Late open conversion after failed endovascular aortic aneurysm repair

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Objective: **Endovascular aortic aneurysm repair (EVAR) is widely used for the treatment of abdominal aortic aneurysms. Complications secondary to EVAR are also treated with endovascular techniques. When this is not applicable, open surgical repair is mandatory. This study aims to present our experience in open surgical repair after failed EVAR.**

Methods: **Within the period from 2004 through 2013, 18 patients (17 men; mean age, 73.9 years) were operated on because of EVAR failure due to persistent type II endoleak (n = 10), type I or III endoleak (n = 3), mixed-type endoleaks (n = 2), stent graft thrombosis (n = 2), and aortoenteric fistulae (n = 1). Stent grafts used for EVAR were Zenith (n = 8), Talent (n = 4), Excluder (n = 4), and Anaconda (n = 2).**

Results: **Mean time interval between EVAR and open conversion was 36 months (range, 2-120 months). Fifteen (83.3%) operations were elective, and three (16.7%) were urgent due to aneurysm rupture (n = 2) and aortoenteric fistula (n = 1). Six (33.3%) patients with type II endoleak were treated with simple ligation of the culprit vessels, without aortic clamping and stent graft explantation. In six (33.3%) patients, the stent graft was partially removed except from the segment attached to the proximal neck, while in five (27.8%) patients, complete removal of the stent graft was necessary. Finally, in one patient, with type III endoleak, a hybrid endovascular and open repair was performed. Clamping of the aorta was necessary in 12 (66.7%) patients (infrarenal, n = 10 or suprarenal, n = 2). Overall operative mortality was 5.6%. Postoperative complications included one abdominal wall defect requiring surgical revision and paroxysmal atrial fibrillation both in the same patient, and one case of pulmonary infection, requiring prolonged intubation and intensive care unit stay for 6 days.**

Conclusions: **Late open conversion after failed EVAR remains challenging. Avoidance of aortic cross-clamping and if possible, partial or total preservation of the stent graft may improve outcomes in terms of operative mortality and morbidity. Elective operations seem to be associated with better outcomes, prompting thus for close follow-up of EVAR patients and early decision for conversion if other options are doubtful. (J Vasc Surg 2014;59:291-7.)**

Endovascular aortic aneurysm repair (EVAR) has changed the management of abdominal aortic aneurysms (AAAs) during the last 2 decades. More than half of the patients are nowadays treated with EVAR, and in many centers, elective open AAA repair is reserved only for rare cases anatomically unsuitable for EVAR.[1] EVAR offers a clear benefit in terms of perioperative morbidity and mortality over open repair, but it is also associated with increased rates of late secondary reinterventions.[2] Indeed, although improvements in endovascular technology and physicians' growing experience have led to better EVAR results, late complications after EVAR still remain an issue. Most of the time, these can be successfully treated with endovascular means, but open conversion can still be required in 0% to 9% of cases,[3-10] with a more representative rate of 2.1% as reflected in the European Collaborators on Stent Graft Techniques for Aortic Aneurysm Repair (EUROSTAR) Registry.[11] Indications for secondary conversion vary and include endoleaks not amenable to endovascular management, stent graft infection, aneurysm rupture, and stent graft thrombosis.[12]

Surgical reintervention following EVAR is considered to be more demanding compared with primary open repair.[13] The pre-existing stent graft adds more challenges to the procedure and can lead to increased perioperative morbidity and mortality.[14-17] In the present study, we review our experience on late open conversions after failed EVAR, aiming to highlight technical factors that may improve outcomes.

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METHODS

All consecutive patients with AAAs that were treated with late open conversion after previous failed EVAR within the period of May 2004 through January 2013 in a single-center institution were included in this study. Data were prospectively collected in a database and were retrospectively analyzed for this study.

