Pivotal results of the Medtronic Vascular Talent Thoracic Stent Graft System: The VALOR Trial

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Objective: **This report summarizes the 30-day and 12-month results of endovascular treatment using the Medtronic Vascular Talent Thoracic Stent Graft System (Medtronic Vascular, Santa Rosa, Calif) for patients with thoracic aortic aneurysms (TAA) who are considered candidates for open surgical repair.**

Methods: **The study was a prospective, nonrandomized, multicenter, pivotal trial conducted at 38 sites. Enrollment occurred between December 2003 and June 2005. Standard follow-up interval examinations were prescribed at 1 month, 6 months, 1 year, and annually thereafter. These endovascular results were compared with retrospective open surgical data from three centers of excellence.**

Results: **The Evaluation of the Medtronic Vascular Talent Thoracic Stent Graft System for the Treatment of Thoracic Aortic Aneurysms (VALOR) trial enrolled 195 patients, and 189 were identified as retrospective open surgical subjects. Compared with the open surgery group, the VALOR test group had similar age and sex distributions, but had a smaller TAA size. Patients received a mean number of 2.7 ± 1.3 stent graft components. The diameters of 25% of the proximal stent graft components implanted were <26 mm or >40 mm. Left subclavian artery revascularization was performed before the initial stent graft procedure in 5.2% of patients. Iliac conduits were used in 21.1% of patients. In 33.5% of patients, the bare spring segment of the most proximally implanted device was in zones 1 or 2 of the aortic arch. In 194 patients (99.5%), vessel access and stent graft deployment were successful at the intended site. The 30-day VALOR results included perioperative mortality, 2.1%; major adverse advents, 41%; incidence of paraplegia, 1.5%; paraparesis, 7.2%; and stroke, 3.6%. The 12-month VALOR results included all-cause mortality, 16.1%; aneurysm-related mortality, 3.1%; conversion to open surgery, 0.5%; target aneurysm rupture, 0.5%; stent graft migration >10 mm, 3.9%; endoleak (12.2%), stent graft patency, 100%; stable or decreasing aneurysm diameter, 91.5%; and loss of stent graft integrity, four patients. No deployment-related events or perforation of the aorta by a graft component occurred. The Talent Thoracic Stent Graft showed statistically superior performance with respect to acute procedural outcomes ($P < .001$), 30-day major adverse events (41% vs 84.4%, $P < .001$), perioperative mortality (2% vs 8%, $P < .01$), and 12-month aneurysm-related mortality (3.1% vs 11.6%, $P < .002$) vs open surgery.**

Conclusions: **The pivotal VALOR 12-month trial results demonstrate that the Medtronic Talent Thoracic Stent Graft System is a safe and effective endovascular therapy as an alternative to open surgery in patients with TAA who were considered candidates for open surgical repair. (J Vasc Surg 2008;48:546-54.)**

Conventional open repair of a descending thoracic aortic aneurysm (TAA) remains a major invasive surgical procedure with significant inherent risk. These operations require thoracotomy, aortic clamping, partial aortic bypass to support the circulation, and considerable blood loss with associated transfusions. The surgical mortality rate may approach 12% even when performed by experienced surgeons in patients with good cardiac reserve and who are deemed excellent surgical candidates.[1] Perioperative morbidity in this referenced cohort included spinal cord ischemia in 14%, respiratory failure in 20%, and renal insufficiency in 13% of patients undergoing open repair. These results have been achieved in centers of excellence using an experienced multidisciplinary team both intraoperatively as well as postoperatively, and may not be widely reproducible.

Physicians have embraced thoracic endograft technology with greater zeal than after United States Food and Drug Administration (FDA) approval of the first endovascular devices to treat abdominal aortic aneurysms. The Medtronic Vascular Talent Thoracic Stent Graft System (Medtronic Vascular, Santa Rosa, Calif) is a minimally invasive endovascular device that offers an alternative treatment for patients with TAA. This report summarizes the pivotal 30-day and 12-month results of the Evaluation of the Medtronic Vascular Talent Thoracic Stent Graft System for the Treatment of Thoracic Aortic Aneurysms (VALOR)

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Table I. Anatomic and medical inclusion and exclusion criteria

Inclusion criteria
- Age between 18 and 85
- SVS/AAVS criteria 0, 1, or 2
- Women with negative pregnancy test 7 days before implant
- Fusiform focal TAA ≥5 cm or ≥2 times nonaneurysmal aorta *and/or* focal saccular TAA or penetrating atherosclerotic ulcer
- TAA 20 mm distal to origin of left common carotid artery and 20 mm proximal to the origin of the celiac artery
- Proximal and distal neck diameter 18 to 42 mm
- Proximal and distal aneurysm neck length >20 mm
- TAA confirmed by CTA/MRA with optional three-dimensional reconstruction 3 months before screening
- Subject must be able and willing to undergo follow-up imaging and examinations at 1, 6, and 12 months, and annually thereafter

Exclusion criteria
- Planned placement of the covered portion of the stent graft in zones 0 or 1
- Access vessel precludes safe insertion of the delivery system
- Planned aortic conduit
- TAA with contained rupture
- Connective tissue disease (eg, Marfan syndrome, medial degeneration)
- Mycotic aneurysm or is suspected of having systemic infection
- Previous stent *and/or* stent graft or previous surgical repair in the DTA
- Treatment of an infrarenal aneurysm at the time of implant
- Previous surgical or endovascular treatment of an infrarenal aortic aneurysm
- History of bleeding diathesis, coagulopathy, or refuses blood transfusions
- Vascular interventional procedure or major surgery 30 days before enrollment
- Planned vascular interventional procedure or major surgery ≤30 days of the implant procedure
- Cerebrovascular accident ≤3 months
- Currently participating in an investigational drug or device clinical trial
- Known allergy or intolerance to the device components
- Known hypersensitivity or contraindication to anticoagulants or contrast media, which is not amenable to pretreatment
- Significant *and/or* circumferential aortic mural thrombus at proximal or distal attachment sites
- Medical condition that may cause noncompliance with the protocol, confound the data interpretation, or a limited life expectancy of <1year

CTA, Computed tomography angiography; *DTA,* descending thoracic aorta; *MRA,* magnetic resonance angiography; *SVS/AAVS,* Society for Vascular Surgery/American Association for Vascular Surgery; *TAA,* thoracic aortic aneurysm.

trial, a study designed to evaluate the Talent Thoracic Stent Graft System in patients with TAAs. These endovascular results are compared with retrospective open surgical data from three centers of excellence: The Cleveland Clinic Foundation (Cleveland, Ohio), Massachusetts General Hospital (Boston, Mass), and The Hospital of the University of Pennsylvania (Philadelphia, Pa).

