Endovascular treatment of abdominal aortic aneurysms with the Powerlink Endograft System: Influence of placement on the bifurcation and use of a proximal extension on early and late outcomes

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Objective: **We evaluated the influence of placement of the bifurcated Powerlink endograft (Endologix Inc, Irvine, Calif) on the aortic bifurcation, with the addition of a proximal extension, in the endovascular treatment (EVAR) of selected patients with atherosclerotic abdominal aortic aneurysms (AAAs).**

Methods: **From September 1999 to June 2007, 205 patients were treated with the bifurcated Powerlink endograft for atherosclerotic AAA at two Italian centers with shared protocols. Patients were retrospectively divided in two groups according to treatment with the bifurcated graft only (n = 126), or its placement on the bifurcation with the addition of a proximal extension (n = 79) at the initial procedure. Study end points included postoperative complications, secondary procedures, immediate and late conversion, migration, endoleak, death, and aneurysmal sac behavior.**

Results: **Overall technical success was 98.5%. Additional procedures were performed in 18%, and postoperative complications occurred in 11.2% (systemic, 8.3%; local, 2.9%). Median follow-up was 42.4 months (range, 6-94 months). Secondary procedures were recorded in 11.2%, migration in 3.9%, type I proximal endoleak in 7.8%, and late conversions in 2.4%. Placement on the bifurcation and the addition of an extension were associated with a higher incidence of postoperative complications (7.1% vs 17.7%, $P = .020$). A reduced incidence of endoleak (19% vs 8.9%, $P = .048$), secondary procedures (14.3% vs 6.3%, $P = .04$), and migration (6.3% vs 0%, $P = .024$) were observed in the group with a proximal extension. Analysis of single variables reveals that migration was significantly influenced by placement of the graft on the bifurcation (47% vs 0%, $P < .001$). Both placement on the bifurcation and the addition of an extension positively influenced the type I proximal endoleak rate (3.8% vs 35.3% $P < .001$) and the need for a secondary intervention (6.3% vs 35.3% $P < .001$) Two aneurysm ruptures and five cases of late conversion occurred in the group treated with a bifurcated graft only (4%, $P = .52$, $P = .159$). Analysis of aneurysm sac behavior was not statistically significant: enlargement, 4.1% vs 1.3% ($P = .158$); reduction, 34.1% vs 40.5% ($P = .542$).**

Conclusion: **The placement of the bifurcated Powerlink endograft on the aortic bifurcation with a proximal extension for complete sealing seems to improve late outcomes, particularly secondary procedures, migration, and endoleak development. Larger prospective studies with longer follow-up are necessary to confirm these promising results. (J Vasc Surg 2008;48:795-801.)**

Immediate results associated with endovascular treatment (EVAR) for abdominal aortic aneurysms (AAAs) during the 1990s were encouraging,[1-3] but mid-term results of the first- and second-generation endoprosthesis[4-9] called into question the longer-term suitability of the treatment. Hence, commercial manufacturers promptly enhanced the endoprostheses to improve common failures and enhance their efficacy into the mid- to long-term.

Recently, EVAR 1[10] and EVAR 2,[11] multicenter randomized controlled trials comparing open treatment and EVAR for AAA, reported significantly lower rates associated with EVAR for postoperative complications and aneurysm-related postoperative death. Several devices have been evaluated in clinical trials[10-19] and are currently available on the market.

The Powerlink device (Endologix Inc, Irvine, Calif) is a unique, unibody bifurcated endograft that has been commercially available in Europe since 1999. Prospective multicenter[18,19] and single-center trials[20] have studied the safety and efficacy of the device for immediate and mid-term follow-up in selected patients.

We present our study as an analysis of the best deployment technique for the unibody bifurcated Powerlink endograft at primary, elective EVAR in selected low- and high-risk patients with atherosclerotic AAA. The analysis includes the influence on immediate and late outcomes of the addition of a proximal extension and the placement of the main body of the graft at the aortic bifurcation.

