# The Short Proximal AAA Neck

A comparison of EVAR outcomes among groups of patients with different proximal neck lengths.

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Patient selection for endovascular repair of aortic aneurysms involves careful assessment of anatomical features of the aneurysm, including the proximal neck length and angulation, presence of thrombus or calcification, shape, access vessel diameter, and degree of tortuosity.[1-3] Favorable proximal neck anatomy increases the likelihood of adequate proximal fixation and seal.[4] When the proximal neck seal is poor, type IA (proximal) endoleaks can occur and lead to increased perigraft flow and risk of aneurysm rupture.

All approved endograft devices in the US require a proximal neck length of at least 15 mm. However, in clinical practice, devices have been placed in aneurysms with shorter necks and, in certain clinical trials, suprarenal fixation devices can be placed in necks as short as 5 mm.[5] The short proximal aortic neck presents a technical challenge for endovascular aneurysm repair (EVAR). The objective of this study is to examine EVAR outcomes in patients with short proximal aortic necks measuring less than 15 mm and compare the results with those in the conventional group of patients. We hypothesized that endografts can be placed in patients with short proximal aortic necks without significantly affecting aneurysm-related mortality.

## METHODS

Between 1994 and 2005, 612 patients with infrarenal abdominal aortic aneurysms (AAA) underwent EVAR at our institution. The procedures were performed by eight vascular surgeons and six interventional radiologists. A large portion of the Baptist Cardiac & Vascular Institute (BCVI) experience with short necks has been made possible by participation in two studies: (1) Talent bifurcated endograft (Medtronic, Inc., Santa Rosa, CA) study (1997-1999), including low-risk patients (studies are still in follow-up) that permitted the use of devices in necks ≥5 mm[5]; and (2) physician investigational device exemption (IDE) study for high-risk patients using the Talent device (2001-present). Five hundred eighty patients had complete data sets available for analysis; the remaining 32 patients were either very early in the experience, or brought outside films for measurements when seen in consultation. These films were not available for verification of measures. Seventy-one percent of all patients in this study were treated with a Talent bifurcated endograft. The patients were retrospectively identified from a prospective database maintained by the BCVI Division of Clinical Outcomes.

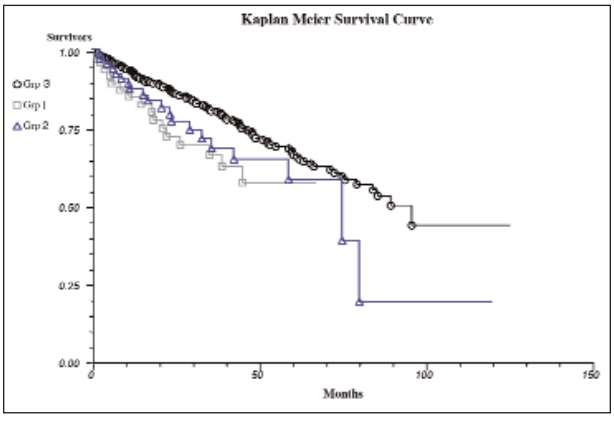


**Figure 1. Kaplan-Meier survival curves for the three groups.**

Patients with short necks were originally accepted based on specific protocols. For example, the Talent protocol specified a minimum neck length of 5 mm (most patients with 5-mm necks had just that, if there was a longer segment for sealing with an oversized more distal segment, it was considered unusual). We do not have information on how many patients with necks <15 mm were rejected for EVAR. We view an acceptable angle to be 30° or less. Also, in patients with short necks, additional attention was paid

**TABLE 1. DEMOGRAPHICS, RISK STRATIFICATION, FOLLOW-UP TIME**

| | Overall | Group 1 (5-9 mm) | Group 2 (10-14 mm) | Group 3 (>15 mm) | *P* |
|---|---|---|---|---|---|
| | N = 580 | n = 49 | n = 68 | n = 463 | |
| Age (years) | 75 ± 8 (53-95) | 77 ± 9 (55-92) | 75 ± 8 (56-91) | 76 ± 8 (53-95) | .222 |
| Sex distribution | 9% F, 91% M | 12% F, 88% M | 9% F, 91% M | 8% F, 92% M | .669 |
| Risk stratification | 1.71 ± 0.8 | 1.8 ± 0.8 | 1.74 ± 0.68 | 1.7 ± 0.8 | .564 |
| Median months follow-up | 18 | 19.7 | 11.16 | 15.8 | |
| Mean months follow-up | 20.7 ± 58 (0-114) | 23.4 ± 20.6 (0-72) | 18.3 ± 22 (0-108) | 20.7 ± 64 (0-114) | .895 |

