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Cutdown Technique is Superior to Fascial Closure for Femoral Artery Access after Elective Endovascular Aortic Repair☆

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WHAT THIS PAPER ADDS

Previous studies have independently confirmed the safety and durability of fascial closure after endovascular aneurysm repair (EVAR); however, studies differed in patient selection and clinical follow up. This single centre study of 225 patients investigated 439 groins closed with fascial closure and cutdown techniques after EVAR. Although cutdown was performed as a second line closing technique and in patients with more challenging access vessel anatomy, the technical success was better compared with fascial closure. Because wound complications were infrequent for both methods, this study contributes a divergent opinion on this topic and indicates that fascial closure should be avoided after elective EVAR.

Objectives: Arterial access closure after endovascular aneurysm repair (EVAR) can be achieved using three different approaches: percutaneous closure devices, surgical exposure and direct suture ("cutdown"), and the less invasive fascial closure technique. The aim of this study was to report on the intra-operative, in hospital, and three month outcome of fascial closure and cutdown, and to determine risk factors for failure.

Methods: The primary outcome was assessed in 439 groins in 225 elective EVAR patients recruited consecutively and prospectively from February 1, 2011 to August 31, 2014. During the study period, fascial closure and cutdown were first and second line closing techniques. Compared with fascial closure, procedures completed with cutdown had lower BMI, thinner subcutaneous tissue of the groin and more complex femoral anatomy. Computed tomographic angiography (CTA) and duplex ultrasound (DUS) of the groin were performed pre-operatively and three months after EVAR. Retrospective review of medical records and CTA were used to determine intra-operative and in hospital outcome, and risk factors for failure.

Results: In total, 64%, 33%, and 3% were completed with fascial closure, cutdown, and closure device, respectively. Intra-operative, in hospital, and three month technical success rates of fascial closure vs. cutdown were 91% (283/310 groins) vs. 99% (114/115 groins), 89% (277/310 groins) vs. 99% (114/115 groins), and 89% (275/310 groins) vs. 99% (114/115 groins) ($p < .001$). Wound complications within three months were infrequent for both methods. No risk factor was significantly associated with failure after fascial closure.

Conclusion: This study shows that cutdown is superior to fascial closure for femoral artery access after elective EVAR. In acute EVAR, however, fascial closure is still considered to be a good and fast method, and it has been kept in the present authors' armamentarium for this indication.

Keywords: Fascial closure, Fascial suture, Cutdown, EVAR, EVAR-surveillance, Access complications
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INTRODUCTION

Endovascular aneurysm repair (EVAR) is a minimally invasive alternative to open aneurysm resection with an early survival benefit.[1–3] Transfemoral access with large bore sheaths demands safe closure of the artery, which can be achieved using three very different approaches. Complete percutaneous arterial closure gains ground but may fail because of calcification (3–12%), deviating anatomy, or lack of technical proficiency.[4] Surgical exposure and direct suture of the arterial

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access, also referred to as "cutdown," constitutes a durable solution although it is associated with more groin complications (2%) compared with the percutaneous technique.[5] Suture of the subcutaneous fascia overlying the femoral vessels is a technique in between cutdown and percutaneous closure, and was first described > 20 years ago as a means to secure haemostasis without exposing the vessels.[6] Even if the fascial closure technique is safe and feasible (8—15% primary failure rate; 1% > wound complications), most failures can be handled intra-operatively;[7,8] groin complications such as arterial stenosis and pseudoaneurysm formation (PA) are a concern; and midterm results are sparsely described.[9,10] The primary aim of this study was to compare the early and three month outcome between fascial closure and cutdown after EVAR. Second, the study aimed to describe selection criteria for fascial closure vs. cutdown. Third, the study aimed to determine risk factors associated with closure failure after EVAR completion.

METHODS

Patients and design

During a 43 month inclusion period (February 1, 2011 to August 31, 2014), 255 elective EVAR patients were recruited consecutively and prospectively in the same tertiary referral centre for vascular surgery (Fig. 1). Enrolment was performed during a research fellowship (KB) responsible for patient recruitment and all duplex ultrasound (DUS) examinations. Ten patients without vascular access complications died prior to three month follow up and were excluded. Groins with simultaneous peripheral reconstruction planned pre-operatively, thrombo-endarterectomy, insertion of femorofemoral or peripheral bypass were excluded, leaving 439 eligible groins in 225 patients eligible for further analysis (Table 1). The first line closure technique according to the team policy was fascial closure, although direct cutdown was used for specific indications (Table 2). All patients gave written informed consent and the study was approved by the local ethical committee of Copenhagen (H-2-2011-016).

