

Chapter 1

Vascular Access

Thach N. Nguyen, Hoang Pham, Ta Tien Phuoc

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*Basic; **Advanced; ***Rare, exotic, or investigational.

\$ < 100.00 \$US extra; **\$S** > 100.00 \$US extra

⌚ < 10 minutes extra; ⌚⌚ > 10 minutes extra

♠ low risk of complications; ♠♠ high risk of complications

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FEMORAL APPROACH

Locate the femoral artery and inguinal ligament that runs from the anterior superior iliac spine to the pubic tubercle. The true position of the inguinal ligament is 1–2 cm below that line [1]. Ninety-seven percent of patients have the femoral artery lying on the medial third of the femoral head. Only 3% have the artery totally medial to the femoral head [2].

Preparations in Obese Patients: The femoral pulse at the inguinal crease is not a reliable landmark for the common femoral artery (CFA), particularly in the obese or elderly patients whose crease tends to be much lower than the inguinal ligament. The protruding abdomen and panniculus should be retracted, and taped to the chest with 3- to 4-inch tapes that are in turn secured to the sides of the catheterization table. Keep the tissue layer above the artery as thin and taut as possible, so the needle will not be deflected from the projected angle and selected pathway.

TECHNICAL TIPS

***Directing the Needle:** Once the needle tip is near the artery, it tends to pulsate except in those patients with severe local scarring (following many prior remote femoral artery cannulations, total hip replacement, or in severely calcified arteries etc.). If the hub inclines to the right, the needle should be withdrawn by 1 or 2 cm and the tip redirected to the right before advancing forward. If the hub inclines to the

left side, the tip is redirected to the left before pushing in. If the needle pulsates on the vertical axis, it just needs to be inserted deeper [2].

***If the Wire Cannot be Inserted:** Most often, this is because the needle hit the contralateral wall. Just move the needle by a slight pull or rotate it a little, the wire may be able to be inserted. If there is a problem, it is better to withdraw the needle and re-puncture the artery rather than dissect the artery with a slippery wire [3]. After the sheath has been inserted where there is strong arterial back flow and the wire is not able to negotiate the tortuous iliac artery, then pull the sheath a little (to disengage it from under a plaque if that is what has happened) and a gentle injection of contrast may help to delineate the anatomy and determine the reason why the wire could not be advanced. If there is no strong back flow, then the sheath is not in the arterial lumen. In a very tortuous iliac artery, a diagnostic Judkins Right (JR) catheter can be inserted with caution and advanced in order to help steer the wire tip. Injection through the JR would also help to find out why there is a problem advancing the wire.

***Sequential Order for Arterial and Venous Puncture:** The order of arterial and venous access is often a matter of personal preference. We prefer to puncture the vein first and insert a wire inside the vein to secure the access. Then, less than a few seconds later, after puncturing the artery, we would insert the sheath into the artery and the vein. Because there is only a wire in the vein, there is minimal distortion of the arterial puncture site, which may be caused by the placement of the venous sheath. Less than 1 minute without a sheath will not produce a hematoma at the venous site. If inadvertently the artery is punctured first, we would cannulate the artery, then puncture the vein under fluoroscopy, with the needle medial and parallel to the arterial sheath.

****Kinked Wire:** It is not unusual that the wire will pass into the lumen easily but attempts to advance any dilator over the wire will result in kinking of the wire at the point of entry. Instead of exchanging the wire, if the wire is not too crooked, the first best maneuver is to advance the wire further, so the dilator can be advanced to dilate the entry site on a straight and stiff segment of the wire. If the wire is too soft, then the second best maneuver is to exchange the softer wire with a stiffer wire over the needle at the straight portion or over a smallest size 4F dilator [4].

****Puncture of Pulseless Femoral Artery:** As usual, the artery should be punctured over the middle of the medial third of the femoral head. Localize the skin puncture site by fluoroscopy just below the inferior border of the femoral head in order to prevent high punctures (above the inferior epigastric artery) that may lead to uncontrollable bleeding. However, these proportions are valid only in the anterior-posterior (AP), neutral position. Internal or external rotation of the femur can considerably change the relationship of the femoral artery

to the femoral head [5]. Another way to puncture the femoral artery is to use Doppler guidance with the SmartNeedle (Escalon Medical, New Berlin, WI), which is an arteriotomy needle that incorporates a continuous Doppler probe, and enable the identification of arterial or venous vessels by means of continuous auditory feedback. This technique is very helpful in puncturing an artery with very weak pulse or a pulseless artery, especially when the standard anatomy is disturbed by a large hematoma, or thick scar after surgery for artificial femoral head replacement [6].

