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Late open conversion: a reliable solution for endoleak management after endovascular aortic aneurysm repair – a single center experience and literature review

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Abstract

Background/Objectives: Despite the efficacy of endovascular approaches for most secondary interventions post-endovascular aortic aneurysm repair (EVAR), a small proportion of patients need open conversion (OC) procedures. We shared our experience regarding patient outcomes after late OCs post-EVAR. We also performed a literature review of data published on this topic. *Patients, Materials and Methods*: Medical records of patients who underwent late OCs post-EVAR at a Public Hospital in Germany (2017–2019) were retrospectively analyzed. OC involved total or partial endograft removal followed by aortic reconstruction. Preoperative patients' characteristics, indications for OC, and intra-/post-operative outcomes were assessed. Studies published in English (2014–2024) on OCs post-EVAR complications were descriptively analyzed. *Results*: Six patients underwent late OCs throughout the study (males: 66.67%; age [mean±standard deviation]: 66.50±2.89 years). Grafts were excised after a median of 72 months (range: 24–132 months), with 2/6 (33.33%) urgent removals and 4/6 (66.67%) elective. 4/6 (66.67%) patients underwent complete removal, and 2/6 (33.33%) were partial. Clamping site was suprarenal in 3/6 (50.00%) patients, supraceliac in 2/6 (33.33%), and infrarenal in 1/6 (16.67%). Technical success was 100%, with 32 minutes mean clamping time and 1.67 L blood loss. Median follow-up was 13 months. No aneurysm growth was observed, and implanted grafts functioned well. 1/6 (16.67%) patients died during the postoperative intensive care unit stay. Seven studies were included in our review. The 30-day mortality post-OCs was 6.2–10.0% in elective setting and up to 40% in urgent. *Conclusions*: Late OC can be a reliable procedure for managing endoleak post-EVAR. Its success relies on accurate preoperative assessment and surgical expertise.

***Keywords*:** endoleak, open conversion, endovascular aneurysm repair, complications, aortic aneurysm.

Introduction

Abdominal aortic aneurysm (AAA) is a significant pathological entity characterized by progressive dilatation and weakening of the abdominal aorta, which carries a substantial risk of rupture and mortality. The management of AAA has undergone a profound evolution throughout history, driven by advancements in surgical and endovascular techniques focused on enhancing patient outcomes and reducing the morbidity and mortality associated with this condition [1–3].

Endovascular aortic aneurysm repair (EVAR) has revolutionized the treatment of AAA. However, like any medical procedure, EVAR is associated with potential complications that require careful management. Prompt recognition and appropriate intervention are essential to optimizing patient outcomes. Common complications of EVAR include endoleaks (62%), endograft infection (31%), endograft migration (8%), and endograft limb occlusion (6%) [4–6].

Endoleaks are the most common complications after an EVAR. There are five different types of endoleaks, described by all standard vascular surgery and interventional radiology guidelines and summarized by the *Society of Vascular Surgery*:

- type I is characterized by a gap between the graft and vessel wall, which poses a high rupture risk, often due to unsuitable anatomy or device selection;
- type II is characterized by continuous blood flow and

high pressure in lumbar arteries, being considered benign but unpredictable;

▪ type III is stemming from defects between endograft components and requires urgent intervention due to systemic pressure buildup;

▪ type IV is developed shortly following EVAR procedures because of the graft material porosity (rare scenario); and

▪ type V, also named “endotension”, is believed to develop when pressure transferred through the aneurysm sac affects the native aortic wall, but its mechanism is not well understood [7].

Most secondary interventions following EVAR are being effectively managed using endovascular methods. Nevertheless, somewhere between 0.7% and 4.0% of patients cannot be addressed percutaneously and require an open conversion (OC) procedure, which involves removing the stent graft [8–12].

