increase in transfemoral access has not reached 100% (and is unlikely to do so) because of the prevalence of vascular disease in this patient population. Attempting to use a transfemoral approach when the patient is not an appropriate candidate due to vascular anatomy will increase the risk of vascular injury and death. Therefore, when TAVR cases cannot be performed via a transfemoral route, it is important for the valve team to be versed in alternative access approaches, including transaortic, subclavian, or axillary, and their safe and appropriate closure.

ACCESS

Transfemoral access is the preferred approach for our TAVR team. It is chosen based on careful three-dimensional CT angiographic (CTA) assessment of the iliofemoral and aortic arterial systems. We generally perform our transfemoral cases under local anesthesia with sedation and use a percutaneous approach with preclosure. However, excessive atherosclerosis, calcification, and/or tortuosity may make an iliofemoral approach either impossible or excessively risky. In such cases, we move to an alternative approach.

SUBCLAVIAN OR AXILLARY APPROACH

The subclavian arteries arise in the chest and end where they cross the first rib behind the clavicle. It is possible to approach the second portion of the subclavian artery from a supraclavicular approach, but this is not commonly done. Although the terms *subclavian* and *axillary* approach have often been used interchangeably, the artery is almost always approached below the clavicle in the deltopectoral groove, where

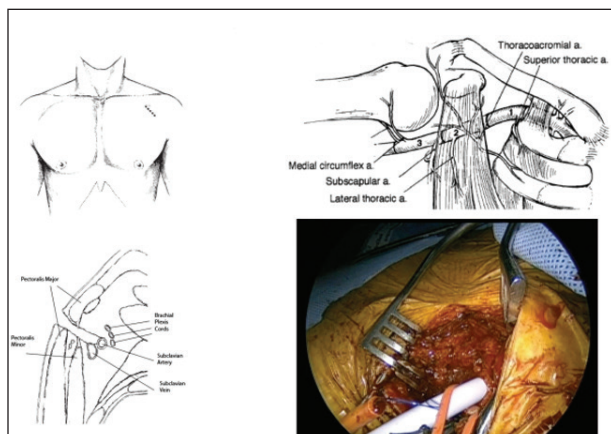


Figure 1. Anatomy of the axillary approach.

it is the axillary artery. This approach shares several features in common with a femoral approach: no body cavity is broached; it can be performed under local anesthesia, although our team has consistently used general anesthesia with immediate extubation at the end of the case; and a percutaneous technique using the Perclose ProGlide device (Abbott Vascular) can be used, but we have chosen surgical cutdown for axillary access due to the proximity of the brachial plexus and the simplicity of the surgical approach. Axillary access has mainly been used with the CoreValve device and Evolut R valve (Medtronic) at our institution, although the Sapien XT and Sapien 3 valves (Edwards Lifesciences) are also well suited for this approach. In the following paragraphs, we describe our approach using the CoreValve or Evolut R systems.

Preprocedural planning using three-dimensional CTA of the axillary and subclavian arteries is important to evaluate vessel size, calcification, and tortuosity. The angle of the aortic annulus from the horizontal is also important. For delivery using an 18-F sheath, a minimal vessel lumen of 6 or 6.5 mm is necessary if there is calcification that extends over more than 270° of the vessel circumference. For a bareback insertion or use of the Evolut R with the in-line sheath, the true outer diameter is 18 F, and 0.5 mm can be subtracted from the minimal lumen diameter. Consideration must also be given for the presence of a patent internal mammary artery graft, in which case at least 0.5 mm should be added to these numbers for safety. In the United States CoreValve pivotal trial, the left axillary approach was limited to aortic angles of $< 70^\circ$ and $< 30^\circ$ for the right axillary approach. We have

found that steeper angles (more horizontal aortas) can be successfully treated with experience, but the left axillary artery is generally an easier option for implantation than the right.

