Preliminary Results from a Prospective Study of Laparoscopic Aortobifemoral Bypass Using a Clamping and Sutureless Aortic Anastomotic Technique

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WHAT THIS PAPER ADDS
This technique, performed in a single center, appears to be feasible and safe. It offers the advantages of laparoscopy and those of endovascular surgery, especially in the challenging conditions encountered during aortic laparoscopic surgery. This approach using existing materials could make laparoscopic aortic surgery for occlusive disease accessible for more vascular surgeons accustomed with laparoscopic surgery.

Objective: This prospective study describes the feasibility and safety of a new clampless and sutureless aortic anastomotic technique used during retroperitoneal laparoscopic aortobifemoral bypass in extensive aortoiliac occlusive lesions. This is a case series of a previously published technique, demonstrating wider applicability of the technique.

Materials and methods: Twelve patients underwent a clampless and sutureless laparoscopic bypass for TASC D aortoiliac occlusive lesions using the EndoVascular REtroperitoneoScopic Technique (EVREST). Dissection of the retroperitoneal space and the infrarenal aorta was performed laparoscopically. A bifurcated graft was inserted into the retroperitoneal space. The main body of the graft was connected on the left side of the aorta by an intra- and extra-aortic covered stent-graft. An aortic clamp was used temporarily on four patients because of excessive bleeding when the connector was deployed. The femoral anastomoses were performed by classic open surgery. Initial technical success, complications, and bypass patency were assessed.

Results: Median follow-up was 9.3 months. Median operative time was 265 minutes. Median duration of aorto-prosthetic connection was 60 seconds. Thirty-day postoperative mortality was 0%. No major postoperative complications were observed. All grafts were patent at the end of follow-up and there was no early or late disruption of the proximal assembly.

Conclusions: EVREST greatly facilitates laparoscopic aortic surgery in occlusive disease with no need for suture or clamping of the aorta. This technique performed in a single center on 12 patients, seems to be feasible and safe. It offers the advantages of laparoscopy and those of endovascular surgery, especially in the challenging conditions encountered during aortic laparoscopic surgery. Early experience supports procedural and initial postprocedural safety and demonstrates proof-of-concept for EVREST.

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INTRODUCTION
International recommendations for the treatment of occlusive disease were established by the Trans-Atlantic Inter-Society Consensus II Working Group (TASC II) in 2007. For bilateral and extensive aortoiliac lesions (TASC D), surgical reconstruction is advised. The classic procedure for aortobifemoral bypass is open surgery, which is associated with an overall mortality rate of 3.3%.

In 1997, Yves-Marie Dion performed the first totally laparoscopic aortobifemoral bypass using a transperitoneal approach. Since then, it has been considered to be a minimally invasive alternative for treating aortoiliac occlusive disease. The authors of the present study, and others, have described the use of a totally retroperitoneal laparoscopic approach as an alternative treatment in cases...
of hostile abdomen.8–10 Whatever the approach, the aorto-
thoracic anastomosis is a challenging technique, making
it unpopular despite obvious advantages for patients.11
This study presents experience of totally retroperitoneal
laparoscopic aortobifemoral bypass performed on 12 pa-
tients using a clampless and sutureless technique for the
proximal anastomosis. The feasibility and safety of the
technique, called EndoVascular REtroperitoneoScopic
Technique (EVREST), is evaluated.