The techniques used for resolving the endoleaks encompass graft-preserving intervention with branch vessel ligation for type II endoleaks and external banding of the aneurysm neck for type IA endoleaks [13], which reinforces the proximal end of the endograft with a Dacron graft and a Teflon Felt, thus preserving the endograft *in situ* [14]; the “neo-neck” technique with preservation of the proximal covered stent of an endograft with suprarenal fixation by the incorporation of the aorta to the suture line [15], and the complete removal of the endograft with implantation of a Dacron *Y*-shaped graft sutured in a classical way to the aorta wall and both iliac arteries [16].

Information regarding how often OCs are performed and their prognostic implications is mainly derived from small retrospective series, primarily based on experiences from single institutions. This scarcity of data is due to the infrequency of this procedure [17–20].

Aim

This study aimed to share our experience regarding late OC interventions following the EVAR procedure, focusing on the surgical approach and clinical outcomes. We also systematically reviewed the literature and analyzed reported studies of OCs following the EVAR procedure to ascertain the frequency, surgical approach, and patient outcomes.

Patients, Materials and Methods

Medical records data

Medical records of patients with EVAR who underwent late OC procedures at a Public Hospital in Germany from January 2017 to January 2019 (pre-pandemic) were analyzed retrospectively. Individual patient consent was waived due to the retrospective nature of the analysis.

Late OC was defined as a total or partial endograft removal at least 30 days after the initial EVAR procedure, followed by reconstruction of the aorto-iliac anatomy. Computed tomography angiography (CTA) was used to make a diagnosis before surgery. All patients included in our study qualified for late OC procedure.

Late OC indications and surgical procedures

Indications for endograft removal and late OCs in aortic aneurysm endoleaks following previous endovascular procedures included persistent type II and V endoleaks with significant aneurysm growth, graft infection or complications, ongoing aneurysm sac expansion despite endovascular therapy, and other complications of endovascular repair. A sac enlargement defined as an increase in aneurysm diameter >5 mm at two consecutive CTAs at least 12 months following EVAR was considered an inclusion criterion for the late OC procedure [21]. The decision to pursue open surgical intervention was made on a case-by-case basis, considering the patient’s overall health status, anatomy, and risk profile.

Each patient underwent general anesthesia. Access to the arterial system was obtained through a median laparotomy. The native aorta was exposed proximally and distally to the site of the previous endograft placement. This may require extensive dissection to ensure an adequate landing zone for the new graft. The previously placed endograft was carefully dissected and mobilized from the surrounding tissues. Fixation mechanisms such as hooks or barbs and dissection of any adhesions that have formed between the graft and the aortic wall were released if needed. A Dacron *Y*-shaped vascular graft appropriately sized to match the dimensions of the native aorta and the branches that needed to be revascularized, such as the iliac arteries, was used. The *Y* graft was then anastomosed to the proximal and distal ends of the native aorta and iliac arteries using continuous or interrupted sutures. Special attention was paid to ensuring adequate hemostasis and a secure seal at the anastomotic sites. If necessary, additional anastomoses were created between the branches of the *Y* graft and the iliac arteries or other target vessels to restore blood flow to the lower extremities. The graft was thoroughly inspected for leaks or kinks, and hemostasis was ensured before closing the incisions and completing the procedure.

Postoperative patient follow-up

Clinical examinations and duplex ultrasonography were performed at 3, 6, 12, and 18 months, and CTA at 6 and 12 months. The follow-up period was shortened due to the coronavirus disease 2019 (COVID-19) pandemic.

Study variables

The following variables were collected: demographic characteristics (age, sex, risk factors for a late OC), clinical characteristics (existing endograft type, time from EVAR, reason for removal, indications for late OC), intraoperative characteristics (extent of endograft removal, clamping type and time, blood loss, type of reconstruction), and post-operative follow-up (complications, intensive care unit [ICU] stay, 30-days mortality).

Statistical analyses

The data was analyzed using Microsoft Excel 2016. For continuous variables, data were tabulated as mean ± standard deviation (SD) or median with interquartile range (IQR). Categorical variables were tabulated as numbers (percentages). Perioperative and postoperative results regarding technical success and renal insufficiency were evaluated using Fisher's exact test. Statistical analysis was performed using IBM Statistical Package for Social Sciences (SPSS) Statistics and Microsoft Excel.

