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Commentary: "CIRSE Standards of Practice for the Endovascular Treatment of Visceral and Renal Artery Aneurysms and Pseudoaneurysms" How FDS have expanded the possibilities of endovascular treatment and hypotheses on the causes of possible failures

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Introduction

Visceral artery aneurysms (VAAs) and pseudoaneurysms (VAPAs) are uncommon but potentially life-threatening vascular pathologies. Although most lesions are asymptomatic, the widespread use of imaging techniques such as computed tomography and ultrasonography, has led to an increasing rate of incidental detection. Marked heterogeneity in clinical presentation, anatomical location, growth behaviour, and rupture risk necessitates tailored treatment indications for each VAA. Treatment is generally indicated for VAPAs regardless of size, whereas the management of unruptured and asymptomatic true aneurysms is guided by multiple variables including aneurysm size, the involved artery, patient age, and associated comorbidities [1,2].

Endovascular treatment has demonstrated a high safety and efficacy profile and is currently considered the preferred therapeutic approach. Endovascular options include transcatheter embolization using coils, liquid agents, or plugs; stent-grafting; percutaneous thrombin injection and combined or multimodal approaches. Among these, transcatheter embolization and covered stenting remain two of the most frequently adopted techniques for VAA/VAPA management [3].

Flow-diverting stents (FDS), originally developed for intracranial aneurysms, have recently been applied to selected complex VAAs/VAPAs when conventional embolization or stent grafting imply unacceptable ischemic risks or when the parent artery is impractical due to small calibre, tortuosity, or inadequate landing zones. Unlike conventional stent-grafts, FDS achieve aneurysm exclusion indirectly by modulating intra-aneurysmal flow, promoting progressive thrombosis while maintaining patency of the parent artery and collateral branches [4].

Recent systematic reviews and multicentre experiences allow a more structured discussion of indications, pharmacotherapy, technical conduct, and adverse events.

Principles Of Flow Diversion And Device Design

Flow-diverter stents are densely braided tubular meshes, typically made of cobalt–chromium or nitinol alloys, often combined with platinum to enhance radiopacity. Their hemodynamic performance is determined by key structural parameters, including porosity (the ratio of metal-free surface area to total stent surface), metal coverage (the proportion of the vessel wall covered by metal), and pore density (pores per unit area) [5].

Computational hemodynamic models suggest that devices with an overall porosity in the range of 50-70% can markedly reduce aneurysmal inflow [6]. Novel thin-film nitinol flow diverters can provide substantially higher pore density than traditional braided devices, with the potential to enhance flow modulation across complex aneurysm-branch geometries [7].

Importantly, these parameters are not unalterable but change according to the degree of expansion or constriction, the curvatures, the variability in size of side branches, the longitudinal extension and the traction/push effects manually applied during release. As a result, the effective hemodynamic behavior of a flow diverter may differ from its nominal design characteristics.

FDS induce local hemodynamic effects while keeping free blood flowing in the parent artery. Fist, FDS decrease the high-velocity inflow jet into the aneurysm sac and promote laminar flow along the longitudinal axis of the parent artery, a phenomenon known as central diversion. Subsequent flow redistribution leads to increased blood stasis and progressive thrombus formation. Over time, the reduction in wall shear stress and sustained flow stagnation facilitate aneurysm remodelling, promote neointimal endothelialization across the aneurysm neck and long-term arterial reconstruction [8].

A practical limitation is that currently available devices are up to 8 mm in diameter, which may restrict applicability in larger visceral segments [2].

Pre-Procedural Imaging

High-resolution CTA with multiplanar reconstructions is the cornerstone of pre-procedural planning, enabling accurate definition of aneurysm morphology, branch anatomy, calcification and thrombus, and access strategy [2]. Dedicated software provide, from CTA data, 3D high-resolution simulation of proximal and distal landing zones, device conformability and correct wall apposition along complex arterial curvatures, identify possible sites of deformation or kinking, and suggest optimal sizing of the stent, optimal oblique view for deployment or contraindication to their use.

