What Constitutes a Compromised Aortic Neck in 2018?

Anatomic risk factors associated with an increased risk of proximal seal failure with standard EVAR in the era of device and technique advancement.

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Endovascular aneurysm repair (EVAR) is now clearly the preferred and predominant approach for treatment of infrarenal abdominal aortic aneurysms (AAAs), including those that rupture. Despite advancements in endograft technology over the last several years, approximately 40% of patients are deemed unsuitable for standard EVAR based on anatomic criteria, particularly if device-specific instructions for use (IFU) are followed.[1,2] A substantial number of these patients are anatomically unsuitable due to proximal aortic neck anatomy. As the boundaries of anatomic suitability are challenged with newer endografts and as more interventions proceed outside the IFU, which occurs up to 60% to 70% of the time in some series,[3,4] the number of "unsuitable" candidates considerably decreases. Although treating AAAs outside the IFU has shown mixed results,[3-6] surgeon comfort and experience with more complex endovascular interventions, including branched or fenestrated EVAR (FEVAR), snorkel or chimney EVAR (ChEVAR), or anchoring devices, has called the use of standard infrarenal endovascular devices into question for these more challenging anatomies. The basis for this question primarily stems from proximal aortic neck anatomy and which intervention is best suited to obtain a durable proximal seal.

Discussions of the compromised neck ultimately derive from what is considered an ideal aortic neck, which is typically related to the IFUs of commercially available endografts. For most devices, the infrarenal neck must be a minimum of 10 to 15 mm in length and 17 to 32 mm in diameter based on current IFU criteria. The aortic wall should be parallel when viewed in two-dimensional imaging and absent of reverse taper configuration. The suprarenal and infrarenal angulation

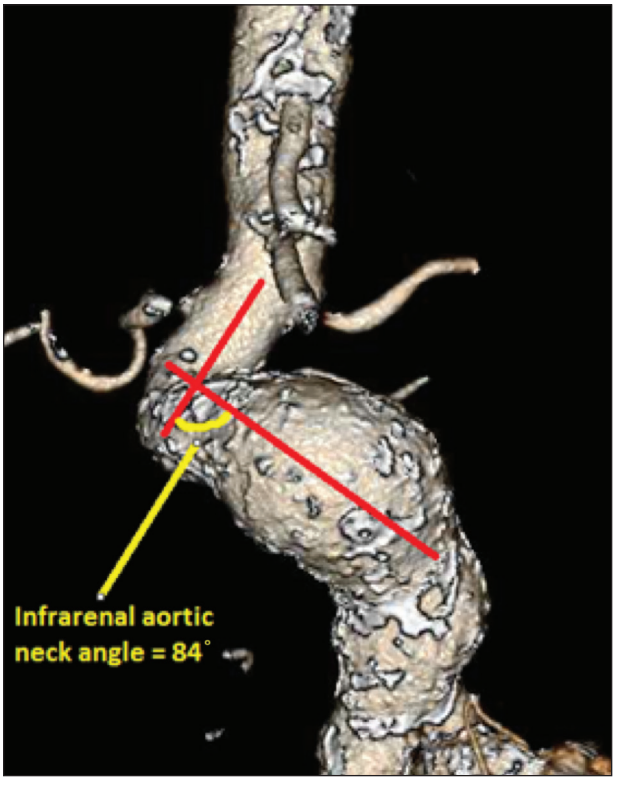

Figure 1. Severe infrarenal aortic angulation challenges the flexibility of the endograft and makes the desired circumferential wall apposition for proximal seal difficult.

is < 60° and the aortic wall should be void of significant calcium or thrombus. Anything outside of these boundaries is considered treating outside the IFU, potentially compromising the durability of the proximal seal. Recently, concerns have been raised over the durability of landing a standard device in a relatively large-diameter neck despite still falling within the IFU criteria. This article highlights the anatomic variables associated with the compromised aortic neck and increased risk of proximal seal failure with standard EVAR.

