

Is There a Role for Diagonal Coronary Artery Stenting in Patients Undergoing Robotic Coronary Artery Bypass Graft Surgery?

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Abstract

Background: The efficacy of diagonal coronary artery stenting in patients undergoing robotic left internal thoracic artery-to-left anterior descending (LITA-to-LAD) anastomosis is not well defined. The objective of this study was to assess graft and stent patency in a single-stage hybrid revascularization with LITA-to-LAD anastomosis and PCI to a diagonal coronary artery.

Methods: From 2004 to 2014, a total of 25 patients consented to robotic-assisted LITA harvesting and a small left anterior thoracotomy for off-pump coronary artery bypass anastomosis onto the LAD along with concomitant PCI to the diagonal coronary artery. PCI to the diagonal coronary artery was performed in the same fluoroscopy-equipped hybrid operating room.

Results: Patients were on average 66 ± 11 years with 32% female. Pre-operative characteristics of these patients included 8% with a grade 3 or 4 left ventricle, 16% with a recent MI, and 92% with CCS III/IV symptoms. There were no death, one patient required an intra-aortic balloon pump, and one patient required re-operation for bleeding. The average ICU stay was 1.1 ± 0.53 days, and the average hospital stay was 4.6 ± 2.4 days. Fitzgibbon Grade A LITA-to-LAD patency at 6-month follow-up was 100%. As well, at 6-month follow-up the DES to the diagonal coronary artery had a patency rate of 96%.

Conclusions: Single-stage hybrid revascularization strategy for bifurcating lesions of the LAD and diagonal coronary arteries with

LITA-to-LAD anastomosis and PCI to a diagonal coronary artery appears to have acceptable clinical results with excellent 6-month angiographic patency results.

Keywords: Revascularization; Coronary artery bypass surgery; Robotics; Percutaneous coronary intervention; Hybrid

Introduction

Minimally-invasive coronary artery surgery was developed to reduce surgical trauma, pain, hospital stay and associated wound complications [1-4]. The initial approach, termed minimally invasive direct coronary artery bypass surgery (MID-CAB), is typically performed on the beating heart using stabilizing devices, and is particularly useful in cases of isolated left anterior descending (LAD) artery disease [1]. Morbidity and mortality rates with MIDCAB have been comparable to standard coronary artery bypass grafting surgery (CABG); however with the development of computer-enhanced instrumentation, the least invasive approach for coronary revascularization, totally-endoscopic coronary artery bypass, has become an expanding and rapidly evolving field of cardiac surgery [2-6].

A growing subset of robotic-assisted CABG patients is undergoing hybrid procedures. Hybrid coronary artery revascularization is defined as the combination of left internal thoracic artery (LITA) to LAD artery grafting and percutaneous coronary intervention (PCI) of ≥ 1 non-LAD coronary arteries [7]. Hybrid revascularization procedures are attractive surgical options that look to encompass the advantages of both surgical and percutaneous techniques. That is, a hybrid procedure includes the survival and symptom advantages of a surgically anastomosed LITA to LAD, along with the advantage of avoiding cardiopulmonary bypass and a median sternotomy, potentially faster recovery, overall decreased risk of blood transfusions and decreased hospital length of stay, which PCI affords while continuing to offer complete revascularization [7-9].

The emerging efficacy of robotic-assisted CABG and hybrid revascularization has led to an increase in the number of centers and cases performing such procedures over the last decade. Recently, others and our group have shown that a single-

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stage hybrid revascularization strategy appears to have acceptable 6-month results [10-12]. The patency of the diagonal artery graft in bifurcating lesions of the LAD and diagonal artery is always questionable due to competition of flow from the LITA graft. However, the efficacy of diagonal coronary artery stenting in patients undergoing robotic LITA-to-LAD anastomosis is not well defined. The objective of this study was to assess graft and stent patency in a single-stage hybrid revascularization with LITA-to-LAD anastomosis and PCI to a diagonal coronary artery.

Patients and Methods

Study cohort

From September 1, 2004 to July 1, 2014, 25 consecutive patients underwent a single stage hybrid coronary artery revascularization strategy, with surgical anastomosis of the LITA to LAD and PCI to the diagonal coronary artery. Briefly, this single stage approach involved LITA to LAD surgical revascularization immediately followed by PCI to the diagonal coronary artery in the same operating theatre during the same operative session. The heart team reviewed all patients pre-operatively, and patients underwent a computed tomographic scan of the thorax and pulmonary function testing. The heart team consisted of cardiac surgeons, interventional cardiologists and cardiac anesthesiologists.