*****Puncture in Cyanotic Patients:** In children with cyanotic heart disease, especially those weighing less than 15 kg and with severe polycythemia, the blood flow from a femoral puncture can resemble a venous sample: a gentle flow of dark blood. This color is due to arterial desaturation and hyperviscosity secondary to polycythemia. If there is doubt, confirm the arterial puncture by attaching the needle to a pressure transducer or by making a small contrast injection into the arterial lumen [7].

TROUBLE-SHOOTING TRICKS

*****Insertion of Intra-Aortic Balloon Pump (IABP) Through Diseased Iliac Artery:** When an IABP needs to be inserted and an iliac lesion is found, the lesion should be dilated first. Insert the balloon pump, then perform stenting of the lesion later after the IABP is removed. When a balloon pump is to be inserted through a previously stented iliac artery, do it under fluoroscopy to be sure the balloon does not get stuck on the stent struts. To remove the IABP deflated balloon, insert a large femoral sheath and withdraw the winged balloon into the sheath so the folds of the winged balloon are not caught by struts at the stent edges. Chronic endothelialization of the stent struts should diminish this problem.

*****Two Catheters Inserted With One Puncture Technique:** Used in situations such as angioplasty for chronic total occlusion (CTO) when there is a need for contralateral injection. Another puncture higher or lower than the puncture site of the first site of vascular access, or in the contralateral artery, is suggested. However, if there is no need for another puncture, then change the sheath to an 8F introducer. There two 4-Fr diagnostic catheters can be inserted and attached to separate injection manifolds for diagnostic purposes [8].

Puncture of Femoral Bypass Graft: The problems involving puncture of an old vascular graft in the femoral area include: uncontrollable bleeding and hematoma formation because of the nonvascular nature of the punctured graft; disruption of the anastomotic suture line with subsequent false aneurysm formation; infection of the graft site; and catheter damage, kinking, and separation due to scar tissue in the inguinal area and firmness of the healed graft material [4].

Inadvertent entry to the native arterial system may lead to the dead-end stump in the common femoral or iliac artery.

TECHNIQUE Bypass Graft Puncture: Because the exact location of the suture line is not known, to avoid puncture of the anastomotic site, it is best to puncture the proximal end of the inguinal incision site or as close to the inguinal ligament as possible. To avoid kinking of the catheter at the puncture site, it is better to introduce the needle at an angle of approximately 30–45° to the estimated long axis of the graft [4]. Sometimes, because of severe scarring, the entry site has to be prepped by sequential dilation with small to progressively larger dilators **up to 1Fr** size larger than the sheath selected for the procedure.

TROUBLE SHOOTING TRICKS

*****Parallel Technique:** If the native artery is punctured and the wire could not be advanced because the artery ends up with a dead-end pouch, then leave the small 4F sheath inside as a landmark. Palpate again the femoral artery and try to feel the two pulsations there: the first one is the native artery with the sheath and the second stronger and harder one is the bypass graft. Then puncture the second pulsatile artery while avoiding the one with the sheath in it. This can be done under fluoroscope guidance to avoid any area near the first sheath.

ANTEGRADE PUNCTURE

The antegrade femoral puncture can be greatly simplified and is more successful if the tissue thickness between the skin surface and the artery is as thin as possible. This may be made possible by placing a pillow under the buttocks. The hyperextension of the hip joint by this maneuver stretches the skin taut over the puncture site and decreases tremendously the tissue thickness. In obese patients, fatty panniculus may have to be retracted away from the puncture site manually and taped in position before the puncture is attempted [5].

TECHNIQUE Antegrade Puncture: The first step is to localize the CFA and its bifurcation under fluoroscopy. The CFA usually overlies the medial third of the femoral head and the bifurcation occurs below the lower border of the femoral head [3]. Once the landmark is located, to make the puncture, the needle may be directed toward the superior aspect of the femoral head, under fluoroscopy. The purpose of this maneuver is to prevent the inadvertent puncture of either or both the superficial femoral or the profunda femoral arteries. It is important to puncture the femoral artery as high above the bifurcation as possible so that there will be enough space between the puncture site and the bifurcation for catheter exchanges and manipulation of catheters into the SFA.