METHODS

From September 1999 to June 2007, 283 patients were treated with EVAR using the Powerlink endograft in two Italian centers. Of these, 205 were treated for atherosclero-

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rotic AAA with the bifurcated Powerlink endograft and are the subject of this study. The remaining 79 patients were treated with a straight tube (n = 25), an aortomonoiliac graft (n = 4), and for other abdominal aortic diagnoses (n = 49), such as inflammatory AAA, symptomatic or ruptured AAA, pseudoaneurysms, and dissections.

Anatomic inclusion and exclusion criteria have previously been defined by Carpenter and Albertini.[18-19,21-22] Our treatment group included patients treated outside of these criteria: 4.4% (9 of 205) with abdominal aortic necks that were extremely short (range, 10-14 mm), straight (<30°), and without calcification, and 31% of patients with narrow necks (range, 18-21 mm) or wide necks (range, 27-32 mm). Descriptions of the device and the operative deployment procedures have already been published.[21,23]

All of the patients were studied preoperatively with computed tomography angiography (CTA) (98%) or magnetic resonance angiography (2%). All procedures were performed in a dedicated vascular operating room equipped with mobile C-Arm (OEC 9800, GE Medical System, Salt Lake City, Utah), IVUS (Volcano s5, Rancho Cordova, Calif), and echo duplex scanner (Esaote AU 5, Genova. Italy).

The EVAR teams include two vascular surgeons (at least one endovascular expert), an anesthesiologist, an endovascularly trained operating nurse, and a radiology technician. The centers have two surgeons who work at both locations.

All patients underwent a postoperative abdominal radiography before hospital discharge. Our follow-up protocol in both centers includes a physical examination, abdominal four-view radiography, and CTA at 1, 6, and 12 months, and then a biannual abdominal radiography and annual CTA. Throughout the follow-up, the maximum aneurysm diameter and position of the endograft in relation to the most distal renal artery were measured and recorded in 154 of the 205 patients. In recent years CTA has been replaced with an annual echo duplex scan, reserving the CTA for patients in whom endoleak or anatomic changes are suspected, such as aneurysm diameter enlargement (>5 mm), aortic neck dilation, endograft migration (>5 mm) and kinking, and occlusion of the endograft branch. Aneurysm sac diameter and migration were defined as an enlargement, reduction, or slippage of >5 mm as measured at CT compared with preoperative and intraoperative measurements.

All data were prospectively collected at both centers and registered in an Excel database (Microsoft Inc, Redmond, Wash) managed by the same surgeon.

Patients were retrospectively divided into two groups according to treatment at the primary EVAR: 126 patients had placement of a single endograft (on the aortic bifurcation 72.5% and above the aortic bifurcation 13.5%), and 79 had an endograft procedure with a single unibody bifurcated graft deployed, on the aortic bifurcation, with proximal sealing established with a proximal extension.

Study end points include postoperative complications, mortality at 30 days, secondary procedures, conversion, migration, endoleak, late mortality, and aneurysmal sac behavior throughout the follow-up period.

Table I. Summary of patient demographics, comorbidities, and preoperative aneurysm anatomic features

Variable	*Value*
Patients, No.	205
Age, median years (range)	74 (52-91)
Sex, No.	
Male	192
Female	13
ASA class, %	
1	0.5
2	41.5
3	49
4	9
Comorbidities, %	
Diabetes	14
Smoker	24
Hypertension	66
Hyperlipemia	29
Cardiac disease	53
Carotid disease	10
Renal disease	8
Respiratory disease	20
Previous laparotomy	11
Obesity	15
AAA max diameter, mm (range)[a]	53.78 (39-93)
Neck diameter, mm (range)	23.87 (18-32)
Neck length, mm (range)	26.51 (10-70)

ASA, American Society of Anesthesiologists; *AAA*, abdominal aortic aneurysm.
[a] Including blisters.

