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European multicentric experience with Fenestrated-Branched ENDOvascular stent-grafting after previous FAILed infrarenal aortic repair: the EU-FBENDO-FAIL Registry

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Running Title: Multi-center F-BEVAR after Previous AAA Repair

Mini-Abstract: Multi-center F-BEVAR of failed AAA repair.

ABSTRACT

Objective. To report the mid-term outcomes of fenestrated-branched endovascular aneurysm repair (F-BEVAR) following a failed previous endovascular aneurysm repair (pEVAR) or previous open aneurysm repair (pOAR).

Methods. Data from consecutive patients who underwent F-BEVAR for pEVAR or pOAR from 2006-2021 from 17 European vascular centres were analyzed. Endpoints included technical success, major adverse events (MAE), 30-day mortality, and 5-year estimates of survival, target vessel primary patency, freedom from reinterventions, type I/III endoleaks, and sac growth > 5mm.

Summary Background Data: Treatment of a failed previous abdominal aortic aneurysm (AAA) repair is a complex undertaking. F-BEVAR is becoming an increasingly attractive option, although comparative data are limited regarding associated risk factors, indications for treatment, and various outcomes.

Results. There were 526 patients included, 268 pOAR and 258 pEVAR. Median time from previous repair to F-BEVAR was 7 (IQR, 4-12) years, 5 (3-8) for pEVAR and 10 (6-14) for pOAR, p<.001. Predominant indication for treatment was Type Ia endoleak for pEVAR and progression of disease for pOAR. Technical success was 92.8%, pOAR (92.2%) and pEVAR (93.4%), p=.58. The 30-day mortality was 6.5% overall, 6.7% for pOAR and 6.2% for pEVAR, p=.81. There were 1853 treated target vessels with 5-year estimates of primary patency of 94.4%, pEVAR (95.2%) and pOAR (94.4%), p=.03. Five-year estimates for freedom from type I/III endoleaks were similar between groups; freedom from reintervention

was lower for pEVAR (38.3%) than for pOAR (56.0%), p=.004 The most common indication for reinterventions was for type I/III endoleaks (37.5%).

Conclusions. Repair of a failed previous EVAR or OAR is safe and feasible with comparable technical success and survival rates. While successful treatment can be achieved, significant rates of reintervention should be anticipated, particularly for issues related to instability of target vessels/bridging stents.

Keywords. Fenestrated-branched endovascular repair; Previous aortic surgery; Failed endovascular aneurysm repair; Thoracoabdominal; Aortic disease; Reintervention

Introduction

The failure of a infrarenal abdominal aortic aneurysm (AAA) repair is not uncommon, and depends both on the original treatment modality as well as on disease progression.[1–4] Schermerhorn et al noted a decreased incidence of conversion over time, but a significant rate of late rupture, as high as 5.4% for EVAR patients and 1.4% for OAR patients, was reported.[5] While the type and frequency of reinterventions following a previous OAR (pOAR) might differ from reinterventions for previous EVAR (pEVAR), redo open surgery after pOAR and pEVAR is significantly more demanding than a primary procedure, owing to both increased age and frailty of patients, as well as to the additional technical challenges that are imposed by the presence of a prior prosthesis or endograft.[6–8] Several recent reports have highlighted promising results when using fenestrated-branched endovascular aneurysm repair (F-BEVAR) in favour of a second open aortic repair.[9–11] This option nonetheless comes at a cost of increased complexity as well as peri- and post-operative risks.[7] Given the disparities and variations between countries and centres regarding treatment modalities, the aim of the present study is to report the outcomes for this procedure from a multi-center and multi-national perspective.

