Thermal Endovenous Ablation of the Saphenous Vein

The histological findings of endovenous ablation show that it is a successful treatment option.

BY RONALD BUSH, MD, FACS

Thermal endovenous ablation of the saphenous vein, either by laser or by means of radiofrequency (RF)-induced heat, is rapidly becoming the treatment of choice for insufficiency of the greater saphenous vein and the short saphenous vein. The main reasons for this switch from standard surgical procedures are the ease, cost effectiveness, and rapid recovery time. Also, it is an office-based procedure and requires no conscious sedation. Another important aspect is that neovascularity at the greater saphenous vein junction very rarely occurs after truncal ablation.

At the Midwest Vein Center in Dayton, Ohio, we have performed more than 3,000 ablations since 2001. Our preferred choice is laser thermal ablation because it is more effective in terms of recanalization rates, and there are fewer complications compared to RF.

We recently completed a histological comparison of the effects of different laser wavelengths on the saphenous vein. Our goals were to better understand the mechanism of injury, any differences in injury with regard to wavelength, and what actually occurs at 3 to 4 months when, by ultrasound, the treated vein is barely visible. All patients gave informed consent to be included in this study. To be included in the study, the distal saphenous vein had to be within 2 cm of the skin surface around the knee level for ease of removal of the vein either at the time of the acute injury study or at 3 to 4 months thereafter. At the time of ablation, access was through either a cutdown at the knee level or percutaneous puncture. Endovenous ablation was done in the standard method, as has been described in numerous publications. Compression of the vein by hand was not done because this increases the likelihood of contact of the laser tip to the vein wall, which leads to perforation. Using different laser wavelengths and, in one patient, using RF, determination of histological findings was made after removing the distal portion of the vein at the completion of the endovenous ablation procedure, or at intervals thereafter.

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ACUTE INJURY FINDINGS

Table 1 shows our findings in comparing the different wavelengths in regard to not only the histological examination but also the presence or absence of perforation. In microscopic examination after fixing with hematoxylin and eosin stain, the subsequent findings were common to all specimens. Uniformly, there was loss of endothelium. In the muscularis level, there were minimal findings but usually some evidence of mild damage, except in veins that had perforation in which there was frank evidence of disruption and damaged muscle fibers in the vicinity. In the 810-nm, 940-nm, and 980-nm groups, delivery of energy in the continuous pullback mode uniformly caused perforation. Using the pulsed method (thermal relaxation time between firings), there were no perforations (940-nm group). At 60 J/cm, which correlated to a rapid pullback, there was lack of perforation in the 980-nm group. In the 1,319-nm group

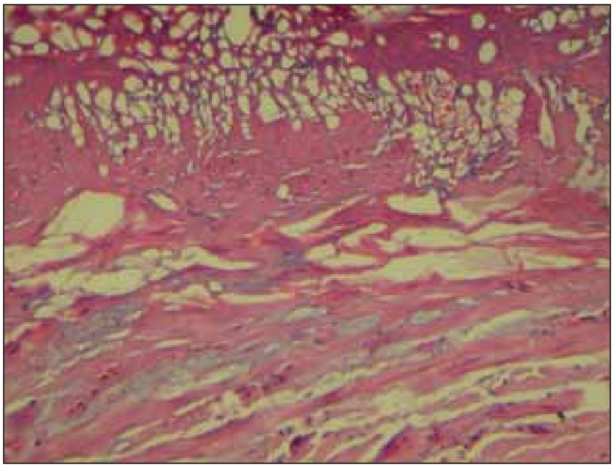

Figure 1. Vacuoles in a 1,319-nm–treated vein.

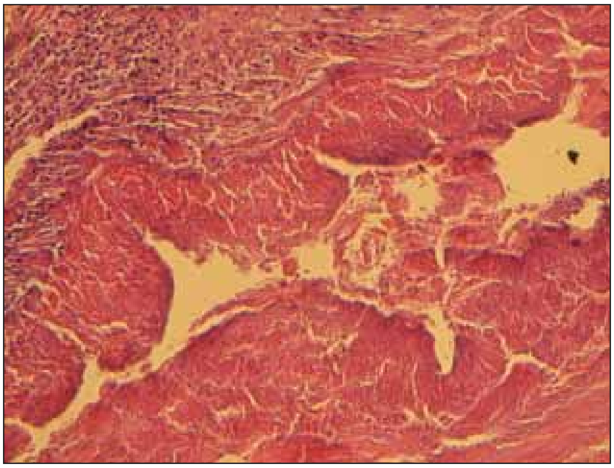

Figure 2. A 940-nm–treated vein at 4 months.

