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Chapter 1

Groin complications during neuroendovascular procedures

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Many challenging scenarios can occur before, during, and after percutaneous arterial access has been attempted or obtained for endovascular procedures. Anatomic knowledge of the access region and the patient's past history is important in planning the endovascular approach and treating associated complications. It is always important to review any available prior imaging studies to assess the aortic arch and vascular tree anatomy. Despite careful planning, access complications occur, and some common problems along with treatment options are presented in this chapter.

Risk factors for percutaneous access site complications

Risk factors include the patient's age, peripheral vascular disease, obesity, female gender, periprocedural anticoagulation/antiplatelet medication, thrombolytic therapy, and larger caliber sheaths used during procedures. If heparin was administered during procedure, an activated clotting time (ACT) level could be obtained at the appropriate time to determine when sheath removal will be safer with less bleeding risk. Depending on institution protocols and size of sheath used, the ACT value should be less than 150–200 seconds prior to sheath removal (unless transradial access was used)[1,2].

Accessing "pulseless" femoral region

Large body habitus or atherosclerosis may impair palpation of the femoral pulse. A large soft tissue pannus can be retracted and restrained with assistance from technologist or taped across patient onto table. Ultrasound can be used to identify and access the artery, but if vessels are heavily calcified, consider using a larger gauge needle (instead of a 21 gauge micropuncture needle) to allow passage of a 0.035 guidewire. Otherwise, it may be difficult to advance the smaller micropuncture sheath through the calcified vessel over the smaller 0.018 guidewire. Alternatively, a stiff micropuncture sheath may be used. Using ultrasound in the transverse plane is preferred, and the femoral artery is located lateral to the compressible femoral vein. If calcified plaque is present in the artery, sonographic shadowing can be seen at the location of the artery.

The groin crease is not a reliable site for identifying the location of the common femoral artery (CFA), owing to variation with body soft tissue habitus. Therefore, fluoroscopy can be used as a guide to target bony landmarks or a calcified atherosclerotic vessel. Typically, the CFA overlies the medial third of the femoral head and should be accessed over the

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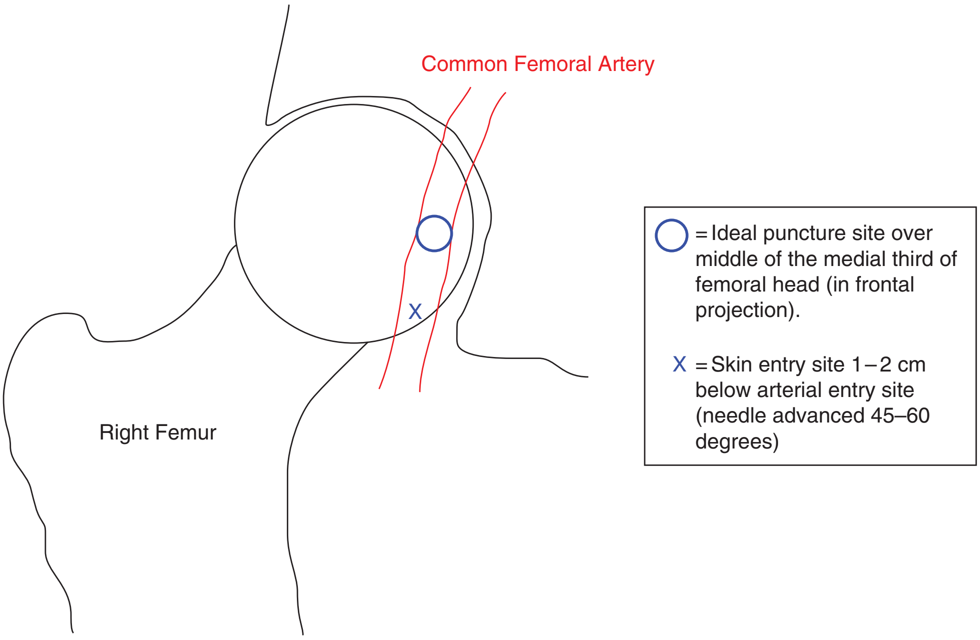

Figure 1.1 Landmarks for access to common femoral artery.

femoral head to allow for compression at conclusion of procedure (Figure 1.1). To avoid parallax, the femoral head should be centered on the fluoroscopic image.