Statistical analysis was performed with SPSS 12.0 software (SPSS Inc, Chicago, Ill). The Kaplan-Meier analysis was used for the study of survival. Independent factors affecting outcome were analyzed with binary regression logistics. Covariates resulting with a univariate analysis of >0.10 were inserted into a multivariate model, which were calculated with the c-statistic and Hosmer-Lemeshow. The Cox univariate regression analysis was used to evaluate endoleak and mortality when variables of $P < .10$ were found. The level of significance was considered as $P < .05$.

RESULTS

The bifurcated Powerlink device was used to treat 205 patients with atherosclerotic AAAs. Patient demographics, comorbidities, and preoperative aneurysm anatomic features are reported in Table I.

The main aortic body was placed on the aortic bifurcation in 188 (91.7%). A total of 79 patients (38.5%) were treated with the addition of a proximal extension; of these, 11 were not preoperatively planned but were added intraoperatively due to the presence of a type I proximal endoleak at the final intraoperative angiography, and three patients (1.5%) had both a proximal and distal extension. One patient was also treated with a Palmaz stent (Cordis, Miami Lakes, Fla) to straighten an angulated proximal aortic neck due to a persistent type I proximal endoleak at the postprocedural angiography. Intraoperative events are reported in Table II.

Table II. Operative details

Variable	*EVAR*
Total patients, No.	205
Anesthesia, No.	
General	142
Local	62
Epidural	1
Procedural details (range)	
Fluoroscopy, minutes	9.62 (2-80)
Volume contrast agent, mL	157.94 (20-430)
Duration skin to skin, minutes	78 (50-450)
Endograft fixation site, %	
Infrarenal	68
Suprarenal	32
Endograft composition, % (No.)	
Unibody main body	61.5 (126)
Unibody + proximal extension	37 (79)
Combination (proximal + distal)	1.5 (3)
Intra-op details, % (No.)	
Additional procedures	18 (37)
Conversion	1.5 (3)[a]

[a]One patient died during the operation.

Primary technical success was achieved in 202 patients (98.5%). Immediate conversion was performed in three patients (1.5%). Two endograft technical failures were experienced at the beginning of our experience with the first model device, and the third was due to an unintentional coverage of the renal arteries (Table III). The postoperative mortality rate was 0.5% (1 of 205).

Endoleaks were noted in five patients at the 30-day CT scan (primary endoleak rate of 2.4%) and in 31 patients (15%) at an average follow-up of 42.42 months, with an endoleak-free survival of 79% at 8 years. All endoleak data are reported in Table III. No patients were lost to follow-up, but the measurements of sac behavior for 23.4% were insufficient for full analysis owing to check-ups performed at other centers or with echo duplex scanning.

Secondary procedures were necessary in 23 patients (11.2%), and 31 interventions were required. Surgical procedures were performed in 10 of 31 cases (32%: 5 type I proximal endoleak, 3 type II endoleak, and 2 branch occlusions); and in the remaining 21 cases, late complications were managed by endovascular approaches (68%: 15 type I proximal endoleak, 5 type I distal endoleaks, and 1 thoracic dissection). Five late conversions (2.4%) were performed for persistent type I proximal endoleaks, including four open conversions after attempted EVAR correction of type I proximal endoleak and one EVAR conversion. These five patients had one or more factors of "hostile neck," as defined by Chaikof et al.[24]

The demographic and morphologic characteristics of the two groups were relatively homogeneous, with a higher average age ($P = .097$) and risk in the group of patients with the addition of an extension (Table IV).

The two groups had similar results in early outcomes with respect to intraoperative additional procedures and immediate conversions, but these results are counterpoised by a significant difference in overall postoperative complications in the second group. This difference was significant for local complications (0.8% vs 6.3%) but not for systemic complications (6.3% vs 11.4%; Table IV).

