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The durability of endovascular repair of para-anastomotic aneurysms after previous open aortic reconstruction

Jan A. Ten Bosch, MD,[a] **Evert J. Waasdorp, MD,**[b,c] **Jean-Paul P. M. de Vries, MD, PhD,**[c] **Frans L. Moll, MD, PhD,**[b] **Joep A. W. Teijink, MD, PhD,**[d] and **Joost A. van Herwaarden, MD, PhD,**[b] *Heerlen, Utrecht, Nieuwegein, and Eindhoven, The Netherlands*

Introduction: **Anastomotic pseudoaneurysms and true para-anastomotic aneurysms after initial open abdominal aortic prosthetic reconstruction often need reintervention because they are at risk for rupture. However, open surgical reinterventions are technically challenging procedures with high mortality and morbidity rates. In the present multicenter study, we describe the long-term clinical course in an expanded number of patients who underwent endovascular repair of para-anastomotic aneurysms after previous open reconstruction.**

Methods: **The study included all patients who were treated with an endovascular stent graft between July 1999 and July 2009 for an aortoiliac anastomotic pseudoaneurysm or a true para-anastomotic aneurysm after previous aortic prosthetic reconstruction for aneurysmal or occlusive disease in one of the four participating centers. Main outcomes were long-term complications, reinterventions and conversion rate, mortality, and hospital length of stay.**

Results: **An endovascular stent graft was used to treat 58 patients (53 men; mean age, 71 ± 9 years), with 80 aortic or iliac pseudoaneurysms or true para-anastomotic aneurysm, or both. Bifurcated stent grafts were used in 32 patients, endovascular tube grafts in eight, aortouniiliac stent grafts in seven, and iliac extension grafts in 11. Stent graft deployment was successful in 55 patients, for a technical success rate of 95%. Median hospital admission was 3 days (range, 1-122 days). The 30-day and in-hospital mortality rates were 3.4% (n = 2) and 6.9% (n = 4), respectively. The 30-day clinical success rate was 91% (n = 53). Median follow-up was 41 months (range, 0-106 months). The cumulative and procedural-related mortality during follow-up was 19% (n = 11) and 10% (n = 6), respectively. Follow-up computed tomography angiography revealed nine endoleaks (three type I; six type II) in eight patients and endotension in two patients. The overall reintervention and conversion rate during follow-up was 26.9% (n = 15) and 6.9% (n = 4), respectively. Life-table analysis showed reduced freedom from reintervention for aortouniiliac and tube stent grafts. Type I endoleaks were observed in 25% of patients with endovascular aortic tube grafts for proximal anastomotic aneurysms.**

Conclusions: **The present study demonstrates that endovascular repair of para-anastomotic aortic and iliac aneurysms after initial prosthetic aortic surgery is safe and durable in patients with an appropriate anatomy. The long-term follow-up showed fewer complications occurred after procedures with bifurcated stent grafts compared with procedures with tube grafts, aortouniiliac, or iliac extension stent grafts. (J Vasc Surg 2011;54:1571-9.)**

Conventional aortic prosthetic reconstruction for repairs of abdominal aortic aneurysm (AAA) or aortoiliac obstructive disease is considered to be a durable procedure and is still widely performed. A typical complication after conventional aortic prosthetic reconstruction is para-anastomotic aneurysm (PAA) formation. PAAs after previous open reconstruction may present as continuing dilatation of the aortoiliac arteries adjacent to the anastomosis (true PAAs) or as a disruption of the anastomosis leading to pseudo-PAA formation (false PAAs).[1] The reported incidence varies widely. In a retrospective 15-year follow-up study of 208 patients, proximal and distal aortic PAAs occurred in six (2.9%) and 18 patients (8.7%), respectively.[2]

Most open reinterventions after initial abdominal aortic prosthetic reconstruction are for repairs of pseudo-PAA and true PAAs because they are at risk for rupture.[2,3] However, these open surgical reinterventions are technically challenging, with mortality rates of 8% to 70% and morbidity rates of 70% to 83%, which are considerably higher than the rates associated with primary prosthetic reconstructions.[4-8]

Endovascular PAA repair (EVPAR) allows for local or regional anesthesia without requiring dissection through the scars of previous operations and might be preferred instead of repeated open repair.[9] Except for case reports, a few small case series have suggested that endovascular exclusion of noninfected PAAs after previous abdominal aortoiliac surgery is feasible, with low perioperative mortality and morbidity.[9-15] Earlier, we showed that EVPAR is effective with bifurcated stent grafts.[9] However, larger

From the Department of Vascular Surgery at Atrium Medical Center Parkstad, Heerlen[a]; University Medical Center Utrecht, Utrecht[b]; St. Antonius Hospital Nieuwegein, Nieuwegein[c]; and Catharina Hospital Eindhoven, Eindhoven.[d]

Competition of interest: none.