Literature review

We performed a thorough literature review to synthesize the complications of EVAR and its management over the past decade, particularly emphasizing late OCs. A systematic search for original articles, clinical trials, and experimental studies was performed on *PubMed*. The search was performed using the following keywords: "AAA", "EVAR", "endoleak", "surgery", "endovascular", "Aortic Aneurysm, Abdominal/surgery" [MAJR] as medical subject headings (MeSH) strategy, using "AND" between keywords as a Boolean Operator. All titles referred to in English and published from 2014 to 2024 were screened for eligibility by title and abstract by two researchers to avoid bias and to remove double counting. Articles referring to endovascular approach in EVAR complications, open surgery without a prior EVAR intervention, thoracic aorta endovascular complications, and thoracoabdominal endovascular complications were excluded. Articles about late open surgery in EVAR complications of any type were included in our analysis.

Data were descriptively analyzed.

Results

Preoperative demographic characteristics and surgical procedures

Six patients with EVAR underwent late OC during the study period. Their mean (± SD) age was 73.83±4.36 years and four (66.67%) were males. Preoperative demographic characteristics and risk factors for EVAR are shown in Table 1.

Two out of the six (33.33%) patients underwent an emergency late OC intervention because they were admitted to our department with abdominal and back pain, and CTA showed a ruptured aneurysm sack in the retroperitoneal area. Four (66.67%) patients underwent an elective late OC intervention due to significant growth of the aneurysm observed in repetitive CTAs (Table 1). The preoperative characteristics of each patient are shown in Table 2.

The indication for late OC was persistent endoleak type II associated with sac enlargement, defined as >5 mm increase in aneurysm diameter at two consecutive CTAs at least 12 months following EVAR, and type V, defined as sac enlargement in the absence of identifiable endoleak (three patients in each category). One patient with type II endoleak had several unsuccessful lumbar artery embolization attempts. Another patient had a prior type II endoleak and underwent successful lumbar artery embolization, but, at follow-up, a sac enlargement of >5 mm compared to previous CTA examinations was observed without any identifiable source of endoleak. Therefore, this patient was recategorized as type V. The other four patients did not undergo any type of endovascular treatment for their respective endoleaks prior to surgery (Table 3). The type II persistent endoleak was associated with a mean ± (SD) aneurysm growth of 8.67±2.89 mm, and the type V with a mean ± (SD) aneurysm growth of 8.20±1.74 mm. Our patients did not experience endograft infection or complete degeneration of the proximal neck.

Table 1 – *Preoperative patients' demographics and comorbidities*

Variables	Patients (*n*=6)
Age at the time of EVAR, mean ± SD [years]	67.83±5.12
Age at the time of late OC, mean ± SD [years]	73.83±4.36
Male sex, n (%)	4 (66.67)
Smoking status, n (%)	
▪ Non-smoker	2 (33.33)
▪ Current smoker	4 (66.67)
Comorbidities, n (%)	
▪ Hypertension	6 (100%)
▪ Dyslipidemia	4 (66.67)
▪ Diabetes mellitus	3 (50.00)
▪ MI	3 (50.00)
▪ Renal insufficiency*	2 (33.33)
▪ Onyx-embolization	2 (33.33)
▪ Abdominal hernia	1 (16.67)
▪ Inguinal hernia	1 (16.67)
▪ Coronary disease	1 (16.67)
▪ Carotid EEA	1 (16.67)
▪ TIA's	1 (16.67)
▪ Iliac stenting	1 (16.67)
▪ Prostate CA	1 (16.67)
▪ COPD	1 (16.67)
▪ Aortic valve replacement	1 (16.67)
▪ Mammary CA	1 (16.67)
▪ Hemicolectomy	1 (16.67)
▪ PTCA	1 (16.67)
▪ Absolute arrhythmia	1 (16.67)
▪ Hyperthyreosis	1 (16.67)
Indications for late OC, n (%)	
▪ Endoleak	
∗ Type I	0 (0)
∗ Type II	3 (50.00)
∗ Type III	0 (0)
∗ Type IV	0 (0)
∗ Type V	3 (50.00)
▪ Urgent setting	2 (33.33)
▪ Elective setting	4 (66.67)

