# Operative results and outcome of twenty-four totally laparoscopic vascular procedures for aortoiliac occlusive disease

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***Purpose:*** **The study objective was to apply laparoscopic techniques to conventional bypass procedures for aortoiliac occlusive disease.**

***Methods:*** **From October 1995 to August 1997, we performed seven iliofemoral (IFB), five unilateral aortofemoral (UAFB), and 11 aortobifemoral (AFB) bypass procedures and one aortic endarterectomy (TEA) totally laparoscopic. A transabdominal approach with pneumoperitoneum was preferred, and only laparoscopic vascular instruments were used. Endoscopic intervention followed principles of vascular surgery. As in open surgery, we used Dacron grafts and polypropylene sutures.**

***Results:*** **Twenty procedures were carried out totally laparoscopic; four conversions to open surgery were necessary. Severe complications included one postoperative respiratory failure requiring ventilatory support for four days, and one iliac vein lesion with subsequent open surgery. Mean operating time was 258 ± 49 minutes for IFB, 218 ± 54 minutes for UAFB, 279 ± 69 minutes for AFB, and 290 minutes for aortic TEA. Mean blood loss was 92 ± 49 ml for IFB, 390 ± 316 ml for UAFB, 563 ± 516 ml for AFB, and 100 ml for aortic TEA. Mean postoperative stay was 7.4 days for IFB, 7.8 days for UAFB, and 10.1 days for AFB. After the aortic TEA, the patient was discharged on day 6. At control examination all grafts were patent; two patients had mild claudication because of one progressive disease and one distal suture stenosis.**

***Conclusion:*** **Laparoscopic vascular surgery for aortoiliac occlusive disease is feasible, safe, and effective. At the beginning, a cooperation between experienced laparoscopists and vascular surgeons is needed to overcome procedural challenge, because operating time and conversion rate decrease with growing experience. The advantages observed in the majority of our patients were minimal tissue trauma, decreased blood loss, and faster postoperative recovery when compared with patients who had open aortic surgery at our institution. Further evidence has to be gained by clinical trials to define the role of laparoscopic vascular surgery for aortoiliac occlusive disease. (J Vasc Surg 1998;28:136-42.)**

Gynecologist K. Semm performed the first laparoscopic appendectomy in 1982, initiating a revolutionary development in general surgery.[1] Just a few years after their development in the early 1990s, laparoscopic cholecystectomy, fundoplication, and hernia repair are now routinely performed by laparoscopic techniques. Similar progress did not occur in vascular surgery, in which only a few case reports exist. In 1993, Dion et al. were the first to describe a laparoscopy-assisted aortobifemoral bypass.[2] They dissected the infrarenal aorta under video control, but performed the anastomosis conventionally through an 8 cm midline incision. A similar approach was used by Berens and Herde,[3] who performed four procedures on aortoiliac vessels in a gasless laparoscopic technique, still requiring a 4 cm working incision. Indeed, the first totally laparoscopic aortobifemoral bypass was reported by Dion et al.,[4] who performed the procedure by a retroperitoneal approach. We present our experience with 24 totally laparoscopic-performed vascular procedures for aortoiliac vascular disease.