Peri And Post Procedural Management

This is a key issue. Dual antiplatelet therapy (DAPT) is mandatory. In most reported visceral studies, DAPT consists of aspirin plus a P2Y12 inhibitor (most commonly clopidogrel) for 6 months, followed by lifelong aspirin monotherapy [2]. A recent multicentre study adopted a shorter DAPT regimen of 3 months and reported an increased risk of stent thrombosis, highlighting the need to balance thrombotic and haemorrhagic risk [9].

DAPT may be initiated 5 days before the intervention or a clopidogrel loading dose (e.g., 300 mg) can be administered on the day of the procedure. Schob et al. [9] described two cases of periprocedural stent occlusion, one of them occurring intraoperatively in the setting of clopidogrel resistance, highlighting the value of platelet function testing and alternative antiplatelet strategies when indicated.

Peri-procedural antibiotic prophylaxis is generally recommended for visceral FDS implantation [2] to reduce the risk of device-related infection, mainly due to skin flora. In this setting, a single pre-procedural dose of cefazolin is a commonly used regimen [10]

State-Of-Art: Where We Are Now?

Despite their therapeutic potential, flow-diverting stents remain underutilized in routine clinical practice, largely because of their high cost and the suboptimal outcomes reported with first-generation devices, which often failed to achieve reliable intra-aneurysmal thrombosis.

In a recent systematic review, 99 visceral and renal aneurysms and pseudoaneurysms were treated with flow-diversion techniques demonstrated high procedural safety (98%), with reported efficacy of 78% and sac thrombosis of 89%, while overall side-branch patency remained high (96.9%). When outcomes were stratified by device generation, newer flow diverters were associated with higher efficacy than the older multilayer devices (93.75% vs. 66.66%); however, contemporary FDS are often selected for anatomically complex lesions, which may intrinsically increase procedural difficulty and influence periprocedural event rates [11].

Similarly, a 2026 German multicentre observational cohort reported 100% technical success with progressive sac thrombosis over serial follow-up (82% at 3 months) and a small number of stent occlusions [9].

The field is now moving toward structured registries designed to reduce methodological bias that has characterized earlier series. The DEDICATE protocol [12], involves 29 Italian centres with a target population of 100 patients, will evaluate Derivo peripher and Derivo 2 devices using standardized CTA follow-up and objective endpoints, including technical efficacy, stent and side-branch patency, aneurysm thrombosis grade, and volumetric stability at 1 year.

Overall, the available evidence supports a cautious but increasingly favourable view of FDS for selected,

