ORIGINAL CONTRIBUTION

Mammary Artery Patch Reconstruction of Left Anterior Descending Coronary Artery

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ABSTRACT

Most patients with diffuse coronary disease require endarterectomy for revascularization. In view of the high morbidity and mortality associated with coronary endarterectomy, patch angioplasty and reconstruction of the coronary artery was developed. We retrospectively evaluated 104 patients who underwent mammary artery patch angioplasty of the left anterior descending coronary artery. The procedure consisted of laying open the entire diseased segment of the coronary artery and patching it with an in-situ left internal mammary artery onlay patch, without endarterectomy, in an off-pump procedure. One (0.9%) patient died, 2 (1.8%) suffered perioperative myocardial infarction, and an intraaortic balloon pump was used in 2. The mean blood loss was 224 mL. Intensive care unit stay was 2.5 days, and hospital stay was 7.8 days. At 1-year follow-up, most patients were in New York Heart Association functional class I. Follow-up angiography was carried out in 16 patients and showed good patency of all anastomoses. Arterial patch reconstruction of the left anterior descending coronary artery can be performed safely and effectively in an off-pump procedure, with excellent early and intermediate results.

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INTRODUCTION

Diffuse coronary artery disease is now more frequently treated surgically.[1,2] Previously, coronary endarterectomy was the chosen technique for reconstruction of diffusely diseased and occluded coronaries.[3] Although this procedure gives acceptable results, the risk of perioperative events is higher and the long-term prognosis significantly worse than coronary artery bypass grafting (CABG) alone.[4–8] Coronary reconstruction without endarterectomy is an attractive option because it avoids removing the protective endothelium from the coronary artery. This helps to reduce perioperative events and improve long-term results.[9,10] The left internal mammary artery (LIMA) is the conduit of choice for revascularizing the left anterior descending artery (LAD).[11,12] Off-pump CABG is well-established as a safe and effective method of revascularization.[13–16] Performing arterial patch angioplasty on a beating heart is technically demanding, but possible, with good results.[17] The purpose of this retrospective study was to evaluate the early and intermediate results of this procedure.

PATIENTS AND METHODS

Arterial patch angioplasty was defined in this study as reconstruction of the LAD with a LIMA patch, without endarterectomy, for a length of at least 2 cm. A diffusely diseased LAD was defined as a diseased segment measuring 2 cm or more, involving the middle and distal third of the LAD. Patch angioplasty exceeding 4 cm was termed long arterial patch angioplasty. Between October 2003 and September 2006, 1,227 patients underwent CABG in our institute; 972 procedures were off-pump. Diffuse LAD disease required arterial patch angioplasty in 104 patients whose results were analyzed retrospectively. Their characteristics are given in Table 1. Preoperative evaluation included routine blood tests, coronary angiography, and echocardiography. On angiography, if the distal LAD was seen filling retrogradely or antegradely, and if any septal or diagonal was seen arising from the diseased segment, arterial patch angioplasty was planned (Figure 1). Based on this assessment, arterial patch angioplasty could be predicted in 41.3% of patients.

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Table 1. **Preoperative Characteristics of 104 Patients Needing Patch Angioplasty**

Variable	No. of Patients
Male/female	99/5
Age (years)	55.24 ± 8.17
Diabetes	67 (64.4%)
Hypertension	47 (45.2%)
Dyslipidemia	72 (69.2%)
NYHA functional class	
Class I	34 (32.7%)
Class II	56 (53.8%)
Class III	9 (8.7%)
Class IV	5 (4.8%)
LV ejection fraction	
Normal	63 (60.6%)
Mild-moderate dysfunction	36 (34.6%)
Severe dysfunction	4 (3.8%)
Angiographic findings	
3-vessel disease	83 (79.8%)
2-vessel disease	10 (9.6%)
1-vessel disease	11 (10.6%)

LV = left ventricular, NYHA = New York Heart Association.