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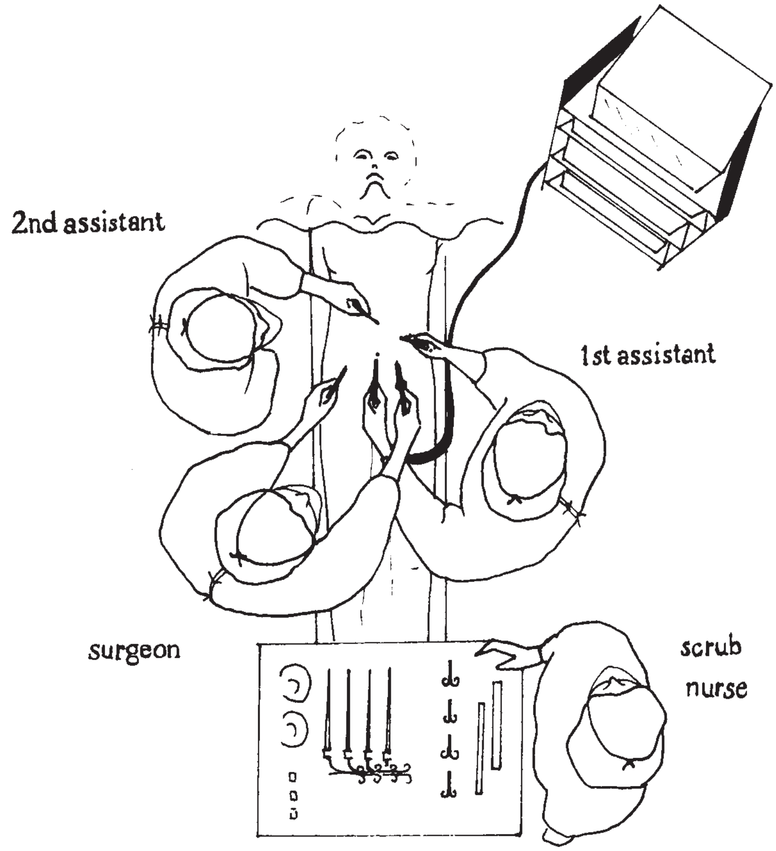


**Fig. 1.** Position of personnel and equipment.

## MATERIAL AND METHODS

From October 1995 to June 1997, we performed seven iliofemoral (IFB), five unilateral aortofemoral (UAFB), and 11 aortobifemoral bypasses (AFB) and one aortic thromboendarterectomy (TEA). All patients were referred to our institution for aortoiliac occlusive disease, which could not be treated by stenting and/or percutaneous transluminal angioplasty (PTA). Patients with significant comorbid medical problems and patients who had major abdominal surgery were excluded from the clinical study. Informed consent was obtained from all patients. All procedures were performed by an experienced laparoscopist and two vascular surgeons. Preclotted Dacron grafts were used (Uni-Graft K DV, Braun, Melsungen, Germany); the diameter was 8 mm for IFB and UAFB, 16 x 8 mm for AFB. The arteriotomy after the TEA of the aorta was closed with a Dacron patch. A 30 cm double-armed, 3-0 polypropylene suture was fixed with a U-shaped stitch in the proximal circumference of the graft for proximal anastomosis. The graft and the suture were then introduced in a 10 mm rigid trocar. As in open surgery, the patient was positioned supine with both arms extended; supports for the shoulders and a belt around the thighs prevented the patient from slipping during surgery. The position of personnel and equipment are shown in Fig. 1. In all aortic procedures six access sites were required (Fig. 2); in iliac procedures four ports were necessary (Fig. 3). The position of the endoscopic instruments and the ports has been standardized (Tables I and II). Dissection, proximal anastomosis, and peritoneum closure were performed with two instruments; a suction cannula helped to keep bowel loops off the operating field. After induction of pneumoperitoneum using a Veress needle, a laparoscope with a 30° view direction was inserted below the umbilicus. After abdominal exploration, the remaining trocars were introduced under video control, and the table was tilted in a 30° Trendelenburg position. The greater omentum and the small bowel were shifted in the upper abdomen using atraumatic graspers. This

