Technique: Ultrasound Guidance for Lower Extremity Interventions

Exploring ultrasound mapping of the tibiopedal arterial tree in patients with critical limb ischemia.

BY JIHAD A. MUSTAPHA, MD; MATTHEW SEVENSMA, DO; LARRY J. DIAZ-SANDOVAL, MD; AND FADI SAAB, MD

As tibial arterial intervention is becoming more prevalent, noninvasive imaging modalities can increasingly assist endovascular revascularization. Arterial duplex ultrasonography has become an integral part of tibial vessel endovascular interventions in our laboratory. Many procedures are scheduled with an ultrasound technologist present to assist the endovascular specialist in achieving access and delivering therapy.

For arterial access, we use the 15-MHz i7 hockey stick probe (Philips Healthcare, Andover, MA) (Figure 1) or a standard linear probe, depending on vessel depth. Tibial access is performed in the distal segments where vessel depth is shallow. Our observation is that the 15-MHz probe offers better spatial resolution at shallower depths. Its lower profile allows the technologist to move freely and change from transversal to longitudinal axis views without interfering with the interventionist while he or she is performing the puncture for arterial access. Ultrasound is a benign, noninvasive imaging modality that has become the cornerstone of interventional endovascular procedures at our institution.

TIBIOPEDAL ACCESS

Ultrasound allows us to accurately visualize and identify the tibial arteries and the accompanying veins (Figure 2A). The vessels are evaluated with color Doppler and pulse wave in both cross-sectional and longitudinal planes. The accurate identification of all vascular structures decreases the likelihood of venous puncture, venous sheath placement, arteriovenous fistulas, and tibial artery spasm. By allowing direct visualization of the lumen in the longitudinal plane (Figure 2B), operators will be able to maneuver the guidewire around the plaque (Figure 2C) and avoid punctures of the posterior wall. It also allows for identification of heavily calcified distal tibiopedal vessels (Figure 3), which is of paramount importance, as sometimes we may be able to achieve access in segments that are proximal (cephalad) to distal total occlusions and can lead to prolonged procedures that will end with no outflow and no benefit to the patient.

Figure 1. A 15-MHz i7 hockey stick probe.

RETROGRADE OR ANTEGRADE COMMON FEMORAL ARTERY ACCESS

In our lab, we use the Site-Rite Vision ultrasound system (Bard Access Systems, Inc., Salt Lake City, UT) or

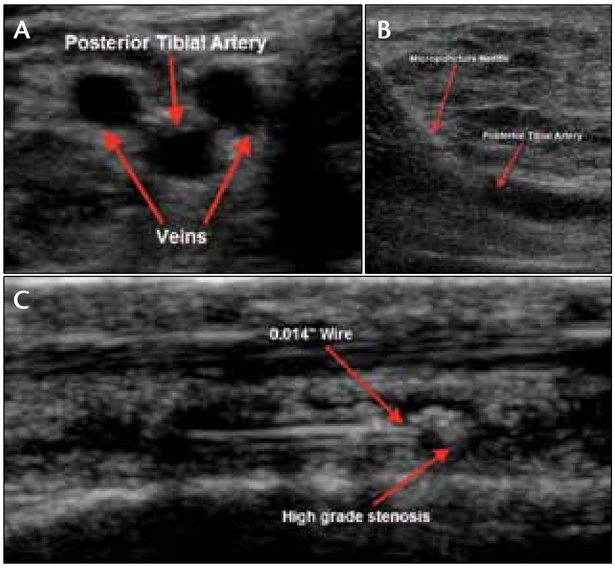

Figure 2. Ultrasound image obtained using the hockey stick probe (A). The short and long access views reveal the access point (B). The operator will monitor the introduction of the access needle. Retrograde tibial access will identify a hibernating lumen of these vessels not identified with traditional angiography due to proximal vessel occlusion. It is our practice to visualize the wire under ultrasound guidance while it is traveling inside the vessel (C). Once access is gained into the tibial vessel, a microsheath is introduced into the vessel.