METHODS

Enrollment. The VALOR trial was a prospective, nonrandomized, multicenter clinical study conducted in the United States to evaluate the safety and efficacy of the Medtronic Vascular Talent Thoracic Stent Graft in the treatment of thoracic aortic diseases. Enrollment occurred from December 2003 to June 2005 at 38 institutions across the United States (Appendix 1, online only). This report focuses on the pivotal test group population, which included patients diagnosed with TAAs. These patients were considered candidates for open surgical repair and were low to moderate risk (0, 1, and 2) per the modified Society for Vascular Surgery and the American Association for Vascular Surgery criteria (Appendix 2, online only).[2] The anatomic and medical inclusion and exclusion criteria are presented in Table I.

Surgical candidates with a fusiform thoracic aortic aneurysm ≥5 cm or ≥2 times the diameter of the nonaneurysmal aorta, as well as focal saccular thoracic aneurysms (penetrating atherosclerotic ulcers), were considered for inclusion. The aneurysm had to be at least 20 mm distal to the left common carotid and 20 mm proximal to the celiac artery, have a proximal and distal nonaneurysmal aortic neck diameter of between 18 and 42 mm, and proximal and distal nonaneurysmal aortic neck lengths of at least 20 mm. A notable exclusion criterion was previous surgical or endovascular treatment of an infrarenal aortic aneurysm.

Device description and deployment. The Talent Thoracic Stent Graft System consists of a preloaded stent graft and the CoilTrac delivery system (Medtronic). The implanted endoprosthetic portion of the Talent system is composed of a polyester graft fabric sewn to a self-expanding nickel-titanium (chemically polished nitinol) wire frame (Fig 1). Catalog and custom stent graft configurations were made available for this trial (Appendix 3, online only). Stent graft oversizing of 2 to 4 mm relative to the native aortic diameter (measured as adventitia to adventitia) was recommended to provide the necessary outward radial force, maintaining stent graft apposition against the aortic wall. Preoperative diameter and length measurements were obtained from detailed computed tomography angiography (CTA) or magnetic resonance angiography (MRA). The overall design concept is modular, such that additional main sections as well as proximal and distal extensions are introduced separately and mated in vivo as needed to complete the exclusion of the TAA.

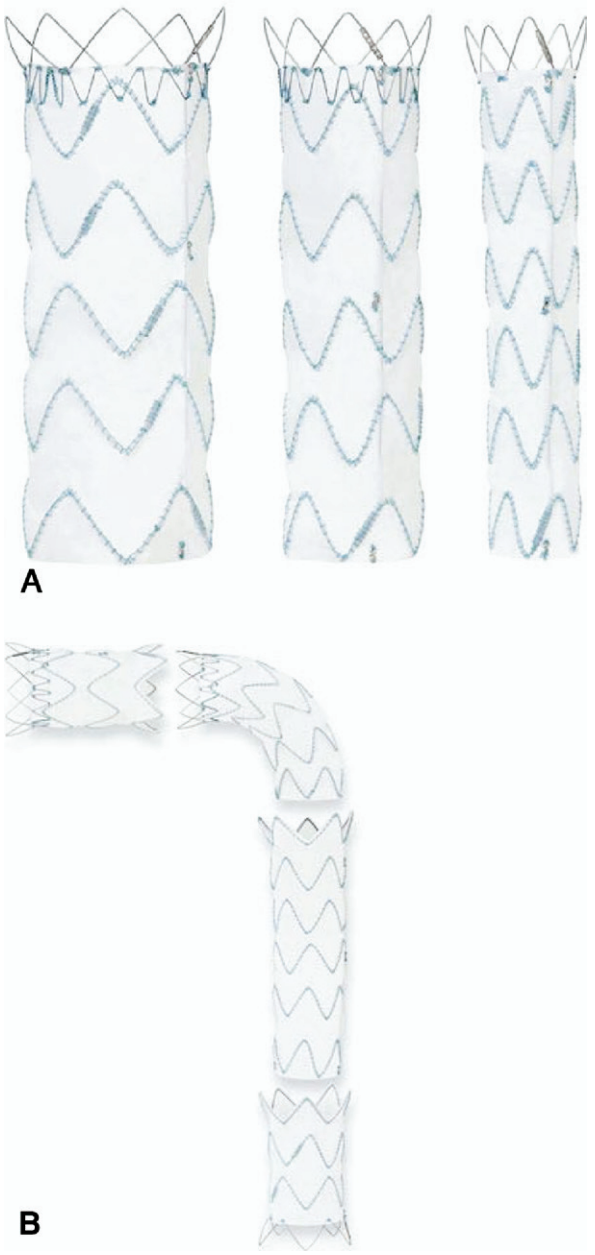

Fig 1. A, The Talent Thoracic Stent Graft Device consists of a polyester graft fabric sewn to a self-expanding nickel-titanium (chemically polished nitinol) wire frame. **B,** The modular design concept of the Talent Thoracic Stent Graft Device is illustrated.

The loaded delivery system is inserted in the femoral or iliac artery, tracks through the vasculature, and delivers the stent graft at the target site. Deployment of the proximal stent graft occurs as the outer sheath is withdrawn, initially exposing the proximal bare spring and first covered stent graft. A minimum overlap of 30 mm was required for multiple stent grafts, and the Reliant balloon catheter (Medtronic) could be used at the discretion of the physician to model the stent graft against the aortic wall. Adjunctive surgical techniques, including iliac artery conduits, spinal drains, and left subclavian artery (LSA) revascularization were left to the discretion of the investigator.

The study protocol was approved by the FDA and site institutional review boards. Patients signed an informed consent before participation in the investigational study.

Follow-up protocol. Standard follow-up evaluations were performed at 1, 6, and 12 months, and annually thereafter. Follow-up visits included a CT scan, chest radiograph, and physical examination. All clinical data were reported by the investigative center on case report forms and monitored by the sponsor. A Clinical Events Committee adjudicated major adverse events (MAEs) for device and procedure relatedness. Medical Metrx Solutions (M2S; West Lebanon, NH) served as the imaging core laboratory and provided critical and comprehensive data evaluation of all imaging studies, ensuring third-party assessment of graft effectiveness.

