International Medical Case Reports Journal

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CASE REPORT

Endovascular Repair of an Abdominal Aortic Aneurysm with an S-Shaped and Severely Tortuous Proximal Neck: A Case Report

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Background: Endovascular aneurysm repair (EVAR) is a minimally invasive treatment for abdominal aortic aneurysm (AAA). However, severely angulated or S-shaped "hostile" proximal necks remain challenging, increasing the risk of type IA endoleak and early procedural failure. Morphological indices such as neck angles, tortuosity index (TI), and angle-length index (ALI) have been proposed to predict EVAR outcomes. However, their measurement in clinical practice remains limited, particularly in highly deformed necks, and they do not assess axial torsion.

Case Presentation: We report a 65-year-old male with a 73 mm infrarenal AAA and a 39 mm S-shaped proximal neck (suprarenal angle 105°, infrarenal angle 111°, TI ≈1.42), outside the recommended IFU thresholds. EVAR was performed using the Endurant™ II system (Medtronic). An in-traoperative type IA endoleak occurred and was successfully treated with an addi-tional proximal cuff and ballooning, achieving complete sealing. The patient recovered uneventfully and was discharged in stable condition. Follow-up CTA at 24 months demonstrated a stable stent graft, no endoleak, and unchanged aneurysm diameter.

Conclusion: This case report demonstrates that durable outcomes can be achieved with EVAR even in the setting of a "hostile neck" with severe S-shaped morphology and torsion. Experience from this case suggests that comprehensive morphological assessment—including novel indices for torsion—combined with timely intraoperative management of type IA endoleak using a proximal cuff is critical for long-term success. This underscores the importance of improving current risk models to more accurately incorporate complex 3D deformities in preoperative planning.

Keywords: abdominal aortic aneurysm, EVAR, hostile neck, tortuosity, type IA endoleak, cuff extension

Introduction

Over the past two decades, endovascular aneurysm repair (EVAR) has become the treatment of choice for infrarenal abdominal aortic aneurysms (AAA) in many centers, owing to its lower early complication rates and faster recovery compared with open surgery. However, the long-term success of EVAR depends primarily on the morphological characteristics of the proximal neck.[1] Features such as short length, wide diameter, severe angulation, or marked tortuosity are collectively referred to as a "hostile neck," all of which are associated with a higher risk of type IA endoleak, stent graft migration, and treatment failure during follow-up.[2]

The instructions for use (IFU) provided by most stent graft manufacturers specify strict anatomical criteria for the proximal neck: typically- a minimum length of 10–15 mm, a diameter of 18–32 mm, and a maximum angulation of 60–75°.[3–5] In real-world practice, however, a substantial proportion of AAA patients do not meet these criteria, particularly those with an S-shaped neck or multiple sequential angulations. In such patients, the risk of procedural failure or the need for adjunctive techniques (such as proximal cuff, chimney grafts, or fenestrated EVAR) is significantly higher.

https://doi.org/10.2147/IMCRJ.S573160
Received: 11 October 2025
Accepted: 7 January 2026
Published: 21 January 2026

Beyond these conventional parameters, several novel geometric indices have been proposed to better quantify anatomical risk, including the tortuosity index (TI) and the aortic length index (ALI). TI reflects the degree of vessel curvature, whereas ALI has been shown to correlate with an increased risk of endoleak when exceeding 4.8.[6] Nevertheless, these indices still do not adequately capture complex anatomical variations such as axial torsion or pronounced S-shaped deformities of the neck.

We report the case of an AAA patient with a severely angulated S-shaped proximal neck well beyond IFU thresholds, successfully treated with EVAR using an additional proximal cuff and balloon molding. This case underscores the challenges of morphological assessment in hostile neck anatomy and highlights the need for more refined indices to accurately characterize axial torsion deformities.

Case Presentation

The patient is a 65-year-old male with a BMI of 22.5 and a medical history notable for hypertension, a 20 pack-year smoking history, dyslipidemia, and chronic kidney disease stage 3a (serum creatinine 138 µmol/L, eGFR 48 mL/min/1.73 m^2). He presented with a one-week history of dull, persistent lower abdominal pain. Physical examination revealed a pulsatile periumbilical mass with a positive DeBakey sign, while hemodynamics remained stable and there were no signs of acute rupture. Laboratory investigations showed mild anemia (hemoglobin 12.2 g/dL) and normal coagulation parameters.

Based on his comorbidities—particularly chronic kidney disease and cardiovascular risk factors—the patient was classified as ASA Physical Status III, indicating severe systemic disease with functional limitation. Given this risk profile, open surgical repair is not the preferred approach, as it carries higher perioperative morbidity in ASA III patients. Therefore, endovascular aneurysm repair (EVAR) is generally considered the safer and more appropriate option when anatomically feasible.