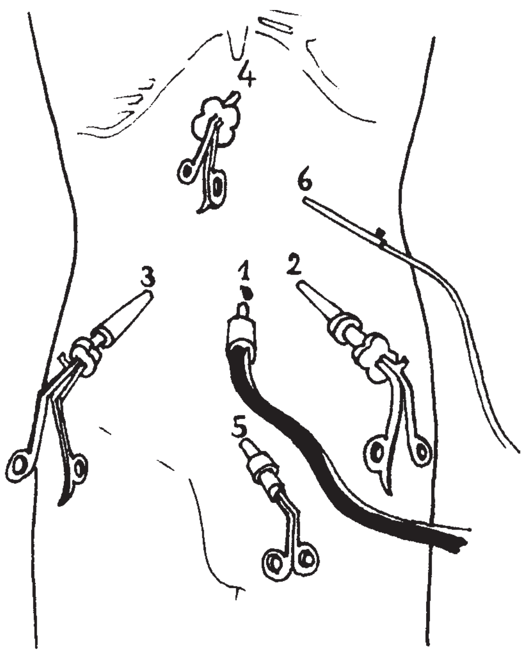


**Fig. 2.** Position of trocars for procedures on infrarenal aorta.

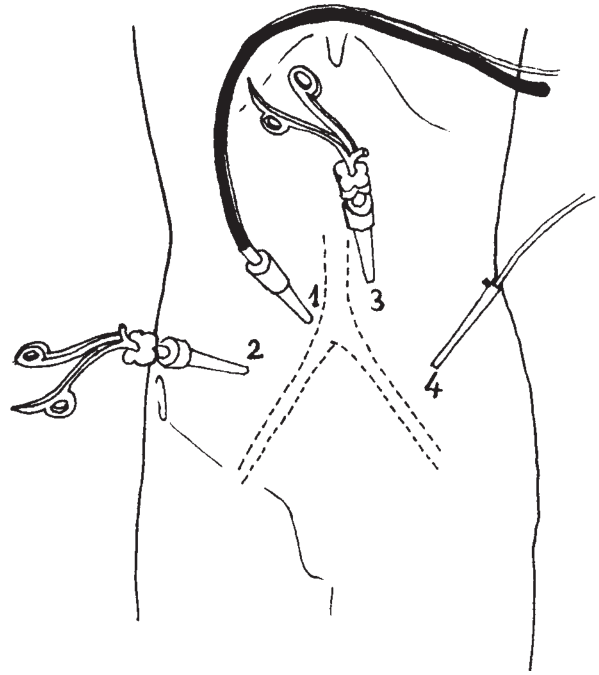


**Fig. 3.** Sites of trocar insertion for left iliofemoral bypass.

**Table I.** Standard access sites and instruments for aortic surgery

| *Access site* | *Trocar diameter (mm)* | *Instruments* |
|---|---|---|
| 1 | 12.5 | Laparoscope |
| 2 | 12.5 | Needle driver, scissor |
| 3 | 12.5 | Atraumatic grasper |
| 4 | 10 | Proximal clamp |
| 5 | 10 | Distal clamp |
| 6 | 5 | Grasper, suction device |

**Table II.** Standard access sites and instruments for iliac surgery

| *Access site* | *Trocar diameter (mm)* | *Instruments* |
|---|---|---|
| 1 | 12.5 | Laparoscope |
| 2 | 12.5 | Needle driver, scissor |
| 3 | 12.5 | Clip applicator, grasper* |
| 4 | 5 | Suction device |

* Two endo vessel clips were used to occlude the iliac artery.

maneuver had to be repeated several times during surgery because the bowel tends to fall into the operating field. The transverse colon was located on the stomach and the liver, while the sigmoid colon remained in the left lower quadrant (Fig. 4). Only a 5 cm incision was required to open the retroperitoneum, after which the aorta was dissected between the left renal vein and the inferior mesenteric artery (IMA) for AFB, between IMA and aortic bifurcation for UAFB, and between aortic and iliac bifurcation for IFB. Particular attention was required in identifying and closing lumbar branches to avoid disturbing bleeding. Preoperative lateral aortography helped localizing lumbar branches, which were occluded with clips. After the patients were given 5000 IU of heparin intravenously, the proposed site for anastomosis was clamped proximally and distally. Whereas 370 mm vascular clamps (De Bakey atraumatic clamp, Aesculap AG & Co. KG, Tuttlingen, Germany) were required for the closure of aorta, IMA was occluded with a 25 mm curved clamp (temporary atraumatic endo vessel clips, Aesculap), which was inserted with an applicator. A 3.5 to 4 cm arteriotomy was performed with Potts-de Martell scissors (Aesculap). The vascular graft within the 10 mm trocar was then inserted in the abdomen through a 12.5 mm trocar shaft. The end-to-side anastomosis was accomplished with a continuous running suture beginning in the distal edge of the arteriotomy. After the suture line was completed, the ends of the thread were tied together with five knots. The clamps were successively opened, and the anastomosis was controlled. Conventional dissection of femoral arteries followed. A long, curved atraumatic grasper was inserted in the groin and gently moved through the retroperitoneum under video control. The graft limb was then grasped and pulled down to the groin, where distal end-to-side anastomosis was performed in an open technique. The retroperitoneum was easily closed with a running suture, preventing direct contact of the intestine with the graft. After the pneumoperitoneum was withdrawn, the port sites were closed with a Dacron (peritoneum) and a polypropylene (skin) suture. Postoperative monitoring and care was the same as after open procedures; patients were discharged after control angiography and healing of inguinal wounds. Clinical characteristics and outcome results were assessed according to the reporting standards developed by the Ad Hoc Committee.[5] Only descriptive statistics were used.