Endoleaks were defined according to the well-established type I to IV nomenclature.[3] In the event the core laboratory could not identify the source, the endoleak was classified as unknown. Migration was defined as >10 mm proximal or distal movement of the stent graft relative to fixed anatomic landmarks, and aneurysm expansion was defined as >5-mm increase in diameter from the 1-month to 12-month follow-up visit. An MAE was defined as death due to the procedure, any death ≤30 days of the procedure, respiratory complications, renal insufficiency or failure, cardiac events, neurologic events, aneurysm rupture, bowel ischemia, major bleeding, or vascular complications. A MAE that was identified as a serious adverse event by the clinical investigator was defined as serious MAE.

Aneurysm-related death was defined as any death ≤30 days from initial implantation or occurring as a consequence of an aneurysm rupture, a conversion to open repair, or any other secondary endovascular procedure relative to the aneurysm that was treated by the Talent Thoracic Stent Graft System as evidenced by CT scan, angiography, or direct observation at surgery or autopsy. Excluded were aneurysms in anatomic areas other than the targeted segment treated by the Talent Thoracic Stent Graft System. Aneurysm-related death after open repair included any death ≤30 days from the surgical procedure or any death caused by reintervention of the targeted aortic segment, or by complications related to the graft or the procedure.

Summary statistics presented for categoric variables are the number in each category and the percentage of known values that this number represents. For continuous variables, the mean and standard deviation are provided; *P* values were calculated using standard *t* tests. In some cases the median is provided as well. Kaplan-Meier curves were used to plot freedom from event over time.

RESULTS

Demographics. The VALOR trial enrolled 195 patients. Fig 2 details patient accountability of the 195 test group patients at 12 months of follow-p. A total of 189

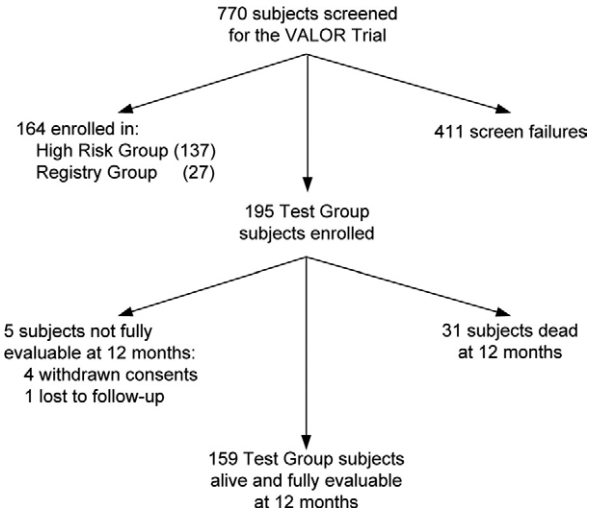

Fig 2. Flow chart shows follow-up for participants in the participants Evaluation of the Medtronic Vascular Talent Thoracic Stent Graft System for the Treatment of Thoracic Aortic Aneurysms *(VALOR)* trial.

Table II. Subject demographics: VALOR test group vs open surgery

Variable	*VALOR test group*	*Open surgery*
Age		
Total Population		
N	195	189
Mean ± SD (years)	70.2 ± 11.1	69.6 ± 9.1
Median	73.0	71.0
Min-Max	27-86	27-85
Male		
N	115	99
Mean ± SD (years)	69.3 ± 11.7	69.9 ± 8.5
Median	72.0	71.0
Min-Max	27-85	40-84
Female		
N	80	90
Mean ± SD (years)	71.6 ± 10.1	69.3 ± 9.8
Median	74.0	71.0
Min-Max	38-86	27-85
Sex, % (No.)		
Males	59.0 (115)	52.4 (99)
Females	41.0 (80)	47.6 (90)
Ethnicity, % (No.)		
White, non-Hispanic	83.1 (162)	93.7 (177)
Black, non-Hispanic	12.8 (25)	5.8 (11)
Hispanic (white or black)	2.6 (5)	0.5 (1)
Asian/Pacific Islander	1.0 (2)	0 (0)
Native American	0 (0)	0 (0)
Other[a]	0.5 (1)	0 (0)

SD, standard deviation; *VALOR,* Evaluation of the Medtronic Vascular Talent Thoracic Stent Graft System for the Treatment of Thoracic Aortic Aneurysms.
[a]One subject had ethnicity specified as "none given."

patients were identified as retrospective open surgical subjects. Subject demographics, baseline history, and aneurysm dimensional characteristics for VALOR test group and the open surgery group are presented in Tables II, III, and IV. Compared with the open surgery group, the subjects in the VALOR test group had similar age and gender distributions but had lower TAA size and were less likely to have a previous abdominal aortic aneurysm (AAA) or AAA repair. At the time of enrollment, 51 of 195 patients (26%) in the VALOR test group had aneurysm-related symptoms. The mean aneurysm length was 121.4 ± 72.7 mm as measured by the core laboratory. These data were not available for the open surgery group.

Table III. Baseline medical history: VALOR test group vs open surgery

Medical history	*VALOR test group % (m/n)*	*Open surgery % (m/n)*
Cardiovascular		
Angina	14.4 (28/195)	22.8 (26/114)
Arrhythmias	26.7 (52/195)	20.3 (37/182)
Congestive heart failure	8.7 (17/195)	11.2 (21/187)
CABG	10.3 (20/195)	13.3 (25/188)
Coronary artery disease	40.5 (79/195)	49.2 (91/185)
Hypertension	87.2 (170/195)	88.8 (166/187)
Myocardial Infarction	13.8 (27/195)	20.9 (39/187)
Peripheral vascular disease	16.4 (32/195)	37.4 (70/187)
AAA	19.0 (37/195)	37.0 (70/189)
AAA repair	2.1 (4/195)	27.5 (52/189)
Gastrointestinal conditions	53.8 (105/195)	NA
Renal insufficiency	17.4 (34/195)	16.0 (30/187)
Musculoskeletal conditions	53.8 (105/195)	NA
Neurologic		
Cerebral vascular accident	9.7 (19/195)	13.4 (25/186)
Paraplegia	1.0 (2/195)	0.5 (1/186)
Paraparesis	0.5 (1/195)	NA
Transient ischemic attack	7.7 (15/195)	NA
Pulmonary		
COPD	36.9 (72/195)	42.6 (80/188)
Tobacco use	76.9 (150/195)	75.9 (142/187)
Other abnormal body systems		
Hyperlipidemia	43.6 (85/195)	NA
Diabetes	15.9 (31/195)	8.6 (16/187)
Bleeding disorders	2.6 (5/195)	NA

AAA, Abdominal aortic aneurysm repair; *CABG,* coronary artery bypass grafting; *COPD,* chronic obstructive pulmonary disease; *NA,* not available; *VALOR,* Evaluation of the Medtronic Vascular Talent Thoracic Stent Graft System for the Treatment of Thoracic Aortic Aneurysms.