Computed tomography angiography (CTA) demonstrated an infrarenal abdominal aortic aneurysm (AAA) with a maximal diameter of 73 mm and a length of 15 cm, extending to the aortic bifurcation (Figure 1).

The proximal neck measured 39 mm in length and exhibited an S-shaped configuration with two angulated segments. The suprarenal angle was 105°, the infrarenal neck angle was 111°, and the rotational angulation was 70° (Figure 2).

The transverse neck diameter measured 21 mm. The right external iliac artery measured 6.9 mm and the left 6.5 mm in diameter, both just sufficient to accommodate an 18 Fr sheath, with no calcification. The tortuosity index was approximately 1.42, and the aortic neck angle–length index was about 2.9 (Table 1).

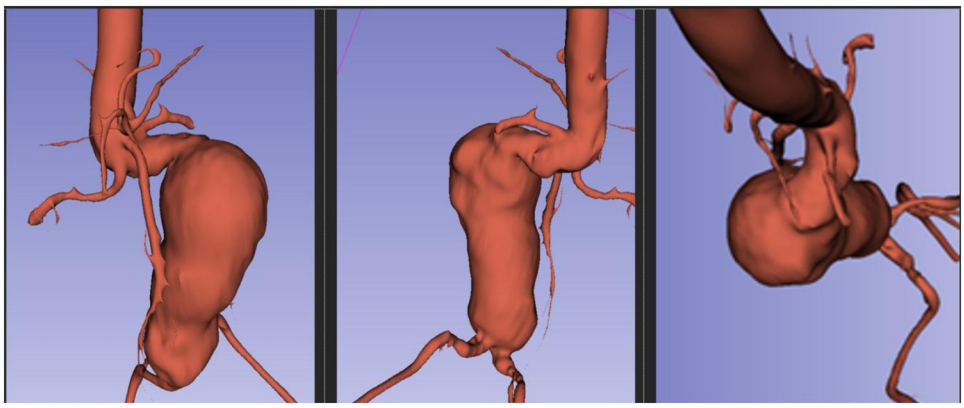

Figure 1 CT angiography showing an infrarenal AAA with an S-shaped neck.

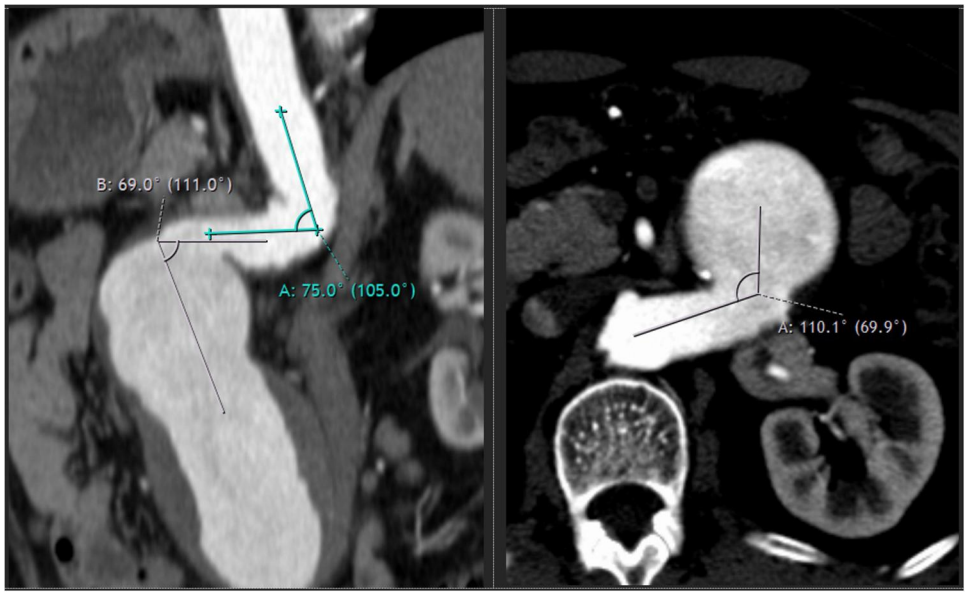

Figure 2 CTA measurements of the proximal aneurysmal neck and iliac access. Left Panel (Sagittal View): Measurement of angulation in the longitudinal plane. Angle A (75.0°) is the Inferior Aortic Neck Angle; Angle B (69.0°) is the Iliac Access Angle. Right Panel (Axial View): Measurement of angulation in the transverse plane. Angle A (110.1°) represents the Transverse Neck Angle.

