Endoaneurysmorrhaphy has been the gold standard of abdominal aortic aneurysm (AAA) repair since Creech reported it in 1966. It was not until the 1990s that AAA repair entered the field of less invasive surgery. Following our first success with hand-assisted laparoscopic surgery for AAA in 2004, we moved toward total laparoscopic aortic aneurysm repair. The goal of laparoscopic AAA repair is to perform the durable endoaneurysmorrhaphy with minimal surgical trauma. Since 2001, the technique has been developed and refined but only performed in a few vascular institutes. We describe the technique of total laparoscopic AAA repair with tube graft interposition through a transperitoneal, left retrocolic approach. The main technical issues are discussed.

Case Report

A 49-year-old woman presented with exertional dyspnea to our clinic last year. Marfan appearance was obvious. Ascending aortic aneurysm and severe aortic regurgitation were discovered. Bentall’s operation using mechanical valve and coronary button reimplantation was performed.
in March 2006. During the same hospitalization, a 4.5-cm infrarenal AAA was found. The patient had an uneventful recovery after cardiac surgery. The AAA increased in size to 4.8 cm in diameter 6 months after the first computed tomography. Surgical resection was recommended based on the diagnosis of Marfan syndrome.

**Surgical technique**

The anesthetic preparation was as for routine abdominal aortic surgery. The patient was intubated. A large-bore central venous catheter was used to monitor the fluid status. Two additional large-bore peripheral catheters were ready for volume expansion. The patient lay with a towel roll under the left trunk which kept the patient at 45-degree right decubitus. The left hand was raised in front of her face. The abdomen was hyperextended by bending the operating table and draped from the right midclavicular line to the left posterior axillary line.

Initially, the surgeon and assistant stood to the right of the patient (Figure 1). The first 1.5-cm incision was made below the umbilicus. A Veress needle was inserted to create carbon dioxide pneumoperitoneum, followed by a 12-mm port for a 10-mm, 30-degree videoscope. Two additional 12-mm ports (nos. 2 and 3 in Figure 2) were inserted in the midline above and below the first one. By using these three ports, the peritoneal cavity was inspected. Initial dissection and mobilization of the descending and sigmoid colon was carried out. The paracolic gutter was incised to expose the retroperitoneum. The splenic flexure was detached from the splenic hilum. The descending mesocolon was dissected medially leaving Gerota’s fascia intact. Care was given to the ureter and gonadal vein which are visualized easily at the pelvic brim and run cross over the iliac vessels. During the dissection, the table was turned right to keep the bowel away using gravity.

Following the landmark of the gonadal vein, the dissection was done cephalic to the renal vein. Then, the surgeon and camera holder moved to the left side of the patient (Figure 3). Three additional 12-mm ports (nos. 4, 5 and 6 in Figure 2) were inserted. Three 2-O straight-needle Prolene sutures (Ethicon Inc., Somerville, NJ, USA) served as stay sutures to hold the left hemicolon apron. They pierced into the abdomen right lateral to
ports 1, 2 and 3, passed through the peritoneal margin of the left hemicolon, and were brought out to the abdomen using endoscopic instruments. The traction sutures and right decubitus position helped the exposure of the retroperitoneal space. One laparoscopic fan retractor was used to keep the visceral organs away from the dissection. The infrarenal aneurysm neck and bilateral common iliac arteries were isolated to facilitate the following clamping. The lumbar arteries behind the aneurysm were clipped and divided. The inferior mesenteric artery was clipped and divided as well.

Prior to aortic clamping, 5000 IU of heparin and nitroglycerin were given. Two additional ports (nos. 7 and 8 in Figure 2) were inserted for laparoscopic clamps (Karl Storz, Tuttlingen, Germany). The right common iliac artery was clamped using the straight clamp via port no. 1. The left common iliac artery was clamped via port no. 7. The infrarenal aorta was clamped via port no. 8. A stab wound over the aneurysm was used to test the occlusion of these clamps and also the amount of collateral flow. Intermittent suction was used to get rid of excess fluid or blood. Then, the aorta was transected at the infrarenal level and the level just above the bifurcation. The entire aneurysm was dissected free using electrocautery and grasped out of the abdomen via port no. 5. A segment of 20-mm Dacron graft was inserted into the abdomen via port no. 5. The proximal anastomosis was carried out using 15-cm 2-O Ticron suture (Davis & Geck Co., St. Louis, MO, USA) starting from the far side and running the dorsal aspect of the anastomosis. The other 2-O Ticron was used to finish the rest of the anastomosis. Prior to making the knot, extra-length nerve hook was used to stretch and tighten the running suture stitch by stitch. The adequate length was trimmed. The distal anastomosis was carried out in the same way. The laparoscopic clamps were removed from the bottom up. The overall ischemic time was 99 minutes. One bleeder over the proximal anastomosis demanded additional stitches. Hemostasis was easily achieved after protamine infusion. A rubber drain was left in the Pouch of Douglas via port no. 5. All ports were closed in layers (Figure 4). The total operative time was 7 hours and 25 minutes. The estimated blood loss was 400 mL.

The patient was sent to the intensive care unit and was extubated 4 hours after the operation. Oral intake was resumed on the first postoperative day. There was minimal drain amount and the drain was removed on the second postoperative day. The patient was discharged home on the sixth postoperative day in good condition.

