EndoVAC hybrid therapy for salvage of patients with infected femoral artery reconstructions

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Abstract

Background: EndoVAC hybrid therapy for infected femoral artery reconstructions consists of endovascular relining with a stent graft, surgical debridement and vacuum-assisted wound closure (VAC), and may be considered as a bailout procedure. The aim of this study was to analyze differences in risk factors of patients receiving EndoVAC compared to standard VAC therapy for perivascular infected femoral artery reconstructions, and to describe the technique, complications and outcome of EndoVAC therapy.

Methods: Retrospective analysis of 183 patients receiving VAC or EndoVAC therapy for perivascular infections in the groin from January 2004 to December 2017 was performed. Failure of wound treatment was defined as a wound not healed within four months, visible graft material or native artery after one month, bleeding from the wound leading to discontinuation of treatment, death or amputation due to groin infection.

Results: The EndoVAC patients (n = 13) more often had ischemic heart disease (P = 0.008), more late wound infections after index operation (P < 0.001), had more often undergone previous ipsilateral groin incisions (P = 0.006) and presented more often with hemorrhage/femoral pseudoaneurysm (P < 0.001), compared to the standard VAC patients (n = 170). Major complications after EndoVAC therapy were stent graft occlusion (n = 3), major hemorrhage from the repaired reconstruction (n = 2), major amputation within six months (n = 4) and death due to infected reconstruction (n = 2). Ten (77%) groins healed, eight without major complications.

Conclusion: EndoVAC therapy appears to be a life-saving minimally invasive treatment option in surgical high-risk patients with infected femoral artery reconstruction and disrupted vascular anastomosis.

Key words: negative pressure wound therapy, surgical site infection, vacuum-assisted closure, endovascular surgery, EndoVAC, infected vascular reconstruction.

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Vacuum-assisted wound closure (VAC) has become a viable option for graft preservation in deep perivascular surgical site infections (SSI) in the groin after vascular surgery and a way to avoid the use of traditional radical surgical solutions associated with long and costly hospital stay, leg amputation and death [1]. VAC-mediated mechanical contraction of the wound cavity and decreased blood vessel permeability, less edema formation and stimulation of angiogenesis [2] are believed to promote wound healing [3]. Major VAC-mediated bleeding from any vascular anastomosis has been reported to be up to 10%, creating a serious challenge and an important factor to consider regarding the safety of the treatment [4]. Persistence of infection or reinfection rate in the groin after VAC at mid- or long-term follow-up are very important issues to study, since the vascular reconstructions are left in situ [5]. There is one randomized controlled trial (RCT) showing faster wound healing for VAC compared to alginate dressings of infected perivascular reconstructions in the groin wound [6]. There is, however, currently no high-level evidence based on RCT regarding the clinical effectiveness of VAC in the treatment of surgical wound healing by secondary intention [7].

EndoVAC hybrid therapy [8] for infected femoral artery reconstructions has recently been introduced as a minimally invasive treatment option in those patients in need of more advanced treatment than

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standard VAC due to major hemorrhage or pseudoaneurysm in vascular anastomosis or failure of standard VAC therapy. EndoVAC therapy consists of 1) endovascular relining with stent graft, 2) surgical debridement without need of proximal and distal clamping for control of bleeding and 3) VAC for active wound treatment. The aim of this study was to analyze differences in risk factors in patients undergoing EndoVAC compared to standard VAC therapy of perivascular infected femoral artery reconstructions, and to describe the technique, complications and outcome of EndoVAC therapy.

METHODS

Study population and setting

Vascular Center, Malmö, Skåne University Hospital is a tertiary referral center in southern Sweden. This study retrospectively included patients at the clinic from 1st January 2004 to 31st December 2017 and who developed a deep perivascular groin infection after vascular surgery treated with surgical debridement and VAC. The department used cloxacillin as prophylactic antibiotic therapy between 2004 and 2012, and trimethoprim/sulfamethoxazole between 2013 and 2017. Patients having been diagnosed with postoperative infection according to ICD-10 code T81.4 were retrieved. This list of patients was scrutinized by their medical charts to establish whether they met criteria set for inclusion in the study. This research was considered to be a clinical follow-up study without need of ethical approval and the study protocol conformed to the ethical guidelines of the 1975 Declaration of Helsinki.