The study was a non-randomised observational study comparing the early and three month outcome of fascial closure vs. cutdown. DUS and CTA were performed pre-operatively and three months post-operatively. Intra-operative- and in hospital outcomes were retrieved retrospectively from medical records.

Ultrasound examination

All patients had a DUS examination of the groin the day before EVAR and after three months. All DUS examinations were performed by one operator proficient in vascular DUS (KB) using the same DUS system (iU22 with a 9 MHz linear array transducer; L9-3, Philips Medical Systems, Bothell, WA, USA). Brightness mode and color Doppler were set to investigate the common femoral artery (CFA), including the proximal 5 cm of the superficial femoral artery. Access related pseudo-aneurysm formation was defined as color flow outside the arterial lumen. Significant stenosis was defined by peak systolic velocity increase exceeding 200% obtained in the longitudinal scan plane.[11]

Pre-operative evaluation of access site with CTA

Pre-operative CTA was used to estimate vessel calcification and the vessels were divided into two groups: 1) < 50% calcification of the anterior vessel wall circumference and 2)

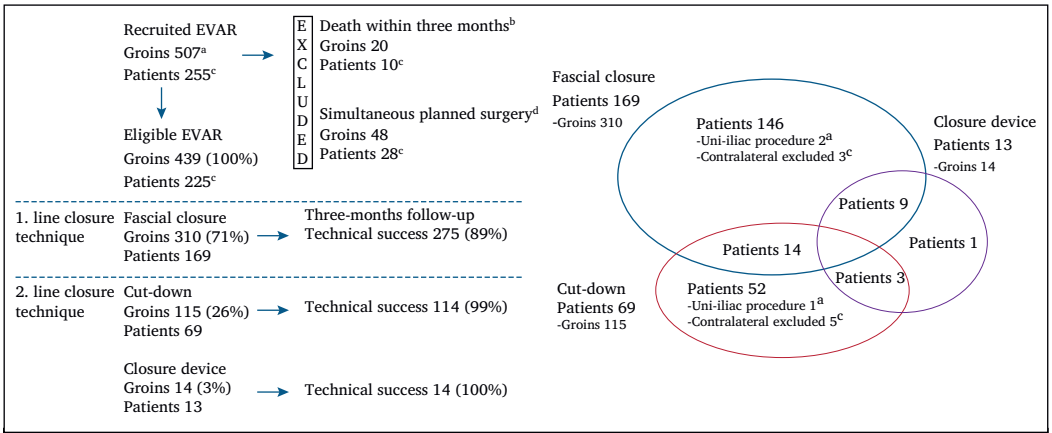

Figure 1. Patient selection and three month outcome. Left: According to team policy, fascial closure and cutdown were the first and second line closure techniques, respectively. Closure devices were used occasionally at the end of the study period without distinctive selection criteria. [a] There were three uni-iliac procedures. [b] In 10 patients, three month follow up was incomplete because of death; intra-operative ($n = 2$), in hospital ($n = 2$), and after discharge ($n = 6$). [c] In 20 patients both groins underwent planned surgery as opposed to eight patients where fascial closure ($n = 3$) or cutdown ($n = 5$) were performed in the contralateral groin. [d] Simultaneous peripheral vascular reconstruction was planned based on pre-operative CTA in 48 groins: femorofemoral bypass ($n = 26$), femoral thrombo-endarterectomy (n = 21), peripheral bypass (n = 1). Right: This figure illustrates patients having cutdown in one groin and contralateral fascial closure ($n = 14$), fascial closure and contralateral closure device ($n = 9$), and cutdown and contralateral closure device ($n = 3$). EVAR = endovascular aneurysm repair.