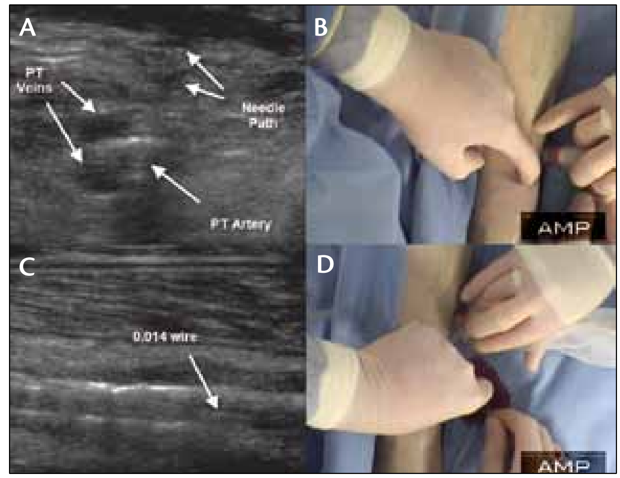

Figure 3. The position of the veins in relationship to the artery and the projected safe path for the access needle (A). The relationship between the ultrasound probe and the access needle (B). Notice the steep angle of the needle to ensure it crosses the ultrasound path at the level of the target vessel. After achieving access in a cross-sectional view, switch to a long access view to advance the guidewires and ensure that they are in the true lumen (C). Sheath advancement under ultrasound guidance (D).

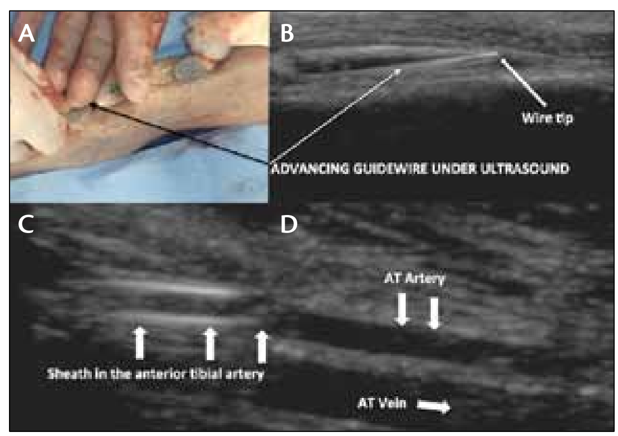

Figure 4. Ultrasound-guided needle access in the anterior tibial artery (ATA) (A). Access guidewire visualized under ultrasound (B). Ultrasound visualization of the tibial sheath in the ATA (C). Ultrasound visualization of the ATA and AT vein (D).

the Linear 15 MHz probe with the iU22 xMatrix (Philips Healthcare). The optimal entry site is identified under direct ultrasound visualization by localizing the bifurcation of the common femoral artery (CFA) into the deep femoral and the superficial femoral arteries (SFAs). The transducer is then moved cranially or caudally to identify the CFA. Longitudinal imaging of the CFA, SFA, and profunda artery is performed. Then antegrade or retrograde access is obtained in either the CFA or SFA depending on the approach being used. If there is significant CFA disease, then the SFA is chosen in a noncalcified area to allow for the use of a closure device at the end of the case to achieve hemostasis.

CROSSING CHRONIC TOTAL OCCLUSIONS

Ultrasound is able to visualize wires, balloons, stents, atherectomy devices, and all of the tools in the armamentarium of endovascular specialists. Real-time visualization of the wire maneuvering in the true lumen (Figure 4), and in areas where the wire stops advancing, allows us to avoid maneuvers in which the wire would normally advance into the subintimal space. Instead, we can redirect our efforts and stay within the true lumen. Of paramount importance has been the ability of ultrasound to identify the "hibernating lumen," which describes the hypoechoic vessel segments located between the proximal and distal chronic total occlusion (CTO) caps (Figure 5), as it does not show evidence of flow by color flow, power Doppler, or pulse-wave Doppler.