Endograft placement on the bifurcation and the additional deployment of a proximal extension significantly

Table III. Results of endovascular treatment with the Powerlink bifurcated endograft

Variable	*Overall*
Total patients, No.	205
Immediate conversion, % (No.)	1.5 (3)
Successful graft deployment, % (No.)	98.5 (202)
30-day mortality, % (No.)	0.5 (1)
Aneurysm rupture, % (No.)	1 (2)[a]
Late conversion, % (No.)	2.4 (5)[b]
Intra-op additional procedures, % (No.)	18 (37)
Post-op systemic complications, % (No.)	8.3 (17)
Cardiac, No.	3
Renal, No.	3
Pulmonary, No.	2
Postimplantation syndrome, No.	7
Limb thrombosis, No.	2
Post-op local complications, % (No.)	2.9 (6)
Hematoma, No.	2
Infection, No.	2
Pseudoaneurysm, No.	1
Lymphorrhea, No.	1
Reintervention rate	
Overall, % (No.)	12.6 (26)
Post-op ≤30 days, % (No.)	1.5 (3)
Secondary interventions, % (No.)	11.2 (23)
Patients with endoleak, % (No.)[c]	15 (31)
Type I	10.2 (21)
Proximal[a]	7.8 (16)
Distal	2.4 (5)
Type II	7.3 (15)
Type III	0
Type IV	0
Migration	3.9 (8)
Aneurysmal sac behavior, % (No.)	
Augmentation	2.9 (6)
No change	35.6 (73)
Reduction	36.6 (75)
Inconclusive[d]	23.4 (48)
Immediate conversion, No.	3
Hospital stay, mean days (range)	3.79 (1-28)
Overall mortality, % (No.)[e]	10.2 (21)
Aneurysm-related mortality, % (No.)[f]	1 (2)
Major organ failure (post-op), No.	1
Renal insufficiency, No.	1
Non-aneurysm-related mortality, % (No.)	9.2 (19)
Cardiac, No.	6
Cancer/tumor, No.	5
Stroke	4
Respiratory insufficiency	3
Sepsis[g]	1
Average follow-up, months (range)	42.42 (6-93)

[a]Two patients treated for a ruptured aneurysm at 12 and 36 months; no patients died.
[b]Includes 1 endovascular conversion.
[c]5 patients had more than one type of endoleak.
[d]Data on sac aneurysm size was insufficient.
[e]Follow-up was 42 months.
[f]30-day mortality from major organ failure plus aneurysm-related mortality at a distance (renal insufficiency).
[g]Sepsis 2 years after the initial intervention.

Table IV. Endograft configuration: one-piece device compared with the one-piece device plus extension

Variables	*One piece*	*One piece + proximal extension*[a]	P[b]
Patients, No.	126	79	
Mean age, years	72.38	74.94	.097
ASA, %			
2	47	33	.049
3	45	54	.200
4	6	13	.120
Immediate conversion, No.	2	1	>.99
Mortality at 30 days, No.	0	1	
Aneurysm rupture, No.	2	0	.524
Late conversion, % (No.)	4 (5/124)	0	.159
Intra-op additional procedures, % (No.)	17.5 (22/126)	19 (15/79)	.782
Post-op complications, % (No.)	7.1 (9/126)	17.7 (14/79)	.02
Systemic	6.3 (8/126)	11.4 (9/79)	.208
Local	0.8 (1/126)	6.3 (5/79)	.033
Secondary procedures, % (No.)	14.3 (18/126)	6.3 (5/79)	.039
Endoleak, % (No.)[c]	19.0 (24/126)	8.9 (7/79)	.048
Type I	13.5 (17/126)	5 (4/79)	.06
Proximal	10.3 (13/126)	3.8 (3/79)	.09
Distal	3.2 (4/126)	1.3 (1/79)	.651
Type II	9.5 (12/126)	3.8 (3/79)	.125
Migration, % (No.)	6.3 (8/126)	0	.024
Aneurysmal sac			
Immediate conversion, No.	2	1	>.99
No change, % (No.)	36.5 (46/126)	34 (27/79)	.679
Enlargement, % (No.)	4.1 (5/126)	1.3 (1/79)	.158
Reduction, % (No.)	34.1 (43/126)	40.5 (32/79)	.542
Inconclusive, % (No.)[d]	23.8 (30/126)	22.8 (18/79)	.856
Mortality, % (No.)	9.5 (12/126)	12.7 (10/79)	
Follow-up, months (range)	45.69 (6-93)	36.38 (6-93)	

