

Large-Bore Access Site Management

State-of-the-art closure techniques for large-bore access.

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Successful cardiac catheterization begins with safe vascular access and ends with effective hemostasis after equipment removal. Over time, cardiac catheterization has progressed to encompass a wide range of diagnostic and interventional procedures including coronary, peripheral, endovascular, and structural heart disease interventions. Vascular access has evolved from an approach requiring surgical cutdown in the 1940s with primitive catheters to current percutaneous techniques using advanced catheters, guides, wires, and closure devices that allow safe arteriotomy and effective closure.¹⁻³

Despite multiple adjustments in devices and techniques, bleeding and vascular complications continue to be a substantial source of morbidity, especially in patients undergoing large-bore access procedures.⁴⁻⁶ Although femoral access is the most common approach in the United States, adoption of transradial access has been increasing.⁷⁻⁹

Over the years, elderly patients with multiple comorbidities have been increasingly referred for high-risk structural and endovascular interventions that may require mechanical circulatory support (MCS). These new and advanced technologies require large-bore arterial access.^{10,11}

This article addresses large-bore sheath insertion, maintenance, and removal. Techniques for the maintenance of lower limb perfusion during large-bore sheath access and the management of vascular complications are also discussed in detail.

IMPACT OF PERIPHERAL VASCULAR DISEASE ON VASCULAR ACCESS

The iliac and common femoral arteries vary greatly in size, mainly based on the patient's body habitus but also may be affected by the extent of atherosclerosis and tortuosity.^{12,13} Peripheral vascular disease (PVD) and coronary artery disease (CAD) have similar risk factors, and thus, it is common to encounter the challenge of treating structural or complex high-risk indicated patients with concomitant significant PVD.^{14,15} Small-caliber common femoral and iliac arteries (< 5.5 mm) with significant PVD increase the risk for vascular complications. The risk increases even more when larger-bore sheaths are used.^{6,16-18} In some patients,

femoral vascular access is prohibitive or carries extreme risk due to small caliber, complete occlusion, or severe calcification. This is often discovered at the time of the procedure when a patient presents with an acute coronary syndrome or cardiogenic shock that requires immediate attention and access for mechanical support. In these cases, alternative arterial access sites such as the axillary artery, carotid artery, subclavian artery, transcaval, and direct transapical approaches may be contemplated.¹⁹⁻²³

MECHANICAL CIRCULATORY SUPPORT DEVICES

Temporary percutaneous MCS devices are indicated for patients presenting with cardiogenic shock and those who are undergoing particular high-risk coronary interventions. Based on the amount of hemodynamic support required, operators select different percutaneous MCS devices that provide adequate circulatory support during high-risk procedures. Venoarterial extracorporeal membrane oxygenation (ECMO) and the TandemHeart centrifugal flow pump (TandemLife) are available in the United States. Both devices require two large-bore cannulas—one inserted into the vein (and into the left atrium via transseptal puncture for TandemHeart) and another into the artery. The ECMO and TandemHeart devices require an arterial cannula ranging between 15 to 20 F. MCS devices that only require arterial access include iVAC2L (Terumo Europe, formerly PulseCath) and Impella (Abiomed, Inc.). The iVAC2L device uses an intra-aortic balloon pump console and requires a 19-F sheath. This device provides approximately 2 L/min of pulsatile flow. The Impella 2.5 and CP devices (Abiomed, Inc.) are FDA-approved for up to 6 days for cardiogenic shock and up to 6 hours for high-risk coronary interventions. The Impella 2.5 and CP provide direct cardiac unloading and antegrade continuous flow of up to 2.5 and 4 L/min, respectively, and require a single arterial access of 13 and 14 F, respectively.

TRANSCATHETER AORTIC VALVE REPLACEMENT

Transcatheter aortic valve replacement (TAVR) has proven to be a viable tool for the high- and intermediate-risk populations with severe aortic stenosis (AS). Recent studies

have also suggested that TAVR is safe compared with surgery for low-risk patients with severe AS.^{24,25} This new reality may lead to wide adoption of TAVR for patients with AS in many cath labs that are not familiar with large-bore vascular access.

Vascular access complications are not uncommon with TAVR and may increase early and late mortality. Therefore, proper planning and choosing the most suitable femoral artery can often prevent serious vascular complications. With experience and careful screening, we are now able to risk-stratify patients who may be at increased risk of vascular complications. It is imperative for TAVR operators to be familiar and comfortable with different vascular approaches, as each of them has its own advantages and weaknesses. In general, every patient should be treated uniquely, and the best option is usually one in which the procedure is tailored to the patient's anatomy and comorbidities.

