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Closed Chest CABG on the Beating Heart With a Computer-Enhanced Articulating System: Case Report

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INTRODUCTION

Endoscopic coronary artery bypass grafting (CABG) has been facilitated by the use of sophisticated robotic surgical systems [Loulmet 1999, Boyd 2000]. Since September 1999, our institute has performed 76 coronary artery bypass procedures on the beating heart using robotic telemanipulation. In this series, 15 patients have undergone totally endoscopic beating heart CABG using the ZEUS™ telemanipulation system (Computer Motion, Goleta, CA) and a prototype endostabilizer. For the first 12 patients in the series, the ZEUS instruments had rigid wrists with four degrees of freedom. At that time, a group of newly developed articulating instruments named Microwrist (Computer Motion, Goleta, CA) were introduced and used at our institution for beating heart CABG. The Microwrist devices added an articulating wrist on the 3 mm instruments that allowed an additional degree of freedom. When using this system, a surgeon is able to change the angle of the wrist at the console by finger activation on each hand-controller. This report describes our preliminary clinical experience using the Microwrist.

CASE REPORT

Three consecutive patients successfully underwent totally endoscopic off-pump coronary artery bypass grafting of the left internal thoracic artery (LITA) to the left anterior descending artery (LAD) with the use of the ZEUS telemanipulation system and a robotic arm with a shaft-driven wrist. All of the patients had single-vessel disease in the LAD.

All operations were performed under general anesthesia using a double lumen endotracheal tube. Patients were placed in the 30-degree right lateral decubitus position. The anesthetic techniques of this procedure have been reported previously [Kiaii 2000].

The ZEUS telemanipulation system used in this series has been described in detail in previous reports. In all cases, the LITA was harvested using the ZEUS system and the harmonic scalpel introduced through three 5 mm ports placed in the left chest. A 5 mm, 2-dimensional, 30-degree camera was used for taking down the LITA. LITA harvest times for the three patients were 110 minutes, 65 minutes, and 45 minutes (mean 73 min.). After the surgeon had opened the pericardium and detected the LAD, the LITA was clipped and cut following systemic heparinization and verification that the activated clotting time (ACT) was greater than 400 seconds. The specially designed endostabilizer (Computer Motion, Goleta, CA) was positioned through a 10 mm port placed in the second interspace in the lateral clavicular line.

The new articulating instruments were inserted into the chest cavity through 5 mm ports. A 3-dimensional, 10 mm camera (Karl Stortz, Culver City, CA) replaced the 5 mm camera for the anastomosis. After gaining proper stabilization of the target area, the surgeon placed two silastic tapes around the LAD using the ZEUS articulating instruments. After arteriotomy was performed, a 1.5 mm intracoronary shunt was placed in the LAD. An Octopus® Tissue Stabilization Arm (Medtronic, Minneapolis, MN) was positioned on the table to hold a 3 mm endoscopic grasping instrument that held the distal end of the harvested LITA to facilitate stabilization. The anastomosis was then fashioned using 7 cm, 8-0 Gore-Tex® suture (W.L. Gore & Associates, Flagstaff, AZ). After stitching around the heel area, the distal end of the harvested LITA was cut away and the conduit parachuted down. In the first case, the Gore-Tex suture broke during the procedure and another suture was used to complete the anastomosis.

Anastomosis time averaged 106 minutes and intraoperative graft flow averaged 54 ml/min. Total operation time averaged 538 minutes, with postoperative hospital stay time averaging 65 hours. Postoperative angiography showed good-quality anastomoses.

COMMENT

Endoscopic coronary artery surgery has been made possible by the introduction of robotic surgical systems [Loulmet 1999, Reichenspurner 1999, Boyd 2000, Falk 2000]. Although small movements performed with the robotic arm are more refined than with human hands, the dexterity permitted by four degrees' freedom of motion is suboptimal for some tasks. Falk et al. [Falk 1999] have demonstrated that the performance of endoscopic surgical tasks is facilitated by

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using computer-enhanced robotic systems with end-effectors having six degrees rather than four degrees of freedom. To improve the instruments' dexterity, Computer Motion Inc. developed new 3 mm instruments with an additional degree of freedom at the distal end. The addition of an articulating joint on the instrument has facilitated the performance of many maneuvers that are necessary during surgery.

CONCLUSION

We have employed the Microwrist system clinically and confirmed the usefulness of the additional dexterity it provides. Each joint angle is easily changed by a control switch touched by the surgeon's finger. With these new instruments, we have successfully completed totally endoscopic off-pump CABG in three successive cases. Although the operation time was long for a single-vessel CABG, the patient recovery time was short, with one patient being discharged from the hospital only 39 hours after surgery.

Totally endoscopic off-pump CABG is still experimental, and the final goal of routinely performing it is yet to be realized. Some of the issues still to be resolved include the limited camera views and anterior working space, cardiac stabilization difficulties, and the lack of assistance and tactile feedback. The fixed pivot points of the endoscopic instruments may also cause difficult surgical approach angles and robotic arm singularity. Although this report and others [Falk 2000] have shown that totally endoscopic surgery can be performed on the beating heart, further refinements are necessary before the procedure is broadly applied.

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