(we assume identical findings with the 1,320-nm wavelength), continuous pullback below 9 W did not perforate the vein. Histological findings acutely revealed the formation of vacuoles in the muscularis layer (Figure 1). This was not seen with the 810-nm, 940-nm, or 980-nm groups. This is partially due to increased heat absorption by the subendothelial layers, secondary to the greater affinity for water in this wavelength. In the one RF specimen studied, perforation was apparent with the vacuoles present in the outer muscularis level just beneath the adventitia.

After injury with thermal ablation, all veins developed a thrombus. What occurs next leads to the eventual obliteration of the lumen and makes this procedure effective. All clots undergo reorganization or what is commonly known as *remodeling*. However, negative modeling soon ensues with massive collagen deposition.

LONG-TERM FOLLOW-UP STUDIES

Three specimens were examined at 2 months: 940 nm (2), 1,319 nm (1); and five specimens at 4 months: 940 nm (3), 1,319 nm (2). At 2 months, inflammatory cells were present in the muscularis level. There were eosinophils and neutrophils present. The clot itself showed numerous areas of recanalization, which was apparent by numerous small blood vessels. However, there were few red cells in these vessels. Recanalization is a form of remodeling of the thrombus after entry. The majority of these small ves-

TABLE 1. ACUTE STUDY OF DIFFERENT WAVELENGTHS IN REGARD TO HISTOLOGICAL EXAM AND THE PRESENCE OR ABSENCE OF PERFORATION

Laser or RF	Number of Patients	Absence of Endothelium and Subendothelium	Subendothelium Changes	Perforation
8 W (810 nm) 1 mm/s	3	+, -	+	+
10 W (940 nm) 1 mm/s	6	+	+	+
18 W (940 nm) pulsed	17	+	+	-
10 W (980 nm) 1 mm/s	2	+	+	+
10 W (980 nm) 3 mm/s	1	+	+	-
7.4 W (1,319 nm) 1 mm/s	4	+	+	-
8.4 W (1,319 nm) 1 mm/s	5	+	+	-
9 W (1,319 nm) 1 mm/s	2	+	+	+
RF (VNUS)	1	+	+	+

sels have regressed and collagen is now a predominant finding in 4 to 6 months. Many fibroblasts were also present. By 4 months, a marked change occurred. Numerous fibroblasts were present in the old thrombus. The predominate histological finding was collagen, as previously mentioned. There were even more inflammatory changes in the muscularis level with collagen also being deposited there. This was more marked in the 940-nm group (Figure 2) when compared to the 1,319-nm group. Whether this will be of clinical significance remains to be determined. In some specimens studied, the muscularis level was almost totally replaced with collagen. This finding was uniform throughout the area of the cross section that was studied. This means that contact with the laser tip to the vein wall was not the mechanism of injury. When a comparison was made between a normal skin scar and histological findings after thermal ablation vein, the two were almost identical.

CONCLUSION

The acute findings after thermal ablation were almost identical except for vacuole formation in the 1,319-nm group. In comparing the 1,319-nm and 940-nm groups at 4 months, identical results were seen histologically but were much more pronounced and intense in the 940-nm group. The mechanism of injury with the laser was steam bubbles that occur after activation of the laser in the saphenous lumen. Our preliminary temperature study shows this temperature is between 95˚C and 100˚C at the laser tip, with a rapid decrease in temperature 1 cm from the point of activation (45ºC). The loss of intimal surface caused acute thrombosis of the vein. Barring any persistent flow (ie, perforator or large branch), remodeling of the clot occurred. The infiltration of macrophages, neutrophils, and eosinophils occurs first followed by the intense mobilization of fibroblasts in response to the injury. Collagen secretions by these fibroblasts led to the formation of a matrix almost identical to that of scar formation. If there was not a focus of high flow into the thrombus, this process will be completed, and the vein will become obliterated within 4 to 6 months.

The fibroblasts and their response to thermal injury are what make endovenous ablation successful. Fibroblast migration occurs from the advential layer to infiltrate the thrombus with eventual extracellular matrix (collagen) deposition. ■

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