Optimal Femoral Access Prevents Complications

Fifty-five years after the introduction of the Seldinger technique, there is demand for reassessment of femoral access and argument for routine femoral angiography.

BY ZOLTAN G. TURI, MD

Percutaneous femoral access has changed relatively little in the more than half century since Sven Seldinger liberated invasive cardiologists and radiologists from having to perform cutdowns.[1] In general, however, vascular access has missed the invasive vascular revolution that has taken place in the subsequent 55 years. The original technique has been modified to avoid backwall puncture. The introduction of arterial sheaths in 1979[2] eliminated multiple transcutaneous catheter exchanges, a process that was associated with some morbidity. Extrapolating from the estimates of annual procedure volumes, several hundred million femoral artery access procedures have been performed worldwide. Despite the ever more sophisticated cardiac and endovascular procedures, femoral access remains the single greatest cause of complications.[3]

A survey of invasive radiologists and cardiologists conducted in England in 1990[4] revealed three primary techniques for access (Figure 1): the inguinal crease, the point of maximal pulsation, or the bony landmarks (typically a line drawn from the anterior superior iliac crest to the symphysis pubis). A minority of angiographers use a combination of these approaches. The survey found that the most common single technique (40%) involves using the inguinal crease alone. This is unfortunate because an important misconception exists in the literature—that the inguinal crease overlies the center of the femoral head. In fact, the typical location is below the femoral head, and equally important, below the femoral bifurcation (Figure 2).

LOCATION OF FEMORAL PUNCTURE

There is compelling evidence that vascular complications are related to the location of femoral puncture. High sticks correlate strongly with retroperitoneal hemorrhage, and low sticks with pseudoaneurysms, hematomas, and arteriovenous (AV) fistulae. The inferior epigastric artery (IEA), which originates above the inguinal ligament, initially descends but does not cross through the ligament. The lowest point in its sweep provides a best estimate for the path taken by the ligament (Figure 3). Punctures above this point have been associated with odds ratios for retroperitoneal hemorrhage as high as 17:1.[5] In our series of quantitative femoral angiograms, this inferior sweep of the IEA rarely descends significantly below the centerline of the femoral head. Thus, avoidance of puncture above the femoral head centerline is an essential element in minimizing complications. Because retroperitoneal hemorrhage remains a cause of vascular access-related mortality, puncture below the centerline is probably the single most important safety recommendation among those listed in Table 1. It is important to point out that punctures below the inguinal ligament do not preclude extravasation of blood through the ligament and into the retroperitoneal space, and other factors, such as penetration of the needle during femoral puncture through the posterior wall of the artery, likely predispose to retroperitoneal hemorrhage as well.

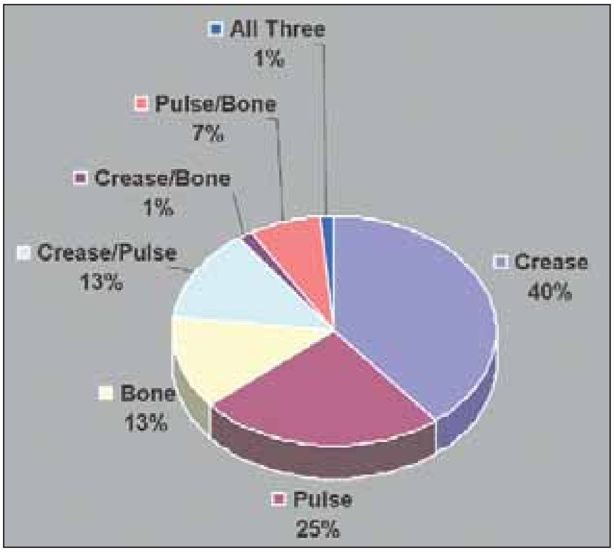

Figure 1. Distribution of primary landmarks for femoral puncture in a survey of 200 invasive radiologists and cardiologists in England.[4] The primary puncture site is the inguinal crease.

