Around the typical hospital, ultrasound machines are increasingly used at the point of care. Well beyond the radiology and echocardiography suites, there are now ultrasound machines in the emergency departments, intensive care units, and medical floors. Peripherally inserted central catheter line nurses roam the floors with their portable ultrasound machines. Vascular surgeons and interventional radiologists routinely use ultrasound for their vascular access procedures. Only in the cardiac catheterization lab has the use of ultrasound been notably limited, despite the significant rates of bleeding and other vascular complications from coronary, peripheral, and structural interventions.

ULTRASOUND IN CENTRAL VENOUS ACCESS

Real-time, two-dimensional ultrasound guidance has become the standard of care for placement of central venous catheters and is highly recommended by government agencies, such as the National Institute for Clinical Effectiveness and the United States Agency for Healthcare Research and Quality. Multiple randomized controlled trials and two meta-analyses have demonstrated a > 50% reduction in the risk of accidental arterial puncture, vascular complications, pneumothorax, or failed access with ultrasound guidance. Ultrasound guidance was associated with a 41% improvement in first-pass success rates, an average of 1.5 fewer attempts required, and a time to cannulation that was 69 seconds faster than the traditional landmark technique. Most trials have focused on the internal jugular vein, but similar results have been observed with subclavian and femoral venous access. The benefits are more limited with the Doppler audio-guided needle (SmartNeedle, Vascular Solutions, Inc., Minneapolis, MN) or with the use of ultrasound to merely mark the insertion site; neither technique is recommended as highly as real-time, two-dimensional ultrasound.

FEMORAL ARTERIAL ACCESS

Femoral access remains the predominant site for coronary and peripheral arterial procedures in most cardiac catheterization labs worldwide. Significant progress has been made in reducing the risk of vascular complications, such as hematoma, dissection, arteriovenous fistula, and retroperitoneal hemorrhage, but the overall rate of complications remains approximately 3.7% to 4%. Reductions in sheath size, changes in antithrombotic regimens, and vascular closure devices have all contributed to this improvement, but ultimately, placing a needle into a deep artery by palpation is prone to error. Multiple needle advancements may be required to gain access, accidental femoral venipunctures may occur, or the arteriotomy may be superior or inferior to the desired location, all of which may increase the risk of bleeding complications.

Multiple retrospective studies have associated inappropriate puncture locations with an increased risk of complications. Cannulation above the inguinal ligament is associated with retroperitoneal hemorrhage, whereas insertion below the common femoral artery (CFA) bifurcation is...
associated with pseudoaneurysm and arteriovenous fistula formation.9 The CFA provides the largest-caliber artery (7–10 mm) for the 18- to 24-F (6–8 mm) devices used in percutaneous aortic valve replacement procedures. A single anterior wall CFA cannulation is also required for the safe deployment of most vascular closure devices. Deployment outside the CFA is not only “off-label” but is associated with higher vascular complication rates.

The location of the CFA bifurcation can be partially predicted by fluoroscopy of the femoral head.10 The current expert recommendation is to insert the needle just below the center of the femoral head to minimize the risk of retroperitoneal hemorrhage while avoiding most CFA bifurcations.11 However, despite nonrandomized data12 suggesting that fluoroscopy is associated with fewer complications, three randomized controlled trials13-15 failed to demonstrate a benefit for fluoroscopic guidance in non-CFA cannulations or clinical complications compared with

Figure 1. The attached needle guide fixes the needle’s angle of entry to intersect the vessel at the imaging plane at a depth of 1.5, 2.5, or 3.5 cm below the skin (A). The right common femoral bifurcation is imaged in the axial plane, demonstrating the profunda femoral artery and superficial femoral artery (B). Compression is used to differentiate arteries from the femoral vein. Modified from JACC: Cardiovascular Interventions, 3, Seto AH, Abu-Fadel MS, Sparling JM, et al. Real-time ultrasound guidance facilitates femoral arterial access and reduces vascular complications: FAUST (Femoral Arterial Access With Ultrasound Trial), 751–758, Copyright (2010), with permission from Elsevier.17 The probe is moved or angled superiorly to the CFA (C). During needle advancement, the anterior wall of the vessel is indented by the needle tip. The guidewire insertion point (arrow) can be imaged after cannulation to confirm that the insertion is above the CFA bifurcation (D).