The tortuosity index (TI) was calculated using the following formula:

$$\mathrm{TI} = \frac{\text{length of the centerline when stretched}}{\text{straight} - \text{line distance between the start and end points of the centerline}}$$

$$\mathrm{TI}_{neck} = \frac{39mm}{27.5mm} = 1.42$$

(Figure 3).

Both external iliac arteries were just sufficient in diameter to accommodate an 18 Fr sheath, with no calcification (Table 2).

The EVAR procedure was performed under local anesthesia via bilateral femoral access using the percutaneous Seldinger technique. The left femoral access was used to advance the main body of the stent-graft. An Endurant™ II

Table 1 Morphological Characteristics of the Proximal Aneurysmal Neck

Parameter	Measured Value	Recommended Threshold in IFU*
Neck length	39 mm	≥ 10–15 mm
Neck diameter	21 mm	18–32 mm
Suprarenal angle	105°	≤ 60° (Endurant II)
Infrarenal neck angle	111°	≤ 60° (Endurant II)
Rotational Angulation/Axial Torsion	70°	Not specified in IFU
Neck morphology	S-shape, two angulations	Not specified in IFU
Tortuosity index	~1.42	≤ 1.4 (literature)
Aortic neck angle–length index	2.9	≤ 4.8 (literature)

Note: Thresholds not specified in IFU are derived from published literature. (*) IFU: Refers to the Medtronic Endurant II system (Source 8) and general IFU guidelines.

https://doi.org/10.2147/IMCRJ.S573160

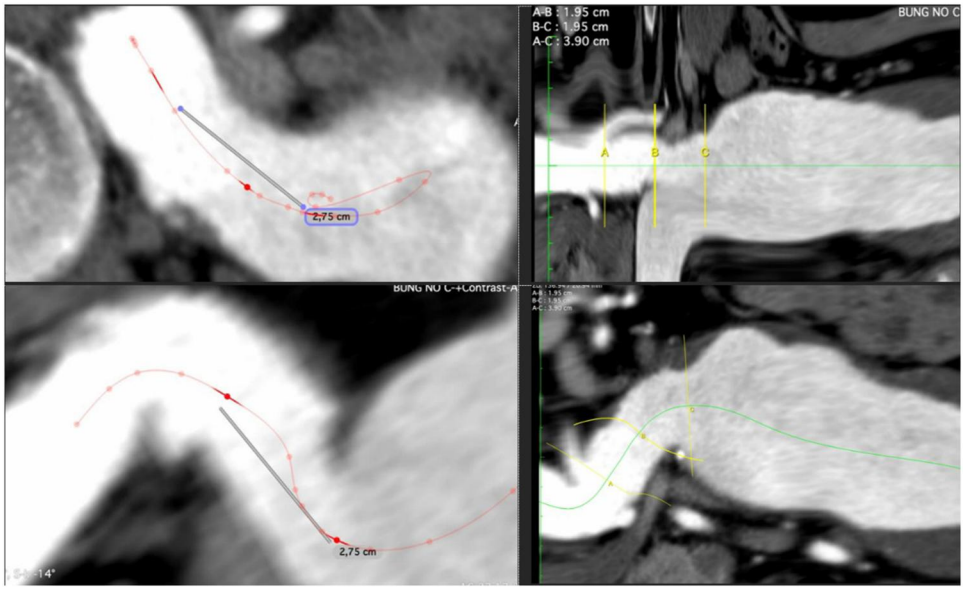

Figure 3 Centerline measurement of the proximal neck for tortuosity index (TI). Red curve: Represents the centerline (Lcenterline), illustrating the actual vessel path. Yellow line: Represents the straight-line distance (Lstraight) between the measurement points. (**A**–**C**) Key anatomical measurement points used to define the segment and calculate the Tortuosity Index (TI). TI is calculated as (L_centerline - Lstraight)/Lstraight.

stent graft system (Medtronic) was deployed. In this case with severe neck angulation, advancement of the delivery system required a stiff guidewire to improve trackability, along with careful torque and rotation control to navigate the S-shaped curvature and maintain coaxial alignment for accurate deployment. The main body was positioned with attention to achieving a secure proximal seal. A total of 110 mL of contrast agent was used (see Table 3 for summary). (Table 3) (Figure 4).

