

The Narrow Distal Aorta

A risk factor for limb occlusion and an anatomic challenge for endograft selection.

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Endovascular abdominal aortic repair (EVAR) has evolved considerably since its introduction. Large, multicenter, randomized, prospective trials such as EVAR-1, DREAM, and OVER, in addition to device-specific postmarket studies, have demonstrated that EVAR is superior to open repair.¹⁻³ This difference in outcomes is most applicable to patients with aortic anatomy within the indications for use of the currently available stent graft devices. As surgeon expertise, familiarity, and facility with endovascular techniques have increased, and as we have become more comfortable with current EVAR devices, we have broadened our inclusion criteria and pushed the limits of anatomic challenges addressed with EVAR. Little is known about the prevalence of these complex aortic anatomies and the behavior of commercially available endografts therein. Professional society guidelines for EVAR often recommend against repair in certain anatomies, which have thus been excluded from the majority of prospective industry-sponsored clinical trials.

Most of the attention regarding complex aortic anatomy has been focused on challenging neck anatomy and the question of when to attempt infrarenal repair in a suboptimal neck or opt for fenestrated pararenal/paravisceral repair. The narrow distal aorta poses a distinct set of challenges that has received less attention than other anatomic scenarios. In this article, we highlight the complexity of the narrow distal aorta, which is defined by the European Society for Vascular Surgery as ≤ 20 mm in diameter.⁴ We will discuss the technical challenges and clinical implications of EVAR in this patient population, as well as the procedural and clinical impact of endograft design. Finally, we will describe two EVAR cases that presented with narrow distal aortas (10.5 and 13 mm).

LIMB OCCLUSION IN EVAR

The primary procedural and clinical concern during EVAR in the context of a narrow distal aorta is the risk of limb occlusion. The incidence of limb occlusion has been reported to be between 3.2% and 7.2%.⁵⁻⁷ In one

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of the most comprehensive analyses of EVAR-related limb occlusion to date, Cochennec and colleagues reviewed the treatment of 460 abdominal aortic aneurysm (AAA) patients with various endografts between 1995 and 2005.⁷ A key finding highlighted the delayed nature of occlusions across the entire cohort, with more than 50% presenting 6 months or more post-procedure. Importantly, 9.1% of limb occlusions did not present until after 3 years, and reintervention was required in all but two of the 33 patients (93.9%) with limb occlusions. The secondary treatments included femorofemoral bypass grafting, axillobifemoral bypass grafting, and thrombectomy/thrombolysis with adjunctive stenting. Two patients experienced reocclusions after thrombolysis and stenting and required further procedures.

In larger registry series of newer endografts, rates of limb occlusion are lower but still significant. The EUROSTAR registry (more than 6,700 patients) confirms an annual incidence of 2.3% for graft kinking and 3.2% for limb occlusion.⁶ The more recent ENGAGE registry of more than 1,200 patients highlights a 3% reintervention rate for graft occlusion, stenosis, or kinking.⁸ Although the relative frequency of these adverse events is low, the absolute significance—both in terms of patient morbidity and mortality and incurred cost—becomes magnified by the sheer volume of EVAR procedures being performed today. Currently, we are not able to reliably identify which patients are at increased risk of limb kinking and thrombosis, although we can

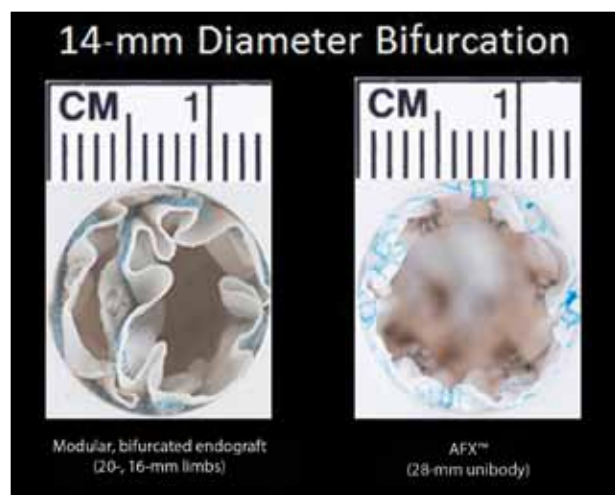


Figure 1. Simulation of limb positions of a bifurcated endograft and a unibody endograft in a tight distal aorta (14 mm). There is asymmetric compression of the limbs of the bifurcated endograft, whereas the lumen of the unibody endograft is preserved.

hypothesize what may be predictive and potentially exacerbating anatomic factors.