## RESULTS

### Iliofemoral bypass procedure

All patients (*n*=7) except one had severe claudication, and smoking was the most outstanding atherogenic risk factor. The mean age of the seven patients was 54.8 ± 8.0 years (41–69 years); the male-female ratio was 2.5 to 1. Mean operating time was 258 ± 49 minutes (180–320 minutes); clamping time was 80 ± 16 minutes (60–110 minutes). The average blood loss was 92 ± 49 ml (50–200 ml). Patient 5 underwent conversion to open surgery for subtotal occlusion of the proximal anastomosis by a stitch, which grasped the opposite suture line (Table III). That patient had prolonged recovery for postoperative adynamic ileus. No further complications have been observed. Graft patency has been documented by angiography before hospital discharge. The mean hospital stay was 7.4 ± 2.4 days (3–12 days). At the follow-up examination, after a mean interval of 12.8 months (4–20) all grafts were patent. Patient 3 had mild claudication because of a 1.5 cm, 70% stenosis of the common iliac artery proximal to the bypass. The stenosis was treated with a PTA. Patient 4 refused the control examination; nonetheless, he reported complete relief of claudication.

### Unilateral aortofemoral bypass procedure

All patients (*n* = 5) in this group were males with a mean age of 56.4 ± 3 years (53–62 years). Three patients had severe claudication; two had moderate claudication. The most important risk factor was smoking. Mean operating time was 218 ± 54 minutes (150–285 minutes); clamp time was 66 ± 7 minutes (55–75 minutes). Mean blood loss was 390 ± 316 ml (150–1000 ml); two red blood cell (RBC) units were transfused (Table III). Patient 2 underwent transfemoral embolectomy of the contralateral side for intraoperative thrombosis. Several embolectomy maneuvers were done, causing the patient to have a blood loss of 1000 ml. Furthermore, a painful hematoma developed in his left rectus sheath after lesion of the epigastric artery by a triangular trocar obturator. On angiographic study all grafts were patent; the mean hospital stay was 7.8 ± 2.1 days (6–12 days). At the follow-up evaluation after a mean interval of 3.4 months (2–6 months), no hemodynamically significant occlusive disease was detected (Table III).

