Percutaneous Transluminal Therapy of Occluded Saphenous Vein Grafts
Can the Challenge Be Met With Ultrasound Thrombolysis?

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Background—Percutaneous transluminal treatment of a thrombotic vein graft yields poor results. We have previously reported our experience with transluminal percutaneous coronary ultrasound thrombolysis (CUT) in the setting of acute myocardial infarction (AMI). This report describes the first experience with ultrasound thrombolysis in thrombus-rich lesions in saphenous vein grafts (SVGs), most of which were occluded.

Methods and Results—The patients (n = 20) were mostly male (85%), aged 64 ± 4 years old. The presenting symptom was AMI in 2 patients (10%) and unstable angina in the rest. Fifteen patients (75%) had totally occluded SVGs. The median age of clots was 6 days (range, 0 to 100 days). The ultrasound thrombolysis device has a 1.6-mm-long tip and fits into a 7F guiding catheter over a 0.014-in guidewire in a “rapid-exchange” system. CUT (41 kHz, 18 W, ∼6 minutes) led to device success in 14 (70%) of the patients and residual stenosis of 65 ± 28%. Procedural success was obtained in 13 (65%) of the patients, with a final residual stenosis of 5 ± 8%. There was a low rate of device-related adverse events: 1 patient (5%) had a non–Q-wave myocardial infarction, and distal embolization was noted in 1 patient (5%). Adjunct PTCA or stenting was used in all patients. There were no serious adverse events during hospitalization.

Conclusions—Ultrasound thrombolysis in thrombus-rich lesions in SVGs offers a very promising therapeutic option. (Circulation. 1999;99:26-29.)

Key Words: thrombolysis ■ ultrasonics ■ grafting ■ occlusion ■ bypass

Saphenous vein graft (SVG) occlusion is the predominant cause of recurrent ischemia in patients who have undergone coronary bypass surgery.1 Atherosclerotic disease in SVGs is characterized by diffuse friable plaques with a propensity for rupture and large clot formation.2 The increasing number of patients who have undergone bypass surgery in the last 3 decades has made obstructive disease of bypass vein grafts a therapeutic challenge.

Recently, we reported our experience with percutaneous transluminal coronary ultrasound thrombolysis (CUT) in myocardial infarction (MI).3 The technology was found to be a safe and effective method to lyse fresh clots in native coronary arteries.

The purpose of this report is to describe for the first time experience with CUT in clot-rich lesions in SVGs.
1.6-mm-long tip. The device fits into a 7F angioplasty guide catheter and accepts a 0.014-in wire in a “rapid-exchange” fashion.

Before sonication, the lesion was crossed with a 0.014-in guidewire. The ultrasound probe was then introduced onto the guidewire and positioned at the occlusion. During sonication (≤6 minutes), the probe was moved slowly back and forth throughout the extent of the clot. Adjunct pharmacotherapy and the use of balloon angioplasty or stent was left to the discretion of the operator. During hospitalization, patients were treated at the discretion of the attending physician.

Data Collection and Analysis
Clinical report forms (CRFs) were completed by the operators and sent to the database. The age of the clot was assessed on clinical grounds. Major adverse cardiac events (death, MI, or emergent bypass surgery) and angiographic adverse events (abrupt closure, perforation, major dissection, embolization, or no reflow) during the procedure and hospitalization were noted. Angiograms were evaluated by the operators using on-line quantitative coronary angiography at baseline, after sonication, and at the final angiogram. In the CRFs, specific emphasis was placed on the assessment of Thrombolysis In Myocardial Infarction (TIMI) grade flow, thrombus score,4 percent diameter stenosis, and angiographic adverse events. In the case of an adverse event, the operator had to comment on its relationship (not related, probably not related, possibly related, or related) to the index procedure.

Definitions
Device success, for occluded vessels, was defined as TIMI 2 to 3 flow. For patent vessels, it was defined as a decrease of ≥1 point in the clot score.

Procedural success was defined as final TIMI 2 to 3 flow and no device-related clinical or angiographic adverse events at the end of the interventional procedure.

Statistical Analysis
The Friedman and Wilcoxon signed rank tests were applied to compare TIMI flow at baseline, after sonication, and at the end of the interventional procedure.

Results
The patients treated (n=20) were mostly (85%) male, aged 64±4 years old. The presenting symptom was acute MI in 2 patients (10%) and unstable angina in the rest. The median age of clots was 6 days (range, 0 to 100 days). In the 2 cases with acute MI, fresh clots were successfully treated with CUT. Before the procedure, aspirin was used in 19 patients (95%) and ticlopidine in 7 (35%).