Using fluoroscopy, the site of the intended arterial puncture is identified (upper or middle third of the femoral head). The femoral pulse

is palpated against the femoral head. Local anesthetic is infiltrated 2–3 cm cranial to the intended site of puncture. A 18 gauge needle is advanced at 45–60° directed caudally, aiming at the intended site of arterial puncture. Once pulsatile flow is obtained, a soft tip wire is inserted toward the SFA. The wire should follow a straight caudal course in to the SFA. Lateral deviation indicated entry into the profunda femoral artery (PFA). The wire can be withdrawn and the needle tip deflected laterally to redirect the wire into the SFA.

TECHNICAL TIPS

****Manipulation of Wire:** If the wire was inserted into the PFA, it can be withdrawn and redirected by angling the tip of the needle medially toward the SFA. The other option is to have a wire with a curved tip and manipulate it so the tip points toward the SFA. The needle may be exchanged for a short dilator with a gently curved tip, which can be directed toward the SFA. This dilator can be withdrawn slowly from the PFA while injecting the contrast agent. Once the orifice of the SFA is seen under fluoroscopy, it can be selectively catheterized or it can be used to direct a wire into the SFA [5].

****Puncture of CFA with High Bifurcation:** In patients with high bifurcation, one single puncture can result in entries of both the SFA and PFA. When this occurs, the first spurt of blood may indicate that the PFA is punctured. Do not remove the needle completely. Instead, withdraw it slowly and watch for a second spurt of blood. At this point, the contrast injection may show that the needle is in the SFA. In the rare cases of high bifurcation, it may not be possible to puncture the CFA that is excessively high in the pelvic area [5]. When the bifurcation is located more proximally, puncture of the CFA is more challenging, especially in the obese. In these cases, it may be acceptable to selectively puncture and cannulate the SFA, if this appears without significant atherosclerotic disease and of adequate size [9].

****Puncture with Abduction and External Rotation of the Thigh:** Another option to cannulate the SFA is with the thigh in abduction and external rotation. The goal of this maneuver is to facilitate a more mediolateral puncture site in the CFA. In the usual antegrade puncture, the needle is seen to point more toward the PFA that is lateral to the SFA. In the abduction and external rotation position, the needle points more toward the SFA, and the PFA is seen medial to the SFA. This relationship is important when observing the course of the wire during its intended selective entry into the SFA. If the patient is punctured in this position, after the procedure, the local compression of the artery should be in the abduction and external rotation of the thigh because the puncture site is more mediolateral than usual [5].

BRACHIAL APPROACH

Even though the radial artery is the most common location used in the upper extremity, the brachial artery is still the access site of choice for procedures requiring a large sheath: subclavian artery stenting, renal stenting, or aortic aneurysm exclusion. The radial access is discussed in the following chapter.

TRANSLUMBAR APPROACH

In patients with total occlusion of arteries to lower and upper extremities, percutaneous coronary interventions (PCI) can still be performed through the translumbar approach [10]. This problem occurs rarely, only once in 6000–9000 cases. However, if the lumbar approach is the only access available in those rare circumstances in which conventional sites are not available, then it is worth offering the option to the patient [11].

TECHNIQUE Translumbar Puncture: The patient is placed in the prone position. Utilizing the left flank approach, an appropriate puncture site is selected, which is approximately four fingerbreadths lateral to the midline and two fingerbreadths below the left 12th rib margin. Verification that this position is below the posterior sulcus of the lung is made by fluoroscopy. After local anesthesia, a small skin incision is made with a blade and enlarged by the hemostat. The tip of the translumbar access needle (TLA) and the outer Teflon sheath (Cook, Bloomington, IN) are placed in the skin incision and directed toward the T12 vertebral body. Three successive attempts are made, with each increasing the vertical degree of the pass in order to “step off” the vertebral body. When the needle tip abuts the aorta, pulsation can be felt against the fingertip. The TLA needle is then given a short thrust until the initial resistance is not felt. The tip of needle is watched closely and should never cross the midline of the body. The inner stylet of the TLA needle is removed, and blood is seen at the hub. A floppy J wire is inserted and an introducer sheath is inserted in the usual fashion. Coronary angiogram and angioplasty are performed by the standard technique. After documentation of active clotting time (ACT) less than 150 sec, the sheath is removed without complication while the patient is in the prone position. Given the prone position of the patient, the fluoro scopic images appear in reverse, compared to standard images. This problem can be corrected by using the sweep reversal mode on the video monitor [10].