*n ± standard deviation (range).*

**TABLE 2. ANEURYSM CHARACTERISTICS**

| | Overall | Group 1 (5-9 mm) | Group 2 (10-14 mm) | Group 3 (>15 mm) | *P* |
|---|---|---|---|---|---|
| AAA diameter (mm) | 57.8 ± 9.7 (30-100) | 61.1 ± 7.7 (45-78) | 59.7 ± 8.8 (42-92) | 57.2 ± 10.1 (30-100) | .0099 |
| Proximal neck Length (axial/mm) | 22.5 ± 11.1 (2 - 69) | 6.9 ± 1.76 (2-9) | 11.8 ± 1.3 (10-14) | 25.7 ± 9.9 (15-69) | <.0001 |

*n ± standard deviation (range).*

to angulation and luminal contour. In general, patients with short necks did not have unfavorable angulation or luminal thrombus.

Proximal neck length measurements were obtained from helical CT scans utilizing 3-mm slice thickness from the upper abdominal aorta to the pubic symphysis. When available, images from diagnostic angiography with calibrated catheters were also used. Neck length is defined as the length of parallel segment of the neck proximal to the AAA sac itself; it was determined by the length from a level beginning below the lower portion of the lowest renal artery to the point where the diameter increased greater than 1 mm. It is possible that the sealing zone could be longer than the true neck length, if the neck were conical. We sized to the largest neck diameter. Of note, the actual neck length using the central lumen line is potentially longer than the length measured using axial length by table position.

The cohort was divided into three groups according to the length of the proximal aortic neck: group 1 = 5-9 mm; group 2 = 10-14 mm; group 3 = ≥15 mm. Devices used included Ancure (Guidant, Menlo Park, CA), AneuRx (Medtronic), Excluder (Gore & Associates, Flagstaff, AZ), Talent, Trivascular (Boston Scientific Corporation, Natick, MA), Vanguard (Boston Scientific Corporation), and Zenith (Cook Incorporated, Bloomington, IN).

Demographic data and pertinent risk factors were collected. All patients were stratified by predicted risk of mortality with conventional AAA repair using the Society for Vascular Surgery (SVS)/International Society for Cardiovascular stratification based on age, cardiac disease, pulmonary disease, and renal disease (range, 0-3).[6] A score of 3 in any category means the patient is at highest risk. The diameter of the aneurysm was measured. The following outcome measures were assessed: operating room time, estimated blood loss, fluoroscopic time, contrast dose, procedural success, technical success, type IA endoleak rate (early and late), conversion rate, aborted procedure rate, difference in preprocedure to postprocedure creatinine clearance, aneurysm-related mortality rate, need for reintervention, late (≥30 days) overall mortality rates, and survival. Type IA endoleaks were identified on procedural angiograms and postoperative CT scans. Procedural success was defined as insertion of the endograft and fixation. Technical success was defined as deployment of the endograft without AAA rupture, conversion to open surgery, or mortality with no evidence of type I or III endoleaks, without aneurysm expansion, without device migration, and without limb obstruction. The SVS reporting standards for endovascular repair were used for this study.[7]

Statistical analysis was conducted with SPSS 12.0 (SPSS Inc., Chicago, IL). Results are expressed as the mean plus or minus the standard deviation. Differences among groups were determined with Student's *t*-test and analysis of variance for continuous data. Time-dependent data were analyzed with the Kaplan-Meier method. A *P* value <.05 was

**TABLE 3. DEVICE USE**

| | Overall | | Group 1 (5-9 mm) | | Group 2 (10-14 mm) | | Group 3 (>15 mm) | |
|---|---|---|---|---|---|---|---|---|
| | N = 580 | | n = 49 | 8.4% | n = 68 | 11.7% | n = 463 | 79.8% |
| Ancure | 174 | 30% | 7 | 14.3% | 12 | 17.6% | 155 | 33% |
| Talent | 172 | 29.7% | 36 | 73.5% | 31 | 45.6% | 105 | 23% |
| AneuRx | 84 | 14.5% | 3 | 6.1% | 13 | 19.1% | 68 | 15% |
| Excluder | 83 | 14.3% | 2 | 4.1% | 6 | 8.8% | 75 | 16% |
| Zenith | 41 | 7.1% | 1 | 2% | 6 | 8.8% | 34 | 7% |
| Vanguard | 20 | 3.4% | 0 | 0% | 0 | 0% | 20 | 4% |
| Trivascular | 6 | 1% | 0 | 0% | 0 | 0% | 6 | 1% |