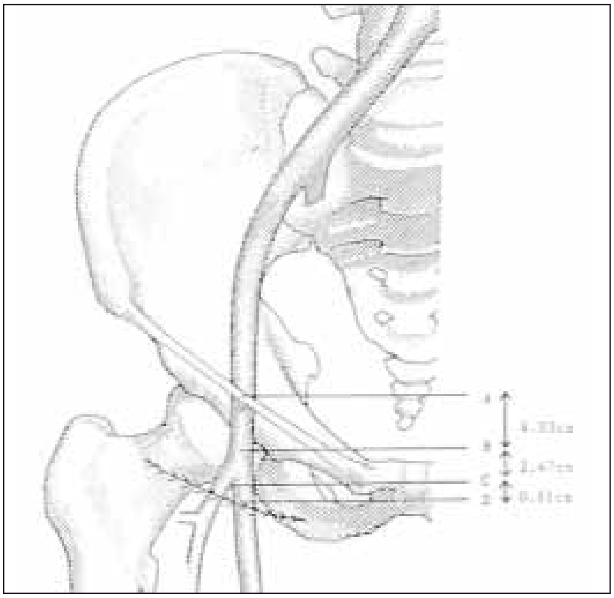

Figure 2. Location of the inguinal crease with relationship to the femoral bifurcation. Note that contrary to common perception (and the figures in virtually all texts), the inguinal crease is below the femoral bifurcation and not over the center of the femoral head. (Reprinted with permission from Grier G, Harthle G. Percutaneous femoral artery puncture: practice and anatomy. Br J Radiol. 1990;63:602-604.)

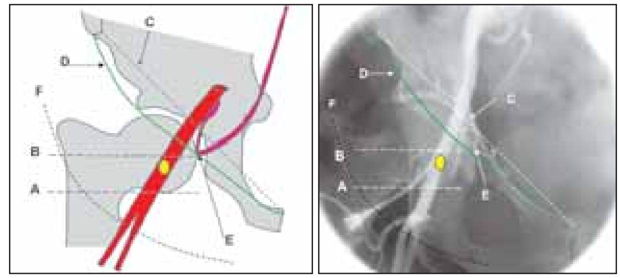

Figure 3. Anatomic landmarks for vascular access. Puncture below the bottom of the femoral head (line A) predisposes to hematoma, pseudoaneurysm, and AV fistulae. Puncture above the centerline of the femoral head (line B) predisposes to retroperitoneal hemorrhage. A line drawn from the palpable ridge at the anterior superior iliac crest to the symphysis pubis (line C) approximates the location of the inguinal ligament (line D). Puncture below the inferior-most sweep of the inferior epigastric artery (point E) minimizes but does not eliminate the risk of retroperitoneal hemorrhage. Puncture at the skin crease (line F), particularly in obese patients, may increase the risk of puncture into the femoral bifurcation vessels or, at a minimum, into the common femoral artery below the femoral head. The ideal location for arterial entry is approximately over the area in the yellow oval. (Reprinted with permission from Turi Z. An evidence based approach to femoral arterial access and closure. Rev Cardiovasc Med. In Press.)

There are two reasons why low punctures are associated with complications. First, puncture into the femoral bifurcation vessels (the superficial femoral [SFA] or profunda femoris [PFA] arteries) results in sheath placement into smaller blood vessels than the common femoral artery (CFA). For example, a 6-F sheath has an approximate 2.7-mm outside diameter and takes up nearly three fourths of the CFA lumen in many diabetic women (Figure 4). The bifurcation vessels are typically 1 mm smaller than the CFA, so the possibility of at least partial obstruction is significantly increased with puncture into the bifurcation vessels. In addition, patients with peripheral vascular disease are most likely to have SFA disease. Although the PFA is less commonly affected, in patients with total SFA occlusion, any disruption of the PFA intima and subsequent progression of disease in this vessel can eventually jeopardize leg viability.

Low punctures are not necessarily just those below the femoral head. Although we believe puncture below the centerline of the femoral head helps prevent retroperitoneal hemorrhage, progressively lower puncture over the femoral head results in increasing risk of bifurcation access. We have defined femoral bifurcation types as type 1 (bifurcation at or below the bottom of the femoral head, as in Figure 3A) and type 2 (bifurcation above the bottom of the femoral head). Type 2 bifurcations occur in approximately 25% of patients.[6]

A second source of morbidity from low sticks relates to puncture below the femoral head, whether or not it is into the CFA or a bifurcation vessel. The femoral head can be considered an anvil. During manual compression, if the puncture is below the femoral head, pressure is applied primarily against soft tissue, which is less effective, and complete hemostasis is less likely to be achieved, resulting in a predisposition to hematoma and pseudoaneurysm formation. Finally, femoral venous branches may course along and anterior to the bifurcation vessels, predisposing to AV fistulae.