Late open conversion was defined as an open surgical procedure performed at >30 days after the initial EVAR operation. Patients were excluded from analysis if conversion was performed at the time or within 1 month of the

Table I. Preoperative patient characteristics

Comorbidity/risk factor	*Patients, No. (%)*
Coronary artery disease	8 (44)
Hypertension	13 (72)
Chronic obstructive pulmonary disease	5 (28)
Smoking (current or past)	10 (56)
Diabetes mellitus	4 (22)
Hypercholesterolemia	10 (56)
Serum creatinine >100 μmol/L	6 (33)
Previous stroke/transient ischemic attack	3 (17)
Hostile abdomen	1 (6)
Antiplatelet therapy	12 (67)
Anticoagulant therapy	1 (6)

Table II. Summary of indications for late open conversion

Treatment indication	*Patients, No. (%)*
Type II endoleak + sac enlargement (1 rupture)	10 (56)
Type III endoleak	1 (5.6)
Type Ia and II endoleak	1 (5.6)
Type Ia and Ib endoleak	1 (5.6)
Type Ia endoleak + rupture	1 (5.6)
Stent graft thrombosis + type II endoleak	1 (5.6)
Aortoenteric fistula	1 (5.6)
Limbs' thrombosis	1 (5.6)
Type Ib endoleak	1 (5.6)

initial EVAR intervention. Cases with total, partial, or no stent graft removal were included. In the latter case, open surgery was performed to repair endoleaks without explant of the stent graft. Preoperative collected and analyzed data included patient demographics, previous endovascular reinterventions, indication for open conversion, stent graft type, and time frame between the initial EVAR and open conversion. The physical status of all patients was assessed preoperatively with the American Society of Anesthesiologists (ASA) score. The intraoperative details were also reviewed including the surgical approach, use of aortic cross-clamping, stent graft removal or not, estimated blood loss, and operative time. Postoperative analyzed variables included major perioperative (<30 days) complications, length of intensive care unit (ICU) and hospital stay, and 30-day mortality.

SPSS for Windows (version 17.0; SPSS Inc, Chicago, Ill) was used for statistical analysis. Continuous variables are presented as mean (range) and categorical variables as percentages.

RESULTS

Patients. Between May 2004 and January 2013, a total of 895 AAA repairs, comprised of 453 open procedures and 442 EVARs, were performed in our institution. A total of 18 patients (17 male; mean age, 73.9 years; range, 55-91 years) required late open conversion after failed previous EVAR during this period. Thirteen (72.2%) patients were classified as ASA III, four (22.2%) patients as ASA II, and one (5.6%) patient as ASA IV. Patients' comorbidities are shown in Table I. In eight patients (44.4%), EVAR had been performed in our hospital, and 10 patients (55.6%) had been operated upon elsewhere.

Previous stent grafts and current aneurysm characteristics. Mean time interval from previous EVAR to open conversion was 36 months (range, 2-120 months). Seventeen of the initially implanted stent grafts were bifurcated, and one was aorto-uni-iliac. Eight (44.4%) patients were previously treated with a Zenith (seven bifurcated, one aorto-uni-iliac) stent graft (Cook Inc, Bloomington, Ind), four (22.2%) with a Talent (Medtronic World Medical, Sunrise, Fla), four (22.2%) with an Excluder (W. L. Gore & Associates, Flagstaff, Ariz), and two (11.1%) with an Anaconda (Vascutek, Inchinnan, Scotland, UK). Mean maximal AAA diameter was 73 mm (range, 61-120 mm).

Indications for late conversion. The most frequent reason for elective open reintervention was persistent type II endoleak with aneurysm sac enlargement (n = 10; 56%). Other indications included type Ia, type Ib and type III endoleaks, or a combination of them. One patient was operated on due to total stent graft thrombosis and concomitant type II endoleak with aneurysm sac enlargement, and one was operated on because of both limbs' thrombosis due to excessive kinking. Fifteen (83.3%) patients were operated on electively, and three (16.7%) on an emergency basis due to aneurysm rupture in two cases and aortoduodenal fistula in one. The first patient with rupture had not complied with follow-up and presented 5 years after EVAR, with free rupture and hypovolemic shock due to a large type Ia endoleak. The second patient had an unremarkable follow-up without any endoleak the first 2 years after EVAR. He did not have any further follow-up and presented 2 years later with a retroperitoneal rupture due to a new-onset type II endoleak originating from the inferior mesenteric artery. Finally, one patient required conversion for an aortoduodenal fistula 9 months after EVAR and subsequent proximal cuff placement for type Ia endoleak. Table II summarizes the indication of conversion in the whole patient cohort.