**TABLE 4. EVAR OUTCOMES**

| | Overall | Group 1 (5-9 mm) | Group 2 (10-14 mm) | Group 3 (>15 mm) | *P* |
|---|---|---|---|---|---|
| | N = 580 | n = 49 | n = 68 | n = 463 | |
| Fluoro time (min) | 28 ± 14 | 29.3 ± 15 | 27.9 ± 12 | 27.6 ± 14 | .7347 |
| Contrast dose (mL) | 174.9 ± 83 | 146 ± 87 | 178 ± 89 | 178 ± 81 | .0365 |
| EBL (mL) | 441 ± 537 | 527 ± 459 | 378 ± 323 | 441 ± 568 | .3355 |
| OR time (min) | 151 ± 64 | 157.5 ± 54 | 153.8 ± 99 | 149 ± 59 | .6335 |
| Procedural success | 96% | 90% | 97% | 97% | .0804 |
| Technical success | 86% | 80% | 90% | 86% | .3051 |
| Aborted | 2.2% (13) | 6% (3) | 1.5% (1) | 1.9% (9) | .1547 |
| Converted | 1.2% (7) | 0% (0) | 0% (0) | 1.5% (7) | .4098 |
| Mean change CrCl pre to postprocedure (mL/min) | 13.2 ± 18 | 9.23 ± 13 | 12.2 ± 14 | 13.8 ± 19 | .2065 |
| *Early mortality <30 days + AAA rupture | 11 (2%) | 1 (0%) | 2 (2.9%) | 8 (1.7%) | .7894 |
| Late mortality | 159 (27.4%) | 16 (32.7%) | 20 (29.4%) | 123 (26.6%) | .614 |

**Includes periprocedural mortality and death from aneurysm rupture.*
*n ± standard deviation.*

considered significant. The study was approved by the institutional review board.

## RESULTS

The age, sex distribution, risk stratification, and median and mean follow-up times of each group were statistically similar (Table 1). The most detailed and precise follow-up data are available for patients in research studies; patients treated with a market device are strongly encouraged and reminded to return, but overall follow-up of market device patients is limited. The mean and median follow-up time was 28.3/25.6 months, respectively, (n=295) for research patients and 12.7/6.9 months, respectively, (n=285) for market patients (*P* = .0006). The features of the aneurysms are shown in Table 2. In terms of mean aneurysm diameter, group 1 differs significantly (*P* = .03) from group 3. Proximal neck length differs significantly among the three groups. We had access to a wide variety of devices that facilitated the treatment of challenging aneurysms, and the distribution of their use is shown in Table 3. The Talent device was used in the short neck groups (groups 1 and 2) 57% of the time, whereas other devices were used for a combined 43% of the time.

**TABLE 5. TYPE IA ENDOLEAK RATES AND REINTERVENTION RATES**

| | Overall N = 580 | Group 1 (5-9 mm) n = 49 | Group 2 (10-14 mm) n = 68 | Group 3 (>15 mm) n = 463 | *P* |
|---|---|---|---|---|---|
| All type IA | 7.3 % (42) | 14.3% (7) | 4.4% (3) | 6.2% (32) | .1062 |
| Early (procedural) type IA | 4.2% (24) | 4.1% (2) | 2.9% (2) | 4.3% (20) | .8666 |
| Late type IA | 3.1% (18) | 10.2 % (5) | 1.5% (1) | 2.6% (12) | .0099 |
| Required intervention | 4.8% (28) | 10.2% (5) | 2.9% (2) | 4.6% (21) | .1591 |

Outcomes are detailed in Table 4. The overall aneurysm-related and late mortality rates were 2% and 27.4%, respectively. There was no significant difference among conversion, aneurysm-related mortality, and late mortality rates for the three groups. The distribution of endoleaks among the groups is detailed in Table 5. Group 1 had a statistically higher rate of late type IA endoleaks (10.5%) compared to the other two groups ($P = .0099$). Group 1 also required a greater number of interventions, both early and late (Table 6). The majority of interventions involved the placement of extensions. A Kaplan-Meier survival curve is displayed in Figure 1. The curves are not significantly different. Overall patient survival probabilities are presented in Table 7.