IMPACT OF INTRINSIC ANATOMY ON LIMB OCCLUSION

It seems intuitive that the most common cause of limb occlusion is device kinking. In a recently reported EVAR series, graft kinking has been held responsible for approximately 25% to 40% of occlusions.⁹⁻¹¹ Cochenne et al found that stent graft kinking (odds ratio, 11.9; confidence interval, 3.39–42.1; $P = .0001$) was independently related to the occurrence of graft limb occlusion (57.1% for limbs with kinks vs 3.4% for limbs without kinks).⁷ In two abstracts presented at the 2012 Vascular Annual Meeting, higher than expected limb occlusion rates of 4.9% and 7.7% were reported in series describing the latest generation of bifurcated devices.^{12,13} Limb kinking due to narrow distal aortic anatomy was proposed as a major mechanism for these events.

The impact of intrinsic anatomy and morphology on limb kinking and subsequent occlusion cannot be underestimated. Pre-existing iliac stenosis with heavy calcification, the presence of concomitant iliac aneurysm, and a high degree of iliac angulation and/or tortuosity are factors that can contribute to both kinking and limb occlusion.¹⁴ A narrow distal aorta, especially with heavy or circumferential calcification, poses perhaps the biggest challenge to traditional bifurcated repair. The limited space within the tight distal aorta may result in limb competition that does not allow for

complete expansion of the iliac limb components in the available aortic lumen. The limb competition can result in compression and/or kinking of one or both of the iliac artery limbs and can lead to a higher rate of limb occlusion. In a retrospective study of 1,696 early EVAR procedures, Gabrielli et al reported higher rates of lower limb ischemia due to graft limb kinking and twisting in distal aortas measuring < 18 mm.¹⁵ However, more research is needed to understand the prevalence and correlation of limb occlusion and small aortic diameters.

EVAR STRATEGIES AND ENDOGRAFT SELECTION IN PATIENTS WITH NARROW DISTAL AORTAS

Of the commercially available stent grafts approved for EVAR of infrarenal AAAs, all but two consist of a main body with two limb extensions that extend from the lower margin of the main body through the distal aorta and into the bilateral iliac arteries. Selection of such a device, in which the aortic bifurcation is artificially elevated, requires additional procedural considerations in the setting of a narrow distal aorta. In these patients, gate cannulation can be significantly impeded once the ipsilateral limb is deployed through the narrow aorta, thereby effectively “sealing” the distal aorta. Maintaining sheath access into the aneurysm sac from the contralateral side is imperative during this part of the procedure but does not help in managing the limb compression that occurs subsequently with delivery of the contralateral iliac limb. If the diameter of the distal aorta through which the two limbs must pass is the same (or less) than the sum of their diameters, there may be compression of one of the limbs, increasing the risk of occlusion or kinking (Figure 1).

Adjunctive maneuvers that may be performed to maintain limb patency in this setting include kissing-balloon angioplasty and (more commonly) selective or routine bilateral stent reinforcement of the iliac limbs. Although acutely successful, these intraprocedural secondary interventions add additional cost (balloon, stent, and other accessory devices), time, and risk. Some interventionists have advocated “cracking” of a circumferentially calcified narrow distal aorta with high-pressure kissing-balloon angioplasty, the so-called napkin ring aorta. Although this adjunctive procedure may improve the patency of the compressed and/or kinked limbs, the risk of aortic rupture is significant and could be devastating in the presence of an endoleak. The long-term clinical and economic outcomes of EVAR involving secondary intraprocedural stenting and/or ballooning have not been reported.