Presented at the 2010 Vascular Annual Meeting of the Society for Vascular Surgery, Boston, Mass, June 10-13, 2010.

Reprint requests: J.A. van Herwaarden, MD, PhD, Department of Vascular Surgery, Rm G.04.129, University Medical Center, PO Box 85500, 3508 GA Utrecht, the Netherlands (e-mail: j.a.vanherwaarden@umcutrecht.nl).

The editors and reviewers of this article have no relevant financial relationships to disclose per the JVS policy that requires reviewers to decline review of any manuscript for which they may have a competition of interest.

0741-5214/$36.00

doi:10.1016/j.jvs.2011.04.072

series with longer-term follow-up are necessary to confirm the long-term effectiveness of this approach.[9,10,12]

In the present multicenter study, we describe the long-term clinical course in an expanded number of patients who underwent EVPAR after previous open reconstruction.

MATERIALS AND METHODS

Patients. Four centers in the Netherlands participated in the study: Atrium Medical Center Parkstad, University Medical Center Utrecht, St Antonius Hospital Nieuwegein, and Catharina Hospital Eindhoven. The study included all patients who were treated with an endovascular stent graft between July 1999 and July 2009 for an aortic or iliac false PAA or true PAA after previous aortic prosthetic reconstruction for aneurysmal or occlusive disease. The short-term follow-up of 14 patients included in the current study was described previously.[9]

Variables analyzed included age, sex, comorbidities, initial aortic pathology, graft configuration at the initial open reconstruction, time between the initial open prosthetic reconstruction and the endovascular repair, PAA characteristics, stent graft configuration at endovascular repair, hospital admissions, survival, complications, reinterventions (freedom from reinterventions), and conversion rate during follow-up.

Diagnostic studies and operative technique. All patients underwent a preoperative contrast-enhanced spiral computed tomography angiography (CTA) scan with a slice thickness of 1.5 to 3 mm or digital subtraction angiography (DSA), or both, to confirm the presence of a PAA and to evaluate its anatomic characteristics. Criteria for PAA intervention were 1.5 times the diameter of the nondiseased aorta or iliac artery at that segment, symptoms of acute onset of abdominal or back pain combined with pain at aneurysm palpation (symptomatic PAA), and signs of contained rupture on preoperative CTA or DSA.[16]

Criteria for EVPAR were proximal aortic neck length of ≥10 mm between the lowest renal artery and the beginning of the aneurysm, proximal aortic neck or iliac artery angulation <90°, lack of circumferential calcification or thrombus of the aortic neck or iliac arteries, and adequate iliac-femoral access to the PAA. During the study period, endovascular repair was preferentially performed in anatomically suitable PAAs. The exclusion criterion for endovascular repair was anatomic unsuitability.

General, regional, or local anesthesia was used. Groin incisions with open femoral arteriotomy were performed to gain access to the common femoral artery. Endovascular devices used were AneuRx (Medtronic, Sunnyvale, Calif), Endurant (Medtronic), Excluder (W. L. Gore and Associates, Flagstaff, Ariz), Quantum LP/Fortron (Cordis Corp, Warren, NJ), Relay (Bolton Medical, Sunrise, Fla), Talent (Medtronic), Valiant (Medtronic), and Zenith (Cook Vascular, Bloomington, Ind). Tube grafts, aortouniiliac stent grafts, and bifurcated stent grafts were used. The device type was chosen according to anatomic suitability, preferences of the vascular surgeon, availability of the type of stent graft of suitable caliber at the time of the procedure in each participating center, and PAA location and configuration, including aortic neck diameter and length as well as the presence of iliac stenosis or occlusion.

Tube grafts were used exclusively for proximal PAAs, whereas bifurcated or aortouniiliac stent grafts were used to treat patients with proximal or distal PAAs, or both. Aortouniiliac stent grafting was combined with a femorofemoral crossover bypass to restore blood flow to the contralateral leg and with an occluder in the contralateral common iliac artery to prevent back bleeding into the aneurysm sac. Exclusion in patients with a single iliac PAA and a proximal iliac sealing zone of at least 0.5 cm was obtained by placement of an endovascular iliac extender graft.