Standard VAC therapy

After surgical debridement, a continuous VAC device (Kinetic Concepts Inc, San Antonio, Texas, USA) of 125 mm Hg (17 kPa) was applied. In cases of visible graft material or native arteries in the wound, a silicon-based dressing (Mepitel, Mölnlycke Health Care AB, Göteborg, Sweden) was used for coverage of vessels, followed by application of black thick polyurethane sponge. While initial debridement of the wound was performed in the operation room, regular changes of the dressings were usually done in the ward. When VAC was continued after discharge, the patients were followed closely by nurses at the outpatient clinic.

EndoVAC therapy

The first EndoVAC case was performed in March 2006. The EndoVAC technique consists of three steps: 1. Endovascular relining of the femoral artery reconstruction with a stent graft from the external iliac artery (EIA) into either the profunda femoris artery (PFA) or the superficial femoral artery (SFA) (Figure 1A). The flexible self-expandable stent grafts with expanded polytetrafluoroethylene (ePTFE) inner lumen lining used were Viabahn (W.L. Gore & Associates, Flagstaff, AZ, USA), Fluency (C.R. Bard, Murray Hill, NJ, USA) and/or Hemobahn (W.L. Gore & Associates, Flagstaff, AZ, USA). If both SFA and PFA were patent as outflow arteries, adjunctive endovascular embolization with coils (Figure 1B) and/or vascular plugs of the most appropriate artery was performed prior to stent graft deployment in order to avoid retrograde bleeding and for better sealing by the stent graft. 2. Meticulous surgical revision without need of proximal and distal clamps for bleeding control. Removal of the infected prosthesis was performed when possible, resulting in exposure of the stent graft (Figure 1C). 3. VAC therapy (see above; Figures 1D–F).

Definitions

Both former and current smokers were defined as smokers. Critical limb ischemia was defined as ischemic ulceration or gangrene of the forefoot or toes or rest pain together with ankle pressure < 50 mm Hg (< 7 kPa) or toe pressure < 30 mm Hg (< 4 kPa). Diabetes mellitus was considered if the patient was treated medically or with diet. A hypertension diagnosis or treatment with antihypertensive drugs was considered as hypertension. Ischemic heart disease included history of myocardial infarction, angina pectoris, percutaneous coronary intervention or coronary artery bypass graft. Cerebrovascular disease was recorded for patients with a history of stroke or transient ischemic attack. Hemoglobin levels of < 134 g L^{-1} for men and < 117 g L^{-1} for women were defined as anemia. Renal insufficiency was defined as creatinine levels of > 105 µmol L^{-1} (1.19 mg dL^{-1}) for men and > 90 µmol L^{-1} (1.02 mg dL^{-1}) for women. Early SSI was defined as an infection diagnosed within three months of the index operation. Major hemorrhage was defined as bleeding requiring treatment with blood transfusion [9]. Reinfection was recorded for an infection that occurred after completed healing. Healed wound was defined as full skin epithelialization. Major amputation was defined as amputation above the ankle.

Data analysis

Continuous variables were expressed as median with interquartile range (IQR) and group differences were analyzed by Mann-Whitney *U* test. Discrete variables were analyzed with Pearson's χ^2 test or Fisher's exact test. A *P*-value of < 0.05 was considered significant. All statistical analyses were performed using SPSS Statistics 24.0 (IBM Corp, Armonk, NY, USA).