*Pre-existing renal insufficiency is defined as serum creatinine level ≥1.5 mg/dL; CA: Carcinoma; COPD: Chronic obstructive pulmonary disease; EEA: Eversion endarterectomy; EVAR: Endovascular aortic aneurysm repair; MI: Myocardial infarction; OC: Open conversion; *n*: Total No. of patients in a specific category; PTCA: Percutaneous transluminal coronary angioplasty; SD: Standard deviation; TIA: Transient ischemic attack.

Table 2 – *Preoperative individual patient characteristics*

Age [years]	Sex	Type of endograft	Time from EVAR [years]	Reason for removal	Type of late OC
72	M	*Y*-endograft	9	Type II endoleak	Urgent
75	M	*Y*-endograft	5	Type V aneurysm growth	Elective
72	M	*Y*-endograft	5	Type II endoleak	Elective
81	F	*Y*-endograft	4	Type II endoleak	Elective
68	M	*Y*-endograft	2	Type V aneurysm growth	Elective
75	F	*Y*-endograft	11	Type V aneurysm growth	Urgent

EVAR: Endovascular aortic aneurysm repair; F: Female; M: Male; OC: Open conversion.

Table 3 – *Intraoperative data of patients with EVAR undergoing late OC*

Extent of endograft removal	Clamping type	Clamping time [minutes]	Blood loss [mL]	Type of reconstruction (mm)
Complete	Suprarenal	30	1500	Dacron *Y*-graft (18/9)
Complete	Supraceliac	27	900	Dacron *Y*-graft (18/9)
Complete	Supraceliac	37	2000	Dacron *Y*-graft (16/8)
Partial (neo-neck)	Suprarenal	30	1500	Dacron *Y*-graft (18/9)
Complete	Suprarenal	34	2000	Dacron *Y*-graft (18/9)
Partial (neo-neck)	Infrarenal	34	2100	Dacron *Y*-graft (18/9)

EVAR: Endovascular aortic aneurysm repair; OC: Open conversion.

Intraoperative and short-term postoperative outcomes

The technical success rate was 100%. Endograft implantation occurred with a mean (± SD) of 6.00±3.35 years before late OC. The endograft was completely removed in four of six (66.67%) cases. Partial removal was performed in two of six (33.33%) cases. A suprarenal clamping was present in three (50.00%) cases, a supraceliac clamping in two (33.33%) cases, and an infrarenal clamping in one case (16.67%). Reconstruction was performed with Dacron *Y*-graft, with the 18/9 dimension in five of six (83.33%) cases and 16/8 dimension in one of six (16.67%) cases. The mean clamping time (±SD) was 32±3.63 minutes, and the mean blood loss was 1666.67±458.98 mL.

One female patient, the oldest from our case series, who previously underwent multiple endovascular interventions for type II endoleaks (repeated lumbar arteries Onyx-embolization) died during the postoperative ICU stay due to a multiorgan failure.

Table 3 summarizes the intraoperative data for each patient with EVAR who underwent late OC intervention.

Mid-term follow-up outcomes

The mean follow-up was 13 months. Due to the COVID-19 pandemic, we faced difficulties following up with our patients. Two patients were rigorously followed up for more than 18 months. One patient moved to another county, which made it impossible for us to track his clinical status after the 18th month. The remaining two patients were lost to follow-up due to the pandemic restrictions (Table 4).