In our institution, we preferentially treat EVAR complications with endovascular means. Open conversion is reserved for those patients that are not amenable to endovascular revision, or if such an approach has already been attempted and failed. Ruptured/urgent cases are also preferentially treated with open conversion. Especially for type II endoleaks, we lately tend to more liberally suggest direct open conversion aiming for graft preservation and no aortic cross-clamping as a more likely definite treatment option. In this series, seven patients (46.7%) of the elective group had undergone secondary endovascular reinteventions before ending up with open conversion. These included multiple attempts of coil embolization for type II endoleak in four patients, limb graft extension for type Ib endoleak in two, and stent graft relining with a proximal cuff and two limb grafts for suspected endotension in one patient. The

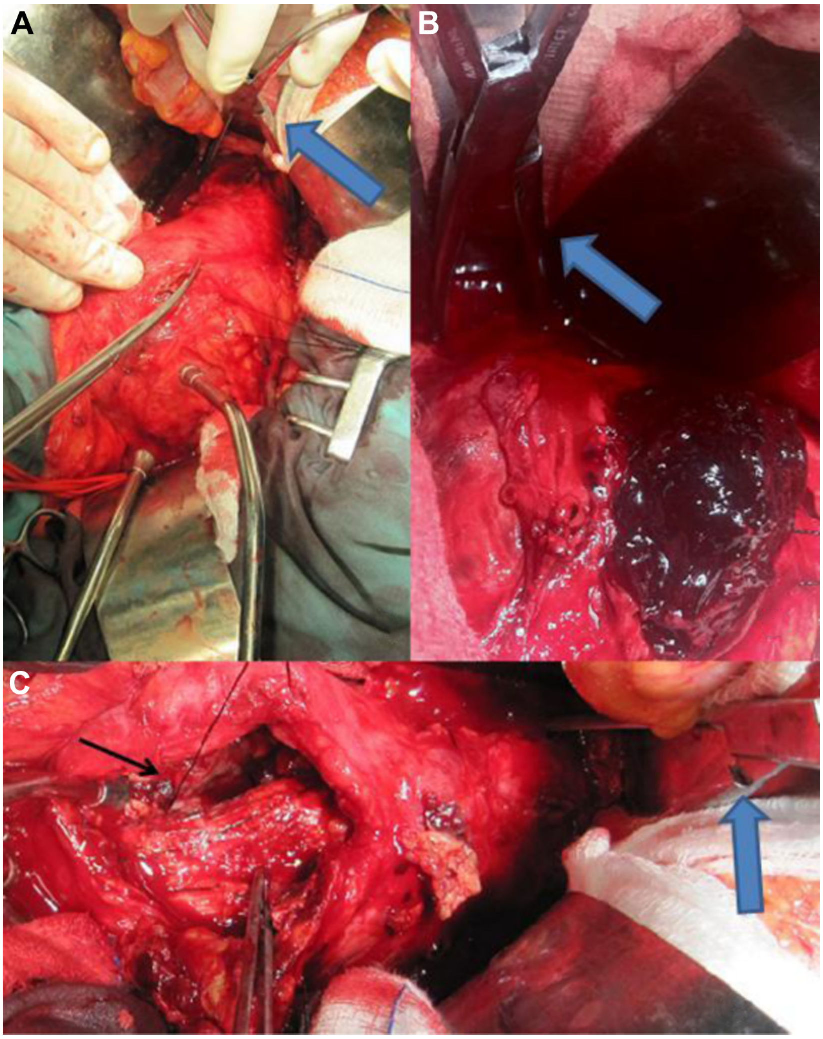

Fig 1. Aneurysm sac opening without aortic cross-clamping **(A** and **B)** and ligation of the culprit lumbar artery with complete preservation of the stent graft **(C)**. Note the proximal aortic clamp that is kept open in position to be used in case of bleeding (*blue arrows*).

remaining patients had direct open conversion without a previous endovascular attempt either because they were not good candidates for endoluminal correction due to juxtarenal aneurysm anatomy (n = 2), aortoduedenal fistula and infection (n = 1), severe limb-graft kinking (n = 1), complete stent graft thrombosis (n = 1) and rupture (n = 2), or due to their willingness for a most likely definite treatment (n = 4).

Operative details. Sixteen patients (88.9%) were operated on through a transperitoneal approach, one (5.6%) through a right retroperitoneal approach, and one (5.6%) with right transverse incision for concomitant right partial nephrectomy. Mean operative time was 200 minutes (range, 90-280 minutes), and the mean estimated blood loss was 1200 mL (range, 300-3300 mL).