ASA, American Society of Anesthesiologists.
[a]Includes 3 patients treated with both proximal and distal extensions.
[b]Values of $P < .05$ were considered significant.
[c]Five patients had more than 1 type of endoleak.
[d]Information on the aneurysm sac was inconclusive owing to inadequate measurements.

Table V. Significant outcomes analyzed according to placement of the endograft above or on the aortic bifurcation and the use of an extension

	One piece		*One piece + proximal extension*	P *(significance < .05)*		
Variables	*Above Bif*	*On Bif*	*On Bif (cuff)*	*Above Bif vs on Bif*	*Above Bif vs cuff*	*On Bif vs cuff*
Patients, No.	17	109	79			
Endoleak, type I proximal, % (No.)	35.3 (6)	6.4 (7)	3.8 (3)	<.001	<.001	.524
Migration, % (No.)	47 (8)	0	0	<.001	<.001	>.99
Secondary intervention, % (No.)	35.3 (6)	11 (12)	6.3 (5)	.008	<.001	.269

Bif, Bifurcation.

decreased the probability that an endoleak would develop (19% vs 8.9%, $P = .048$), requiring a secondary procedure (14.3% vs 6.3%, $P = .04$), and of endograft migration (6.3% vs 0%, $P = .024$) throughout the follow-up period. There was a trend suggesting a better outcome for late conversions. The two cases (1%) of AAA rupture were recorded in patients treated with a single unibody endograft at 12 and 36 months from the intervention. Both patients had missed the last advised follow-up examination, and both underwent successful conversion to open surgery after type I proximal endoleaks were found at emergency CTA.

The statistically significant late outcomes were analyzed in a further division of the groups according to single variables: a single endograft placed above the aortic bifurcation (n = 17), a single endograft placed on the aortic bifurcation (n = 109), and a single endograft placed on the bifurcation with the addition of an extension (n = 79). The analysis reveals that placement of the device on the bifurcation with the addition of the proximal extension positively influenced all three outcomes (Table V).

Statistical significance was not found between the two groups with regards to aneurysmal sac behavior throughout

the follow-up period, even if a higher percentage of patients in the group with an extension experienced sac shrinkage (34.1% vs 40.5%, $P = .542$) and a lower percentage of sac augmentation (4.1% vs 1.3%, $P = .158$; Table IV). Five of the six cases of graft augmentation were due to type I proximal endoleak and the other to endotension.

Data regarding proximal aortic neck dilation revealed an increase in mean neck dilation throughout the follow-up of 0.4 mm (23.87 mm vs 24.27 mm). A comparatively better result of 0.26 mm was noted in the group with an extension (24.72 vs 24.98 mm) compared with 0.41 mm in the group with a single endograft (23.36 vs 23.77 mm).

The all-cause mortality was similar in the two groups; both groups had two aneurysm-related deaths (Table IV).

DISCUSSION

Authors of published studies[7,18-21,25,26] dedicated to endograft safety and efficacy in the immediate- and mid-term suggest that the unique structural design of the Powerlink device offers advantages in terms of resistance to material fatigue and improved protection from AAA rupture, with lower incidences of endoleak and secondary procedures in selected patients compared with other commercially available endografts. The results of our 8-year experience confirm the feasibility, safety, and relatively positive late outcomes of this device.