MATERIALS AND METHODS

Materials
From February 2012 to March 2013, EVREST was used in 12
patients who presented with TASC D aortoiliac occlusive
lesions for which endovascular revascularization was not
indicated. Ethical approval was obtained, and all patients
gave their informed consent before the procedure. Preop-
erative evaluation included cardiac stress test, pulmonary
function test, and supra-aortic trunk arterial Doppler im-
aging. Computed tomographic angiography was performed
on each patient to confirm TASC D lesions, measure the
infrarenal abdominal aortic diameter, and evaluate aortoil-
iac calcification. The calcification was heavy in five patients
(42%), moderate in six (50%), and smooth in one (8%). In-
clusion criteria, based on the clinical complaint, clinical
findings, and angio CT scan issues, were Fontaine classi-
fication from stage II b (claudication <100 m) to IV (tissue
loss), and aorto-iliac TASC D lesions with at least 4 cm of
patent aorta beneath the renal arteries. Patients with a
heavily calcified aorta and patency of the inferior mesen-
teric artery were not excluded. Exclusion criteria were jux-
taresal thrombosis or thrombosed unilateral or bilateral
external iliac artery with patent aorta and internal iliac ar-
teries. Patients with TASC D lesions who were not candi-
dates for endovascular treatment were scheduled for
EVREST. During the same period, 26 patients underwent an
endovascular procedure to treat aortoiliac occlusive dis-
ease. Median patient age was 58.2 years (range 45–67
years), with ten males and two females. Median body mass
index (BMI) was 25.9 kg/m² (range: 21.3–33.5). The EVREST
procedure was contraindicated in patients for whom an
endovascular procedure was an option or who were not
candidates for general anesthesia for any reason. In-
dications for surgery included disabling claudication in three
patients (25%), ischemic rest pain in six patients (50%), and
tissue loss or gangrene in three patients (25%). Three pa-
tients had a history of prior vascular surgery; one had a left
iliofemoral bypass and two had bilateral common or
external iliac endovascular reconstructions. All of the pa-
tients were active smokers (100%), ten had arterial hyper-
tension (83%), eight had hyperlipemia (66%), and four had
diabetes (33%). Five patients had a history of coronary
disease (42%), and eight (67%) had previous chronic
obstructive pulmonary disease (COPD) (Table 1). Preoper-
ative daily treatment included aspirin 80 mg for five pa-
tients and clopidogrel for two patients. Those treatments
were not interrupted prior to surgery. Aortic calcification,
thrombus, plaque, and other morphologic variables were
evaluated by CT scan, and no morphological variables
affected the decision to perform EVREST. In order to apply
an endovascular sutureless anastomosis, the patient had to
have been diagnosed with TASC D aortoiliac occlusive
lesions for which endovascular revascularization was not
indicated.

Initial technical success, complications, preoperative and
postoperative ankle brachial pressure index, assessment of
bypass patency, and integrity of the proximal assembly were
assessed, the latter by computed tomographic-angiography
at 1 week, 1 month, 6 months, and 1 year.

Surgical technique
This technique has been described in a previous study.12 To
perform EVREST, each patient was positioned, under gen-
eral anesthesia, in a 30° right lateral decubitus position. The
operator, first assistant, and scrub nurse were on the left
date of the patient. The videomonitor was positioned on the
right side (Fig. 1). A pneumo-peritoneum was created using
a Veress needle introduced at the umbilicus. A 30°
video-endoscope was first inserted to check good positioning of
three trocars in the left retroperitoneal space. After exsuffla-
tion of the pneumo-peritoneum, dissection of the retroperito-
real space was performed by CO₂ insufflation at a maximum
pressure of 14 mmHg, and by blunt dissection with laparoscopic
forceps. The left common iliac artery was easily
visualized above the psoas muscle and dissected with
monopolar electrocoagulation. The left ureter was then
visualized and the aorta was isolated up to the left renal
artery. One additional 12-mm trocar was placed between
the 11th rib and the umbilicus, to support a laparoscopic
aortic clamp (Aesculap, AG & Co KG Company). The aortic
clamp was left open in the retroperitoneal space, being
used as a retractor but ready to clamp the aorta in the
event of uncontrolled bleeding. A 14/7 mm diameter