Table 1. Eligible endovascular aneurysm repair (EVAR): femoral characteristics and patient demographics

Femoral access characteristics (n = 439)	Fascial closure	Cutdown	Closure device	p[a]
	n = 310	n = 115	n = 14	
Previous surgery or percutaneous access, no (%)	34 (11)	17 (15)	3 (21)	.28
Sheath diameter, mm, median (range[b])	5 (4)	5 (3)	7 (3)	.48
Vessel diameter, mm, mean (SD)	13 (3)	12 (3)	15 (2)	.15
Sheath/vessel ratio, mean (SD)	0.5 (0.1)	0.5 (0.1)	0.4 (0.1)	.27
Calcification degree $\geq$ 50%, n (%)	17 (5)	17 (15)	0 (0)	.002
Calcification degree < 50%, n (%)	293 (95)	98 (82)	14 (100)	<.001
Subcutaneous fat layer, mm, mean (SD)	31 (11)	26 (10)	25 (9)	<.001
Patient demographics (n = 225)[c]	N = 169[c]	N = 69[c]	N = 13[c]	
Abdominal aortic aneurysms, n (%)	126 (75)	58 (84)	11 (85)	.11
Aorto-iliac aneurysms, n (%)	29 (17)	8 (12)	2 (15)	.28
Iliac aneurysms, n (%)	14 (8)	3 (4)	0 (0)	.29
Re-intervention, n (%)	1 (<1)	3 (4)	1 (8)	.04
Age, years, mean (SD)	77 (6)	78 (7)	78 (7)	.32
Male gender, n (%)	152 (90)	58 (84)	13 (100)	.20
Body mass index (BMI) kg/m^2, mean (SD)	27 (4)	25 (4)	25 (2)	<.001
Current smoker, n (%)	54 (32)	20 (29)	2 (15)	.65
Chronic obstructive pulmonary disease (COPD), n (%)	29 (17)	14 (20)	1 (8)	.57
Cardiac disease, n (%)	46 (27)	20 (29)	5 (38)	.78
Peripheral arterial disease, n (%)	8 (5)	10 (14)	2 (15)	<.001
Diabetic, n (%)	18 (11)	11 (16)	1 (8)	.26
Hypertension, n (%)	118 (79)	45 (65)	9 (69)	.49
Antiplatelets, n (%)	126 (75)	44 (64)	11 (85)	.10
Lipid lowering agents, n (%)	122 (72)	50 (73)	8 (62)	.77

BMI = body mass index; COPD = chronic obstructive pulmonary disease; EVAR = endovascular aneurysm repair; SD = standard deviation.
[a] Fascial suture compared with cutdown.
[b] Interquartile range.
[c] In 26 patients, haemostasis was secured differently, for further information please see Fig. 1 explaining the overlap.

$\geq$ 50% calcification of the anterior vessel wall circumference.[4] Approximately 1 cm proximal to the femoral artery bifurcation, the axial image with the highest degree of calcification was used to assess calcification. The maximum diameter of the CFA was measured from outer to outer wall, and the same axial image was used to measure the maximum thickness of the subcutaneous tissue from the CFA to surface of the skin. Abdominal apron was not considered.

Endovascular aneurysm repair

In general, patients received identical EVAR devices (Zenith Flex, Cook Medical Inc., Bloomington, IN, USA). The femoral artery access location was identified by manual pulse palpation, guided by fluoroscopy and bony markers. Ultrasound guided puncture was not routinely used.

Fascial closure

In 2007, fascial closure after EVAR was introduced and was gradually implemented as the first line closure technique. After completion of the intervention, the subcutaneous fascia (fascia lata) was exposed through a 5–7 cm oblique skin incision near the introducer sheath following Langer's lines (Fig. 2). A longitudinal mattress suture (Prolene 2-0; Ethicon, Johnson & Johnson, Europe) was placed in the fascia around the sheath and guidewire. First, the sheath with the dilator inserted was retracted and the suture was tightened (Fig. 2). Thereafter, and only if haemostasis was achieved and distal pulse preserved, the guidewire was withdrawn and the knot was further tightened.[6] Immediate cutdown was performed for bleeding (the sheath was repositioned), missing foot pulses, or other doubts about the distal vascularisation. Completion angiography was not routinely performed after fascial closure. Vascular surgeons participating in this study had a self reported experience of >50 fascial closures.