In patients with a proximal PAA of the abdominal aorta, the covered portion of the endovascular device was proximally anchored just below the lowest renal artery for optimal sealing in the native aortic neck above the lesion. The distal fixation for an endovascular tube graft was in the previous graft, with overlap of the endovascular device and the previous graft of at least two stent rings. For a bifurcated or aortouniiliac stent graft, the common iliac artery was used as distal landing zone in most patients. If the PAA was near the hypogastric artery, the stent graft was extended in the external iliac artery after embolization of the hypogastric artery. According to the instructions for use, all stent grafts were oversized at least 10% to 20%.

Surveillance protocol. Postoperatively, all electively treated patients went to a regular ward or medium care unit where they were fed a normal diet and started ambulating on the first postoperative day. Some patients who were endovascularly treated for a ruptured PAA initially went to an intensive care unit for close monitoring. Postdischarge surveillance after EVPAR included basic laboratory testing for renal function, physical examination, and triple-phase (nonenhanced, arterial, and delayed-phase) CTA scans before discharge or ≤3 months, at 12 months, and yearly thereafter. In patients with significant renal insufficiency (glomerular filtration rate <40 mL/min), a renal protection protocol consisting of prehydration and administration of acetylcysteine was used before and after CTA. Otherwise, noncontrast CT scanning, combined with contrast-enhanced ultrasound imaging, was performed at the discretion of the vascular surgeon and scheduled at the same intervals as the regular EVAR protocol.

Statistical analyses. Data were collected and analyzed using SPSS 15.0 software (SPSS Inc, Chicago, Ill). Categoric variables are presented as frequency and percentages. Continuous variables are presented as mean ± standard deviation for a normal distribution, or as median and range for a skewed distribution. Survival and freedom from reintervention after EVPAR was evaluated using Kaplan-Meier curves, log-rank tests, and annual risk with the related standard error (SE).

RESULTS

Patients. From July 1999 to July 2009, 58 patients (53 men; mean age, 71 ± 9 years) with 80 aortic or iliac pseudo-PAA or true PAAs, or both, were treated with an

Table I. Baseline characteristics and clinical details after initial open conventional tube and bifurcated graft

	Graft type		
Variables[a]	*Tube (n = 28)*	*Bifurcated (n = 30)*	*All (n = 58)*
Baseline characteristics			
Age	68 (62-78)	74 (65-78)	73 (63-78)
Male	26 (93)	27 (90)	53 (91)
Comorbidity	25 (89)	26 (87)	51 (88)
Cardiovascular[b]	25 (89)	25 (83)	50 (86)
Pulmonary	8 (29)	12 (40)	20 (35)
Renal	5 (18)	6 (20)	11 (19)
Serum creatinine, μmol/L	95 (91-115)	116 (98-165)	115 (95-161)
ASA class	3 (2-4)	3 (2-4)	3 (2-4)
1	0 (0)	0 (0)	0 (0)
2	9 (32)	8 (27)	17 (29)
3	12 (43)	10 (33)	22 (38)
4	7 (25)	12 (40)	19 (33)
Latency time, years[c]	7 (4-11)	16 (12-21)	13 (6-18)
Clinical details			
PAA, No.	42	38	80
Proximal			
Pseudo-PAA	9	10	19
True PAA	0	0	0
Distal			
Pseudo-PAA	7	25	32
True PAA	26	3	29

ASA, American Society of Anesthesiologists; *PAA,* para-anastomotic aneurysm.
[a]Data are presented as number (%) or as median (interquartile range).
[b]Other than previous aneurysmal or occlusive aortic disease.
[c]Time between initial open prosthetic surgery and endovascular PAA repair.

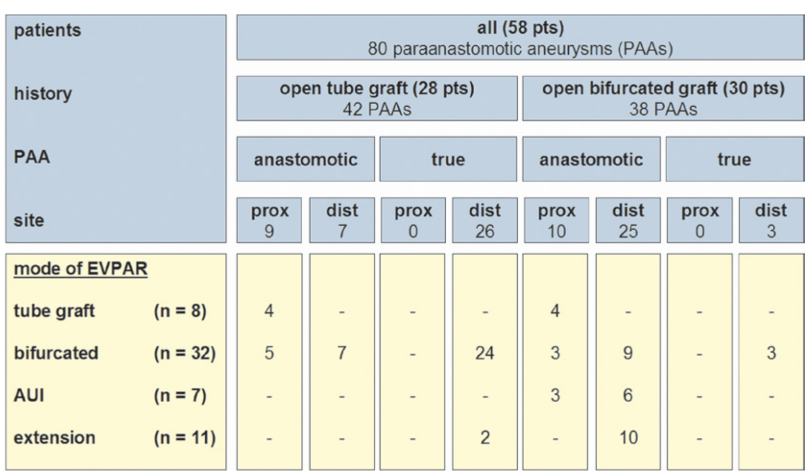

Fig 1. Flow chart shows the stent grafts (*yellow*) that were used for different localizations of anastomotic and true para-anastomotic aneurysms (*PAA*s) after previous open tube or bifurcated graft (*blue*). *AUI,* Aortouniiliac; *EVPAR,* endovascular para-anastomotic aneurysm repair.