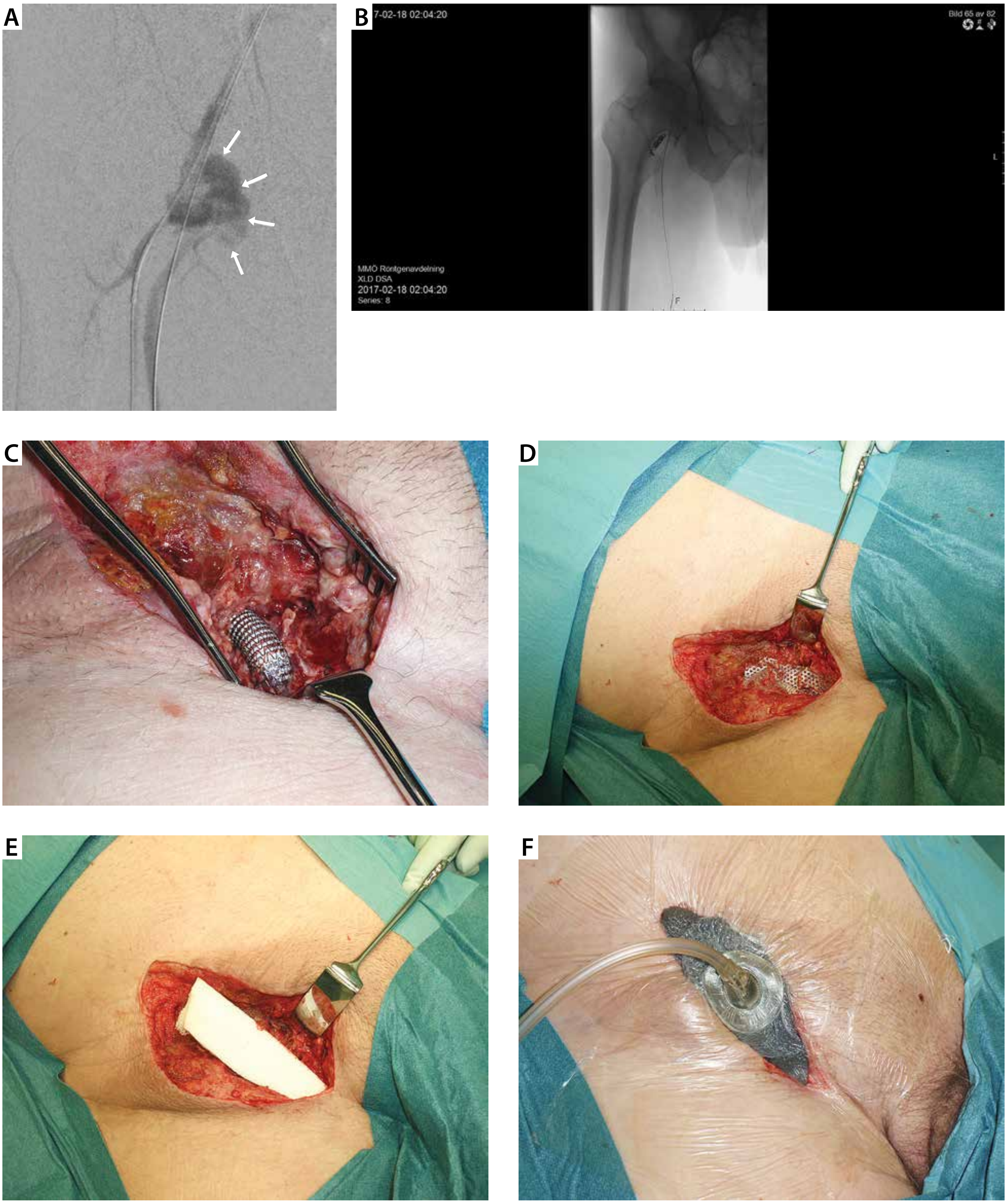

FIGURE 1. Patient with an abdominal aortic aneurysm, 72 mm in maximal diameter, who underwent an endovascular aneurysm repair and a thromboendarterectomy and patch angioplasty with pericardial bovine material of the common femoral artery due to atherosclerotic stenosis. A wound infection with *Staphylococcus aureus* three weeks afterwards developed and medication with cloxacillin was initiated. The patient developed fever at eight weeks and was admitted ten weeks postoperatively with a severe swelling in the right groin and *Staphylococcus aureus* sepsis. C-reactive protein (CRP) was 382 mg L^{-1}. The graft infection was treated with the EndoVAC procedure (case no. 11 in Tables 4-7). Angiography showed a pseudoaneurysm (arrows) arising from the vascular anastomosis in the common femoral artery with extravasation (**A**). After achieving access from the right axillary artery, stent grafts were placed from the right external iliac artery to the superficial femoral after coiling of the profunda femoris artery (**B**). The groin was then reopened and the wound revised with application of VAC. The stent graft was uncovered for a distance of 6 cm (**C**). A non-adhesive silicon-based dressing (Mepitel, Mölnlycke Health Care AB, Göteborg, Sweden) covered the graft (**D**), followed by white foam (**E**), and on top black foam. A hole was cut in the black foam and negative pressure wound therapy with 125 mm Hg (17 kPa) (KCI Medical San Antonio, Texas, USA) was commenced (**F**)

RESULTS

Comparison of patient characteristics in standard VAC and EndoVAC groups

Patients in the EndoVAC group more often had ischemic heart disease (*P* = 0.008) and there was non-significantly higher frequency of any previous vascular surgery (*P* = 0.098), compared to the standard VAC group (Table 1).