ACCESS SITE SELECTION

Careful assessment of the femoral artery for the MCS or structural large-bore sheath is imperative. This can be done in different ways using multimodality imaging. The advantage of structural heart procedures is that the anatomy of the iliofemoral arteries is known from CT scan imaging, which is standard of care. Access may be achieved with either fluoroscopy or ultrasound guidance. The fluoroscopy-guided technique calls for the identification of anatomic landmarks using fluoroscopy and palpation of the pulse. A hemostat or needle is then placed at the body surface and used as a reference to identify the location of the femoral head landmarks.^{11,26,27}

ULTRASOUND-GUIDED VASCULAR ACCESS

Ultrasound-guided vascular access for the femoral artery gained attention, especially among large-bore operators, because it was associated with a higher rate of success and lower rates of hematoma and venipuncture vascular complications.²⁸ Ultrasound-guided access can be used to improve arterial puncture safety by appropriately targeting the puncture at the level of the common femoral artery, thereby avoiding puncture of the profunda artery and superficial femoral artery (SFA) and disruption of a heavily calcified area. Seto et al showed that routine real-time ultrasound guidance improved common femoral artery cannulation only in patients with high common femoral artery bifurcations but also reduced the number of attempts, time to access, risk of venipunctures, and vascular complications with femoral arterial access overall compared with standard fluoroscopic guidance.²⁸ Other studies have suggested that ultrasound-guided access results in more precise common femoral artery anterior wall puncture and may result in fewer posttherapy complications when compared with fluoroscopy.²⁹

MICROCATHETER ACCESS AND ANGIOGRAPHY

After the first arterial access is established, confirmatory angiography is recommended (Figure 1). If the access is low or high, the operator can pull the 4-F microcatheter out, hold pressure, and reaccess again using the same technique and landmarks. This is an important step, especially for the side receiving the large-bore sheath. After confirming a proper access site, a 0.035-inch wire is advanced through the microcatheter and the catheter is exchanged for a 6-F sheath. If the operator plans to use this site for the large sheath, the sheath will be removed and two suture-based closure devices are deployed, as subsequently described. However, if this site is to be used for a smaller sheath, the operator can take advantage of this access to define the anatomy of the contralateral vessel. A 0.035-inch wire is advanced through the sheath and 5-F internal mammary artery (IMA) catheter is advanced to the iliac bifurcation. Using 10 mL of contrast media, angiography is performed on the contralateral side. This technique will help identify any calcification, stenosis, or tortuosity of the vessel that is receiving the large sheath.

It is important to study the vessel size, degree of vessel tortuosity, and calcification. For TAVR cases, this can be easily done using the planning CT scan that was performed prior to the procedure. However, in cases where the CT scan was not helpful or for MCS large sheaths, careful evaluation at the time of procedure is important. Favorable vessel features include an iliac artery diameter of ≥ 5.5 mm with minimal tortuosity ($< 90^\circ$) and atherosclerosis. Alternatively, an iliac diameter of < 5 mm with high tortuosity and significant atherosclerosis may preclude use of the vessel for large-bore (> 14 F) sheath access. Although rarely used, intravascular ultrasound may provide excellent assessment of the vessel anatomy, including vessel size, plaque, calcification,

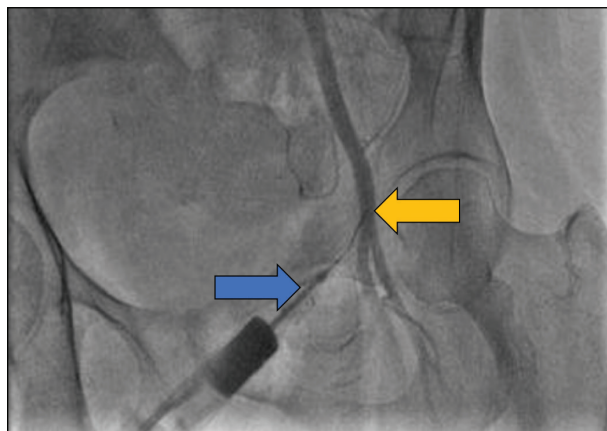


Figure 1. Angiogram of the left common femoral artery using a 4-F microcatheter (blue arrow). Access was in the middle of the femoral head, above the common femoral artery bifurcation (yellow arrow).

and tortuosity, and can provide the access point guidance with no need for contrast.

Planning access for TAVR requires knowledge of the luminal size as well as the degree of vessel calcification and tortuosity. Ramlawi et al consider a high-quality thin-slice CT scan with contrast that extends from the femoral artery to the subclavian artery the cornerstone of evaluation.³⁰ Also, CTA of the iliofemoral vasculature enables evaluation of vessel tortuosity, calcification, and vessel diameter and may thereby inform decisions on the most suitable approach.

