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Is Robotic Surgery Appropriate for Vascular Procedures? Report of 100 Aortoiliac Cases

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Abstract *Aim:* The aim of our study was to evaluate our clinical experience of the da Vinci™ system for robot-assisted aortoiliac reconstructions to treat occlusive disease and aneurysm.
Material and methods: Between November 2005 and January 2008 100 consecutive patients were scheduled to undergo robot-assisted laparoscopic aortoiliac procedures. Patients with serious medical problems and those who had previously undergone major abdominal surgery were excluded from the clinical study. Ninety patients were prospectively evaluated for arterial occlusive disease (AOD), seven patients for abdominal aortic aneurysms (AAA), two for common iliac artery aneurysms (CIAA) and one for a combination of CIAA and AOD.
Results: Ninety-seven of 100 procedures (97%) were successfully completed robotically, while conversions were necessary in three patients (3%). The median operating time was 235 minutes (range 150 to 360 minutes), with a median clamp-time of 42 minutes (range 25 to 120 minutes). The median anastomosis time was 29 minutes (range 12 to 60 minutes) and median blood loss was 430 mL (range 50 to 1500 mL). The median intensive care unit stay was 1.7 days and the median hospital stay was 5.1 days. A regular oral diet was resumed after a mean of 2.4 days. Thirty-day survival was 100% and non-lethal postoperative complications were observed in three patients (3%).
Conclusions: Robotic aortoiliac surgery appears to be safe, with a high technical success rate, with operative times and success rates comparable to conventional open surgery. The creation of the aortoiliac anastomosis appears to be quicker, and more accurate than regular laparoscopic techniques.

Introduction

Major developments in laparoscopic surgery in the 1990s have had a delayed impact on vascular surgery. Minimally invasive approaches used in general surgery have gradually been introduced as novel techniques that can be employed in vascular surgery.[1] The main reasons for this initial lack of interest in laparoscopic vascular surgery were the difficulties associated with the suturing of the vascular anastomosis and the long clamping time. These same reasons have also prevented the further expansion of vascular laparoscopy. Robotics, which was first introduced in 2000, is

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a state-of-the-art surgical technology[2] and the growing experience of physicians with robotic surgery has brought new benefits.[3] This technique does not require direct contact between the patient and surgeon, while also significantly enhancing the precision of the surgery by eliminating tremor from the surgeon's hands and providing perfect 3D visualization. Currently it is also possible to perform surgical interventions in different places of the human body that would be hard to access using classical surgical or laparoscopic techniques (e.g. pelvic or visceral area).[4] Robot-assisted surgery has raised laparoscopic surgery to a higher level of quality and facilitates almost perfect movements of the instruments.

Methods

The Department of Vascular Surgery at Na Homolce Hospital has been performing a range of robot-assisted vascular reconstructions of the pelvic arteries and abdominal aorta since the end of 2005. Some of these procedures have been performed for the first time ever with robotic assistance (an operation on an isolated common pelvic arterial aneurysm or the reconstruction of the abdominal aorta by prosthetic patch). We have developed surgical procedures for aorto- and ilio- femoral bypasses, endarterectomies of the abdominal aorta and resection and replacement of abdominal aortic aneurysms (AAA), which are now performed as standard practice (Figs. 1—3). The basis for robotic vascular reconstruction is the modified transperitoneal approach.[5] Usually, three surgeons are present around the operative table during robot-assisted vascular surgery. The pneumoperitoneum was secured via a minor incision above the umbilicus with abdominal pressure of 12 mm Hg and perfusion of 6 l of CO_2 per minute. Trocar positioning was slightly different from conventional laparoscopy. Standardly we used six 12 mm trocars. The small bowel and the omentum were moved to the right part of the body towards the diaphragm. The retroperitoneum was opened on the left side of the aorta from its bifurcation to the left renal vein alongside the left gonadal vein. The posterior peritoneum including the preaortic fat and ganglia were dissected as necessary up to the right aortic wall and stitched to the parietal peritoneum. A Dacron Vascutec® (Vascutec Terumo Company, Scotland, UK), Albograft® (Sorin Biomedica Cardio, SpA, Italy) or Braun® (Aesculap AG, Germany) vascular prosthesis with attached shortened Gore 3/0® (W.L. Gore and Associates, AZ, USA) stitches (25 cm long) was inserted into the abdomen through a 12 mm trocar.

