Robot-assisted laparoscopic aortobifemoral bypass for aortoiliac occlusive disease: A report of two cases

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This article describes the use of robotic technology in laparoscopic aortobifemoral bypass grafting. In two patients with disabling intermittent claudication on the basis of severe aortoiliac occlusive disease, laparoscopic aortobifemoral bypass grafting was performed with a proximal end-to-side anastomosis constructed with robotic arms that had been mounted on the operating table and were controlled from a separate console. No complications occurred. Operating times were 290 and 260 minutes, and aortic anastomosis times were 48 and 37 minutes, respectively. Blood loss was less than 200 mL in both cases. A normal diet was resumed on the second postoperative day, and the patients were discharged home on postoperative days 4 and 6. To our knowledge, this is the first report on robot-assisted laparoscopic aortobifemoral bypass in the world literature. (J Vasc Surg 2002;36:1079-82.)

Laparoscopic aortic surgery to date has not been widely embraced by vascular surgeons probably because of the highly specific technical skills needed especially in performing the aortic anastomosis.[1,2] Robotic technology has been shown to simplify endoscopic surgical manipulation by increasing the degrees of motion and facilitating hand-eye coordination and could therefore potentially stimulate acceptance of laparoscopic aortic grafting into the vascular surgical arena. We report two cases of robot-assisted laparoscopic aortobifemoral bypass grafting for aortoiliac occlusive disease.

PATIENTS AND METHODS

In two male patients, 53 and 56 years old, with disabling claudication and a walking distance of less than 80 m, angiography revealed occlusion of the entire left iliac trajectory and sequential stenoses on the right. Because of the extension of the occlusive disease, we chose to offer the option of primary laparoscopic aortobifemoral bypass grafting. Several years of experience with laparoscopic assisted aortofemoral bypass grafting with laparoscopic aortic dissection[3] followed by a "handsewn" aortic anastomosis via a 10-cm to 15-cm flank incision and a 4-month period of extensive in vitro practice sessions and animal experimentation with a robotic surgical system (Zeus, Computer Motion, Santa Barbara, Calif) preceded approval of our hospital Investigational Review Board and patient informed consent. On February 20 and 21, 2002, the two patients underwent robot-assisted laparoscopic aortobifemoral bypass grafting in the Vrije Universiteit Medical Center.

Surgical technique. With general anaesthesia, the patient was positioned with the left flank slightly tilted on a pillow to provide adequate access to the lateral abdominal wall. Three robotic positioner arms were connected to the operating table rails and prepared into the sterile field, one for a 30-degree endoscope (Aesop Endoscope Positioner, Computer Motion) on the right and two instrument arms on the left side of the patient, in such a fashion that interference with the insufflated abdominal wall was avoided (Fig 1). The arms then were simply rotated away to allow ample room around the table for the aortic dissection with conventional laparoscopic techniques. Via small groin incisions, the common femoral arteries were dissected free bilaterally. Laparoscopic retroperitoneal dissection of the aorta was performed after the creation a of a peritoneal "apron" that was being suspended to the anterior abdominal wall. This technique, with six 10-mm trocars, has been described in detail by one of the authors (CG).[1] Once the infrarenal aorta and its bifurcation were dissected free, lumbar arteries at the proposed site of aortic clamping were ligated with clips and the inferior mesenteric artery was temporarily controlled with a silastic loop to control back bleeding. After systemic heparinization, the aorta was clamped just distal to the renal arteries and just below the inferior mesenteric artery with laparoscopic aortic clamps that were positioned via separate stab incisions. A longitudinal aortotomy was made with laparoscopic scissors after a 14-mm × 7-mm polytetrafluoroethylene prosthesis was introduced into the retroperitoneal cavity via the lower median port. With robotic steered instruments consisting of a needle driver on the right and a grasper on the left and with a voice-controlled robotic positioned endoscope (Micro Joint Heavy Needle Driver, Micro Joint De Bakey