Table 2 Vascular Access Characteristics

Parameter	Right Side	Left Side	Notes
External iliac artery diameter	6.5 mm	6.9 mm	No calcification
Common femoral artery diameter	6.5 mm	6.5 mm	No calcification
Sheath used	16 Fr	18 Fr	Percutaneous
Additional procedure	None	None	Balloon dilatation, conduit

Table 3 Summary of the EVAR Procedure

Parameter	Value
Type of anesthesia	Local anesthesia
Access	Bilateral femoral (percutaneous)
Cath wire	0.035”
Catheter	5 Fr JR 0.038” PerformaR
Graft system	Endurant™ II, main body size 32×14×103 mm
Proximal cuff	Yes/No (size 32×32×49 mm)

(*Continued*)

Table 3 (Continued).

Parameter	Value
Right common iliac artery stent	16×10×156 mm
Left common iliac artery stent	16×13×124 mm
Balloon dilatation	Yes (at the neck and both common iliac arteries)
Procedure duration	180 minutes
Contrast agent	110 mL
Post-procedure angiography	Both renal arteries patent, internal iliac arteries patent
Procedural complication	Type IA endoleak, managed with cuff + balloon
Final outcome	Stent graft patent, endoleak resolved

During deployment, a type IA endoleak was detected. It was managed by placing an additional proximal cuff to extend the sealing zone, followed by balloon dilatation to ensure complete circumferential apposition against the aortic wall, resulting in immediate resolution of the endoleak. The patient had pre-existing chronic kidney disease stage 3a, and the relatively low volume of contrast was carefully chosen to minimize nephrotoxicity. No further deterioration of renal function was observed following the procedure.

Figure 4 Intraoperative DSA showing hostile infrarenal neck anatomy with severe angulation during stent-graft deployment.

https://doi.org/10.2147/IMCRJ.S573160

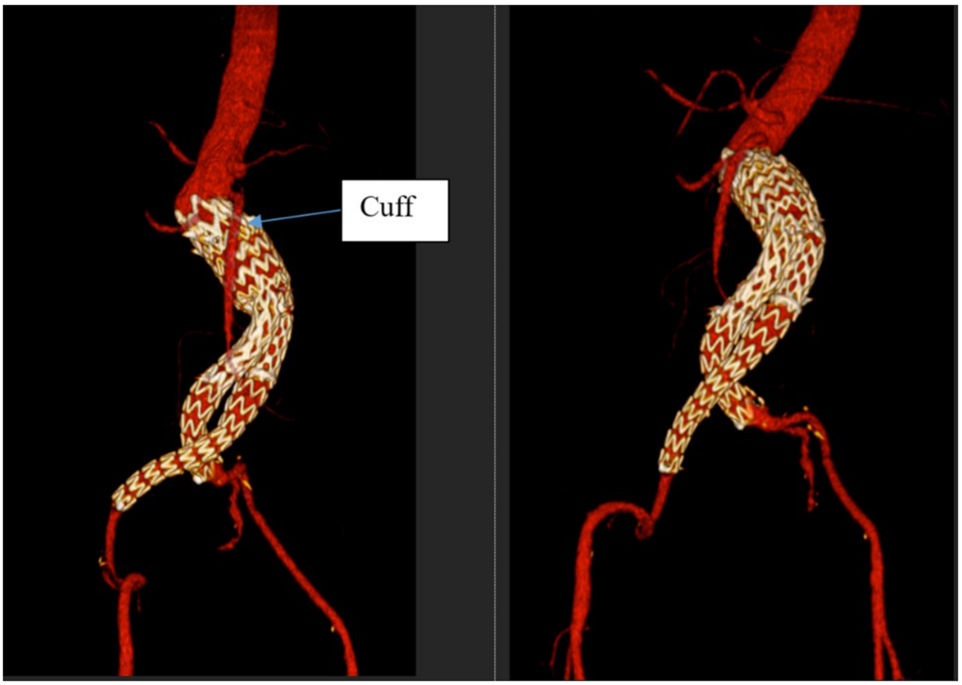

Figure 5 CT imaging at 1.5 months after intervention.

The patient had an uneventful recovery, with no access-site complications and no renal impairment. CTA at 1.5 months demonstrated a stable graft without migration or endoleak, and an aneurysm sac diameter of 35×46 mm (Figure 5).

At 24-month follow-up, the stent graft remained stable, with no evidence of endoleak or migration; however, the aneurysm sac diameter showed no further reduction over time (Table 4).

This case highlights the technical challenges of EVAR in hostile neck anatomy and provides a foundation for discussion regarding morphological assessment, procedural strategy, and long-term outcomes.

Discussion

This case report details the successful execution of Endovascular Aneurysm Repair (EVAR) in a challenging anatomical setting, characterized by a severely angulated, S-shaped, and axially tortuous aortic neck.[7] The procedure and subsequent 24-month success serve as a valuable study on the interplay between complex morphology, device performance, and interventional strategy.