| Table 1. Demographic data, risk factors, and surgical data in 12 patients. |
|-----------------|-----------------|-----------------|
|                | EVREST (N = 12) | EVREST (N = 12) |
| Mean age (y)   | 58.2 (10/2)     | 58.2 (10/2)     |
| Male/Female    | 10/2            | 10/2            |
| Smoking        | 12 (100)        | 12 (100)        |
| Hypertension   | 10 (83)         | 10 (83)         |
| Hyperlipemia   | 8 (66)          | 8 (66)          |
| Diabetes       | 4 (33)          | 4 (33)          |
| Cardiac ischemia | 5 (42)    | 5 (42)          |
| COPD           | 8 (67)          | 8 (67)          |
| Claudication   | 3 (25)          | 3 (25)          |
| Rest pain      | 6 (50)          | 6 (50)          |
| Tissue loss/gangrene | 3 (25) | 3 (25) |
| Operative time (min) | 265 (180–330) | 265 (180–330) |
| Deployment time (sec) | 60 (50–80) | 60 (50–80) |
| Aorto-femoral time (min) | 53 (25–85) | 53 (25–85) |
| Intensive care unit stay (h) | 32.4 (17–48) | 32.4 (17–48) |
| Hospital stay (d) | 6.2 (3–8)    | 6.2 (3–8) |
bifurcated graft (Gelsoft Plus Bifurcate, Vascutek Terumo, UK) was inserted into the retroperitoneal space through the 12-mm trocar. Under videoscopic control, the prosthetic limbs were brought to the groins that had been previously dissected. The tunnel to the right groin was made by videoscopic vision and finger dissection along the iliac vessels. A laparoscopic grasping forceps was then introduced into the retroperitoneal space through the tunnel under videoscopic vision. The limbs were sealed by ligation prior to introduction of the bifurcated graft into the retroperitoneal space. An 18 gauge, 27 cm catheter needle (transhepatic cholangiography catheter needle, Cook Medical Inc., USA) was inserted through the left prosthetic limb into the retroperitoneal space. The left lateral side of the infra-renal aorta was then punctured at the level of the origin of the inferior mesenteric artery (Video 1). A 0.035” hydrophilic guide wire (Terumo Corporation, Tokyo, Japan) was positioned into the aorta. Heparin (100 IU/kg) was given intravenously. A pigtail catheter was positioned for angiography to localize the renal arteries. The hydrophilic guide was changed for a stiff guide wire (Lunderquist, Cook Medical Inc., USA). A 20 mm diameter and 80 mm length iliac extension of an Endurant stent-graft system (Medtronic, Endovascular, Santa Rosa, CA, USA) was introduced over the wire up to 4 cm into the aorta through the left prosthetic limb of the bifurcated graft (Fig. 2, Video 2). The left limb was sealed with a protected grasping mosquito during the puncture of the aorta but no sealing was necessary while the stent graft was introduced into the left limb. The covered stent-graft, used as a connector, was deployed into the infra-renal aorta and into the main body of the bifurcated graft (Fig. 1). The deployment was controlled by fluoroscopy and by direct retroperitoneal visualisation on the monitor. An 80 mm long, 20 mm diameter non-compliant balloon (Z-Med-X, Nu MED Canada inc., Cornwall, ON, Canada) was inflated at a controlled maximum pressure of 2.5 atmospheres to ensure sealing of the aorto-prosthetic junction and perfect deployment of the endograft (Fig. 2, Video 3). For the first two patients, a

Figure 1. Location of the laparoscopic ports, position of the patient, surgeon (S) and first assistant (A).

Figure 2. (A) Endurant stent-graft system introduced over the wire into the aorta through the left prosthetic limb of the bifurcated graft: perioperative view. (B) Endurant stent graft is deployed into the aorta and into the main body of the bifurcated graft: perioperative view. (C) A non-compliant balloon is inflated to ensure sealing of the aorto-prosthetic junction. The aortic clamp is left open, ready to be used in case of bleeding.
10 mm diameter non-compliant balloon (Passeo-35, Biotronik, Berlin, Germany) and a compliant balloon (Coda balloon catheter, Cook Medical Inc., USA) were used, but there was concern that the small balloon might lead to restenosis in this cohort of heavy smokers so a switch was made to the 20 mm balloon for the last 10 patients. Restenosis was not observed at the 1-year computed tomographic angiography in the two patients who received the 10 mm balloon treatment (data not shown). The femoral anastomoses were performed by classic open surgery with 6/0 polypropylene running sutures (Fig. 3). Prior to wound closure, videoscopic inspection was made of the abdominal cavity to assess bowel viability. Two drains were left in the retroperitoneal space for 24 hours, and one drain in each femoral access site.

Supplementary videos related to this article can be found online at http://dx.doi.org/10.1016/j.ejvs.2014.06.036.

The following are the Supplementary videos related to this article: Video 1 The left lateral side of the aorta is punctured with a 27 cm catheter needle. Video 2 Introduction of the covered stent graft over the wire into the aorta. Video 3 Final endoscopic vision.

Statistical analysis

Statistical analysis was done with Statistical Package for Social Sciences Software (SPSS Inc, Chicago, IL, USA). Pre-procedural and post-procedural ABIs were compared by paired Student t test with Bonferroni correction. Statistical significance was set at $p < .05$.