Inclusion criteria consisted of patients with a lesion of the LAD, that was not amenable to PCI but was suitable for surgical revascularization, and a lesion of the diagonal coronary artery that was suitable for PCI. Patients with contraindications to PCI, robotic assisted coronary surgery, or off-pump coronary artery bypass surgery were excluded [13].

Surgical procedure and graft patency assessment

The procedure for single-stage hybrid revascularization performed by our institution has been formally described previously [13]. Briefly, the LITA was harvested using the da Vinci system (Intuitive Surgical, Sunnyvale, CA, USA). Following this, the pericardium was opened, the LAD was exposed, and the LITA was divided once an adequate location for LITA to LAD anastomosis was identified. The LAD was stabilized using the Octopus TE stabilizer (Medtronic, Minneapolis, MN, USA) inserted via the appropriate intercostal space, depending on patient body habitus. A small non-rib-spreading thoracotomy was made and the LITA was manually anastomosed to the LAD using an off-pump, beating heart technique. Graft patency and flow was measured using Medistim (Medistim USA, Plymouth, MN, USA) transit-time Doppler assessment. Following completion of the surgical component, the surgical wounds were closed. The PCI procedure was subsequently performed in collaboration with the interventional cardiology team.

The hybrid OR was reconfigured, as ceiling-mounted viewing screens were positioned and a floor mounted C-arm was moved into position. Femoral access was obtained, and

angiographic patency of the LITA-LAD graft was assessed. Attention was then turned to the diagonal lesion, which was treated with either a bare-metal stent (BMS) or drug-eluting stent (DES). Prior to PCI completion, while still on bivalirudin infusion, a 600 mg loading dose of clopidogrel was administered through a nasogastric tube, and then orally daily. Eighty-one mg of acetylsalicylic acid were administered through a nasogastric tube 6 h after the operation, followed by once daily. The femoral arterial sheaths were removed after the discontinuation of bivalirudin.

Patients were scheduled for 1-month, 6-month and then yearly follow-up by the operating cardiac surgeon and/or referring cardiologist. At each visit, Canadian Cardiovascular Society (CCS) symptoms of angina and New York Heart Association (NYHA) symptoms of heart failure were recorded. If symptoms of chest discomfort or shortness of breath were reported, patients were offered coronary angiography to assess graft patency.

Approval was obtained from the Research Ethics Board of Western University. Informed consent for participation was obtained from all eligible patients, and their clinical notes, health records and coronary angiograms were reviewed. Consenting patients were booked for follow-up coronary angiography at 6 months post procedure. Graft patency was evaluated using a modified Fitzgibbon score, whereby A = completely patent, B = > 50% narrowing and C = occluded vessel [14]. All grafts were assessed by interventional cardiologists and/or cardiac surgeons. PCI interventions were evaluated and reported as being patent, partial in-stent restenosis or occluded.

Statistical analysis

All statistical analysis was performed using Microsoft Excel (Redmond, WA). Continuous variables are expressed as mean and standard deviation (SD). Categorical variables are expressed as percentages.

Results

Baseline patient characteristics

Between September 1, 2004 to July 1, 2014, hybrid revascularization including robotic-assisted LITA harvesting, off-pump LITA to LAD anastomoses and PCI to the diagonal coronary artery occurred in a total of 25 consecutive patients (32% female) with a mean age of 66 ± 11 years. The baseline characteristics and significance are summarized in Table 1. Pre-operatively, 8% of patients had a grade 3 or 4 left ventricle. As well, 16% had a recent MI, and 92% had CCS III/IV symptoms and 28% had type II diabetes mellitus.

Perioperative results and graft patency

At 6-month post single-stage hybrid revascularization with robotic-assisted LITA to LAD anastomosis and PCI to the

Table 1. Patient Demographics (N = 25)

Profile	No. (%) or mean (SD)
Age	66 (11)
Sex	
Male	17 (68%)
Female	8 (32%)
Left ventricular grade	
I/II	23 (92%)
III/IV	2 (8%)
CCS functional class preoperative	
I/II	2 (8%)
III/IV	23 (92%)
Recent MI	4 (16%)
Diabetes	7 (28%)

diagonal coronary artery, a protocol directed coronary angiogram was completed in all 25 patients (100% follow-up, Table 2). Fitzgibbon Grade A LITA-to-LAD patency at 6-month follow-up was 100%. Furthermore, all 25 patients in this study received a drug-eluting stent (DES) to the diagonal coronary artery. At 6-month follow-up 24 patients (96%) had a patent DES to the diagonal coronary artery. As well, of the cohort of 25 patients, 14 patients are now at 7 - 10 years follow-up. These 14 patients have a 100% patency rate of the LITA to LAD anastomosis and diagonal coronary artery DES.

