Percutaneous Coronary Laser Thermal Angioplasty

TIMOTHY A. SANBORN, MD, DAVID P. FAXON, MD, FACC, MIRLE A. KELLETT, MD, FACC, THOMAS J. RYAN, MD, FACC
Boston, Massachusetts

Percutaneous coronary laser thermal angioplasty was successfully performed before conventional balloon angioplasty in a 55 year old white man with a 90% left anterior descending artery stenotic lesion and angina at rest (Canadian Heart Association class IV). The lesion was reduced to 50% residual stenosis using a 1.7 mm laser-heated metallic capped fiber and two pulses of 8 W of argon laser energy, each delivered for 5 seconds. With subsequent balloon angioplasty, the lesion was further decreased to 10% residual stenosis. The entire procedure was well tolerated without chest pain or burning.

The use of laser energy transmitted through flexible fiberoptic fibers has the potential to serve as an adjunct or alternative to conventional balloon angioplasty because it removes obstructing atheroma or thrombus by vaporization rather than by merely stretching or fracturing the plaque as balloon angioplasty does (1). However, to date the technique of laser recanalization or laser angioplasty has been limited by inadequate delivery systems that result in an unacceptably high perforation rate in experimental (2,3) and clinical studies (4,5). In addition, direct laser angioplasty creates small recanalized channels that result in poor long-term patency (4). Recently, a novel fiberoptic laser delivery system has been developed (Trimedyne, Inc.) in which argon laser energy is converted to heat in a rounded metallic cap at the end of a fiber (6) (Fig. 1). Experimental studies in atherosclerotic rabbits (2) indicate that less vessel perforation and greater resolution of angiographic stenoses were possible with this laser-heated probe than with bare fibers.

With this background in experimental animals, a clinical trial was conducted with the laser-heated probe in which percutaneous laser recanalization was possible in 50 (89%) of 56 femoropopliteal occlusions (7). Thus, laser thermal angioplasty as an adjunct to balloon angioplasty was found safe and effective in human peripheral vessels and there was a suggestion that the technique may increase the proportion of patients suitable for angioplasty. Based on this experience, a trial of percutaneous coronary laser thermal angioplasty as an adjunct to balloon angioplasty was begun using a specially designed 1.7 mm coronary laser-heated probe developed in a canine model (Sanborn TA, et al., unpublished results). This brief report describes our first experience with percutaneous coronary laser thermal angioplasty.

Case Report

A 55 year old white man was referred for angioplasty of a 90% eccentric left anterior descending artery lesion because of a 6 month history of angina on effort progressing in severity to angina at rest (Canadian Heart Association class IV) despite treatment with nadolol (40 mg/day), nitroglycerin patch (10 mg/day), nifedipine (20 mg three times/day), aspirin (325 mg three times/day) and dipyridamole (75 mg three times/day). On June 27, 1986, after informed consent was obtained under a protocol approved by the Institutional Review Board at University Hospital, Boston University Medical Center and the United States Food and Drug Administration, the patient was prepared for laser thermal angioplasty using standard angioplasty techniques by way of the percutaneous femoral approach. After heparin bolus (10,000 U given intravenously) and intracoronary nitroglycerin administration (200 μg), biplane right vessel perforation or spasm, thrombus formation or embolization of debris. The patient was free of pain at 1 month follow-up.

This case demonstrates the feasibility of safely performing percutaneous coronary laser thermal angioplasty. Additional studies are indicated to determine the clinical role and potential benefits of coronary laser thermal angioplasty in relation to the established procedures of bypass surgery and conventional balloon angioplasty. (J Am Coll Cardiol 1986;8:1437–40)
and left coronary arteriography confirmed a 90% eccentric atherosclerotic or thrombotic left anterior descending artery lesion located just after the first septal perforator.

**Laser thermal angioplasty procedure.** With an 8F large lumen guiding catheter (USCI) in place in the ostium of the left main coronary artery, a 1.7 mm coronary laser-heated probe (Trimedyn, Inc.) on a 300 μm diameter quartz core fiber was advanced through the guiding catheter over a 0.012 inch (0.03 cm) diameter, 118 inch (300 cm) long Kalenbach guide wire (Schneider Medntag). First, under fluoroscopic guidance the guide wire was advanced separately through the lesion into the distal left anterior descending artery with its location confirmed angiographically as in the standard angioplasty technique. Second, the 1.7 mm coronary laser probe was advanced over the guide wire through the left main coronary artery and proximal left anterior descending artery up to the lesion. With gentle pressure, mechanical advancement of the laser probe through the lesion without laser power was attempted but was unsuccessful. Next, advancement of the laser probe was attempted using a 5 second pulse of 8 W of continuous argon laser energy delivered through the fiber from a 14 W argon laser (Optilase, model 900, Trimedyn, Inc.). During advancement of the laser probe, a continuous motion was applied to the device, particularly during the cooling period (2 to 5 seconds), to prevent adherence of the device to the vessel wall.