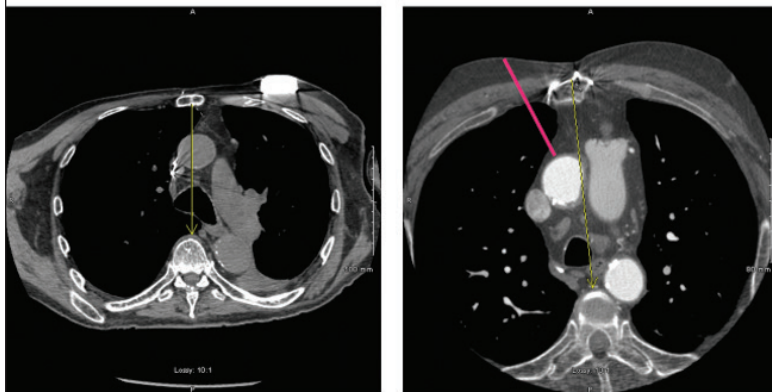
We have found that the most common error made by surgeons who are new to the axillary approach is placing their incision too medially, where the artery is high and just emerging from under the clavicle. We make an incision in the deltopectoral groove below the clavicle. The fibers of the pectoralis major are divided, and the pectoralis minor is easily seen. This muscle can be retracted or divided with impunity. Once deep to the pectoralis minor, the surgeon will encounter the axillary artery just inferior to the brachial plexus. It is important not to use cauterization once past this point. The artery is gently dissected free and surrounded with a vessel loop. It is then easily punctured, and a 6-F sheath is placed (Figure 1).

Through this sheath, the TAVR team will use their catheter of choice to cross the aortic valve and obtain hemodynamic measurements. A stiff wire (we use an Amplatz super stiff, Boston Scientific Corporation) is then passed into the left ventricle. The 18-F sheath is then placed over this stiff wire, or the delivery system can be placed bareback. It is important not to pass the sheath or delivery system over the soft wire to avoid injury to this frail artery. Delivery of the valve is now similar to the transfemoral approach, with the caveat that because the delivery site is closer and does not wrap around the aortic arch, there tends to be less movement and a more accurate deployment of the valve. Once the implantation is complete, the delivery system and/or sheath are removed. If there is a patent left internal mammary artery graft, we will perform final subclavian arteriography to ensure that no damage has been done to the graft and then close the artery with a 5-0 Prolene suture. This incision generally causes no more pain or morbidity than a femoral incision.

	Sternotomy	Upper Mini Sternotomy	Right mini Thoracotomy	Port Thoracotomy	Suprasternal
Incision Location	Sternotomy	Upper Stern.	Thoracotomy	Port thoracotomy	Suprasternal
Incision Size	12+ cm	5+ cm	4-5 cm	1 cm	2-3 cm
Visualization	Direct	Direct	Direct	Indirect	Direct

Figure 2. Options for direct aortic access.

Thoracotomy or Sternotomy?



What is behind the sternum?

Figure 3. Considerations when choosing between a hemisternotomy and right thoracotomy. For a right thoracotomy approach, you should see at least 50% of the aorta to the right of the midline (panel on the left), and the distance between the proposed puncture site and the skin should be < 8 cm; otherwise, the aorta is hard to reach. As long as there are no structures behind the sternum that are at risk of injury (eg, patent bypass grafts), we always prefer a mini-sternotomy.

TRANSAORTIC APPROACH

The transaortic approach to TAVR can be performed using a small anterior right thoracotomy, an upper J-hemisternotomy, or a suprasternal nonchest opening technique (Figure 2). The following sections describe the commonly used upper hemisternotomy and right anterior thoracotomy approaches, as well as the newer suprasternal approach, which allows a direct aortic access without opening the chest.

Upper Hemisternotomy

A 6-cm incision is made over the upper sternum. The sternal notch is freed, and the right second or third interspace is opened next to the sternum. The interspace used depends on how low the heart sits in the chest, which can be quite low in patients with severe chronic obstructive pulmonary disease. An oscillating saw is then used to open from the chosen interspace to the midline and from the sternal notch down to this point, creating a small “J” in the right upper sternum that can be opened like a trapdoor. A small sternal

retractor is then inserted with the handle pointing to the chin to keep the body of the retractor out of the working fluoroscopic field. The pericardium is identified and opened to the level of the innominate vein, and pericardial stay sutures are placed, which create a pericardial well that exposes the distal ascending aorta.

We then insert a 6-F sheath through a purse-string of pledgetted 3-0 Prolene sutures on a Rummel tourniquet to use in placing a pigtail catheter into the noncoronary cusp for CoreValve devices or the right coronary cusp for Sapien valves. A second set of two concentric pledgetted 3-0 Prolene purse-string sutures on Rummel tourniquets are placed, and a second 6-F sheath is placed through these. The aortic valve is then crossed in standard fashion, and hemodynamic measurements are obtained. A stiff wire appropriate to the valve being used is placed through the sheath in the double purse-string site, the 6-F sheath is removed, and an 18-F sheath is placed.

To control the depth of this sheath, we place a silicon bumper 2 cm back from the end and tie a suture behind it to lock it in place. When the sheath is inserted, this bumper allows the sheath to stop at the proper depth.