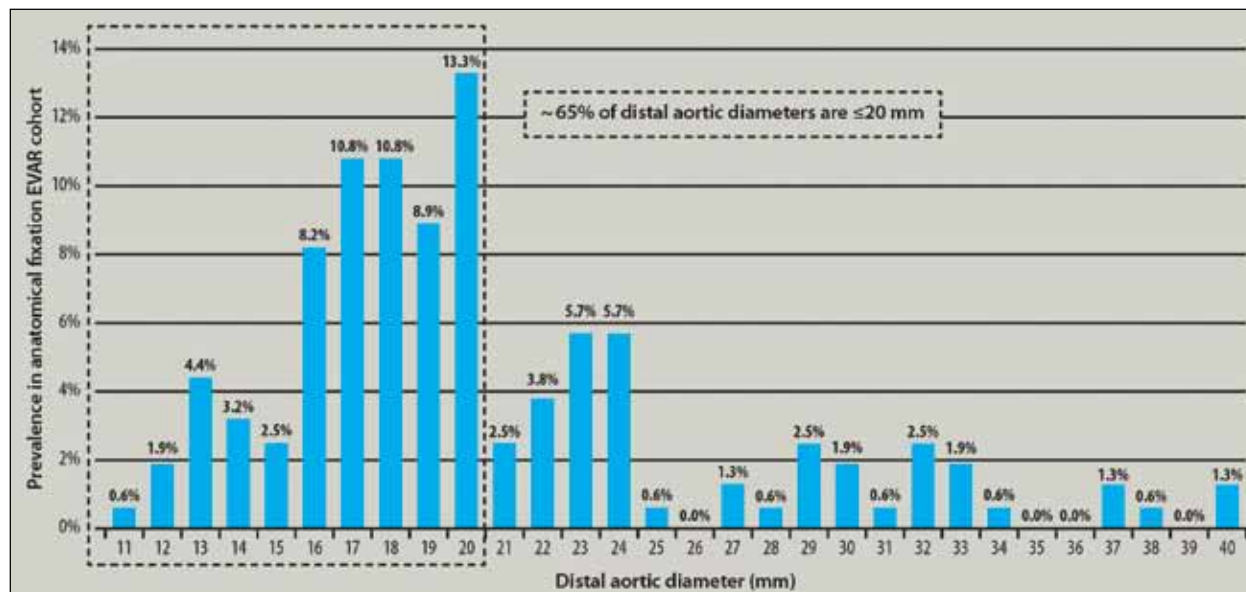


Figure 2. Histogram of the distribution of distal aortic diameters in a pooled analysis of three prospective multicenter trials of the Endologix endograft system.

Another possible solution to allow EVAR in the presence of a narrow distal aorta may be an aorto-uni-iliac (AUI) graft. Although AUI implantation is an attractive option when compared to the use of a modular main body device in this anatomy, there are limitations to its applicability. The primary issue with the use of an AUI device is the necessity of a femorofemoral bypass, which requires bilateral groin incisions and has the drawback of adding procedural time and further risk of morbidity, with graft surveillance required due to the risk of prosthetic graft infection and eventual graft thrombosis. Deployment during the AUI implantation of the contralateral iliac artery occlusion device can also be technically challenging. Taking these factors into consideration, along with the concern that any limb kinking in the AUI configuration could lead to acute aortic occlusion, makes the placement of an AUI in these patients an option of last resort.

Citing the risk of graft limb thrombosis through graft impingement, in-folding, and kinking, Swiss surgeons recently reported the use of a custom reversed flared endoprosthesis (requiring a 4-week lead time) in two patients with narrow distal aortas (17 and 19 mm).¹⁶ The authors advocate the value of single-lumen endografts to address this anatomy and avoid more invasive procedures such as AUI and femorofemoral bypass. One such device, the AFX™ Endovascular AAA System (Endologix, Inc., Irvine, CA), is a single-lumen main body endograft that is commercially available in the United States and Europe with excellent long-term data

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in patients with narrow distal aortic anatomy.¹⁷ The fully supported unibody design of the bifurcated AFX™ device preserves the natural aortic bifurcation while providing anatomic fixation and proximal seal. The single-lumen design obviates the previously cited concerns of limb competition and compression, decreases the need for concomitant ballooning or stenting, and may provide an improved safety profile if postimplantation balloon dilation is desired.