Figure 2. Ultrasound guidance improves CFA cannulation in patients with high bifurcations. Typical insertion into the profunda femoral artery with fluoroscopic guidance (A). CFA cannulation using ultrasound guidance (B). Increasing experience with ultrasound guidance demonstrated a trend toward improved CFA cannulation success after a short learning curve (C). Reprinted from JACC: Cardiovascular Interventions, 3, Seto AH, Abu-Fadel MS, Sparling JM, et al. Real-time ultrasound guidance facilitates femoral arterial access and reduces vascular complications: FAUST (Femoral Arterial Access With Ultrasound Trial), 751–758, Copyright (2010), with permission from Elsevier.17
anatomical landmarks alone. Several reasons may explain this absence of benefit: (1) fluoroscopic guidance does not reduce the number of puncture attempts required to achieve access, (2) puncturing a deep artery at a level identified by a surface marker can be difficult without repeated fluoroscopy, and (3) individual patient anatomy may vary. Our recent analysis of 989 angiograms demonstrated the CFA bifurcation occurred over the femoral head in 30% of cases. At the same time, the inferior epigastric artery origin and most inferior border (which are angiographic markers of the inguinal ligament) occurred over the center third of the femoral head in 10% and 35% of patients, respectively. This variation suggests that there may be no perfect fluoroscopic landmark that can be applied to all patients.

ULTRASOUND-GUIDANCE TECHNIQUE AND THE FAUST TRIAL

With ultrasound guidance, the precise location of the CFA bifurcation can be identified in an individual patient prior to needle insertion. An 18-gauge needle guide (Site-Rite, Bard Access Systems, Inc., Salt Lake City, UT) fixes the needle angle to intersect the ultrasound plane at the desired depth, ensuring that the needle inserts at a point just superior to the CFA bifurcation (Figure 1). By keeping the artery in the centerline of the image, the needle will also avoid accidental venipuncture and reduce the number of attempts required to gain arterial access.

In the 1,004-patient Femoral Arterial Access With Ultrasound Trial (FAUST),17 we demonstrated that ultrasound guidance reduced the number of attempts required to successfully cannulate the femoral artery (1.3 vs 3; \( P < .001 \)), increased the first-pass success rate (82.7% vs 46.4%; \( P < .001 \)), and reduced the risk of accidental venipuncture (2.4% vs 15.8%; \( P < .001 \)). As a result, the incidence of any vascular complications was reduced with ultrasound (1.4% vs 3.4%; \( P = .041 \)). In addition, the average time to access was reduced with ultrasound guidance from 213 to 185 seconds (\( P = .016 \)), excluding time to set up the device.

In the FAUST trial, the overall rate of CFA cannulation was not significantly different with ultrasound guidance compared with fluoroscopy (86.4% vs 83.3%; \( P = .17 \)) but was higher in the 31% of patients with high CFA bifurcations (82.6% vs 69.8%; \( P < .01 \)). This may have been due to the limited training (three procedures) performed by the operators before they used these skills in study subjects. However, after a learning curve of only 10 ultrasound procedures, operators had higher CFA access success with ultrasound guidance (Figure 2), and the most experienced operator in the trial attained a CFA insertion rate of 95%.

We found that the needle guide system is the most precise and easiest ultrasound-guided femoral access method to learn. However, as it is a proprietary system limited to the Site-Rite devices, it may not be available to all operators. Many other systems are available that facilitate vascular access, with the SonoSite, Inc. (Bothell, WA) devices being particularly versatile and easy to use. Without a needle guide, short jabbing motions are made with the needle to image its path. Somewhat more experience may be required to control the relative positions and angles of the probe and needle, especially to avoid high femoral artery punctures. Accuracy may be increased by puncturing the skin close to the center of the probe, at an angle that is relatively steep (45°–60°). With a needle guide, the probe can be angled to make the needle insertion as shallow as necessary, but the CFA bifurcation should be imaged at the same angle to avoid a higher-than-expected puncture.

PATIENT POPULATIONS

Although we would recommend gaining experience in all patient populations, certain patients and procedures may be more likely to benefit from ultrasound guidance. Patients who are likely to have a more difficult access by palpation include those with weak pulses, hypotension, peripheral vascular disease, prior scar tissue, and obesity. Patients at higher risk for bleeding include those at extremes of weight, women, children, the elderly, and those receiving anticoagulation, glycoprotein inhibitors, and thrombolytics. Successful CFA cannulation is most critical for patients with large-bore sheaths, especially in structural heart disease interventions but would be desirable in any patient in whom a closure device is planned.