FEMORAL ARTERY LARGE-SIZE SHEATH INSERTION TECHNIQUES

Using an ultrasound or direct fluoroscopy technique, a micropuncture needle can be used to access the common femoral artery. A 6-F sheath is then advanced over the micropuncture wire. Through the 6-F sheath, a stiff 0.035-inch wire (Hi-Torque Supra Core [Abbott Vascular] or Lunderquist [Cook Medical]) is advanced and two Perclose ProGlide suture-mediated closure systems (Abbott Vascular) are deployed at the 10 o'clock and 2 o'clock positions. This facilitates future successful closure of the large-bore puncture site.^{31,32} Subsequently, sequential sheath upsizing can be facilitated with the use of a series of dilators over a (stiff) 0.035-inch wire prior to placement of the large sheath.

MAINTAINING LOWER EXTREMITY PERFUSION

Limb perfusion distal to the large sheath is especially important in patients receiving MCS in need of prolonged support. After the large-bore sheath is positioned and secured, angiography is performed from the contralateral side to assess vessel patency and ensure preserved distal perfusion into the extremity (Figure 2). Aortoiliac or contralateral angiography is performed using the contralateral vascular access. The extremities are able to tolerate a low-perfusion state for short periods of time (< 30 minutes).³³ However, when limb perfusion is compromised, it may be necessary to establish flow distally by ex vivo ipsilateral bypass using an antegrade access technique.

REPERFUSION TECHNIQUES

Peel-Away Sheath

The Impella mechanical support device comes with a specially designed two-step peel-away sheath with a tapered shaft (14-F base to 9-F tip) that allows for adequate blood flow even in smaller-caliber iliofemoral arterial vessels. In case of an occlusive sheath compromising limb perfusion, peeling away the 14-F introducer sheath leaves the Impella with the smaller 9-F repositioning sheath, which may be sufficient to restore limb perfusion. One potential complication of this technique is catheter migration while peeling away the sheath. To minimize this complication, one opera-

tor should stabilize the Impella while the other operator peels away the external sheath. The repositioning sheath can then be readvanced through the arteriotomy site. This maneuver, however, may lead to increased bleeding as the sheath size is tapered down.

External Contralateral Bypass Circuit

If there is occlusion of the external iliac artery and common femoral artery by the large-bore sheath, the ipsilateral SFA is accessed via a 4- or 6-F sheath (with a micropuncture kit) in an antegrade fashion. Contralateral common femoral artery access is then obtained with a 6-F sheath. The side arm of the contralateral sheath is then connected to the side arm of the ipsilateral antegrade sheath using a male-to-male connector. The result is an external femoral-femoral bypass whereby blood flows from the contralateral 6-F sheath through the side arm into the side arm of the ipsilateral 4- to 6-F antegrade sheath down the ischemic limb providing adequate perfusion (Figures 3 and 4). In situations when occlusion of flow is anticipated (eg, with an ECMO sheath), antegrade access can be secured preemptively prior to the large-bore sheath insertion. The target activated clotting time (ACT) should be longer than standard to maintain the flow (range, 200–220 seconds). Also, hourly serial Doppler ultrasound assessment of the lower extremity pulsations is recommended.

External Ipsilateral Bypass Circuit

Another alternative strategy utilizes the side arm of the large-bore occlusive sheath to create an ipsilateral bypass circuit. A 4- to 6-F short sheath is inserted in the ipsilateral SFA in an antegrade fashion. The side arm of the ipsilateral antegrade sheath can then be connected via a male-to-male connector to the side arm of the large-bore occlusive sheath, constituting an ipsilateral bypass circuit that provides adequate perfusion to the lower limb. When using this strategy with an Impella device, the repositioning sheath must not be advanced into the

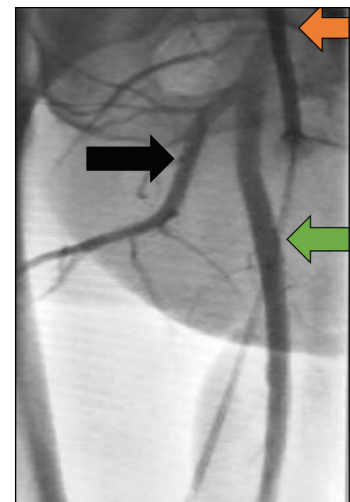


Figure 2. Using the contralateral femoral access, right iliofemoral angiography was performed with the large-bore sheath (orange arrow) showing adequate flow into the SFA (green arrow) and deep femoral arteries (black arrow) and confirming the patency of the flow distal to the large-bore sheath.

