Early clinical and angiographic outcomes after robotic-assisted coronary artery bypass surgery

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Objective: Robotic-assisted coronary artery bypass grafting has emerged as an alternative to traditional coronary artery bypass grafting or percutaneous intervention for patients with coronary artery disease. However, the safety and efficacy of this minimally invasive procedure have not been established in large series.

Methods: From October 2009 to September 2012, 307 consecutive robotic-assisted coronary artery bypass grafting procedures were performed at a single US institution by 2 surgeons. Isolated, off-pump, left internal thoracic artery to left anterior descending coronary artery grafting was planned via a 3- to 4-cm non–rib-spreading minithoracotomy after robotic left internal thoracic artery harvest in all patients. Hybrid coronary revascularization was planned in 159 patients (51.8%). Of the 199 angiograms (64.8%) performed before discharge, 63 were performed as completion angiograms in a hybrid suite immediately after left internal thoracic artery–left anterior descending artery grafting.

Results: Thirty-day mortality occurred in 4 patients (1.3%), conversion to sternotomy occurred in 16 patients (5.2%), postoperative myocardial infarction occurred in 5 patients (1.6%), and reexploration for bleeding occurred in 7 patients (2.3%). There was 1 (0.3%) postoperative stroke. For the 199 patients with follow-up angiography before discharge, the left internal thoracic artery was confirmed to be patent (<50% stenosis) in 189 patients (95.0%). Among the 10 patients with significant (≥50% stenosis) defects, 5 had graft occlusion or distal left anterior descending occlusion, 2 had poor flow distal to the anastomosis, and 3 had anastomotic lesions (≥50% stenosis). Among the 63 patients with intraoperative completion angiography, 5 patients underwent surgical graft revision, 3 patients underwent minithoracotomy, and 2 patients underwent conversion to sternotomy.

Conclusions: Robotic-assisted coronary artery bypass grafting is an effective alternative to traditional coronary artery bypass grafting for patients with single or multivessel coronary artery disease, with comparable short-term clinical and angiographic results. (J Thorac Cardiovasc Surg 2014;147:179-85)

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Coronary artery bypass grafting (CABG) is an established method of treating patients with coronary artery disease, with recent trials reemphasizing its efficacy and durability.[1,2] An important component of the benefit conferred by CABG is derived from the left internal thoracic artery (LITA) graft to the left anterior descending (LAD) coronary artery. Minimally invasive approaches to CABG have become more commonplace, fueled in part by patients' desire for less-invasive procedures, as well as significant technologic advances in robotics, perfusion devices, off-pump CABG, and retraction systems.

The 3 most common minimally invasive CABG procedures use a sternal-sparing approach and include minimally invasive direct coronary artery bypass (MIDCAB), robotic-assisted coronary artery bypass (CAB), and robotic-assisted totally endoscopic coronary artery bypass (TECAB). Each approach has unique advantages and disadvantages, but results have been excellent when performed by experienced surgeons.

Robotic-assisted CAB capitalizes on the main advantage of surgical revascularization, the LITA-LAD graft; although diagonal grafting is also possible, circumflex and right coronary vessels are usually treated with percutaneous coronary intervention (PCI) when robotic-assisted LITA-LAD grafting is performed in patients with multivessel disease. The LITA harvest, pericardiotomy, and LAD identification are accomplished with robotic assistance, but the anastomosis is performed manually, under direct vision, through a non–rib-spreading 3- to 4-cm anterolateral thoracotomy without the use of cardiopulmonary bypass. The purpose of this analysis is

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Abbreviations and Acronyms

CAB = coronary artery bypass
CABG = coronary artery bypass grafting
LAD = left anterior descending
LITA = left internal thoracic artery
MIDCAB = minimally invasive direct coronary artery bypass
OR = operating room
PCI = percutaneous coronary intervention
PROM = predicted risk of mortality
TECAB = totally endoscopic coronary artery bypass

to describe the short-term clinical and angiographic results in a large consecutive cohort of patients undergoing robotic-assisted CAB for both isolated LAD and multivessel disease.

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MATERIALS AND METHODS

Patients and Design

During the 37-month period between October 2009 and September 2012, data from 307 consecutive patients undergoing robotic-assisted CAB were prospectively entered into a customized database that included operative, technical, and angiographic details that were not available from the Society of Thoracic Surgeons (STS) database. This database was then merged with data from the STS database and retrospectively reviewed. All consecutive cases from 2 surgeons, including the earliest learning curve cases, were included in the analysis. The institutional review board at Emory University in compliance with Health Insurance Portability and Accountability Act regulations and the Declaration of Helsinki approved the study. The institutional review board waived the need for individual patient consent.