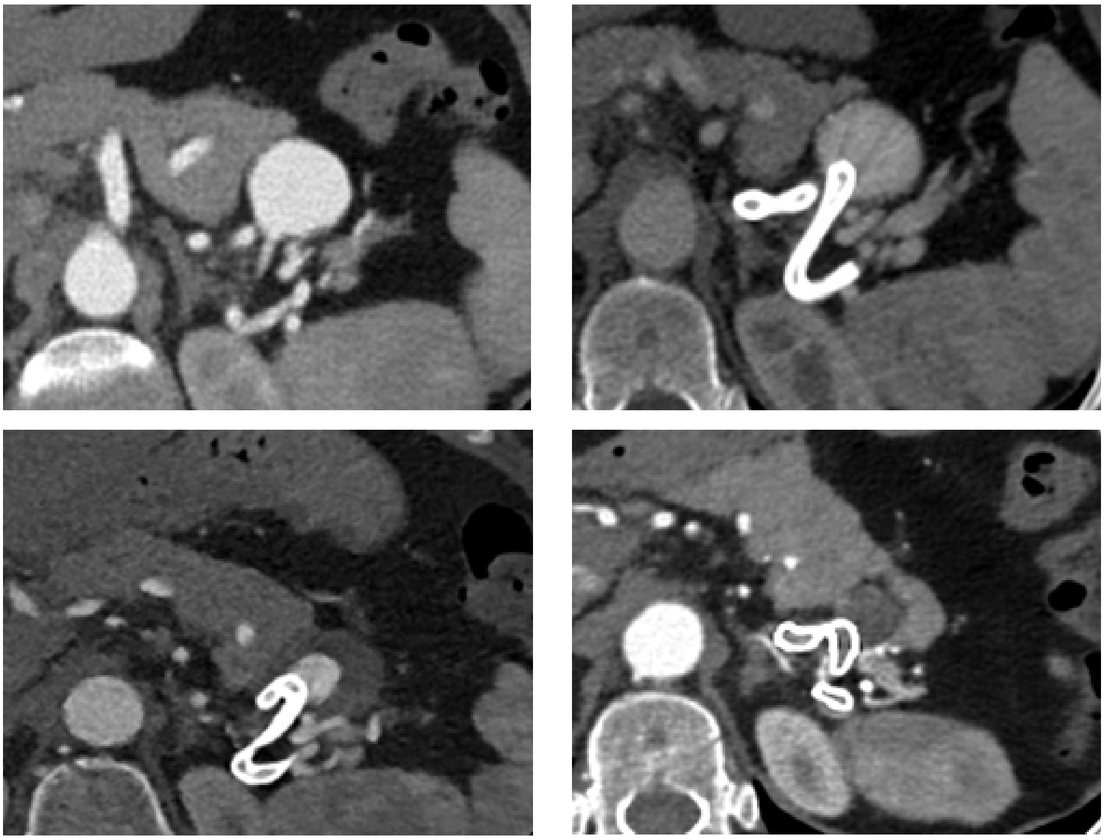

Figure 1. (A–D) (A)Contrast-enhanced CT angiography of a 55-year-old woman with distal splenic artery aneurysm with three efferent vessels. (B) Axial CT angiography obtained a day after flow-diverting stent implantation. (C, D) Corresponding CT angiography at 1 and 24-month FU shows partial and total thrombosis of the sac, with preserved patency of efferent vessels. Complete occlusion of the FDS is observed at 24-month FU, associated with reduction in size of the thrombosed aneurysm sac. The patient remained completely asymptomatic.

anatomically complex, predominantly unruptured visceral aneurysms (Figure 1. A-D).

Discussion

The complication profile of visceral and renal flow diversion is mainly related to technical deployment issues and thrombotic events, whereas aneurysm rupture appears exceptional. Reported complications in the extensive intracranial practice include device malposition or migration, often in the setting of suboptimal sizing, and rarely prolapse into the aneurysm sac. Proximal or distal incomplete opening may reduce effective luminal flow, promote stasis at the stent edges, and precipitate acute thrombosis [13].

In the most recent systematic review [11], intraprocedural complications occurred in 7% of cases and events beyond 1 month in 21%, driven mainly by incomplete sac thrombosis and in-stent stenosis. Major events were uncommon, with mortality around 1%, stent disconnection and isolated reports such as splenic septic infarction around 1%. Notably, when outcomes were stratified by device generation, long-term complications were not observed with new generation devices, but higher intraprocedural complication rates (31.25%) and lower technical success (75%) were reported.

Based on our institutional experience, long-term failures, even if asymptomatic, are essentially attributed to two events: thrombotic occlusion of the stent (and the aneurysm) or persistent patency of the stent and side branches in the absence of aneurysm sac thrombosis.

In our practice thrombotic occlusion is more likely in highly tortuous segments, particularly when edge expansion is suboptimal or when landing zones are short; critically, it is also influenced by the effectiveness and adherence to antiplatelet therapy. Persistent aneurysm sac filling despite a patent device occurs in branch-bearing aneurysms or insufficient effective coverage across the aneurysm neck.

As aforementioned in paragraph 2 mechanical properties are the basis of hemodynamic performance of FDS but their modifications in vivo during and after deployment cannot be checked by the operators.