SPECIAL APPLICATIONS OF ULTRASOUND

Beyond facilitating femoral access and reducing complications, femoral ultrasound may have additional applications in vascular access. After sheath insertion, the ultrasound device can be used to image the precise insertion point of the guidewire relative to the CFA bifurcation, perhaps obviating the need for femoral angiography prior to closure device insertion. Femoral angiography may not adequately image either the CFA bifurcation or the actual point of sheath insertion, as it is prone to distortions of angulation and sheath overlap.11 Optimal femoral angiography often requires pulling the sheath in a medial direction and possibly pushing upward on the patient’s pannus, which increases radiation exposure to the operator. For patients already receiving ultrasound-guided access, repeated imaging of the CFA bifurcation after sheath insertion requires very little time and can provide reassurance that a closure device can be used after the intervention if there are no other contraindications.

Ultrasound guidance is particularly useful in patients with peripheral vascular disease (Figure 3). Closure devices

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may be contraindicated in calcified vessels because suture-mediated devices may fail to penetrate the vessel wall, nitinol clips may fail to grab onto the vessel wall or bring the arteriotomy into apposition, and the intravascular anchor of collagen plug devices may cause dissection or fail to lay flat against the vessel wall, causing persistent hemorrhage. With ultrasound, calcification can easily be visualized and potentially avoided, allowing the safe deployment of closure devices, even in peripheral vascular disease patients. The location and entry point of femoral bypass grafts are also easily seen with ultrasound. Depending on the procedure, the bypass graft can be avoided or directly accessed. For lower extremity interventions, ultrasound has been demonstrated to be useful in patients requiring antegrade common femoral, selective superficial femoral, or popliteal access.

RADIAL ACCESS

One of the barriers to the use of transradial catheterization is the difficulty of achieving vascular access. The average radial artery measures only 2.2 to 2.6 mm in diameter, which is only slightly larger than the 20-gauge needle and near the two-point limit of discrimination of manual palpation. The artery may also be calcified, easily collapsible, or mobile. A meta-analysis of four trials of ultrasound guidance for radial artery access in noncardiac settings noted that ultrasound increased the first-pass success rate by 71%. Ultrasound is useful for assessing the size of the radial artery, which determines the risk of radial artery occlusion and spasm. Ultrasound may also detect anatomical anomalies, such as the dual-radial system, which can increase the procedure time and risk of transradial failure (Figure 4). Several single-center studies have documented success in using ultrasound in transradial catheterization, and we are nearing completion of a prospective, multicenter, randomized, controlled trial testing this hypothesis.

BILLING AND REIMBURSEMENT

Ultrasound guidance for vascular access has established reimbursement. Medicare (United States) guidelines require permanent recording and reporting of images to enable billing of the add-on code (+76937) for ultrasound guidance for vascular access. Reporting must

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**Figure 3. Femoral ultrasound images.** Axial view of femoral bypass graft directly over the CFA (A). Longitudinal view of the anastomosis of the femoral bypass graft with the CFA. Ultrasound enabled puncture away from the bypass graft insertion (B). CFA with extensive circumferential calcification (Ca++), causing posterior shadowing (C). The same patient imaged higher in the CFA, with calcification restricted to the posterior wall and pulsatility noted in the anterior wall (D). A right anterior oblique fluoroscopic image demonstrating sheath insertion at the point (D) where posterior but not anterior calcification is present (arrowheads). A StarClose closure device (Abbott Vascular, Santa Clara, CA) was successfully deployed at this location (E). An Angio-Seal anchor (arrow; St. Jude Medical, Inc., St. Paul, MN) in another femoral artery placed 1 week previously (F).
address the patency of the selected vessel, and real-time ultrasound images of the vascular access must be stored in an archive. This provides an additional $15.52 in professional and $18.04 in technical fees to the cardiac intervention procedure.24

SUMMARY

Ultrasound guidance for femoral access reduces vascular complications, number of attempts, accidental venipunctures, and time to access. It is a straightforward technique that is relatively easy to learn and utilizes equipment that is readily available in most hospitals. With some experience, it facilitates precise CFA cannulation regardless of anatomic variation, which can increase the success of closure device placement. Ultrasound guidance has particular utility in patients with challenging femoral access or high bleeding risk. It is a widely used technique with well-established reimbursement. With only minimal setup time required, we think that ultrasound guidance for arterial access is the way to go.2

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24. Medicare (ODA) 2010 Physician Fee Schedule. Center for Medicare and Medicaid Services, Department of Health and Human Services, Baltimore, MD. CMS-1413-FC.