Methods

Study design

Retrospectively collected data from all patients who underwent F-BEVAR following either pOAR or pEVAR from January 2006 to April 2021 from 17 European vascular centres were analyzed (Supplementary Table 1, Supplemental Digital Content 1, http://links.lww.com/SLA/E41). All centres had experience with F-BEVAR procedures, defined as having carried out at least thirty F-BEVAR interventions. Demographic and comorbidities were recorded, as well as type of primary procedure and number of years until

reintervention. Indications for treatment (progression of disease, proximal anastomosis pseudoaneurysm, type I endoleak, AAA-sac expansion with no leak, or graft migration) aneurysm size, and the status, i.e., acuity of the procedures were reported. Procedural details including operation duration, fluoroscopy time, and volume of contrast, as well as the need for brachial artery access and use of prophylactic spinal drain. The stent-graft design (branched and/or fenestrated) was recorded, while the number of target vessels treated was recorded categorically as either less than four, or four and more. Notably, all F-BEVAR procedures were performed using Cook Medical endografts (Cook Medical Inc, Brisbane, Australia), including custom-made, physician-modified and off-the-shelf endografts. All participating centres adhered to their own practices regarding obtainment of informed consent and ethical approval. The study did not alter follow-up practices endorsed at participating institutions.

Endpoints & definitions

The primary endpoint was technical success in accordance with previously published reporting standards with the allowance for deliberate initial incomplete sealing that was subsequently treated, i.e., staged treatment.[12] More specifically, technical success was defined as the successful placement of the aortic and bridging stent grafts, with patency of the planned treated target vessels, the absence of type I/III endoleaks, without need for unplanned open surgical adjuncts/conversion, and the patient surviving the procedure within the 24-hour period. Target vessel instability is a composite endpoint of bridging stent occlusion, device migration, branch-related growth, or the need for any secondary intervention.[13] Secondary outcomes included 30-day mortality, major adverse events (MAE) within 30 days, as well as five-year estimates of survival, primary patency of target vessels, and freedom from re-interventions, type I/III endoleaks, and AAA-sac growth>5mm. Outcomes were reported

according to the Society for Vascular Surgery reporting standards for endovascular aortic repair of aneurysms involving the renal-mesenteric arteries.[12]

Statistical analysis

Normality of data was assessed with quantile-quantile plots. Continuous data are presented with mean values and standard deviation (SD) or median values with interquartile range (IQR). Normally distributed data were compared using t-tests with 95% confidence intervals (CIs), whereas the Wilcoxon rank sum test was used for non-normally distributed data. Categorical variables are reported as absolute numbers (%) and compared using the χ^2 test. For comparisons with multiple categories, the Bonferroni correction was used. Time-to-event analyses were performed using Kaplan-Meier curve estimates. A Cox proportional hazard model was then produced using a forward selection process with all covariables. Interactions were tested using a probability value of .01. Group effect was included in the model, in order to adjust for the possible correlation within different treatment centres. The fit of the final model was tested using residual analysis. Hazard ratios (HRs) are presented with 95% confidences intervals (95% CIs). A competing risks model using subdistribution dependent on the specific cause was employed to calculate the cumulative incidence of reinterventions with death as the competing risk. A p-value of less than 0.05 was statistically significant. Subanalyses of freedom from type I/III endoleaks and AAA-sac growth>5mm were performed based on the indication to treat, as these indications inherently differ because of the initial method of treatment. Finally, because of the differing volumes of procedures at centres, a sensitivity analysis of technical success for the three lowest volume-centres was compared against the three highest volume-centres. All data analysis and graphical presentation were carried out using Stata/SE, version 16.1 (StatCorp. 2019. Stata Statistical Software: Release 16. College Station, TX, USA: StataCorp LP.)

Results

Study cohort

There were 258 pEVAR and 268 pOAR patients included in the study period (Supplementary Figure 1, Supplemental Digital Content 2, http://links.lww.com/SLA/E42). There was a total of 10 (1.9%) ruptures, 2 (.8%) after pEVAR and 8 (3.0%) after pOAR, p=.06. The mean age for the entire cohort was 73.8 ± 6.7 years, while pEVAR patients were older (75.0 ± 6.9) than the pOAR patients (72.7 ± 6.3), p < .001. The median time from previous repair to F-BEVAR was 7 (IQR, 4-12) years: 5 (IQR, 3-8) years for pEVAR, and 10 for pOAR, p<.001. The median follow-up was 13.1 months (IQR, 2.1 – 37.2 months). Further demographic data and patient comorbidities are given in Table 1.

