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Synergy of Old and New Technology Results in Successful Revascularization of the Anterior Myocardium with Relief of Angina in the Absence of Suitable Targets

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ABSTRACT

Background: Diffuse and distal left anterior descending (LAD) coronary disease that is refractory to conventional surgical and/or percutaneous revascularization represents a clinical and economic dilemma. Transmyocardial laser revascularization (TMLR) has improved angina without clear measurable improvement of myocardial perfusion. This study was undertaken to determine if combining a Vineberg implant with TMLR of the LAD distribution enhances myocardial perfusion and relieves symptoms.

Methods: Twenty-one patients with an obliterated LAD and a viable anterior wall underwent off-pump coronary artery bypass grafting (OPCAB) (2.6 grafts/patient). Eight were studied with preoperative, postoperative-early (4-9 days), and postoperative-late (3-5 months) stress and rest nuclear imaging. In all but 3 cases, the Vineberg implant was modified such that the distal end of the conduit, as it emerged from the muscular tunnel, was anastomosed to any patent LAD segment. The anterior wall, to the left of the LAD, was also instrumented with a Holmium yttrium-aluminum-garnet laser (8-16 sites).

Results: There has been 100% follow-up with durations ranging from 6 to 36 months. There were no deaths. All patients had complete relief of their angina. Serial perfusion scans demonstrated a 2-phase improvement in perfusion. Three of the patients underwent angiography of the implant at 6 to 9 months; angiography in each case demonstrated a patent robust conduit. The 1 patient studied at 24 months demonstrated several sites of a myocardial "blush" consistent with neovascularization.

Conclusions: Although some of the benefits of TMLR/Vineberg may be a consequence of collateral blood flow from other revascularized regions, we believe there to be a synergistic effect on perfusion and angina relief by these combined procedures which may be related to angiogenesis.

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INTRODUCTION

More than 12% of patients with symptomatic coronary artery disease (CAD) have anatomy not amenable to either percutaneous intervention (PCI) or coronary artery bypass grafting (CABG) [Mukherjee 1999]. Under these circumstances transmyocardial laser revascularization (TMLR) has previously been shown to be more effective than medical therapy alone, at least in the short term [Burkhoff 1999]. Furthermore, in this same subpopulation adjunctive TMLR combined with CABG is associated with a lower operative mortality than CABG alone [Allen 2000]. Despite the continued use of TMLR in clinical practice, clear indications for its use have yet to be defined [Peterson 2003].

Half a century ago Vineberg [1950] introduced the concept of indirect myocardial revascularization surgery. However, it was not until the introduction of coronary angiography 20 years later that the clinical benefits of this controversial procedure could be proven [Effler 1965].

It has been suggested that that the efficacy of both TMLR and the Vineberg implant may be due to angiogenesis resulting in improved myocardial perfusion. We therefore hypothesized that combining these 2 therapeutic interventions may result in a synergistic clinical benefit. Here we report the results of our pilot study in a series of 21 patients with an objective focus on myocardial perfusion.

MATERIALS AND METHODS

Patients

Twenty-one patients (16 men, 5 women) with a mean age of 64 years (range, 58-75 years) underwent elective TMLR/Vineberg CABG between June 1999 and December 2003. Three of the procedures were redo CABG, and all but 4 included revascularization of other myocardial regions (2.6 grafts/patient). All patients included in the study had symptomatic CAD, left anterior descending (LAD) disease not amenable to conventional techniques of revascularization

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Figure 1. Coronary arteriography of the left main coronary artery. On this right anterior oblique projection the left anterior descending artery is noted to be a diffusely diseased unsuitable target for either percutaneous coronary intervention or coronary artery bypass graft.

