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On-Pump Beating-Heart with Axillary Artery Perfusion: A Solution for Robotic Totally Endoscopic Coronary Artery Bypass Grafting?

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ABSTRACT

Robotic totally endoscopic coronary artery bypass grafting (TECAB) can be performed on the arrested heart or on the beating heart without heart-lung machine support. In high-risk patients or in patients where technical difficulties are expected with a complete off-pump approach, a beating heart concept with heart-lung machine support can be an important option. Femoral arterial cannulation is associated with additional risk of retrograde cerebral embolization, and axillary cannulation is an accepted method in aortic surgery. We describe a case where an axillary artery cannulation method was used for the first time in TECAB performed with the da Vinci telemanipulation system.

BACKGROUND

With the advent of robotic technology, totally endoscopic coronary artery bypass grafting (TECAB) has become feasible. Most groups who have implemented these procedures started out using remote access heart-lung machine perfusion and aortic balloon endoocclusion [Dogan 2002]. This technique, however, requires specific operator skills and carries the disadvantage of endoaortic catheter manipulation, which may lead to dislodgement and embolization of atherosclerotic material. A completely endoscopic approach with the heart beating, on the other hand, avoids the above challenges but is technically more difficult and does not include the safety net provided by extracorporeal circulation. An on-pump beating-heart concept is occasionally discussed but has to our knowledge not been carried out on a broader basis. For a few cases, a femoral access for arterial cannulation was used (Thierry Folliguet, personal communication), which carries the risk of retrograde embolization of atherosclerotic material.

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The axillary artery is a well accepted arterial inflow site for heart-lung machine perfusion in aortic surgery [Schachner 2002]. To our knowledge this option has not yet been chosen for robotic TECAB. We describe a successful case performed using this concept.

CASE REPORT

An 84-year-old obese female patient presented to our hospital with Class III angina. Her risk factors were hypertension, hyperlipidemia, and diabetes mellitus. Coronary angiography revealed a significant proximal stenosis of the left anterior descending artery (LAD), significant stenosis of a small ramus branch, and a significant stenosis of the circumflex coronary artery. The intention to reduce the surgical trauma in an obese patient with advanced age after a recent myocardial infarction was the reason for choosing a hybrid revascularization procedure.

The patient was prepped and draped in typical manner for TECAB with the left chest slightly elevated. Through a left

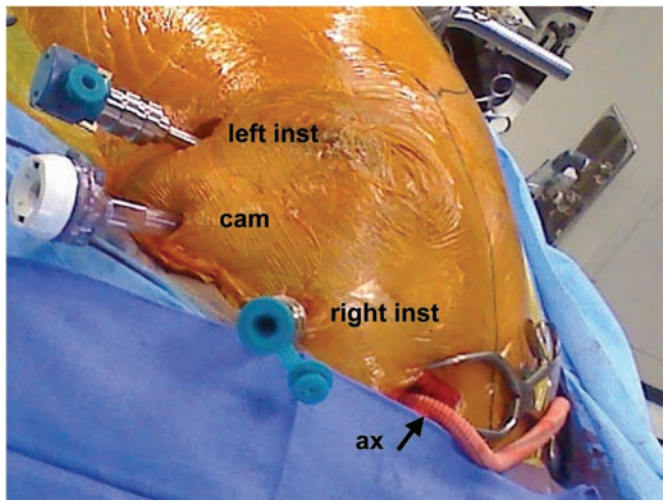

Figure 1. The intraoperative setup is shown. The robotic ports are placed on the patient's left chest. Axillary cannulation was performed using a side graft (arrow). Left inst indicates left instrument; cam, camera; right inst, right instrument, ax, axillary cannulation.