Table 4 – *Postoperative follow-up and complications in patients with EVAR undergoing late OC*

Postoperative complications					ICU [days]	30-days mortality	Follow-up length [months]	Late complications
Renal insufficiency	*Spinal*	*Respiratory insufficiency*	*Digestive*	*Cardiac*				
Yes	No	Yes	No	No	5	No	>18	Iliac aneurysm
No	No	No	No	No	2	No	>18	Potency deficiency
No	No	Yes	Yes	No	4	No	18	Incisional hernia
No	No	No	No	Yes	2	Yes	0	*Exitus letalis*
Yes	No	No	No	No	3	No	12	No
Yes	No	Yes	Yes	Yes	9	No	12	Pacemaker implantation

EVAR: Endovascular aortic aneurysm repair; ICU: Intensive care unit; OC: Open conversion.

The 3, 6, 12, and 18-month follow-ups showed a clinically stable situation without any documented aneurysm growth and good functioning of the implanted grafts.

One patient experienced arrhythmia during the follow-up and needed pacemaker implantation; another patient developed an incisional hernia, which was resolved surgically. One patient developed a left common iliac aneurysm 18 months after late OC and underwent another open surgical procedure with aneurysm repair consisting of an extension of the left iliac branch to the external iliac artery through a retroperitoneal approach. Table 4 summarizes the post-operative complications of each patient.

The preoperative renal insufficiency recorded in two patients was not a predictor for postoperative renal insufficiency (p=0.3787). Preoperative cardiac comorbidity was not a predictor for postoperative cardiac complication (p=0.4545). Preoperative respiratory comorbidity did not predict postoperative respiratory complications (p=0.0909). The suprarenal clamping of the endograft was not a predictor for postoperative renal insufficiency (p=0.4329). Complete *versus* partial removal of the endoprosthesis did not influence postoperative renal insufficiency (p=0.3787).

Literature review outcomes

Our literature review yielded 570 articles that matched our search strategy. Of these, 145 were published between 2014 and 2024, and seven full-text articles met our inclusion criteria and were included in this review (Figure 1).

Patient characteristics from the studies included in this analysis are presented in Table 5. The most common complication in EVAR was endoleaks (172 cases), specifically types I and II, followed by ruptures (78 cases). Other complications (118 cases) included graft infection, migration, thrombosis, and graft-organ fistulas.

The 30-day mortality following OC procedure ranged from 6.2% to 10.0% of patients in the elective cases and from 33% to 40% in the urgent cases.

Discussions

We want to highlight that much of our understanding of the complexity of assessing and treating post-EVAR complications comes from single-center reports. Isolated cases treated at other centers may provide further insights into these challenging complications, but they go unreported, adding further complexity to the issue.

The incidence of late OC after EVAR remains relatively low, occurring in approximately 0.7–4.0% of patients [8–12]. This low incidence underscores the challenges in studying and managing patients with this condition and highlights the need for specialized expertise in vascular surgery. However, we are unable to provide insights on this aspect because all the patients presented here underwent an EVAR procedure for infrarenal aortic aneurysm in a different hospital. Although our experience with treating aneurysm growth due to endoleaks after EVAR is limited to six cases over a short period (two years), our data aligns with other literature reports, in which 1–2 cases were reported yearly in single centers [4, 22, 27]. The mean age of patients who underwent late OC procedure post-EVAR in our study was 74 years, which was similar to the data reported in other studies (range: 73–79 years) [13, 22, 23, 25, 26]. Even if the proportion of male patients (67%) tends to be lower in our study compared to other studies (range: 75% to 93%) [13, 22, 23, 25, 26], this could be explained by the small cohort included in our study.