Comparison of surgical and wound related factors between the standard VAC and EndoVAC group

Patients in the EndoVAC group more often had undergone previous vascular surgery via groin incision on the same side (*P* = 0.006), presented more often with hemorrhage/femoral pseudoaneurysm (*P* < 0.001), were more often diagnosed late after the index operation (*P* < 0.001) and had positive wound cultures for a longer time during wound treatment (*P* < 0.001), compared to the standard VAC group (Table 2). Microbiology results are shown in Table 3.

Overall major amputation and mortality

The 30-day and crude 1-year major amputation rates were 4.4% (8/183) and 15.3% (28/183), respectively. The 30-day and crude 1-year mortality rates were 4.9% (9/183) and 15.8% (29/183), respectively. The 30-day and crude 1-year major amputation-free survival rates were 92.3% (169/183) and 74.3% (136/183), respectively. Major amputation within 1 year was associated with mortality at 1 year (*P* = 0.002).

Clinical presentation prior to EndoVAC therapy

There were four and five patients with infected synthetic and biologic graft material, respectively, in the EndoVAC group (Table 4). The index operations involving the common femoral artery, time to EndoVAC procedure and presenting symptoms prior to EndoVAC are specified in Table 4. The Endo-

TABLE 1. Patient characteristics

	Standard VAC (*n* = 170)	EndoVAC (*n* = 13)	*P* value
Gender (M : F)	107 : 63	9 : 4	0.65
Median age (IQR)	71 (64–77)	72 (65–80)	0.61
Smoker or ex-smoker (%)	149/169 (88.2)	12 (92.3)	0.65
Co-morbidities (%)			
Hypertension	114/169 (67.5)	10 (76.9)	0.48
Ischemic heart diseases	66/169 (39.1)	10 (76.9)	0.008
Diabetes mellitus	66 (38.8)	4 (30.8)	0.56
Cerebrovascular disease	40/169 (23.7)	4 (30.8)	0.56
Any previous vascular surgery	90/169 (53.3)	10 (76.9)	0.098
Renal insufficiency	53/163 (32.5)	6 (46.2)	0.32
Anemia	113/164 (68.9)	7 (53.8)	0.26
Indication for vascular surgery (%)			
Acute limb ischemia	12 (7.1)	0 (0)	1.00
Critical limb ischemia	68 (40.0)	3 (23.1)	0.23
Claudication	24 (14.1)	2 (15.4)	0.90
Aortic aneurysm	36 (21.2)	1 (7.7)	0.47

TABLE 2. Surgical- and wound-related factors

Factor	Standard VAC (*n* = 170)	EndoVAC (*n* = 13)	*P* value
Type of vascular surgery (%)			
Open	84 (49.4)	7 (53.8)	0.76
Hybrid	46 (27.1)	5 (38.5)	0.38
Endovascular	39 (22.9)	1 (7.7)	0.30
Surgical factors (%)			
Previous ipsilateral groin incision	44/169 (26.0)	8 (61.5)	0.006
Synthetic graft infection	53 (31.2)	5 (38.5)	0.59
Wound related factors			
Presentation with hemorrhage/femoral pseudoaneurysm (%)	18/167 (10.8)	10/13 (76.9)	< 0.001
Early : late SSI after index operation	151 : 18	6 : 7	< 0.001
Median (IQR) C-reactive protein (mg L^{-1}) just prior the surgical revision	75 (25–165)	137 (44–256)	0.17
Erroneous initial antibiotic therapy according to bacterial resistance pattern (%)	53/155 (34.2)	5 (38.5)	0.76
Median (IQR) time in days from surgical revision to last positive culture	10 (0–35)	61 (40–76)	< 0.001
Presence of an ipsilateral foot ulcer (%)	60/168 (35.7)	4 (30.8)	0.72