Anatomic details & procedural data

The overall median aneurysm diameter at the time of re-treatment was 65 (58-78) mm. The diameter for pEVAR patients was 70 (60-83) mm, which was larger than that of the pOAR patients, 62 (56-71) mm, p <.001. The majority of pEVAR patients were treated for a type I endoleak (64.3%), and the majority of pOAR patients were treated for proximal disease progression (81.7%). For the patients with proximal disease progression, there were 161 (59.4%) who had either a type I or III thoracoabdominal aneurysms (TAAAs). Of the 52 pEVAR patients, there were 25 (48.1%), and of the 219 pOAR patients, there were 136 (62.1%), who had either a type I or III TAAA, p=.19. The two pEVAR patients with proximal pseudoaneurysm were identified as infected stent grafts. Furthermore, of the pEVAR patients, 164 (69.5%) had a previous EVAR with suprarenal fixation.

The median operative time for all procedures was 286 (225-380) minutes: for pEVAR patients, 263 (IQR, 194-345) minutes, and for pOAR patients, 308 (240-420) minutes, p

<.001. The amount of contrast used was 135 (82-195) mL for pEVAR patients and 168 (120-243) mL for pOAR patients, p <.001. There was a significantly lesser use of off-the-shelf stent grafts for the pEVAR cohort (7.0%) than for the pOAR cohort (20.2%), p < .001. Devices using fenestrations only were more often used for pEVAR patients (69.8%) than for pOAR patients (39.6%), p<.001. The number of target vessels treated was more often four or more among the pOAR patients (70.5%) than among the pEVAR patients (55.4%), p <.001. Upper extremity access was also more often utilized for pOAR patients (69.8%) than for pEVAR patients (36.8%), p <.001. Finally, the use of prophylactic spinal drainage was also more often used for pOAR patients (49.6%) than for pEVAR patients (26.2%), p<.001. Further procedural data are provided in Supplementary Table 2, Supplemental Digital Content 3, http://links.lww.com/SLA/E43.

Technical success & peri-operative morbidity

The overall technical success was 92.8%; there was no significant difference between pOAR (92.2%) and pEVAR (93.4%) patients, p=.58. The 30-day mortality was 6.5% overall, 6.7% for pOAR and 6.2% for pEVAR, p=.81. As detailed in Supplementary Table 3, Supplemental Digital Content 4, http://links.lww.com/SLA/E44, the most common technical failure for pEVAR was a failure to cannulate a target vessel (3.5%), in comparison to .8% for pOAR patients, p=.03. Conversely, a persistent type IIIc endoleak was the main failure among pOAR patients (52.4%), as opposed to 11.8% for pEVAR patients, p=.04. As iterated above for the purpose of a sensitivity analysis, the overall technical success rate was 88.7% at the three highest volume-centres and 83.3% at the three lowest volume-centres, p= .49.

There were no differences for rates of any MAEs: pOAR, 28.7%, pEVAR, 23.3%, p =.15. Specified adverse events revealed greater rates of estimated blood loss (EBL) > 1000mL among pOAR patients (22.4%) than among pEVAR patients (14.3%), p =.02. There was also

a greater number of post-operative strokes among pOAR patients (4.1%) than among pEVAR patients (0), p =.001. Of these 11 strokes, 10 (90.9%) were observed in patients for whom upper extremity access was used during the procedure, p=.01. The LoS was 6 (4-10) days for pEVAR patients, significantly shorter than 8 (5-14) days for pOAR patients, p =.001.