**TABLE 6. TYPES AND TIMING OF REINTERVENTION/RESOLUTION**

| No. of Patients | Type IA Endoleak | Intervention/ Resolution |
|---|---|---|
| 6 | Early | Self-resolved |
| 14 | Early | Extensions |
| 3 | Early | Ballooning |
| 1 | Late | Ruptured prerepair |
| 2 | Late | Died prerepair |
| 2 | Late | Explant (early Ancure) |
| 4 | Late | Self-resolved |
| 10 | Late | Extensions |

## DISCUSSION

The results of this study show that endografts can be placed in short proximal aortic necks without a significant change in mortality, conversion to open surgery, or aneurysm-related mortality rates. When devices were placed in the group with the shortest necks (5 mm to 9 mm), there was a significant increase in the rates of late type IA endoleaks and a greater overall rate of secondary interventions. Patients with proximal necks 10-mm to 14-mm in diameter fared just as well as those in the ≥15-mm group. While other devices were used, treatment of these patients was accomplished mostly with the Talent bifurcated endograft, which included suprarenal attachment.

Other investigators have also found an increased rate of attachment site endoleaks in patients with short proximal aortic necks.[2,4] The higher rate of late type IA endoleaks in the group with the shortest aortic necks is likely due to the more difficult job of attaining adequate fixation and seal with a smaller landing zone. The use of suprarenal fixation devices (Talent and Zenith) enabled us to place more grafts in the 5- to 9-mm neck group. The increased type IA endoleak rate was treated most often with extender cuffs at the time of the procedure. The aggressive treatment of type IA endoleaks (early or late) probably had a significant impact on the lack of difference in mortality, survival, conversion to open repair, and aneurysm-related rupture rates among the groups.

Greenberg et al[13] found that the endoleak rate for all types was similar in the group of patients with necks ≥10 mm and in those <10 mm. That study, however, did not examine the relationship between neck length and type of endoleak, as we did. In addition, our study examined multiple devices, whereas Greenberg et al looked at just the Talent device. Also, our sample size was at least two times larger.

Hovespian et al[14] evaluated AneuRx grafts and the association with short-term complications and found a significant association between the length of the proximal neck and intraoperative and postoperative complications and early and late survival. Interestingly, AAA size did not have a similar relationship. We did not see an association with decreased survival or increased mortality rates, perhaps because we studied more than one type of endograft and the largest percentage of our endografts were fixated suprarenally.

Studies have detailed risk factors for endoleak development. Larger aneurysms have been shown to result in

**TABLE 7. CUMULATIVE SURVIVAL PROBABILITIES**

| Time | Group | No. at Risk | Survival Rate (%) | 95% CI |
|---|---|---|---|---|
| 12 months | 1 | 43 | 87.7 ± 40.9 | 74.8 - 94.3 |
| | 2 | 59 | 85.5 ± 31.7 | 74.7 - 91.9 |
| | 3 | 429 | 92.7 ± 17.2 | 89.9 - 94.7 |
| | All | 530 | 91.3 ± 14.2 | 88.8 - 93.4 |
| 24 months | 1 | 37 | 77.4 ± 30.2 | 62.9 - 86.8 |
| | 2 | 57 | 82.6 ± 28.9 | 71.4 - 89.7 |
| | 3 | 405 | 87.7 ± 13.3 | 84.3 - 90.4 |
| | All | 497 | 86.0 ± 11.1 | 82.9 - 88.6 |
| 36 months | 1 | 35 | 73.3 ± 27.9 | 58.4 - 83.5 |
| | 2 | 53 | 76.8 ± 25.1 | 64.9 - 85.1 |
| | 3 | 383 | 83.1 ± 11.3 | 79.4 - 86.2 |
| | All | 469 | 81.3 ± 9.6 | 77.9 - 84.3 |
| 48 months | 1 | 32 | 66.9 ± 25.2 | 51.9 - 78.3 |
| | 2 | 49 | 72.4 ± 23.0 | 60.3 - 81.5 |
| | 3 | 359 | 78.6 ± 10.1 | 74.5 - 82 |
| | All | 439 | 76.8 ± 8.7 | 73.2 - 80.1 |
| 60 months | 1 | 31 | 64.9 ± 24.5 | 49.7 - 76.5 |
| | 2 | 49 | 72.4 ± 23.0 | 60.3 - 81.5 |
| | 3 | 345 | 75.5 ± 9.4 | 71.3 - 79.2 |
| | All | 424 | 74.2 ± 8.2 | 70.4 - 77.6 |
| 72 months | 1 | * | * | * |
| | 2 | 48 | 69.7 ± 22.5 | 58.7 - 80.2 |
| | 3 | 334 | 73.2 ± 9.1 | 69.2 - 77.3 |
| | All | 412 | 72.4 ± 7.9 | 68.6 - 75.9 |
| 84 months | 1 | * | * | * |
| | 2 | 48 | 69.5 ± 21.9 | 57.1 - 78.9 |
| | 3 | 330 | 72.6 ± 8.9 | 68.3 - 76.5 |
| | All | 407 | 71.6 ± 7.8 | 67.7 - 75.1 |