SSI – surgical site infection

TABLE 3. Microbiology results at initial surgical debridement

Bacteria	Standard VAC (*n* = 170) (%)	EndoVAC (*n* = 13) (%)	*P* value
Gram-negative	74/166 (44.6)	5 (38.5)	0.67
Pseudomonas aeruginosa	14 (8.2)	2 (15.4)	0.38
Gram-positive	72/164 (43.9)	4 (30.8)	0.36
Staphylococcus aureus	29 (17.1)	4 (30.8)	0.22
Positive culture	138 (81.2)	11 (84.6)	0.76
Poly-microbial cultures	72 (42.4)	5 (38.5)	0.78

VAC procedure was performed at the initial operative procedure in ten patients due to hemorrhage (*n* = 8), sepsis (*n* = 1) and infected hematoma (*n* = 1), and performed after failure of standard VAC therapy in three patients due to hemorrhage (*n* = 2) and persistent infection by multidrug resistant *Pseudomonas aeruginosa* (*n* = 1).

EndoVAC therapy – technique, vascular complications, major amputation and mortality

Viabahn stent grafts were used alone (*n* = 8) or in combination with other stent grafts (*n* = 4). Two stent grafts or more was used in seven patients. Adjunctive embolization procedures prior to stent graft deployment were performed in eight (62%) patients (Table 5) and considered necessary in seven for occlusion of either the profunda femoral artery (PFA; *n* = 6) or superficial femoral artery (SFA; *n* = 1). Median follow-up time was 18 months. Major complications after EndoVAC therapy were stent graft occlusion (*n* = 3) ending up in major amputation in all three, fatal major hemorrhage from the repaired reconstruction (*n* = 2) and major amputation within 6 months (*n* = 4) (Table 6).

Wound outcomes in the EndoVAC group

Nine patients had positive and three negative wound cultures. *Staphylococcus aureus* (31%) was the most common pathogen isolated from the wound. Two patients had the same bacteria cultured in the wound, removed graft material and blood. Four patients received adjunctive surgical procedures for wound coverage in terms of two sartorius muscle flaps, one contralateral rectus abdominis flap and one skin transplant. Ten (77%) groins healed, eight without major complications. No clinical local reinfection was diagnosed in any of the ten evaluable wounds (Table 7).

DISCUSSION

The present retrospective large cohort study on consecutive patients in need of surgical revision in the groin due to deep perivascular SSI after vascular surgery showed that a conservative approach with VAC was effective in the majority of patients, which has been reported previously [6, 10]. However, a minority of patients will arrive at hospital with major bleeding from the infected vascular anastomosis or

TABLE 4. Clinical presentation prior to EndoVAC treatment

Case	Index operation	Graft material	Time from index operation to EndoVAC	Presenting symptoms prior to EndoVAC
1	Arteriorraphy	None	1.5 months	Hemorrhage
2	Femoro-femoro interposition graft/femoro-distal bypass	Polyester impregnated with silver, vein	3.5 months	Persistent infection by multiresistant *Pseudomonas aeruginosa*
3	Aortobifemoral bypass, femoro-distal bypass	ePTFE, vein	13 years	Hemorrhage
4	Aortobifemoral bypass	ePTFE	10 years	Femoral pseudoaneurysm
5	SFA patch	Artery	1 month	Hemorrhage
6	Aortobifemoral bypass, femoro-femoro crossover	ePTFE, ovine collagen + polyester	5.5 months	Hemorrhage
7	Patch	Bovine	3.5 months	Femoral pseudoaneurysm
8	Patch	Bovine	21 months	Femoral pseudoaneurysm
9	Self-inflicted needle injuries due to drug addiction	None	–	Hemorrhage + deep vein thrombosis
10	Arteriorraphy	None	4.3 years	Femoral pseudoaneurysm
11	Patch	Bovine	2.5 months	Sepsis
12	Femoro-popliteal bypass	Vein	22 years	Hemorrhage
13	Femoro-popliteal bypass after removal of sarcoma	Ovine	3 weeks	Infected hematoma

ePTFE – expanded polytetrafluoroethylene, SFA – superficial femoral artery
*Biomaterial culture