Indications and Contraindications

Patients eligible for robotic-assisted CAB had clinical and anatomic indications for surgical coronary revascularization. These patients (1) presented with isolated LAD that was not amenable to PCI or had LAD disease that was considered better treated with LITA-LAD grafting or (2) presented with multivessel coronary disease that was amenable to a hybrid revascularization approach, defined as LITA-LAD grafting combined with PCI of non-LAD lesions.

Absolute contraindications to robotic-assisted CAB included hemodynamically unstable patients, those with intra-aortic balloon pumps, or those with evolving myocardial infarction. Patients with a poor or nongraftable distal target vessel, previous sternotomy or thoracotomy, body mass index greater than 40, or severe lung disease with inability to tolerate single-lung ventilation were considered relative contraindications.

Technical Details

All patients underwent single lung ventilation using a dual lumen endotracheal tube or bronchial blocker or bilateral lung low tidal volume ventilation. Beta-blockers were administered within 24 hours of the procedure. Aspirin 1000 mg was administered per rectum after induction. Before dividing the LITA, 180 IU/kg of intravenous heparin is administered to achieve an activated clotting time greater than 350 seconds. The patient is positioned with a roll under the left chest beneath the scapula to allow the left shoulder to be lowered when the left upper extremity is tucked loosely. A 12-mm thoracoscopic trocar is inserted into the fourth or fifth interspace, in the midportion of the sternum, approximately 2 fingerbreadths lateral to the midclavicular line. Ideally, the camera port is inserted at the location that is at a 45-degree angle to the plane of the sternum. This allows optimal visualization of the LITA but adequate distance away from it to allow for easy dissection. Before inserting the trocar, the ventilator is disconnected allowing the heart to fall toward the right hemithorax. The chest is initially entered with a blunt instrument to prevent ventricular or pulmonary injury with port placement. After the trocar is inserted, the chest is insufflated with carbon dioxide at 10 to 15 mm Hg, and the right lung is ventilated. An 8.5-mm trocar is placed 2 interspaces above the camera port under direct vision slightly medial to the camera port. The final 8.5-mm trocar is placed 2 interspaces below the camera port in line or slightly medial to the camera port. The da Vinci Robotic surgical system (Intuitive Surgical, Sunnyvale, Calif) is then docked and instruments inserted under direct vision. The surgeon then scrubs out, and the LITA is harvested using both the robotic monopolar cautery spatula and the bipolar cautery forceps. In general, the LITA is harvested in a semiskeletonized fashion. Overlying muscle and fascia are removed only to provide complete exposure during the harvest. After LITA harvest, pericardial fat is dissected off the pericardium and draped laterally. A small pericardiotomy posterior to the left phrenic nerve can be performed to facilitate pericardial drainage. A full longitudinal pericardiotomy is then performed anteriorly, and the LAD is identified and inspected for a suitable grafting site. The LITA is divided distally between clips after systemic heparinization and clipped to the edge of the pericardium or allowed to fall toward the apex.

At this point, the robotic system is undocked, and the surgeon uses the endoscope to identify the planned site of anastomosis without carbon dioxide insufflation. This allows the heart to return to its natural position within the chest. A spinal needle is inserted through the chest wall to identify the precise location for the incision over the target LAD site. In female patients, the breast is usually retracted medially for the robotic portion of the procedure and then repositioned superiorly/laterally to facilitate an infrathoracic incision if feasible. All ports are then removed, and the anterolateral thoracotomy incision is made. A soft tissue retractor (CardioVations, Edwards Lifesciences, Irvine, Calif) is used to provide exposure through the interspace. Rib spreading is avoided. The LITA is retrieved into the operating field and prepared. The LAD target is exposed and stabilized using a minimally invasive stabilizer (Octopus NUVO, Medtronic, Inc, Minneapolis, Minn), and the anastomosis is performed manually off-pump using fine 8-0 monofilament suture.

Angiography

Since September 2010, it has been our preference to use a hybrid operating room (OR) when available to perform completion angiograms or 1-stop hybrid revascularization when indicated. During our initial experience, we routinely performed selective LITA angiography in the postoperative period to assess graft patency. Patency was defined as less than 50% stenosis in the graft or at the anastomosis. For cases in which a completion angiogram in the hybrid suite revealed graft defects or target vessel errors, the anastomosis was revised during the same operative setting, regardless of whether there was clinical evidence of ischemia.

RESULTS

From October 2009 to September 2012, 307 patients underwent planned robotic-assisted CAB with LITA-LAD grafting. In all patients, the intention was LITA-LAD grafting as an isolated procedure (148, 48.2%) or as part of a hybrid coronary revascularization strategy for multivessel coronary disease (159, 51.8%). All consecutive cases for 2 surgeons during this interval were included