Because the location of the IEA and femoral bifurcation are not known before puncture, the operator needs to consider puncture not only below the femoral head centerline, but also relatively high within the lower inner quadrant (the CFA is almost invariably medial) of the femoral head. The optimal location as we see it is shown in Figure 3.

THE CASE FOR ROUTINE FEMORAL ANGIOGRAPHY

A corollary to optimal access to prevent complications is the importance of ascertaining the location of the sheath entry with relationship to the IEA and femoral bifurcation. This can only be accomplished by routinely performing angiography through the sheath. We advocate performing the angiography as soon as access is achieved and, in all

TABLE 1. CHECKLIST FOR FEMORAL ACCESS
1. Place hemostat over the presumed location of the femoral head, and confirm location using fluoroscopy.
2. Place the drape in such a way that opening allows access to the common femoral artery over the femoral head. The drape is commonly misplaced, especially in obese patients.
3. Puncture the skin at a 45° angle to enter the common femoral artery approximately 5 to 15 mm below the centerline of the femoral head and over its medial portion.
4. *Before* entering the artery, but after penetrating with the needle through the skin and to where pulsation can be felt through the needle, remove hand from the field and repeat fluoroscopy. Adjust the needle location to approximate entry at the location shown in Figure 3A and B. The appearance of the needle on fluoroscopy should be similar to that seen in Figure 5.
5. After sheath placement, perform femoral angiography in an ipsilateral view on every patient. If the location of the sheath entry cannot be clearly identified, and the question of puncture into the femoral bifurcation or one of the bifurcation vessels is suspected, perform an angiogram in the ipsilateral caudal view.
6. If the puncture location is high, avoid administering anticoagulation if possible. In case of an elective and/or *ad hoc* intervention, perform diagnostic angiography and bring the patient back in 24 hours for a repeat femoral puncture and intervention.

TABLE 2. POSSIBLE RISK FACTORS FOR VASCULAR ACCESS COMPLICATIONS
1. Female gender
2. Diabetes
3. Femoral artery size*
4. Femoral artery vascular disease*
5. Puncture location*
6. Sheath size
7. Fixed-dose anticoagulation
8. Aggressive anticoagulation
9. Postprocedure anticoagulation
10. Body surface area (primarily low [obesity paradox], but also morbidly obese)
11. Immune suppression
12. Repeat puncture, multiple puncture, back-wall puncture
13. Age
14. Glycoprotein IIb/IIIa inhibition
15. Prolonged sheath dwell time
The evidence base for the above is modest. The most commonly proposed risk factors are included (not in order of relative risk).
**Ascertainable with femoral angiography at time of sheath placement.*

cases, before administering anticoagulation. Although performing femoral angiography before vascular closure device use has become the standard of care in the US (although it remains uncommon in the rest of the world), it is rarely performed by operators if manual compression is planned. Even when angiography is performed, it is predominantly done at the end of the case.

There are several important arguments for routine femoral angiography in all patients. First, femoral puncture is a procedure with significant associated morbidity, the success of which and the likelihood for associated complications cannot be assessed without angiography. Angiography provides information not just about puncture location but also about vessel size and presence of atherosclerotic disease, all of which have been shown to correlate with vascular complications. In addition, occasional incidental findings include dissection, extraluminal course of sheath entry, contrast extravasation, AV fistulae, and inadvertent puncture or transection of the inferior epigastric or circumflex hip arteries.

Second, in patients who have planned interventional procedures, or in whom ad hoc angioplasty is performed, ascertaining that the puncture is outside the CFA can prevent major complications if, based on the information obtained from the angiogram, anticoagulation is avoided. Retroperitoneal hemorrhage correlates not only with high sticks but also with anticoagulation: even with glycoprotein IIb/IIIa inhibitors on board, the incidence of retroperitoneal hemorrhage is <0.2% when anticoagulation is allowed to wear off before sheath removal.

TOWARD FEWER COMPLICATIONS

Vascular complication rates have declined steadily in the past decade, particularly in the interventional setting. A list of possible causative factors of vascular complications is found in Table 2. Cardiologists have been slow to adapt the techniques advocated in this article, and the evidence that either optimizing puncture location or routinely performing femoral angiography has improved outcomes is anecdotal. I do believe that following the steps listed in Table 1 can decrease complication rates significantly, but this remains unproven by adequately designed or powered randomized trials.

Several techniques widely used by interventional radiologists should be considered by interventional cardiologists.