TABLE 5. Technical details of the endovascular therapy part in EndoVAC patients

Case	Stent graft placement	Stent graft models and sizes (mm)	Adjunctive procedures	Arterial access	Arterial closure
1	EIA into PFA	Viabahn 8 x 100	Coil embolization of SFA	Open puncture of brachial artery	Open arteriorraphy
2	EIA into vein bypass	Viabahn 8 x 100, Hemobahn 10 x 100, Fluency 10 x 120, Wall stent 10 x 94		Open retrograde puncture of bypass	Open arteriorraphy
3	Aortobifemoral bypass limb into vein bypass	Fluency 12 x 120, Fluency 12 x 80, Fluency 10 x 80		Open retrograde puncture of bypass	Open arteriorraphy
4	Aortobifemoral bypass limb into SFA	Viabahn 13 x 100	Open ligation of PFA and EIA	Open retrograde puncture of SFA	Open arteriorraphy
5	EIA stent into PFA	Viabahn 9 x 100		Open puncture of brachial artery	Open arteriorraphy
6	Femoro-femoro crossover bypass into PFA	Viabahn 10 x 100, Viabahn 8 x 100		Open puncture of femoro-femoro crossover	Open arteriorraphy
7	EIA into PFA	Viabahn 8 x 100	Coil embolization of two PFA branches, continuous thrombolysis with rt-PA 8.9 mg	Retrograde contralateral CFA puncture	CFA compression device
8	EIA stent into SFA stent	Viabahn 7 x 100	Coil embolization of PFA	Retrograde contralateral CFA puncture	Percutaneous closure device
9	EIA into SFA	Viabahn 8 x 150, Viabahn 7 x 150	Coil and vascular plug embolization of PFA	Retrograde contralateral CFA puncture	Percutaneous closure device
10	EIA into SFA	Fluency 13.5 x 60, Viabahn 13 x 100, Fluency 13.5 x 120, Fluency 12 x 80, Fluency 12 x 80	Vascular plug embolization of PFA	Retrograde contralateral CFA puncture	Percutaneous closure device
11	EIA into SFA	Fluency 12 x 80, Viabahn 10 x 50, Viabahn 10 x 100	Coil embolization of PFA	Percutaneous right axillary artery puncture	Open arteriorraphy
12	EIA into vein bypass	Fluency 10 x 100, Viabahn 8 x 150	Vascular plug embolization of PFA	Retrograde contralateral CFA puncture	Percutaneous closure device
13	EIA into biological bypass	Viabahn 8 x 150		Retrograde contralateral CFA puncture	Percutaneous closure device

EIA – external iliac artery, CFA – common femoral artery, PFA – profunda femoral artery, SFA – superficial femoral artery, rt-PA – recombinant tissue plasminogen activator

TABLE 6. Postoperative vascular complications and major outcomes in EndoVAC treated patients

Case	Follow-up (months)	Stent graft occlusion	Major hemorrhage	Reintervention	Major amputation due to SSI	Death due to SSI
1	8 (dead)	No	No	None	No	No, unrelated
2	106	Yes, at 3 months	No	Resection of reconstruction	Yes, below knee	Alive
3	5 (dead)	Yes, at 2 months	No	Thrombectomy, restent grafting with wall stent 10 x 60 due to CFA stent graft stenosis, reoccluded after 2 months	Yes, above knee	No, died due to ruptured atherosclerotic TAAA (autopsy)
4	12 (dead)	No	No	None	No	No, unrelated
5	2.2 (dead)	No	Yes, at 1 month	Resection of reconstruction	Yes, above knee	Yes
6	75	No	No	No	No	Alive
7	38	No	No	No	No	Alive
8	18 (dead)	No	No	No	No	No, unrelated
9	20	No	No	No	No	Alive
10	2.5 (dead)	No	Yes, at 2 months	None, palliation	No	Yes
11	18	No	No	No	No	Alive
12	18	Yes, at 6 months	No	Mechanical thrombectomy, restenting EIA, reoccluded within a few days	Yes, below knee	Alive
13	8	No	No	No	No	Alive

