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Case Report

The Mechanism of Peripheral Recanalization by Laser-Assisted Thermal Angioplasty: Confirmation by Intravascular Sonography

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The mechanism of recanalization during laser-assisted angioplasty in the treatment of obstructive atherosclerotic vascular disease has been controversial. Initial reports claimed that the laser-heated metal-tipped probe ablated atheroma as the hot tip "sought the lumen" and progressed down the artery as it created a new lumen in the central portion of the plaque [1-3]. In distinction to the initial animal and clinical studies, an in vitro study of the mechanism of recanalization with laser-assisted thermal angioplasty found it to be a predominantly mechanical process in which the laser probe was deflected by the hard, fibrocalcific plaque away from the true lumen and followed a dissection plane between the intimal plaque and the arterial media [4]. However, in human clinical trials, it is difficult to prove the exact pathway of the laser probe by using angiography or angioscopy.

Recent work has documented the feasibility of imaging arteries in cross-section with a miniaturized catheter-mounted sonographic transducer that generates arterial images from inside the artery lumen [5, 6]. This report documents that the information obtained from the intravascular sonographic device in vivo is consistent with the hypothesis derived from our in vitro study for the mechanism of recanalization by the laser probe.

Case Report

A 73-year-old man with claudication had bilateral superficial femoral artery (SFA) occlusions at the bifurcation with the common femoral artery. Both popliteal arteries were reconstituted, and distal runoff was good. The patient refused surgical intervention but was willing to undergo percutaneous angioplasty. The length of the occlusion of the right SFA was 20 cm, and the left SFA was occluded 23 cm.

The right femoral artery was recanalized in a retrograde fashion from a puncture in the popliteal fossa. A 1.5-mm-diameter laser probe (Model PLR-plus, Trimedyne Inc., Santa Ana, CA) was inserted and advanced under fluoroscopic control through an introducing sheath and an 8-French angioplasty guiding catheter. The laser probe was used as a cold mechanical device without turning on the argon laser. The laser probe was advanced by using intermittent forward pressure to puncture the occlusive atheroma. The course of the laser probe was followed under fluoroscopic control until it advanced to the proximal end of the SFA and reentered the lumen of the common femoral artery. The laser probe was then removed, and a guidewire was inserted through a 7-French diagnostic catheter, which was used in a rotary maneuver to enlarge the communication between the SFA and the common femoral artery. The 20-MHz sonographic catheter (InterTherapy, Inc., Costa Mesa, CA) was advanced in the new channel to the level of the common femoral artery.

Figure 1A shows the intravascular sonogram that was obtained at the level of the distal SFA before the sonographic catheter entered

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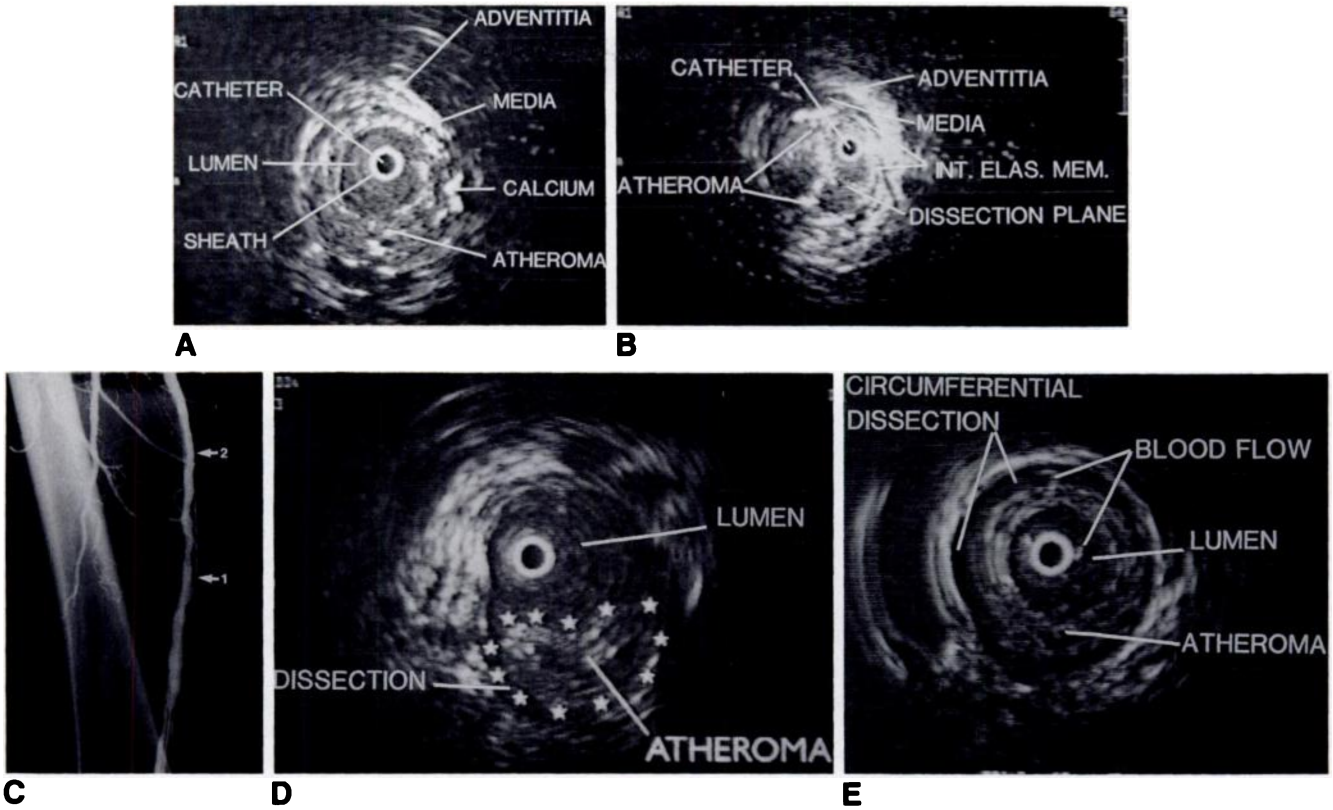

Fig. 1.—*A*, Intravascular sonogram in distal superficial femoral artery before entering area of recanalization. Central black area is from catheter; around this is a white echo reflection from plastic sheath. In a radial distribution is echolucent lumen, then a thick atheroma with variable echo reflections depending on amount of collagen within plaque or presence of calcium.