The high percentage of technical success and the positive early and late results at follow-up are most likely not only linked to many factors, including patient selection based on anatomic measurements, and skill of the surgical team, but also the structural configuration of the Powerlink endograft system. The uniqueness of the long body design makes it possible for different AAA exclusion techniques: the delivery of a single bifurcated graft close to the most proximal renal artery, independent of the aortic bifurcation, or the main aortic body placed on the bifurcation with proximal sealing with the addition of an extension.

Others authors[18,20] have previously reported their preference of the delivery of the Powerlink endograft placed on the aortic bifurcation, the "anatomic fixation," accompanied with the successive positioning of extensions for adequate proximal sealing to avoid body displacement. These studies, however, focused on an analysis of migration only. Qu et al[20] reported a statistically significant difference in distal migration between patients treated with the Powerlink endograft placed on and placed above the anatomic bifurcation ($P \leq .001$). The French Trial[19] and the American Endologix Investigators[21] both reported three cases each of stent graft migration (4.7% and 2.2%, respectively) in which the endograft was placed above the bifurcation. Our study confirms results supporting the positioning of the endograft on the bifurcation: Migration occurred in eight patients (4%), and all were treated with a single endograft placed above the bifurcation.

In addition, the unique implantation method of the Powerlink endograft often leaves a segment of the diseased aorta uncovered and so explains the relatively high use of proximal extensions in our study of 38.5%, which is in line with other authors who report a range of 36.6% to 56.2%.[19-20,23,26] Regardless of the high percentage of proximal cuffs used, no incidence of migration was reported in this group.

With experience, we developed a preference for the addition of a proximal cuff after placement of the graft on the bifurcation, which we call a "two-step deployment procedure," for various reasons. The data from literature combined with our personal experience proposed the possibility of distal migration of the main body not placed on the bifurcation.[18,20-21] In our study, 11 cases of inadequate proximal sealing were detected after the deployment of the bifurcated graft, and the addition of an extension was therefore necessary. When deployment of the endograft is required close to the most distal renal artery, the use of the proximal extension is more precise.

The retrospective analysis of our experience showed that patients treated with the main aortic body placed on the bifurcation with the addition of a proximal extension showed significantly improved outcomes throughout the follow-up in terms of lower endoleak detection ($P = .048$), a reduced need for secondary procedures ($P = .04$), and a lower migration rate ($P = .024$). These results were achieved despite a lower incidence of immediate conversion or additional intraoperative procedures.

A higher percentage of overall postoperative complications was found in the group with a proximal extension ($P = .02$), but this was only significant for local complications ($P = .033$) and not for the systemic complications. The introduction of more than one device in difficult arterial accesses and the higher exposure time of the femoral artery during a longer procedure could be a possible hypothesis for this unexpected higher incidence of local complications. The group with a proximal extension includes patients with an increased median age and percentage of high-risk patients (American Society of Anesthesiologists category 3 and 4), which could partly explain the different results regarding systemic complications.

Late conversions were all recorded in the group with a single endograft, which may be related to the group's higher detection of endoleak, migration, and secondary procedures. The aneurysmal sac behavior of the group with a proximal extension showed a positive trend towards greater sac shrinkage and reduced sac enlargement. The lower incidence in this group of endoleak and graft migration, which are the most significant events influencing sac behavior, have surely contributed to these results.

An analysis of the influence of the placement of the endograft on the bifurcation or above it and the addition of a proximal extension on late outcomes found that 47% of the endografts placed above the bifurcation migrate. Placement on the aortic bifurcation influences all three statistically significant late outcomes, with no incidence of distal migration (0%), a lower endoleak rate (6.4%), and the need for a secondary procedure (11%). Therefore, the placement of the graft bifurcation on the natural anatomic bifurcation offers improved stability to the device. Further, the addition of the proximal extension seems to again improve the

rate of endoleak (3.8%) and secondary interventions (6.3%). Although the population sizes are small, the data tend to suggest that even if adequate aortic neck coverage is obtained with a single endograft placed on the bifurcation, still greater stability is achieved with the addition of a proximal cuff.