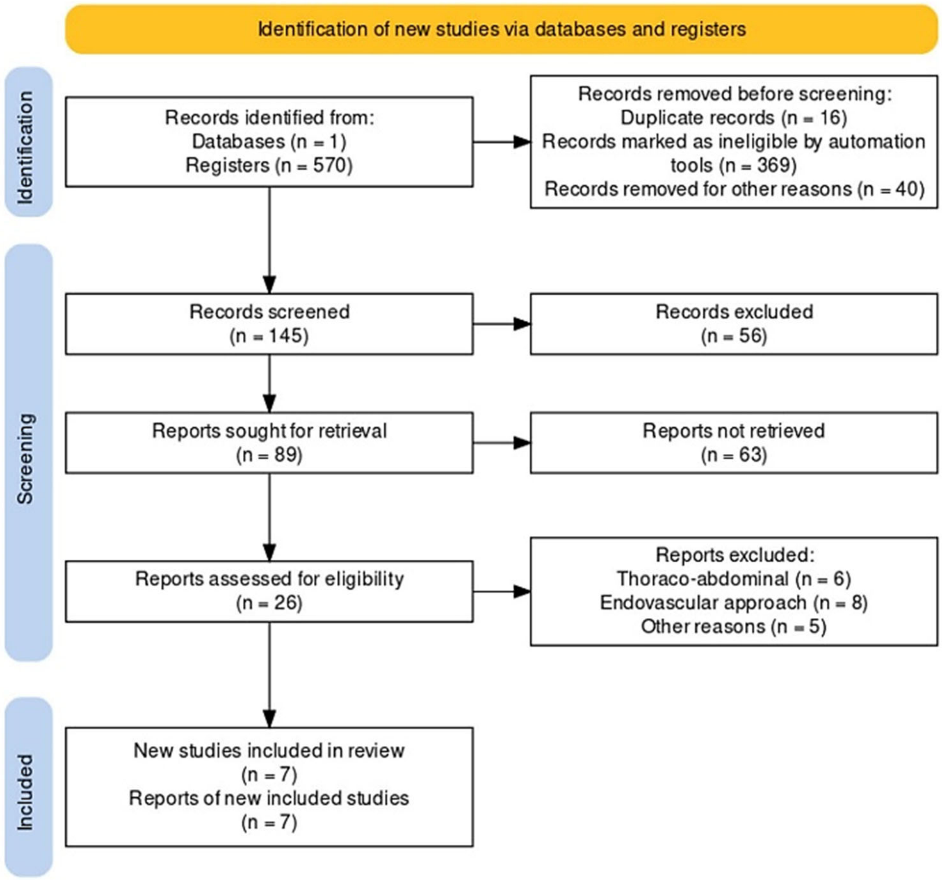

Figure 1 – ***Flow diagram of the identified studies. n: No. of records.***

Table 5 – ***Clinical characteristics of patients with EVAR undergoing OC and outcomes following urgent or elective surgical procedures***

Study type (study period)	Patients (*n*)	Mean age [years] (±SD or IQR)	Sex, M (%)	Diagnosis	Time from EVAR [months] (±SD or range)	Urgent / Elective	Ruptures	Endoleak	30-day mortality following OC
Retrospective analysis [14] (2000–2010)	15	79.2±8.9	73	CTA	31.1 (13.8–57.3)	15 / 0	15	9	Overall: 44%
Retrospective cohort study [22] (1999–2015)	16	79.0 (76–81.7)	75	US/CTA	37.2 (12–62.4)	6 / 10	2	7	Urgent: 33.3% Elective: 10.0%
Retrospective chart review [13] (2002–2017)	102	75.4±8.2	84.3	CTA/Aortography	45.7±37.2	37 / 65	20	65	Urgent: 40% Elective: 6.2%
Retrospective analysis [23] (1996–2017)	28	75.11±6.65	92.9	CTA	41.4 (5.97–112.67)	7 / 21	Excluded	27	Elective: 9.5%
Retrospective chart review [24] (2010–2017)	31	NR	NR	CTA	NR	6 / 25	6	20	Overall: 16.12%
Retrospective analysis [25] (1996–2017)	42	75.8±9.0	88.1	US/CTA	37 (1.6–132.1)	24 / 18	24	30	Urgent: 33.3%
Retrospective analysis [26] (2008–2016)	31	73±11	84	CTA	35 (0–228)	12 / 19	6	24	Overall: 6%

CTA: Computed tomography angiography; EVAR: Endovascular aortic aneurysm repair; IQR: Interquartile range; M: Male; *n*: No. of patients; NR: Not reported; OC: Open conversion; SD: Standard deviation; US: Ultrasonography.