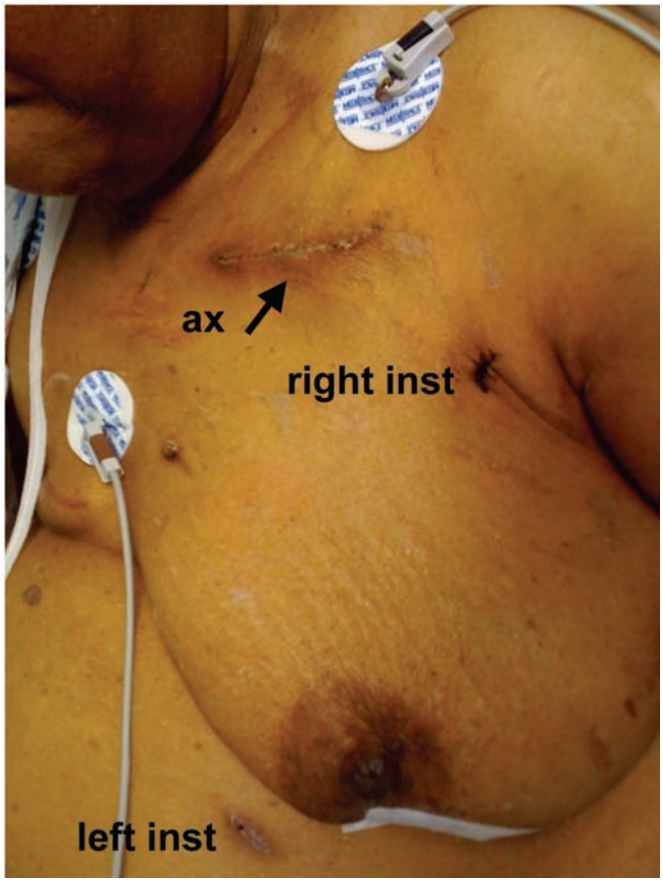

Figure 2. The portholes and the infraclavicular axillary artery exposure site (arrow) are shown. Note complete sternal stability and minimal surgical trauma in an obese patient. Ax indicates axillary artery exposure site; right inst, right instrument port; left inst, left instrument port.

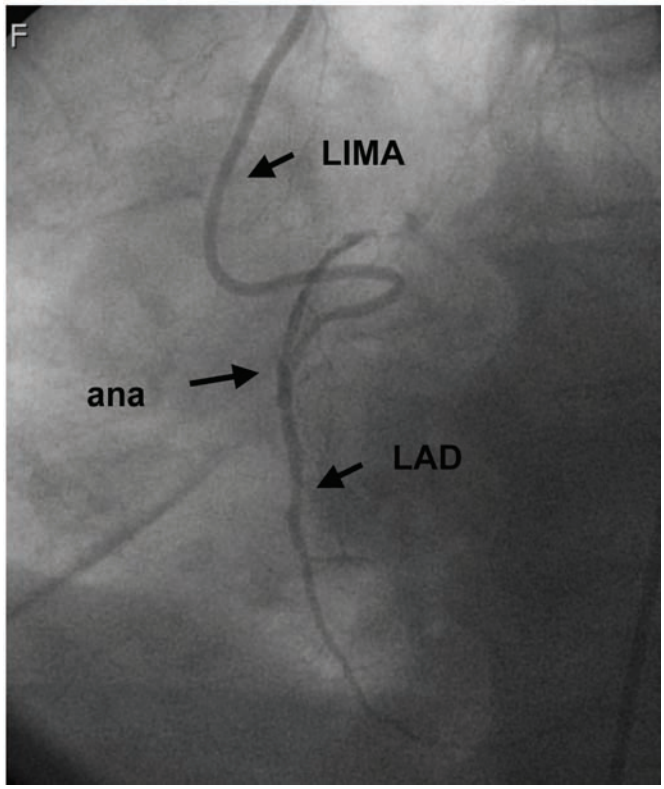

Figure 3. A graft angiogram performed during the staged hybrid coronary intervention shows a patent left internal mammary artery (LIMA) to left anterior descending artery (LAD) graft with excellent run-off into the proximal and distal target vessel and a widely patent anastomosis (ana, arrow).

infraclavicular incision the axillary artery was exposed. The patient was given 5000 IE of heparin, and an 8 mm Dacron graft was sutured to the axillary artery. This graft was connected to the arterial heart-lung machine tubing (Figure 1). A venous return cannula was introduced into the right atrium using the Seldinger technique through the left common femoral vein.

The daVinci S Surgical System (Intuitive Surgical, Sunnyvale, CA, USA) was docked to the patient. Then the internal mammary artery was harvested endoscopically; a skeletonized technique was chosen. After additional heparinization to an activated coagulation time (ACT) of 460 seconds, the graft was endoscopically clamped, divided distally, and checked for adequate free flow. Subsequently the pericardial fat pad was removed, and the pericardial sac was opened in L-shaped fashion.

