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Hybrid Cardiac Revascularization Using a Totally Closed-Chest Robotic Technology and a Percutaneous Transluminal Coronary Dilatation

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INTRODUCTION

We report the case of a 52-year-old man who underwent a combined treatment for multiple coronary artery disease using a robotic closed-chest approach for the grafting of a left anterior descending coronary artery occlusion and a percutaneous transluminal angioplasty of a circumflex stenosis.

CASE REPORT

A 52-year-old man was referred to the thoracic and cardiovascular department of surgery for multiple coronary artery disease. Risk factors included tobacco abuse and family antecedents. In his medical history, we noticed an anteroseptal infarct in 1994 that was treated by early thrombolysis. The coronarography revealed a significant stenosis of the proximal segment of the left anterior descending coronary artery (LAD). Left ventricular ejection fraction was measured at 44%. Transthoracic echography (TTE) showed left ventricular hypertrophy, anteroseptal akinesia, and apical dyskinesia. A percutaneous transluminal coronary dilatation (PTCA) without stenting was performed with a good immediate result. Medical history was free of events until September 1998, when the patient was referred for typical angina at exertion and at rest. The electrocardiograph showed a sequel of an anteroseptal infarct, without modification compared with 1994. An effort test revealed signs of ischemia in V5-V6 and in DII, DIII, aVF. The TTE was not modified compared with 1994. The coronarography performed in May 1999 showed a proximal occlusion of the LAD with retrograde filling and a significant (90%) stenosis of a large second marginal branch. The patient asked for a minimally invasive cardiac procedure. He was offered a hybrid therapy including a minimally invasive surgical approach for the LAD combined with an endoluminal treatment of the marginal lesion.

Surgical intervention was performed on September 2, 1999. The patient was placed in dorsal decubitus with an inflatable pillow under the left flank. After general anesthesia and selective intubation, a 10-mm port was created in the left 4th intercostal space at the anterior axillary line to allow a three-dimensional thoracoscope. Thoracoscopic instruments were introduced through a 2-cm port in the 4th anterior intercostal space and the left internal thoracic artery (LITA) was harvested using electrocautery and titanium microclips. After general heparinization, a cardiopulmonary bypass (CPB) using the Heartport™ system (Heartport Inc, Redwood City, CA) was inserted in the right groin. Using the Seldinger technique, a guidewire was introduced into the femoral artery and progressed into the descending aorta under transesophagal echographic (TEE) control. A 23-French arterial cannula with a Y-arm was placed in the femoral artery and a 28-Fr double stage venous cannula was placed into the right atrium. Cardiac arrest was achieved after aortic clamping by the Heartport Endoclamp® with a cold (4°C) cristalloid antegrade solution. The videoscope was then passed through the anterior port and positioned using the voice-controlled AESOP™ arm (AESOP™, Computer Motion, Inc,

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Goleta, CA). The right arm of the robotic instrument (Zeus Robotic Surgical System®, Computer Motion, Inc, Goleta, CA) was introduced through a 5-mm port in the 4th axillary intercostal space and the left arm through a 5-mm port in the left anterior 8th intercostal space (Figure 1, ◎). After cardioplegic arrest, the pericardium was opened longitudinally, using long-shafted instruments. Traction sutures were placed and brought out of the thorax with an Endoclose™ (Autosuture) and fixed to keep the pericardium open. The LAD was easily located and its intermediate segment was dissected over 2 cm before a longitudinal arteriotomy was made. An end-to-side 7-mm-long anastomosis was performed (Figure 2, ◎) between the LITA and the LAD using a 7-0 Prolene® running suture (Ethicon Inc, Somerville, NJ). Cross-clamping time was 110 minutes, and CPB time was 159 minutes. Weaning from CPB was achieved with inotropic support (dobutamine 4 µg/kg per min). The pericardium was then closed and a chest drainage was established using a 24-Fr chest tube through the 8th intercostal port. The patient was extubated at postoperative day (POD) 0 and discharged from the intensive care unit at POD 1.