An alternative method to localize the femoral artery is to perform a contralateral femoral artery puncture with subsequent angiogram to roadmap the ipsilateral femoral artery, or advancing a guidewire across the bifurcation into the ipsilateral artery. The guidewire can be used as a target for puncture. This method is helpful for iliac interventions but likely unnecessary for neurovascular interventions unless an additional access site is required. Upper extremity access may be necessary if the common femoral or iliac arteries are occluded[3].

Accessing "bypass" graft at site of femoral puncture

See Figure 1.4. Aortobifemoral bypass grafts can be directly accessed with similar rates of complications as native vessels. Typically, aortobifemoral bypass grafts are placed anterior to the native vessels and can be easily palpated. If inadvertent access of the native vessel is performed, a second puncture may be necessary unless the anastomosis is more proximal. In this scenario, the guidewire may need to be negotiated into the bypass graft with the aid of a curved catheter or angled guidewire. Knowledge of anatomy and location of anastomosis may be helpful in determining where to access, particularly if there are imaging studies available for review prior to the start of procedure[4].

Complications subsequent to percutaneous access

Femoral arterial dissection

Dissections related to femoral puncture can occur from subintimal passage of guidewire during initial arterial access or the use of vascular closure devices[5]. Caution must be taken

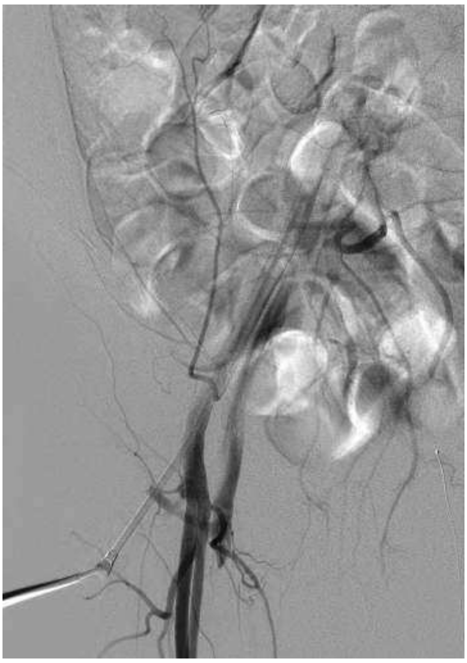

Figure 1.2 Right common femoral artery injection demonstrates early filling of femoral vein, confirming fistulous connection.

when advancing a guidewire if there is poor blood flow from the needle, as the distal end of the needle may be in a subintimal location. Femoral arterial dissections may extend into the external iliac artery or result in local arterial thrombosis and occlusion.

Endovascular repair and surgery are treatment options. Contralateral groin access may be necessary if dissection is located near the ipsilateral access. Prolonged balloon inflation may be sufficient to allow for intimal apposition, although a stent may be necessary. If thrombotic occlusion has occurred, catheter-directed thrombolysis followed by prolonged balloon angioplasty or stent placement may be necessary.

Anatomic considerations need to be factored into the decision to place a stent into the CFA. Care must be taken to avoid occluding the bifurcating vessels. Additionally, self-expanding nitinol stent grafts are preferred in the femoral artery because of their resistance to compression and deformity at the hip joint[6].

Hematoma /retroperitoneal hematoma

See Figure 1.3. Retroperitoneal hemorrhage may be caused by puncture above the inguinal ligament resulting in arterial puncture in the anterior or posterior wall after the artery has entered the retroperitoneal space. Symptoms include back or flank pain with a drop in hemoglobin, hypotension, and tachycardia. Hypotension may be a late sign, although in some cases, hypotension resistant to standard fluid resuscitation may occur early on. There may be compression signs to adjacent structures such as femoral vein compression leading to thrombosis/edema, or femoral nerve compression leading to sensory or motor deficit and skin necrosis.

Diagnosis is confirmed with non-contrast computed tomography (CT) scan of abdomen and pelvis. For groin hematomas, ultrasound may be adequate to evaluate for

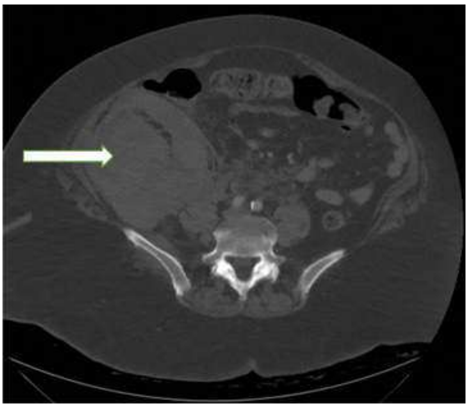

Figure 1.3 CT abdomen and pelvis: large right-sided retroperitoneum hematoma measuring 11.8 × 12.8 cm. Patient was stabilized with fluids, discontinuation of antiplatelet medications, and transfusion of packed red blood cells.