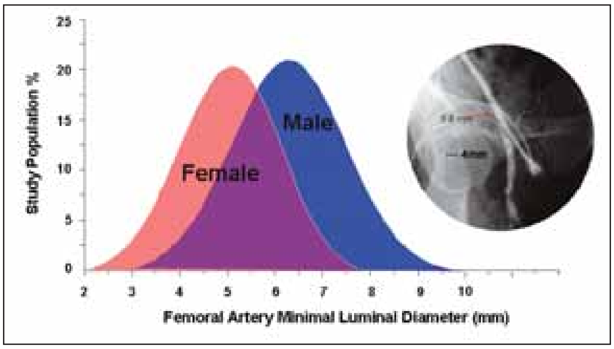

Figure 4. Distribution of *minimal* common femoral artery diameter in 200 patients undergoing cardiac catheterization. Note the Gaussian distribution; the mean minimal arterial size (a measurement that incorporates any atherosclerotic narrowing) is approximately 1.3 mm smaller in women. The inset shows an example in a diabetic woman with no symptoms of peripheral vascular disease; the 4-mm line over the femoral head is for reference. In this patient who had an uncomplicated cardiac catheterization, the common femoral diameter is 3.8 mm in size, whereas the 6-F sheath used has an outer diameter of 2.7 mm; thus, the sheath obstructs nearly three fourths of the femoral diameter. Sheath entry is below the inferior epigastric artery in this patient, although the right anterior oblique view tends to distort the level of puncture superiorly (compare with Figure 3).

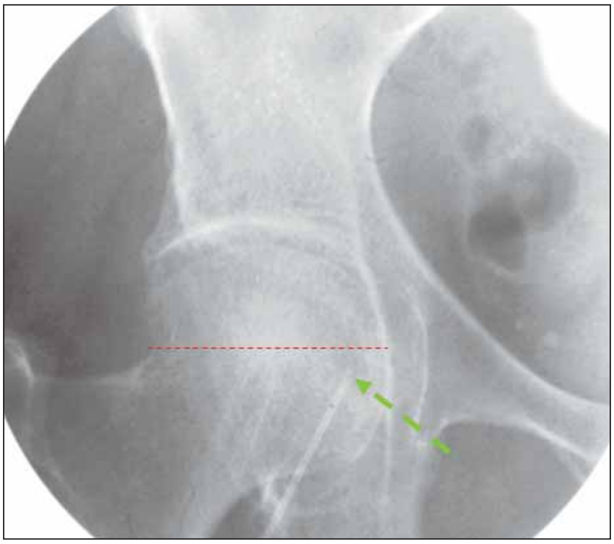

Figure 5. Appearance of the needle on fluoroscopy after penetration of the skin down to a point just before femoral artery entry. Pulsation can usually be felt through the needle at this juncture. The location should be below the centerline of the femoral head (dashed red line) and over the medial aspect at the approximate location shown (green arrow).

These include use of ultrasound for vascular access, using portable equipment that allows visualization and guidance of needle passage from the skin surface into the artery. A second technique is the use of a micropuncture 21-gauge needle with a .018-inch guidewire instead of the standard 18-gauge needle with a .035-inch guidewire; use of the latter, which unfortunately represents nearly universal practice in femoral puncture (and a significant portion of my practice, as well) could be considered unnecessarily traumatic, especially if, as is frequently the case, there is unsuccessful entry into the artery or if the back wall is penetrated. Again, although intuitive, there is no evidence base to confirm the benefits of micropuncture. A simple technique that we use in our laboratory in patients undergoing repeat catheterization is to take advantage of having done routine femoral angiography on every patient for the past 6 years. We review the previous femoral angiograms to assess for bifurcation location and the presence of femoral artery disease. If the patient has a type 1 bifurcation, the longitudinal target zone for access increases substantially to cover most of the bottom half of the femoral head.

CONCLUSION

Although we are 55 years into the Seldinger technique, the much-delayed time has come for a thorough and scientific re-examination of our femoral access techniques. Radial access, a popular alternative in the rest of the world, remains uncommon in the US, and is limited to some degree by the size of the radial artery. With the advent of evermore creative invasive technologies, femoral access remains the route of choice for a host of complex procedures, including percutaneous heart valves, aortic stent graft placement, and ventricular assist devices, among others. These technologies require placement of large sheaths, frequently in patients with diseased femoral and iliac arteries and with multiple comorbidities. The use of an evidence-based approach to vascular access in these patients is an essential element in the safe expansion of cardiac intervention to a host of new therapies. ■

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