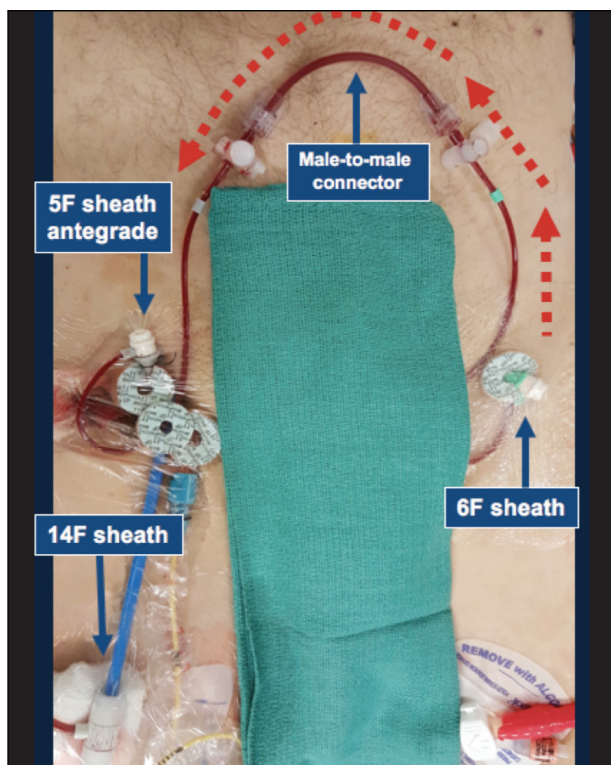


Figure 3. Right common femoral artery with a large-bore sheath in situ. In this case, the large-bore sheath was inserted for prolonged MSC and was occlusive to distal flow. An external contralateral conduit was created from the contralateral femoral artery. A 6-F sheath was used in the left common femoral artery, and through it, a 4-F, 45-cm-long catheter was advanced over a 0.035-inch hydrophilic stiff wire from the left common femoral artery into the right common femoral artery and beyond the large-bore access point. Then, the catheter and wire were further advanced to the SFA. The side arm of the “donor/mother” sheath and “recipient/daughter” catheter on the left side were connected using a male-to-male connector to create flow from the left to right femoral artery (dotted arrows).

Impella 14-F sheath to avoid occlusion of the side arm that is now providing perfusion (Figure 5). Management of this conduit follows the same protocol as previously outlined for the contralateral bypass technique. The advantage of this strategy is that it does not require contralateral arterial access.

Internal Contralateral Bypass Circuit

An SFA that is diseased and totally occluded is not an uncommon finding in patients with CAD and precludes antegrade SFA access. In such cases, internal contralateral femoral-to-profunda bypass might be an alternative option to maintain perfusion to the ischemic limb. This is achieved by first inserting a 7-F sheath in the contralateral common femoral artery. Through this sheath, a 5-F cath-

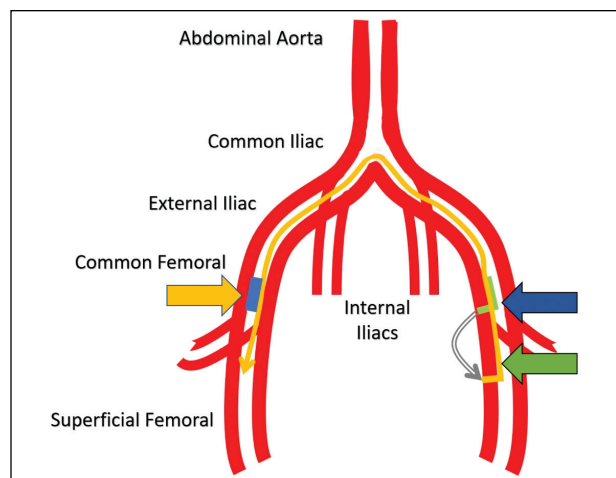


Figure 4. Illustration of the contralateral bypass circuit for a large occlusive sheath in the right common femoral artery. Blood flows through the left 7-F sheath (blue arrow) to the 4-F daughter sheath (green arrow) and through the 45-cm catheter to the contralateral right side. The catheter then passes along the large-bore sheath (yellow arrow) and to the right SFA to bypass the occlusion and provide perfusion to the right leg.

eter (IMA or Omni Flush [AngioDynamics]) is advanced and selectively engaged into the ipsilateral common iliac artery. A 0.035-inch hydrophilic wire (Glidewire, Terumo Interventional Systems) is then advanced through this system, across the aortoiliac bifurcation, past the occlusive large-bore sheath, and beyond the arteriotomy site into the ipsilateral profunda femoris artery in case of SFA occlusion. The 5-F catheter is then exchanged for a 4-F, 45- to 55-cm-long sheath that is advanced over the wire into the ipsilateral profunda femoris. By connecting the side arm of the 7-F contralateral sheath and that of the 4-F, 45- to 55-cm sheath using a male-to-male connector, a bypass circuit is created whereby blood flows from the contralateral femoral artery via the connected side arms, through the crossover 4-F sheath, and into the ipsilateral profunda femoris artery distal to the occlusive sheath, providing sufficient perfusion to maintain limb viability. The management of this conduit follows the same protocol as previously outlined for the contralateral and the ipsilateral bypass techniques with anticoagulation for a target ACT range of 200 to 220 seconds.