Through a median sternotomy, the LIMA was harvested semi-skeletonized well beyond its bifurcation, for adequate length. Dilute papaverine was injected from the distal divided end, and the LIMA was clipped distally and allowed to pulsate against this distal occlusion. The pericardium was opened widely, and retraction sutures were placed. The LAD was brought into the field by placing wet packs behind the heart and drawing back the retraction sutures. Coronary arteriotomy was performed after stabilization of the target LAD segment with a Guidant Acrobat SUV vacuum stabilizer (Guidant Corporation, Santa Clara, CA, USA). The caliber of the LAD was assessed on the basis of the diameter of the appropriate intracoronary shunt. The decision for patch angioplasty was taken at this time. If the diseased segment was > 2 cm with diagonals and/or septals arising from it, patch angioplasty was undertaken. A single stabilizer was used if the arteriotomy was < 4 cm. If it exceeded 4 cm, 2 stabilizers were placed facing each other (Figure 2).[17] The arteriotomy was extended distally to reach the normal LAD lumen. The proximal extent of the arteriotomy was kept just short of the most severe proximal lesion, to avoid competitive flow from the native LAD. Distal coronary perfusion during anastomosis was maintained using conventional intracoronary shunts (Clearview, Medtronic Inc, Minneapolis, MN, USA). If

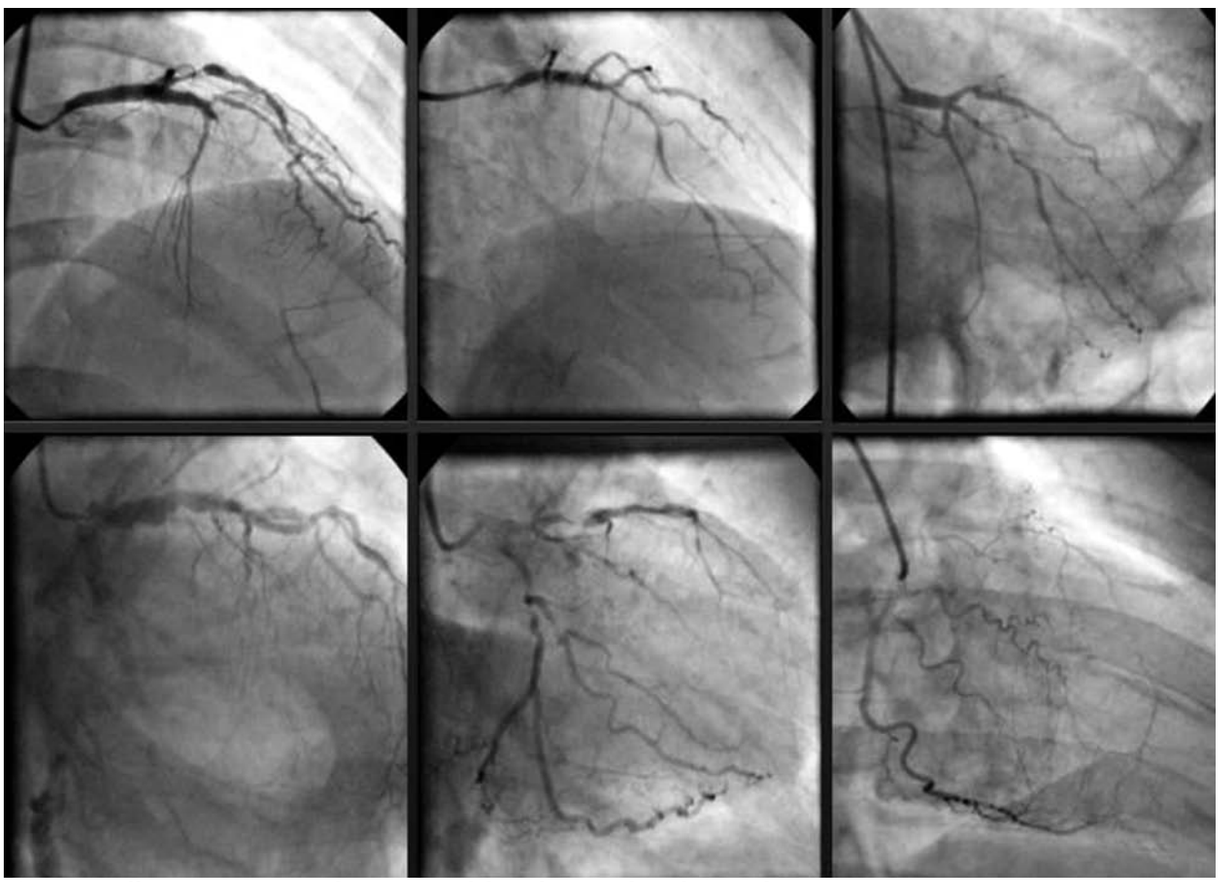

Figure 1. Diffuse coronary artery disease in candidates for arterial patch angioplasty.