In a pooled analysis of results from three prospective multicenter trials with the Endologix endograft system in which two-thirds of patients had distal aortic diameters < 20 mm (Figure 2), Carpenter and colleagues found no aneurysm-related deaths, ruptures, conversions, or migrations out to 5 years in 157 patients undergoing elective AAA patients.¹⁷ During extended follow-up in this complex cohort, with the high prevalence of narrow distal aortic anatomy, only two patients (1.27%) underwent reintervention for limb occlusion.

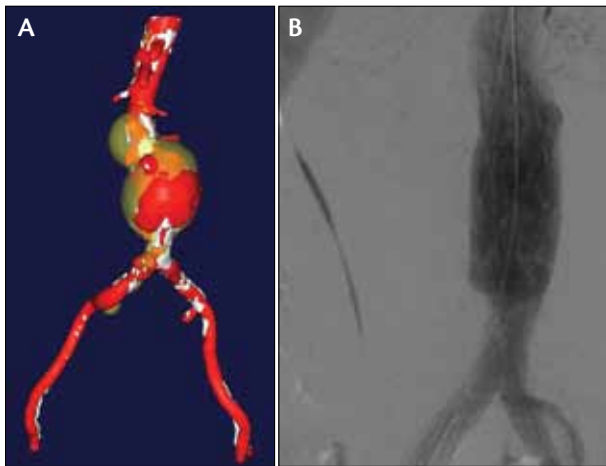


Figure 3. Preoperative appearance of a 5.9-cm juxtarenal AAA with a complex neck but, most notably, a heavily calcified narrow distal aorta (10.5 mm) in a 75-year-old patient undergoing elective EVAR (A). Postoperative angiography after successful EVAR using a 25-mm AFX™ unibody bifurcated endograft and a Ventana™ fenestrated endograft construct (B).

CASE STUDIES

The first case is that of a 75-year-old man who presented with an asymptomatic infrarenal aortic aneurysm

(5.9 cm). This patient had multiple cardiac comorbidities including significant coronary artery disease, cardiomyopathy, and congestive heart failure with an ejection fraction of < 30% and an implanted cardioverter defibrillator, rendering him a suboptimal candidate for open repair. The distal aortic bifurcation was heavily calcified and measured 10.5 mm in diameter (Figure 3A). A 25-mm AFX™ unibody endograft was successfully implanted, and the limbs and distal aorta were postdilated with two 12-mm kissing balloons, providing a widely patent distal outflow with good seal and no endoleak (Figure 3B). The procedural and postoperative course were uneventful, with successful AAA exclusion and no evidence of migration, endoleak, or limb kinking based on short-term follow-up and imaging.

The second case is an 85-year-old woman with a sacular aneurysm in the infrarenal aorta. Her medical history was significant for hypertension, coronary artery disease, and oxygen-dependent chronic obstructive pulmonary disease. Aneurysm diameter enlargement occurred rapidly over a period of 6 months, from 4.9 to 5.5 cm. At an outside institution, when the patient was evaluated for EVAR as the first-line therapy for aneurysm repair, her distal aortic anatomy was deemed to rule out EVAR with a modular device. Due to her comorbidities, she was not a candidate for open AAA repair.