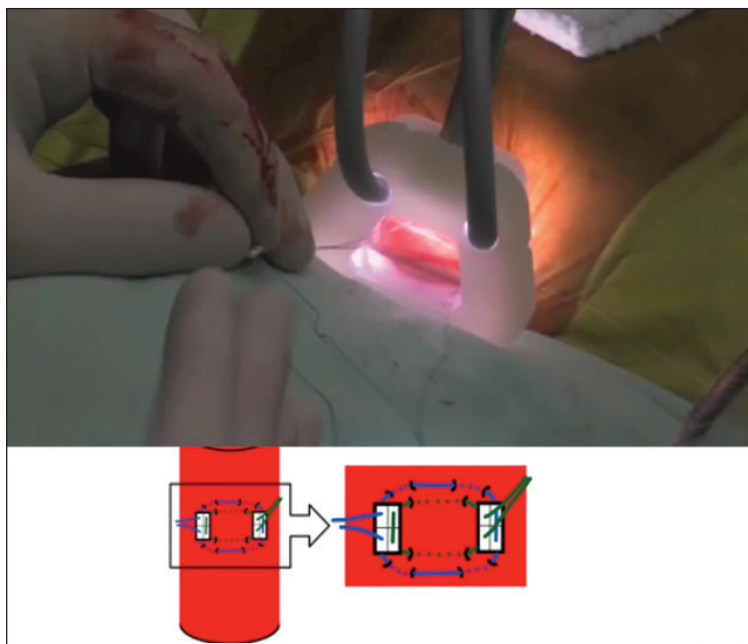


Figure 4. Suprasternal direct aortic approach.

The sheaths are tied to the Rummel tourniquets and also sutured to the skin. They are very stable at this point and do not need to be held, allowing the operator to concentrate on appropriate valve delivery without worrying about sheath placement or dislodgement. Valve deployment is generally easy and accurate using the transaortic approach because the valve goes straight into position without going around the arch. When using the transfemoral approach, the delivery system can both gain and expend energy in the arch, and delivery can be somewhat like flying a kite as the string tenses and loosens in the wind. For transaortic deployment, the valve is literally on a stick, and so accurate deployment is easier to achieve.

The right mini-sternotomy generally exposes more aorta for the surgeon to use for access and closure and is generally a more comfortable approach for surgeons early in their experience. This approach also avoids entering the pleura, which is an advantage in patients with lung disease. We look at the CTA, and if at least a half of the ascending aorta is not to the right of the line connecting the middle of the sternum to the spine, then the distance may cause a right thoracotomy to be difficult. We also measure the distance from the planned puncture site to the skin for a thoracotomy; if this is > 8 cm, a right thoracotomy may be difficult. The most important aspect, however, is what is behind the sternum (Figure 3). For a “virgin” chest, a hemisternotomy is almost always easy; however, for redo cases, patent grafts and aorta stuck to the posterior sternum can make a right thoracotomy safer. We have previously published our approach to these techniques.^{10,11}

Right Anterior Thoracotomy

A small incision is made over the right second intercostal space. The second costal cartilage is exposed and removed. A soft tissue retractor is placed for exposure. It is important to avoid a rib spreader with the thoracotomy approach, as this will significantly increase the postprocedure pain for the patient. The pericardium is opened, and stay sutures are placed, exposing the distal ascending aorta. The purse-string placement and valve delivery are then the same as with a hemisternotomy. Because the pleural space is transgressed with this approach, we place a 24-F soft Blake drain (Ethicon, a Johnson & Johnson Company) in the right chest, which is usually removed on the first morning after implantation.

Suprasternal Transaortic Technique

A new approach to transaortic TAVR was pioneered by Kiser et al.¹² A transverse suprasternal incision is made much like a mediastinoscopy. The dissection is carried

along the innominate artery to the aorta at its base. The SuprAA system (Aegis Surgical Ltd) is inserted, which maintains the space and provides illumination. A pledgetted box and diamond stitch is placed, and the aorta is accessed through this (Figure 4). The valve is crossed as in the other transaortic approaches, and the stiff wire is passed into the LV. An 18-F sheath is passed into the aorta, and TAVR can be accomplished using either the Sapien or CoreValve device.

CONCLUSION

With continued improvements in technology and the downsizing of TAVR systems, it is likely that use of the transfemoral approach will increase in use with time. However, the transfemoral approach will still not be appropriate for every single TAVR case, and knowledge of alternative access routes and the ability to safely perform these approaches is important for all TAVR teams. ■

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