The LAD was identified. Through a subcostal port an endostabilizer was inserted, and the target vessel was immobilized. After snaring and incision, the LAD significant backbleeding was noted. Additional snaring showed no effect, therefore cardiopulmonary bypass (CPB) was started, which led to reduction of backbleeding and gain of space as the heart was unloaded and both lungs were deflated. The left internal mammary artery (LIMA) was then sutured to the target vessel using a completely endoscopic technique. The LAD was extremely atherosclerotic with a tendency to dissect in typical "onion-like" fashion. The anastomosis was performed using a 7/0 polypropylene suture. The anastomotic time was 37 minutes. The Video shows performance of the LIMA to LAD anastomosis.

CPB was reduced, and the patient was decannulated. The pump time was 78 minutes. An endoscopic inspection of the chest after heparin reversal showed adequate hemostasis. The robotic system was removed, and the thoracic portholes as well as the axillary artery exposure site were closed.

The patient showed nonsignificant bleeding postoperatively and was hemodynamically stable without any signs of myocardial ischemia. She was extubated 11 hours postoperatively. During the further postoperative course, a paralytic ileus developed which was treated by conservative means.

On the eighth postoperative day, the patient was taken to the cardiac catheterization lab where she underwent percutaneous transluminal coronary angioplasty (PTCA) and stenting of the circumflex coronary artery. Two bare metal stents were implanted (a 3.5 × 23 mm Guidant Multilink Vision™ (Santa Clara, CA, USA) stent into the mid circumflex artery, and a 3.0 × 1.5 mm Guidant Multilink Vision™ stent into

the distal circumflex artery). The patient left the hospital on the ninth postoperative day. She resumed everyday activities approximately 3 weeks postoperatively.

DISCUSSION

TECAB on the beating heart without any heart-lung machine support is commonly regarded as the ultimate goal of procedure development. In the first phase of beating heart TECAB application, however, conversion rates were in the 30% range [Dogan 2002], and a very recent series on beating heart TECAB reports a considerable rate of patients who were excluded intraoperatively [Srivastava 2008]. In the majority of these, hemodynamic instability, intolerance of single lung ventilation, and arrhythmia were the causes for changing the operative strategy and conversion. These issues may be manageable with a beating heart approach using the heart-lung machine.

A method that avoids endoaortic catheter manipulation and provides the safety net of extracorporeal circulation would be an attractive option in TECAB. Femoral artery retroperfusion is associated with an increased risk of retrograde aortic dissection. Arterial perfusion through the axillary artery provides antegrade flow on the descending thoracic and aortoiliac level and may thereby be a factor preventing embolism from those sites. In addition, the risk of retrograde aortic dissection is reduced.

Performing the present case in a completely endoscopic fashion without heart-lung machine was regarded as too risky for the following reasons: First, given the patient's obesity, we expected space problems inside the chest. Second, a conversion from TECAB to an open procedure for myocardial ischemia or technical difficulties was regarded as a situation that should absolutely be avoided in an 84-year-old patient. In off-pump coronary surgery, conversion is known to be associated with excess mortality. Contraindications for an arrested heart concept with aortic balloon endoocclusion also existed because of extensive aortoiliac atherosclerosis.

In the present case several factors helped control the backbleeding from the target vessel, which had significantly obstructed the view through the robotic 3D camera. By starting the heart-lung machine, the heart was unloaded, and by good venous drainage, target vessel backflow was reduced. In addition, space was gained by deflating both lungs, which enhanced the comfort of endoscopic surgical work.

Mizutani and coworkers recently observed a significantly reduced hospital mortality in patients undergoing on-pump beating-heart CABG as compared to a propensity matched group of patients who were operated on using cardioplegic arrest [Mizutani 2007]. In a study by Miyahara, the on-pump beating-heart CABG reduced mortality and morbidity in patients after myocardial infarction [Miyahara 2008]. Rastan of Leipzig demonstrated that the on-pump beating-heart approach in comparison to a complete off-pump technique leads to increased myocardial enzyme release. Myocardial muscle creatine kinase isoenzyme (CK-MB) and Troponin I were increased in the on-pump beating-heart group, and the same was true for coronary sinus lactate levels. This release, however, reached only moderate levels. The on-pump beating-heart group showed slightly longer ICU and ventilation times as well as increased inotropic support. Hospital mortality, however, was similar [Rastan 2005].

We conclude that TECAB can be carried out on the beating heart using heart-lung machine support with cannulation of the axillary artery for arterial inflow. This represents a promising concept for high-risk patients in whom intraoperative hemodynamic instability and retrograde transfemoral pump flow should be avoided.

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