PTCA with stenting of the marginal lesion was performed on September 4, 1999. The angiographic control of the LITA-LAD graft demonstrated excellent patency of the anastomosis. The patient left the hospital on POD 7. The postoperative course at three months was uneventful.

DISCUSSION

Minimally invasive cardiac surgery has evolved over recent years to offer benefits over conventional procedures. Different strategies have been adopted to lessen invasiveness with variable results [Lytle 1996]. The LAD approach via a mini-thoracotomy through the 4th anterior intercostal space was first described by Nataf et al [1996]. This direct approach combined the benefits of a reduced incision with off-pump surgery. Nevertheless, the treatment of multiple vessel disease cannot easily be performed through tiny ports with the safety and the standard results of conventional sternotomy. Some authors have proposed a hybrid therapy combining a mini-invasive direct surgical approach to the LAD through a small thoracotomy with percutaneous endoluminal treatment of associated coronary lesions in a rapid sequence [Wittwer 1999]. The next step was to move toward a totally endoscopic approach to the LAD lesion, which was made possible by robotic assistance and 3-dimensional vision [Loulmet 1999, Reichenspurner 1999, Wittwer 1999]. The long-term results of PTCA allow a safe myocardial revascularization as soon as the LAD is secured by a LITA graft [Faxon 1990]. Cardioplegic arrest seemed necessary for this case but with the improvement of robotic practice, the performance of a totally endoscopic coronary artery bypass on a beating heart is likely to occur in the future.

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REVIEW AND COMMENTARY

1. Editorial Board Member AR11 writes:

Evolving technology; provocative manuscript. I question whether this was "the best" operation for the patient, however. It seems as though the patient dictated medical therapy to his doctors, who were only too willing to apply a new technology to his case. Did he really need 2 hours of myocardial ischemia and 2 1/2 hours of pump time to do an operation that could be better done off-pump, with potentially better long-term results?

Authors' Response by Hugo Vanermen, MD:

This was our first CABG case using a robotic technology, which can explain the CPB and the cross-clamp times. We also agree that this surgery was more a patient's demand but based on the reputation of our Department of Cardiac Surgery than on some kind of a surgical bet. Furthermore, we do not have evidence that off-pump coronary surgery can provide better long-term results compared to anastomoses performed under cardiac arrest.

2. Editorial Board Member PB44 writes:

This is an innovative approach to CABG and an example of what we can do with current technology. I am concerned, however, that for a young patient there was not a total arterial revascularization. If the circumflex stenoses

again, it will require further surgery, which may be made interesting by the previous approach. Although the patient may have wished for a minimally invasive approach, I wonder if he was fully aware of the implications.

Authors' Response by Hugo Vanermen, MD:

The hybrid technique is known worldwide and has been validated (e.g., Wittwer 1999). The long-term outcome of dilatations concerning the different coronary arteries allows this combination as soon as the LAD is secured with a LITA. We did not do anything more than transform a MIDCAB into a totally closed-chest approach that was rendered possible by the robotic assistance. Moreover, our goal is to perform multiple grafts using totally closed-chest surgery including a harvesting or RITA by the left thorax. That could be combined to PTCA on the right coronary artery.

3. Editorial Board Member JZ39 writes:

This is simply a case of "I did it first". Importantly, the patient did not go home quickly, and possibly most importantly, this young patient did not have an arterial graft to the circumflex as well. I do not think that this represents "the best" that we, as thoracic surgeons, have to offer. I feel that this case represents the triumph of technique over judgment. There was no arterial conduit to the circumflex, and CPB time was way too long for one graft, thereby increasing the morbidity in this young patient. There was no early dismissal and a lot of expense.