Overall survival

Estimates from the Kaplan-Meier curve in Figure 1a reveal a 90-day survival of 91.0% (95% CI, 88.1-93.3) for the entire cohort, 92.2% (95% CI, 87.9-95.0) for pEVAR, and 90.0% (95% CI, 85.4-93.2) for pOAR. The 5-year estimate for survival for the entire cohort was 55.5% (95% CI, 48.1-62.3). As depicted in Figure 1a, there was no difference in the 5-year survival estimates between pEVAR patients, 52.2% (95% CI, 40.5-62.7), and pOAR patients, 57.5% (95% CI, 47.9-66.7), p=.83. Two of the deaths were due to rupture of the common iliac artery, both with identified type Ib endoleaks in patients who were previously treated with OAR (tube grafts). A multivariate-adjusted analysis, provided in Supplementary Table 4A, Supplemental Digital Content 5, http://links.lww.com/SLA/E45, demonstrated no association between 5-year survival and the type of previous repair. The hazard ratio (HR) for every five years of age was 1.23 (95% CI, 1.08-1.41), p=.003. The HR for aneurysm diameter was 1.04 (95% CI, 1.00-1.07), p=.02 for every 5mm of diameter. The use of an off-the-shelf device also had a significant HR of 1.93 (95%CI, 1.03-3.63), p=.03.

Primary patency of target vessels

Among the 526 patients, 1853 target vessels underwent bridging stent treatment. The five-year estimates of primary patency for target vessels for all patients was 94.4 % (95% CI, 91.4-96.3). As shown in Figure 1b, the five-year estimates were 95.2% (95% CI, 92.6-96.9)

for pEVAR and 94.4% (95% CI, 89.5-97.0%) for pOAR, p=.03. Of the 27 events among pEVAR patients, 13 (48.2%) were in patients treated without suprarenal fixation and 14 (51.8%) in patients treated with suprarenal fixation, p=.790. Multivariable adjusted modelling (Supplementary Table 4b, Supplemental Digital Content 5, http://links.lww.com/SLA/E45) revealed no significant predictive factors. Notably, the 5-year primary patency was 94.2% (95% CI, 89.5-96.8) for renal arteries.

Type I or III endoleaks

There was a total of 90 (17.1%) type I or type III endoleaks during follow-up, of which type IIIc was the most frequent type of endoleak, n= 39 (7.4%). There were nine type Ia endoleaks (1.7%), of which six were among pEVAR patients (Supplementary Figure 2, Supplemental Digital Content 6, http://links.lww.com/SLA/E46). The overall 5-year estimate for freedom from type I or type III endoleak (Figure 1c) was 57.9% (95% CI, 48.5-66.1). For pEVAR patients, the estimate was 57.2% (95% CI, 42.6-69.4), and for pOAR patients, the estimate was 58.6% (95% CI, 46.1-69.2), p=.84. The multivariable adjusted HR analysis (Supplementary Table 4c, Supplemental Digital Content 5, http://links.lww.com/SLA/E45) revealed only the size of the aneurysm as a predictive factor for a type I or type III endoleak, HR = 1.10 (95% CI, 1.06-1.14), p<.001, for every 5mm of diameter.

Sac growth>5mm

The overall 5-year estimate for freedom from sac growth > 5mm was 62.6% (95% CI, 53.5-70.4). As displayed in Figure 1d, the estimate for pEVAR patients was 44.7% (95% CI, 31.5-57.1), and for pOAR patients, the estimate was 78.0% (95% CI, 65.9-86.2), p <.001. The multivariable adjusted HR analysis (Supplementary Table 4d, Supplemental Digital Content 5, http://links.lww.com/SLA/E45) revealed the size of the aneurysm as a significant

predictive factor of sac growth, HR=1.14 for every 5mm of diameter (95% CI, 1.08-1.21), p<.001. A previous EVAR was not predictive, HR=1.40 (95% CI, .83-2.32), p =.21.

Reinterventions

There was a total of 136 patients (25.9%) who underwent reinterventions (pEVAR, n= 76 (29.5%), pOAR, n= 60 (22.4%), p=.06) in the study period. Eight patients underwent more than one reintervention. The most common indication for reintervention, as revealed in Supplementary Table 5, Supplemental Digital Content 7, http://links.lww.com/SLA/E47, was related to type Ic or IIIc endoleaks (overall, n= 51 (37.5%), pEVAR, n= 17 (22.4%), pOAR, n= 34 (56.7%), p<.001). Type Ia endoleaks were statistically equivalent, whereas both type Ib endoleaks and type II endoleaks were more often the indications for reintervention among the pEVAR cohort.