TRANSEPTAL APPROACH

Femoral and radial access is universally used for interventional procedures. However, in some patients with pulseless disease (Takayasu's arteritis), there are no arterial pulses in four extremities, then the PCI has to be done through the femoral vein approach. Tips and tricks for puncturing the septum are discussed and illustrated extensively in Chapter 24.

CAVEAT**Maintaining a Long Loop in the Ventricle:** At

all times, care must be taken to maintain a loop of catheter or wire in the left ventricular apex.

Shortening of this loop to the straight path between the mitral and aortic valves could result in trauma to the anterior mitral leaflet causing acute mitral regurgitation [12].

There are few problems cannulating the left main (LM); however, it is difficult to cannulate the right coronary artery (RCA) because the catheters keep dropping into the ventricle when manipulated [13].

**TRANSTHORACIC LEFT VENTRICULAR PUNCTURE**

TECHNIQUE Transthoracic Apical Puncture: In order to perform left ventricular puncture, the left ventricular apex is identified by palpation or echocardiography. The skin and the intercostal space area below the apex is infiltrated with 1% xylocaine. Transthoracic puncture is performed, entering the chest wall in the intercostal space below the site of maximal impulse using a 5.5Fr \times 20.5 cm One-Stem fluid drainage assembly (Electro-Catheter, Rahway, NJ). This assembly is composed of a trocar, a needle, and a pigtail catheter. The assembly is introduced percutaneously through the chest wall and directed posterior aiming to the right shoulder. Upon contact with the left ventricle, the assembly is advanced rapidly in a single motion aiming from the apex to the mitral plane. The needle and trocar are removed, leaving the pigtail catheter in the left ventricular cavity. The incidence of major complications of direct left ventricular puncture includes ventricular fibrillation (0.2%), tamponade (1.4%), pneumo- or hemothorax (2.7%), stroke or transient ischemic attack (0.3%), vasovagal reaction (1.0%), unsuccessful puncture (0.9%), and death (0.5%). In patients with multiple previous cardiac operations, this complication rate may be even lower as the pericardium becomes thickened and adhesive, making tamponade less likely to occur [14].

CLOSURE DEVICES

Closure device can be used after any procedure such PCI, valvuloplasty, IABP or due to inadvertent arterial puncture such as after cannulation of a subclavian artery instead of a jugular vein. The choice between collagen plugs and suture closure is largely a matter of personal preference and experience. The time needed to deploy the various devices is unique to each system. When physicians' time to utilize the device and staff time for adjunctive compression or puncture site management are considered together, sealing devices do not provide an advantage over manual pressure in decreasing complications [15]. Thorough training of operators in how to use any device is warranted to reduce vascular access complications. When deploying an AngioSeal device (St Jude

Medical Devices, Minneapolis MN), an iliac angiogram needs to show the artery diameter is at least 4 mm and there is no bifurcation within 2 cm of the arterial entry site.

Preclosure of Large Arterial Access: In cases where a large sized sheath is needed (e.g. for aortic valvuloplasty), preplacement of untied sutures using the Perclose percutaneous suture delivery system (Abbotts Vascular, Redwood City CA) prior to placement of a large intended sheath can be done. A 5Fr to 6Fr sheath may be used for arterial angiography to identify appropriate anatomy for suture delivery, and then a suture device is used to place untied sutures. At the end of the procedure, the existing “purse string” is then closed around the arteriotomy [16].

Preclosure of Large Venous Access: The technique of “pre-closure” involves preloading a 6Fr Perclose suture closure device into the femoral vein after access with a 6Fr or 8Fr dilator, prior to insertion of a 14Fr venous introducer sheath used for antegrade aortic valvuloplasty. Intravenous placement of the Perclose device within the venous system is then verified by either back-bleeding from the marker port, or contrast injection through the marker port. Then the needles are pulled and the sutures clipped, and after the sutures are deployed, a wire is placed into the femoral vein through the Perclose device, and an exchange is made over the wire for a 14Fr sheath while the sutures are laid alongside of the puncture and covered with betadine-soaked gauze. Upon completion of the valvuloplasty procedure, a wire is passed through the 14Fr sheath to secure the vessel in case the suture closure fails. Heparin is not reversed. The sheath is then removed through the existing sutures, and the sutures are tied around the wire. If hemostasis is successfully achieved with the suture, the wire is gently removed, and the knot pushed further to complete the closure.