Cutdown

Cutdown was achieved through the same oblique skin incision extended down to the femoral arteries using the introducer sheath as guidance. After exposure, clamping and removal of the sheath, and direct arterial suture were performed (Prolene 5-0, Ethicon, Johnson & Johnson, Europe) followed by closure of the subcutaneous tissue (Coated Vicryl 4-0, Ethicon, Johnson & Johnson, Europe) and skin (Ethilon Nylon 4-0, Ethicon, Johnson & Johnson, Europe).

All patients received 50 IU unfractionated heparin/kg during the procedure, with selective reversal with protamine sulphate. Femoral compression systems were not used for haemostasis. Mobilisation and antithrombotic prophylaxis with 3500 IU low molecular weight heparin/day was commenced 6 h after the procedure (Tinzaparin, Innohep, LEO Pharma Nordic, Malmö, Sweden). Ambulation policy did not differ between groups.

Table 2. Reasons to refrain from fascial closure in 129 groins (79 patients[a])

Variable	Groins (patients)
Cutdown, 115 groins (69 patients)	
Pre-operative decision	
Inexperienced[b]	11 (8)
Chronic obstructive pulmonary disease or dementia[c]	8 (4)
Anticoagulated patients	3 (2)
Intra-operative decision	
Calcification/complicated access[d]	42 (26)
Undefined or thin fascia[e]	11 (6)
Scar tissue[f]	7 (5)
Sheath lost	5 (4)
Accidental supraligamentary access	4 (4)
Complicated endovascular aneurysm repair[g]	6 (3)
Unspecified/missing information	18 (10)
Closure device, 14 groins (13 patients)[h]	14 (13)

[a] Six patients occur twice in different subcategories: completion with cutdown in one of the groins and closure device in the contralateral ($n = 3$), cutdown in both groins with different reason to refrain from fascial closure ($n = 3$), explaining the sum of 85 in the parentheses.
[b] Surgeon inexperienced with fascial closure.
[c] COPD (chronic obstructive pulmonary disease) or dementia precluding post-operative bedrest.
[d] Severe calcification or several percutaneous attempts.
[e] Thin or missing fascia.
[f] Pronounced groin scarring after previous surgery.
[g] Multiple sheath changes during the operation.
[h] Used occasionally at the end of the study period.

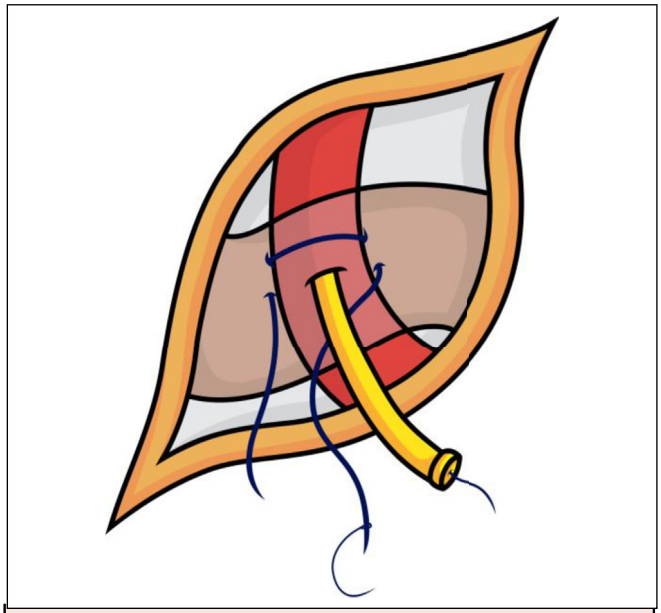

Figure 2. Fascial closure technique performed through an oblique groin incision. A longitudinal mattress suture was placed in the fascia, ready to tighten when the sheath and guidewire were retracted stepwise.

Percutaneous closure device

At the end of the study period, and only in selected cases without calcification of the common femoral artery, a few patients were closed using a percutaneous device (ProGlide, Abbott Laboratories, Chicago, IL, USA).

Discharge

At discharge, patients had a clinical examination focusing on signs and symptoms of surgical site infection, lymphatic leak, pseudo-aneurysm formation, and limb ischaemia, including pulse palpation and/or ankle brachial pressure index measurement (ABPI) by the attending physician and not necessarily by the same member of the team. DUS was only performed on indication or at the discretion of the operator.