The overall 5-year estimate for freedom from reinterventions was 48.1% (95% CI, 39.6-56.1). As shown in Figure 2a, the estimate for pEVAR patients was 38.3% (95% CI, 26.1-50.4), and for pOAR patients, the estimate was 56.0% (44.2-66.3), p=.004. The multivariable adjusted HR (Supplementary Table 4e, Supplemental Digital Content 5, http://links.lww.com/SLA/E45) for pEVAR was 1.50 (95%CI, 1.06-2.13), p=.02. The size of the aneurysm was also predictive, HR= 1.05 (95% CI, 1.01-1.10), p=.02, for every 5mm of diameter. As demonstrated in Figure 2b, the cumulative incidence of reinterventions was 39.4% (95% CI, 33.3-45.4), with death as the competing event.

Subgroup analyses

- *Subanalysis based on indication for treatment amongst pEVAR patients.* Of the 258 pEVAR patients, there were 204 (79.1%) treated for either a type I endoleak or sac expansion with no

obvious leak, and 54 (20.2%) treated for progression of disease. The 5-year estimate for freedom from endoleak was 56.1% (95% CI, 39.2-70.0) for the former group and 60.9% (95% CI, 32.9-80.2) for the latter group, p=.98. A similar analysis for freedom from sac growth > 5mm revealed a 5-year estimate of 41.7% (95% CI, 26.4-56.3) for those treated for a type I endoleak or sac expansion, and 51.7% (95% CI, 26.6-72.1) for those treated for progression of disease, p=.90.

- *Subanalysis of patients treated for progression of disease.* As previously noted, the 5-year estimate for freedom from endoleak for pOAR patients was 58.6% (95% CI, 46.1-69.2). For the pEVAR patients treated for progression of disease (n= 54), the 5-year estimate was 60.9% (95% CI, 32.9-80.2), p=.95. For the patients treated for progression of disease, the 5-year estimate for freedom from sac growth among the pOAR patients was 78.0% (95% CI, 65.9-86.2) and 51.7% (95% CI, 26.6-72.1) for the pEVAR patients, p=.02.

Discussion

Treatment of a previously failed infrarenal AAA repair is a complex undertaking, and this analysis of F-BEVAR for a failed previous EVAR or OAR confirms its feasibility and safety in terms of technical success and 30-day mortality, as well as satisfactory mid-term effectiveness as demonstrated in previous studies.[6,9,14–16] However, only few studies have analysed the comparative outcomes of F-BEVAR after either previous open or endovascular repair, a novel aspect of this report.[17] In that sense, the presented cohort is the largest of its kind to date, and the inclusion of an almost equal number of pEVAR and pOAR patients offers important insights in future treatment considerations. Indeed, the pooled rate of peri-operative morbidity is comparatively low, in light of some of the contemporary series of surgical conversion after EVAR,[18–20] as well as recent series of complex endovascular repair for native aortic aneurysms[21,22] This supports the adoption of F-BEVAR as the first-line treatment for rescue of post-infrarenal AAA repair failures, provided the anatomy is suitable, although open surgical conversion may still be needed in selected circumstances including

cases of graft infection as suggested by contemporary experts opinion and clinical practice guidelines[24, 25].

The similar rates of technical success and five-year survival rates between study groups in the present report would suggest an analogous undertaking, but there are differences that deserve further consideration. For instance, the observed duration from the initial repair to the secondary F-BEVAR procedure was significantly shorter for pEVAR patients as compared to pOAR subjects. Whether this is a result of intrinsic issues of durability or a reflection of increased surveillance among endovascularly-treated patients cannot be ascertained and should be investigated in future studies. Also, whether heterogeneity in follow-up protocols amongst participating institutions may have contributed to the findings could not be determined. The pEVAR patients were also older and had significantly larger aneurysms at presentation, which may be a result of selection bias, as AAA patients selected for first-time EVAR may more likely be physiologically frail than their open surgical counterparts. As noted above, the rates of technical success were similar, although the underlying failures differed between the cohorts. Perhaps the significant use of suprarenal fixation among the pEVAR patients may explain the greater rates of target vessel cannulation failure, but this relationship cannot be demonstrated.