**Laser thermal angioplasty results.** Laser recanalization of the 90% left anterior descending artery lesion was successfully performed with the 1.7 mm laser probe using two pulses, each lasting 5 seconds. During the first laser pulse delivery, recanalization was not complete, in part because the guiding catheter buckled out of the left main coronary artery. With a better guiding catheter position, the second laser pulse to the laser probe successfully recanalized the lesion. The patient did not experience any chest pain, burning sensation or arrhythmia during the laser pulse delivery. Repeat coronary angiography demonstrated a residual 50% lesion without evidence of luminal irregularities, dye extravasation, spasm, thrombus formation or embolization of debris.

**Balloon angioplasty procedure.** To ensure an adequate lumen after laser thermal angioplasty, conventional balloon angioplasty was performed. Leaving the guide wire in place distal to the lesion, the laser probe was withdrawn from the

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**Figure 1.** A 1.7 mm laser-heated metallic capped fiber positioned over a 0.012 inch (0.03 cm) guide wire. A channel at the distal end of the laser probe allows it to be advanced over the guide wire.

**Figure 2.** The 60° left anterior oblique, 10° caudal views of the 90% eccentric left anterior descending artery lesion (arrows) before treatment (top), after laser thermal angioplasty with the laser probe through the lesion and the angiographic result of laser thermal angioplasty (middle panels) and after balloon angioplasty (bottom).
guiding catheter, a 3.0 mm LPS balloon dilation catheter (USCI) was exchanged over the guide wire and conventional balloon angioplasty was performed. During the laser probe and balloon catheter exchange over the guide wire, there was no significant change in the percent stenosis as documented by repeat angiography just before balloon advancement through the lesion. After the enlargement of the arterial lumen with the laser probe, the residual lesion was crossed very easily with the 3.0 mm LPS balloon catheter. After two balloon inflations to 4 and 6 atm of pressure for 20 and 30 seconds, respectively, repeat angiography revealed a smooth contoured vessel without any luminal irregularities and a 10% residual stenosis. Angiographic examples of the lesion before treatment, after laser recanalization and after balloon dilation are shown in Figure 2. The patient tolerated the entire procedure very well and was discharged home within 48 hours. Four weeks after the procedure, he remains asymptomatic.

Discussion

Percutaneous coronary laser thermal angioplasty. This patient represents the first case report of a successful percutaneous coronary laser thermal angioplasty procedure. The 1.7 mm coronary laser-heated probe proved effective in partially reducing the 90% left anterior descending artery lesion to 50% residual stenosis without any complications such as chest pain, burning, arrhythmia, vessel perforation, spasm, thrombosis, dissection or embolization. A left anterior descending artery lesion was chosen for this first case to evaluate the potential of this technique in a vessel with minimal tortuosity and provide the least risk to the patient (8,9).

Study intent and implications. These results are quite encouraging in that they demonstrate the feasibility of performing percutaneous coronary laser thermal angioplasty safely in a nonoperative setting to remove a coronary atherosclerotic or thrombotic obstruction using standard cardiac catheterization techniques. Prior clinical studies of coronary laser angioplasty have been performed intraoperatively during coronary artery bypass surgery (4,10). The intent of this study was only to document the safety of this procedure, not its effectiveness in assisting balloon angioplasty. However, taken together with a prior study in peripheral vessels (7), this technique of percutaneous laser thermal angioplasty does have considerable potential in expanding the anatomic subsets in which angioplasty is feasible. Conceivably, it may also diminish the incidence of restenosis. Further device modifications will be required, however, to approach the more tortuous coronary vessels and to achieve a more complete result. An important goal in future studies will be to determine the clinical utility of this new technology in the treatment of coronary artery disease in relation to existing treatment modalities such as bypass surgery and conventional balloon angioplasty.

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Addendum

Since this initial case was performed, percutaneous coronary laser thermal angioplasty has been attempted on a total of seven patients at Boston University Medical Center. Laser recanalization proved successful in four patients, but failed in three instances in which vessel tortuosity and device profile prevented complete recanalization of the lesion. In two of these laser angioplasty failures, a successful result was obtained with more flexible, lower profile balloon catheters. In one patient, neither laser recanalization nor balloon angioplasty was successful, and the patient underwent a successful bypass operation. We encountered no perforations, dissections, distal emboli or myocardial infarctions as a result of the laser procedure.

Two brief reports of coronary laser thermal angioplasty have already appeared since this case was performed on June 27, 1986 (11,12). Cumberland et al. (11) used a protocol similar to ours but encountered complications of myocardial infarction or myocardial enzyme elevation in three of four patients. Another group working intraoperatively perforated one of three coronary arteries using a probe designed for peripheral laser angioplasty which was not equipped for passage over a guide wire (12).

While these studies demonstrate that coronary laser thermal angioplasty is feasible, it seems clear that considerable technologic advancements in catheter design are required to improve the safety and efficacy of this new technique.

References

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