Procedure and hospital course. Vessel access and deployment of the study device at the intended site was successful in 194 (99.5%) of the 195 patients enrolled in the VALOR trial. One patient did not receive a study device because of access failure. Iliac conduits were required for arterial access in 21.1% of the patients. A mean number of 2.7 ± 1.3 stent graft devices (range, 1-7) were implanted per patient. Approximately 25% of the patients had proximal main Talent Thoracic Stent Graft components implanted with diameters <26 mm (3 patients, 1.9%) or >40 mm (49 patients, 23.2%). The highest implantation zone (Fig 3) of the bare spring segment of the most proximally implanted device was zone 1 in 6.7% of patients, zone 2 in 26.8%, zone 3 in 35.6%, and zone 4 in 30.9%.

Table IV. Baseline maximum aneurysm diameters: VALOR test group vs open surgery

Aneurysm diameter, mm	*Site reported, % (m/n)*[a]	*Core lab reported, % (m/n)*[b]	*Open surgery, % (m/n)*
10-17	0 (0/188)	0 (0/187)	0 (0/189)
18-29	0 (0/188)	0.5 (1/187)	0 (0/189)
30-39	4.3 (8/188)	7.5 (14/187)	0 (0/189)
40-49	10.6 (20/188)	20.3 (38/187)	0.5 (1/189)
50-59	34.6 (65/188)	34.8 (65/187)	13.8 (26/189)
60-69	33.5 (63/188)	24.6 (46/187)	40.7 (77/189)
70-79	12.2 (23/188)	10.2 (19/187)	24.3 (46/189)
80-89	3.2 (6/188)	2.1 (4/187)	16.9 (32/189)
90-99	1.1 (2/188)	0 (0/187)	0.5 (1/189)
100-109	0.5 (1/188)	0 (0/187)	1.6 (3/189)
110-119	0 (0/188)	0 (0/187)	0.5 (1/189)
120+	0 (0/188)	0 (0/187)	1.1 (2/189)

VALOR, Evaluation of the Medtronic Vascular Talent Thoracic Stent Graft System for the Treatment of Thoracic Aortic Aneurysms.
[a]Denominator is 188 subjects with site reported data.
[b]Denominator is 187 subjects with evaluable scans.

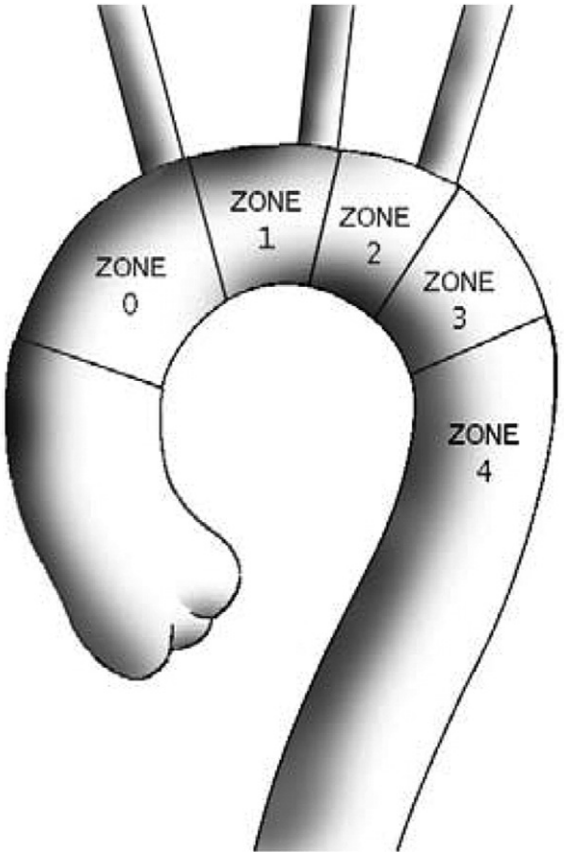

Fig 3. Zones of stent graft implantation for thoracic aortic aneurysms.

The decision to revascularize the LSA was left to the implanting physician and was performed before the initial stent graft procedure in 10 of 194 patients (5.2%).[4] At the conclusion of the procedure, the 194 patients with a device implanted had patent stent grafts, with integrity maintained and freedom from twisting or kinking.

Clinical utility measures for the VALOR test group and the open surgery group are compared in Table V. The VALOR test group showed superiority in regards to subjects requiring blood transfusion, procedural blood loss, and length of procedure, as well as intensive care unit and overall hospital stay ($P < .001$).

Mortality. Four of 195 VALOR patients (2.1%) died ≤30 days after implantation. Causes of death for these patients included atheroembolic multisystem failure, stroke, periprocedural cardiac arrest, and complications from a myocardial infarction and perforated ulcer. Table VI describes the 30-day mortality rates for the VALOR test group compared with the open surgery group. The VALOR test group experienced a significantly lower rate of early mortality (2% vs 8%, $P < .01$). All-cause mortality at 12 months is presented in Table VII (16.1% vs 20.6%, $P =$ NS). Freedom from all-cause mortality is presented for both groups in Fig 4. Predictors of all-cause mortality at 12 months in the VALOR patients included prior stroke, with an odds ratio of 4.45 ($P = .019$), chronic obstructive lung disease, with an odds ratio of 3.72 ($P = .008$), and aneurysm length, with an odds ratio of 1.008 ($P = .017$) for each additional millimeter.

Aneurysm-related mortality. Six of 192 patients (3.1%) in the VALOR test group died of an aneurysm-related cause through 12 months of follow-up. Four patients died ≤30 days of the procedure. Two additional late deaths were adjudicated as aneurysm-related. In the open surgery group, 22 of 189 patients (11.6%) died of aneurysm-related causes, and this difference was statistically significant at $P < .002$. Freedom from aneurysm-related death for both groups is presented in Fig 5.

Conversion to surgery. One patient (0.5%) was converted to open surgical repair approximately 9 months after implantation for complications related to an apparent infection in the stented segment of the aorta. This patient was alive and fully evaluable at the 12-month postimplantation follow-up.