Authors' Response by Hugo Vanermen, MD:

The "long" time before discharge from hospital (POD 7.5 days after PTCA) was not motivated by the patient's medical state. When we started performing MIDCABs, the mean time of hospital stay was 7.9 days and was not motivated by the patients' medical states. We continue performing control angiograms at POD 3 or 4 and discharge the patients immediately thereafter. For the other arguments, see responses for 1 and 2 above.

5. Editorial Board Member MB134 writes:

The paper does demonstrate the potential of endoscopic CABG facilitated by robotic or telemanipulation instruments. This is hopefully an early-phase work and thus, is worthy of publication. There are serious concerns about the fate of hybrid therapy, however. Angioplasty, as is currently practiced, still carries an unacceptable high rate of readmission and re-intervention when compared with full arterial reconstruction. This patient had already undergone angioplasty with failure and total occlusion. He therefore presents as a host with a proliferative response to transcatheter therapies and will likely need further angioplasty. This defeats the purpose of endoscopic CABG surgery to some extent. Even if a patient has an interest in a minimally invasive approach, perhaps it would be better to advise the patient of the long-term results with full arterial grafting, or to select patients with contraindications to a standard approach. In addition, the cross-clamp and cardiopulmonary bypass times are certainly long enough to be a disadvantage that is not outweighed by the freedom from an open incision. If the patient is a manual laborer who cannot return to work until the sternum is healed, then this approach has some advantages. However, almost 2 hours of cross clamp is too long for a single-vessel graft, even when inaugurating a program such as this. Before clinical application should occur, the procedure times must be reduced. Did the authors have extensive laboratory or cadaver practice prior to this case?

Authors' Response by Hugo Vanermen, MD:

We did have an extensive laboratory practice before performing this case (animals and cadavers). Once again, the hybrid approach is not new and the midterm results of PTCA and stenting do not seem to be as catastrophic as the reviewer affirms. Our aim is to perform multiple-vessels anastomoses using a totally-closed-chest technique, but we cannot climb a stair starting at the fourth step

Invited Commentary from John H. Calhoon, MD, Professor and Head, Division of Thoracic Surgery, University of Texas Health Science Center

The case reported by Dr. Farhat is a fascinating one and at first glance represents an excellent triumph for our field. A word of caution, however, is important. In our zeal to do what the patient asks, ie, a minimally invasive cardiac procedure, we should be sure we do no harm. We, as thoracic surgeons and physicians, should guard against overly-aggressive application of technology. An easy 7-mm long end-to-side anastomosis between a left internal mammary artery and the LAD through port access using robotic assistance is, indeed, a tremendous triumph. However, having a patient on a heart–lung machine for over 2-1/2 hours and cross clamping for nearly 2 hours to do a single-vessel bypass, represents a "triumph of technique over judgment." The patient required inotropic support, and although extubated at day 1, had an ischemia that was neither necessary nor in his best interest. As we strive to embrace, utilize, become competent with, and, ultimately, to become experts in the use of robotic and percutaneous techniques in cardiac surgery, we should remain aware of patient safety. More than likely, this circumflex could have been easily accomplished through a small MIDCAB incision with a much safer profile and in a much more efficient time period. The article does not mention whether the patient required blood but one would assume that he may well have, with such a long pump run and the requirement of an intervention within 2 days after surgery. I am a fervent and ardent supporter of minimally invasive technology but, first, I remain a physician; speaking for all physicians, I believe "premum no nocere" to be our overriding concern. Dr. Kit Arom did a number of off-pump LIMA-to-LAD anastomoses with a sternotomy and only later adopted a left anterior thoracotomy when he was satisfied with his technique. Likewise, Dr. Randy Chitwood, has proceeded to smaller and smaller incisions only after positive experiences in the lab. To me, this case represents what we should

avoid. I am not proposing MIDCAB over robotics, or vice versa, but simply not using a technique that exposes a patient to that much time on CPB, in the name of being minimally invasive. More time should be spent in the lab with robotics and with any other new technology until the operating times can be brought into line with or at least somewhat closer in line with the time periods we now have for open techniques whether utilizing a pump or not.