AXILLARY ACCESS FOR LARGE-BORE SHEATHS

The axillary artery has been shown to be an acceptable alternative access site for large sheaths for both TAVR and MCS in patients with severe peripheral artery disease.^{34,35} The axillary artery originates from the subclavian artery as it passes out of the rib cage at the lateral margin of the first rib, where it becomes extra thoracic. The axillary artery is divided into three segments based on its relation

to the pectoralis minor muscle. During angiography, those segments can be identified by the origin of the arterial branches: the superior thoracic artery emerges from the first segment, the thoracoacromial and lateral thoracic arteries from the second segment, and the subscapular artery from the third segment. The caliber of the axillary artery ranges from 6 to 7 mm, which makes it suitable to accommodate sheaths with an outer diameter of up to 18 F (Figure 6A).

The patient is prepared and draped in a supine position with the arm abducted at 90° away from the body. A 6-F sheath is placed in the ipsilateral radial artery or in either femoral artery. A 5-F Judkins right (JR) 4 guide catheter is advanced over a guidewire via the femoral artery and selectively engaged in the left subclavian artery or innominate artery. Angiographic assessment and identification of the axillary artery branches are important to precisely define the access point that is lateral to the thoracoacromial artery and medial to the circumflex humeral and subscapular arteries (ie, the “sweet spot”) (Figure 6A). Once the appropriate axillary artery site is identified, local anesthesia is administered 2 to 3 cm lateral to the sweet spot.

There are three ways to target the sweet spot with the access needle. First, one JR 4 or multipurpose catheter is used to engage the left subclavian artery or the innominate artery to perform contrast angiography to identify the axillary artery anatomy and identify the sweet spot (Figure 6B). In cases when there is a contrast limit, wire-guided access is often used. In this technique, a 0.038-inch wire is advanced in the axillary artery and into the brachial artery. After one contrast injection, the sweet spot is identified, and the operator targets the wire over the sweet spot using live fluoroscopy. Similar to the guidewire technique, the operator can use a pigtail catheter to target the sweet spot. Alternatively, the axillary artery and landmark vessels can be identified with ultrasound precluding fluoroscopy. A micropuncture needle is then advanced under angiographic guidance at an angulation of $\leq 45^\circ$ from the skin toward the access point that is lateral to the thoracoacromial artery (between the second and third segment of the axillary artery), immediately medial to the shoulder (Figure 6B). A 0.035-inch J-tip wire is then advanced into the subclavian artery and the micropuncture sheath is exchanged for a 6-F sheath. We dilate the tract with a 7- or 8-F sheath prior to introducing the Perclose ProGlide devices to prepare the access. Utilizing the “preclose” technique, two Perclose ProGlide suture-mediated closure devices are deployed at the 10 o’clock and 2 o’clock positions, respectively, and left uncinched. The arteriotomy is then sequentially dilated prior to introduction of the large sheath over a stiff 0.035-inch wire of choice (Figure 6C).

A 5- or 6-F multipurpose catheter is then used to cross from the aortic valve to the left ventricle using standard crossing techniques. A 0.018-inch Platinum Plus guide-

