CASE REPORT

Axillary artery as alternative access for transcatheter aortic valve implantation in a patient with thoracic and abdominal multilayer flow modulator stents, and in a patient with occluded bilateral carotid and iliac arteries

Aksiller arter, torakal ve abdominal çok katmanlı akış modülatörü stentli bir hasta ile iki taraflı karotis ve iliak arteri tıkanmış bir hastada transkateter aort kapak implantasyonu için alternatif giriş

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Summary– Transaxillary access is an alternative to femoral access in patients with iliofemoral occlusion for transcatheter aortic valve implantation (TAVI). A Multilayer Flow Modulator (MLFM) stent is frequently used in patients with a complex thoracic and abdominal aortic aneurysm. The MLFM stent is particularly used in cases where large arteries, such as the renal or celiac artery, feed from the aneurysmal sac. To the best of our knowledge, there is no prior report in the literature of a TAVI case with a pre-existing MLFM stent. Presently described are 2 TAVI cases, one with thoracoabdominal MLFM stents, and the second with occluded bilateral carotid and iliac arteries.

Özet– Aksiller arter girişi iliyofemoral oklüzyonlu hastalarda kateter aracılı aort kapak implantasyonu (TAVI) için alternatif bir yoldur. Kompleks torasik ve abdominal aort anevrizması olan hastalarda çok katmanlı akım modülatörü (MLFM) stenti kullanılır. MLFM stent, özellikle böbrek arteri, çölyak arter gibi geniş arterlerin anevrizmal kesesi içinden çıktığı durumunda kullanılır. Literatürde MLFM stentli hastada rapor edilmiş TAVI olgusu yoktur. Bu yazıda, biri torasik ve abdominal aortada MLFM stenti ve diğeri iki taraflı karotis ve iliyak arterleri tıkalı olan, aksiller arter aracılığı ile TAVI uygulanan iki olguyu sunuyoruz.

Experience with transcatheter aortic valve implantation (TAVI) is growing rapidly. TAVI was developed as an alternative to aortic valve surgery in high-risk patients. This approach can be superior to medical therapy alone.[1] It is preferred because it is less invasive than a conventional surgical valve replacement.[1] The main access sites for TAVI are the femoral, subclavian, axillary, or carotid artery, or the apex of the heart and the ascending aorta.[1] The most commonly used route is transfemoral because it is minimally invasive and it is feasible under conscious sedation in a totally percutaneous fashion, but the access site must be carefully chosen based on individual comorbidities.[2] When transfemoral access is not feasible (e.g., occluded femoral artery, small vessel sizes, severe calcification, tortuosity of the aorta, or previous surgical interventions), the axillary artery is regarded as a reliable alternative access route for TAVI.[2] Valve positioning may be simplified as a result of the shorter distance between the puncture site and the aortic valve.[3] The left axillary artery is preferred more often because it has a more appropriate angle.[2] The right axillary artery is rarely used.[4]

Abbreviations:

EVAR	*Endovascular aneurysm repair*
MLFM	*Multilayer Flow Modulator*
TAVI	*Transcatheter aortic valve implantation*

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Despite percutaneous innovations, such as hybrid repair or a branched endograft, the gold standard remains open surgical repair for patients with thoracoabdominal aortic pathologies. Regardless of treatment choice, these patients have a high risk of death, renal failure, and paraplegia. Less invasive methods for thoracoabdominal aortic aneurysm repair are needed, given the high incidence of morbidity and mortality associated with surgical repair.[5] Multilayer Flow Modulator (MLFM) stents (Cardiatis SA, Isnes, Belgium) are emerging as a treatment alternative for patients with a thoracoabdominal aortic aneurysm.[6] Conventional endografts exclude the aortic aneurysmal sac and stop blood flow of the side branches, whereas the MLFM stent serves to modulate the blood flow of the aorta, allows blood flow to the side branches, and reduces wall stress.[6]

In patients with abdominal aortic occlusion, the axillary and carotid arteries or the apex of the heart and the ascending aorta are alternative access points for TAVI. Presently described are 2 transaxillary TAVI cases, one with thoracoabdominal MLFM stents and the other with bilateral iliac and carotid occlusion.