In six (33.3%) patients with type II endoleak and ongoing sac enlargement, no aortic clamping was performed, and the stent graft was completely preserved. Four of these patients had previously undergone two or more transarterial coil embolization attempts of the culprit arteries without success in the long term and were therefore finally subjected to open conversion. Two patients underwent open conversion directly, without any endovascular attempt, due to their willingness for a more likely definite treatment.

In one case, the IMA was clip-ligated externally at its origin through a right transverse incision for right partial nephrectomy, and in the remaining five cases, including one patient with rupture, the aneurysm sac was opened without aortic cross-clamping, and the culprit lumbar orifices were ligated from inside the sac, without removal of the stent graft (Fig 1). Opening the sac and ligating the culprit vessels from inside rather than laparoscopic or via laparotomy ligation from outside the sac was our

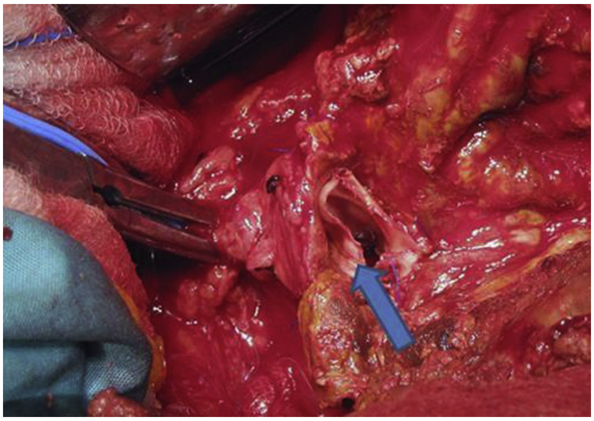

Fig 2. Partial removal of the stent graft. A proximal rim (*arrow*) is preserved and is included together with the aortic wall in the suture line of the proximal anastomosis.

preferred strategy, so as to be sure under direct vision that all back-bleeding vessels were identified and ligated. The aneurysm sac was again sutured only after complete hemostasis was achieved and no more back-bleeding (even minimal) was evident. In one of the above patients, an additional endovascular limb bridging was performed due to threatened limb dislodgement noticed in preoperative imaging (plain X rays). Despite avoidance of aortic cross-clamping, the proximal aortic neck was carefully exposed in all these cases to ensure prompt clamping in case of stent graft dislodgment after sac opening during maneuvers for lumbar artery ligation.

In six (33.3%) patients, partial removal of the stent graft was performed. In three of them with sac enlargement due to type II endoleak, the stent graft was dislodged after sac opening, during maneuvers for lumbar artery ligation from inside the sac, and inevitably was cut and removed under infrarenal clamping. The proximal part of the stent graft that was attached to the aneurysm neck was maintained, since it was found to be well incorporated into the aortic wall, and we did not want to risk denudation/laceration of the juxtarenal aorta during complete removal attempts (Fig 2). A conventional tube or bifurcated Dacron graft was sutured with 3.0 Prolene, including both the maintained part of the stent graft and the aortic wall in the suture line. In one patient with type II endoleak and intraoperative ipsilateral limb graft dislodgement, we cut and removed the dislodged limb under proximal limb graft clamping and bridged it to the common iliac artery with a short Dacron bypass graft. In one patient with limbs thrombosis due to kinking, the distal stent graft was removed under infrarenal clamping, and the aorta was reconstructed with a bifurcated Dacron graft sutured proximally to the preserved stent graft part. Finally, in one patient with a totally thrombosed Anaconda stent graft and a type II endoleak, the stent graft was partially removed under suprarenal clamping, preserving a proximal rim due to dense incorporation in the atrophic aortic wall. Patent lumbar arteries were ligated, and a Dacron aorto-bi-iliac graft was accomplished.

In five (27.8%) patients, complete stent graft removal was considered necessary due to inadequate proximal and/or distal sealing or infection. Indications for surgery in these five patients were endoleak type Ia and II, type Ia and Ib, type Ib, aneurysm rupture, and aortoduodenal fistula, respectively. Infrarenal clamping was performed in four cases, while in one case, suprarenal clamping was required. Aortic reconstruction after stent graft removal was performed with a tube and a bifurcated graft in two cases each and aortic ligation and axillo-bifemoral bypass in one case with infection due to aortoduodenal fistula.