NECK DIAMETER

Current commercially available endografts have proximal diameters ranging from 22 to 36 mm within the IFU to treat aortic neck diameters of 18 to 32 mm. Despite IFU parameters, including diameters up to 29 to 32 mm, recent studies have shown adverse outcomes in treating AAAs with large neck diameters. Although a few earlier studies demonstrated the feasibility of this approach,[7] several others have shown that aortic neck diameters ≥ 28 mm are a risk factor for proximal seal failure.[4,8-11] Oliveira et al reported on a multi-institutional study utilizing the Endurant endograft (Medtronic), which demonstrated an increased risk of type Ia endoleak and neck-related secondary interventions in patients with infrarenal necks ≥ 30 mm (odds ratio [OR], 3.8; 95% confidence interval [CI], 1.6–9.1).[10] Similarly, our group recently explored our institutional data of all standard EVARs from 2000 to 2016 and noted a fourfold increase in failure of proximal fixation in patients treated with devices that had large proximal diameters (34–36 mm).[12] Further, on multivariate analysis, we showed that a neck diameter ≥ 29 mm was an independent risk factor for proximal seal failure (OR, 2.5; 95% CI, 1.12–5.08).

A primary concern with the durability of standard infrarenal EVAR in patients with a dilated neck is progressive aortic dilatation after EVAR. Our group has also demonstrated a mean increase in aortic neck diameter of 3.3 ± 0.6 mm at latest follow-up scans in 86 patients, with a median radiologic follow-up of 21.9 months. No significant difference in neck dilation across devices was identified, but a positive correlation between percent change in neck diameter and degree of oversizing did exist (r_s = 0.41; P < .001).[13] This suggests that perhaps evolution in device fixation strategy needs to be explored. Gargiulo and colleagues examined this concept further and not only demonstrated progressive neck dilatation in patients with wide aortic necks (≥ 28 mm), but also demonstrated that the rate of dilatation differed at distinct levels of the aorta. The mean increase in diameter at the level of the lowest renal artery was 11%, as opposed to 3% to 5% at the renal arteries and < 3% at the superior mesenteric artery and celiac trunk, suggesting more durable endovascular approaches should involve proximal fixation into a healthier segment of perivisceral aorta for this subset of patients with dilated infrarenal necks.[11]

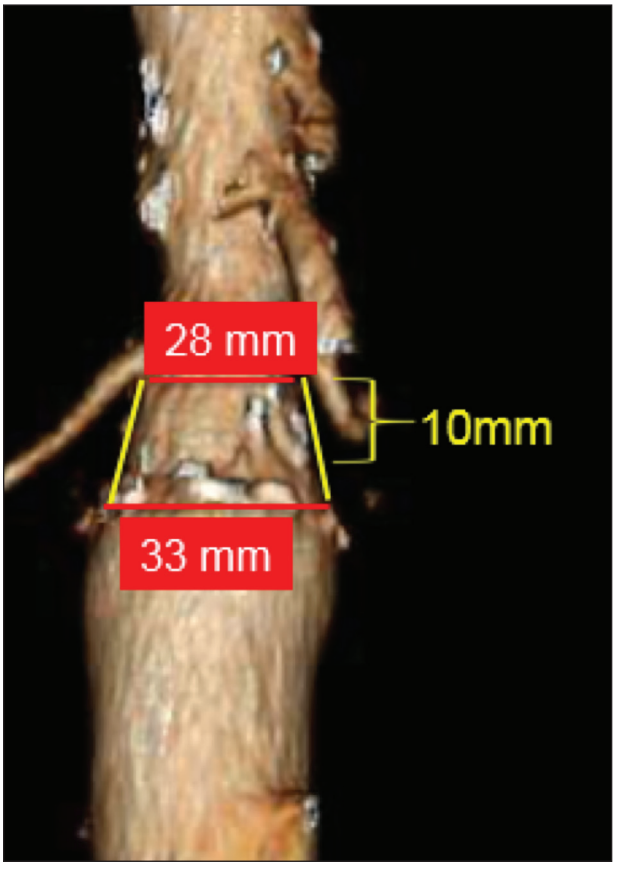

Figure 2. A reverse taper neck configuration with progressive dilatation within the proximal seal zone complicates accurate graft oversizing and the long-term durability of standard EVAR.