CASE REPORT

Case 1– A 76-year-old male patient was admitted to the clinic with complaints of fatigue and dyspnea. The patient history included an MLFM stent implanted 3 years earlier due to a thoracoabdominal aortic aneurysm, and another MLFM stent added to the abdominal segment of the stent 1 year before presentation. The patient had also undergone a sternotomy due to bullae in the lung 20 years ago. The transthoracic echocardiographic examination revealed severe aortic stenosis (gradient: 74/42 mm Hg) and moderate aortic regurgitation. The ejection fraction was 55% and the pulmonary artery systolic pressure was 60 mm Hg. Multislice computed tomography (CT) showed the multiple MLFM stents present in the thoracic and abdominal aortas (Fig. 1a) without serious lesions in the coronary arteries. Three cusps were visualized in the aortic valve (Fig. 1c). The aortic annulus measurement was calculated at 25.5 mm (22.8x28.3 mm) (Fig. 1d) and the left axillary artery at 7.9 mm (Fig. 1b). The logistic EuroSCORE was 24% and the STS mortality or morbidity score was 27%. The cardiology and cardiac surgeon's council decided that a TAVI procedure would be appropriate, and because the MLFM stents were in the thoracic and abdominal regions, the left axillary region was selected as the access site.

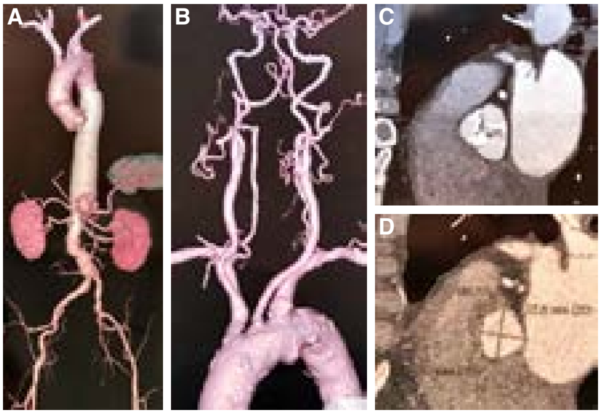

Figure 1. **(A)** Multilayer Flow Modulator (MLFM) stents (Cardiatis, SA, Isnes, Belgium) in the thoracic and abdominal aorta; **(B)** Aortic arch and left subclavian and axillary arteries; **(C)** Three cusps and calcific aortic valve; **(D)** Aortic annulus size.

Case 2– An 82-year-old male patient was referred to the clinic with severe aortic stenosis. The patient had experienced a transient ischemic attack 2 months earlier and was in follow-up treatment for peripheral arterial disease. Coronary angiography had been performed at the previous center through the radial artery 1 month earlier with no finding of a significant coronary lesion, but a mean 60 mm Hg gradient was detected in the aortic valve. A transthoracic echocardiographic examination revealed severe bicuspid aortic stenosis (gradient: 92/64 mm Hg) and mild aortic regurgitation. The ejection fraction was 52% and the pulmonary artery systolic pressure was 45 mm Hg.

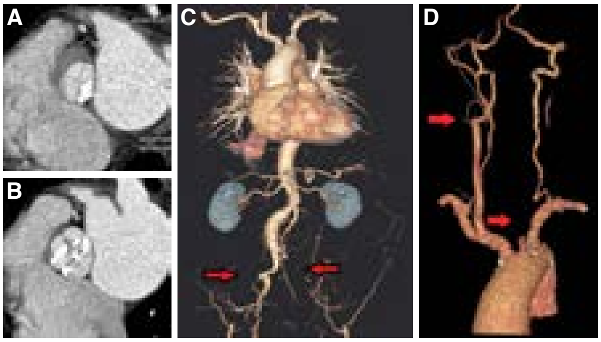

Figure 2. **(A)** Aortic annulus size; **(B)** Bicuspid calcific aortic valve (bicommissural raphe-type); **(C)** Occluded bilateral iliac artery (red arrows: right external iliac artery, left common iliac artery); **(D)** Occluded bilateral carotid artery (red arrows: occluded right internal carotid artery, occluded left common carotid artery).