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Competition of interest: Computer Motion Corp, Santa Barbara, Calif, has provided a Zeus robotic system to the VU Medical Center at no cost to the institution. None of the authors have received financial support from Computer Motion.
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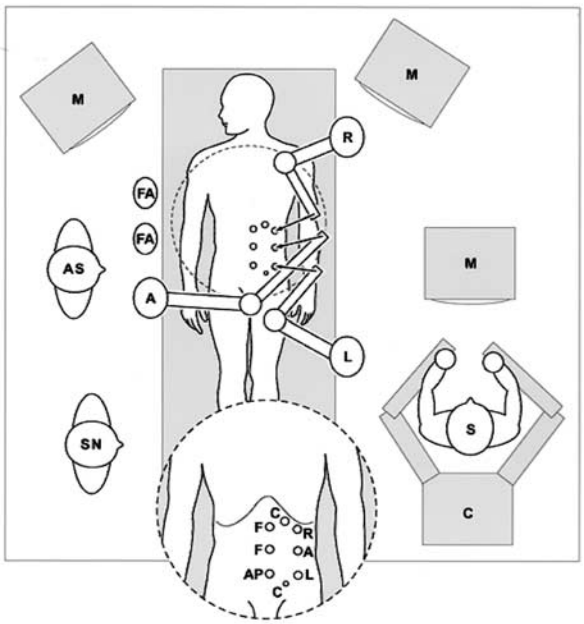

Fig 1. Operating room set-up. *M,* Monitor; *C,* surgeon control console; *AS,* assistant surgeon; *SN,* scrub nurse; *FA,* connection site for fan arm retraction holders; *R,* right robotic arm; *L,* left robotic arm; *A,* surgical endoscope positioner (Aesop). Inset: trocar positions in abdominal wall: *C,* Aortic clamp; *F,* fan retractor.

Grasper and Aesop Robotic Endoscope Positioner, Computer Motion), an end-to-side anastomosis was performed with a running monofilament polytetrafluoroethylene suture (Fig 2). The robotic positioner arms were controlled from a separate surgeon control console consisting of a monitor and two device control handles that provided a natural robotic interface for scaled hand-to-instrument tip movement (Fig 3). The robotic instrument controls were activated via a foot switch. The first assistant stood at the operating table and introduced conventional laparoscopic instruments via the suprapubic trocar for suction and to maintain the tension on the suture. After completion of the aortic anastomosis, the two graft limbs were tunneled to the groins, where a conventional end-to-side anastomosis was performed to the common femoral artery.

The authors were involved in the study design, had full access to all of the data in this study, and take complete responsibility for the integrity of the data and the accuracy of the data analysis and interpretation and for writing the manuscript and submitting it for publication.

RESULTS

No operative complications occurred. Operating times were 290 and 260 minutes, with aortic anastomosis times of 48 and 37 minutes, respectively. In the first case, one additional stitch was necessary to obtain a completely dry anastomosis; no extra stitching was necessary during the second operation. The time to set up the robotic positioner arms and connect the robotic instruments was 12 minutes. Blood loss was less than 200 mL in both cases. A normal diet was resumed on the second postoperative day, and the patients were discharged home on postoperative days 4 and 6. The relatively long hospital admission time of the second patient was because of a perianal fungal infection that necessitated medical treatment.

DISCUSSION

Although its long-term patency rates remain unsurpassed, the classical open aortobifemoral bypass procedure has been largely replaced by endoluminal techniques, such as percutaneous transluminal angioplasty, with or without stent or stent graft placement. However, in the presence of diffuse long segment stenoses or occlusions, in particular with involment of the external iliac arteries, endoluminal recanalization may not be technically possible or may yield disappointing long-term results.[4,5] Therefore, the continued search for a procedure that will combine the excellent patency rates of the surgical bypass with the minimal invasiveness of percutaneous transluminal angioplasty seems justified. Laparoscopic aortic surgery to date has not gained widespread acceptance or applicability, probably because of the highly specific technical skills necessary to perform a laparoscopic aortic anastomosis.[6] Indeed, instrument movement that is limited by the constraints of the abdominal wall and counterintuitive hand motions make laparoscopic suturing difficult if one does not perform these procedures on a daily basis. Especially in suturing of the aorta, needle passage in any other than a true plane may cause tearing of the aortic wall. Therefore, minimally invasive procedures, such as laparoscopic assisted and hand-assisted laparoscopic aortofemoral bypass, have been developed with the entire aortic dissection performed laparoscopically except for the aortic anastomosis, which necessitates an abdominal incision of 7 cm or more.[6,7] Clearly, the added degrees of motion provided with the robotic instruments facilitate passage of the needle in a true plane in all directions. The ergonomic and natural interface between the surgeon's hands and the instruments and the wrist action of the instruments result in a steep learning curve; a simple stitch can be performed after minutes of practice in the in vitro laboratory trainer.