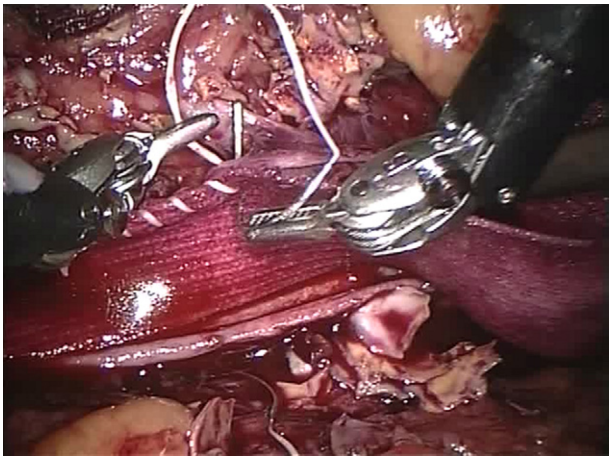

Figure 2 Aortoiliac prosthetic patch.

The da Vinci robotic system was placed on the patient's right side. The patient was placed on his or her right side at a 30—45° angle, in a mild Trendelenburg position (10° to 15°), with the left arm lying along the length of the body. All operations were performed under general anaesthesia and dissections of the aorta and iliac arteries were performed laparoscopically. The robotic system is used to construct the central anastomosis (twice for both anastomoses in the case of tube grafts), to perform the thromboendarterectomy, to suture lumbar arteries, and usually for posterior peritoneal suturing (Figs. 4 and 5).[6]

Results

Between November 2005 and January 2008, 100 consecutive robot-assisted aortoiliac reconstructions were performed at the Department of Vascular Surgery at Na Homolce Hospital in Prague, Czech Republic (Table 1).

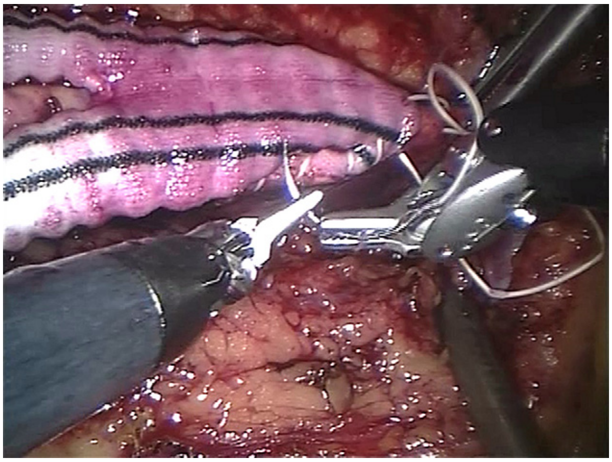

Figure 1 Robot-assited central anastomosis of an ABFB (ABFB, Aortobifemoral bypass).

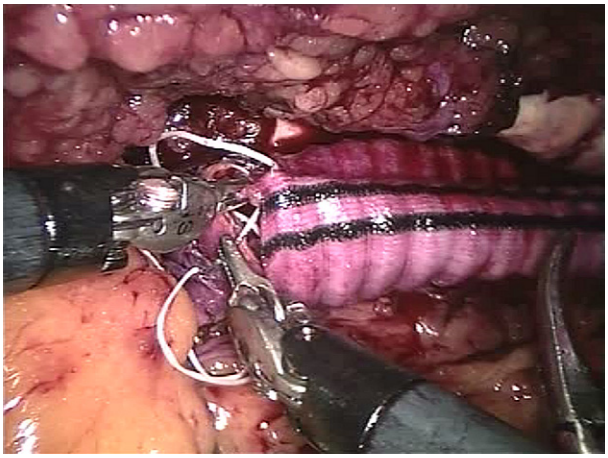

Figure 3 Robot-assisted distal anastomosis of an AAA treated with a tube graft (AAA, Abdominal aortic aneurysm).