EVALUATING APPOSITION OF THE BALLOON OR STENT TO THE ARTERIAL WALL

This particular application is of incredible utility. Generally, apposition is judged by a visual estimate of the balloon size to the presumed arterial lumen size by the

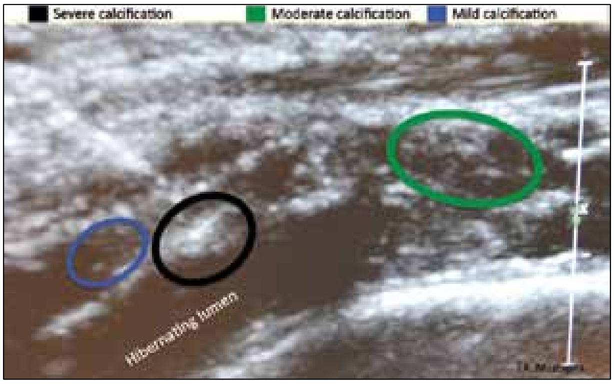

Figure 5. Extravascular ultrasound (EVUS) showing the variable densities of calcium deposits in a peripheral CTO cap of a patient with critical limb ischemia.

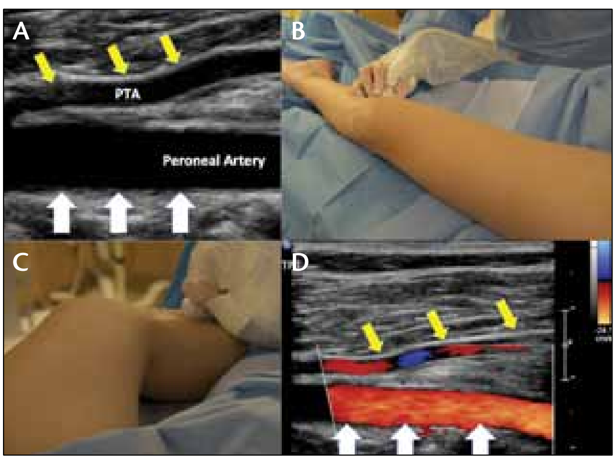

Figure 7. White arrows showing the proximal peroneal artery (A, D). Yellow arrows showing the proximal posterior tibial artery (PTA). The ultrasound probe position to visualize the proximal segments of the PTA and proximal peroneal artery (B, C).

information obtained from the column of contrast seen on angiography. We have proven that most of the time, our balloons are not apposed against the arterial wall (by ultrasound) when it appears that they are by angiography.

DISCUSSION

All of these applications are possible without the use of iodinated contrast and radiation, which significantly decreases the amount of dye that patients receive and the radiation exposure that both patients and operators are submitted to during these prolonged procedures. Some limitations to the use of ultrasound in endovascular interventions mainly stem from the limited resolution for evaluating tibial vessels among patients with significant lower extremity edema and large body habitus and for deep arterial segments such as the proximal tibial arteries and the peroneal artery. We have adopted the use of a 17-MHz probe to better visualize the

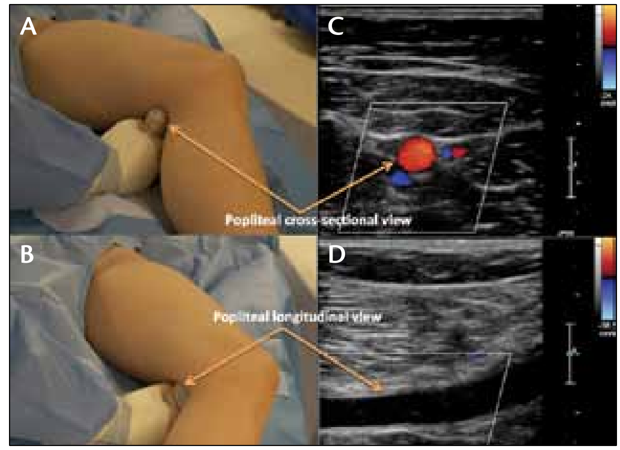

Figure 6. Leg and ultrasound probe positioning for cross-sectional visualization of the popliteal artery (A). Leg and ultrasound probe position for longitudinal visualization of the popliteal artery (B). Ultrasound image of the popliteal artery in cross-sectional view with color flow (C). Ultrasound image of the popliteal artery in longitudinal view (D).