Finally, in one (5.6%) patient, with type III endoleak, a hybrid repair was performed, consisting of open catheterization of the contralateral gate and the dislodged contralateral limb under infrarenal proximal aortic control and deployment of a bridging stent graft, under fluoroscopy.

Overall, proximal aortic clamping was required in 12 (66.7%) patients, infrarenal in 10 (55.6%), and suprarenal in 2 (11.1%) cases.

In this cohort, two distinguished patterns of aortic wall reaction were observed: (1) inflammatory response (n = 6; 33.3%); and (2) atrophy of the aortic wall (n = 3; 16.7%). In nine (50%) patients, the aortic wall was found to be unaffected intraoperatively.

Postoperative mortality and morbidity. There was one perioperative death in this series, in a patient operated on urgently due to aneurysm rupture, accounting for an overall 30-day mortality of 5.6%. This patient had a large type Ia endoleak and presented with free rupture and hypovolemic shock. He underwent complete stent graft explantation and aortic reconstruction with a tube graft but succumbed to multiple organ failure 1 day later. Postoperative complications included one abdominal wall defect requiring surgical revision and a paroxysmal atrial fibrillation, both in the same patient. One patient, who suffered from acute respiratory distress syndrome, required intubation and an ICU stay for 6 days. Overall, the need for ICU stay was 2/18 (11.1%). Mean hospital stay was 7.8 days (range, 3-13 days). There were no late complications or deaths in a mean follow-up of 25.7 months (range, 2-60 months).

DISCUSSION

Improvements in endovascular technology and imaging equipment along with physicians' increasing experience have led to improved outcomes of EVAR during the last decade. Nevertheless, the need for late reinterventions after EVAR persists. Although many complications after EVAR can be successfully managed with secondary endovascular interventions,[18] open conversion is, in some cases, unavoidable. Rates of late open conversion after failed EVAR vary among the published series from 0% to 9%.[3,7-12,14]

Open surgical reintervention after failed EVAR is associated with unique technical challenges. Dissection can be cumbersome due to periaortic inflammation that is often observed after endovascular graft implantation.[10] The preexisting stent graft and the additional devices possibly placed

Table III. Summary of series reporting late open conversion after endovascular aneurysm repair (EVAR)

Author (year)	*Late conversions, No.*	*Mean time after EVAR, months*	*Elective/ urgent*	*30-day mortality, % (elective/ urgent/total)*
Lipsitz (2003)	11	30	4/11	25/14/18
Terramani (2003)	9	24	7/2	NR/NR/11
Verhoeven (2004)	9	41	8/1	0/0/0
EUROSTAR (2004)	26	32	20/6	NR
Kong (2005)	16	34	15/1	0/100/6.5
Lifeline Registry (2005)	28	NR	NR/NR	0/0/0
Verzini (2006)	29	33	25/4	0/0/0
Brewster (2006)	20	31	15/5	13/40/20
Tiesenhausen (2006)	26	42	20/6	0/50/14
Jimenez (2007)	12	26.5	NR/NR	0/0/0
Kelso (2009)	25	33.3	NR/NR	6.4/50/17
AURC (2009)	20	41	12/8	8.3/25/15
Pitoulias (2009)	39	NR	34/5	8.8/20/10.2
Nabi (2009)	12	44.7	12/0	8.3/NA/8.3
Brinster (2011)	21	33.4	16/5	0/0/0
Chaar (2012)	44	45	19/25	8/28/18
Present series	18	36	15/3	0/33/5.6

NA, Not applicable; *NR,* relative information could not be retrieved.

during previous endovascular reinterventions pose difficulties to achieve proximal or distal vascular control. Suprarenal aortic clamping may be frequently required.[10,19] Complete explantation of the stent graft, especially of those with suprarenal fixation, can also be challenging due to dense incorporation to the aortic wall.[15] Finally, patients after failed EVAR represent most likely a high-surgical-risk patient cohort, given that open surgery was avoided as primary treatment option for their AAA.

The above factors frequently result in higher operative mortality and morbidity rates of open conversion compared with primary open AAA repair. May et al[12] reported a 17% mortality rate and a similarly high incidence of renal failure requiring hemodialysis after late open conversion. Other authors have reported mortality rates up to 20%, in elective cases requiring supraceliac clamping.[9] The EUROSTAR registry, which reflects a large multicenter experience, showed a 24% mortality rate after late surgical conversion.[11] Finally, a systematic review, with a total of 8304 patients, revealed a cumulative mean mortality of 23%,[20] and a more recent one showed a mortality of 10%.[21] Table III summarizes the previously published series reporting late conversion after failed EVAR.