A potential disadvantage of current robotic technology is the lack of sensory feedback. Practice with the instruments and excellent close-up visibility with the voice-controlled endoscope, however, can somewhat compensate for this shortcoming. In the two cases described in this paper, most of the aortic dissection and both aortic anastomoses were performed by a vascular surgeon with modest laparoscopic experience and limited practice with the robotic surgical system in the animal laboratory. Total operating time was relatively long, 290 and 260 minutes. Relatively little time was necessary for set up of the robotic positioner arms and exchange of robotic instruments. Laparoscopic creation of the peritoneal "apron" and dissection of the infrarenal aorta and bifurcation are labor intensive; however, with increasing experience, operating time is likely to

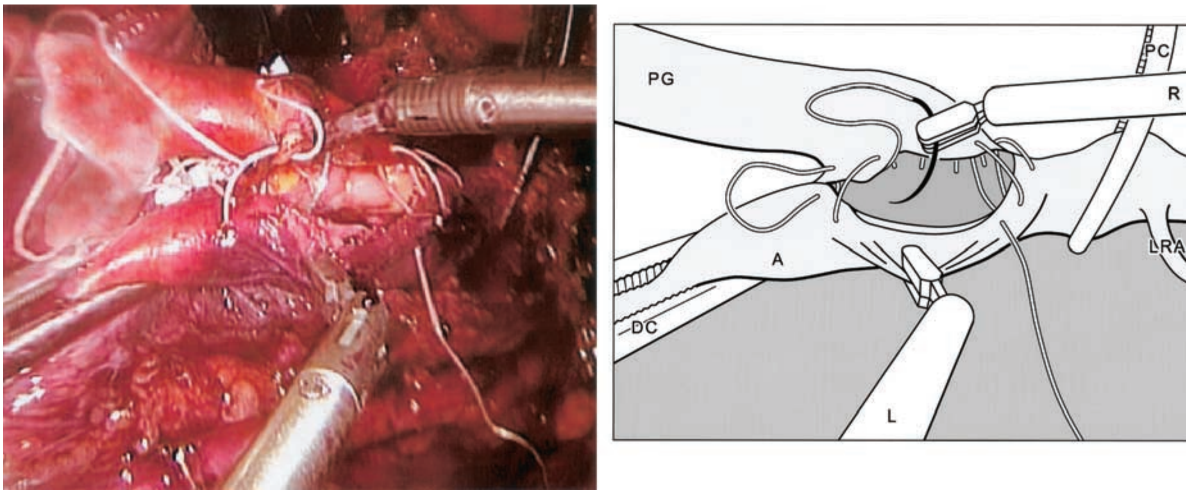

Fig 2. Aortic anastomosis in progress. *L,* Robotic grasper, controlled with left hand; *R,* robotic needle holder, controlled with right hand (note controllable angle between intstrument and arm); *A,* aorta; *DC, PC,* distal and proximal aortic clamp; *PG,* prosthetic graft; *LRA,* left renal artery.

Fig 3. Surgeon performing aortic anastomosis from separate surgeon control console.

be reduced. Also, once sufficient experience is gained, an end-to-side aortic anastomosis is likely to take no more than 20 to 25 minutes.

In this technical note, successful human application of a novel technique for laparoscopic aortobifemoral bypass grafting with robotic-guided instruments has been described. The precise natural steering of instruments with increased freedom of motion offered by this new technology may increase acceptance of laparoscopic aortic surgery among vascular surgeons. Prospective randomized studies are needed to examine the true value of robotic technology in the field of aortic bypass surgery.

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