TECHNICAL TIPS

***Preclosure of the Venous Access with the Perclose:

Since veins are comparatively thin-walled, the amount of tension applied when pulling back the Perclose device is necessarily LESS than for arterial closure. It is possible to securely contact the vessel wall with the foot of the device while applying steady pressure, with LESS force than needed for arterial closure. Back-bleeding through the marker port occurs in the vast majority of cases. Due to the lower pressure in the venous system, this is of course less prominent than in arterial closure. Usually, a slow dribbling of blood from the marker port can be noted. There is a delay in the appearance of back-bleeding due also to the low venous pressure, and this may be accentuated by having the patient take in a deep breath or by employing the Valsalva maneuver [17].

CAVEAT**Suspecting Intra-Arterial Deployment of**

Collagen Plug: During deployment of an AngioSeal

device, intra-arterial deployment of the collagen

plug can be due to inadequate tension on the

suture, vigorous tamping, too deep insertion of

device into the artery then the anchor is caught in the posterior

wall, etc. Suspicion of a problem is aroused when there is a long

travel distance of the tamper tube or continued bleeding [18].



CASE REPORT Management of Intra-Arterial Deployment of Collagen Plug:

In a case reported by Stein *et al.*, a possible intra-arterial deployment of the collagen plug was suspected. At that time, while inserting deeper the tamper tube, it was observed that it could be inserted much deeper than usual. The patient continued to bleed, so a tension spring was placed as usual. At that time, the author used a Hemostat to secure the end of the suture, and a FemoStop compression device (Femostop, Radi Medical Systems AB, Sweden) was applied above the AngioSeal to stop bleeding. Then the author waited for 4 hours, so the anchor that is composed of an absorbable polymer material, becomes softened and so pliable. A Hemostat was placed on the suture at the level of skin. If the suture were to break during traction, the hemostat would prevent the anchor and the collagen plus from embolizing. Then steady traction was applied to the suture, perpendicular to the femoral artery. The pressure should not be excessive. After 20 minutes, the plug was removed. The FemoStop was reapplied and hemostasis was achieved [18]. The management is summarized in Table 1-1.

Table 1-1 What To Do if Collagen is Inserted Intra-arterially [18]

- 1 Prevent the problem: always maintain tension on the suture and avoid tamping with excessive force
- 2 Recognize the problem: absence of resistance during tamping and inadequate hemostasis are clues
- 3 Duplex ultrasound can document intra-arterial collagen
- 4 Apply tension string in the usual fashion; secure suture with hemostat at the skin level to add security
- 5 **Do not cut suture:** embolization of the anchor and plug may occur
- 6 If there are signs of embolism and thrombosis, obtain vascular surgery consultation
- 7 Wait at least 4 hours to allow softening of the anchor
- 8 Steady vertical traction on suture with approximately 10lbs of force
- 9 If removal of the device is achieved, maintain manual compression to achieve hemostasis
- 10 Femo-Stop device should be ready for rapid deployment after device is removed
- 11 Remove the collagen plug by atherectomy device (not needed)

Removal of Intra-arterial Collagen Plug by Atherectomy:

One of the complications of using the AngioSeal device is the partial protrusion of the collagen sponge into the artery, likely due to insufficient tension on the suture while the collagen is deployed. It has been difficult to treat this problem with balloon angioplasty alone, because of the highly eccentric nature of the lesion in an otherwise relatively healthy CFA. Suboptimal results of balloon angioplasty in markedly eccentric lesions have been attributed to the compliance and elastic recoil of healthier portions of the arterial wall. Percutaneous approaches to AngioSeal-related complications include angioplasty, thrombectomy with the AngioJet system, extraction with a snare catheter or even with an endomyocardial biopsy device, and angioplasty followed by stenting. Stenting of the CFA should be avoided if at all possible, since it can result in deformation and strut fracture secondary to hip flexion and could compromise future arterial access and surgical repair. The unique design of the SilverHawk atherectomy catheter allows clear visualization of the cutter position during the procedure and enables preferential excision in the direction of the lesion, thus sparing the normal portions of the arterial wall. Although the initial technical success of this device in femoro-popliteal lesions is high, distal embolization may complicate the procedure, particularly in patients with poor distal runoff [17].

COMPLICATIONS

Hematoma: Their frequency is 1–3% and increases with the increasing size of the sheath, increasing level of anticoagulation, and the obesity of the patient [15]. Surgical evacuation is not required even for large hematomas, unless there is undue tension on adjacent structure or in the case of a truly huge hematoma. Surgical evacuation and arterial repair are required when the hematoma is pulsatile and expanding, an indication of communication between the hematoma and the femoral artery and the presence of a false aneurysm [19].