NECK LENGTH

Most commercially available endografts recommend an aortic neck length of 10 to 15 mm for treatment within the IFU. The concept of why a short aortic neck length leads to poorer outcomes is relatively simple: the lesser the amount of seal zone, the more likely that seal zone will fail. This has been described and demonstrated in multiple studies.[14-16] Data from the EUROSTAR registry indicate both increased risk of early type Ia endoleak (OR, 4.46; 95% CI, 2.61–7.61) and late type Ia endoleaks (hazard ratio [HR], 2.13; 95% CI, 1.17–4.60) in patients with aortic necks < 10 mm in length.[15] A study by AbuRahma et al found similar results in

patients with neck lengths < 10 mm in both the early occurrence of type Ia endoleak (53% vs 12% in necks > 15 mm; $P < .001$) and late (3-year follow-up) freedom from type Ia endoleaks (53% vs 80%; $P = .0263$).[14]

A more recent study by AbuRahma et al found that neck lengths < 10 mm had an OR of 4.26 (95% CI, 1.33–13.68) for type Ia endoleak.[8] Further, Jordan and colleagues, through the ANCHOR database, demonstrated that shorter neck lengths with a cut point of 17 mm were associated with a higher rate of type Ia endoleak ($P = .017$).[16] Many reports on FEVAR and ChEVAR describe the concept of additional neck length gained that might lengthen an already compromised region of potential fixation.

NECK ANGULATION

Neck angulation includes both suprarenal and infrarenal (Figure 1) aortic neck angulation measurements as standardized by van Keulen and colleagues in their 2010 publication.[17] A cutoff of ≥ 60° is used to classify an aortic neck as angulated. The main concern when attempting to obtain a proximal seal within an angulated aortic neck is the ability for the device to contort enough to achieve circumferential wall apposition.

Several studies have documented neck angulation as an independent risk factor for type Ia endoleak.[6,8,18] In the previously mentioned study by AbuRahma et al, neck angulation > 60° had an OR of 2.81 (95% CI, 1.06–7.47) for sac expansion and 3.28 (95% CI, 1.71–6.29) for early reintervention.[6] Further data from the EUROSTAR registry determined that the risk of type Ia endoleak was higher in the perioperative period (OR, 2.17; 95% CI, 1.20–3.91; $P = .0105$) than it was in the long term (HR, 1.80; 95% CI, 1.25–2.58; $P = .0016$).[19] Finally, Schanzer et al reported that in over 10,000 patients undergoing EVAR between 1999 and 2008 with M2S core laboratory analysis of both pre- and post-EVAR anatomy, patients with neck angulation > 60° had an increased risk of aneurysm sac enlargement (HR, 1.96; 95% CI, 1.63–2.37; $P < .0001$).[4]

NECK CONFIGURATION

Aortic necks with nonparallel walls risk compromising the full 10 to 15 mm of seal required to stay within the IFU. This primarily refers to a reverse taper or conical configuration (Figure 2) that is often defined as a > 10% increase in diameter over a 5-mm increment in the aortic neck. Again, the concern lies in decreasing the length of seal as the neck dilates, which in turn makes it more challenging to accurately oversize the selected endograft. In a 2011 study, AbuRahma et al demonstrated that the reverse taper configuration