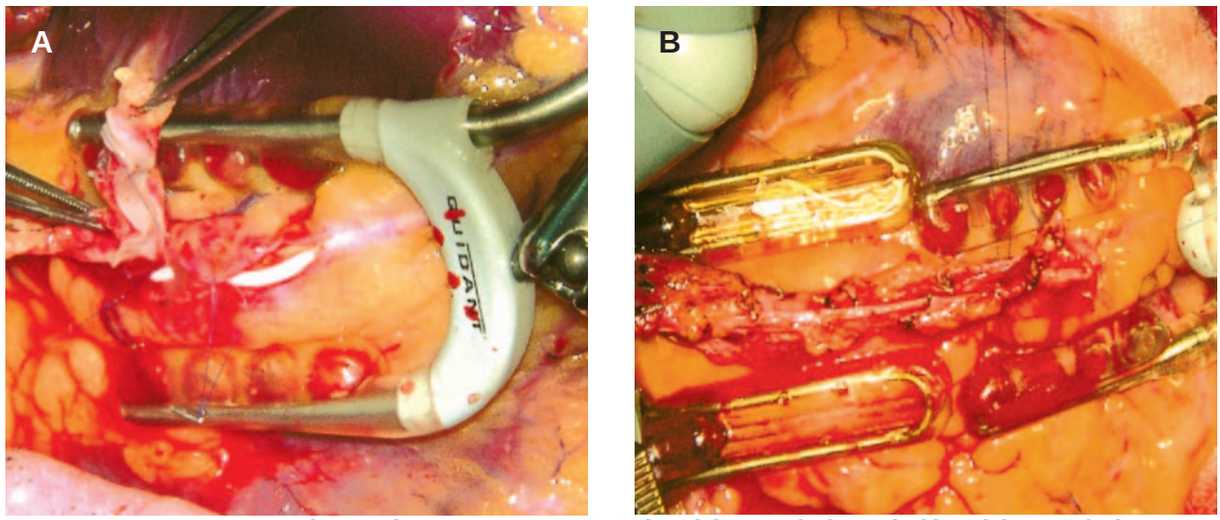

Figure 2. Mammary artery patch angioplasty in progress: (**A**) single-stabilizer method, (**B**) double-stabilizer method.

the arteriotomy exceeded 3–4 cm, the distal perfusion tip of an aortocoronary shunt (Quickflow, Medtronic Inc, Minneapolis, MN, USA) was cut and inserted into the coronary artery. The bulb was inserted into the end from which the blood flowed (distal coronary lumen if flow was retrograde). Tips could be tailored for arteriotomies up to 6–7 cm. If the shunt did not sit inside the coronary artery (or if it bow-stringed), it was secured with a tacking suture of 7/0 polypropylene at the midpoint of the arteriotomy. This tacking suture was taken out on completion of anastomosis, along with the shunt. When native coronary flow was negligible and/or the coronary lumen was < 1 mm, the LAD was snared proximally with a circumferential suture, and LIMA-to-LAD anastomosis was undertaken. The LIMA was slit to match the coronary arteriotomy, and LIMA-to-LAD anastomosis was performed using 7/0 polypropylene. Plaques were excluded from the lumen of the reconstructed LAD. Diagonals and perforators were included in the new lumen. The posterior 25% of the reconstructed coronary artery was formed by the native artery, and the anterior 75% by LIMA.[10] Approximately 10 min were needed to construct a 2-cm patch, with another 5 min for each additional cm of patch.

No special postoperative monitoring protocol was employed in these patients. An electrocardiogram was recorded daily, and enzyme analysis was carried out immediately postoperatively and on postoperative days 1 and 2. An echocardiogram was obtained on postoperative day 6. After discharge (usually planned for postoperative day 7), the patients were seen at 2 weeks, 1 month, 3 months, and 1 year. All patients were requested to have a LIMA angiogram at 1 year; those who agreed underwent the procedure via a radial artery. Postoperative myocardial infarction (MI) was diagnosed if there was a 3-fold increase in creatinine kinase-MB from the preoperative level, or new Q waves or conduction blocks on an electrocardiogram.[18]

Table 2. **Operative Variables in 104 Patients Undergoing Patch Angioplasty**

Variable	No. of Patients
LAD diameter (mm)	1.41 ± 0.3 [0.75–2.0]
LAD arteriotomy (cm)	3.2 ± 1.02 [2.0–10.0]
Distal coronary perfusion	
Intracoronary shunt	82 (78.8%)
Modified aortocoronary shunt	10 (9.6%)
No shunt	12 (11.5%)
Single stabilizer	92 (88.5%)
Double stabilizer	12 (11.5%)

LAD = left anterior descending coronary artery.