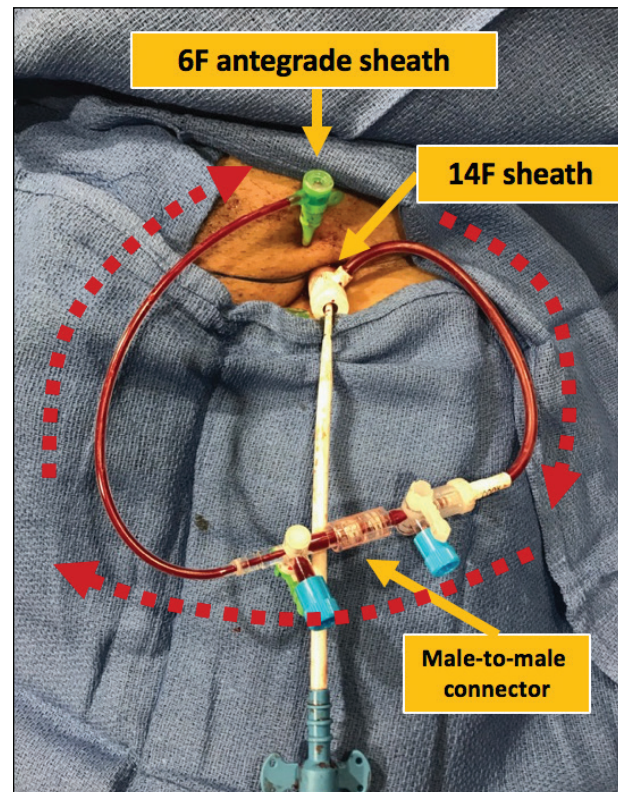


Figure 5. Left common femoral artery with occlusive Impella 14-F sheath in situ. To maintain flow to the left leg, a bypass circuit was created. A 6-F sheath was used to access the left common femoral artery in an antegrade puncture position distal to the large sheath. The side arm of the 6-F sheath was connected to the large sheath using a male-to-male connector, creating flow (dotted arrow).

wire (Boston Scientific Corporation) is then advanced through the multipurpose catheter into the left ventricle. The catheter is then removed and the Impella CP device is inserted over the wire and advanced under fluoroscopic guidance into the left ventricle. Angiography of the proximal subclavian artery is required to ensure adequate perfusion distal to the large-bore sheath to prevent limb ischemia. Hemodynamic support is then initiated. Coronary angiography and subsequent percutaneous coronary intervention (PCI) may then be performed from the femoral access site. If prolonged hemodynamic support is needed after completion of the procedure, the Impella sheath should be sutured and secured before the patients leaves the cath lab. We recommend clamping the Perclose sutures with a hemostat and wrapping them with a sterile towel covered with a sterile Tegaderm dressing (3M).³⁶

SHEATH REMOVAL AND HEMOSTASIS

Hemostasis after removal of small arterial sheaths is often achieved with manual compression or with arterial closure

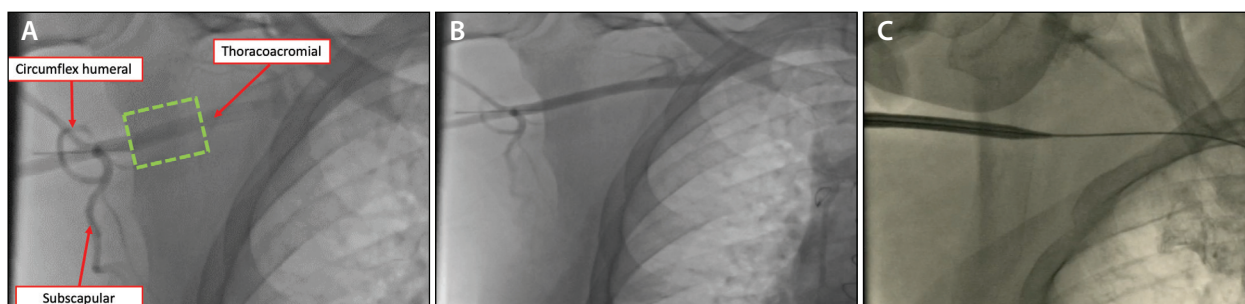


Figure 6. Angiographic assessment and identification of the axillary artery branches is important to precisely define the access point that is lateral to the thoracoacromial artery and medial to the circumflex humeral and subscapular arteries (ie, the “sweet spot”) (dotted green box) (A). A JR 4 or multipurpose catheter is used to engage the innominate artery to perform contrast angiography to identify the axillary artery anatomy (B). Introduction of the large sheath in the right axillary artery over the stiff wire (C).

devices that are readily available. Larger sheaths have been associated with worse outcomes due to bleeding and vascular complications.⁶ Removal of large-bore sheaths requires meticulous technique to prevent major or even life-threatening bleeding complications and to ensure vessel patency. Manual compression of a large arteriotomy is not the ideal technique due to lack of direct visualization and poor control of the puncture site.

The Perclose ProGlide system is a suture-mediated closure device designed to close 5- to 8-F access sites.^{31,32} It is possible to use more than one suture and to predeploy the suture before upsizing to a large-bore sheath, as previously described. Complete deployment of the Perclose sutures is performed when the large-bore sheath is removed. It is recommended to perform large-bore sheath removal in the cardiac catheterization laboratory, which provides the best controlled environment. In the cath lab, one operator can apply manual pressure above the access point and pull the large sheath, while the second operator deploys the closure device. In certain cases when the risk of bleeding is high (eg, anticoagulation, calcified vessel), we recommend the dry closure technique. Dry closure is achieved by advancing a 6- to 9-mm X 40-mm peripheral balloon proximal to the access site. Once the balloon is inflated, the sheath is then removed, the Perclose device is fully deployed, and sutures are cinched to the arteriotomy site.^{31,32}