endovascular stent graft. Of these, 54 patients (93%) were initially treated for aneurysmal disease and four (7%) for occlusive aortoiliac disease, of which two had end-to-end and two had end-to-side anastomoses. Twenty-eight patients were conventionally treated with a tube graft to exclude an AAA and 30 with a previous bifurcated prosthesis or bifurcated bypass. Baseline characteristics and clinical details of these patients are described in Table I.

In patients with a previous tube graft, 42 PAAs were present, including pseudoaneurysms at the proximal (n = 9) or distal (n = 7) anastomosis, and true iliac aneurysms at one (n = 6) or both sides (n = 10; Fig 1). In patients initially treated with a conventional bifurcated prosthesis, 38 PAAs were present, including pseudoaneurysms at the proximal aortic anastomosis (n = 10), at one (n = 19) or both (n = 3) distal iliac anastomosis, and unilateral (n = 1) or bilateral (n = 1) true iliac aneurysms.

Table II. Types of endovascular stent grafts that were used

	Graft type			
Device	*Tube*	*Bifurcated*	*Aortouniiliac*	*Extension*
AneuRx	1	8	0	1
Talent	3	19	7	6
Endurant	0	1	0	0
Valiant	1	0	0	0
Zenith	1	1	0	1
Quantum LP	0	1	0	0
Gore Excluder	1	2	0	3
Relay	1	0	0	0
Total	8	32	7	11

Aneurysm diameters ranged from 3.4 to 11.0 cm for aortic pseudoaneurysms, from 1.5 to 8.3 cm for iliac pseudoaneurysms, and from 2.1 to 7.5 cm for true iliac aneurysms.

The PAAs in 40 patients were detected by a routine surveillance protocol that included ultrasound imaging 1 year after open aortic surgery and every 3 or 5 years thereafter. The PAAs in five patients were incidentally detected by diagnostic imaging that was performed for purposes other than surveillance after open AAA repair. Eight patients presented with a symptomatic PAA, and five with a ruptured PAA. None of the patients in this series had symptoms or signs at CT suggesting graft infection.

Through preoperative risk assessment of pre-existent disease, 17 patients were classified as American Society of Anesthesiologists (ASA) 2, 22 were ASA 3, and 19 were ASA 4. At baseline, cardiovascular comorbidity was present in 50 patients (86%) and pulmonary comorbidity in 21 patients (36%).

Endovascular intervention. The median interval between the initial open reconstruction and EVPAR was 12.5 years (range, 1-25 years). EVPAR was performed with general anesthesia in 38 patients, spinal anesthesia in 17, and local anesthesia in three. An endovascular tube graft was used in eight patients, a bifurcated stent graft in 32, an aortouniiliac stent graft in seven, and an iliac extension graft in 11 (Fig 1). Devices that were used are listed in Table II. Median procedure time was 120 minutes (range, 45-355 minutes), and median blood loss was 250 mL (range, 30-1900 mL). The median radiation time was 23 minutes (range, 3-66 minutes), and median contrast dose administration was 87 mL (range, 20-150 mL).

No patients died during the EVPAR procedure. Stent graft deployment was successful in 55 patients for a technical success rate of 95%. One patient needed an adjunctive surgical procedure. In this patient, access to the retroperitoneum was gained to ligate the contralateral limb of the previous open bifurcated graft after successful aortouniiliac endoprosthesis placement for a ruptured proximal PAA.

In three patients (5%), primary stent graft deployment was unsuccessful, of whom one needed an additional laparotomy. In this patient, the short contralateral leg of the bifurcated stent graft was deployed accidentally in the ipsilateral limb of the primary existing bifurcated graft. The bifurcated stent graft was then converted into an aortouniiliac stent graft by extending the graft to the right external iliac artery. A suitable endovascular occluder was not available, so a laparotomy was performed for ligation of the right hypogastric artery and the left common iliac artery to prevent back bleeding into the aneurysm sac. A femorofemoral crossover bypass was placed to restore blood flow in the left leg.

The secondary technical success rate was 97%. In the two other patients with unsuccessful stent graft deployment, one (n = 1) or both (n = 1) renal arteries were inadvertently overstented during stent graft deployment by a tube and bifurcated stent graft, respectively. No type I or III endoleaks were observed at completion angiography. There were no statistically significant differences in the primary ($P > .99$) or secondary success rate ($P > .99$) between patients included in the first or final 5 years of the study period.