Three month follow up

Three month follow up included clinical examination, ABPI, DUS of the groins, and CTA for endoleak detection. Only PAs >2 cm were considered for surgical revision or intra-arterial thrombin injection according to the team policy, and smaller PAs were handled conservatively with an additional six month follow up and thereafter annual follow up with DUS examination of the groin. An ABPI reduction >15% was considered to be significant.[12] Data on readmissions and re-interventions in the study period were obtained from electronic medical records.

Endpoints

Technical success and groin complications of the fascial closure and cutdown were assessed at three time points: 1) intra-operatively, 2) in hospital, and 3) at three month follow up. Intra-operatively, technical success was defined as haemostasis and preserved distal pulses. In hospital and three month technical success were characterised by the absence of major bleeding (leading to surgical revision at the discretion of the operator or person on call), PA < 2 cm, no CFA thrombosis, and ABPI reduction < 15%. Minor bleeding was defined as haemostasis obtained after manual compression alone.

Descriptive endpoints were pre-operative risk factors related to the technical success rate and other groin complications. Other groin complications (infection, oozing, and neuralgia) within three months of the EVAR procedure, leading to surgical revision, prolonged hospital stay, or readmission, were recorded but not considered to be a technical failure of the closure technique.

Statistics

Continuous variables were reported as mean (SD) or median (range), and categorical variables as frequencies. The Student *t* test, Mann—Whitney *U* test, and chi-square test were used to test for differences between observed means, medians, and frequencies, respectively. Association between pre-operative variables and failure after the fascial closure technique was tested using logistic regression

Table 3. Access related complications requiring immediate re-intervention in 439 groins (225 patients)

Variable (groins)	Fascial closure (n = 310)		Cutdown (n = 115)		Closure device (n = 14)	
	Groins (%)	Patients	Groins (%)	Patients	Groins (%)	Patients
Intra-operative						
Major bleeding leading to cutdown	18 (6)	13	–	–	–	–
Thrombectomy	9 (3)	9	1 (<1)	1	–	–
In hospital						
Major bleeding necessitating re-intervention	5 (2)	4	–	–	–	–
Thrombectomy of the common femoral artery	1 (<1)	1	–	–	–	–
Minor bleeding	6 (2)	6	6 (5)	5	1 (7%)	1
Three month follow up						
Thrombosis leading to re-intervention	1[a] (<1)	1	–	–	–	–
Pseudo-aneurysm requiring intervention	1[b] (<1)	1	–	–	–	–
Pseudo-aneurysm treated conservatively	12 (4)	9	3 (3)	3	–	–
Wound complication requiring re-intervention	1 (<1)	1	–	–	–	–

[a] Iliac limb thrombosis, revascularisation by insertion of a femorofemoral bypass.
[b] Pseudo-aneurysm (5 × 7 cm) excluded by thrombin injection.

models. To adjust for mass significance, the Bonferroni correction was used to eliminate type I error where $p < .004$ was considered significant. Statistical analysis was performed using SAS Enterprise Guide 7.1 (SAS Institute, Cary, NC, USA).

RESULTS

During the study period 64%, 33%, and 3% of the groins were completed with fascial closure, cutdown, and percutaneous closure device, respectively (Table 1).

Technical success

The intra-operative, in hospital, and three month technical success rates of fascial closure were 91% (283/310 groins), 89% (277/310 groins), and 89% (275/310 groins), respectively. The corresponding technical success rates in patients completed with cutdown were 99% (114/115 groins), 99% (114/115 groins), and 99% (114/115) groins. Comparing technical success rates, cutdown performed significantly better than fascial closure ($p < .001$). There were no technical failures observed after percutaneous closure (Fig. 1).

Intra-operative results

Fascial closure. Intra-operative failure of fascial closure in 9% (27/310 groins) was caused by bleeding in 6% (18/310 groins) and arterial thrombosis in 3% (9/310 groins) where limb function was restored after cutdown and thrombectomy (Table 3).

Cutdown. Intra-operative failure followed by successful thrombectomy was performed in <1% (1/115 groins) completed by cutdown (Table 3).

Closure device. Intra-operative failure after completion with closure device was not observed.