For axillary access, the TAVR delivery system or MCS device is removed from the sheath and a 0.035-inch wire is passed from the large-bore arteriotomy sheath into the descending aorta. The subclavian or innominate artery is engaged again with a JR 4 guide catheter (or catheter of choice) from the femoral sheath. An exchange-length 0.035-inch wire (our preference is the Glidewire Advantage, Terumo Interventional Systems) is advanced through the subclavian artery, past the large-bore axillary sheath, and into the brachial artery. A 7- to 10-mm X 40-mm peripheral balloon that is sized in a 1:1 ratio to the parent artery diameter is used for dry closure of the axillary access (Figure 6A).

The balloon is advanced over the 0.035-inch wire from the femoral sheath and inflated at low pressure (2–4 atm) under fluoroscopy to prevent traumatic injury to the vessel wall. To ensure adequate hemostasis without traumatic vessel injury, the balloon should be inflated while observing the arterial pressure tracing transduced from the axillary artery sheath side arm. The balloon should be inflated until the tracing is observed to be completely dampened or until the plethysmographic signal measured on the ipsilateral index finger is lost.³⁶ Once endovascular hemostasis is achieved, the Impella sheath is then completely removed over the 0.035-inch wire and the preclosure is completed by cinching and locking the previously deployed Perclose ProGlide sutures. The balloon in the distal subclavian artery is then deflated and digital subtraction angiography is performed to evaluate for extravasation from the arteriotomy site. If no leak is noted, the 0.035-inch wire and JR 4 guide catheter are removed. If extravasation at the access site is observed, another prolonged balloon inflation can be performed for 15 to 20 minutes. If balloon and manual compression fail, a covered stent (Viabahn [Gore & Associates] or iCast [Getinge]) may be deployed as a final bailout strategy.

Alternatively, and in particular when closing large-bore axillary artery access in the cath lab immediately after TAVR or high-risk PCI, a 7-F sheath could be inserted into the ipsilateral radial artery. A 6-F JR 4 catheter can be advanced into the axillary artery. After delivering the sutures, angiography can be used to confirm hemostasis. In the case of incomplete hemostasis, a 0.035-inch wire can be advanced from the ipsilateral artery into the descending aorta. Over this wire, a 7-F compatible balloon-expandable Advanta (Getinge) covered stent can be used to bail out and obtain complete hemostasis.

Vascular Closure Devices

Increased use of large-bore sheaths for structural heart procedures and advanced MCS devices introduced the practice of preclosure with the Perclose vascular closure

device (VCD). Preclosure is done with partial deployment of a suture-mediated VCD after the artery is accessed with a small-caliber sheath and before insertion of the large-bore arterial sheath.

Once the procedure is done, preclosure will facilitate hemostasis when the large-bore sheath is removed. Observational data have demonstrated that a percutaneous approach to TAVR using a VCD with preclosure is associated with

similar vascular outcomes to surgical cutdown for arterial access but with a shorter length of stay.³⁷⁻³⁹ The routine use of VCDs for large-bore access might reduce bleeding and vascular complications, as well as facilitate patient ambulation and decrease hospital length of stay. Despite increasing experience with VCDs, complications can include infection, embolization, and device failure leading to ischemia or access site bleeding. VCD-related complications increase with a lack of operator proficiency with the selected device.⁴⁰ Several new large-caliber VCDs are in development for structural heart interventions and are undergoing clinical investigation.⁴¹

For patients treated with Impella and who require delayed hemostasis, the closure system needs to be sterilized and secured, especially if MCS is indicated for several days. Our practice is to sterilize the Perclose sutures, snare knot pusher, and suture trimmer with chlorhexidine gluconate (ChlorPrep, BD) and use Tegaderm to keep them separate and away from the access site. We then resterilize the site with ChlorPrep and wrap all Perclose parts with sterile towels.⁴² We keep the Perclose sutures under the Tegaderm for 2 to 3 days on average. The duration depends on the severity of current shock and time to recovery.