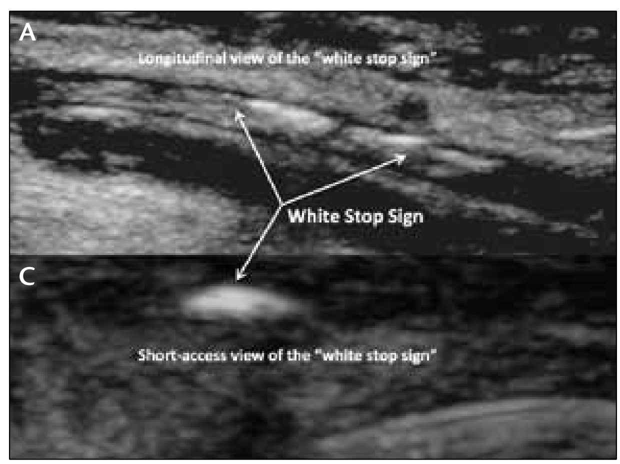

Figure 8. Longitudinal (A) and cross-sectional (B) views showing a severely calcified plaque occupying the full lumen of the tibial vessel, consistent with the white stop sign.

popliteal and proximal tibial arteries (Figures 6 and 7).

The use of ultrasound as part of our approach to revascularization does not end in the angiography suite. We have implemented a protocol system by which patients undergo a systematic evaluation both before (to identify access sites and therapeutic targets based on the angiosome concept, which allows us to plan the strategy ahead of time) and after the procedure as part of the prespecified follow-up to monitor vessel patency after endovascular or surgical intervention.

Some CLI patients have severe plaque burden that is complicated with severe calcification, making it impossible to access or cross these types of lesions. We refer

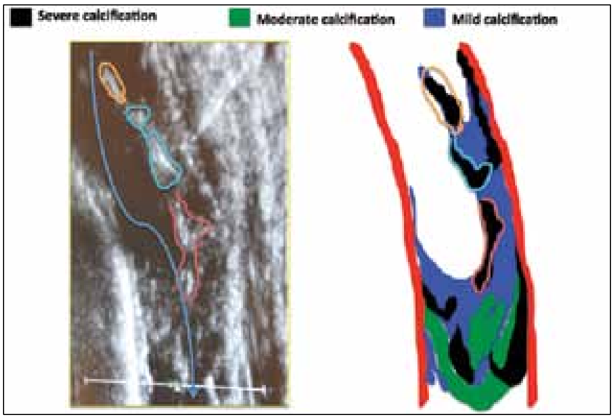

Figure 9. Ultrasound mapping of a severely calcified and ulcerated CTO cap (left). Graphic mapping depicting the calcium distribution within a tibial plaque (right). Note the variable densities of calcium deposit based on color differentiation.

