

## Robotic-Assisted Off-Pump Sole Transmyocardial Revascularization: Case Report

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### ABSTRACT

Thoracoscopic transmyocardial revascularization (TMR) has been recently demonstrated. We report 2 patients who underwent robotic-assisted thoracoscopic off-pump sole TMR. A 2-inch minimally invasive left anterolateral thoracotomy was made. Pericardial dissection and TMR were performed in an open manner facilitated by improved visualization using voice-activated robotic-assisted thoracoscopy (AESOP, Computer Motion, Santa Barbara, CA, USA). Patient 1 was a 73-year-old man with class IV angina who underwent coronary artery bypass grafting (CABG)  $\times$ 4 20 years earlier. Cardiac catheterization revealed occluded grafts, no native vessels that were amenable to percutaneous coronary intervention (PCI) or CABG, and an ejection fraction (EF) of 55%. Forty-five Holmium-Yag (CardioGenesis, Foothill Ranch, CA, USA) laser channels were created in the left ventricular wall. Total operating room (OR) time was 93 minutes. He was extubated in the OR and was discharged from the intensive care unit (ICU) in 18 hours and from the hospital on the second postoperative day angina free. Patient 2 was a 48-year-old woman with class IV angina who had undergone CABG  $\times$ 6 3 years earlier but who had persistent chest pain following the revascularization. After 12 cardiac readmissions in 1 year, including multiple PCIs, a recent catheterization showed patent grafts except for the circumflex branches and an EF of 45%. Forty-six channels were created in the left ventricle in a similar fashion. OR time was 62 minutes, ICU time was 20 hours, and postoperative length of stay was 2 days. The patient also was angina free at discharge. This report suggests that robotic-assisted thoracoscopy provides enhanced visualization and efficient delivery during off-pump sole TMR, and this technique may be associated with reduced operative times and improved recovery time.

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### INTRODUCTION

Numerous studies have demonstrated the efficacy of transmyocardial revascularization (TMR) for patients with angina (Allen 1998, Wehberg 2003). Sole TMR has been shown to improve angina, reduce hospital readmission rates, and improve exercise tolerance in patients for whom percutaneous coronary intervention (PCI) or coronary artery bypass grafting (CABG) is not possible.

Most sole TMR procedures are performed through an anterolateral thoracotomy, which provides excellent exposure of the left ventricle. Recent reports suggest the feasibility of left thoracoscopic sole TMR (deGuzman 1997, Horvath 1998, Milano 1998a, Milano 1998b), but these procedures involved prolonged hours in the operating room (OR) and moderate postoperative recovery.

We report a technique for sole TMR that involves a minimally invasive incision, improved visualization, a short amount of time in the OR, and less patient recovery time.

### CASE REPORTS

#### Case 1

The first patient was a 73-year-old man with class IV angina who underwent CABG  $\times$ 4 20 years earlier; greater saphenous vein grafts (SVG) were used. Cardiac catheterization now revealed occluded vein grafts, no native vessels that were amenable to percutaneous coronary intervention (PCI) or CABG, and an ejection fraction (EF) of 55%. Stress cardiolyte nuclear medicine imaging revealed reversible ischemia in the anteroapical and lateral segments of the left ventricle. Transthoracic echocardiography demonstrated no valvular problems, inferior wall hypokinesia, and an estimated EF of 50% to 55%.

After systemic arterial and pulmonary arterial catheters were placed, the patient was positioned supine with a roll placed under the left side to prop up the left chest. A 2-inch minimally invasive left anterolateral thoracotomy incision was made in the inframammary crease, and the left ventricle (LV) was exposed in the fifth intercostal space (ICS). A 5-mm trocar thoracoscopic port was placed in the seventh ICS space of the left midaxillary line. A voice-activated robot arm (AESOP, Computer Motion, Santa Barbara, CA, USA) was