While there is widespread consensus on the need for aggressive treatment of type I and III endoleaks, managing type II endoleaks remains a subject of debate [28].

Reintervention outcomes within the cohort documented by Aziz *et al.* (2012) were predominantly unsuccessful [29]. They noted a consistent rate of sac growth before and after reintervention, with persistent or recurrent leaks documented in 72% of cases despite endovascular therapeutic efforts [29]. Multiple series have documented elevated rates of continued aneurysm sac expansion, reaching up to 60%, even following reintervention [30–32]. These findings underscore the challenges associated with effectively managing type II endoleaks.

In our case series, the indications for late OC primarily revolve around persistent endoleaks, particularly type II and V, associated with aneurysm growth and sac expansion despite endovascular therapy attempts. These findings align with the existing literature, highlighting the importance of meticulous surveillance and timely intervention in managing post-EVAR complications. To note, in our study, these complications occurred between two and 11 years post-EVAR, which is comparable to data reported in other studies (between less than one and up to 10 years) [13, 22, 23, 25, 26]. Furthermore, our literature review corroborates these findings, emphasizing the diverse etiologies and clinical presentations of late endoleaks necessitating late OC [13, 15, 22–26]. Similar to other studies, most patients included in our study underwent elective late OC surgery [22–24, 26].

Surgical techniques for late OC vary depending on the specific indications and patient anatomy. Two previous studies prefer the transperitoneal approach as it enables an excellent exposure of the distal iliac arteries [33, 34]. As reported by other studies, retroperitoneal access is possible, which ensures continuous control of the aorta [35, 36]. In our opinion, both techniques are efficient, and the choice between retroperitoneal and transperitoneal, when both approaches are feasible, should be left in the hands of the operating surgeon. This has also been pointed out in a study conducted by Kelso *et al.* (2009) [10].

In our Center, we have vast experience in treating abdominal aneurysms that are not suited for EVAR through a transperitoneal approach, and that was also the preferred technique for the late OCs. An essential aspect of the late OC, which, in our opinion, determines the postoperative outcome, is the clamping site and duration. It is common knowledge that to obtain good results in aortic surgery, proximal and distal clamping sites in a relatively good, low residual, or atherosclerotic wall are crucial. In accordance with that, we chose our clamping sites according to wall quality and extent of the stent graft. Böckler *et al.* (2002) recommend that positioning the proximal aortic clamp far from the stent graft facilitates improved maneuverability when removing the securely anchored proximal end of the stent graft. This strategy offers greater flexibility in achieving optimal reconstruction during the procedure [37].

Our strategy was to remove the endograft completely, which was feasible and successful in four cases. In the other two cases (one elective and one urgent), it was impossible to completely remove the proximal part of the stent graft securely without tearing the aortic wall, so we decided to adopt the aforementioned neo-neck technique [37]. There was no need for visceral or renal artery reconstructions.

After the proximal part of the stent graft was removed, the clamp could be repositioned infrarenal to avoid or reduce the risk of postoperative renal insufficiency. In our study, one patient was treated in an urgent setting, and one elective setting patient experienced temporary postoperative renal insufficiency, which was corrected during their ICU stay.

Our study demonstrated technical success rates of 100%, reflecting the proficiency of experienced vascular surgeons in performing complex reconstructive procedures. Bifurcated Dacron grafts and meticulous anastomoses facilitated effective aortic reconstruction, ensuring adequate hemostasis and graft integrity. Notably, some of the reviewed studies identified different approaches to late OC, such as graft-preserving interventions and complete endograft removal, highlighting the need for tailored treatment strategies based on individual patient characteristics and pathology [38].