Major adverse events. One or more MAEs occurred in 41% (80 of 195) of the VALOR patients ≤30 days after implantation compared with 84.4% (151 of 179) in the open surgery group ($P < .001$; Table VIII). Most of the individual MAE categories in the endovascular group were lower, but vascular complications were higher in the VALOR patients, at 21% (41 of 195), compared with the open surgery patients, at 12.3% (22 of 179). Freedom from MAEs is presented in Fig 6.

Cerebrovascular accidents. Seven VALOR patients (3.6%) had a periprocedural stroke. Three patients had resolution of stroke-related disability at 12 months, death, or last follow-up. Logistic regression analysis was performed on the occurrence of stroke ≤30 days after the implantation procedure. Patients who had a history of AAA had an odds ratio of 7.1 for the occurrence of stroke ($P = .031$), and implantation in zone 1 or zone 2 had an odds ratio of 15.2 for the occurrence of stroke ($P = .018$).

Table V. Acute procedural data: VALOR test group vs open surgery

Variable	*VALOR test group*	*Open surgery*	P[a]
Subjects requiring blood transfusion, % (m/n)	22.7 (44/194)	93.7 (164/175)	<.001
Blood loss during procedure, mean ± SD mL[b]	371.2 ± 514.4	3054.9 ± 1702.4	<.001
Duration of implant procedure, mean ± SD min	154.2 ± 76.0	303.3 ± 97.6	<.001
Length of stay, mean ± SD			
ICU (accessible subjects), hours	46.8 ± 114.3	185.3 ± 204.7	<.001
Overall hospital, days	6.4 ± 11.5	16.7 ± 15.0	<.001

SD, Standard deviation; *VALOR,* Evaluation of the Medtronic Vascular Talent Thoracic Stent Graft System for the Treatment of Thoracic Aortic Aneurysms.
[a]For difference between groups. Percentage of subjects requiring blood transfusion were compared using the Fisher exact test. Other variables were compared using the Wilcoxon test.
[b]Only one open surgical site could provide blood loss during procedure data.

Table VI. All-cause mortality at 30-days

Group	*30-day mortality, % (m/n)[a]*
VALOR test group	2.1 (4/195)
Open surgery	7.9 (15/189)

VALOR, Evaluation of the Medtronic Vascular Talent Thoracic Stent Graft System for the Treatment of Thoracic Aortic Aneurysms.
[a]$P < .01$.

Table VII. All-cause mortality at 12 months

Group	*12 Month Mortality, % (m/n)[a]*
VALOR test group	16.1 (31/192)
Open surgery	20.6 (39/189)

VALOR, Evaluation of the Medtronic Vascular Talent Thoracic Stent Graft System for the Treatment of Thoracic Aortic Aneurysms.
[a]$P = .29$.

Spinal ischemia. Postoperative paraplegia occurred ≤30 days in three of 195 VALOR patients (1.5%) and in a fourth patient at 32 days after implantation. All patients had placement of a lumbar drain at the time neurologic deficits were identified. None of these patients experienced recovery at the 1-year follow-up or by the time of death, and none of the patients with paraplegia had a previously treated AAA. Onset of paraparesis occurred ≤30 days in 14 VALOR patients (7.2%). The proportion of patients with unresolved paraparesis within 12 months or last known follow-up fell to 3.1% (6 of 192).

Logistic regression analysis was performed on the incidence of paraplegia or paraparesis within ≤30 days after the implantation procedure. The only covariate that was found to be a significant predictor was the use of a conduit for access, with an odds ratio of 4.13 ($P = .020$).

Stent graft effectiveness. The core laboratory identified seven patients with a type I endoleak by the 30-day follow-up visit, as noted in Table IX. Most endoleaks were type II. Sixteen patients had 17 additional endovascular procedures, of which two procedures (1.0%) occurred in the 30-day period before discharge, and 15 procedures (8.1%) occurred at 31 to 365 days. Fourteen procedures were performed to resolve an endoleak. One patient had a procedure to resolve migration and to cover a pseudoaneurysm. One patient was treated for an aneurysmal expansion, and one patient was treated for a second aneurysm.

The core laboratory noted four stent graft migrations ≤12 months. Two migrations involved the proximal end of the graft moving distally, and two involved the distal end of the graft moving proximally. Only one patient required an additional intervention related to the migration. Aneurysm sac diameter was stable or shrinking in 91.4% of patients. In 11 patients (8.5%), the increase in maximal aneurysm diameter was >5 mm during this interval, and seven of these patients had endoleaks during follow-up. No study patient had loss of stent graft patency or instances of compression or collapse of the endograft ≤12 months.

In two patients the core laboratory confirmed stent fractures ≤12 months. Neither patient had adverse events related to these fractures.

DISCUSSION

The Talent Thoracic Stent Graft System was first implanted in Australia in January 1996 and received the Conformité Européene (CE) mark in April 1998. The original device has undergone two iterative changes leading up to this pivotal clinical trial, including a delivery system change and chemical polishing of the nitinol stent. Most importantly, the device has not been withdrawn from the commercial market for any reasons related to safety or effectiveness.

Data from worldwide experiences with the Talent Thoracic Stent Graft System have been reported in numerous articles, which describe the use of the device in the whole spectrum of thoracic aortic pathologies. Encouraging results in the elective treatment of thoracic aortic dissection were first reported in 1999,[5] followed by positive outcomes in the emergency treatment of aortic perforations due to ruptured TAA, type B aortic dissection, and traumatic injury.[6-8] The most comprehensive long-term experience with the device was described by Fattori et al.[9] In the United States, Criado et al[10] described their 8-year experience with the Talent Thoracic Stent Graft in 111 TAA patients and 75 type B aortic dissection patients, with an average follow-up of 40 months. The investigators found low mortality and morbidity and favorable midterm survival results.[10] After FDA approval of the TAG thoracic endo-

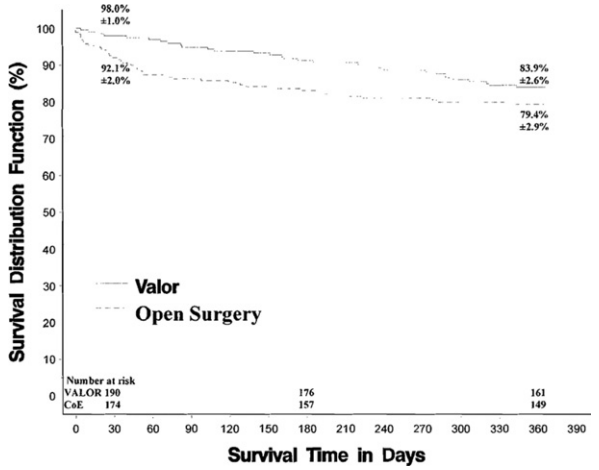

Fig 4. Kaplan-Meier plot of freedom from all-cause mortality for Evaluation of the Medtronic Vascular Talent Thoracic Stent Graft System for the Treatment of Thoracic Aortic Aneurysms *(VALOR)* trial participants *(solid line)* and the open surgery cohort *(dashed line)*.