**Data are not yet available for group 1 at 72- and 84-month follow-up.*

an increased incidence of endoleaks.[13] In addition, the presence of neck thrombus and calcification are known to affect the ability to achieve adequate seal between the device and aorta. Others have noted an increased endoleak rate in patients with severe neck angulation.[2,15]

This study was limited by its retrospective methodology, significantly smaller number of patients in the two short-neck groups, and procedural performance by 14 different physicians. These physicians are highly experienced and primarily used endografts that are not commercially available. The investigators had the benefit of access to the Talent device that is not yet on the market in the US, but is widely used in Europe and elsewhere. The relationship enabling access to the Talent device was done through a sponsored clinical trial and an institutional IDE. As a result of these trials, clinical experience was allowed in patients with shorter necks than those in clinical trials. We had clinical experience with necks shorter than the conventional ≥15 mm that is used in US trials because we had access to the Talent device and participated in an IDE and a special sponsored trial.

Recently, other approaches to treatment of patients with short AAA neck lengths have included branched and fenestrated grafts, as well as endostapling techniques.[16] These types of devices were not placed in our study group. Selection bias may have been introduced because the majority of the patients in groups 1 and 2 had Talent devices implanted. In addition, we used a measurement of the short neck that focused on length and not on morphology of the neck. Future studies should examine alternative methods, with attention to morphologic descriptions of aneurysm necks. Another limitation is that the patient population may not be representative of the average patient that presents for aneurysm repair because these patients were moderate-to-high risk and were poor candidates for open surgical repair. Finally, longer follow-up may

result in more reinterventions that could affect the aneurysm-related mortality rates and lead to differences among the three groups.

There are likely many other factors that impact the type IA endoleak rate, but this was not the primary purpose of this study. We wanted to analyze our experience with short necks and compare it to the conventional neck length group. Type IA endoleak was chosen as one of the important adverse outcomes of placing endografts in necks at risk for poor proximal seal. Also, we did not study the relationship among device type, neck length, and type IA endoleak rate because there was not adequate distribution of all of the devices among the three groups. Interestingly, we found that group 2 and group 3 patients required significantly more contrast for the procedure; the reason for this is not clear but perhaps future research will help elucidate contributing factors.

The optimal approach to the short proximal aortic neck includes clinical patient selection factors, aneurysm evaluation, access to a wide variety of devices (especially those with suprarenal fixation design), and technical maneuvers. First, the age and comorbidities of patients must be detailed to advise the patients whether they are best suited for EVAR or open repair. Second, an important factor in successful EVAR is the appropriate matching of the endograft device to aneurysm features. This entails accurate measurements of the aneurysm diameter, neck length, and angulation. Third, to deal with challenging proximal necks, access to devices with different features is paramount. In addition, devices that can be customized to suit particular anatomy are helpful with short necks. The choice of graft size for the proximal attachment zone is viewed as vital to enable adequate contact between the aorta and fabric. The suprarenal Talent device is ideally suited for these patients. Finally, placement of the C-arm in cranial and oblique positions, optimization of the image intensifier to view the aneurysm, and placement of a catheter in the renal artery for accurate visualization of the inferior wall are important procedural techniques.

When type IA endoleaks are found during the procedure, they should be aggressively treated, primarily with extender cuffs. Balloon-expandable Palmaz stents (Cordis Corporation, a Johnson & Johnson company, Miami, FL) may be used, but are limited due to size and stent length. We believe that based on the EUROSTAR data showing a relationship between the presence of type IA endoleaks and the development of symptomatic complications and an early risk of aneurysm rupture, the patient should not leave the suite without a vigorous attempt to treat the endoleak.[17]

## CONCLUSION

Each institution that undertakes EVAR must evaluate its practice to assess its ability to treat challenging proximal aortic necks. The center must possess the technology and personnel to adequately treat the complications of this endeavor. In addition, access to a wide range of endograft devices likely facilitates the treatment of this group. There are many factors that must be considered when evaluating EVAR outcomes and likely the most important factor for successful EVAR will represent a combination of many factors; it is unlikely that one factor will stand alone, including the length of the proximal neck. If the appropriate technology and expertise are available, patients with short proximal aortic necks should be considered for endovascular intervention if they are not candidates for open surgical repair. ■

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