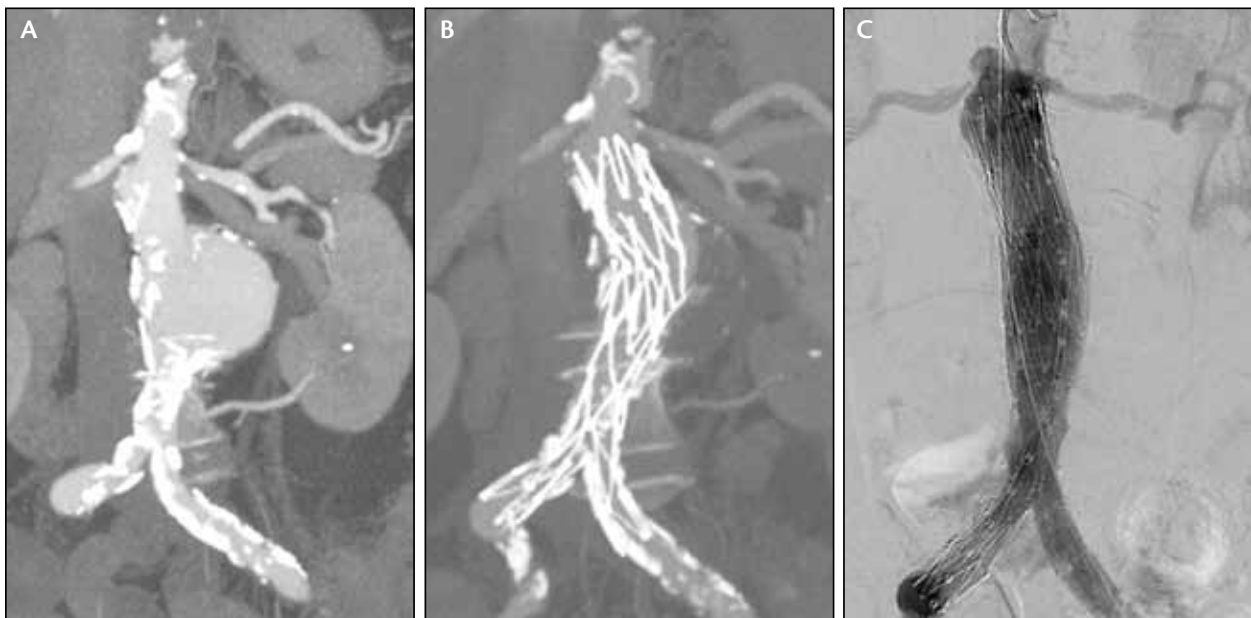


Figure 4. Preoperative maximum intensity projection image of a AAA in an 85-year-old woman with a saccular aneurysm and a narrow (13 mm) calcified distal aorta (A). Postprocedure maximum intensity projection image after successful EVAR with the AFX™ unibody endograft showing orientation of the device on the aortic bifurcation (B). Because the main body of the device sits in the narrow aorta (13 mm), there is no limb competition, kinking, or compression. Postprocedure angiography demonstrates no evidence of kinking or compression, with a widely patent distal aorta (C).

Given that this anatomy is a significant risk factor for limb occlusion and its associated consequences, it stands to reason that optimal endograft selection is imperative.

Evaluation revealed a long segment (27 mm) of the distal aorta that was both narrow (13 mm) and circumferentially calcified (Figure 4A). A 22-mm main body device with 16-mm iliac artery limbs was deployed onto the aortic bifurcation as per the indications for use. A 28-mm infrarenal cuff was placed below the lowest renal artery. Due to the narrow diameter of both common iliac arteries, balloon expansion of both iliac limbs was required. No balloon angioplasty was performed at the level of the narrow aorta. Completion angiography showed excellent flow through the entire graft, including the distal aorta. Follow-up computed tomographic angiography showed no evidence of graft infolding or kinking, and both limbs were patent (Figure 4B and C).

CONCLUSION

A narrow distal aorta, defined by a diameter of ≤ 20 mm, is a risk factor for limb occlusion and presents unique considerations for endograft selection. Based on baseline data from the pooled analysis of three prospective EVAR studies that did not exclude this complex aortic anatomy, it may be far more prevalent than previously thought. In that pooled dataset, upward of 65% of patients presented with a narrow distal aorta.¹⁷ Given that this anatomy is a significant risk factor for limb occlusion and its associated consequences, it stands to reason that optimal endograft selection is imperative. Newer devices are striving for lower-profile delivery and increased flexibility but may demonstrate higher than expected limb occlusion rates as a result. The unibody design of the AFX™ system with its ability to reline and stent the native aortic bifurcation demonstrates remarkably low limb occlusion rates and may provide a significant advantage in the narrow distal aorta. ■

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