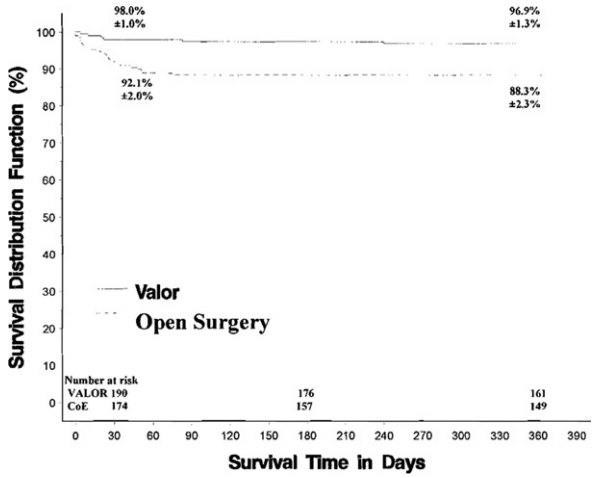

Fig 5. Kaplan-Meier plot of freedom from aneurysm-related mortality for Evaluation of the Medtronic Vascular Talent Thoracic Stent Graft System for the Treatment of Thoracic Aortic Aneurysms *(VALOR)* trial participants *(solid line)* and the open surgery cohort *(dashed line)*.

Table VIII. Major adverse events for VALOR test group vs open surgery group at 30 days

Category	*VALOR test group % (m/n)*	*Open surgery % (m/n)*
Respiratory complications	13.3 (26/195)	46.9 (84/179)
Pneumonia	9.2 (18/195)	22.3 (40/179)
Pulmonary embolism	0.5 (1/195)	0.6 (1/179)
Pulmonary edema	2.1 (4/195)	24.6 (44/179)
Respiratory failure	6.2 (12/195)	26.8 (48/179)
Renal complications	6.2 (12/195)	29.1 (52/179)
Renal insufficiency	1.5 (3/195)	16.2 (29/179)
Renal failure	4.6 (9/195)	19.6 (35/179)
Cardiac complications	12.3 (24/195)	44.7 (80/179)
Myocardial infarction	1.5 (3/195)	5.6 (10/179)
Unstable angina	0.5 (1/195)	0.6 (1/179)
New arrhythmia	8.7 (17/195)	41.3 (74/179)
Exacerbation of CHF	3.1 (6/195)	5.6 (10/179)
Neurologic complications	11.8 (23/195)	20.1 (36/179)
New CVA/embolic events	3.6 (7/195)	7.3 (13/179)
Paraplegia	1.5 (3/195)	3.4 (6/179)
Paraparesis	7.2 (14/195)	12.8 (23/179)
Gastrointestinal complications	1.0 (2/195)	0.6 (1/179)
Bowel ischemia	1.0 (2/195)	0.6 (1/179)
Bleeding complications	15.4 (30/195)	48.0 (86/179)
Coagulopathy	5.6 (11/195)	20.1 (36/179)
Procedural/Postprocedural	14.4 (28/195)	37.4 (67/179)
Vascular complications	21.0 (41/195)	12.3 (22/179)
Expanding hematoma at access site	1.5 (3/195)	2.2 (4/179)
Pseudo/false aneurysm at access site	2.1 (4/195)	1.1 (2/179)
AV fistula	0.5 (1/195)	0 (0/179)
Retroperitoneal bleed	2.6 (5/195)	1.1 (2/179)
Thrombosis	0 (0/195)	6.1 (11/179)
Arterial occlusion	2.1 (4/195)	2.2 (4/179)
Vessel rupture/ dissection	6.2 (12/195)	1.7 (3/179)
Vessel disruption	7.7 (15/195)	0.6 (1/179)
Embolism	5.1 (10/195)	1.1 (2/179)
Re-op for limb ischemia	1.0 (2/195)	0.6 (1/179)
Vascular surgical repair or ultrasound compression required	14.4 (28/195)	3.4 (6/179)
Target lesion aneurysm rupture	0 (0/195)	0.6 (1/179)
Total major adverse events	41.0 (80/195)	84.4 (151/179)

CHF, congestive heart failure; *CVA,* cerebrovascular accident; *VALOR,* Evaluation of the Medtronic Vascular Talent Thoracic Stent Graft System for the Treatment of Thoracic Aortic Aneurysms.

prosthesis (W. L. Gore & Associates, Flagstaff, Ariz) in March 2005, and publication of the phase II multicenter trial results,[11] there has been rapid dissemination of this technology.

The Talent Thoracic Stent Graft offers a wider range of diameter options than is currently available in the commercial United States market. Of the patients implanted with diameters <26 mm or >40 mm, 25% would not have been eligible for endovascular repair using commercially available devices owing to diameter sizing constraints.

In 33.5% of patients, the bare spring segment of the most proximally implanted device was in zones 1 or 2 of the aortic arch. The uncovered proximal stent allows for crossing of the great vessels and proximal fixation in the arch without occluding blood flow. There were no instances of asymmetric opening or asymmetric deployment of the proximal bare spring in this pivotal VALOR trial. In addition, there were no instances of erosion or perforation of the aortic wall by the uncovered proximal nitinol stent. Despite concerns about embolic stroke during endovascular maneuvers in the arch, the incidence of perioperative stroke in this series was remarkably low at 3.6%, and nearly half of these patients had resolution of stroke-related disability at 12 months, death, or last follow-up.