In hospital results

Fascial closure. During the in hospital period, major bleeding required re-operation in 2% (5/310 groins), and thrombectomy of the CFA in one (Table 3). Minor bleeding was seen in 2% (6/310 groins) that resolved after manual compression without PA formation on DUS at three month follow up.

Cutdown. Thrombosis after cutdown was not recorded during the in hospital period. Re-operation because of bleeding or PA was not required in this group.

Percutaneous closure device. In hospital failure or wound complications after completion with closure device were not observed.

Three month follow up results

Fascial closure. One patient with a standard aorto-bi-iliac stent graft experienced thrombosis of an iliac component 70 days post-operatively and was successfully treated with a femorofemoral bypass (<1%). At three month follow up, PA was seen in 4% (13/310 groins), of which all but one had a diameter < 2 cm and were handled conservatively (Table 3). One PA (5 × 7 cm) was excluded by direct thrombin injection, however it was complicated by peripheral embolisation that resolved after 24 h treatment by catheter directed arterial infusion of recombinant tissue plasminogen activator rt-PA (Actilyse, Boehringer Ingelheim Limited, Bracknell, UK). In a median follow up period of 36 months (range 12—48 months), six non-thrombosed PAs resolved spontaneously and six remained stable.

At three months, four asymptomatic patients had unilateral ABPI reduction compared with before EVAR. In these patients, DUS could not identify any significant lesions in the iliac or CFA but revealed a significant stenosis in the distal SFA in one (left untreated as the patient was asymptomatic).

Cutdown. No thrombotic events were noted in patients with cut down. Pseudoaneurysms were recorded in 3% (3/115 groins), all treated conservatively.

Closure device. Complications after completion with closure device were not observed.

Other groin complications

Fascial closure. During the in hospital period, lymph oozing necessitating surgical revision was seen in <1% (1/310 groins). Lymphatic leak lasting >48 h was reported in 4% (12/310), all managed without surgical revision. Surgical site infection was not observed and the median length of stay (LOS) in hospital was three (range 1–27) days. Two patients had prolonged stays (23 and 27 days) because of mesenteric ischaemia and post-operative haematuria and urological investigation, respectively. Removing these two cases, there was no difference in median LOS between fascial closure and cutdown ($p = .932$). At discharge, 6% (18/310 groins) suffered from post-operative neuralgia, but all resolved at follow up. After discharge, 2% (6/310 groins) were returned to the outpatient clinic from general practitioners with suspected groin infections and managed with antibiotic treatment.

Cutdown. Surgical site infection requiring intravenous antibiotics was reported in <1% (1/115 groins). Lymphatic leak >48 h was reported in 10% (11 groins) all handled without surgical revision. Median LOS was three (range 1–9) days. One patient with wound ooze resolved after an additional skin suture and administration of antibiotics during readmission.

Closure device. Wound complications were not observed in groins completed with arterial closure devices.

Descriptive outcome analysis for failure after fascial closure

In the descriptive outcome analysis, alcohol consumption > five units per day was associated with technical failure (OR: 2.8 (1.3–5.9), $p = .009$, non-significant after Bonferroni correction). The technical success rate was not affected by large bore catheters (≥18 Fr) ($p = .76$) or thickness of the subcutaneous tissue ($p = .23$). Moreover, no differences in pre-operative risk factors, CTA, and ultrasound findings were related to fascial closure failure.

Only one technical failure was observed after cutdown, thus explanatory analysis was not performed.

DISCUSSION

The present study, comparing cutdown with fascial closure after EVAR, demonstrates that cutdown is superior to fascial closure with respect to both wound complications and technical success.[13] Based on the results of this study, the present authors advise against fascial closure after elective EVAR and have changed their approach to primary percutaneous closure and secondary cutdown. The decision to move away from fascial closure can be justified not only by its lower technical success rate compared with cutdown, but also because of no improvement in LOS. In the acute EVAR setting however, fascial closure has the advantages of limited exposure and saves time when finalizing the procedure. It is easily done under local anaesthesia and is a much quicker way to start the acute EVAR as compared with percutaneous closure.

Because large PAs and stenotic lesions were infrequent, routine DUS surveillance of the groin does not seem warranted in asymptomatic patients completed by fascial closure or cutdown.