There was no 30-day or in-hospital mortality. In the series of 25 patients who underwent robotic-assisted LITA to LAD anastomosis and PCI to the diagonal coronary artery, there was one peri-operative need for short term use of intra-aortic balloon pump counter-pulsation, and one patient that returned to the operating room for bleeding. The median ICU length of stay was 1.1 ± 0.53 days, and the median length of hospital stay was 4.6 ± 2.4 days.

Discussion

While previous studies have established that single-stage hybrid coronary revascularization has acceptable 6-month and long-term results, patients receiving PCI to the diagonal cor-

onary artery are under-represented in these studies. This has led to questions in management of patients undergoing hybrid coronary revascularization with bifurcating lesions of the LAD and diagonal coronary arteries. This study has extended the evidence base regarding this issue. We have shown that patients undergoing a single-stage hybrid revascularization with robotic-assisted LITA to LAD anastomosis and PCI to the diagonal coronary artery have acceptable 6-month results following revascularization. As well, preliminary data of 12 of the 25 patients that have undergone a hybrid revascularization procedure for bifurcating lesions of the LAD and diagonal coronary arteries have shown that at 7 - 10 year follow-up, all grafts and DES are patent.

Our results are consistent with those of several observational studies in patients undergoing single-stage hybrid coronary revascularization. Adams et al showed that single-stage robotic-assisted hybrid coronary revascularization has excellent 6-month patency, long-term freedom from angina and freedom from coronary reintervention in 94 patients from a single Canadian centre [12]. Modrau et al showed that in a Danish cohort of 100 patients undergoing hybrid coronary revascularization combining off-pump LITA grafting through an inferior J-hemisternotomy with PCI that at 1 year, 98% had patent LITA to LAD anastomoses, however 10% of PCI lesions had evidence of angiographic restenosis [15].

Although we use data collected prospectively on all adults undergoing single-stage hybrid coronary revascularization within a Canadian cardiac surgery center with universal health care access, there are several limitations to our study. First, the present study is an observational assessment. Therefore, due to the inherent nature of an observational study we are not able to comment on causations but only able to explore associations. Second, we lack a comparison group who underwent complete surgical or PCI revascularization. This study was compared to other studies of a similar profile found in the literature; however, a direct comparison source would also prove beneficial. Third, our 7 - 10 years follow-up group only consists of 48% of the entire patient cohort. However, we do feel that the strong results from this subset of the cohort, although preliminary, do give insight into the possibility of long-term success with a hybrid approach to bifurcating lesions of the LAD and diagonal coronary arteries.

In conclusion, we have shown that in patients with complex bifurcating coronary artery disease of the LAD and diagonal coronary arteries, a single-staged hybrid coronary revascularization procedure with surgical anastomosis of the LITA

Table 2. Post-Operative and 6-Month Clinical Outcomes (N = 25)

Variables	No. (%) or mean (SD)
Death	0
Post-operative IABP	1 (4%)
Reoperation for bleeding	1 (4%)
Average ICU stay (day)	1.1 (0.53)
Average hospital stay (day)	4.6 (2.4)
Fitzgibbon grade A LITA-to-LAD patency at 6 months	25 (100%)
DES to diagonal coronary artery "patent" at 6 months	24 (96%)

to LAD and PCI to the diagonal coronary artery is associated with excellent 6-month outcomes and preliminarily appears to be associated with excellent long-term graft and DES patency outcomes. Collectively these findings support the expansion and increased adoption of single-staged hybrid revascularization as an alternative to traditional coronary bypass graft surgery and percutaneous coronary intervention in appropriately selected cohort of patients.

Disclosure

Jeevan Nagendran: none. Chris Tarola: none. Jorge Catrip: none. Stephanie A. Fox: none. Michael Chu is consultant to Medtronic, Canada, Edwards Lifesciences, and Scientific Advisory Board, Neochord, Inc. Patrick Teefy got research grant and honoraria from Medtronic; got support for symposium by St. Jude Medical, and got support for device training by Edwards. Kumar Sridhar got research grant and honoraria from Medtronic. Pantelis Diamantouros got speaker fees from Astra Zeneca. Bob Kiaii is consultant to Medtronic, Canada, and consultant to Edwards Lifesciences. This paper was presented at the 15th Annual Meeting of the International Society for Minimally Invasive Cardiothoracic Surgery (ISMICS).

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