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Robotic Totally Endoscopic Triple Coronary Artery Bypass Grafting on the Arrested Heart: Report of the First Successful Clinical Case

Johannes Bonatti, Atiq Rehman, Kimberly Schwartz, Seema Deshpande, Zachary Kon, Eric Lehr, David Zimrin, Bartley Griffith

University of Maryland School of Medicine, Baltimore, Maryland, USA

ABSTRACT

Robotic technology enables "port only" totally endoscopic coronary artery bypass grafting (TECAB). During early procedure development only single bypass grafts were feasible. Because current referral practice for coronary bypass surgery mostly includes multivessel disease, performance of multiple endoscopic bypass grafts is desirable. We report a case in which a patient received a right internal mammary artery bypass graft to the left anterior descending artery and a left internal mammary artery jump graft to 2 obtuse marginal branches. The procedure was performed through 5 ports on the arrested heart using the daVinci S robotic surgical system. This is the first reported triple bypass grafting procedure using an arrested heart approach.

INTRODUCTION

Robotic totally endoscopic coronary artery bypass grafting (TECAB) has, during the early years of its application, been restricted to placement of single bypass grafts to the anterior wall of the heart, mostly placement of a left internal mammary artery bypass graft (LIMA) to the left anterior descending artery (LAD). Because the indication for placement of single LIMA graft to LAD is rare, development of multivessel TECAB is important for survival and broader application of the method. We—and others—have reported on successful performance of double vessel TECAB [Dogan 2002; Bonatti 2007; Srivastava 2010], but few reports on totally endoscopic triple coronary artery bypass grafting are available [Srivastava 2010]. We report on the first case that was performed in an on-pump arrested heart version.

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Correspondence: Johannes Bonatti, MD, FETCS, Professor of Surgery, Director, Coronary Surgery and Advanced Coronary Interventions, Department of Surgery/Division of Cardiac Surgery, University of Maryland Baltimore, 22 S. Greene St. N4W94, Baltimore, MD 21201 USA; 410-328-9169 (e-mail: jbonatti@smail.umaryland.edu).

CASE REPORT

A 67-year-old male patient with a history of hypertension presented to our center with angina pectoris on exertion. An echocardiogram showed wall motion abnormalities on the anterolateral wall and a left ventricular ejection fraction of 38%. A coronary angiogram revealed significant stenoses of the LAD and both the first and second obtuse marginal (OM1 and OM2) branches.

The patient was evaluated for TECAB. No clinical contraindications were identified. The patient did not report previous thoracic operations or radiation, and there was no history of ipsilateral rib fractures. A preoperative computed tomography (CT) angiogram of the chest and abdomen and preoperative vascular exams showed nonsignificant general atherosclerotic disease. Because the ascending aortic diameter

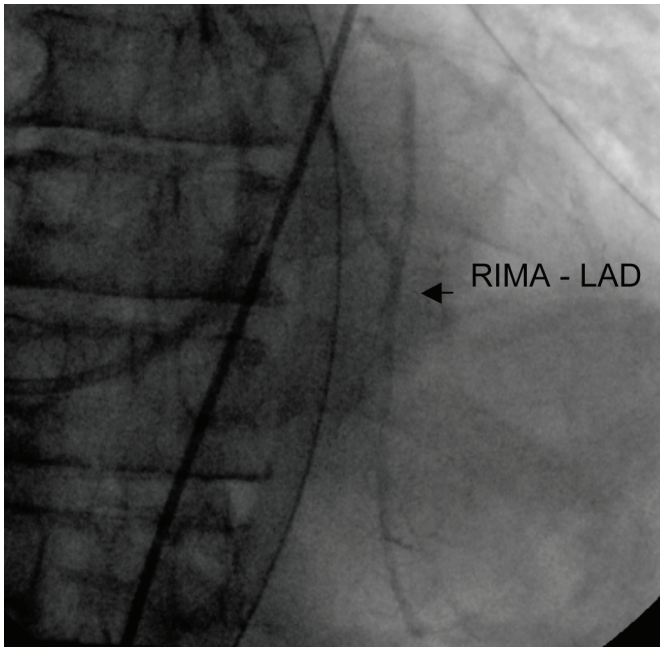

Figure 1. Intraoperative angiogram showing a patent right internal mammary artery (RIMA) bypass graft to the left anterior descending artery (LAD).

