Peripheral Laser Thermal Angioplasty

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By partially removing obstructing atheroma or thrombus through vaporization of tissue rather than merely stretching or fracturing the plaque as in conventional balloon angioplasty, laser angioplasty or laser recanalization has the potential to serve as an aid or alternative to balloon angioplasty by: 1) increasing the initial success rate for lesions that are difficult or impossible to treat by conventional means or, 2) decreasing the incidence of restenosis after angioplasty.

However, in initial experimental studies and early clinical trials with bare argon or neodymium YAG laser fiberoptics, the technique was limited by inadequate delivery systems resulting in an unacceptable high perforation rate and the creation of small recanalized channels that resulted in poor long-term patency.

Initial Clinical Trials With Bare Fiberoptics

In early clinical trials of laser angioplasty, several studies were initiated using bare fiberoptics positioned inside angiographic or balloon catheters. Ginsberg et al were the first to report a case of successful peripheral argon laser angioplasty. Subsequently, they reported success in 8 of 17 (47%) peripheral vessels, with three laser perforations. Cumberland et al, performing argon laser-assisted balloon angioplasty, noted luminal improvement after laser recanalization in 10 of 15 (67%) vessels with two laser perforations of no clinical significance. In addition, Geschwind et al has reported successful percutaneous peripheral laser angioplasty using a neodymium YAG laser positioned inside a balloon catheter in three patients; however, clinical or angiographic follow-up was not included in this brief report.

One ongoing clinical study uses an angioscope to visualize laser recanalization under direct vision during peripheral artery bypass surgery in an attempt to diminish the incidence of vessel perforation. Initial clinical attempts using the angioscope to direct a bare argon fiberoptic fiber were still plagued by perforation in 6 of 13 arteries; however, better results were obtained in later cases performed with a 2-mm laser-heated metallic-capped fiber similar to that to be discussed later. Whether or not angioscopy will improve the safety of laser angioplasty remains to be determined.

Thus, the key limitation in these early clinical trials of laser angioplasty was the lack of an adequate catheter system for safe and effective intravascular delivery of laser energy. The first, but certainly not the last, laser fiberoptic catheter system that shows promise in preliminary animal and clinical trials is a laser-heated metallic-capped device or laser probe.
Laser Thermal Angioplasty: Experimental Results

In the last few years a novel fiberoptic laser delivery system has been developed (Trimedyne, Inc, Santa Ana, CA) in which argon laser energy is converted to heat in a rounded metallic cap at the end of a fiberoptic (Fig 22.1). With this device, temperatures of more than 400°C can be generated at the metallic cap. In initial studies in experimental atherosclerotic animals compared angiographic and histologic results with this new laser device to those of a bare fiberoptic. In a series of in vivo experiments involving the iliac arteries of 24 atherosclerosis rabbits, improved safety and efficacy of laser thermal angioplasty using this modified fiber was demonstrated compared with a conventional bare fiberoptic. The results of angiography indicated that widening of luminal stenosis was seen in only 2 of 12 animals treated with the standard fiberoptic system compared with 8 of 12 animals treated with laser thermal angioplasty ($P < 0.01$). In these 8 animals, the mean percent stenosis was 68% before treatment and was reduced to 13% after treatment. An angiographic example of laser thermal angioplasty is shown in Fig 22.2. More importantly, perforation of the vessel wall occurred frequently with the fiberoptic fiber (9 of 12 animals) as opposed to only one mechanical perforation in 12 animals treated with the laserprobe ($P < 0.001$). With the use of smaller more flexible fiberoptics (less than a 300-μm core diameter) mechanical perforation was eliminated entirely.

In histologic examination 30 minutes after laser angioplasty, strikingly different results were obtained with the two fiber systems (Fig 22.3). With direct laser radiation from the bare fiberoptic, a deep but localized laser defect with near perforation of the vessel wall was