Patients with serious medical problems and those who had previously undergone major abdominal surgery were excluded from the clinical study. The disease was classified in accordance with the American Society of Anaesthesiologists (ASA) classification. Patients with ASA IV—V, significantly abnormal cardiac, pulmonary, hepatic and renal test results were not offered a robot-assisted procedure. They included 4 aortoiliac thromboendarterectomies with prosthetic patch, 17 iliofemoral, 38 aortounifemoral, and 32 aortobifemoral bypasses (ABFB). Seven patients were treated for AAA and two for common iliac artery aneurysms (CIAA). One patient underwent combined incisional hernia prosthetic mesh repair with ABFB during transperitoneal robot-assisted ABFB. As most vascular surgeons, we treat TASC (TransAtlantic Inter-Society Consensus) A and B lesions with endovascular procedures. In the case of our robot-assisted patients, we preferred to treat TASC C and D with surgery.

These patients included 78 men and 22 women, with a mean age of 55 years (range, 38 to 78 years) (Table 2). Mortality in the cohort mentioned above was 0%. In three cases (3%) conversion to mini or full laparotomy was required and three patients (3%) experienced nonlethal post-operative complications.

One patient who was treated for a combination of right CIAA, right external iliac artery occlusion and complete left iliac artery occlusion was converted to a mini-laparotomy. Difficulties with iliac calcification were encountered in this case with the Endo Gia stapler during the exclusion of the CIAA after completion of the robotic anastomosis of the ABFB. We achieved exlusion of the CIAA in the standard manner, using several ligatures.

A second conversion to a full laparotomy was required on the first postoperative day after ABFB because of a haemoperitoneum, caused by bleeding from a clipped lumbar artery. The third conversion to a mini-laparotomy was caused by prolonged bleeding from the lumbar arteries during AAA after robotic creation of the central anastomosis of an aortic tube graft.

The first converted patient had postoperative fever and Methicillin-resistant Staphylococcus aureus (MRSA) was detected from the central venous catheter and blood culture. In this case antibiotics were given over a six week period. One patient had an incisional hernia in the port nine months after the first operation and later developed occlusion of one limbs of the aortic graft. The patient required a thrombectomy and a profundaplasty one year after operation.

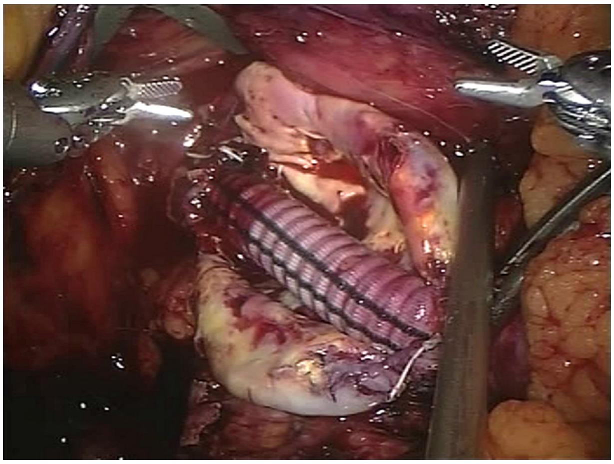

Figure 4 Robot-assisted CIAA repair (CIAA, Common iliac artery aneurysm).

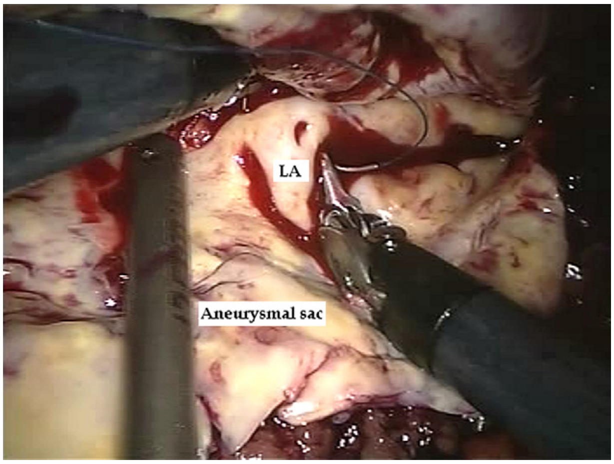

Figure 5 Robotic internally control the lumbar artery (LA).