RESULTS

All patients scheduled for EVREST underwent successful procedures. The retroperitoneal laparoscopic approach to the aorta was possible in every case. In each case, the bifurcated graft was connected to the covered stent-graft on the left side of the infrarenal aorta. Two connectors were used for the fourth patient because the extra-aortic overlap with the first connector was less than 2 cm. All procedures were conducted laparoscopically and no conversion to open surgery was needed. Operative time was defined as the time elapsed from the initial incision to the final skin closure. EVREST operative time was an average of 265 minutes (range 180—330 minutes). Deployment time was defined as the time needed for deployment of the stent-graft and for inflation of the balloon inside it. The median deployment time was 60 seconds (range 50—80 seconds) and during that time the use of the aortic clamp was necessary in four patients. The aorto-femoral time was defined as the time elapsed from the puncture of the aorta to the completion of both femoral anastomoses. Median aorto-femoral time was 53 minutes (range 25—85 minutes). No disruptions of the aorta or inferior mesenteric artery (IMA) were observed in the 12 cases. A bilateral femoral endarterectomy prior to the femoral anastomosis was necessary in two patients because of heavily calcified lesions. A stenosis of the left superficial femoral artery was concomitantly treated by endovascular surgery in one patient. Average blood loss was 680 mL (range 200—1400 mL). The average transfusion volume (cell-saver) was 360 mL (range 100—900 mL). Median intensive care unit stay was 32.4 hours (range 17—48 hours). All patients received intravenous analgesia followed by oral analgesics. No epidural catheter or patient-controlled analgesia pumps (PCA) were needed. Postoperative pain was clinically evaluated as moderate in nine patients and low in three patients. All patients had a nasogastric tube but it was removed at the end of the procedure in all cases. Median 24-hour diuresis was 1390 mL (range 900—2100 mL). No major postoperative complications or deaths were observed. None of the patients needed postoperative surgical revision. The median hospital stay was 6 days. Average hospital stay was 6.2 days (range 3—8 days) (Table 1). All of the patients had a quick recovery with minimal wound pain. There was no postoperative bowel dysfunction. Postoperative medication consisted of oral aspirin (160 mg daily). The 30-day postoperative mortality rate was 0% (0/12). Patency was evaluated by clinical examination, ankle brachial index, and computed tomographic angiography. All grafts were patent at a mean follow-up of 9.3 months (range 1—17 months), and there was no early or late disruption of the proximal assembly. The ankle brachial pressure index was improved in all cases. Primary patency rate was 100%. In one patient, the control angio-CT at 1 week showed a paraprosthetic retroperitoneal hematoma of $6 \times 10$ cm, which did not require additional surgery. The size of the hematoma had decreased significantly at 3-month computed tomographic angiography (Fig. 4). Two

Figure 3. The femoral anastomoses are performed by classic open surgery: postoperative 3-D reconstruction CT scan.
patients underwent limited amputation of toes and one patient had an amputation of the calcaneum. One patient underwent a right femoropopliteal bypass 9 months after EVREST. One patient died at 6 months from acute respiratory failure, with a patent bypass.

DISCUSSION

Since 2004, the authors have performed several retroperitoneal aortobifemoral bypasses using a short left-sided transverse incision. This procedure, described by Charles Rob in 1963,13 is not very popular because of the difficulties encountered in exposing the aorta. Using a surgical retractor system (Condor GmbH Medicaltechnik, Germany), the procedure remains challenging but feasible.14 Increased experience has led to smaller incisions and this, coupled with the laparoscopic skills of the authors, made it feasible to attempt a retroperitoneal laparoscopic approach. Some patients successfully underwent total laparoscopic retroperitoneal aortobifemoral bypass.9

The most popular method for laparoscopic aortobifemoral bypass is the pre-renal transperitoneal approach.3,5,15 However, regardless of the technique used,3,5,8,9,15 the aortoprosthesis anastomosis is a major challenge that makes it unpopular despite obvious advantages for the patients.15 In a study of laparoscopy-assisted aneurysm resection, Kolvenbach et al. reported significant reductions in cytokine release supporting the notion that video-assisted surgery is less invasive and induces less tissue trauma compared with conventional surgery.16 Vascular laparoscopic experts agree that the learning curve is long, that a mini-laparotomy is often needed to complete the aortic anastomosis, and that new materials are needed to make aortic suture more feasible.4,5,17 Some vascular surgeons have presented new devices to facilitate aortic suture but those materials were generally used only in vitro, on pigs and cadavers, or only by the authors themselves.17,18

Connecting blood vessels today is done mostly the same way with sutures as it was 100 years ago, when the French surgeon Alexis Carrel described the technique in 1902.19 This standard anastomotic technique requires a large exposure, circumferential dissection, and clamping of vessels. Moreover, classical surgical access can be quite difficult and time-consuming especially with patients who have heavily calcified vessels.20 These concerns are all the more true for laparoscopic aortic surgery.