Other events during EVPAR were type II endoleaks at angiography at the end of the procedure in four patients, of which one type II endoleak was still present on the predischarge CTA. The left hypogastric artery in one patient was inadvertently covered by the stent graft.

Hospital stay. Median hospital stay was 3 days (range, 1-122 days). The in-hospital and 30-day mortality rates were 6.9% (n = 4) and 3.4% (n = 2), respectively, all in patients with successful stent graft deployment. Two of these four patients were treated for a ruptured PAA. Causes of death were pulmonary insufficiency (day 8), progressive cardiac failure (day 8), pulmonary insufficiency combined with sepsis (day 55), and sepsis after repetitive infections and occlusion of a femorofemoral crossover bypass (day 122). This last patient underwent several reinterventions for critical limb ischemia.

The 30-day clinical success rate was 91% (n = 53). In five patients, 30-day clinical success was not achieved because of death (n = 2), overstenting of both renal arteries causing progressive renal insufficiency (n = 1), distal type I endoleak present on predischarge CTA (n = 1), for which close observation was initiated, and hemodynamic shock (n = 1) caused by rupture of the left external iliac artery after PAA repair for which an extension cuff was placed successfully. An abdominal compartment syndrome developed in this last patient due to a retroperitoneal hematoma, and abdominal decompression was required the next day.

Follow-up. Median follow-up was 41 months (range, 0-106 months). No patients were lost to follow-up. The cumulative mortality during hospital stay and follow-up was 19% (n = 11). Overall, median follow-up until death was 13 months (range, 0-106 months). Patient survival is illustrated using a Kaplan-Meier curve (Fig 2), which shows the annual risk of death was 4.0%. Two of seven deaths during follow-up were procedure-related. In one patient, slight aneurysm expansion (3 mm), without signs of an endoleak, was observed on CTA at 12 months after endovascular treatment with a tube stent graft for a proximal pseudo-PAA. A wait-and-see policy was followed, but this

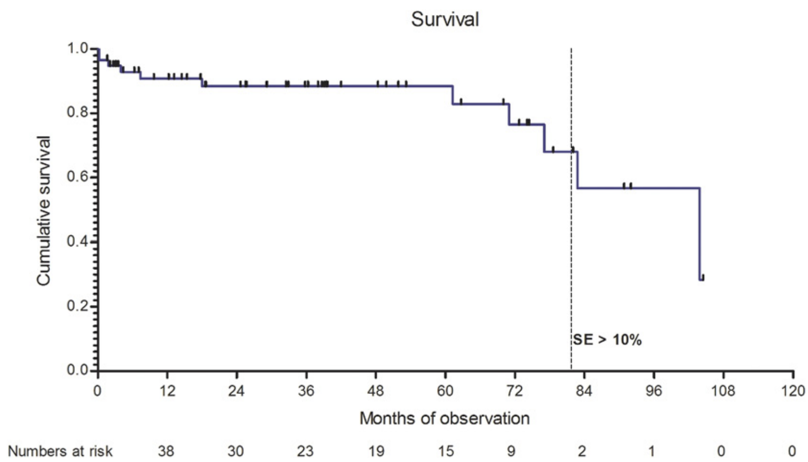

Fig 2. Kaplan-Meier curve shows survival after endovascular para-anastomotic aneurysm repair. The *dashed line* indicates when the standard error exceeds 10%.

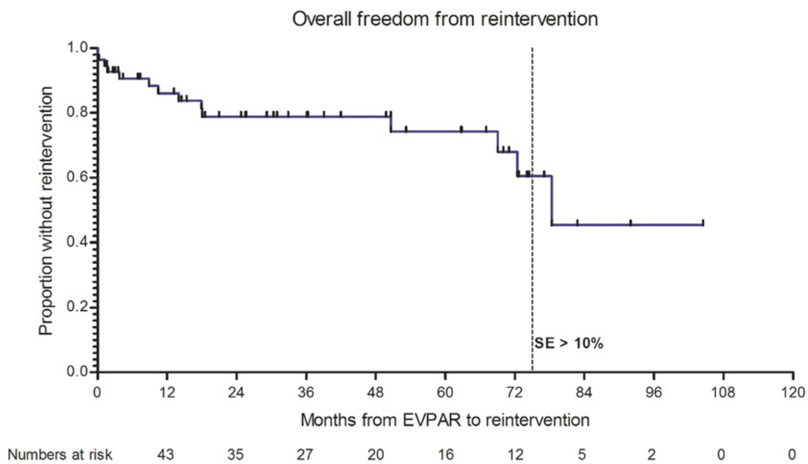

Fig 3. Kaplan-Meier curve shows freedom from reintervention after endovascular para-anastomotic aneurysm repair (*EVPAR*) for all stent grafts that were used. The *dashed line* shows when the standard error exceeded 10%.