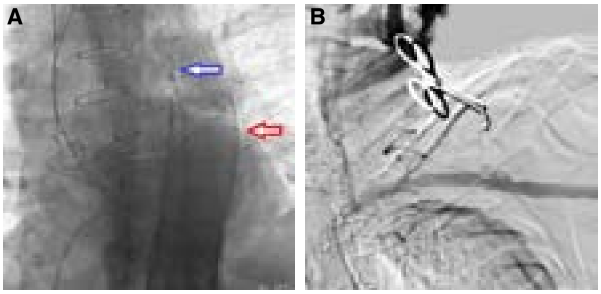

Figure 3. **(A)** A 29-mm, self-expandable aortic valve, Multilayer Flow Modulator (MLFM) stent (Cardiatis, SA, Isnes, Belgium) (red arrow), parked in the descending aorta with 8x40 mm balloon (blue arrow); **(B)** Closed left axillary artery puncture site with closure devices.

Multislice CT showed a calcific bicuspid aortic valve (bicommissural, raphe-type, coronary cusp fusion) (Fig. 2b) and occluded bilateral iliac and carotid arteries (Fig. 2c, d). The aortic annulus measurement was 25.6 mm (22.3x29; bicuspid valve intercommissural distance: 24 mm) (Fig. 2a) and the left axillary artery was measured at 7.4 mm (Fig. 2d). The logistic EuroSCORE was 34% and The Society of Thoracic Surgeons mortality or morbidity score was 24%. In the cardiology and cardiac surgeon's council, a decision was made to perform a TAVI procedure via the left axillary artery.

Procedure

Case 1– The left axillary artery was imaged and punctured using an 8-F right guiding catheter placed in the left femoral artery. Two Perclose ProGlide devices (Abbott Vascular Inc., Santa Clara, CA, USA) were inserted into the left axillary artery. After insertion of the closure devices, a 0.018-in protection guidewire was inserted with a retrograde approach to the left axillary artery through the 8-F right guiding catheter placed in the left femoral artery. An 8x40-mm peripheral balloon was delivered via 0.018-in guidewire and placed in the descending aorta. A pigtail guide catheter was inserted into the aortic annulus via the right radial artery and a temporary pacemaker was inserted into the right ventricle via the right femoral vein. A 29-mm, self-expandable aortic valve (CoreValve; Medtronic Inc., Minneapolis, MN, USA) was delivered with a 14-F catheter in the left axillary region and placed successfully with rapid pacing (Fig. 3a). The left axillary artery puncture site was closed with the ProGlide devices, checked, and the procedure was terminated successfully without any complication. (Fig. 3b). The procedure was performed with sedation and local anesthesia.

Case 2– The left axillary artery was imaged and punctured using a 7-F, 90-cm Flexor Shuttle guiding sheath (Cook Medical LLC, Bloomington, IN, USA) placed in the left radial artery. Two ProGlide closure devices were inserted into the left axillary artery. Once the insertion was complete, a 0.018-in homolateral safety wire was inserted into the left axillary artery through the 7-F Shuttle sheath placed in the left radial artery. An 8x40-mm peripheral balloon was delivered via 0.018-in guidewire and positioned in the distal axillary artery. A pigtail guide catheter was inserted into the aortic annulus via the right radial artery and a temporary pacemaker was inserted into the right ventricle via the right femoral vein. An 18-F sheath was sited from the left axillary artery to the ascending aorta. Balloon aortic valvuloplasty was performed with a 20x40-mm balloon from the 18-F sheath under rapid pacing. Following the valvuloplasty, a 26-mm self-expandable aortic valve (CoreValve) was delivered with an 18-F catheter in the left axillary region and placed successfully with rapid pacing (Fig. 4a).