*Ongoing due to concomitant re-EVAR (endovascular aneurysm repair) due to stent graft infection in the aorta.
TAAA – thoraco-abdominal aortic aneurysm, EIA – external iliac artery

TABLE 7. Wound outcomes after EndoVAC therapy

Case	Follow-up (months)	Cultures at EndoVAC procedure	Adjunctive wound procedures and outcome	Length of antibiotic therapy (months)	Local reinfection
1	8 (dead)	*Staphylococcus aureus*	Sartorius muscle flap, healed	7	No
2	106	*Pseudomonas aeruginosa* (wound, removed graft)	Sartorius muscle flap, healed	5	No
3	5 (dead)	*Staphylococcus aureus* (wound, blood)	Skin transplant, unhealed	5	–
4	12 (dead)	Negative	Healed	0.5	No
5	2.2 (dead)	*Proteus mirabilis*	Unhealed	2	-
6	75	*Enterococcus faecalis, Staphylococcus species*	Healed	3	No
7	38	*Staphylococcus lugdunensis* (wound, removed graft, blood)	Healed	1.5	No
8	18 (dead)	*Pseudomonas aeruginosa* (wound, blood)	Healed	2.5	No
9	20	*Streptococcus anginosus* (wound, blood)	Contralateral rectus abdominis muscle flap, healed	8.5	No
10	2.5 (dead)	Negative	Unhealed	2.5	–
11	19	*Staphylococcus aureus* (wound, removed graft, blood)	Healed	19*	No
12	18	Negative	Healed	0.2	No
13	8	*Staphylococcus aureus, Enterococcus faecalis*	Healed	4	No

*Ongoing due to concomitant re-EVAR (endovascular aneurysm repair) due to stent graft infection in the aorta. TAAA = thoraco-abdominal aortic aneurysm, EIA = external iliac artery

will fail standard VAC therapy in hospital, resulting in bleeding or persistent infection/sepsis. Traditionally, emergency total graft excision with or without in situ or extra-anatomic reconstruction has been advocated [11]. This dogma has been questioned, with endovascular solutions being proposed in high-risk patients [12]. The present study was conducted in a first endovascular strategy center in the treatment of aortic aneurysm and peripheral arterial disease since two decades and with long-standing experience in VAC therapy of wounds, which probably has contributed to the development of a hybrid approach in these emergently challenging cases. The EndoVAC therapy method was first described in 2011 [8], and a longer series with long-term results was published by the same research group in 2016 [13]. In contrast to these reports, this study reports only results after EndoVAC therapy of infected femoral artery constructions. In comparison with other areas, the groin area harbors a high burden of bacteria in a warm and moist environment, often with multiple skin folds. In addition, inadvertent damage to lymphatic vessels may occur during vascular surgery, further contributing to bacterial growth, which makes deep perivascular infected groin wounds particularly challenging to heal [14, 15]. Furthermore, traditional wound dressings tend to attach poorly in this highly mobile area, further prolonging wound healing, whereas VAC therapy performs much better in this respect [16].

The comparison of standard VAC versus EndoVAC groups should not be performed regarding outcomes and complications since EndoVAC therapy is used in the most serious and challenging cases whereas differences in risk factor evaluation between the groups may provide important information. In the present study, patients in the EndoVAC group had a higher frequency of ischemic heart disease and presented more urgently with hemorrhage/femoral pseudoaneurysm. These aspects may have influenced choice of treatment for the minimally invasive option in order to reduce myocardial stress and injury rather than performing emergency major open vascular surgery in a patient with hemorrhagic shock that would substantially increase the risk of myocardial infarction and death [17]. These patients were also found to more often have undergone previous ipsilateral groin incisions, a factor associated with a more challenging dissection at open surgery, which in fact may be a factor that increases risk of reoperation for bleeding [18] and SSI [19]. Unsatisfactory surgical technique has been identified as one possible factor responsible for occurrence of graft infection [20], and it should be clear that the standard of surgical technique at reoperation for graft infection should be at the absolute highest level to minimize further complications [21]. In contrast to the standard VAC group, the EndoVAC therapy group was found to have a high frequency of late graft infections, a factor considered negative for graft preservation therapy [10], which should be taken into account when interpretation of data in the EndoVAC therapy group is done.