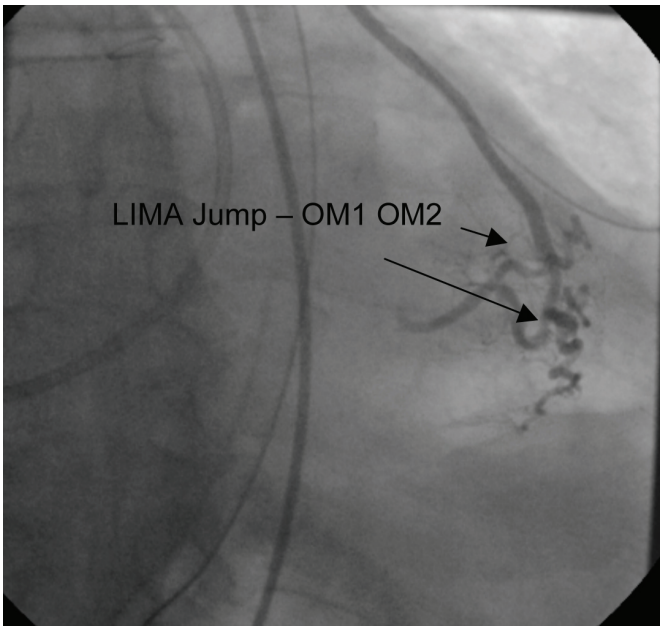

Figure 2. Intraoperative angiogram showing a patent left internal mammary artery (LIMA) jump graft to the first and second obtuse marginal branches (OM1, OM2).

was less than 35 mm, the patient was well suited for a TECAB approach using remote access heart–lung machine perfusion and ascending aortic balloon occlusion for cardioplegia.

SURGICAL TECHNIQUE

The procedure was carried out under general anesthesia with a double lumen tube for left lung collapse. Ports were placed on the lateral left chest wall as described previously [Bonatti 2009]. The daVinci S System (Intuitive Surgical, Inc., Sunnyvale, CA, USA) was docked to the ports. Both internal mammary arteries were harvested endoscopically in skeletonized technique. In parallel to RIMA and LIMA harvesting, the left femoral artery and vein were cannulated using the Edwards Heartport™ system (Edwards Lifesciences, Irvine, CA, USA). The endoballoon was placed into the ascending aorta under transesophageal echo (TEE) control. After excising the pericardial fat pad and pericardiotomy, a subcostal port was positioned for docking of the fourth robotic arm, and a robotic endostabilizer was inserted. Cardiopulmonary bypass was started, and the heart was arrested using the endoballoon catheter. Using the endostabilizer, the lateral wall of the heart was exposed. OM1 and OM2 were exposed and incised. An end-to-side anastomosis between the LIMA graft and the OM2 branch was carried out, followed by a side-to-side anastomosis of the LIMA graft to the OM1 branch. A 7-cm, double-armed 7/0 Pronova suture was used in running fashion. After repositioning of the heart, the LAD was exposed and incised. The RIMA was sutured end-to-side to this target vessel. The cardiac arrest time in this case was 110 minutes, the cardiopulmonary bypass time was 260 minutes, and the TECAB time was 339 minutes. Figures 1 and 2 depict the intraoperative angiogram of the endoscopically placed bypass grafts.

POSTOPERATIVE COURSE

There was nonsignificant postoperative bleeding and the patient was extubated 3 hours postoperatively. He left the intensive care unit on the first postoperative day and was discharged 4 days postoperatively. Household activities and driving were resumed 7 days after the TECAB procedure. The patient is doing well without signs of myocardial ischemia 1 year postoperatively.

DISCUSSION

This case demonstrates that an arrested heart technique is a reasonable approach to performance of completely endoscopic triple coronary artery bypass grafting. We attribute successful performance of this case to the following factors: First, the patient was well suited for the procedure for anatomical reasons, and no major comorbidities were present. Second, the arrested heart technique, where the heart is completely unloaded and flaccid, allowed adequate exposure of the lateral wall of the heart and precise, tremor-free anastomotic suturing. Third, the team performing the procedure had passed the main parts of the learning curve for TECAB and was experienced with double vessel coronary artery bypass grafting using the same technique.

Arrested heart TECAB showed promising clinical results in early studies [Falk 2000; deCannière 2007]. The cumulative perioperative mortality rate in the literature approaches zero percent. The main advantages of this technique as compared to a beating heart off-pump approach are the immediate availability of a heart–lung machine safety net and significant gain of space because the heart is unloaded and both lungs can be deflated. Suturing comfort and precision are enhanced. We have previously shown that an endostabilizer, which is a useful tool for beating heart TECAB, can be applied for exposure of the lateral and back wall of the heart during arrested heart TECAB [Bonatti 2006]. This also proved to be true in the current case of endoscopic triple coronary artery bypass grafting. Our cardiac arrest time was slightly less than 2 hours. In another previous study, we demonstrated that arrest times up to 3 hours can be well tolerated in arrested heart TECAB with cardiac enzyme release in the range of standard on-pump coronary artery bypass graft through sternotomy [Schachner 2007]. An on-table angiogram confirmed adequate patency of the RIMA graft to the LAD and the LIMA jump graft to the obtuse marginal branches. Performance of robotic endoscopic sequential grafts has been described for the anterior wall of the heart [Dogan 2002]. As our case demonstrates, this is also a suitable approach for endoscopic surgical revascularization of the lateral wall of the heart.

We conclude that totally endoscopic triple coronary artery bypass grafting is feasible using an arrested heart approach. This procedure can be regarded as a significant step in the development of robotic endoscopic surgery for multivessel coronary artery disease.

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