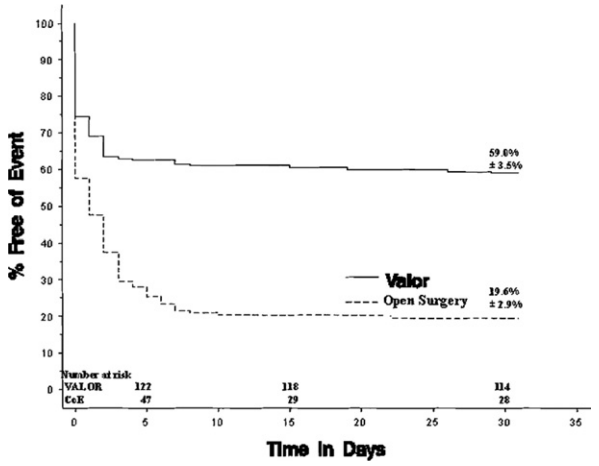

Fig 6. Kaplan-Meier plot of freedom from major adverse events at 30 days for Evaluation of the Medtronic Vascular Talent Thoracic Stent Graft System for the Treatment of Thoracic Aortic Aneurysms *(VALOR)* trial participants *(solid line)* and the open surgery cohort *(dashed line)*.

Table IX. Endoleaks at 1 and 12 months (core laboratory)

Device-related event	*At 1-month visit, % (m/n)*	*At 12-month visit, % (m/n)*
Endoleak of any size	25.9 (45/174)	12.2 (15/123)
Type I	4.0 (7/174)	4.9 (6/123)
Type II	15.5 (27/174)	4.9 (6/123)
Type III	1.7 (3/174)	0 (0/123)
Type IV	0 (0/174)	0 (0/123)
Indeterminate	4.6 (8/174)	2.4 (3/123)

Retrograde type A dissections have been reported with other thoracic endovascular devices as well as in association with open thoracic aortic procedures. In the VALOR trial, retrograde type A dissection developed in three of 195 enrolled patients (1.5%). In one of the patients, the core laboratory determined that the proximal neck length was in fact shorter than 10 mm, although this was not recognized by the site investigators. In another patient the proximal neck was also <20 mm, and the core laboratory recognized evidence of a chronic type B dissection, which was an anatomic exclusion for enrollment in the pivotal arm. In the third patient there was a proximal type I endoleak at the end of the procedure and overzealous ballooning, which inadvertently included the proximal bare spring, was the likely etiology. Further discussion of incidence and prevention of retrograde type A dissection during thoracic aortic endovascular procedures is beyond the scope of this article.

Although the delivery systems were mostly 24F and 25F in size, successful vessel access and deployment occurred in 99.5% of cases, with iliac artery conduits used in 21%. A subset analysis failed to reveal any correlation between French size, conduit use, or vascular complications at 30 days. The use of conduits in this study is comparable to that reported in other contemporary series,[12,13] and experience has dictated that vascular access complications are frequent and may result in death. The need for conduits should be anticipated before arterial injury, particularly in elderly women with small, calcified, stenotic external iliac arteries. Because the longest Talent covered device available for this pivotal trial was 116 mm, 2.7 ± 1.3 devices were placed per patient (range, 1-7 devices). Longer covered endografts (ie, 150 and 200 mm) would have resulted in fewer devices placed per patient. Despite this, the incidence of serious vascular complications in the VALOR pivotal trial (Table IV) compares favorably with the Gore TAG phase II multicenter trial in which longer endografts were introduced and deployed through an indwelling 22F or 24F sheath.

The 30-day paraplegia rate was low, and paraparesis was moderately high in the acute phase. Despite the 30-day paraparesis rate, this event carried a reasonably favorable prognosis, as demonstrated by the unresolved paraparesis rate of 3.1% at 12 months or last known follow-up. Strategies potentially mitigating paraplegia, such as spinal drains, were used at the discretion of the investigator when the perceived risk was significant. An interesting observation is that covariate analysis revealed conduit use was predictive of paraplegia or paraparesis. This is consistent with published reports defining retroperitoneal hemorrhage/hematoma, perioperative hypotension, and injury to the external iliac artery as contributing factors for spinal cord ischemia.[14] Future studies will need to identify effective perioperative spinal cord monitoring techniques and interventions, as well as postoperative treatment algorithms.

Although a mean number of 2.7 ± 1.3 stent graft components (range, 1-7 devices) were implanted per patient, no junctional or type III endoleaks were detected at the 12-month follow-up. After deployment, there were no instances of loss of patency or stent graft collapse in this cohort of patients with 12-month follow-up. Continued follow-up of these patients will be necessary to document the long-term efficacy of the device; however, several single-center series using the Talent thoracic device have demonstrated durability.[15-17]

The VALOR trial results support the use of the Talent Thoracic Stent Graft System as a safe and effective alternative to open surgical repair in patients with descending TAAs. These elderly patients, despite their significant comorbidities, had low mortality at 30 days and 12 months, as well as aneurysm-related mortality at 12 months, supporting a high rate of successful aneurysm treatment. Specifically, the device showed statistically superior performance with respect to acute procedural outcomes, 30-day MAEs, perioperative mortality, and 12-month aneurysm-related mortality compared with open surgery. These data are particularly meaningful given that the open surgery data were derived from high-volume centers with a reputation for surgical excellence and where the best surgical outcomes would be anticipated.

A review of the recent medical literature allows for comparison between the Talent Thoracic Stent Graft expe-

rience vs the Gore TAG device based on Kaplan-Meier estimates.[18,19] Similar rates in 30-day and 12-month all-cause mortality and 12-month aneurysm-related mortality rates have been reported. When serious MAE rates are compared through 12 months by organ system, the VALOR test group and the subjects with a Gore TAG device have essentially the same profile of MAE rates. These comparisons demonstrate that despite fundamental differences in stent graft design, the Talent Thoracic Stent Graft as used in the VALOR test group performed in a substantially similar manner to the Gore TAG device when implanted in a similar group of study subjects.

CONCLUSIONS

The Talent Thoracic Stent Graft System has demonstrated reasonable assurance of safety and effectiveness in treating patients with aneurysms of the descending thoracic aorta who are open surgical candidates with low to moderate surgical risk. The VALOR trial data demonstrate that endovascular therapy with this device results in lower perioperative death, 12-month aneurysm-related death, and lower rates of morbidity than open surgery. Vascular complications associated with thoracic aortic endovascular interventions, including vessel disruption, dissection, rupture, and embolism, are higher than in open surgery and demonstrate the need for further refinement of endovascular thoracic delivery systems. Reduced blood loss and time in intensive care and overall hospital length of stay continue to represent additional advantages of endografting vs open surgical repair. The benefits of the device clearly outweigh the risks when considering the clinically significant results of the VALOR Trial conducted in the intended population.