In 2007, Lachat21 published the VORTEC technique (Via-bahn Open Revascularisazion TEChnique), which is a clampless and sutureless method that appears to be faster, safer, and easier than classic arterial sutures for complex anastomoses in open surgery. Lachat described his experience of more than 300 cases in which he encountered no major bleeding or leaks.22 This technique represents a significant improvement over traditional vascular anastomotic surgical techniques.

The present authors decided to apply this technique to total retroperitoneal laparoscopic aortobifemoral bypass.12 Patients were selected based on their clinical stage (Fontaine classification) and on computed tomographic angiography. Inclusion criteria were Fontaine classification from stage II b (claudication <100 m) to IV (tissue loss), and aorto-iliac TASC D lesions with at least 4 cm of patent aorta beneath the renal arteries. Heavily calcified aorta and patency of inferior mesenteric artery were not exclusions for the technique (Table 2). Exclusion criteria were juxtarenal thrombosis or thrombosed unilateral or bilateral external iliac artery with patent aorta and internal iliac arteries.

The aorta was clamped temporarily in four patients (33%) because of excessive bleeding when the connector was deployed. The clamp was removed when the non-compliant balloon was inflated into the connector. Median blood loss was less than that described for open surgery.23 Operative mortality was 0% and there were no complications during surgery. It is important to keep in mind that conversion to open surgery with a short left-sided transverse incision is always possible if technical difficulties arise during the procedure.

There were no endoleaks at 9 months follow-up. The radial force of the endograft (which is not at its maximal diameter at the aortic wall passage) might explain the absence of endoleak during diastole. All of the patients

Figure 4. Evolution of a paraprosthesis retroperitoneal hematoma. One week (A) and 3 months (B) postoperative computed tomographic angiography.
treated with EVREST had heavily calcified aortas, forming a very-hard-to-break rigid aortic wall frame, which would be expected to prevent further tearing. However, a direct hammer effect on the aortostomy inferior edge leading to a leak could be an issue for patients with soft, non-calcified aorta.

The median operative time was close to those published in large laparoscopic series, but it must be considered that the last two patients had operative times close to the shorter range of those published series. With increased experience, the authors believe that the operative time for the procedure will decrease significantly.

Median hospital stay (6 days) and mean hospital stay (6.2 days, range 3 to 8 days) were shorter than those published in a study dealing with a comparable population who underwent open surgery (mean 12.8 days, range 6 to 81 days) or laparoscopic surgery (mean 7 days, range 3 to 19 days). Lachat, who used an endograft connector in open surgery for aortoiliac occlusive disease with heavy calcified aorta, reported a mean hospital stay of 16.5 ± 12 days. The prolonged discharge time was related to inexperience, social issues, and severe comorbidities associated with patients with TASC D lesions.

**Conclusions**

EVREST greatly facilitates laparoscopic aortic surgery in occlusive disease with no need for suturing or clamping of the aorta. The most attractive feature of EVREST is that it allows surgeons to avoid performing the technically challenging aortoprosthetic anastomosis. This technique, performed in a single center on 12 patients, seems to be feasible and safe. It offers the advantages of both laparoscopy and endovascular surgery, especially in the challenging conditions encountered during aortic laparoscopic surgery. This approach, using existing materials, could make laparoscopic aortic surgery for occlusive disease accessible to more vascular surgeons accustomed to laparoscopic surgery.

For patients who are candidates for an aortobifemoral bypass, the authors now propose EVREST as an alternative to an open procedure.

More patients are required to assess the value of this promising technique. As for other new techniques, the reproducibility and long-term outcomes of patients treated with EVREST will need to be evaluated, preferably in multicenter studies. However, this early experience supports procedural and initial postprocedural safety and demonstrates proof of concept for EVREST.

**FUNDING**

None.

**CONFLICT OF INTEREST**

None.

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**Table 2. Imaging data.**

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