Studies dedicated to the outcome based on the adjoining of endovascular extensions are limited and mostly concern those deployed during a secondary procedure.[7,27-29] Biebl et al[30] evaluated the effects of the adjunctive use of proximal aortic cuffs for EVAR during primary deployment. Their use was not found to affect postoperative survival, type I endoleak rate, or the need for secondary procedures, but was associated with a higher rate of late endograft migration. Hobo et al[26] analyzed data from the European Collaborators on Stent-Graft Techniques for AAA and Thoracic Aortic Aneurysm and Dissection Repair (EUROSTAR) Registry to study the influence of both proximal cuffs and iliac limb extensions at primary EVAR. Data were collected for all types of commercially available endografts, including 123 Powerlink endografts. The cumulative all-graft analysis (mean follow-up, 21.3 months) concluded that the use of proximal aortic cuffs did not influence outcomes. Data collected at our center focuses on a single endograft with specific characteristics collected during a longer (mean, 42.42 months), more accurate follow-up period.

The reasons for different outcomes in the two Powerlink groups are not clear and could be found in the unique structural device conformation. The association of a long aortic body and the placement of the graft bifurcation on the natural anatomic bifurcation seems to offer greater stability to the device. Although the population sizes are small, the data tend to suggest that even if adequate aortic neck coverage is obtained with a single endograft placed on the bifurcation, greater stability is achieved with the addition of a proximal cuff.

The placement of the endograft on the bifurcation and the long aortic body could act against the downward force of pulsatile blood flow, limiting the effect of distal migration, which is one of the major causes of endoleak. The overall 10.2% incidence of type I endoleak in this study is in line with the average 10.5% rate in literature.[31] Thereafter, maintenance of the natural anatomic shape of a long aortic body (with long endograft coverage of the aorta and aortic neck) and the natural bifurcation could preserve natural aortic laminar blood flow.[32] This preservation could reduce the parietal pressure on both the endograft and the aortic wall and, therefore, could positively influence the evolution of the neck and sac behavior over time,[23,33] as supported by data from our study.

Another possible explanation for improved results associated with the deployment of the proximal extension is that the "two-step procedure" permits a more accurate and precise proximal fixation. The deployment systems are different: The main body is deployed from the distal tip to the proximal one, and the extension is deployed conversely, that is, from its proximal tip to the distal one; hence, the proximal extension is considered easier and more accurate to deploy.[23]

A further consideration is that the Powerlink device achieves a modular configuration when a proximal cuff is placed. A long overlap of the segments is mandatory and is favored by the length of Powerlink proximal cuff (5.5, 7.5, and 9.5 mm), minimizing the risk of component separation. With a minimum overlap of 3 cm at our center, no component separation or disconnection was experienced.

Finally, when compared with other modular devices, this kind of "anatomic two-step" deployment, together with the limited diameters and lengths of the main body and cuffs, makes the Powerlink device easier to size and implant.[20] During the implantation process, attention should be mainly focused on the aortic body length; proximal cuffs should be delivered just below the most distal renal artery, resulting in both reduced operative time and volume of contrast medium.[18,19,34]

CONCLUSION

The data from this study suggest that the best deployment method for the Powerlink endograft includes placing of the device on the natural aortic bifurcation, thereby avoiding distal migration and reducing the incidence of proximal endoleak and the need for secondary procedures, with the addition of the proximal extension further improving these late outcomes. Prospective studies with longer follow-up are necessary to confirm these results. The significant difference in late outcomes encourages the selection of the "two-step anatomic" endograft deployment in anatomically suitable conditions as a preferred approach.

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AUTHOR CONTRIBUTIONS

Conception and design: GC, RS, ST, SG, GS, SV
Analysis and interpretation: GC, RS, ST, SG, GS
Data collection: RS, ST, GS, GV
Writing the article: GC, ST
Critical revision of the article: GC, RS, ST, SG, GS, SV
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