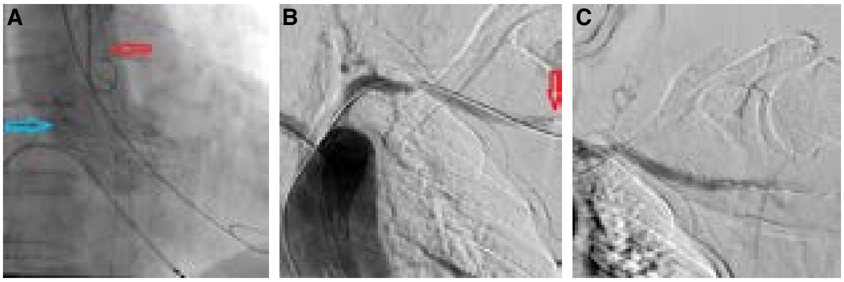

Figure 4. **(A)** A 26-mm, self-expandable aortic valve (blue arrow), left radial artery to the descending aorta and 0.018-in safety wire (red arrow); **(B)** Positioned 8x40-mm balloon in the distal axillary artery (red arrow); **(C)** Closed left axillary artery puncture site with closure devices.

Due to moderate aortic insufficiency, balloon post-dilation was performed with a 25x40-mm balloon under rapid pacing, and the aortic insufficiency decreased to a mild level. The left axillary artery flow was stopped with an 8x40-mm balloon and the puncture site was closed with the ProGlide devices, checked, and the procedure was terminated successfully without any complication (Fig. 4b, c). The procedure was performed with sedation and local anesthesia.

DISCUSSION

The standard approach for TAVI is through the transfemoral retrograde route because it is minimally invasive and conscious sedation is sufficient for the entire procedure. However, transfemoral access cannot be used when there is severe stenosis, tortuosity, or calcification in the femoral artery, iliac artery, or abdominal aorta, or if the femoral diameter is less than the required sheath size.[7] The transfemoral approach should be considered carefully for patients with an aneurysm of the thoracic or abdominal aorta. The axillary approach is an alternative to the transfemoral approach for percutaneous aortic valve implantation.[8] It is most commonly used when the transfemoral approach is not appropriate. Experience with the axillary approach is currently still very limited compared with the femoral approach.[8]

Alternative access routes to the femoral artery for TAVI that have recently been described include transapical, transaortic, axillary, and carotid artery access techniques.[8–10] Transapical and transaortic access require general anesthesia, and transapical access can lead to left ventricular injury. The reported complication rate for transarterial access (femoral, axillary, or carotid) has been lower than that of transapical access procedures.[11] A transaxillary approach is a less invasive alternative to a transfemoral approach, compared with a transapical or transaortic approach.

The axillary approach can be performed under sedation and local anesthesia. The ideal puncture site for axillary access is between the medial border of the pectoralis minor muscle and the outer border of the first rib.[8] An axillary artery puncture should be performed with angiography via the ipsilateral radial artery or a retrograde femoral artery puncture. After completing the puncture, 2 vascular closure devices (ProGlide, in this case) are applied as a pre-closure technique. A safety wire is placed in retrograde fashion via the ipsilateral radial artery or antegrade manner via the femoral artery. An appropriately sized percutaneous transluminal angioplasty balloon is inserted over the safety wire into the distal axillary artery or descending aorta and left in place to allow for immediate puncture site occlusion, if needed. After the wire, an 18-F sheath (or 14-F sheath for the CoreValue Evolut R; Medtronic Inc., Minneapolis, MN, USA) is inserted into the ascending aorta over the stiff wire. The TAVI procedure is then performed using the same technique as with a transfemoral approach. The left axillary artery is preferable to the right axillary artery as an access point for TAVI because it allows for a more coaxial orientation of the valve with the aortic root and annulus. For left axillary access, the aorta-annular angle should be less than 70°, and for right axillary access, the aorta-annular angle should be less than 30°. Right axillary access should be used only when left axillary access is not feasible.