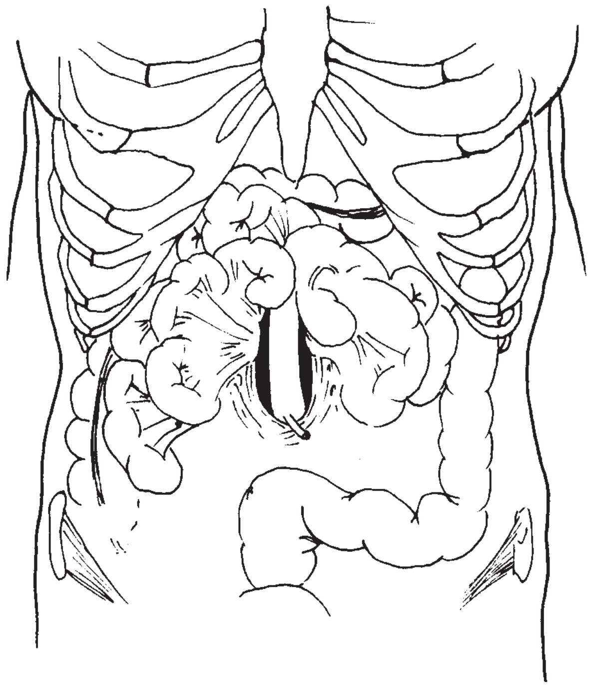

**Fig. 4.** Positioning of small intestine and colon for exposure of infrarenal aorta.

### Aortobifemoral bypass procedure

All patients (*n* = 11) in this group were male, and smoking was the most outstanding atherogenic risk factor. The average age was 53.8 ± 6.7 years (43–66 years). Mean operating time was 279 ± 69 minutes (210–450 minutes), mean clamp time was 70 ± 19 minutes (55–120 minutes). Mean blood loss was 563 ± 516 ml (50–1500 ml); two patients required transfusions of RBC. Three conversions to open surgery were performed: in patient 2 for clamping problems of the severe calcified aorta; in patient 5 for difficulty in dissecting fatty retroperitoneum; in patient 7 for an iliac vein lesion after previous aortoiliac TEA. Patient 1 underwent a 7.5 hour surgery because of initial inexperience with the new technique and difficulty in retaining the small bowel. This patient went into respiratory failure after the prolonged procedure, requir-

**Table III.** Clinical characteristics, operative data and outcome after laparoscopic vascular procedures

| *Patient* | *Age (years)* | *Gender* | *ABI* | *Clinical Categories** | *Operative time (minutes)* | *Clamp time (minutes)* | *Blood loss (ml)* | *RBC (units)†* | *Conversion‡* | *Follow-up (months)* | *Outcome** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Iliofemoral | | | | | | | | | | | |
| 1 | 56 | M | 0.6 | 3 | 320 | 90 | 50 | 0 | No | 17 | 3 |
| 2 | 49 | M | 0.7 | 3 | 280 | 90 | 50 | 0 | No | 20 | 3 |
| 3 | 54 | F | 0.6 | 3 | 220 | 70 | 100 | 0 | No | 19 | 1 |
| 4 | 60 | M | 0.7 | 3 | 180 | 60 | 50 | 0 | No | – | – |
| 5 | 69 | F | 0.5 | 3 | 320 | 110 | 100 | 0 | Yes | 10 | 3 |
| 6 | 55 | M | 0.5 | 3 | 265 | 75 | 100 | 0 | No | 4 | 3 |
| 7 | 41 | M | 0.6 | 2 | 225 | 65 | 200 | 0 | No | 7 | 3 |
| Aortofemoral | | | | | | | | | | | |
| 1 | 53 | M | 0.5 | 3 | 285 | 75 | 200 | 0 | No | 4 | 3 |
| 2 | 62 | M | 0.6 | 3 | 275 | 70 | 1000 | 2 | No | 6 | 3 |
| 3 | 55 | M | 0.6 | 2 | 210 | 70 | 200 | 0 | No | 2 | 3 |
| 4 | 56 | M | 0.7 | 3 | 170 | 60 | 150 | 0 | No | 2 | 3 |
| 5 | 56 | M | 0.7 | 2 | 150 | 55 | 400 | 0 | No | 3 | 3 |
| Aortobifemoral | | | | | | | | | | | |
| 1 | 60 | M | 0.6 | 3 | 450 | 120 | 1200 | 4 | No | 16 | 3 |
| 2 | 48 | M | 0.5 | 3 | 360 | 95 | 1100 | 0 | Yes | 9 | 3 |
| 3 | 57 | M | 0.4 | 3 | 250 | 75 | 200 | 0 | No | 3 | 3 |
| 4 | 43 | M | 0.7 | 3 | 285 | 65 | 100 | 0 | No | 2 | 1 |
| 5 | 57 | M | 0.5 | 3 | 240 | 60 | 1100 | 0 | Yes | 3 | 3 |
| 6 | 57 | M | 0.6 | 3 | 240 | 65 | 400 | 0 | No | 3 | 3 |
| 7 | 66 | M | 0.5 | 3 | 330 | 70 | 1500 | 4 | Yes | 2 | 3 |
| 8 | 52 | M | 0.5 | 3 | 215 | 55 | 150 | 0 | No | 2 | 3 |
| 9 | 56 | M | 0.8 | 2 | 240 | 60 | 150 | 0 | No | 2 | 3 |
| 10 | 43 | M | 0.7 | 3 | 250 | 60 | 250 | 0 | No | 2 | 3 |
| 11 | 53 | M | 0.7 | 3 | 210 | 55 | 50 | 0 | No | 0 | 3 |
| Aortic TEA | | | | | | | | | | | |
| 1 | 52 | M | 0.7 | 3 | 290 | 85 | 100 | 0 | No | 3 | 3 |