An early technical success rate of fascial closures of 89% during the intra-operative and in hospital course is comparable with other studies reporting on fascial closure,[7–10] as well as studies reporting on percutaneous arterial closure devices.[5,13] As expected, the majority (>80%) of complications in the present study were handled intra-operatively, and post-operative re-intervention was hardly ever needed (<2%).[7,10] The observation that bleeding was the most common reason for converting fascial closure to cutdown, has also been observed in two previous studies.[7,10] Surprisingly, femoral occlusion accounted for nearly one third of all conversions of the fascial sutures and may be ascribed to a too deep mattress suture strangulating the femoral artery, emphasizing the need for intra-operative evaluation of the peripheral perfusion. Except for one femoral artery necessitating thrombectomy in the early post-operative period, pulse palpation and clinical signs of ischaemia (pallor and coldness) were enough to identify those complicated cases. Others have implemented completion intra-operative DUS, and it remains speculative whether intra-operative DUS could have prevented the five cases returning to the operating room because of bleeding or the one case with thrombosis of the iliac component.[8] It is recognised, however, that DUS guided puncture may reduce the risk of complications.[14]

Even though all groins were systematically scrutinised with DUS, development of significant stenotic lesions after fascial closure was not demonstrated in any of the approximately 300 groins, being consistent with other studies using DUS or CTA post-operatively.[7–10]

Few groins with fascial closure suffered PA formation, and thrombin injection was only needed in one case, underlining that long term follow up is probably not necessary. The low frequency of PA formation is in line with comparable studies.[7,9,10] A similar risk (2–3%) of PA formation using percutaneous closure was reported in a recent meta-analysis of nearly 8000 EVAR, TEVAR, and transcatheter aortic valve procedures.[15] As seen in the present study, thrombin injection was successfully carried out in most PAs, although this was not necessarily without complications and the decision on when to treat asymptomatic PAs following fascia closure with thrombin must be balanced against the risk of distal embolisation. Nevertheless, in the case of distal embolisation, thrombolysis is an effective treatment.

The need for surgical revision after fascial closure and cutdown was very low (0–1%) and the study cutdown cohort may have been too small (type 2 error) to confirm a

wound complication rate of 2% as reported in a recent large study of >4,000 elective EVAR cases.[13] Additionally, because of the retrospective data entry on readmission, in hospital, and intra-operative outcome, more benign cases of surgical site infections (not requiring intravenous antibiotics, surgical revision or prolonged hospitalisation) could potentially have been missed. Furthermore, primary care notes were not reviewed, something that potentially could have refined the dataset. The present authors have no further suggestions on how to improve the technique and approach of fascial closure. In accordance with previous studies, the present study found that neither the sheath/vessel ratio nor the thickness of the subcutaneous tissue influence outcomes after fascial closure.[7,9]

The study protocol limited the generalisability of the findings where 36% were excluded from fascial closure compared with only 13% in a similar study.[7] Additionally, this was not a randomised controlled trial and may have introduced a bias in favour of fascial closure compared with cutdown. The post hoc analysis showed that heavy calcification of the CFA was three times as frequent (15% vs. 5%) in the group of patients excluded from fascial closure (Table 1). Patients excluded from fascial closure tended to have lower body mass index and thinner subcutaneous tissue than patients completed with fascial closure. Whether subcutaneous tissue thickness affected the cutdown outcome remains speculative because descriptive analysis was not performed in the cutdown group. All in all, patients who underwent cutdown had more challenging femoral anatomy and the difference in outcomes comparing the techniques may have been even greater if patients had been better matched.

Moreover, a learning curve for fascial closure has not been estimated in the study clinic and the present authors refrained from further inter-surgeon assessment as this was not an objective of the study.

In this large cohort, all patients were treated with the same EVAR devices during a relatively short study period, avoiding a potential device related error. On the other hand, it was not possible to correlate sheath size with outcome, something expected to be most relevant for access complications.

In conclusion, fascial closure cannot be recommended as an alternative to cutdown after elective EVAR. Because this was a non-randomised study, the next step would be a randomised controlled trial. Access vessel complications after EVAR were rare however, and because the reported technical success and complication rate differed only slightly between the three methods, a future three arm randomised trial powered to detect such differences is not realistic. Instead, vascular surgeons performing elective and acute EVAR should master all three closure techniques, being prepared with take each patient's clinical situation into account.