pseudoaneurysm (see below). Bleeding is exacerbated by anticoagulation which should be discontinued or reversed using protamine sulfate. If the hematoma is small, conservative management may be sufficient. Treatment strategies include endovascular stent graft placement from contralateral approach, using caution to prevent occlusion of the deep femoral or superficial femoral arteries during deployment. Surgery for hematoma evaluation and arterial repair may be required if there are anatomic limitations or if the source of bleeding is located at the CFA bifurcation. Balloon occlusion may be necessary as a temporizing measure to allow for surgical procedure if life-threatening hemorrhage is ongoing.

Every neurointerventionalist should have a policy to deal with these situations. Following steps are not in any particular order, but typically our strategy includes:

1. Stat hemoglobin and hematocrit measurements.
2. Mark the hematoma in groin and abdomen with skin marker to have some visual objective idea of hematoma dimensions for early identification of expansion. Such markings may not be a reliable criteria for hematoma expansion or amount of blood loss; however, manual compression should be instituted if visible enlarging swelling is noticed while other steps are being taken.
3. Reverse anticoagulation and antiplatelet medications if possible depending on clinical situation.
4. Ensure good intravenous access in case intravenous vasopressors are needed. May need to place central line or peripherally inserted central catheter (PICC line) if situation warrants. Start intravenous fluids. Intravenous fluid boluses may be required for hypotension.
5. Type and screen blood. If rapid drop in hemoglobin and while vascular surgery team is being contacted, packed red blood cell transfusion may be needed along with fluids.

Arterial pseudoaneurysm at site of percutaneous access

A common complication of percutaneous access is pseudoaneurysm development, which is a cavity within hematoma or dilatation at arteriotomy site. The risk increases if large caliber catheters and sheaths are used, or if poor compression occurs after sheath removal. Symptoms include pain, swelling, and pulsatile mass with or without bruit. Diagnosis is confirmed with color Doppler ultrasonography which reveals an anechoic mass with internal flow and typically bidirectional blood flow, commonly referred to as a ‘yin-yang’ appearance.

The two most commonly described treatments are compression and percutaneous thrombin injection, whereas stent grafts and surgery are used in complex cases. Assessment of distal pulses is important before and after treatment.

Prolonged compression is performed with ultrasound probe, orthogonal or perpendicular to the neck of the pseudoaneurysm in an effort to compress the neck. The minimum amount of pressure to occlude the pseudoaneurysm is preferred in order to minimize occlusion of the adjacent artery or vein. This is typically performed at 5–30 minute intervals until complete thrombosis is achieved. Other manual compression devices can be used with or without ultrasound, such as the FemoStop device (St. Jude Medical, Minnetonka, MN). Poor candidates for compression would include large complex pseudoaneurysms with a wide neck, or in presence of comorbities such as obesity, pain, or hemodynamically unstable patients.

Thrombin injection is preferred by many interventionalists since the procedure can be performed rapidly without sedation, particularly in a pseudoaneurysm with a small neck. An arteriovenous fistula (AVF) is a contraindication to thrombin injection, while a wide or short neck of the pseudoaneurysm can be difficult to successfully obliterate and increases the risk of distal embolization[7]. Some interventionalists have suggested using simultaneous balloon occlusion during thrombin injection at the site of the pseudoaneurysm to minimize distal embolization if the neck is large or complex, but this procedure has only been evaluated with a small series of patients. This technique may require contralateral femoral artery access, crossing the aortic bifurcation with administration of heparin to prevent distal thrombus formation during balloon inflation.

Lastly, surgery is a viable option, while stent grafts could be placed in poor surgical candidates. Infected pseudoaneurysm may necessitate surgical debridement with arterial repair and autologous venous graft placement. Careful selection of patients is required for stent placement, and anatomical considerations such as location, tortuosity of the vessel, or mobility of the hip joint may be limiting factors.