Our results compare favorably with the above rates. Operative mortality was 5.6%. The postoperative course of our patients was generally uneventful, and this is reflected in the fact that only 11.1% of the patients needed an ICU stay and that there was a relatively short hospital stay. These results may be attributed to several factors.

Clamping of the infrarenal aorta that contains a stent graft can theoretically be cumbersome, resulting in stent graft damage or incomplete proximal control. In two patients of this series, we felt that initial infrarenal clamping would not be completely hemostatic, which led us to proceed to suprarenal clamping as described above. Otherwise, no case of inadvertent stent graft damage/crashing due to infrarenal clamping was observed. Nevertheless, our patient cohort is too small to advocate general safety of infrarenal aortic clamping upon existence of a stent graft.

Proximal aortic clamping was avoided in 33.3% of the patients, while temporary suprarenal aortic clamping was required only in 11.1%. No patient required supraceliac aortic clamping. The physiological consequences of aortic cross-clamping are well known; prolonged clamping time results in severe renal ischemia, aortic clamp injury, and metabolic disorders.[15] Older multimorbid patients in particular, who represent the most common patient profile requiring late conversion, are more vulnerable to the physiologic effects of aortic cross-clamping. Suprarenal clamping can have an even greater impact, and is much less tolerated compared with infrarenal clamping, resulting in significant increase in operative morbidity and mortality.[15] Our results indicate that open surgical repair of isolated type II endoleaks can be safely performed without aortic cross-clamping and should be attempted whenever possible. This is in line with the recently published series by Chaar et al.[17] Such a strategy additionally results in shorter operative times, a factor that needs also consideration when treating old high-risk patients.

Complete stent graft explantation was required and performed only in 27.8% of the patients. In the remaining cases, the whole or a part of the stent graft was preserved. This could have also contributed to the good results observed herein. Indeed, partial stent graft preservation has been associated with better operative outcomes.[22] We routinely follow a strategy of partial stent graft removal in these cases, and we try to preserve proximal and, in some cases, distal parts of the stent graft when these seem to be well incorporated and seal adequately. The anastomoses, both proximally and distally, can be performed with inclusion of the aortic wall and the stent graft remnant, and this, in our opinion, contributes to a more secure and less prone to bleeding anastomosis. Besides, such a strategy minimizes the risk of severe aortic wall injury during stent graft explantation maneuvers. The latter can result in disastrous complications proximally at the visceral aorta, but also distally, where denudation of the arterial wall after stent graft explantation can make the construction of the anastomoses problematic.

Chronic reaction of the aortic wall in the presence of a stent graft differs among patients. As already stated, herein we did observe two distinguished patterns of aortic wall reaction: (1) inflammatory response; and (2) atrophy of the aortic wall. Both patterns of reaction (inflammation, atrophy) can make the operation more challenging, posing difficulties in initial dissection of the aorta and later during stent graft explantation if needed. Partial preservation of a stent graft cuff at the sealing zones proximally and distally is therefore recommended when it seems to be well incorporated and seal adequately.

Large series in the literature indicate that lumbar artery embolization carries a low midterm success rate, and most patients require multiple reinterventions to treat type II endoleaks.[23] Gallagher et al reported a 17% success rate of the initial intervention at 2 years, while repeated embolization attempts resulted in a 40% secondary success rate. Twenty-four percent of the patients continued to have endoleak despite multiple reinterventions.[24] Sarac et al, in a retrospective review of patients treated with embolization with glue, coils, glue and coils, and Gelfoam due to type II endoleak showed a 5-year freedom from second embolization of 76% (95% confidence interval, 66%-86%) and freedom from sac expansion >5 mm of 44% (95% confidence interval, 30%-50%). The authors concluded that a significant number of patients require multiple reinterventions, and at 5 years, many patients continue to experience sac growth. In line with the above, Aziz et al concluded that percutaneous endovascular intervention, either transcathter or translumbar, for type II endoleak does not inhibit aneurysm sac growth rate, and most of the patients demonstrate persistent/recurrent endoleak.[25] The present experience shows that isolated type II endoleaks associated with sac enlargement can be frequently repaired with simple lumbar artery ligation and complete stent graft preservation, without the need for aortic cross-clamping. This "minimal" type of open conversion has very good results and is well tolerated even by old high-risk patients. Based on that, we have lately become more aggressive, tending to offer an early conversion to patients with type II endoleak, without waiting for endovascular techniques with uncertain long-term efficacy.