One advantage with the EndoVAC technique, compared to open surgery, is the sutureless anastomosis and avoidance of uncontrolled blood spouting at the initial stage for control of hemorrhage or femoral pseudoaneurysm. The surgical revision can then be performed effectively under controlled circumstances, an experience which was particularly appreciated in the present study when managing a patient with hepatitis C and intravenous drug abuse who self-injected illegal substances in the groin. Risk of hand injury by broken needle tips in the wound during surgery was minimized, and subsequently also the risk of exposure to bloodborne infectious diseases. EndoVAC therapy and graft preservation has been warned for in case of *Pseudomonas aeruginosa* [22] infection and sepsis [23], but the wounds of the three study patients at risk healed successfully.

The disadvantage of EndoVAC therapy is the necessary occlusion of one of the main outflow femoral arteries in patients with both arteries patent prior to intervention. Seven of the 13 patients needed such adjunct embolization procedures in the present series, whereas six patients just had one of these two arteries open and did not need embolization prior to stent graft deployment. Even though no acute ischemic leg complications occurred after sacrificing six PFAs and one SFA in these respective patients, it is a factor that increases the likelihood of progression towards critical limb ischaemia. Another setback was the stent graft occlusions during follow-up, ending up with major amputation in all three patients despite reintervention attempts in two. The reason for occlusion in these patients can only be speculated upon, but none of the occluded stent grafts were exclusively Viabahn stent grafts. Instead the arterial segment was treated with at least two stent grafts, and were of different brands in two and they were all Fluency stent graft based. The luminal surface of ePTFE lining in Viabahn stent grafts has a heparin bioactive surface, whereas the inner lumen ePTFE lining in Fluency stent grafts has a carbon impregnated inner lumen, which may be of importance for patency. Stent graft placements in the common femoral artery (CFA) have been looked at with great skepticism due to its proximity to the highly mobile hip joint, and the anticipated high risk of stent graft fracture and occlusion. A recent systematic review of infected iliofemoral pseudoaneurysm found, however, that the stent graft thrombosis rate was only 5.7% during a mean follow-up of 16 months [24]. This low figure [24] should be interpreted cautiously though as this research area may be subjected to publication bias. Two fatal hemorrhages from the infected reconstruction occurred. This worrisome complication was caused by an improper seal by the stent graft and/or ongoing infection. One patient was treated with resection of the reconstruction without revascularization and major amputation above the knee just prior to death. The other patient was treated with five stent grafts, four Fluency and one Viabahn stent graft, which may have indicated technical difficulties in securing a proper seal in the first place, and at rebleed it was decided to palliate only.

Active wound treatment with VAC therapy in the EndoVAC group is considered to be a very important step for accelerating wound healing and improving outcomes. Selective adjunctive procedures such as muscle flap coverage may be advantageous to cover dead space, shorten wound healing time and reduce the risk of recurrent infection [25]. It is advisable to continue VAC therapy on top of the muscle flap to speed up wound healing further [26]. There was no clinical local reinfection during follow-up in the EndoVAC group in the present study, which is in line with another report [13]. Potential pathogens causing groin infections were of a wide spectrum of types and the role and duration of different antibiotic therapy remain elusive. In prospective studies evaluating wound healing, standardization of culture swabbing technique is important for reliable data of bacterial type and load [27]. This would minimize bias, enabling better evaluation on the effects of VAC therapy on bacterial clearance and microbiological environment in the wound. A recent RCT has, compared to VAC alone, shown superior clearance of quantitative biofilm-protected bacteria in the wound with VAC plus instillation therapy using dilute sodium hypochlorite solution [28], which therefore may be a beneficial adjunct if definitive secondary wound closure in selected patients is considered.

LIMITATIONS

The limitations of the present study are, in part, due to its retrospective design and the limited number of patients with EndoVAC therapy. Nevertheless, the EndoVAC technique is still novel with very few published series. In this perspective, the present series adds important information on EndoVAC therapy of infected femoral artery reconstructions.

CONCLUSIONS

Patients undergoing EndoVAC therapy often possessed several risk factors that made them unsuitable for emergency major open surgery. EndoVAC therapy appears to be a life-saving minimally invasive treatment option in surgical high-risk patients with infected femoral artery reconstruction and disrupted vascular anastomosis.

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