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Total Endoscopic Off-Pump Coronary Artery Bypass Grafting

Dr. Falk

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ABSTRACT

Two cases of totally endoscopic off-pump coronary artery bypass grafting (TECAB) of the left internal thoracic artery to the left anterior descending artery using the da Vinci™ telemanipulation system (Intuitive Surgical, Mountain View, CA) are described. A new articulating endoscopic stabilizer with cleats was developed to enable endoscopic anchoring of silastic vessel loops for vascular occlusion. Newly created attachments for irrigation and suction, along with active robotic enhanced assistance by a second surgical console, permitted our group to perform for the first time a truly endoscopic bypass grafting without any thoracotomy.

INTRODUCTION

With the introduction of computer enhanced instrumentation systems, endoscopic coronary artery bypass grafting has become possible [Boehm 1999, Loulmet 1999, Mohr 1999]. Using the da Vinci™ computerized telemanipulation system (Intuitive Surgical, Mountain View, CA), our institution has now performed closed chest coronary artery bypass grafting (CABG) of the left internal thoracic artery (ITA) to the left anterior descending (LAD) on 25 patients [Falk 2000]. Although less invasive in terms of surgical access, the use of the Port-Access™ system (Heartport, Redwood, CA) and thus cardiopulmonary bypass with cardioplegic arrest do not favor this operation as compared to the MIDCAB approach. Others have reported initial results using the ZEUS™ system (Computer Motion, Santa Barbara, CA) for suturing the ITA to LAD anastomosis on the beating heart [Reichenspurner 1999]. However, a minithoracotomy was required to place a conventional stabilizer and manual assistance was applied for pericardiotomy, coronary occlusion, arteriotomy and during suturing. Again, there was no obvious benefit as opposed to the MIDCAB approach.

Utilizing a newly designed endoscopic stabilizer, we have recently reported the first experimental trial of totally endoscopic coronary artery bypass grafting (TECAB) on the beating heart in a canine model [Falk 1999a]. The limitations were numerous. The problem of endoscopic coronary occlusion was not solved, as was the problem of endoscopic irrigation and suction. The first generation of endoscopic stabilizer lacked articulation within the chest, making positioning difficult. In subsequent animal studies these shortcomings were addressed and a new endoscopic stabilizer design has been developed. Based on the architecture of the end-effectors used in the da Vinci system™ (Intuitive Surgical, Mountain View, CA), this second generation endoscopic stabilizer provides full intracorporeal articulation, which facilitates placement of the device parallel to the target vessel and in a plane with the myocardial wall. In addition, slotted cleats were added as holders for the silastic vessel-loops to permit temporary target vessel occlusion analogous to the technique that is currently applied in MIDCAB and OPCAB surgery. By adding an irrigation channel to the end-effectors, directed irrigation at the site of the anastomosis became feasible. The modified instruments were successfully applied in a series of animal experiments. The first two successful clinical cases were performed on January 13 and 14, 2000 respectively.

CASE REPORT

The da Vinci™ telemanipulation system (Intuitive Surgical, Mountain View, CA) used in this case report has

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been described in detail before [Loulmet 1999, Falk 1999b, Falk 2000]. In order to provide intracorporeal assistance and retraction for the primary surgeon, one additional arm was placed and operated from a second console. The endoscope was mounted on a left sided cart and inserted through a central port. The left and right tool of the primary surgeon were operated from the left and right column mounted manipulator arms, respectively. The central column mounted manipulator arm was driven from the second console and used for assistance. The scope was driven from the primary console by the operating surgeon with the image being simultaneously displayed on both consoles.

The second generation endoscopic stabilizer (7 mm in diameter) with fully articulating stabilizer pads was used. The stabilizer pads were manipulated from outside the chest. Once in place, the pads were locked and the stabilizer mounted to a passive articulating arm. Anchoring of the silastic vessel loops for vascular occlusion was provided by means of two cleats on top of each of the stabilizer pads. The diameter of the stabilizer allowed its operation through an 8mm cannula.

In two male patients with a subtotal proximal LAD stenosis, totally endoscopic off-pump coronary artery bypass grafting of the left ITA to the LAD was successfully performed. The surgical approach has been described in part elsewhere [Falk 1999b]. The entire operation was performed without any open thoracotomy using a total of 5 trocar sites (one 12mm port for the camera and four 8 mm ports for the three surgical instruments and stabilizer, respectively). All surgical maneuvers were performed remotely from the da Vinci™ (Intuitive Surgical, Mountain View, CA) console. After take-down of the left ITA and in situ preparation of the distal portion, the pericardium was opened and the LAD was identified (see Movie ◎).

After intravenous administration of 15,000 units of heparin, the ITA was occluded using a vascular occluder and the distal end clipped, divided, and trimmed in preparation for anastomosis. Using a beaver blade, the epicardium was scratched in order to facilitate passage of the blunt tipped silastic tape needle. The stabilizer was placed through a subxyphoid trocar (see Figures 1 and 2, ◎). After blunt dissection of the LAD, the ITA graft was approximated to the site of anastomosis (see Movie ◎). The LAD was occluded with crossed silastic vessel loops that were anchored to the stabilizer cleats (see Movie ◎). The arteriotomy was made using a sharp knife. The anastomosis was performed using a 7 centimeter long 7-0 double armed Prolene® suture (see Movie ◎). Countertraction during suturing was provided by the assistant at the second console. After completion of the anastomosis, the silastics and the stabilizer were withdrawn. Through one of the port incisions, a pleural chest tube was inserted (see Figure 3, ◎). Intraoperative angiography revealed patent grafts, which was confirmed by a pre-discharge angiogram (see Movie ◎). Surgical time for these two initial cases was 4.5 and 5 hours respectively. Target vessel occlusion times were 60 and 45 minutes respectively and were tolerated well in both cases. Both patients were extubated on the day of surgery and discharged after 5 and 6 days, respectively.