Complications related to arteriotomy vascular closure devices

Percutaneous closure devices allow for earlier ambulation and discharge post procedure. Typically, patients are required to spend 4–6 hours lying flat after sheath removal to ensure adequate hemostasis, but the use of a closure device decreases this time to 1–2 hours. There are several different devices that achieve hemostasis through methods including suture-mediated closure, collagen plugs, or nitinol clips. It is important to understand the specific indications and contraindications with each device before deployment, and an anatomic overview may be necessary with a femoral angiogram. An important consideration in the decision to use a closure device is whether a repeat procedure will be needed, as some devices require a certain amount of time before repeat puncture is recommended.

Complications from these devices can result in arterial occlusion or distal embolization. Treatment options include surgical extraction or angioplasty. Angioplasty can be used for stenosis or occlusions and has been described as a treatment related to stenosis from suture-mediated closure devices[8]. Steno-occlusive disease related to collagen plug closure may require surgery if angioplasty or stenting is unsuccessful. Surgery would also be necessary if the closure device material embolized distally or if not accessible by endovascular approach.

If the closure device fails or guidewire access is lost, hemostasis may be necessary with manual compression or stent graft placement.

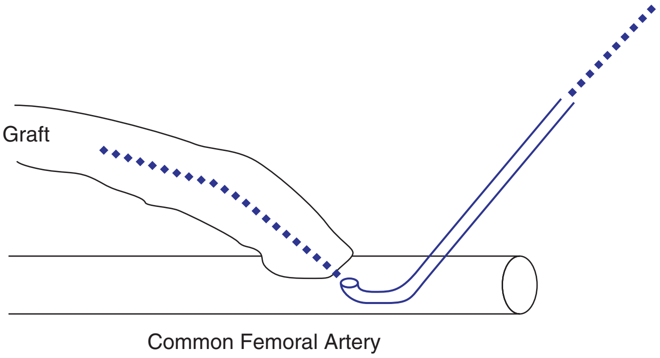

Figure 1.4 Accessing aortofemoral bypass graft. Curved catheter with guidewire (dashed line) to redirect into aortofemoral bypass graft.

Arteriovenous fistula formation

Arteriovenous fistulas (AVFs) are generally caused by distal punctures resulting in formation of communicating channels between artery and adjacent vein. AVFs may be suspected with palpation or continuous bruit on auscultation, and diagnosed with duplex ultrasonography. Ultrasound may show monophasic flow within the proximal portion of the artery and arterialized pulsatile flow within the outflow vein (Figure 1.2). The site of communication may or may not be visualized with ultrasound, while anatomic details are better demonstrated with angiography or cross-sectional imaging. AVFs can be asymptomatic or associated with pain, swelling, distal ischemia, deep venous thrombosis, bleeding, or high-output states.

Conservative treatment measures such as ultrasound-guided compression has variable results and is frequently limited by size of the fistula or periprocedural anticoagulation. More definitive treatment options would include surgical closure or exclusion with endovascular stent graft. Evaluation for stent graft placement is typically performed from the contralateral femoral approach, and care must be taken to avoid occluding the deep femoral or superficial femoral arteries during intervention. Shorter length stents may be needed in the CFA to prevent occlusion of the deep and superficial femoral arteries. Mobility of the hip joint may be a problem with deformity or fracture of the stent if placed in the CFA. Nitinol stent grafts are preferred, owing to the mechanical resistance to external distortion and deformation at a mobile joint. Stent placement may limit future percutaneous access of the groin, although shorter length stents can minimize this problem and maintain an uncovered portion of the artery for future puncture.

Acute lower extremity ischemia

Although rare, femoral artery thrombosis and occlusion may result in acute ischemia of the lower extremity. The ischemia may be due to large sheath size in a relatively smaller caliber artery, unrecognized pre-existing atherosclerosis, dissection, closure device complication (as mentioned above), and arterial spasm.

Figure 1.5 Transbrachial approach to basilar tip aneurysm endovascular coiling. This 79-year-old female presented with subarachnoid hemorrhage. She had severe peripheral vascular disease and therefore left-side transbrachial approach was undertaken. **A:** AP view demonstrating that left vertebral artery was catheterized with 4 French catheter which was exchanged for 6 French Neuron catheter. **B, C:** AP and lateral view demonstrating basilar tip aneurysm measuring 7.3 mm × 3.5 mm sharing origin of right posterior cerebral artery. **D, E:** AP and lateral view demonstrating near-complete obliteration achieved with minimal neck residual.