resulted in acute aneurysm rupture at 18 months that needed acute reintervention, including explantation of the endovascular graft and placement of an open bifurcated prosthesis. The patient died the next day from bowel ischemia. The other patient, whose renal artery was overstented during the endovascular procedure, suffered from postoperative progressive hemodialysis-dependent renal insufficiency. At 51 months, successful conversion to open repair was performed for a type Ia endoleak. However, this patient decided to stop hemodialyses and died at 106 months of follow-up.

Complications occurred in 13 patients (22%) during follow-up. Two patients died due to procedure-related complications, as described above. Hydronephrosis occurred in one patient as the result of external ureter compression by a PAA in the iliac artery. In the other 10 patients (17%), reinterventions were performed for stent graft occlusion in four patients who needed thrombectomy or thrombolysis, followed by percutaneous transluminal angioplasty (PTA) in three patients and replacement with a synthetic prosthesis in one patient; infection of a femorofemoral crossover bypass that was replaced by a venous bypass in one, access site infection and bleeding of a patch in the groin in two, type B dissection for which an aortouniiliac stent graft was placed in one, distal type I endoleak (which had been detected on predischarge CTA, as described previously) of a bifurcated stent graft for which an iliac extension graft was placed in one, and endotension for which the stent graft was converted to a bifurcated prosthesis in one.

During total follow-up, including hospital stay, reintervention was performed in 15 patients (25.9%) at a median of 11 months (range, 0-80 months). The Kaplan-Meier curve for freedom of reintervention after endovascular PAA repair (Fig 3) showed an overall annual risk of reintervention of 5.8% (SE, 0.088). The log-rank test for equality of reintervention distributions between differences in original presentation of PAAs (Fig 4, *A*) showed no significant

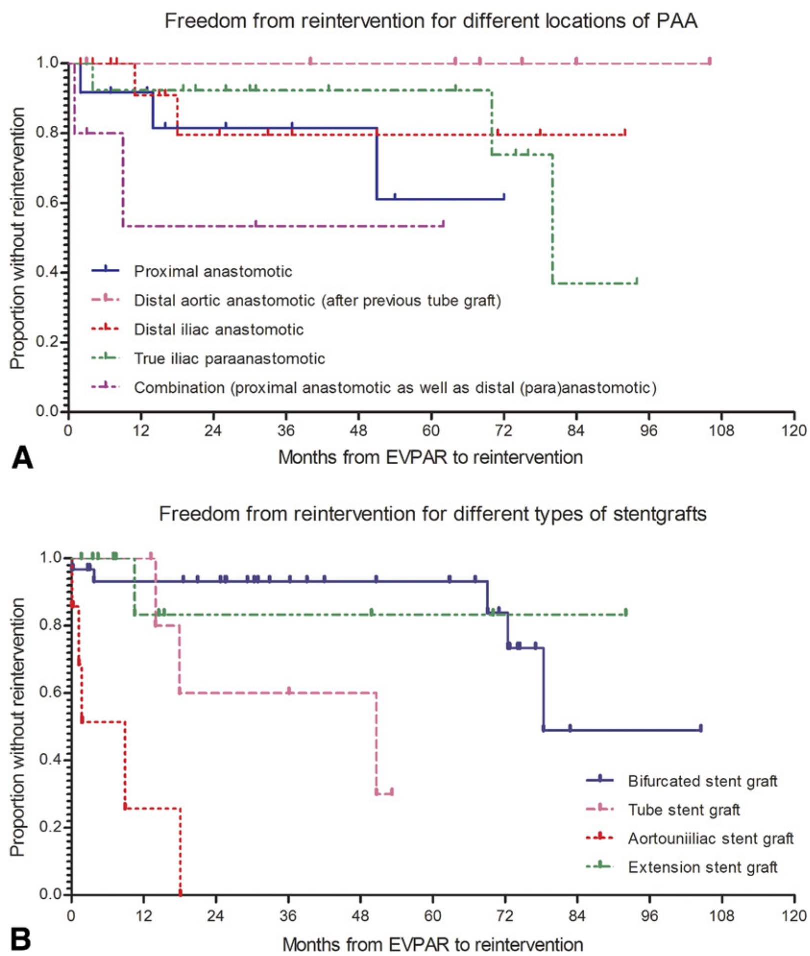

Fig 4. Kaplan-Meier curve shows freedom from reintervention after endovascular para-anastomotic aneurysm repair (*EVPAR*) for **(A)** different locations of para-anastomotic aneurysm (*PAA*) formation and **(B)** the different stent grafts that were used.