Interestingly, the pOAR procedures were significantly longer in duration, which may partially be explained by the following factors: increased use of arm access, increased use of off-the-shelf stent grafts, and increased number of target vessels to cannulate. These could either suggest a difference in the urgency of the procedures, but they may also indicate that the procedures were planned for different anatomies. as there were no differences in the procedural status (i.e., acute, subacute, or elective) It is a further note of interest that more

than one third of the entire patient cohort underwent prophylactic CSF drainage. While rates of spinal cord ischemia were similar between groups, no strokes were reported from the pEVAR patients, whereas 11 (4.1%) were recorded from the pOAR patients. Almost all of the strokes (90.9%) were observed among patients for whom upper extremity access was used, a known factor associated with an increased risk of stroke.[26,27] The more frequent use of this access for pOAR patients may have contributed to this observation.

Having noted these differences between pEVAR and pOAR patients, the critical question is whether and for whom a failed previous AAA treatment can be salvaged. This outcome must be measured both in terms of survival and freedom from reinterventions, as well as endoleaks, target vessel patency, and aneurysmal sac growth. From the Kaplan-Meier curves in Figure 1, it is evident that the estimates of survival are approximately 55.5% at five years, while the freedom from reintervention is slightly less than 50%. A more nuanced understanding of this comes from the competing risks analysis given in Figure 2b, where the cumulative incidence of reinterventions at five years is almost 40% with death as the competing event. Most reinterventions were carried out for target vessel instability and most often treated with endovascular means (Supplementary Table 5, Supplemental Digital Content 7, http://links.lww.com/SLA/E47). Overall, pEVAR patients may be more prone to sac growth and reinterventions following secondary F-BEVAR, regardless of the indication for treatment, and the increased number of treatments for type II endoleaks and distal landing zone instability among pEVAR patients (Supplementary Table 5, Supplemental Digital Content 7, http://links.lww.com/SLA/E47) tends to support this finding. As expected, there were no instances of reintervention performed for type II endoleaks amongst pOAR patients, as these events account for a significant proportion of secondary procedures following standard, as well as, complex endovascular aortic repair.[28,29]

The estimates of freedom from type I/III endoleaks were similar between the pEVAR and pOAR patients, but the freedom from reintervention and freedom from sac growth were significantly lower for pEVAR patients at five years. The underlying indication to treat may have played a role in these differences. That is, the majority of pEVAR patients were treated for a type Ia endoleak, whereas the majority of pOAR patients were treated for proximal progression of aneurysmal disease. The comparison of pEVAR and pOAR patients treated for progression of proximal disease revealed a significantly lower estimate of freedom from endoleaks and sac growth among pEVAR patients. Likewise, a comparison of pEVAR patients treated for progression of disease against a type Ia endoleak or sac growth showed no differences in the freedom from endoleaks or sac growth.

With the above in mind, it might be that progression of disease can be more threatening among pEVAR patients, given that native aorto-iliac tissue remains with the potential for infrarenal and iliac vessel expansion. Indeed, all three of the post-F-BEVAR ruptures were due to distal vessel instability which, although rare, may lead to secondary aneurysm rupture.[30] One could perhaps advocate for more aggressive repair with F-BEVAR, that is, full relining of the previous repair with distal extension. Nonetheless, the main indication for F-BEVAR after prior infrarenal repair in the study cohort was inadequate proximal seal following the prior infrarenal procedure. It is reasonable to conclude that F-BEVAR procedures were successful for the specific indications for which they were applied, as new-onset type Ia or type III endoleaks from the stent-grafts were only a minority.