DISCUSSION

The operation that has optimized access and at the same time obviated the need for CPB for single bypass grafting of the LAD is the MIDCAB operation [Diegeler 1998]. With the introduction of computer controlled instrumentation systems, access for single vessel grafting could be further miniaturized and the operation now performed through three ports [Falk 1999, Loulmet 1999]. Due to the lack of endoscopic stabilizers, the TECAB procedure was initially performed on the arrested heart using the Port-Access™ (Heartport, Redwood, CA) technique with transfemoral cardiopulmonary bypass and endoaortic clamping. As has been demonstrated by Reichenspurner et al., it is possible to endoscopically suture a coronary anastomosis on the beating heart using computer enhanced instrumentation systems [Reichenspurner 1999].

In a number of trials we have developed the neccessary tools to perform truly endoscopic bypass grafting (which by definition requires no thoracotomy) on the beating heart. Using an articulating stabilizer that also provides a mechanism for endoscopic vascular occlusion and irrigating endoscopic tools, the technical prerequisites for a complete closed chest off-pump bypass procedure were met. By using a second console, the concept of remote assistance during endoscopic coronary surgery has been proven. Although the expense of the involved technical equipment is substantial, the benefit of active assistance seems to justify the costs at this time. While still being considered an experimental surgical approach, these preliminary results demonstrate the feasability of this operation. With further refinements and minaturization, the role of TECAB in the future may expand.

REFERENCES

1. Boehm DH, Reichenspurner H, Gulbins H, Detter C, Meiser B, Brenner P, Habazettl H, Reichart B. Early experience with robotic technology for coronary artery surgery. Ann Thorac Surg 68:1542–6, 1999.
2. Diegeler A, Falk V, Matin M, Battellini R, Walther T, Autschbach R, Mohr FW. Minimally invasive coronary artery bypass grafting without cardiopulmonary bypass: Early experience and follow-up. Ann Thorac Surg 66:1022–5, 1998.
3. Falk V, Diegeler A, Walther T, Löscher N, Vogel B, Ulmann C, Rauch T, Mohr FW. Endoscopic coronary artery bypass grafting on the beating heart using a computer enhanced telemanipulation system. Heart Surg Forum 2:199–205, 1999.
4. Falk V, Mc Loughlin J, Guthart G, Sailsbury K, Walther T, Gummert JF, Mohr FW. Dexterity enhancement in edoscopic surgery by a computer controlled mechanical wrist. Min Inv Therapy Allied Tech 8:235–42, 1999.
5. Falk V, Diegeler A, Walther T, Bannusch J, Brucerius J, Rau-

mans J, Autschbach R, Mohr FW. Total endoscopic coronary artery bypass grafting. Eur J Cardiothorac Surg 17:30–7, 2000.
6. Loulmet D, Carpentier A, d'Attellis N, Mill F, Rosa D, Guthart G, Berrebi A, Cardon C, Ponzio O, Aupecle B. First endoscopic coronary artery bypass grafting using computer assisted instruments. J Thorac Cardiovasc Surg 118:4–10, 1999.
7. Mohr FW, Falk V, Diegeler A, Autschbach R. Computer enhanced coronary artery bypass surgery. J Thorac Cardiovasc Surg 117;1212–3, 1999.
8. Reichenspurner H, Boehm DH, Gulbins H, Detter C, Damiano R, Mack M, Reichart B. Robotically assisted endoscopic coronary artery bypass procedures without cardiopulmonary bypass. J Thorac Cardiovasc Surg 118:960–1, 1999.

REVIEW AND COMMENTARY

1. Editorial Board member YT31 writes:

I am curious why the length of stay was 5 and 6 days.

Authors' Response by Volkmar Falk, MD:

According to the German standard of postoperative care following CABG, early discharge after a bypass procedure is as yet not widely accepted. Patients therefore remain in the hospital up to 7 days following the procedure. This may eventually change with the introduction of endoscopic techniques. However, the experience with this new approach is still very limited and we are currently not stressing an early discharge as a measure of effectiveness for this procedure.

2. Editorial Board Member SG14:

This is an extremely important article. It would be helpful to list the number of clinical attempts with the conversions to let the readers gain the right impression of the difficulty of the procedure.

Authors' Response by Volkmar Falk, MD:

It is worthwhile mentioning unsuccessful attempts to get the right impression of the level of difficulty. However, this was not a series of patients conducted to define outcome after a new procedure but rather presents an evolutionary effort in minimally invasive cardiac surgery with the intent to describe the procedure.

We have attempted this operation in a total of seven patients at the time of submission. Five patients were converted to a MIDCAB procedure for the following reasons: Severe coronary calcification requiring endarteriectomy and vein patching prior to insertion of the ITA-graft (1); insufficient exposure due to a lack of space between the heart and the chest wall (2); and bleeding from a septal branch at the site of arteriotomy (despite sufficient stabilization and proximal as well as distal occlusion) (1). This problem may resolve with the endoscopic use of shunts. In another patient, the operation was performed completely as described but the intraoperative angiogram showed insufficient flow of the graft. During revision of the anastomosis that was performed through a MIDCAB incision, no obvious cause was found (anastomosis patent by probing).