The placement of the protection wire before the closure devices may cause the wire to become entrapped under the suture. If the balloon (on the entrapped wire) is inflated at the access site, it may lead to breakage of the closure suture. An occlusion balloon is routinely used over the safety wire because manual compression may not be feasible or sufficient to achieve hemostasis in some cases. In addition, the wall of the axillary artery is thinner than that of the femoral artery, so the risk of dissection and rupture is greater than in the femoral artery. However, the luminal diameter of axillary arteries is usually larger than that of iliofemoral arteries, and axillary arteries are usually less calcified and tortuous than iliofemoral arteries.[12]

The valve selection for transaxillary TAVI is related to axillary and subclavian artery size and curvature. A TAVI procedure with new generation valves (Sapien 3; Edwards Lifesciences Corp., Irvine, CA, USA; Evolut R) can be performed with a 14-F sheath or a 14-F sheathless system. A thin TAVI system is preferred in order to avoid vascular complications. After sheath insertion, aortic balloon valvuloplasty and TAVI are performed via the sheath. This technique protects against artery injury and plaque embolization. When using a sheathless system, the operator must pay close attention to ensure that the nose cone and valve capsule remain integrated, as separation could lead to artery dissection. The Sapien 3 valve delivery system is deflectable, and the delivery system assists with valve positioning during the TAVI procedure; however, the system is not repositionable. The Evolut R valve delivery system is not deflectable, but the valve system is repositionable.

A transaxillary TAVI procedure has some relative contraindications. These include a patent mammary artery graft or a permanent pacemaker in the ipsilateral pectoral region.[8] An axillary approach in these situations may lead to myocardial ischemia due to flow limitation in the mammary artery or cause pacemaker lead damage. Nevertheless, an axillary approach may be performed in patients with patent mammary artery graft if the subclavian artery diameter is at least 7 mm and free of atherosclerotic disease and tortuosity in the proximal segment and at the ostium of the mammary artery. Finally, because the brachial plexus lies just above the subclavian artery, during a transaxillary procedure, care must be taken to avoid plexus injury.

We used a TAVI access algorithm for our cases (Fig. 5). In our first case, we performed a left transaxillary TAVI with a safety wire introduced in an anterograde manner in a patient with MLFM stents in the thoracoabdominal region. In this case, anterograde protection was preferred because the femoral arteries were open and the wire was placed in the axillary artery via a right guiding catheter through the MLFM stents without resulting in any damage to the stents. In the second case, we performed a left transaxillary TAVI with a retrograde safety wire because the patient had bilateral iliac artery occlusion. In this case, the cranial blood flow was only from the posterior system