*Clinical categories of chronic limb ischemia and criteria for reporting significant changes in clinical status according to SVS/ISCVS Ad Hoc Committee.
†Transfused units of red blood cells.
‡Conversion to open surgery.

ing ventilatory support and intensive care for 16 days. Patient 7 also had a prolonged postoperative course after conversion to open surgery and postoperative dehiscence of midline laparotomy. The other patients had fast recoveries and minimal wound discomfort. Mean length of hospital stay for all patients after AFB was 10.1 ± 6.7 days (5–25 days). At the follow-up visit after a mean interval of four months (0–16 months), all grafts were patent on physical examination and ultrasound evaluation. Claudication was solved in all patients except for patient 4, who had a severe stenosis of the left common femoral artery, just behind the distal anastomosis. Patch angioplasty with Dacron was performed, after which ischemic symptoms disappeared.

## Aortic TEA

A 52-year-old male patient with severe claudication had a 3.5 cm subtotal stenosis of the infrarenal aorta. The procedure lasted 290 minutes, with a clamping time of 85 minutes. No RBC transfusion was necessary; oral feeding started the day after surgery. The postoperative angiography documented the complete removal of the occluding plaque, and the patient was discharged on day 6. At a follow-up examination three months later all ischemic symptoms had disappeared, and the ultrasound examination showed a normal aortic lumen.

## DISCUSSION

Although laparoscopy techniques experienced a tremendous development in general surgery, only a few case reports deal with laparoscopic procedures for vascular occlusive disease. Dion et al. were the first authors to report a laparoscopy-assisted aortobifemoral bypass.[2] Three years later, Berens and Herde presented their experience with four video-assisted procedures on aortoiliac vessels.[3] Two IFB, one AFB, and one aortic TEA were performed using a gasless technique through a transperitoneal approach. Conventional instruments were used, the anastomoses were accomplished through a 4 cm paramedian working incision.

This report encouraged us to apply our laparoscopic experience to vascular surgery. The basic idea was to perform a totally laparoscopic aortobifemoral bypass respecting well-known and standardized techniques of traditional vascular surgery. After training in laparoscopic suture techniques in a pelvitrainer and porcine model, we developed a transperitoneal technique for anastomosis on aortoiliac vessels using a pneumoperitoneum. The relatively thin aorta of the piglets, which weighed 30–35 kg, and the difficulties in retaining the small bowel do not allow a general recommendation of that animal model. We actually consider training in a pelvitrainer more effective.

At the beginning, only iliofemoral bypass procedures were performed, because iliac dissection and clamping are easier to accomplish. With growing experience more proximal anastomoses were performed. The method we developed differed in some aspects from that used by the above-mentioned colleagues,[2, 3] because we chose a transabdominal approach using a pneumoperitoneum. Furthermore, we have performed the proximal anastomosis with a continuous suture and used newly developed laparoscopic vascular instruments. The first totally laparoscopic aortofemoral bypass was successfully performed by Dion et al.[4] As described in that report, the aortic end-to-end anastomosis was accomplished through a retroperitoneal approach. We preferred the transabdominal approach used in open surgery, because it offers a proper visualization of the operating field so that section and clamping of the aorta can be performed easily and safely. In addition, laparotomy could soon be performed in an emergency situation without changing patient position. Similarly to Ahn[6] and Fabiani[7] and in contrast to Dion[2] and Berens,[3] we inducted a pneumoperitoneum. This enlarged the abdominal cavity and increased the handling possibility for the suturing devices. Furthermore, both iliac arteries could be routinely identified, which permitted a correct and safe tunneling of the graft limbs. Although some authors[2, 4, 8] began their laparoscopic experience using a transabdominal approach, they soon abandoned it because of difficulties in retaining the small bowel. During our initial experience, we applied some retraction devices, such as fan retractors and polypropylene mesh grafts, but the small bowel always overcame the retaining devices. Finally the problem was solved by tilting the table in a steep Trendelenburg position, by shifting the small bowel into the upper abdomen, and by avoiding the anesthetic nitrous oxide. The latter evoked significant dilatation of bowel loops. Furthermore, the falling of a bowel loop near the aorta was tolerated, because stitches either in the graft or vessel wall required only a small area of visualization.