The median operating time was 235 minutes (range 150 to 360 minutes), with a median clamp time of 42 minutes (range 25 to 120 minutes). Median anastomosis time was 29 minutes (range 12 to 60 minutes). Median blood loss was 430 mL (range 50 to 1500 mL), median intensive care unit (ICU) stay was 1.7 days (range 1 to 5 days), median ventilator support was 7 hours (range 0 to 48 hours), and the median hospital stay was 5.1 days (range 4 to 10 days). The median clamping time was 40 and 76 minutes for patients treated for occlusive disease (OD) and for aneurysm, respectively. The median anastomosis times were 25 and 42 minutes for patients with OD and aneurysms, respectively.

Nearly all patients began a liquid diet 1 day after surgery and a solid diet at a median of 2.4 days (Table 3).

Discussion

The greatest advantage of the robot-assisted procedure has proved to be the speed of construction of the vascular anastomosis.[7] The median reported clamping and anastomotic times of laparoscopic aortic surgery without robots were 89.5 and 37 minutes, respectively.[8,9] Reducing the time needed to construct the anastomosis also shortens the period of temporary ischemia of the lower limbs. This represents a significant reduction in the level of reperfusion

Table 1 Robot-assisted vascular procedures

IFB (iliofemoral bypass)	17
AUFB (aortounifemoral bypass)	38
ABFB (aortobifemoral bypass) one case of them: ABFB with incisional hernia mesh repair	32
AIE (aortoiliac thromboendarterectomy)	4
CIAA (common iliac artery aneurysm)	2
AAA (abdominal aortic aneurysm)	7

Table 2 Demographic data and risk factors

Patients	100
Men	78
Women	22
Age (y)	55 (38—78)
Weight (kg)	78 (47—120)
Tobacco use	73%
Coronary disease	27%
Hypertension	33%
Diabetes	10%

injury and haemodynamic stress. These times are now comparable to those of standard vascular surgery, and provide the advantages of minimally invasive surgical techniques. A further advantage of this method is that it can also be used with obese patients, where standard interventions are technically demanding and often involve problems with the healing of wounds after laparotomy. Laparoscopy with long instruments magnifies natural tremor and reduces tactile sense. The da Vinci system eliminates surgeon tremor and produces motion scaling.[10] The time necessary to set up the robot during the procedure is short (~10 minutes) and learning curve is fast. The cost of the robotic instruments is high, but vary between the USA and Europe (cheaper in the USA).

When this method was being introduced younger patients, with no associated disorders, were selected. With the increasing experience we are now selecting for complex cases. Given the need for a capnoperitoneum, patients suffering from acute forms of obstructive pulmonary disease are not suitable for either laparoscopic or robot-assisted procedures. Usually, a contraindication for capnoperitoneum automatically entails a contraindication for laparoscopic-robotic vascular procedures. On the other hand, physicians from Prague have had successful experiences with two patients with severe left ventricular dysfunction after myocardial infarction (25 and 29%). Here they performed robot-assisted procedures with a low pressure pneumoperitoneum (8—10 mm Hg).

Patients who have undergone major intra-abdominal operations with numerous peritoneal adhesions are also unsuitable for this procedure. Obesity is no longer a major contraindication.

Table 3 Perioperative and postoperative data

Clamping time (min)	42 (25—120)
Anastomosis time (min)	29 (12—60)
Operating time (min)	235 (150—360)
Blood loss (mL)	430 (50—1500)
Conversion	3 (3%)
Ventilator support (hrs)	7 (0—48)
Intensive care unit stay (d)	1,7 (1—5)
Regular diet (d)	2,4 (2—4)
Hospital stay (d)	5,1 (4—10)
Postoperative complications	3 (3%)
30-day mortality	0%

In conclusion, the introduction of robotics represents a fundamental turning point for laparoscopic vascular surgery, which has previously required extended time to construct anastomoses and therefore prolonged aortal clamping times.[11] The robotic system removes these fundamental disadvantages from laparoscopy and opens up the possibility of expanding robotic-assisted laparoscopic surgery in this area.[12]

Major benefits can be expected from its introduction into hybrid procedures.[13] By combining robotic technology with surgical skill, the da Vinci Surgical System can allow the performance of more precise and a greater range of minimally invasive procedures in vascular surgery. In our experience, the concurrent repair of incisional hernia and ABFB is technically feasible and effective, without increased complications or morbidity. In our opinion, robotic surgery can also improve thoracic aorta surgery.

Robotic systems are still being developed and improved. Surgical robots will become smaller, less expensive, capable of providing force feedback, and controllable over telecommunication networks.

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