Histological Evidence of Angiogenesis 9 Months After Transmyocardial Laser Revascularization

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A 66-year-old white male with end-stage ischemic cardiomyopathy was referred to our center for transmyocardial laser revascularization (PLC Eclipse Surgical Technologies) in July 1999. The patient had a long history of interventions for his coronary artery disease, including multiple percutaneous transluminal coronary angioplasties, stent placement in 1991 and 1993, and coronary artery bypass grafting in 1987 and 1992. He was evaluated for a third bypass, but we determined he was not a suitable candidate because of his diffuse small vessel distal coronary artery disease. Given the limitations of conventional therapeutic options, the patient underwent transmyocardial laser revascularization in July 1999. Thirty transmural channels were lased in the ischemic anterior and lateral walls of the left ventricle. The patient tolerated the procedure well and received anginal relief for the following 6 months; he then experienced recurrent symptoms of angina and progressive cardiac failure. Stress thallium-201 imaging at that time demonstrated increased ischemic areas in the posterior and inferior myocardium, with improved perfusion in the previously lased anterior and lateral walls. His clinical situation continued to deteriorate, and he was listed for and subsequently received a heart transplant in March 2000. At that time, his native heart was explanted and examined for evidence of angiogenesis in the lased areas of myocardium.

Gross inspection of cross-sections of the explanted heart revealed visible scar tissue in the inferior and posterolateral areas, consistent with old myocardial infarctions; however, no grossly visible scar tissue was evident in the anterolateral lased wall of the left ventricle, either on the epicardial surface or within the myocardium. The hematoxylin and eosin stained, paraffin-embedded sections of the anterolateral wall of the left ventricle demonstrated residual lased channel remnants, which were \( \approx 1 \) mm in diameter and, therefore, were not evident during gross evaluation (Figure 1). Masson trichrome stains of the same area at the same magnification revealed minimal perichannel scarring (Figure 2). Higher magnifications of the hematoxylin- and eosin-stained sections showed multiple vessels within the channel remnant and adjacent to the channel (Figure 3). Red blood cells were present within the lumen (Figure 4). These vessels showed positive immunohistochemical staining for CD31 and factor VIII antibody, thus demonstrating the presence of endothelial linings (Figure 5). Capillary vascular density analysis performed under high-powered fields on 5 randomly chosen lased areas revealed a mean vessel count of 3989±540; the respective vascular densities of the nonlased areas of the left and right ventricle were 1565±196 and 1523±140 vessels \((P<0.001)\).

To our knowledge, the photomicrographs presented here represent the longest follow-up to date after transmyocardial laser revascularization.1–3 This is also the first time that red blood cells have been visualized in these neovessels.

References
Figure 1. Hematoxylin and eosin stain at low power (1×; reduced 50%) of transmyocardial laser revascularization channel remnant in anterior wall of left ventricle. At this magnification, there appear to be a number of perpendicular channels that communicate with lased channel remnant. Scale, 6 cm=1 mm.

Figure 2. Masson trichrome stain (4×; reduced 50%) of same lased channel remnant demonstrating minimal scarring in surrounding area of myocardium, with numerous blood vessels within channel remnant and branching from channel. Scale, 6 cm=1 mm.

Figure 3. Hematoxylin and eosin stain at higher power magnification (4×; reduced 50%) of transmyocardial laser revascularization channel remnant demonstrating a number of blood vessels within channel and adjacent to it. Scale, 1.5 cm=100 μm.
Figure 4. A high-powered magnification (10×; reduced 50%) of hematoxylin and eosin stain demonstrating neoblood vessels containing red blood cells. Scale, 1.5 cm=25 μm.

Figure 5. Factor VIII antibody stain (10×; reduced 50%), demonstrating presence of endothelial-lined vessels adjacent to channel remnant. At this high-powered view, an endothelial-lined blood vessel adjacent to channel remnant is evident. Scale, 1.5 cm=50 μm.