Despite successful surgical outcomes, postoperative complications remain a concern, as evidenced by one death in our study. The mortality rate recorded in our study (17%) falls within the rates reported in the reviewed studies (range: 6% to 40%) [13, 22, 23, 25, 26]. Also, an unexpected situation occurred when a patient developed an iliac aneurysm distal to the left anastomosis of the bifurcated Dacron graft. The aneurysm growth was first identified at the 6-month follow-up, and the indication for treatment was established at 18 months. The procedure was performed in the same hospital by the same surgical team. Another patient with potency deficiency after EVAR and prior to the late OC experienced a worsening of the symptoms in the follow-up period. Factors contributing to adverse outcomes include patient comorbidities and the complexity of the surgical procedure itself. Marone *et al.* reported a 24% incidence of acute renal failure in their series, necessitating urgent angiography and renal artery stenting in three out of 13 cases. In one case, only one kidney was revascularized, and the patient underwent temporary postoperative hemodialysis [39]. Furthermore, Turney *et al.* observed that renal failure requiring hemodialysis occurred exclusively in patients undergoing supraceliac clamping [40]. In our case series, we recorded a total of three renal insufficiencies, two of them being a condition prior to late OC, and only one case developed it postoperatively with a normalization of serum creatinine after two hemodialysis sessions. The suprarenal or supravisceral clamping of the endograft was not associated with postoperative renal insufficiency in our cohort.

We also reported three cases of postoperative respiratory insufficiency and two cases of cardiac insufficiency. All these complications were transient and resolved prior to discharge. In our opinion, these complications are related to the age and comorbidities of the patients and to the fact that they were most likely categorized as not suitable for an open procedure at the time of the initial EVAR. Other complications, such as acute limb or spinal ischemia, bowel injury, and bleeding requiring reintervention, were not experienced by our cohort. These findings underscore the importance of comprehensive preoperative assessment, multidisciplinary collaboration, and meticulous perioperative care in minimizing complications and optimizing patient outcomes.

The impact of the COVID-19 pandemic on follow-up and surveillance protocols must be addressed, as evidenced by challenges in patient monitoring and data collection. Future studies should explore innovative approaches to remote monitoring and telemedicine to ensure continuity of care and timely intervention in high-risk patient populations.

Study limitations

Our study has several limitations. It is retrospective and presents our single-center experience, limited to the patients who required late OC after EVAR and were referred to our clinic. We could not identify which type of endograft was used when EVAR was performed for each patient, so we decided not to analyze this aspect. Due to the reduced number of cases, any statistical significance of our results is limited to our cohort. The relatively short follow-up period was due to unexpected factors such as the COVID-19 pandemic. Regarding the literature review, we noted limitations related to selection bias, which could have impacted the reported outcomes, as clinicians often tend to document cases with more favorable outcomes. Additionally, all the studies included were retrospective in nature.

Conclusions

OC post-EVAR emerges as a reliable surgical procedure for treating endoleaks. Success largely pivots on thorough preoperative assessment, tailored to each patient's unique clinical profile, prompt identification of the need for conversion, and the experience of the surgical team. Key considerations encompass the surgical approach, including site selection for clamping and the decision regarding total or partial stent graft removal. While complete stent graft extraction may often be favored, its necessity varies, particularly in cases complicated by graft infection, and the decision is almost entirely intraoperative.

Our study contributes to the growing body of literature on late OCs after EVAR, shedding light on the clinical characteristics, surgical techniques, and outcomes associated with this complex procedure. The population of patients facing EVAR failure and lacking further endovascular recourse appears to be increasing. Recent observations of increased instances of OC underscore the necessity for a comprehensive investigation of this patient demographic. Endoleak, as the principal trigger for late OC, persists as the foremost challenge of EVAR. Despite the technical complexities involved, these interventions exhibit relatively modest mortality rates, particularly when executed as planned, elective procedures.

Conflict of interests

The authors declare that they have no conflict of interests.

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