

This thesis is about modern aortic surgery. Operative techniques in minimally invasive or open aortic surgery that may reduce operative trauma and may improve postoperative recovery are investigated.

Chapter 1. Although proven successful and durable, open surgery of the aorta is associated with significant morbidity and a long recuperation time. To reduce operative trauma, minimally invasive techniques have been developed for both dilating and occlusive disease of the aorta. Endovascular and endoscopic surgery offer significant advantages to the patient over traditional surgery, including reduced mortality and morbidity, reduced postoperative pain and shorter hospital stay. Unfortunately, only a limited number of patients can profit from these techniques. Due to patient anatomy and technical limitations, a significant number of patients still require open aortic surgery. The aim of this thesis is to investigate modern techniques in minimally invasive and open surgery of the aorta that may reduce operative trauma and may improve postoperative recovery.

Part one: Aortic aneurysm

Chapter 2. Outcome of ruptured abdominal aortic aneurysms (AAA) may be improved by endovascular aortic aneurysm repair (EVAR). In EVAR, placement of a bifurcated endograft would be preferable because this avoids the need for a subsequent extra-anatomic bypass. However, in case of a ruptured AAA this could lead to excessive blood loss since the aneurysm is not immediately excluded from the circulation. The feasibility of a hemostatic valve placed in the short limb of a bifurcated aortic endograft to avoid blood loss was investigated. A tricuspid valve was constructed in the short limb of a bifurcated stent graft and tested using an in vitro circulation model with pulsatile flow up to 120 mmHg. Angiography showed complete occlusion of the short limb by the valve. The extension graft could be inserted and subsequently deployed without difficulty. Post-deployment angiography showed normal patency, with no signs of stenosis of the compressed valve. In conclusion, placement of a temporary valve in the short limb of a bifurcated endograft can potentially reduce blood loss during endovascular repair of ruptured AAA.

Chapter 3. The common femoral artery is the preferred access site for EVAR. However, unfavourable anatomy of the iliac and femoral arteries may hinder or preclude EVAR in a significant number of patients. Alternatively, the descending thoracic aorta may be used for endovascular access. The feasibility of a direct videoscopic approach to the thoracic aorta for endograft delivery to the aortic arch was evaluated in three pigs. A thoracoscopic approach was used to create

a double purse-string suture on the descending thoracic aorta. The aorta was punctured and a 22-F delivery catheter was introduced directly in the aorta. An aortic endograft was subsequently deployed at the aortic arch. After completion of the procedure, the delivery sheath was withdrawn from the aorta while tightening the purse-string suture, obtaining hemostasis without the need for aortic cross clamping. During autopsy all endografts were deployed in the correct position.

Chapter 4. The thoracoscopic technique could also be advantageous for endovascular repair of AAA and for branched endograft placement. A human cadaver study was conducted to examine the feasibility of a direct videoscopic approach to the descending thoracic aorta for branched endograft delivery to the aortic arch and abdominal aorta. In three human cadavers a circulation model with pulsatile flow was established. After thoracoscopic placement of two purse-string sutures on the thoracic aorta, a fenestrated endograft was deployed in the aortic arch. The second purse-string suture was used to introduce and deploy a branch graft in the left subclavian artery. In the same cadaver a similar procedure was performed for antegrade branched endograft delivery to the pararenal aorta. Branched endograft deployment was successful in all cadavers as shown by post implant angiography and autopsy. A direct videoscopic approach proved a feasible technique for branched endograft delivery to the aortic arch and abdominal aorta.

Chapter 5. Apart from difficulties in vascular access, EVAR may be precluded because of absence of a proximal endovascular landing zone. Juxtarenal aortic aneurysms (JAA) extend up to the orifices of the renal arteries and lack an infrarenal neck required for endovascular repair. Therefore, open repair with suprarenal cross clamping is still required for these patients. To examine outcome of non-ruptured open JAA repair, a systematic literature review was performed. Twenty-one cohort studies, published between 1986 en 2008, were found, reporting on 1,256 patients. Mean perioperative mortality was 2.9% (95% CI, 1.8 to 4.6), mean incidence of new onset of dialysis was 3.3% (95% CI, 2.4 to 4.5). From 13 studies incidence of postoperative renal dysfunction could be derived and ranged from 0% to 39% (median, 18%). Postoperative renal dysfunction could not be compared between the studies because of the wide range of definitions used to describe renal dysfunction. The results of this review show that open JAA repair can be performed with an acceptable postoperative mortality rate. Postoperative deterioration of renal function is a common complication, however, and requires further investigation.

Chapter 6. Renal cooling potentially preserves renal function during suprarenal cross clamping. In chapter 6 a consecutive series of 23 patients receiving elective open repair of JAA with routine cold renal perfusion during renal ischemia time is presented. Balloon-tipped Pruitt irrigation catheters inserted in the orifices of the renal arteries were used for continuous renal perfusion with 4°C NaCl 0.9%. Mean total operative time was 215.2 minutes, with a mean total aortic clamping time of 58.4 minutes. There was no postoperative mortality and none of the patients suffered postoperative renal dysfunction. A standardized strategy to apply renal hypothermia during the ischemic period of elective JAA surgery may reduce postoperative renal dysfunction.

Part two: Aortoiliac occlusive disease

Chapter 7. According to current multidisciplinary guidelines, surgery is the treatment of choice for extensive aortoiliac occlusive disease (AIOD). However, developments of endovascular devices and techniques have prompted the utilization of endovascular therapy. In chapter 7 the literature on contemporary results of endovascular therapy for extensive AIOD was systematically reviewed. Nineteen non-randomized cohort studies, reporting on 1,711 patients were included. In this heterogenic group of studies selected patients with extensive AIOD could be treated using endovascular techniques with high technical success rates (86 to 100%). Although long-term primary patency rates of endovascular treatment (60 to 86%) cannot yet compete with those reported for open reconstructive surgery, reinterventions could often be performed using percutaneous techniques, obtaining secondary patency rates of 80 to 98%. With continuing developments in endovascular techniques and devices as well as growing experience of interventionalists, it is to be expected that indications for endovascular treatment of extensive AIOD will be broadened.

Chapter 8. Laparoscopic aortic surgery is an alternative treatment option for patients unsuitable for or after failed endovascular treatment. Laparoscopic surgery is very challenging and may be enhanced by robot technology. In chapter 8 we present a consecutive series of 28 patients receiving robot-assisted laparoscopic surgery (RALS) for AIOD. We prospectively followed 24 patients receiving robot-assisted laparoscopic aortobifemoral bypass grafting (n=24) or aortoiliac endarterectomy (n=4) during a median follow up of 36 months. Conversion to open surgery was necessary in 4 patients. One patient died postoperative and postoperative morbidity was 14%. Although total operative times were long, postoperative recovery was swift, with a median hospital stay of 5 days. Primary (89%) and secondary patency (91%) after three year follow-up were comparable to those reported for open surgery. These

results suggest that RALS is a feasible and durable technique for patients with AIOD, combining the advantages of minimally invasive surgery with the durability of open surgery.

Conclusion

In this thesis, several new techniques have been examined that may reduce operative trauma and/or improve postoperative recovery in both minimally invasive and open surgery of the aorta. Although some of these techniques have already proven their worth in patient series, ideally, clinical trials need to be performed to properly evaluate the potential advantages over traditional surgical techniques. More than the conclusion of a completed investigation, this thesis is a step towards further research to achieve our goal: to treat patients in the best way possible, while at the same time causing the least possible amount of collateral damage.