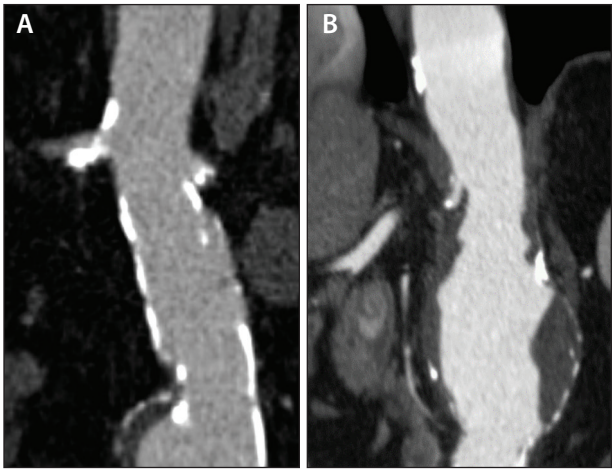

Figure 3. Aortic neck calcification signifies a diseased neck and compromises active fixation of the endograft proximally (A). Circumferential aortic neck thrombus has long been believed to be a risk factor for proximal seal failure; however, recent data have called this into question, leading some to believe thrombus to be protective against proximal seal failure (B).

was a significant predictor for early type I endoleak (OR, 5.25; $P < .0001$).[8] In another study of patients with short aortic necks (< 15 mm), the reversed taper configuration was the most significant contributor to proximal failure when compared to other associated hostile neck characteristics.[20]

NECK CALCIFICATION AND THROMBUS

Neck calcification and neck thrombus have long been considered risk factors for proximal seal failure in EVAR (Figures 3A and 3B). Despite this, there is no universally agreed upon method to quantify the extent of thrombus or calcification in the aortic neck. Kaladji and colleagues previously studied predictive anatomic factors for sac regression after EVAR by assigning a severity score to the aortic neck, AAA, and iliac arteries. On multivariate analysis, they demonstrated that patients with sac regression had a significantly lesser amount of calcification within the neck, and the lesser calcification burden decreased the rate of type Ia endoleak.[21]

Although neck calcification continues to result in adverse outcomes in EVAR, recent studies have found neck thrombus to be less of a risk and more a protective factor with regard to type Ia endoleak. Jordan et al found that the presence of aortic neck calcification was not a significant predictor for type Ia endoleak, and each degree of aortic neck thrombus decreased the risk of type Ia endoleak by 1% ($P = .001$).[16] Another study by Wyss et al similarly demonstrated neck thrombus to

have a protective effect against graft-related complications (HR, 0.96; 95% CI, 0.92–0.99; $P = .018$), whereas aortic neck calcification was associated with a higher risk of graft-related complications (HR, 1.06; 95% CI, 1.00–1.12; $P = .044$).[22]

THE COMPROMISED NECK

Each individual risk factor mentioned increases the risk of proximal seal failure; however, the sum of two or more of these findings may significantly increase the overall risk and truly define the compromised or hostile neck. Few studies have attempted to quantify the added detriment that each factor adds to the next. Kaladji and colleagues quantified an anatomic severity score and noted that the higher the score, the lower the likelihood of aneurysmal regression over time.[21] A meta-analysis of seven observational studies by Antoniou and colleagues demonstrated that patients with the umbrella term *hostile neck anatomy* had a fourfold increased risk of developing a type Ia endoleak (OR, 4.563; 95% CI, 1.430–14.558) and a ninefold increased risk of aneurysm-related mortality within 1 year of intervention (OR, 9.378; 95% CI, 1.595–55.137).[23] Finally, a similar meta-analysis by Stather et al demonstrated that those with hostile neck anatomy had a significant increase in 30-day type Ia endoleak (OR, 2.92; 95% CI, 1.61–5.30; $P < .001$) and late type Ia endoleak (OR, 1.71; 95% CI, 1.31–2.23; $P < .0001$).[24] However, even with these warning signs, and particularly with interventionalists wanting more access to complex devices, the treatment of the compromised neck is likely going to continue to increase, and accurate reporting outcomes are necessary to truly understand which strategy will work in different scenarios.

CONCLUSION

The compromised or hostile aortic neck has been shown to increase the risk of proximal seal failure in standard EVAR. As endograft technology and surgeon comfort with complex aortic repair progress, the use of standard EVAR in this particular patient population should be considered only in those who are not candidates for a more complex approach. Otherwise, in suitable patients, more complex endovascular interventions such as FEVAR or ChEVAR versus a traditional open repair should likely be the standard of care. ■

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