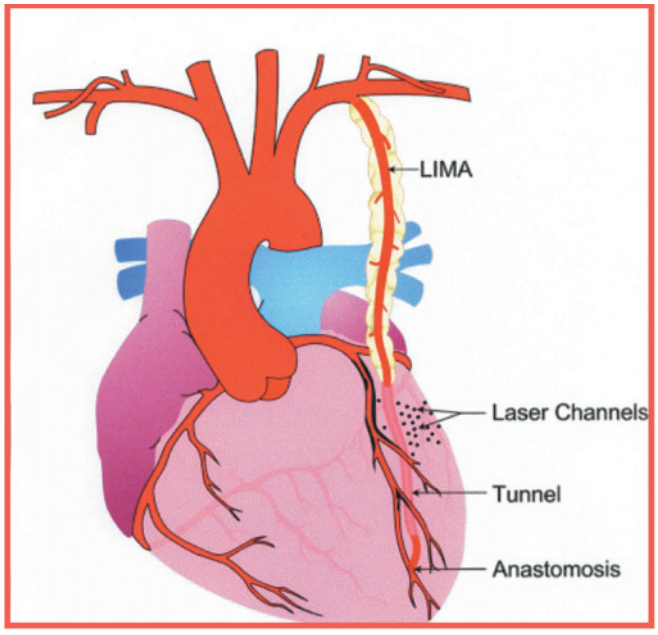

Figure 2. Modified Vineberg implant. The left internal mammary artery (LIMA) is shown here tunneled through the anterior myocardium to the left of the left anterior descending artery (LAD). The distal end of the conduit has been anastomosed to an apical segment of the LAD. Eight to 16 channels have also been created on the anterior wall with the yttrium-aluminum-garnet laser.

(PCI or CABG) (Figure 1), and a viable anterior myocardial wall as indicated by nuclear perfusion imaging.

Operative Techniques

In all relevant cases the Vineberg/TMLR procedure was performed after standard revascularization on the beating heart [Quigley 2001]. A Holmium yttrium-aluminum-garnet laser (Eclipse Surgical Technologies, Sunnyvale, CA, USA) was used to create transmyocardial channels (8-16) approximately every square centimeter in the region of the anterior wall to the left of the LAD. The portion of the left internal mammary artery (LIMA) that was to be implanted into the intramuscular tunnel was completely skeletonized, and side branch clips were not used in this region. A Seldinger technique was used to create the intramyocardial tunnel parallel and to the left side of the LAD underneath the diagonal coronary arteries. On the beating heart, with apical suction, the needle entered the myocardium adjacent to the LAD, 1 or 2 cm above the apex, and emerged from the myocardium cephalad to the highest diagonal in the region of the left atrial appendage. A guidewire was introduced, and then a 14-French dilator/introducer (DAIG Corporation, Minnetonka, MN, USA) was passed from below. The LIMA was then tied to the guidewire and gently pulled into the sheath, which was then withdrawn, leaving the LIMA within the myocardial tunnel. In no case did the tunnel bleed. The mammary pedicle was tacked to the epicardium at the entry site to prevent tension, and the distal end of the LIMA was anastomosed to the apical LAD (modified Vineberg) (Figure 2). In the event that the apical LAD was completely obliterated (n = 3), the distal LIMA, as it emerged from the tunnel, was doubly clipped and tacked to the epicardium (traditional Vineberg). Postoperatively all patients were maintained on their preoperative antianginal medical regimen for 3 months.

Nuclear Scan Analysis and Coronary Arteriography

Eight of the elective surgery patients underwent a preoperative dipyridamole-sestamibi/resting thallium examination to demonstrate viability and reversible ischemia. A second dipyridamole-sestamibi/resting thallium study was performed at 4 to 9 days. A third follow-up examination was performed at 3 to 5 months postoperatively. The scans were performed using standard techniques as outlined elsewhere [Burkhoff 1999]. All studies were read by 2 independent blinded nuclear cardiologists. After giving informed consent, only 4 patients would submit to late postoperative coronary angiography (6 months-2 years).