Discussion

The standard treatment of endoaneurysmorrhaphy and tube graft interposition for AAA is reproducible by most vascular surgeons, provides durable results, and is life-saving. But the procedure itself has a major impact on patient recovery. A meta-analysis covering 37,654 patients reported that the mean 30-day mortality rate varied from 3.5% to 8.2%, and the cardiac complication rate was 6.1–11.1% for elective AAA surgery.4

Endovascular aneurysm repair (EVAR) is an alternative technique that was first introduced by Parodi et al in 1991.5 EVAR is less invasive and is associated with less perioperative morbidity and mortality.6 However, the randomized control study of EVAR (EVAR-1) did not demonstrate any improvement in overall late survival.7 The Dutch Randomized Endovascular Aneurysm Management
(DREAM) trial observed an initial mortality advantage for EVAR, but the overall 1-year survival was similar in both groups. Significantly higher complication and intervention rates and higher hospital costs with EVAR were noted. However, for patients who can afford it, EVAR remains the first choice of treatment due to its lower degree of invasiveness.

Since the advent of laparoscopic surgery, vascular surgeons have applied the technique to operations for AAA. Hand-assisted laparoscopic surgery is an innovative technique that allows surgeons to use their hands and laparoscopic instruments simultaneously in the operative field while maintaining a pneumoperitoneum. Some pioneers started from laparoscopic-assisted aortic surgery or hand-assisted laparoscopic surgery, and moved toward total laparoscopic aortic procedures. Aortoiliac occlusive diseases were usually the initial targets for vascular surgeons involved in the new frontiers of endoscopic surgery. Total laparoscopic AAA repair was reported in the late 1990s. Endoscopic stapling devices were used to exclude the aneurysm, followed by aorto-bifemoral bypass. Dion et al reported the first total laparoscopic AAA repair performed according to the principles of endoaneurysmorrhaphy in 2001.

Some specially designed instruments were usually required to achieve the air-sealing, aortic occlusion, and endoscopic suturing. The number of ports for this procedure varied from six to more than 10. The application of intracorporeal deployable clamps can reduce the number of ports. There are two different approaches for laparoscopic aortic surgery: transperitoneal or retroperitoneal. There is better exposure of the right aortic wall and right iliac vessels with the transperitoneal approach. The left retrocolic approach was originally described by Dion et al as the “apron technique”. The retroperitoneal approach provides more details in the cross of the left renal vein and the aorta. This ensures adequate proximal control. In the context of total laparoscopic aneurysm repair, the apron technique is favorable. In our experience, relocation of the laparoscope, retractors and other instruments allows more appreciation of the right aortic wall and right iliac vessel. Surgeons who wish to perform laparoscopic aortic surgery should have some experience of laparoscopic procedures, either from simulators, training boxes, wet laboratory or animal experiments.

Although this procedure is technically demanding, it provides a durable result as with traditional open aneurysmectomy. A French group reported 30 cases of total laparoscopic AAA repair with a median operative time of 290 minutes, median aortic clamping time of 78 minutes, median blood loss of 1680 mL, and median hospital stay of 9 days. A case-control study concluded from preliminary results that the short-term outcomes of total laparoscopic AAA repair are comparable with those of open surgery. Dion et al reported that their mid-term results with total laparoscopic aortic surgery were encouraging. Kolvenbach et al reviewed a total of 236 total laparoscopic aortic procedures and reported a mortality rate of 3%, with significant reduction in intensive care unit stay, postoperative ileus and length of hospital stay.

In our patient, ventilatory support, intensive care and hospital stay were relatively short despite the prolonged operative time and aortic clamping time. As each innovative procedure emerges, operative time, clamping time and steep learning curve remain the major drawbacks of laparoscopic aortic surgery. Some complications including troublesome bleeding, fatal pulmonary embolism, renal insufficiency, lung atelectasis, bowel obstruction, spleen rupture, vascular injuries, and surgical conversion have been reported.

Laparoscopic aortic surgery is not only indicated in aortoiliac occlusive diseases but also in infrarenal aortic aneurysm. Recent data showed that more than a tenth of patients who underwent endovascular stent grafts required additional intervention. Some endoleaks remain impossible or highly technically demanding for the endovascular approach. This less invasive procedure provides an excellent alternative to circumvent these issues. Some surgeons even suggest a hybrid procedure to ensure better results. Laparoscopic aortic banding and branch clipping facilitate
endovascular aortic repair. Recent advances in robotic technology facilitate the creation of aortic anastomosis. Application of robotic endowrist further shortens aortic clamp time.\textsuperscript{24,25} However, availability, cost and learning curve remain unsettled issues.

There remain many factors that limit the extensive use of laparoscopic surgery in AAA repair. Small stature will jam the ports and hinder the laparoscopic procedures. Obesity is usually considered a relative contraindication for complex laparoscopic surgery and would not be recommended to obese patients, especially if the surgeon is in the learning period. Prolonged ischemic time due to endoscopic suturing is always a concern. Severe aortic calcification will not allow the specialized clamp to occlude completely. Unsuitable anatomies such as involvement higher than the renal artery, short aneurysm neck, severe tortuosity and diffuse aneurysmal changes will significantly increase the surgical risk as well. Patients with other traditional contraindications for laparoscopic surgery such as hostile abdomen, intra-abdominal adhesion, and poor cardiopulmonary status would also not be eligible to undergo the procedure.

Laparoscopic aortic surgery provides better visualization of the aneurysm neck, less bowel manipulation, and avoidance of hypothermia. The lower degree of invasiveness could translate into better perioperative outcomes. Substantial learning commitment remains crucial. We believe that this surgical innovation will play a role in abdominal aortic surgery in occlusive diseases, aneurysmal diseases or hybrid procedures along with endovascular approaches. This first successful case also highlights the technical achievement of Taiwan’s vascular surgeons.

References


Acknowledgments

We thank Ms Fang-Shiang Chen and Mr Chia-Li Chen for their endeavors in participating in laparoscopic training, animal experiments, and instrument preparation.