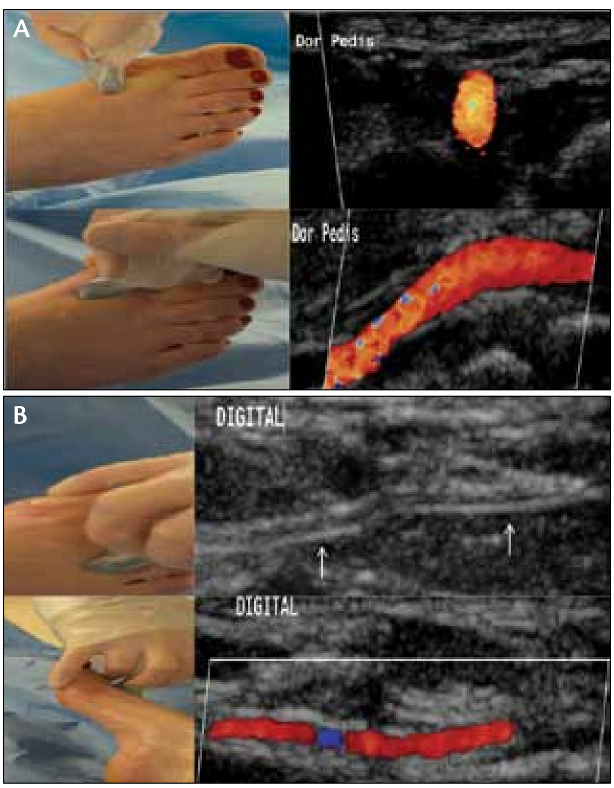

Figure 11. Ultrasound probe used to visualize the dorsalis pedis artery in cross-sectional view with color and longitudinal view with color (A). Hockey stick probe used to visualize the first digital branch in longitudinal view with and without color (B).

to this phenomenon as the "white stop sign" (Figure 8). Extravascular ultrasound (EVUS) has become a primary tool in our daily quest in CLI therapy, sometimes in combination with fluoroscopy. We believe EVUS has a significant impact on accessing, crossing, and treating complex CLI anatomy.

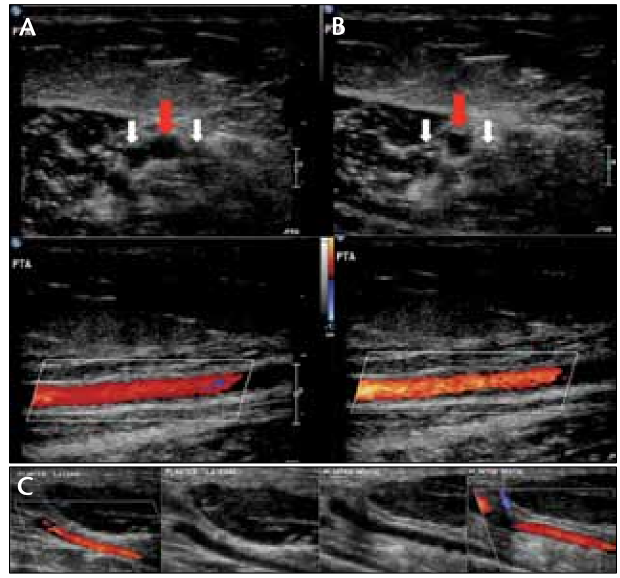

Figure 10. Red arrow showing the PTA, white arrows showing the posterior tibial veins (PTVs) in a noncompressed imaging format (A). Red arrow shows the PTA still open while the PTV closed during a compressed imaging format (B). The medial and lateral plantar arteries with and without color (row, C)

EVUS provides valuable plaque morphology data that can help to determine which therapy to use for different types of plaque (Figure 9). EVUS can visualize tibial pedal vessels with clearly defined anatomy in the tibial arteries, plantar arteries, mid to distal dorsalis pedis arteries and digital branches (Figures 10 and 11). ■

Jihad A. Mustapha, MD, is with the Department of Internal Medicine, Cardiovascular Medicine, Metro Health Hospital, and is Assistant Clinical Professor of Medicine, Michigan State University COM. He has disclosed that he is a trainer and consultant for CSI, Bard, Cordis, Cook, Terumo, and Covidien, and a research investigator for Cook and Bard. Dr. Mustapha may be reached at jihad.mustapha@metrogr.org.

Matthew Sevensma, DO, is with the Department of Internal Medicine, Cardiovascular Medicine, Metro Health Hospital and is Assistant Clinical Professor of Medicine, Michigan State University COM. He has disclosed no financial interests related to this article.

Larry J. Diaz-Sandoval, MD, is with the Department of Internal Medicine, Cardiovascular Medicine, Metro Health Hospital and is Assistant Clinical Professor of Medicine, Michigan State University COM. He has disclosed that he is a consultant to Cardiovascular Systems, Inc.

Fadi Saab, MD, is with Metro Health Hospital in Wyoming, Michigan, and Michigan State University in Lansing, Michigan. He has disclosed that he is a consultant to Cardiovascular Systems, Inc., and Bard Peripheral Vascular.