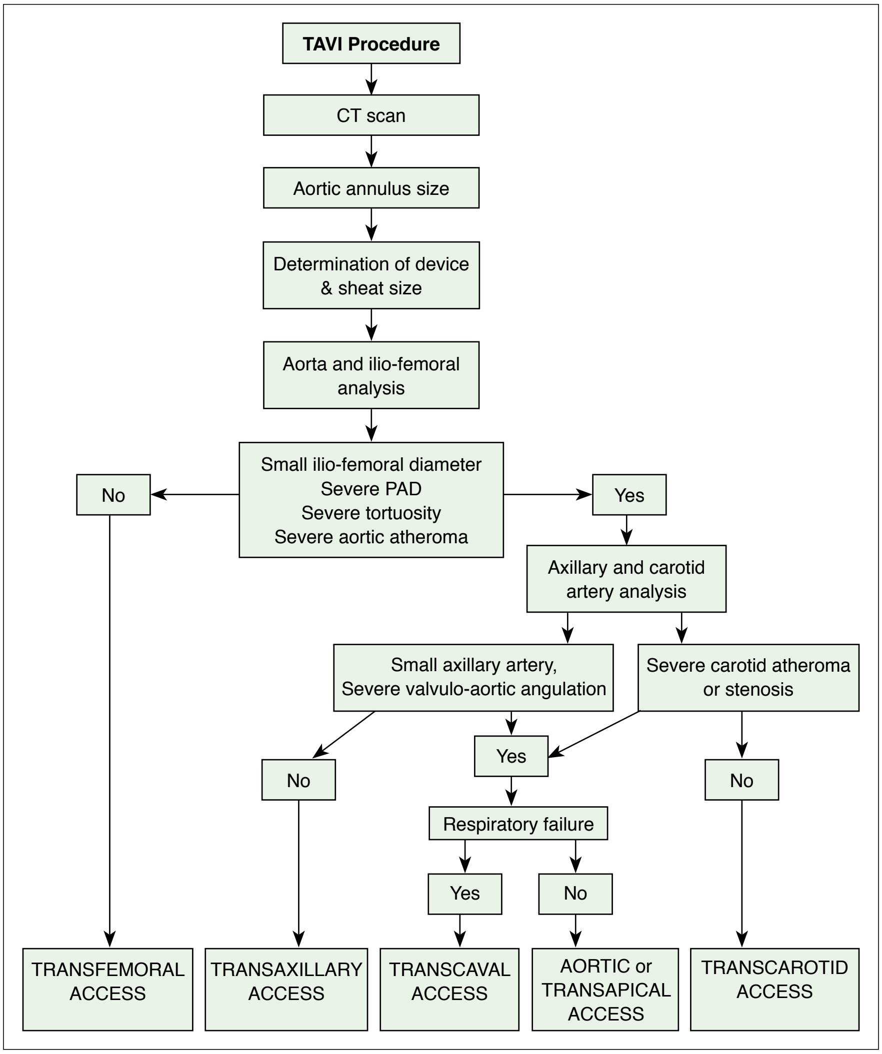

Figure 5. Transcatheter aortic valve implantation access site algorithm.

(both vertebral arteries), which created a risk of cerebrovascular emboli and ischemia. Since the diameter of the subclavian artery was of sufficient size, instead of 14-F sheath-switching during the balloon valvuloplasty and valve (Evolut R) placement, an 18-F sheath was used at the start for the valvuloplasty and the TAVI.

A successful TAVI procedure has been performed on a patient with severe aortic stenosis and comorbidities, including a coexistent abdominal aortic aneurysm, which had previously been treated with abdominal endovascular aneurysm repair (EVAR).[13] In a combined procedure reported by Yanes-Bowden et al.,[14] EVAR was performed before the TAVI portion of the surgery in order to avoid dissections that might be caused by advancing the stiff TAVI devices in a relatively tortuous aorta and to avoid aneurysmal rupture from increased blood pressure after TAVI. However, this technique requires extra precautions during the delivery of the TAVI device over the stiff guidewire, as it could deform or displace the aortic stent already in place. For this reason, in an another combined procedure performed by Orejola et al.,[15] TAVI was successfully performed before the EVAR procedure.

Conclusion

TAVI may be performed using a thoracic or an abdominal endovascular graft. However, endovascular grafts and prosthetic aortic valve may also lead to damage. Endovascular grafts can become displaced or invaginated. As a result of these risks, alternative access routes should be considered for a TAVI procedure in patients, when feasible. Axillary access is a reliable alternative to femoral access for thoracoabdominal endovascular graft and aorta-iliofemoral occlusion cases because it is less invasive and can be performed without general anesthesia in contrast to an transapical or transaortic approach.

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Keywords: Axillary artery; Multilayer Flow Modulator stent; transcatheter aortic valve implantation

Anahtar sözcükler: Aksiller arter; Çok Katmanlı Akım Modülatörü stent; kateter aracılı aort kapak implantasyonu.