Temporary Endovascular Balloon Tamponade

Temporary endovascular balloon tamponade or the “dry field closure technique” is a useful technique for preventing extensive bleeding at the time of large-bore access closure. It allows the operator to have control of the access site while deploying the VCD, especially in patients who are at increased risk for bleeding (eg, on anticoagulation, access site calcification, vascular tortuosity). From a 7-F sheath in the contralateral common femoral artery, a 5-F catheter (IMA, Omni Flush) is advanced and selectively engaged into the ipsilateral common iliac artery. A 0.035-inch hydrophilic stiff wire (GlideWire Advantage) is then advanced into the ipsilateral common femoral artery, where the large-bore sheath is inserted. The wire is further advanced around the large sheath and distal to the arteriotomy site into the SFA. Afterward, the sheath and the catheter are exchanged

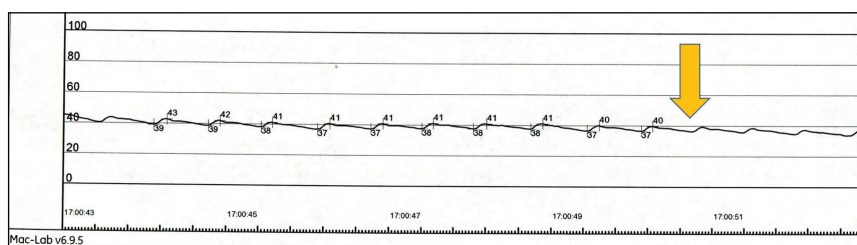


Figure 7. Hemodynamic tracing of the external iliac artery via the large sheath side arm during endovascular temporary 40- X 9-mm balloon inflation. The tracing illustrates the blunting of pulse pressure (arrow) that confirms adequate temporary internal occlusion of the common femoral artery.

for a 45- to 55-cm-long sheath. The long sheath is then advanced to the level of the ipsilateral external iliac artery. The large-bore sheath is withdrawn to the level of the distal segment of the external iliac artery. Subsequently, an 8- to 9-mm-diameter X 20- to 40-mm-long balloon (the size of the balloon is determined by the femoral angiogram) is inflated to low pressure (2–4 atm) to temporarily occlude flow in the external iliac artery proximal to the large-bore sheath. To monitor effective occlusion, a pressure transducer is connected to the large-bore sheath side branch. With effective balloon inflation, the pressure wave form flattens and the pulse pressure diminishes (Figure 7). The large-bore sheath is then removed from the body and the partially deployed Perclose ProGlide sutures seal the puncture site. Once this step is done, the occlusive balloon tamponade is slowly deflated to restore blood flow to the access leg. If residual bleeding is present after Perclose ProGlide suture deployment, the same balloon is then advanced at the arteriotomy and inflated to provide endovascular low-pressure tamponade until hemostasis is achieved. Protamine sulfate can be used to reverse anticoagulation when hemostasis is not achieved.

The dry field technique can be used in emergency situations when a large-bore sheath is inserted quickly without Perclose ProGlide sutures to expedite MCS support. When it is appropriate to remove the large-bore sheath, prolonged endovascular balloon tamponade (30–60 minutes) may be sufficient to achieve hemostasis. Rarely, the arteriotomy site may continue to bleed after this intervention. In that case, a covered stent can be deployed at the arteriotomy site to achieve hemostasis. Once hemostasis is achieved, the recommendation is to confirm vessel patency and rule out sheath-related complications such as vessel dissection, occlusion, or thrombosis by obtaining a final angiogram using a pigtail in the descending aorta or a contralateral femoral catheter.

Viabahn self-expandable covered stents are indicated for iliac and SFA complications. A 6-mm-diameter stent can be delivered via a 6-F arterial sheath while a 7- or 8-mm stent requires a 7-F arterial sheath. iCast, on the other hand, is

a balloon-expandable stent that is available in diameters of 5 to 12 mm and delivered via a 6- or 7-F introducer sheath.

COMPLICATION MANAGEMENT

Acute Limb Ischemia

Acute limb ischemia in the setting of large-bore access can be due to complete vessel occlusion (when the vessel diameter is < 5 mm), arterial dissection, or thromboembolism. Utilization of a femoral-femoral bypass circuit, as previously described, may prevent these complications. Close monitoring to ensure adequate limb perfusion with hourly clinical and Doppler assessment of distal extremity pulses is indicated when the sheath is in place. Serial biomarker evaluation (plasma lactate) is recommended as a surrogate for inadequate limb perfusion and tissue necrosis. Thromboembolism and plaque embolization are not uncommon complications.⁶ Thrombus or debris may flow downstream causing occlusion of the tibioperoneal trifurcation causing acute limb ischemia. After sheath removal, it is recommended to perform complete angiography of the arteriotomy site and runoff to the tibioperoneal trifurcation at the end of procedure to ensure distal vessel patency.

CONCLUSION

Arterial access and hemostasis are fundamental aspects of cardiac catheterization and intervention. In recent years, large-bore sheaths for structural heart procedures and advanced MCS devices have been used more frequently. Emerging approaches to arteriotomy and new-generation VCDs have a role in reducing vascular complications and bleeding associated with large-bore access procedures and accelerating the time to hemostasis and ambulation. ■

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