differences in freedom from reintervention curves during follow-up ($P = .131$). Log-rank test analysis of freedom from reintervention during follow-up for different stent graft configurations (Fig 4, *B*) showed a significantly larger proportion of tube and aortouniiliac stent grafts needed reintervention during follow-up ($P < .001$). The annual reintervention risk (SE) was 3.2% (0.098%) for bifurcated stent grafts, 16.6% (0.239%) for tube grafts, 66.4% (<0.001%) for aortouniiliac stent grafts, and 19.1% (0.152%) for distal iliac extension grafts. Furthermore, the 30% reintervention rate in patients who underwent EVPAR during the first 5 years of the study was comparable with the 23% rate in patients treated during the final 5 years ($P = .560$).

Four patients (6.9%) required conversion to open repair at a median follow-up of 16 months (range, 4-51 months). Two patients needed conversion for endotension, which caused an aneurysm rupture in one patient. In one patient, an endovascular tube graft was replaced by an open tube graft at 51 months after EVPAR for persistent type Ia endoleak. Finally, an axillobifemoral prosthesis was placed in one patient for occlusion of a bifurcated stent graft at 4 months after placement for bilateral true iliac PAAs. Mortality was 50% (two of four) in patients who underwent conversion to open aneurysm repair vs 0% (zero of five) in patients who underwent an endovascular reintervention ($P = .167$).

During follow-up, CTA revealed nine endoleaks (one type Ia, two type Ib, and six secondary type II endoleaks) in eight patients. In one patient, type Ia endoleak was observed after migration of the previously described bifurcated stent graft, which was converted to an aortouniiliac stent graft during EVPAR. Type Ib endoleak was observed in two patients at the distal fixation side of the endovascular tube graft, resulting in replacement of the stent graft by an open tube graft in one patient, as described above. Of the six secondary type II endoleaks, two disappeared spontaneously during follow-up, and the other four received close observation. None of these patients needed reintervention and the AAA did not grow. Endotension was observed in two patients treated with an endovascular tube graft for a proximal PAA, resulting in conversion to open surgical repair in one patient and acute aneurysm rupture in the other patient, as described previously.

DISCUSSION

The reported incidence of PAAs after previous conventional aortic reconstruction varies widely, from 0.5 to 15%.[17,18] This is probably an underestimation, because most patients who undergo open aortic repair do not receive regular imaging surveillance follow-up. PAAs are associated with high rupture rates of 15% to 55% in patients who do not undergo revision surgery.[8,19,20] The rupture risk of pseudo-PAAs might be even more unpredictable compared with true PAAs,[1] with a mortality rate of 61% in the absence of an intervention.[5]

EVPAR allows for local or regional anesthesia without requiring dissection through the scars of previous operative sites.[9] However, EVPAR has some drawbacks, including inadequate proximal or distal fixation zones,[21] showing the importance of accurate preoperative sizing and planning, as well as potential stent graft deformation in patients with previous end-to-side anastomoses.

Several case series describing endovascular management of PAAs and iliac aneurysms have considered this treatment as feasible and safe.[9-15,22,23] However, the available series describing endovascular repair included a small number of patients, and follow-up time was relatively short. The report by Sachdev et al[16] included 53 patients with PAAs treated with EVPAR at a mean follow-up of 18.1 months, excluding patients who were lost to follow-up. However, they studied a mixture of thoracic and abdominal PAAs.

Reported mortality rates of open PAA reconstruction vary widely, from 8% to 70%, with morbidity rates of 70% to 83% reported for open PAA reconstruction.[4-8] One report compared 16 open repairs with 10 EVPAR procedures in patients who were candidates for endovascular repair, showing higher morbidity and complication rates after open repair than after EVPAR.[24] Furthermore, blood loss, procedural time, and hospital length of stay were significantly reduced for EVPAR. The results of the present study focus on durability of EVPAR with different types of stent grafts, with extended follow-up time and more patients.

The present study, with a follow-up up to 106 months, showed endovascular management of PAA and iliac aneurysms is a feasible and durable alternative to open reconstruction. In 95% of patients treated with EVPAR after previous open aortic reconstruction, stent graft deployment was successful (primary technical success rate). Perioperative mortality and morbidity rates in patients (70% with ASA class ≥ 3) were acceptable, with an intraoperative mortality of 0%, 30-day mortality of 3.4%, and in-hospital mortality of 6.9%. Exclusion was successfully maintained during follow-up, without signs of endoleak, in 86% of the PAAs. Furthermore, in patients who needed conversion to open repair after EVPAR, there was a clear trend toward a higher mortality rate compared with patients who underwent an endovascular reintervention.