***B*, Sonogram shows path of laser probe in vivo. Instead of recanalizing artery through central atheroma, catheter is in a dissection plane between atheroma and internal elastic membrane.**

***C*, Angiogram of superficial femoral artery after laser-probe recanalization and balloon angioplasty shows a patent vessel with areas of dissection.**

***D*, Sonogram obtained at level 1 in C shows an eccentric atheroma that has been deformed by balloon. Note dissection around capsule of atheroma that separates atheroma from media.**

***E*, Sonogram obtained at level 2 in *C* shows concentric atheroma that has not been torn at this level, but has been separated from media almost circumferentially. Real-time sonography showed blood pulsating in dissection plane and in lumen.**

the area of recanalized SFA. The echolucent media, which defines the extent of the atheroma, can be seen in the superior and inferior portions of the image. The dimensions of the lumen are 4.4 × 3.6 mm or 14.0 mm^2 by planimeter measurement. Calcification is observed on the right side as intense echo-reflectance with dropout of echoes and shadowing peripherally to this area. The total atheroma area is 30 mm^2, which is 68% of the total available cross-section area within the boundary of the media. The artery at the level where this sonogram was obtained appeared to be normal angiographically.

At a more proximal level, in the area of the SFA that was recanalized, the sonogram showed the pathway that was taken by the laser probe (Fig. 1B). Moving from the peripheral portion of the artery on the right side of the image across to the left, the following structures are visualized: The adventitia is intensely echo-reflective followed by an echolucent circumferential line of media, followed by the echogenic thin line from the reflections from the internal elastic membrane. More central is a dissection plane in which the sonographic imaging catheter is situated. To the left and medial to the catheter are dense echo-reflections from calcium and atheroma that had previously occluded this portion of the SFA, but were mechanically pushed aside by the laser probe and guiding catheter as they created the dissection plane between the atheroma and the internal elastic membrane.

After this initial observation with the sonographic catheter, balloon angioplasty was performed from the level of the adductor canal to the common femoral artery. The angiogram (Fig. 1C) showed adequate patency of the SFA. The sonographic catheter was reinserted, and multiple images were obtained along the length of the SFA. Examples of the effect of balloon dilatation as visualized by the sonographic catheter in vivo are shown in Figures 1B and 1C. At the midportion of the SFA (Fig. 1B), the lumen is reconstituted and measures 6.1 × 5.2 mm in diameter or 23.8 mm^2 in cross-sectional area. In addition, a dissection is present around the eccentric atheroma plaque, which separates the atheroma from the media. The atheroma plaque is 16.4 mm^2 in area and has a deformation consistent with a compression effect of the balloon. In addition, there is a central echolucent arc in the atheroma that is interpreted as representing the original lumen after it was compressed by the balloon inflation in the new periatheroma dissection plane.

At a more proximal portion of the SFA (Fig. 1C), the balloon inflation created almost a complete circumferential dissection with separation of the atheroma from the wall of the artery for 300°. In real time on the video monitor, the atheroma appeared to move independently of the media and external wall of the artery. In addition, because of the relatively slow flow in the lumen, intermittent pulsations of echo-reflectance were seen in the central lumen around the sonographic catheter sheath and also in a portion of the dissection plane (at 12 o'clock), indicating that blood was flowing within this newly created dissection. This type of dissection plane suggests that the atheroma plaque was torn away from the media wall by a force of torsion, which might explain why the dissection was completely circumferential. This type of torsion dissection was observed in our in vitro study [4]; however, it was believed that this was an artifact of the in vitro preparation. The observation from the intravascular sonographic study shows that this type of dissection also exists in vivo and is not due to manual manipulation or histologic preparation.

Discussion

Although laser angioplasty has tremendous potential for expanding the treatment of obstructive atherosclerotic disease, serious complications such as vasospasm, thrombogenicity, and vessel perforation have diminished the initial enthusiasm. This case adds evidence that the predominant mechanism of recanalization in laser-assisted thermal angioplasty is a mechanical process in which the laser probe is deflected by the atheromatous plaque to follow a dissection plane along the arterial wall within the boundary of the internal elastic membrane [4]. In addition, this case demonstrates that the laser-probe catheter can successfully recanalize an occluded artery without the use of laser energy.

Given the technology and cost required to perform laser angioplasty, a definitive demonstration of its superiority over conventional techniques in the treatment of obstructive atherosclerotic vascular disease is necessary [7]. In fact, the application of thermal energy to this process may be detrimental; therefore, randomized clinical trials are necessary to compare the two techniques directly [8].

This report supports the hypothesis that the pathway of recanalization by the laser probe observed in the in vitro studies also occurs in vivo. Not only does intravascular sonography provide a means to study the effect of balloon or laser angioplasty, it also allows accurate quantification of the lumen and atheroma cross-sectional areas. Intravascular sonography could significantly increase our understanding of the pathophysiology of atherosclerotic peripheral disease.

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