Study Limitations

The findings from this study have several limitations. It is a retrospective analysis based on registry data, thus exposing itself to errors in registration and the potential bias of patient selection and patterns of referral. The inclusion of multiple centres strengthens the overall generalizability, but the heterogeneity this introduces is also a weakness, given the lack of documented turn-down rates and various follow-up protocols. In addition, there is a known relationship between operative volume and surgical outcomes after aortic surgery, and the learning curve effect has already been shown to affect results of F-BEVAR interventions.[31, 32] Although all participating units are experienced in complex endovascular aortic procedures, there were significant differences in the patient volume between centres. The potential for group effect from an individual centre was therefore included in the multivariable adjusted models. Lastly, future research may concentrate on the cost-effectiveness of the complex procedures and their impact on patient-reported outcome measures[33].

Conclusions

In many ways, this analysis adds to the lessons learned from previous studies, in that successful treatment of complex aortic disease endovascularly can be achieved, but surveillance is still mandated, and reinterventions should be expected. A pre-existing EVAR or OAR does not prohibit the technical feasibility nor safety of a F-BEVAR, and nor do the significant comorbidities of these patients. While prevention of rupture may be accomplished, the expected 5-year survival of these patients is not praiseworthy. Reintervention rates for these procedures are significant and this could be substantially improved by prevention of target vessel instability.

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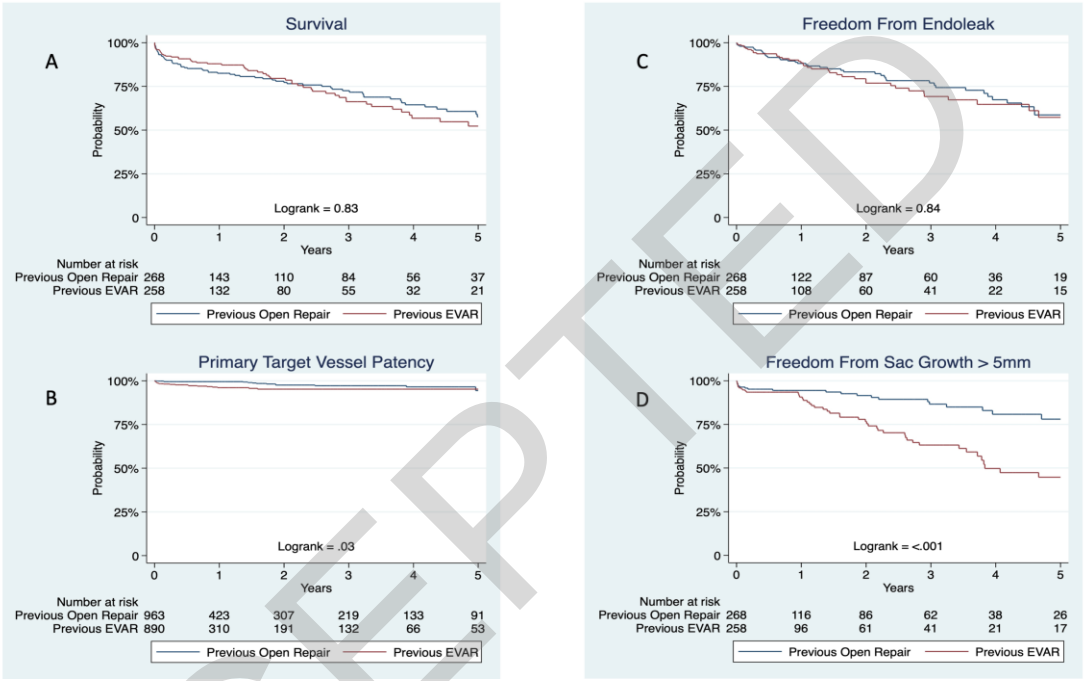
- **Figure 1:** Kaplan-Meier curves for (A) survival, (B) primary patency, (C) freedom from type I or type III endoleaks, and (D) freedom from aneurysm sac growth > 5mm, stratified by the original abdominal aortic aneurysm repair; EVAR, endovascular aneurysm repair.



- **Figure 2:** A) Kaplan-Meier curves for freedom from reintervention, stratified by the original abdominal aortic aneurysm repair. B) The cumulative incidence of reinterventions using a competing-risks subdistribution model with death as the competing risk, revealing a 39.4% incidence of reintervention at five years; EVAR, endovascular aneurysm repair.