RESULTS

All 21 patients subjectively had relief of their symptoms. There has been 100% follow-up ranging from 6 to 36 months. There were no deaths. Four (50%) of the 8 patients who underwent rest/stress nuclear perfusion imaging clearly demonstrated a 2-phase improvement demonstrated by an early postoperative scan that revealed improvement in the anterior wall ischemia and a late scan showing normalization

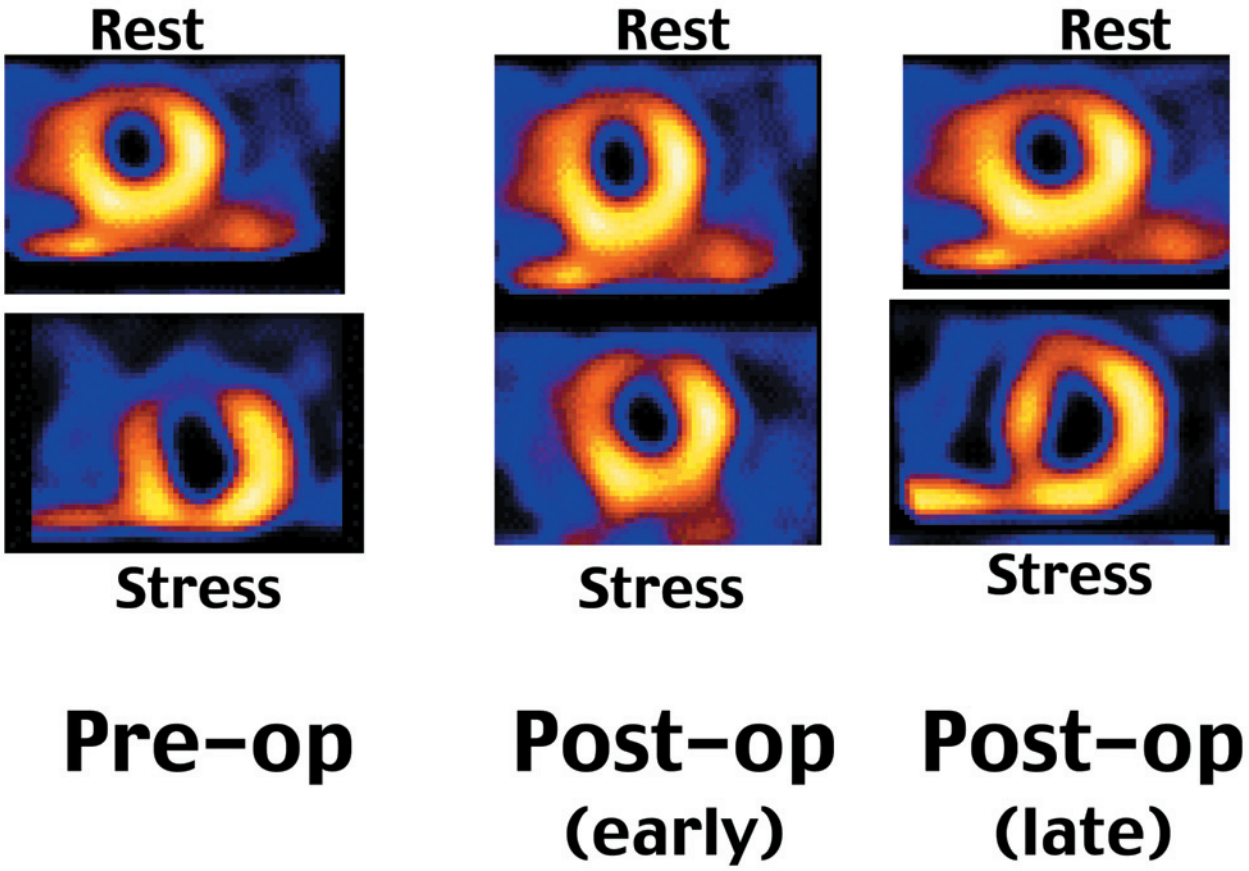

Figure 3. Nuclear perfusion imaging. Resting thallium (top row) and dipyridamole-sestamibi (bottom row) scans of the anterior wall of a typical patient showing a 2-phase perfusion improvement following coronary artery bypass graft/transmyocardial laser revascularization/Vineberg procedure.

of the anterior wall perfusion. Scans from 1 of these patients are shown in Figure 3 and clearly demonstrate the 2-phase improvement in anterior wall perfusion between the preoperative, early postoperative, and late postoperative stress and rest studies. Two of the remaining patients had complete normalization of anterior wall perfusion in the early study, and the other 2 showed minimal changes on the early scan with normalization on the late scan.