Opening the aneurysmal sac and ligating the culprit lumbar arteries from within the sac can occasionally result in stent graft dislodgment and the need for partial or complete stent graft removal. This happened in three of our cases, whereas in five patients, we were able to ligate the lumbar arteries without stent graft dislodgment, which allowed for complete graft preservation. Certainly, dislodgment of the stent graft cannot be excluded after sac opening, and one has to be ready to confront such an event upon occurrence. Clear exposure of the aortic neck before sac opening is therefore strongly recommended to enable prompt clamping upon stent graft dislodgment. Most of the time, however, the operation can be successfully accomplished without stent graft dislodgment, and the patient has important benefits (short operation time, avoidance of aortic cross-clamping, definite treatment in contrast to "blind" ligation of culprit vessels without opening the sac, etc).

There was one death in this series. This patient was lost to follow-up and suffered a free aortic rupture secondary to a large type Ia endoleak. He presented to our emergency department in hypovolemic shock and was immediately transferred to the operating room. Although we were able to finish the procedure in due time and with minimal blood loss, the patient succumbed the following day due to multiple organ failure. The second patient that presented with rupture was free of endoleak for the first 2 years after EVAR, but was thereafter lost to follow-up and presented 2 years later with a retroperitoneal rupture due to a type II endoleak originating from the inferior mesenteric artery. Both these cases highlight the need for continued long-term surveillance of patients treated with EVAR, even in the absence of any signs of endoleak. Our surveillance protocol for stable EVAR patients that are considered to be endoleak-free consists of biannual duplex ultrasound and abdominal X ray. We proceed to computed tomography angiography and occasionally digital subtraction angiography if signs of endoleak and/or aneurysm sac enlargement are detected in ultrasound or stent graft migration or dislodgement is seen in the X ray.

Thirteen (72.2%) patients were on antiplatelet/anticoagulant medications preoperatively (Table I). This may have also contributed to the persistence of the observed endoleaks, although no safe conclusions can be drawn with such a small patient cohort.[26] Bobadilla et al have shown that anticoagulation with warfarin was linked with increased risk for type II endoleak development after EVAR, while Aoki et al[27] reported a correlation between multiagent antiplatelet therapy and lack of aneurysm shrinkage 6 months after EVAR. More recently and in contrast to the above, Johnson et al[28] suggested that oral chronic anticoagulation treatment with warfarin does not affect the incidence of endoleaks after EVAR. Obviously, further investigation is needed to clearly define the potential risk of antiplatelet/anticoagulant medications on endoleak persistence.

This series does not provide reliable information regarding the incidence of late open conversions after EVAR. We do follow our patients strictly and are aware of their complications in about 85% of them. Nevertheless, the patient cohort presented herein also includes patients that were primarily treated elsewhere, making it thus impossible to estimate the real proportion of EVAR patients needing late conversion.

The number of patients treated with EVAR is increasing. This, in combination with a more liberal use of EVAR devices, even outside the instructions for use,[29] and the younger age of treated patients, will likely lead to an increased need for late open conversions after EVAR. Modifications of the current techniques and careful tailoring and planning of the procedure according to each individual's anatomic and risk profile may result in better outcomes. Despite current endovascular enthusiasm, the vascular surgery community should also focus on improving open surgery results after EVAR.

CONCLUSIONS

Late open conversion after failed EVAR remains challenging. Stent graft preservation, aortic clamp avoidance, and careful operative planning seem to improve results in these difficult cases. Elective conversions seem to be associated with better outcomes. Close follow-up of EVAR patients is therefore of pivotal importance in order to diagnose complications early and treat them on an elective basis.

AUTHOR CONTRIBUTIONS

Conception and design: CK, AK, GK
Analysis and interpretation: AK, EP, MD, CV
Data collection: CK, SL, EP, GK, CV, GK
Writing the article: CK, SL, AK, GK, MD
Critical revision of the article: CK, AK, EP, CV, GK
Final approval of the article: CK, SL, AK, EP, GK, MD, CV, GK
Statistical analysis: CK, SL, AK
Obtained funding: Not applicable
Overall responsibility: CK

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