The technical success rates and effective aneurysm exclusion rates reported in the present study are notable because 13 patients with symptomatic or ruptured PAAs were included in this experience. This observation suggests that although careful adherence to stringent selection criteria for endovascular repair is important, this approach can be applied in more urgent settings where preoperative planning may be less thorough.

Several patients in the present study who had aortoiliac PAAs with relatively small diameters were treated with endovascular repair. Indications for treatment in these patients were symptoms or rupture of the aneurysm, or aneurysm growth during routine follow-up after primary open prosthetic reconstruction.

In the present study, there were no statistical significant differences in durability between endovascular repair in proximal aortic anastomotic, distal aortic anastomotic, distal iliac anastomotic and true distal PAAs after previous open aortic reconstruction (Fig 4, *A*). However, the studied numbers were low for subgroup analysis, and Fig 4, *A* gives the impression of a slight nonsignificant trend towards better durability in freedom from reintervention after endovascular repair of anastomotic distal aortic aneurysms (after previous open tube graft placement) and anastomotic distal iliac aneurysms.

When comparing different types of stent grafts in all included patients (Fig 4, *B*), the endovascular reconstruction was less durable in patients treated with aortouniiliac and tube stent grafts for proximal aortic PAAs. The main causes for reintervention in aortouniiliac stent grafts were infections of the femorofemoral crossover bypass and stent graft occlusion. In patients treated with an endovascular tube graft, the main cause of reintervention was endoleak type I, caused by insecure distal anchoring of the stent graft in the previous polyester graft, or endotension. Therefore, when endovascular tube grafts are used for proximal anastomotic aneurysms, the distal fixation site has to be long enough for secure distal anchoring of the tube graft in the previous polyester prosthesis. Or when the proximal anchoring site is short, efforts have to be done to implant a bifurcated stent graft. Follow-up showed the proximal fixation site of the aortouniiliac or bifurcated stent grafts in the previous polyester graft was secure, probably due to the longitudinal columnar support in these types of stent grafts. Stent grafts that were fixated proximally and distally in the native aorta or iliac vessels were all secure.

Although original anatomical presentation of PAAs did not influence long-term durability results significantly (Fig 4, *A*), results from different types of stent grafts that were used (Fig 4, *B*) have to be interpreted with caution due to the limited numbers of cases and anatomic variation influencing stent graft selection. Stent graft selection for endovascular PAA repair should not merely be based on the reported differences in outcome between the various stent grafts, as demonstrated in the present study, but should rather be an individualized approach in which these results are addressed in the view of anatomic considerations.

CONCLUSIONS

The present multicenter study confirms that EVPAR after initial prosthetic aortic surgery is a feasible and safe alternative to open reconstruction, with relatively low perioperative mortality and morbidity in selected cases. At long-term follow-up, treatment with bifurcated stent grafts was durable, with low reintervention rates. Aortouniiliac stent grafts and endovascular tube grafts appeared less durable, requiring more reinterventions. The long-term results of EVPAR in these 58 patients show that endovascular exclusion of anatomically suitable PAAs with bifurcated stent grafts can be considered as the first-choice treatment option. However, EVPAR requires an individualized approach that takes anatomic considerations into account.

AUTHOR CONTRIBUTIONS

Conception and design: JTB, EW, JD, FM, JT, JV
Analysis and interpretation: JTB, EW, JD, JT, JV
Data collection: JTB, EW
Writing the article: JTB, EW, JV
Critical revision of the article: EW, JD, FM, JT, JV
Final approval of the article: JTB, EW, JD, FM, JT, JV
Statistical analysis: JTB, JD, JV
Obtained funding: Not applicable
Overall responsibility: JV

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Submitted Nov 23, 2010; accepted Apr 19, 2011.

INVITED COMMENTARY

Todd E. Rasmussen, MD, USAF MC, *San Antonio, Tex*

This study from Ten Bosch et al reports the technical success and outcomes after endovascular para-anastomotic aneurysm repair (EVPAR) for the most common graft-related complication after aortic reconstruction: anastomotic pseudoaneurysms and true arterial aneurysms.[1] This experience includes 3-year outcomes on patients having been treated for a range of aneurysm pathology >12 years after aortic operation; including 13 who underwent EVPAR for symptomatic or ruptured aneurysms. The 95% techni-