Recognizing occurrence of ischemia as soon as possible is very important. Examining the pulses after procedure is extremely important in every case where femoral artery is punctured for access. Anticoagulation with heparin may be considered if it can be used safely to prevent thrombus propagation. If time allows, CT angiography with aorta run off can be considered; however, if considered emergent then vascular surgeon consult should be made and patient taken to operating room. Emergent revascularization may be performed and, if needed, angiography can be done intra-operatively. Depending on the severity of ischemia, fasciotomy may be considered to prevent morbidity from reperfusion compartment syndrome.

Depending on the suspected etiology, contralateral femoral puncture can be considered to treat thrombotic occlusion with catheter-directed thrombolysis, followed by prolonged balloon angioplasty or stent placement as mentioned above under dissection treatment.

Alternative percutaneous arterial access routes

See Figure 1.5. The radial, axillary and brachial arteries provide an alternative approach to arterial access if the femoral arteries are occluded. These routes are a secondary approach, owing to the additional risks related to brachial plexus injury, distal embolism, hematoma formation, and stroke. The upper extremity arteries have a smaller caliber, increasing the chance of occlusion from the sheaths and resulting in distal upper extremity ischemia. The brachial artery is preferred over the axillary artery since it is easier to compress against the adjacent humerus bone. Obtaining bilateral upper extremity blood pressures is an important consideration to evaluate for a subclavian arterial stenosis. If there is a differential measurement greater than 10–20 mmHg, this finding suggests a stenosis in the side with the lower pressure, and puncture should be made in the opposite arm if clinically feasible. If available, ultrasound guidance with micropuncture needle is preferred.

When evaluating the abdominal aorta or mesenteric arteries, the left upper extremity is preferred to minimize risk of stroke since the carotid arteries are avoided during navigation of the catheter. The right upper extremity may be a better option if imaging the supra-aortic cerebral vessels is desired, especially in the setting of a “bovine” arch (normal anatomic variant with common origin of the brachiocephalic and left common carotid arteries). The left approach would allow easy access to the left vertebral artery if this is a vessel of interest, unless it takes origin directly off the aortic arch (another common anatomic variant).

The radial artery has gained popularity as an alternative to femoral artery access but has certain advantages and disadvantages. The dual blood supply to the wrist limits the potential for limb ischemia, but a normal Allen's test is necessary to confirm patency of the ulnar artery and palmar arch. Others advocate performing pulse oximetry of the thumb before and after compression of ipsilateral radial artery to confirm adequate collateral circulation in the event of radial artery compression.

Some advantages of transradial access include earlier patient ambulation with less frequent vascular complications since the artery is easily compressible. Some disadvantages are related to the smaller size of the vessel requiring smaller sheaths and the potential for vessel spasm. Most 6 French sheaths are well tolerated, and antispasm medications are helpful. Contraindications to transradial access include abnormal Allen's test or known upper extremity vascular disease. If future dialysis access is considered, then the radial artery should be avoided.

The radial artery is typically accessed with a 21 gauge needle approximately 2–3 cm cephalic to the wrist flexion crease (or radial styloid), since it is larger and less tortuous at the crease. A micropuncture set may be used to cannulate the radial artery with a 5 French introducer sheath. A mixture of heparin (5000 IU/ml), verapamil (2.5 mg), lidocaine (2%, 1.0 ml), and nitroglycerin (0.1 mg) is infused through the introducer sheath immediately after insertion to relieve and prevent local vasospasm. Heparin administration to prevent thrombosis or occlusion during the procedure is recommended. Wrist immobilization is also recommended during and briefly after radial artery catheterization to minimize bleeding complications. There are several devices on the market to assist with hemostasis and compression at the wrist, although gauze with pressure dressing or inflatable blood pressure cuff can be used. Sheath removal can be done without reversal of anticoagulation, unlike transfemoral punctures[3,9].

Almost any other artery can be accessed percutaneously, but the small size of distal arteries limits the catheters and sheaths available for use, while potentially increasing risk of complications. If the popliteal artery is chosen, ultrasound guidance is recommended to avoid the adjacent superficial popliteal vein.

Lastly, translumbar access to the abdominal aorta is another infrequently used alternative. This approach requires a prone position with fluoroscopic guidance using bony landmarks. Contraindications include uncontrolled hypertension, coagulopathy, aortic aneurysm, severe atherosclerosis, or severe scoliosis. Self-contained retroperitoneal hematomas are common, but mostly are predominantly asymptomatic.

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