Arteriovenous Fstula (AVF): This happens rarely (<0.4%) when the puncture is made where the artery overlies the vein [20]. Most small AVFs are asymptomatic and usually close spontaneously. A large AVF with symptoms of high output failure needs to be corrected surgically.

Acute Arterial Thrombosis: Occlusion of the femoral artery may occur due to thrombosis or local arterial injury. It happens in 0.1% of patients, mostly in women with small femoral arteries that are completely blocked by the catheter during the procedure and in patients whose superficial femoral artery (SFA) is catheterized rather than the CFA [20].

TECHNIQUE Mechanical Thrombectomy for Acute Thrombosis:

If thrombosis of the femoral artery is suspected, access is obtained from the contralateral side and 5000 units of heparin are given. A 6F crossover sheath is placed in the external iliac artery over a 0.035" stiff Amplatz guide-wire. The occluded/thrombosed/embolized segment or the artery is crossed with a 0.014" or 0.018" wire. Any thrombectomy device is then introduced over the wire and tries to

remove any thrombi. If normal distal flow is established without any residual stenosis, the procedure is terminated. If there is still residual thrombus, then the segment is dilated with a peripheral balloon, and if the post-percutaneous transluminal angioplasty (PTA) result is not optimal, a self-expanding stent may be deployed [21].

If heavy thrombotic burden still persists after mechanical thrombectomy, then tPA 0.05 mg/kg can be given along with heparin through a multi-hole delivery catheter (e.g. 5Fr Mewissen of Boston Scientific, Boston MA) 4 hours later, an angiogram can be carried out to check the progress and if there is thrombus, the patient can undergo longer infusion (12–18 hours) [21].

Limb Ischemia: Patients who develop acute limb ischemia following femoral artery catheterization must be carefully and immediately evaluated by duplex ultrasound. Angiography is mandatory and should not be delayed. The purpose of angiography is to identify the location (aorto-iliac inflow circulation, infra-inguinal outflow circulation, or run-off circulation), and cause (dissection, thrombosis, distal embolization, sheath/vessel mismatch) of ischemia, since these factors will help determine the treatment strategy (vascular surgery, percutaneous revascularization, thrombectomy, intra-arterial thrombolytic infusion). In most cases, digital subtraction angiography is best, since cineangiography may not permit adequate visualization of the runoff circulation [22].

TROUBLE-SHOOTING TRICKS

*****Temporary Relief of Iatrogenic Ischemic Limb: Percutaneous Technique for In-Vivo Femoral Artery Bypass:** During PTA of high-risk patients, if the acute limb ischemia arises during femoral artery catheterization, the sheath in the right femoral artery and the sheath in the left common femoral artery can be connected using standard 12-inch pressure tubing and a male-to-male adapter. In general, this technique is considered a temporizing method to restore blood flow, minimize the metabolic consequences of acidosis and muscle necrosis, permit more definitive percutaneous or surgical revascularization as indicated, and to allow the use of devices for invasive hemodynamic support when such devices cause limb ischemia and there are no other therapeutic alternatives [22].

CAVEAT

Preventing Limb Ischemia: The steps to prevent limb ischemia include: (1) careful examination of femoral pulses and bruits before catheterization; (2) angiography prior to insertion of any hemodynamic support device; (3) angioplasty and stenting of suitable aorto-iliac stenoses before device insertion; and (4) use of a sheathless IABP might reduce the risk of ischemic complications in patients with diffuse aortoiliac disease or small vessels [22].



Retroperitoneal Hematoma: The clinical clues include hypotension without apparent reason, blood loss without possible source, suprainguinal tenderness and fullness, and flank discomfort. A small hematoma is not able to cause any hemodynamic disturbances or any increase of the retroperitoneal cavity pressure to cause neurological symptoms. Only a huge hematoma compressing the lumbar plexus can really produce numbness and weakness of the muscles below the knee. Usually, bleeding into the retroperitoneal site is self-limiting unless the patient is anticoagulated [19]. The management includes stopping heparin and reversing anticoagulation with protamine, then rapid fluid resuscitation to reverse hypovolemia. Transfusion may be needed. If the above treatment does not reverse the low blood pressure quickly, urgent iliac artery angiography is needed and surgical consultation should be called.