The mean creatine phosphokinase MB isoenzyme elevation was 26 ng/mL (range, 17-47 ng/mL). The atrial fibrillation incidence of 25% was not significantly different from the incidence noted with conventional CABG in our institution. The mean length of stay was 9 days, and there were no readmissions within 30 days.

The results of arteriography were totally dependent on the age of the implant. The 3 cases studied at 6 to 9 months revealed robust LIMA conduits despite distal anastomoses to small, diffusely diseased apical LAD targets. The 1 case studied at 2 years revealed a patent triple sequential saphenous vein graft to the diagonal, obtuse marginal, and posterior descending coronary arteries (Figure 4). The intramyocardial LIMA is associated with at least 2 areas of "blush" (Figure 5).

DISCUSSION

Although this report is not the first to describe beating-heart surgery in combination with TMLR, this is certainly the first report of a Vineberg implant being combined with TMLR [Gregoris 2003]. Recently, long onlay patch grafting of the diffusely diseased LAD, not amenable to conventional interventions, has been revisited in the beating-heart literature [Takanashi 2003]. Despite encouraging data on early patency, data on long-term benefits are not available, and misadventures with a long arteriotomy on a diseased LAD can be very unforgiving.

All patients in this series are now subjectively symptom free with coronary anatomy that precluded standard bypass techniques. These subjective data are supported by the objective perfusion scans, which revealed complete myocardial revascularization without any residual reversible ischemia. The robust LIMA seen on arteriography implies a "run-off" that is more extensive than a severely diseased LAD. A visible blush of macroscopic arborization by a Vineberg implant has been shown to require 9 to 12 months to develop, and our earlier angiograms may have been too early to demonstrate the effect seen in Figure 5 [Effler 1965].

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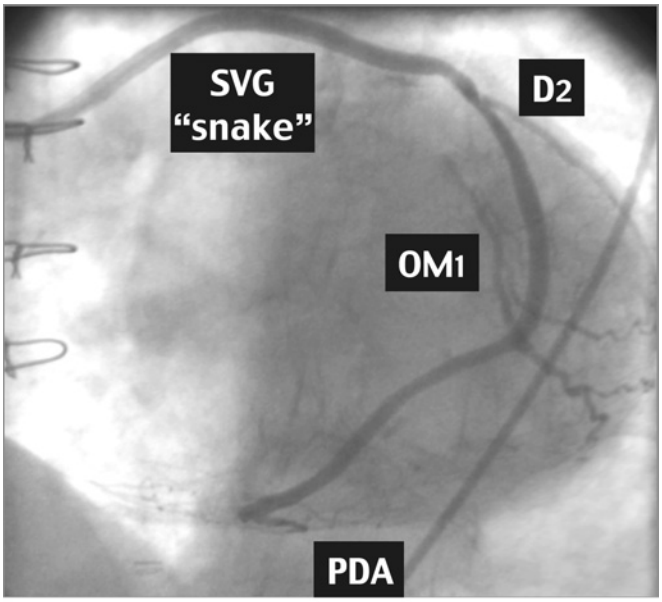

Figure 4. Coronary arteriography of the saphenous vein graft (SVG) bypass conduit. On this projection a patent sequential graft is noted to the diagonal (D), obtuse marginal (OM), and posterior descending arteries (PDA) in a patient who also underwent a modified Vineberg/transmyocardial laser revascularization procedure.

The use of TMLR alone for treatment of end-stage CAD has been shown, in a multicenter trial, to improve angina as well as decrease the number of perfusion defects over a 12-month period [Schofield 1999]. The effect, however, was neither global nor complete. A more recent multicenter study prospectively compared TMLR/CABG to CABG alone [Allen 2000]. However, angina relief and exercise treadmill improvement were indistinguishable between the 2 groups at 12 months. Proven reversal of ischemia has been achieved only in an animal model in which TMLR was combined with vascular endothelial growth factor (VEGF) [Sayeed-Shah 1998]. Although it is not possible from this study to elucidate with certainty the mechanism of the observed perfusion improvement from the Vineberg/TMLR procedure, we postulate an enhancement of TMLR-induced angiogenesis by the presence of the feeding intramyocardial LIMA. Alternative explanations include, but are not limited to, the Vineberg effect alone, direct bypass to a poor outflow native LAD circulation alone, and finally, collateralization from newly revascularized lateral or inferior wall territories.