A new regional wall motion abnormality on echo was also taken as evidence of postoperative MI.

RESULTS

Operative data are given in Table 2. Long arterial patch angioplasty (4–10 cm) was performed in 21 patients. No hemodynamic instability was observed during anastomoses, and conversion to cardiopulmonary bypass was not necessary in any patient. An intraaortic balloon pump was used in only 2 patients; it was removed immediately after grafting in one. There was no reexploration for bleeding. All patients were electively ventilated on the day of surgery and extubated on the 1st postoperative day. Postoperative data are given in Table 3. Two patients suffered postoperative MI based on enzyme criteria. One of them required an intraaortic balloon pump and vasodilators, but developed a new wall motion abnormality of the anterior wall in spite of these efforts, the other patient was treated with intravenous inotropics and nitrates. The only death occurred in a patient

Table 3. **Postoperative Data of 104 Patients Who Had Patch Angioplasty**

Variable	No. of Patients
Postoperative blood loss (mL)	224 ± 156
Blood product use (units)	2.06 ± 0.8
Intensive care unit stay (days)	2.50 ± 0.4
Hospital stay (days)	7.8 ± 0.6
Early mortality	2 (1.9%)
Myocardial infarction	2 (1.92%)
1-year mortality	1 (0.96%)
NYHA functional class (3 months)	
Class I	66 (84.6%)
Class II	8 (10.3%)
Class III	3 (3.8%)
Class IV	1 (1.3%)
LV ejection fraction (3 months)	
Normal	58 (74.4%)
Mild-moderate dysfunction	19 (24.4%)
Severe dysfunction	1 (1.3%)

LV = left ventricular, NYHA = New York Heart Association.

who developed acute hepatic failure in the immediate postoperative period. He succumbed to hepatorenal syndrome on the 2nd postoperative day. Postoperative enzyme analysis showed most patients had enzyme levels < 3-times the upper limit of normal. At 1 year, 9 patients were lost to follow-up, 74 were in functional class I–II, and 4 were in class III–IV. An improvement of at least 1 functional class was noted by 55 patients. One patient had recurrent unstable angina related to progression of disease in the untreated right coronary artery and needed percutaneous angioplasty and stenting. Only 16 patients agreed to have coronary angiography at the 1-year follow-up; all LIMA-to-LAD anastomoses were patent, with good flow across the anastomosis (Figure 3).

DISCUSSION

Diffuse coronary disease was deemed inoperable not so long ago.[1] Patients were managed medically, with a substantial number having persistent symptoms that restricted their activity. Coronary endarterectomy with CABG, although technically challenging, was the only mode of coronary reconstruction for diffuse disease.[4] However, it was associated with more perioperative mortality (4.4% vs 2.6%) and MI (5.4% vs 2.4%) than CABG alone.[5] In addition, the technical complexity and need for anticoagulants and antiplatelets postoperatively led to many surgeons performing coronary endarterectomy on a highly selective basis. In this study, the rate of MI was comparable to that after CABG alone.[19] Barra and colleagues[10] reported 108 cases of patch angioplasty of the