Angiographic analysis revealed that 15 (75%) of the SVGs were occluded (TIMI 0 to 1 flow) before the procedure (Figures 1 and 2). Sonication led to highly significant successful recanalization (device success) in 14 (70%) of the patients (P=0.0003) and to a residual stenosis of 65±28%. Procedural success was obtained in 13 (65%) of the patients, with a residual stenosis of 5±8%. Of note, there were 2 patients (10%) who had successful CUT, and adjunct stenting resulted in no reflow and procedure failure. In 1 patient (5%), CUT did not lead to angiographically evident successful recanalization, but a final, successful procedure was performed. There was a low rate of adverse events during the procedure: in 1 patient (5%), non-Q-wave MI was noted, with elevation of creatine kinase to 400 U. In 1 patient (5%), distal embolization was noted. Adjunct thrombolytic drugs and abciximab (ReoPro) were used in 3 (15%) and 8 (40%) of the patients, respectively. In 6 patients, abciximab was administered before the procedure, and in 2 patients it was used as a bailout after no reflow was induced by stenting. Adjunct PTCA or stenting was used in all patients (stents in 15 [75%] and PTCA in 15 [75%]). There was no use of other devices. There were no serious adverse events during hospitalization.

Discussion
Bypass surgery revolutionized the treatment of patients with coronary artery disease. The procedure, however, suffers from limitations, mainly recurrent ischemia due to atherosclerotic disease in implanted bypass vein grafts; at 5 years, ≈45% of grafts are occluded.5

The management of recurrent ischemia in patients who have occluded venous bypass grafts is challenging. Reoperation is associated with higher mortality and morbidity, whereas the likelihood of achieving complete relief of symptoms is lower than in the first surgery.6 Percutaneous transluminal intervention in these patients has been disappointing. The atheromatous nature of SVG plaques and the propensity for large thrombus formation in vein grafts resulted in frequent occurrence of thrombotic complication or distal embolization during this intervention.7 Even in patent SVGs, with intraluminal thrombus, conventional balloon angioplasty yields low acute success rates and high complication rates due to abrupt closure of the treatment site, distal thrombus embolization, and no reflow.8 Experience to date also suggests that stents do not perform well in stenoses containing thrombus and can yield an especially high risk for subacute thrombosis and distal embolization.9 Distal embolization after SVG intervention is associated with a significant increase in the risk of adverse outcome.10

As a result of these limitations, new atherectomy devices have been tested in patients with symptomatic SVG disease, especially with degenerative or thrombus-laden SVGs. It was hypothesized that these devices, such as directional atherectomy and extraction atherectomy devices, would core the soft atherosclerotic plaque and thrombus. It was hoped that adjunct balloon angioplasty or stents would result in a wide lumen and fewer complications. However, this strategy showed low success rates, high complication rates, and high restenosis rates when used for thrombosed vein grafts.10,11

The safety and efficacy of direct infusion of urokinase into totally occluded SVGs, in an attempt to lyse the occlusive clot, followed by adjunct balloon angioplasty, was studied. A moderate recanalization rate was accompanied by a high major complication rate in 35% of the patients.12-14 This is the first report to describe the use of CUT in SVGs, most of which were occluded. In the present study, CUT achieved a high device success rate with a low complication rate. Similar to our experience in MI, CUT was followed by PTCA or stenting in all cases. This strategy of reduction of clot burden by ultrasound followed by correction of the underlying pathology in the vessel wall by balloon angioplasty and stenting yielded high procedural success and a low rate of peri-procedural complication.

Study Limitations
This is the first report, from a small cohort group of patients in a registry, on the use of CUT in thrombus-rich lesions in SVGs, most of which were occluded.
The optimal adjunct mechanical and pharmacological therapy before and after CUT needs to be identified, namely, the ideal stent to be used after CUT (balloon-expanded versus self-expanding versus covered) and the optimal antiplatelet therapy (aspirin and ticlopidine versus anti-glycoprotein IIb/IIIa antagonists). The role of abciximab in SVG intervention was not addressed. In the EPIC trial (Evaluation of IIb/IIIa Platelet receptor antagonist 7E3 in preventing Ischemic Complications), 101 patients underwent percutaneous revascularization of SVGs. A significant reduction in the rate of distal embolization among patients receiving abciximab was noted. This angiographic finding did not translate to clinical differences between the

Figure 1. A 67-year-old patient who underwent bypass surgery 9 years ago was admitted with chest pain at rest and ischemic ECG changes in the inferior leads. Angiography revealed a large clot in the SVG to the right coronary artery with TIMI 1 flow. The patient was treated medically with aspirin, ticlopidine, and intravenous heparin for 5 days. Then, cardiac catheterization was repeated. A, Baseline angiogram shows totally occluded SVG to the right coronary artery (arrow). B, After sonication, there was restoration of the lumen, with TIMI 3 flow and no embolization. A small dissection can be noted at the proximal portion of the body of the graft (arrowhead). C, After stenting, there is no residual stenosis, TIMI 3 flow, no embolization, and no “no reflow.”
groups. There was no significant difference in the rate of MI, 30-day composite end points, or 6-month composite end points between the treatment groups.\(^\text{15}\)

A large, randomized study on the use of CUT in thrombus-containing lesions in SVGs, the ATLAS trial, was recently launched in the United States. The ATLAS trial will help to further define the role of this new technology in the treatment of thrombus-rich lesions.

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