used for rapid and efficient control of a 5-mm thoracoscopic lighted camera, which also provided improved visualization because of the enhanced lighting. The pericardium was dissected free of the LV through the minithoracotomy using robotic-assisted thoracoscopic guidance. This technique also provided excellent cardiac inspection of the left ventricle, and all coronary artery targets were less than 1.0 mm in diameter. Similarly, the hand-held laser apparatus entered the minithoracotomy, and robotic-assisted thoracoscopic guidance was used. Forty-five Holmium-Yag (CardioGenesis, Foothill Ranch, CA, USA) laser channels were created in the left ventricular wall. Fifteen channels were made in the anterior wall, 10 in the lateral wall, 10 in the posterior wall, and 10 in the inferior wall. No heparin was used. Nitroglycerin and lidocaine drips were used in a 12-hour perioperative period.

Patient 1 had a total OR time of 93 minutes. There were no intraoperative complications, and he tolerated the procedure without ventricular arrhythmias. He was extubated in the OR. Left pleural 19 Fr Blake drainage was minimal and discontinued on postoperative day 1. He was discharged from the intensive care unit (ICU) in 18 hours and from the hospital after the second postoperative day. Before discharge, he ambulated up 10 stairs without angina. He had 1 episode of angina during heavy sexual exertion 2 weeks postoperatively.

### Case 2

The second patient was a 48-year-old woman with class IV angina who had undergone CABG  $\times$ 6 3 years earlier, but who had persistent chest pain 6 months following the surgical revascularization. She required 12 cardiac admissions in 1 year involving multiple PCIs and ending with brachytherapy of the circumflex artery. A recent catheterization showed patent left internal mammary artery–left anterior descending artery, SVG–diagonal, SVG–posterior descending artery, and SVG–right internal artery grafts but an occluded radial artery graft to the obtuse marginal artery. All native vessels had poor runoff despite graft patency. EF was 45%. Stress cardiolyte imaging revealed inferolateral and posterior reversible ischemia. Forty-six channels were created in the LV in a fashion similar to that described above. Patient 2 had an OR time of 62 minutes, ICU time of 20 hours, and a postoperative hospital stay of 2 days. The patient also was angina free at discharge.

### DISCUSSION

The Society of Thoracic Surgeons recently concluded from an evidence-based review, “TMR offers consistent amelioration of severe angina in patients having no conventional therapeutic alternative” ([www.sts.org/doc/8219](http://www.sts.org/doc/8219)). The delivery of sole TMR continues to improve with limited thoracotomies and thoracoscopic technology (deGuzman 1997, Horvath 1998, Milano 1998a, Milano 1998b). We report a technique for sole TMR using robotic-assisted thoracoscopy

to enhance visualization while performing TMR through a minithoracotomy.

The feasibility of totally thoracoscopic TMR has been demonstrated, but certain limitations are evident and are likely related to the learning curve required for surgical skill. Operative times in previous reports were prolonged to 150 minutes or longer (Milano 1998a, Milano 1998b). By comparison, we report operative times of from 60 to 90 minutes. The technique described in this report does not require advanced thoracoscopic surgical skill, given that TMR is still performed through the 2-inch thoracotomy. The present report, however, may suggest that robotic-assisted thoracoscopy facilitates efficient delivery of sole TMR through a minimally invasive incision.

Current reviews suggest that minimally invasive thoracoscopic cardiac surgical procedures may allow early patient recovery (Wehberg 2001). Although previous reports of thoracoscopic TMR describe postoperative length of stay as long as 5 days (Milano 1998a, Milano 1998b), our report suggests that robotic-assisted TMR may be associated with significant reduction in postoperative hospitalization. The difference in length of stay may be related to fewer incisions and less operative time using our technique. Nevertheless, angina reduction was similar using both techniques.

The benefits of robotic-assisted thoracoscopic off-pump sole TMR compared to the open technique are obvious. In addition to excellent relief of angina, this delivery technique may also offer improved benefits of less operative time, early patient recovery, decreased postoperative stay, and potential hospital cost savings. Additional reports are needed to compare the outcomes from this technique and that of the standard thoracotomy.

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