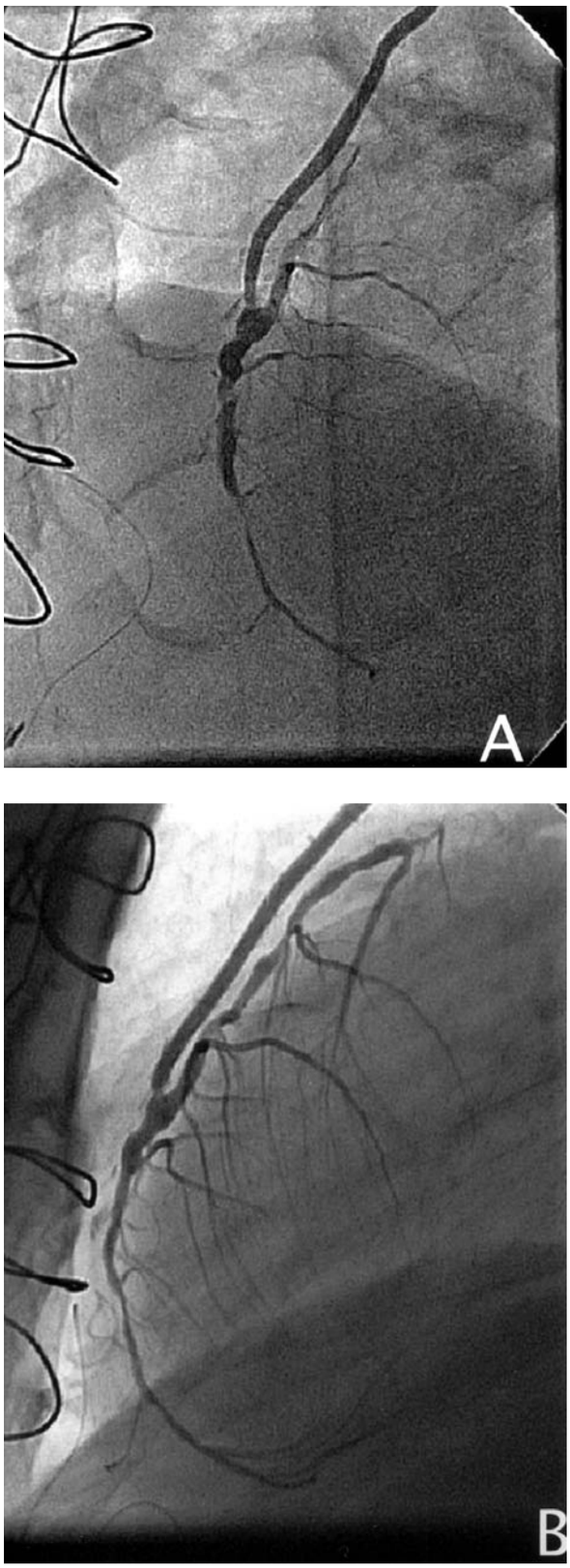

Figure 3. Angiogram of a patient at (**A**) 1 month and (**B**) 2 years after patch angioplasty. There was good flow across the anastomosis into the distal left anterior descending coronary artery and its septal and diagonal branches.

LAD on an arrested heart, with gratifying results; coronary endarterectomy was performed on only a limited number of patients. Arterial patch angioplasty can be undertaken as an off-pump procedure with comparable results.[17] Although the time taken for anastomosis (10 min) is considerably longer than for regular anastomosis (6 min), with an intracoronary shunt in place and good anesthetic support, it can be safely and effectively accomplished.

Coronary endarterectomy was not carried out as an adjunctive procedure in this study. The technique of patch angioplasty involves excluding all major plaques from the neo-coronary lumen while retaining all patent perforators and diagonals in the reconstructed coronary. Extra grafts were placed on totally occluded diagonals, if indicated. As the angioplasty extends from just distal to the most proximal critical occlusion to the normal (or near normal) coronary lumen distally, competitive flow at the proximal end is prevented, giving the best possible run-off distally and augmenting LIMA patency. Patent perforators and diagonals in the reconstructed segment provide additional run-off. As this procedure can be effectively performed off-pump, the side effects of cardiopulmonary bypass were avoided.

Calcified plaques are rare in our patient population. The plaques that we come across are hard and leathery (myofibrointimal hyperplasia), not calcified. However, we never remove even calcified plaques but place sutures around them to exclude them from the neo-coronary lumen. The advantage of this technique is that the endothelium is preserved, hence thrombogenicity and neointimal proliferation are minimized. The need for oral anticoagulants in the immediate postoperative period is avoided. Patients are discharged home on aspirin and clopidogrel only.

This study comprised a small number of patients analyzed retrospectively, with follow-up angiograms at 1 year obtained in only a few of them. A prospective analysis of patients randomized to patch angioplasty or coronary endarterectomy would answer more questions. Nevertheless, coronary reconstruction for diffuse disease was possible without endarterectomy. It can be safely and effectively carried out off-pump, with gratifying early and intermediate results.

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