CONFLICTS OF INTEREST

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REFERENCES

1 Wanhainen A, Verzini F, Herzeele I Van, Allaire E, Bown M, Cohnert T, et al. European society for vascular surgery (ESVS) 2019 clinical practice guidelines on the management of abdominal aorto-iliac artery aneurysms. *Eur J Vasc Endovasc Surg* 2019;**57**:8–93.
2 Tadros RO, Faries PL, Ellozy SH, Lookstein RA, Vouyouka AG, Schrier R, et al. The impact of stent graft evolution on the results of endovascular abdominal aortic aneurysm repair. *J Vasc Surg* 2017;**59**:1518–27.
3 Patel R, Sweeting MJ, Powell JT, Greenhalgh RM. Endovascular versus open repair of abdominal aortic aneurysm in 15-years' follow-up of the UK endovascular aneurysm repair trial 1 (EVAR trial 1): a randomised controlled trial. *Lancet* 2016;**1**:1–9.
4 Manunga JM, Gloviczki P, Oderich GS, Kalra M, Duncan AA, Fleming MD, et al. Femoral artery calcification as a determinant of success for percutaneous access for endovascular abdominal aortic aneurysm repair. *J Vasc Surg* 2013;**58**:1208–12.
5 Nelson PR, Kracjer Z, Kansal N, Rao V, Diego S, Linda L, et al. A multicenter, randomized, controlled trial of totally percutaneous access versus open femoral exposure for endovascular aortic aneurysm repair (the PEVAR trial). *J Vasc Surg* 2016;**59**:1181–93.
6 Diethrich EB. What do we need to know to achieve durable endoluminal abdominal aortic aneurysm repair? *Tex Heart Inst J* 1997;**24**:179–84.
7 Montán C, Lehti L, Holst J, Björses K, Resch TA. Short- and midterm results of the fascia suture technique for closure of femoral artery access sites after endovascular aneurysm repair. *J Endovasc Ther* 2011;**18**:789–96.
8 Larzon T, Roos H, Gruber G, Henrikson O, Magnuson A, Falkenberg M, et al. A randomized controlled trial of the fascia suture technique compared with a suture-mediated closure device for femoral arterial closure after endovascular aortic repair. *Eur J Vasc Endovasc Surg* 2015;**49**:166–73.
9 Mathisen SR, Zimmermann E, Markström U, Mattsson K, Larzon T. Complication rate of the fascia closure technique in endovascular aneurysm repair. *J Endovasc Ther* 2012;**19**:392–6.
10 Harrison GJ, Thavarajan D, Brennan JA, Vallabhaneni SR, McWilliams RG, Fisher RK. Fascial closure following percutaneous endovascular aneurysm repair. *Eur J Vasc Endovasc Surg* 2011;**41**:346–9.
11 Eiberg JP, Rasmussen JBG, Hansen MA, Schroeder T. Duplex ultrasound scanning of peripheral arterial disease of the lower limb. *Eur J Vasc Endovasc Surg* 2010;**40**:507–12.
12 Caruana MF, Bradbury AW, Adam DJ. The validity, reliability, reproducibility and extended utility of ankle to brachial pressure index in current vascular surgical practice. *Eur J Vasc Endovasc Surg* 2005;**29**:443–51.
13 Buck DB, Karthaus EG, Soden PA, Ultee KHJ, Herwaarden JA Van, Moll FL, et al. Percutaneous versus femoral cutdown access for endovascular aneurysm repair. *J Vasc Surg* 2015;**62**:16–21.
14 Arthurs ZM, Starnes BW, Sohn VY, Singh N, Andersen CA. Ultrasound-guided access improves rate of access-related complications for totally percutaneous aortic aneurysm repair. *Ann Vasc Surg* 2008;**22**:736–41.
15 Vierhout BP, Pol RA, El Moumni M, Zeebregts CJ. Arteriotomy closure devices in EVAR, TEVAR, and TAVR: a systematic review and meta-analysis of randomised clinical trials and cohort studies. *Eur J Vasc Endovasc Surg* 2017;**54**:104–15.