

Closed Chest Coronary Artery Bypass on the Beating Heart

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ABSTRACT

Minimally invasive surgical procedures have become a part of routine cardiac surgery. The surgical techniques have been developed for the treatment of coronary artery disease in order to minimize surgical trauma.

With the introduction of a 3-D-based totally endoscopically functioning system into minimally invasive cardiac (MIC) surgery, further reduction of skin incisions became possible and enhanced MIC techniques could be improved. Due to the 6° freedom of motion allowed by wrist-enhanced instruments and a newly developed endoscopic stabilizer, totally endoscopic coronary artery bypass procedures on a beating heart became feasible.

We present here our initial series of totally endoscopic "off-pump" coronary artery bypass grafting in patients suffering from coronary artery single vessel disease. In all patients, the procedure was successfully performed via four 1 cm chest incisions as closed-chest procedures.

INTRODUCTION

The introduction of robotic-enhanced instrumentation led to a new, minimally invasive surgical approach in patients with coronary artery disease [Shennib 1998, Carpentier 1999, Loulmet 1999, Mohr 1999, Reichensperner 1999, Shennib 1999, Kappert 2000a, Kappert 2000b]. The application of an intrathoracic stabilizer enables closed-chest off-pump coronary artery bypass (OPCAB) via a

four-point stab incision, thus avoiding sternotomy and minithoracotomy [Falk 1999, Falk 2000]. After performing over 120 minimally invasive surgical procedures since May 1999 (including a series of uni- or bilateral internal mammary artery harvesting and totally endoscopic coronary artery bypass (TECAB) grafting on an arrested heart), we present this report reflecting our observations regarding the feasibility of TECAB grafting on a beating heart. An initial series of closed-chest OPCAB grafting using wrist-enhanced robotic instrumentation in three male patients suffering from single-vessel coronary artery disease (SVCAD) using the left internal mammary artery (LIMA) is presented.

MATERIALS AND METHODS

The da Vinci™ 3-D based robotic system (Intuitive Surgical, Mountain View, CA) has been described in detail before [Carpentier 1999, Falk 1999, Loulmet 1999]. Three male patients (age 72 ± 7.9 years) suffering from recurrent angina pectoris underwent coronary angiography, which revealed a significant lesion of the left anterior descending artery (LAD) not suitable for percutaneous transluminal coronary angioplasty (PTCA) or stenting. Left ventricular ejection fraction was $65\% \pm 7.5\%$. Physical examination determined the patients to be in New York Heart Association (NYHA) class III and Canadian Cardiovascular Society (CCS) stage II.

For surgery, all patients were placed in a supine position with the left arm resting slightly beneath the posterior axillary line. After introduction of general anesthesia, a double-lumen tube or bronchial blocker was used for single-lung ventilation during surgery. Three 1 cm skin incisions were made in the left chest in the third intercostal space (ICS) at the medioclavicular line, in the fifth ICS at the anterior axillary line, and in the sixth ICS at the medioclavicular line.

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Through the camera port, CO₂ insufflation was started at pressures of 5 to 10 mm Hg. The actuators and camera of the da Vinci™ surgical system were placed via three ports. Following a brief exploration of the left chest cavity, LIMA takedown was begun (see Movie, Ⓜ), creating a pedicle which was then skeletonized and spatulated for anastomosis.

A vessel clamp was introduced via the right port and placed on the artery about 3 cm proximally to the distal end, and the vessel was transected and the pericardium opened (Movie, Ⓜ). Blood flow through the LIMA was assessed by a temporary release of the vessel clamp. Proximal and distal vessel loops were placed along the anastomosis using the two robotic arms (Movie, Ⓜ).

An additional 1 cm subxiphoid port was placed for an endoscopic stabilizing device (see Movie and Figure 1, Ⓜ). After placement of the stabilizing device on the LAD, blood flow through this vessel was temporarily interrupted using the vessel loops (see Movie, Ⓜ). In order to preserve a bloodless operating field we used saline flushing, and the anastomosis was completed with the da Vinci™ system using a 7-0 prolene running suture. The anastomosis was completed, the vessel clamp was released, and the anastomosis was explored for leakage (Movie Ⓜ).

During and after surgery, no signs of acute myocardial ischemia were observed, no inotropic support was necessary. Protamin was administered and the actuators and camera were removed. A chest tube was inserted in the left pleural cavity using the incision at the sixth ICS on the medioclavicular line. Before transfer of the patient to ICU, a single-lumen endotracheal tube replaced the double-lumen endotracheal tube.

RESULTS

All patients survived the procedure. The whole operation was performed via four 1 cm incisions using the wrist-enhanced robotic system. The LIMA was harvested in a median time of 29 ± 8.8 minutes. The time required for endoscopic anastomosis was 37 ± 13.1 minutes, and surgery was completed in 208 ± 42.9 minutes. No perioperative complications occurred. The patients stayed in ICU for 21 ± 2.2 hours.

Postoperatively, the patients were continuously in sinus rhythm, never showing signs of ischemia on electrocardiogram (ECG) or necessity for inotropic support. Evaluation of cardiac enzymes (Troponin-T and Creatinase-Myoglobine/Creatinase, (CK-MB/CK) fraction) excluded a myocardial infarction. Median value of hospitalization was 6 ± 1 days. All patients were discharged at NYHA class I and CCS stage I (Figure 2, Ⓜ). Four weeks postoperatively, stress ECG revealed no signs of ischemia in all patients and all patients were free from angina. Coronary angiogram revealed a progredient lesion of the circumflex artery and an uneventful PTCA for one patient appearing to suffer from angina 12 weeks post-operatively.

DISCUSSION

Totally endoscopic coronary artery bypass grafting (CABG) without extracorporeal circulation was performed in three patients suffering from SVCAD using the da Vinci™ 3-D-based robotic system. This new, minimally invasive technique is a promising alternative for patients suffering from SVCAD that avoids median sternotomy and minithoracotomy. Without extra-corporeal circulation, an additional trauma is prevented. The short hospital stay illustrates an improved convalescence after bypass surgery. Further improvement may eventually lead to a one- to two-day procedure.

In our opinion, the described procedure for SVCAD reflects a major step towards a totally endoscopic surgical treatment of patients with complex coronary artery disease, especially for patients showing serious risk factors for extracorporeal circulation or those at high risk for delayed wound healing.

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