TECHNICAL TIPS

****How to Detect Retroperitoneal Hematoma in a 1 Second Maneuver?** Just an AP view of the pelvic area under fluoroscopy may give a clue to the problem. Usually, the bladder is seen round, filled with contrast. However, if the opacified bladder is seen displaced and its round shape is dented, retroperitoneal hematoma is strongly suspected (Figure 1-1). However, significant blood needs to be sequestered before unilateral external compression occurs [20].

TECHNIQUE How to Seal a Perforation: The initial angiogram revealed laceration of the inferior epigastric artery arising at the origin of the right CFA. A 6Fr crossover sheath is positioned in the right external iliac artery, and a 6Fr right Judkins-4 guiding catheter is then advanced over the crossover sheath to engage the ostium of the lacerated inferior epigastric artery selectively. A 0.014" Balanced Middleweight guidewire (Guidant, Santa Clara, CA) is advanced into the inferior epigastric artery, and the tip positioned distal to the lacerated area. A 2 × 10mm balloon catheter is then advanced and parked at the level of the laceration and inflated at 1 Atm on three sequential occasions for up to 20 min per inflation. Adequate balloon occlusion can be confirmed by injecting contrast through the guide. Further occlusion could seal the perforation. Nevertheless, if the angiogram reveals persistent and significant bleeding after each balloon deflation, attempts should be made to thrombose the lacerated vessel in order to stop the hemorrhage. Microcoils can be used for closure of the small artery. If there are no microcoils available, infusion of thrombin through the lumen of the inflated over-the-wire (OTW) balloon can be done. Careful positioning and sealing of the vessel are confirmed with injection of contrast from the guide and through the balloon lumen to ensure that there is no passage of contrast from the vessel lumen into the common femoral artery. Thrombin-JMI (Jones Pharma, St. Louis, MO) is to be diluted in normal saline at a concentration of 50 IU/cc. Subsequently, a total of three consecutive doses of 100 IU of thrombin can be administered through the balloon-catheter

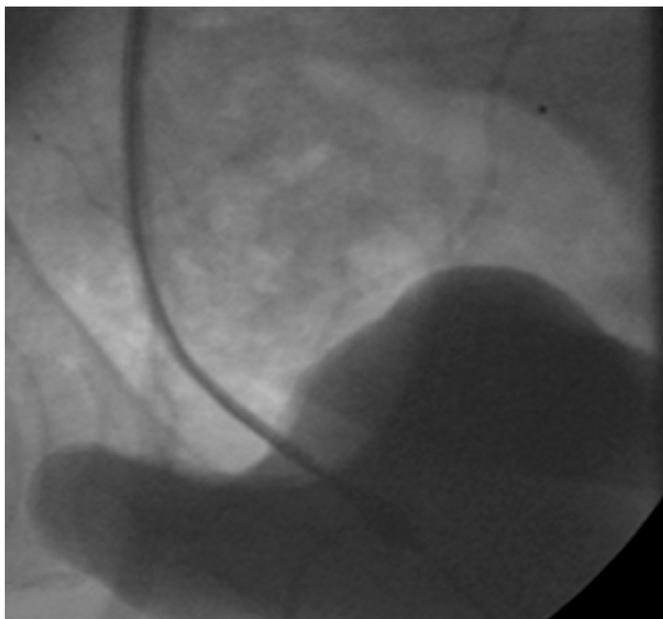


Figure 1-1 A dented bladder due to retroperitoneal hematoma. It looks different from the round shape of the bladder. (Courtesy of the Cardiac Catheterization Laboratories of Community Healthcare System, St Mary Medical Center, Hobart, IN. Reprinted with permission.)

lumen. Contrast can be injected through the balloon lumen after each dose of thrombin. When there is no further evidence of blood flow and no extravasation of contrast through the laceration, the balloon can be deflated. A selective injection with the guide in the common femoral artery is carried out to confirm the thrombotic occlusion of the lacerated inferior epigastric artery. An angiogram of the superficial femoral, popliteal, and infrapopliteal arteries confirm the absence of thrombotic embolization and excellent flow in all these vessels [23].

Perforation: If a balloon bursts and perforates a peripheral artery below the inguinal ligament, the local bleeding can be controlled by direct pressure. In the case of higher perforation, a large peripheral balloon should be inflated above or at the rupture site to stop the bleeding and to seal the puncture site [24].