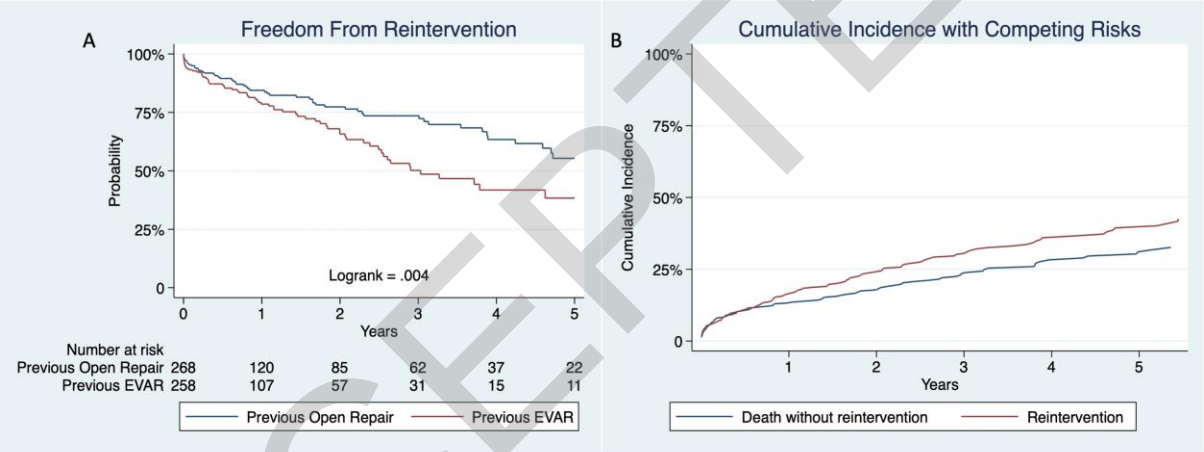


Table 1: Baseline characteristics of the 526 included patients who underwent F-BEVAR after a failed previous OAR or EVAR. Data are presented as mean ± standard deviation, median (interquartile range), or n (%).

Variable	**All patients (n=526)**	**Previous OAR (n=268)**	**Previous EVAR (n=258)**	**P-value**
Demographics				
Years since previous repair	7 (4-12)	10 (6-14)	5 (3-8)	<.001
Age	73.8 ± 6.7	72.7 ± 6.3	75.0 ± 6.9	< .001
Octogenarian	102 (19.4)	37 (13.9)	65 (25.2)	.001
Female sex	49 (9.3)	22 (8.2)	27 (10.5)	.37
Comorbidities				
Obese (BMI >30)	105 (23.2)	40 (17.2)	65 (29.6)	.002
IHD	259 (49.2)	139 (51.9)	120 (46.5)	.22
Atrial fibrillation	95 (18.3)	39 (14.9)	56 (21.8)	.04
CHF	90 (17.3)	45 (17.1)	45 (17.4)	.92
Hypertension	466 (88.6)	242 (90.3)	224 (86.8)	.21
COPD	165 (31.4)	104 (38.8)	61 (23.6)	<.001
DM	71 (13.5)	28 (10.5)	43 (16.7)	.04
Previous stroke/TIA	70 (13.3)	44 (16.5)	26 (10.1)	.03
Smoking				
Never	171 (33.9)	75 (29.5)	96 (38.3)	.12
Previous	181 (35.8)	91 (35.8)	90 (35.9)	1.00
Current	153 (30.3)	88 (34.7)	65 (25.9)	.10
CKD stage III-V (eGFR<60)	203 (41.3)	104 (40.3)	99 (42.5)	.62

BMI: Body mass index
CHF: Congestive heart failure
CKD: Chronic kidney disease
COPD: Chronic obstructive pulmonary disease
DM: Diabetes mellitus
eGFR: Estimated glomerular filtration rate
EVAR: Endovascular aneurysm repair
F-BEVAR: Fenestrated-branched endovascular aneurysm repair
OAR: Open aortic repair