AUTHOR CONTRIBUTIONS

Conception and design: RF
Analysis and interpretation: RF, FC, MF, CK, RW, AL, MM, MT
Data collection: RF
Writing the article: RF, FC
Critical revision of the article: RF, FC, MF, CK, RW, AL, MM, MT
Final approval of the article: RF, FC, MF, CK, RW, AL, MM, MT
Statistical analysis: RF
Obtained funding: Not applicable
Overall responsibility: RF

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Additional material for this article may be found online at www.jvascsurg.org.

Appendix 1 (online only). Trial sites and principal investigators

Principal investigator	*Site*	*City*
Ronald Fairman, MD	Hospital of the University of Pennsylvania	Philadelphia, Pa
Mark Farber, MD	University of North Carolina	Chapel Hill, NC
Christopher Kwolek, MD	Massachusetts General Hospital	Boston, Mass
Michael Dake, MD	University of Virginia	Charlottesville, Va
Frank Criado, MD	Union Memorial Hospital	Baltimore, Md
David Williams, MD	University of Michigan	Ann Arbor, Mich
Zvonimir Krajcer, MD	St Luke's Episcopal Hospital - Houston	Houston, Tex
Alan Lumsden, MD	Baylor College of Medicine	Houston, Tex
Manish Mehta, MD	Albany Medical Center	Albany, NY
Robert Rhee, MD	Shadyside Hospital - UPMC	Pittsburgh, Pa
Anthony Lee, MD	University of Florida	Gainesville, Fla
Sean Lyden, MD	Cleveland Clinic Foundation - Ohio	Cleveland, Ohio
Jim Swischuk, MD	St Francis Hospital	Peoria, Ill
Paul Bove, MD	William Beaumont Hospital	Royal Oak, Mich
Rodney White, MD	Harbor UCLA	Torrance, Calif
Edward Garrett, MD	Baptist Memorial Hospital	Memphis, Tenn
Michael Tuchek, DO	Loyola University Medical Center	Maywood, Ill
Kim Hodgson, MD	Memorial Medical Center	Springfield, Ill
Robert Allen, MD	Physician's Regional Medical Center	Naples, Fla
Phillip Allmendinger, MD	Hartford Hospital	Hartford, Conn
Mark Bates, MD	Charleston Area Medical Center	Charleston, WV
Daniel Benckart, MD	Allegheny General Hospital	Pittsburg, Pa
Tom Bower, MD	Mayo Clinic- Rochester	Rochester, Minn
Mark Eskandari, MD	Northwestern Memorial Hospital	Chicago, Ill
Neal Cayne, MD	NYU Vascular Associates	New York, NY
Peter Faries, MD	New York Presbyterian Cornell University	New York, NY
Mark Fillinger, MD	Dartmouth- Hitchcock Medical Center	Lebanon, NH
Marc Glickman, MD	Sentara Norfolk General, Vascular, and Transplant Specialists	Norfolk, Va
Matthew Jung, MD	Surgical Care Associates	Louisville, Ky
Barry Katzen, MD	Baptist Hospital of Miami	Miami, Fla
Lowell Satler, MD	Washington Hospital Center	Washington, DC
Richard McCann, MD	Duke University Medical Center	Durham, NC
Takao Ohki, MD	Montefiore Medical Center	Bronx, NY
Venkatesh Ramaiah, MD	Arizona Heart Institute	Phoenix, Ariz
Timothy Roush, MD	Carolinas Medical Center	Charlotte, NC
Gregorio Sicard, MD	Washington University School of Medicine	St Louis, Mo
Cary Stowe, MD	Florida Hospital	Orlando, Fla
Christopher Zarins, MD	Stanford University	Stanford, Calif

Appendix 2 (online only). Modified Society for Vascular Surgery/American Association for Vascular Surgery medical comorbidity grading system

	Society for Vascular Surgery risk factor			
Component	*0 (Absent)*	*1 (Mild)*	*2 (Moderate)*	*3 (Severe)*
Age, years	<55	55-69	70-85	>85
Hypertension	None (cutoff: DBP usually <90 mm Hg)	Controlled (cutoff: point DBP <90 mm Hg) with single drug	Controlled with 2 or more drugs	Uncontrolled hypertension
Cardiac	Asymptomatic, with normal ECG	Asymptomatic, but with either remote MI by history (6 months), occult MI by ECG, or fixed deficit on dipyridamole thallium or similar scan	Any one of the following: ● stable angina ● no angina but significant reversible perfusion deficit on Dip-Thal ● significant silent ischemia (1% of time) on Holter monitoring ● EF 25%-45% ● controlled ectopy or asymptomatic arrhythmia	Any one of the following: ● unstable angina ● symptomatic or poorly controlled ectopy or arrhythmia (chronic/recurrent) ● poorly compensated or recurrent CHF ● EF <25% ● MI ≤6 mon with no intervention (CABG, angioplasty or stenting)
Pulmonary	Asymptomatic, normal chest x-ray, PFT ≤20% of predicted	Asymptomatic or mild dyspnea on exertion, mild chronic parenchymal x-ray changes, PFT 65%-80% of predicted	Between 1 and 3	Vital capacity <1.85 L, FEV_1 <1.2 L or <35% of predicted, maximal voluntary ventilation <50% of predicted, P_{CO_2} >45 mm Hg, supplemental O_2 medically necessary, or pulmonary hypertension

CABG, coronary artery bypass grafting; *DBP,* diastolic blood pressure; *Dip-Thal,* dipyridamole thallium scan; *ECG,* electrocardiogram; *EF,* ejection fraction; *FEV_1,* forced expiratory volume in 1 second; *MI,* myocardial infarction; *PFT,* pulmonary function tests.

Appendix 3 (online only). Catalog stent graft specifications and configurations

Variables	*Main sections*	*Additional distal main sections*	*Proximal extensions*	*Distal extensions*
Diameters (2-mm increments)				
Proximal	22-46	26-46	26-46	26-46
Distal	22-46	22-44	26-46	26-46
Total covered length of device, mm[a]	112-116	110-114	46-54	46-54
Proximal configurations	FreeFlo[b] (Bare Spring)	Open Web	FreeFlo[b]	Open Web
Distal configurations	Closed Web	Closed Web	Open Web	Bare Spring[b]

[a]The maximum total length cannot exceed 130 mm.

[b]"Bare Spring" and "FreeFlo" refer to the configuration in which the terminating spring has no fabric coverage. Bare Spring is the term used for devices having a proximal diameter <24 mm, while FreeFlo is the term used for devices having a proximal diameter ≥24 mm. FreeFlo devices feature a support spring to prevent fabric infolding.