TECHNIQUE How to Seal a Perforation with a Covered Stent: Access is gained via the left femoral artery for retrograde approach to right iliofemoral angiography. A 6Fr internal mammary

catheter is inserted over a 0.035" guidewire, and this wire is used to cross into the right superficial femoral artery. This wire is exchanged for an 0.035" Amplatz super stiff wire, and an 8Fr × 65 cm long Superflex sheath advanced under fluoroscopy over the aortoiliac bifurcation to give good support in the right external iliac artery. Balloon tamponade of the perforation site is performed with a 5 minute inflation of a balloon at 2 Atm with persistent extravasation of contrast. An undersized self-expanding covered stent is then placed across the perforation site with a persistent leak. The stent graft can then be post-dilated with a balloon at 8 Atm with complete hemostasis and resolution of the free-flow contrast into the retro peritoneum [25].

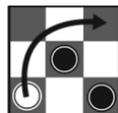
Pseudoaneurysm: The incidence of pseudoaneurysm (PA) is 1–3% by clinical examination or 6% by ultrasound [26]. The main cause is inadvertent puncture of the SFA. Femoral PA forms when the puncture site does not close and there is continuous flow into a small perivascular space contained by the surrounding fibrous tissue and hematomas. It is suspected by the presence of a laterally pulsatile mass, an arterial bruit, and tenderness at the vascular access site. Confirmation is made by ultrasound, which shows a hypoechoic cavity with flow through a neck directly visible by color Doppler, and pulsed Doppler evidence of to-and-fro flow between the cavity and the arterial lumen during systole and diastole [26]. Pseudoaneurysms are characterized by the presence of a to-and-fro blood flow across the PA neck during systole and diastole. Hematomas are seen as hypoechoic collections without any Doppler flow movement. Deep vein thrombosis (DVT) is characterized by a lack of venous compressibility, obstruction of venous return, and a hypoechoic or isoechoic signal [27].

Indications for aggressive management include: large size of the PA, whether it has increased in size, and the need for continued anticoagulation. Usually the small PAs (<3 cm in diameter) will close spontaneously, presumably due to thrombosis. A follow-up ultrasound 1–2 weeks later often demonstrates spontaneous thrombosis and obviates need of surgical repair. The >3 cm diameter PAs are less likely to close spontaneously. When PAs persist beyond 2 weeks or expand, the risk of femoral artery rupture necessitates correction.

The simplest method of treatment is to use a mechanical compression device (Femostop, Radi Medical Systems AB, Sweden). The success rate is 74% with a mean compression of 33 min [26]. The failed patients underwent successful compression guided by ultrasound. Contraindications of mechanical compression are listed in Table 1-2. Ultrasound-guided compression is commonly used with success related to the anticoagulation status and a PA that can be readily visualized and compressed [26]. However, the newest modality of treatment is to inject thrombin into the PA. The technique is simple, quick, and painless [28]. Surgery is indicated rarely when the above-mentioned management fails.

Table 1-2 Contraindications of Mechanical Compression for Pseudoaneurysm

- 1 Sign of local infection
- 2 Critical limb ischemia
- 3 Large hematoma with overlying skin necrosis
- 4 Injuries above the inguinal ligament

TACTICAL MOVE**BEST Options for Exclusion of Pseudoaneurysm [28]**

- 1 **1** **FIRST Best option:** Mechanical compression therapy if there is no thrombin available
- 2 **2** **SECOND Best option:** For patients who fail empiric compression: ultrasound-guided compression
- 3 **3** **4** For patients on anticoagulant or having contraindication to compression: percutaneous injection of thrombin
- 4 **4** **5** **6** **7** **8** **9** **10** **11** **12** **13** **14** **15** **16** **17** **18** **19** **20** **21** **22** **23** **24** **25** **26** **27** **28** **29** **30** **31** **32** **33** **34** **35** **36** **37** **38** **39** **40** **41** **42** **43** **44** **45** **46** **47** **48** **49** **50** **51** **52** **53** **54** **55** **56** **57** **58** **59** **60** **61** **62** **63** **64** **65** **66** **67** **68** **69** **70** **71** **72** **73** **74** **75** **76** **77** **78** **79** **80** **81** **82** **83** **84** **85** **86** **87** **88** **89** **90** **91** **92** **93** **94** **95** **96** **97** **98** **99** **100** **101** **102** **103** **104** **105** **106** **107** **108** **109** **110** **111** **112** **113** **114** **115** **116** **117** **118** **119** **120** **121** **122** **123** **124** **125** **126** **127** **128** **129** **130** **131** **132** **133** **134** **135** **136** **137** **138** **139** **140** 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