Table 4 Post-Procedural Outcomes and Follow-Up

Time Point	Graft Status	Endoleak	Aneurysm Sac Diameter	Other Complications
Immediate	Stable, cuff sealed	None	50 mm	None
1 month	Stable	None	35 × 46 mm	None
6 months	Stable	None	33 × 42 mm	None
12 months	Stable, no migration	None	33 × 40 mm	None
16 months	Stable, no migration	None	32 × 40 mm	None
24 months	Stable, no migration	None	32 × 40 mm	None

 https://doi.org/10.2147/IMCRJ.S573160

A primary focus of this discussion is the inadequacy of current 2D-based risk stratification models. While the neck length (39 mm) complied with the Medtronic Endurant™ II IFU (≥10 mm),[8] the angulation (105° suprarenal, 111° infrarenal) far exceeded the ≤60° limit.[8] This high-degree biplanar angulation created severe biomechanical stress.[9]

Crucially, the Angle-Length Index (ALI) was 2.9, a value technically below the high-risk threshold >4.8.[6] This discrepancy—between a seemingly "safe" ALI and the actual intraoperative occurrence of a Type IA endoleak—clinically demonstrates that simplified indices can be misleading in complex 3D scenarios where a long neck can mathematically dilute the risk posed by extreme angulation. Furthermore, the report highlights a rotational angle of 70° (axial torsion), a critical 3D characteristic that 2D metrics cannot quantify.[10] This underscores the need for more sophisticated 3D morphological analysis tools to provide accurate, patient-specific risk profiling, in line with recommendations for complex EVAR planning.[11,12]

The technical challenge was dominated by achieving coaxial deployment through the tortuous S-shaped curve.[13] The subsequent intraoperative Type IA endoleak was driven by the stent-graft's longitudinal stiffness, which caused the graft to straighten the aorta rather than conform to the wall, creating sealing channels.[14]

The successful management employed a standard, reactive strategy: a proximal extension cuff and balloon molding.[15] This pragmatic approach challenges the assumption that hostile anatomy must invariably necessitate complex, high-cost technologies such as EndoAnchors or FEVAR/chEVAR.[16,17] Instead, it demonstrates that meticulous procedural planning and the readiness to effectively manage complications using standard bailout strategies can be both clinically effective and resource-efficient.

The 24-month follow-up with a stable stent graft is a significant mid-term success.[18] However, the observation of no further sac shrinkage between 12 and 24 months warrants cautious interpretation, suggesting the potential for low-level endotension.[19] Given the severe initial angulation and inherent biomechanical stresses, the patient remains in a high theoretical risk group for progressive neck dilatation and late Type IA endoleak.[20,21] Therefore, this case highlights a key paradigm shift: EVAR should be viewed as a chronic disease management strategy requiring lifelong, vigilant surveillance.

In conclusion, while this case successfully demonstrates the technical feasibility of standard EVAR in an extreme, IFU-outside anatomy,[22] its success should inform—but not routinely expand—the application of this approach without considering advanced alternatives or open repair for high-risk patients.[23]

Conclusion

This case demonstrates the technical and anatomical challenges of EVAR in pa-tients with severely angulated, S-shaped, and torsioned "hostile" proximal necks. Comprehensive preoperative morphological assessment—including neck angles, tor-tuosity index (TI), angle-length index (ALI/ANLI), and recognition of axial torsion—is essential. Flexibility in defining the measurement axis (morphological centerline versus flow axis) can improve accuracy in risk assessment. Timely intraoperative management of type IA endoleak with a proximal cuff and ballooning enabled complete sealing and durable results. This report underscores the critical role of detailed procedural plan-ning, quantitative assessment, and operator experience in achieving long-term success in anatomically complex AAA cases.

Institutional Review Board Statement

The study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Review Board of Thong Nhat Hospital. Institutional approval for conducting this case study was obtained, and separate approval for the publication of the case details was not required.

Data Sharing Statement

The original contributions presented in this study are included in the article. Further inquiries can be directed to the corresponding author.

Consent for Publication

Written informed consent was obtained from the patient for the publication of this case report and any accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal.

Acknowledgments

The authors thank all colleagues and staff at the Cardiovascular and Thoracic Surgery Department, Thong Nhat Hospital, and the University of Health Sciences, Vietnam National University Ho Chi Minh City, for their support during the study.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Funding

No separate funding was received for this study. This word was conducted as part of the research project "Evaluate the results of endovascular intervention of aortic disease in elderly", supported by the University of Health Sciences, Vietnam National University Ho Chi Minh City (VNUHCM-UHS), Grant Number C2024-44-21.

Disclosure

The authors report no conflicts of interest in this work.

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