No deaths or injuries to the bowel or to the mesenteric root occurred in our study group. However, after AFB one patient had ventilatory support until postoperative day 4, probably because of the combination of a steep, Trendelenburg position and long-lasting surgery causing apical atelectasis. A lesion to the left common iliac vein requiring open surgery for bleeding control occurred in a patient, after the long, curved grasper was inserted into the left retroperitoneum to pull the graft limb to the groin. This patient had previously undergone an endarterectomy of the aortoiliac vessels by a retroperitoneal approach. One further conversion to open surgery was necessary in an obese patient, in which dissection of aorta in fatty retroperitoneal tissue was extremely time consuming. Therefore we actually consider severe obesity, pulmonary disease, and previous aortoiliac surgery to be contraindications for laparoscopic vascular surgery.

Almost all laparoscopic procedures required longer surgery times than open surgery, but a trend toward faster procedures has be recorded. Similarly to progress in laparoscopic cholecystectomy or hernia repairs, we expect further shortening of operating times as experience grows.

The careful bleeding control required in the laparoscopic setting made for small blood losses; however, two patients required RBC transfusions after successful laparoscopic bypass procedures. In our institution, we observed a mean blood loss of 805 ml (150–1700 ml) after conventional AFB for aortoiliac occlusive disease. Concomitantly, the mean blood loss after laparoscopic AFB betrayed 563 ml.

A major benefit of laparoscopic surgery is a faster recovery. Indeed the mean postoperative stay after laparoscopic AFB was 10.1 days in comparison to 15 days (7–30 days) after an open procedure. Although postoperative pain and analgetic demand were not evaluated in this study, we observed a very comfortable course in almost all patients. The day after the procedure, mobilization and oral feeding were usually started and were well tolerated. After positive initial experience, monitoring and care were simplified, to shorten postoperative course. In this way, discharge occurred usually on day 7, but still a faster ambulation could be achieved. In Germany, hospital costs are fully supplied by insurance companies, so patients are used to longer hospital stays than in the United States. For example, some patients are kept in the hospital although they do not need medical care. Moreover, social issues are responsible for prolonged hospital stay. Postoperative angiographic controls always demonstrated patent bypasses and correct anatomic positioning. At follow-up examination all grafts were patent, and two patients had moderate claudication. One progressive iliac disease and one stenosis of femoral anastomosis were responsible for the reduced ankle-brachial-index (ABI). Respectively, PTA of common iliac artery and patch angioplasty of distal anastomosis were successfully performed. The cosmetic effect of the laparoscopic access sites was good, and no hernias were found.

All advantages advocated for minimally invasive surgery, namely minor tissue trauma, diminished risk of contamination, reduced blood loss, decreased wound pain, faster recovery, and minimal scarring, have been observed in almost all patients after successful laparoscopic bypass. At the same time, excellent functional outcome was assessed. Nonetheless, further randomized trials are needed to define the role of the laparoscopic approach in vascular surgery. Similarly, follow-up examinations of the study groups is needed to describe the durability of the presented procedure.

## CONCLUSION

We demonstrated that iliofemoral and aortofemoral bypass procedures and aortic endarterectomy are feasible, safe, and effective when performed laparoscopically. Nevertheless, a proper patient selection is mandatory in the beginning. Growing experience and technological progress may in the future broaden the spectrum of laparoscopic procedures on vessels to reduce tissue trauma and at the same time still apply established, well working principles of vascular surgery.

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