If these unique results are indeed due to angiogenesis, the addition of more potent angiogenic stimulators such as VEGF [Sayeed-Shah 1998] or fibroblast growth factor [Kawasuji 2000] may be fruitful areas of further study.

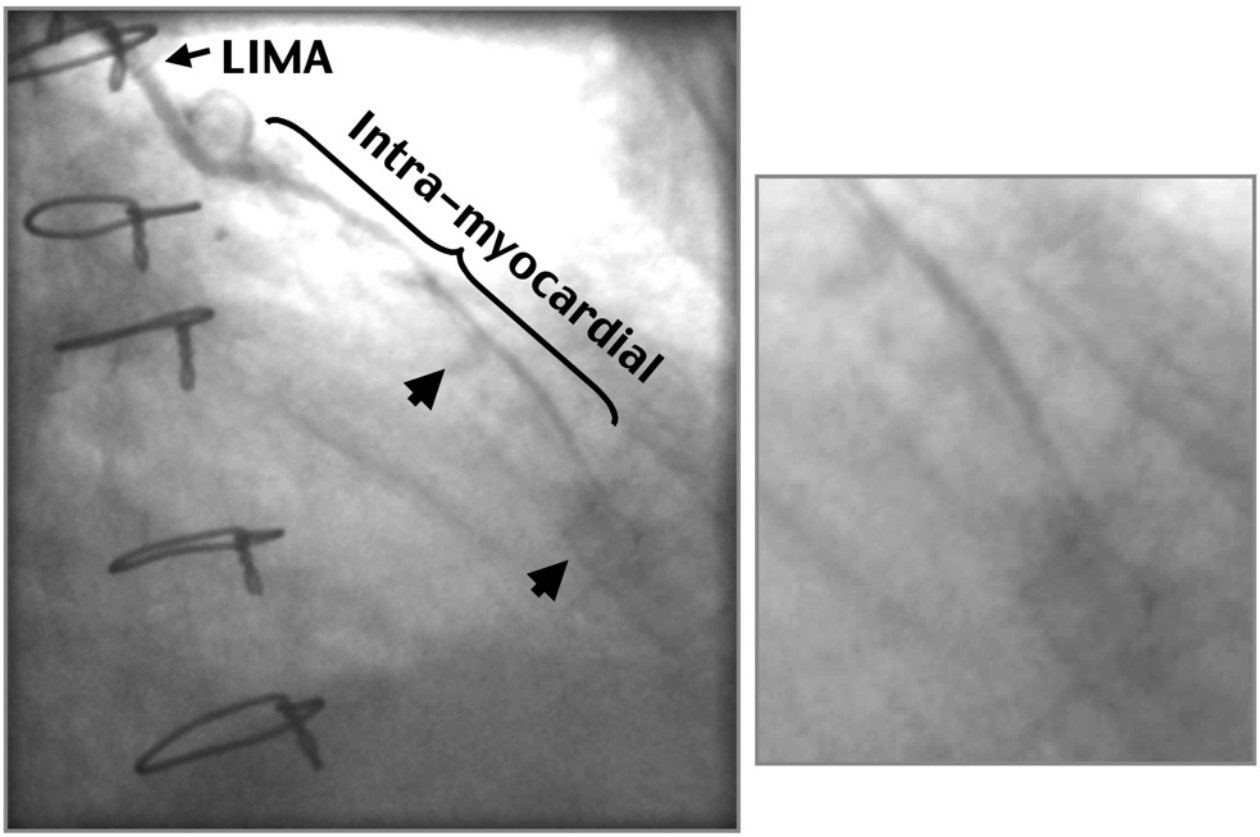

Figure 5. Coronary arteriography of the modified Vineberg implant in the patient shown in Figure 4. The 2 arrows indicate 2 separate areas of "blush" present in the region of the intramyocardial conduit. LIMA indicates left internal mammary artery.

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