While antithrombotic regimens can be adjusted in

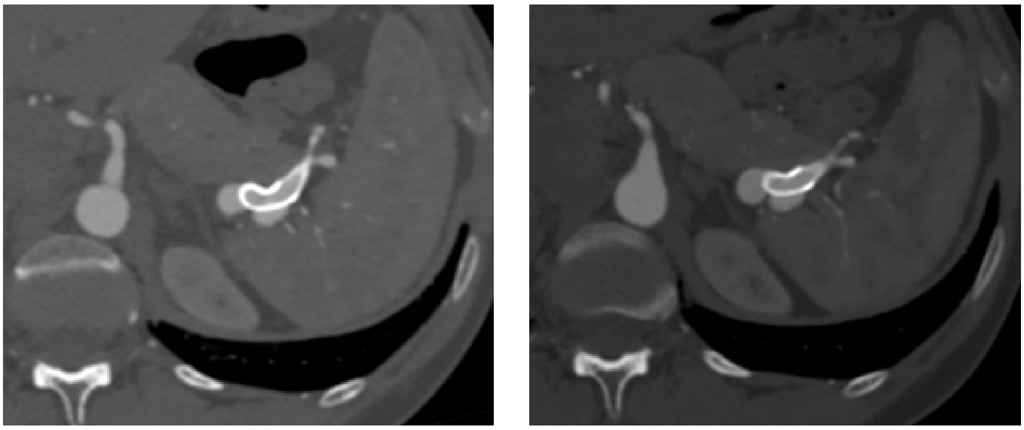

Figure 2. (A–B) Angio-CT of a 54-year-old woman with two distal splenic artery aneurysms. (A) Axial CT angiography obtained at 1-month follow-up after flow-diverting stent implantation. (B) Corresponding enhanced-CT at 12-month follow-up. Dual antiplatelet therapy was initiated one week before the procedure and interrupted 6 months thereafter, followed by aspirin monotherapy. The 12-month follow-up demonstrated dimensional stability and preserved patency of the aneurysm sacs; therefore any antiplatelet therapy was subsequently suspended.

cases of incomplete aneurysm thrombosis, an unresolved issue remains whether rupture risk is effectively reduced despite the absence of complete sac exclusion. Figure 2 (A-B) describe a case of VAAs from our institution.

Conclusion

Flow diversion represents a safe therapeutic alternative for selected complex peripheral VAAs and VAPAs when other endovascular or surgical techniques are not feasible. Achievement of the primary endpoint, the complete aneurysm sac thrombosis with preservation of side-branch patency, is not guaranteed in all cases and is influenced by multiple factors.

There is a lack of investigation on these factors related to the amount of data available and to their heterogeneity. More responses are desirable on these arguments in the future from larger prospective studies with standardized endpoints and longer follow-up. Until then, FDS in visceral territories should be considered as an advanced device for anatomically challenging, predominantly unruptured disease in centres with strong endovascular expertise.

References

1. C. PRATESI *et al.*, "Guidelines on the diagnosis, treatment and management of visceral and renal arteries aneurysms: a joint assessment by the Italian Societies of Vascular and Endovascular Surgery (SICVE) and Medical and Interventional Radiology (SIRM)," *J. Cardiovasc. Surg. (Torino).*, vol. 65, no. 1, Mar. 2024, doi: 10.23736/S0021-9509.23.12809-6.
2. M. Rossi, M. Krokidis, E. Kashef, B. Peynircioglu, and M. A. Tipaldi, "CIRSE Standards of Practice for the Endovascular Treatment of Visceral and Renal Artery Aneurysms and Pseudoaneurysms," *Cardiovasc. Intervent. Radiol.*, vol. 47, no. 1, pp. 26–35, Jan. 2024, doi: 10.1007/s00270-023-03620-w.
3. M. Venturini *et al.*, "Endovascular Treatment of Visceral Artery Aneurysms and Pseudoaneurysms in 100 Patients: Covered Stenting vs Transcatheter Embolization," *Journal of Endovascular Therapy*, vol. 24, no. 5, pp. 709–717, Oct. 2017, doi: 10.1177/1526602817717715.
4. Y. Zhang, D. Xiang, Q. Lu, M. Wu, and J. Cui, "A systematic review and meta-analysis of the performance of flow-diverting stents in the treatment of peripheral and visceral artery aneurysms," *Catheterization and Cardiovascular Interventions*, vol. 97, no. 3, pp. 461–469, Feb. 2021, doi: 10.1002/ccd.29373.
5. G. A. Maragkos *et al.*, "Overview of Different Flow Diverters and Flow Dynamics," *Neurosurgery*, vol. 86, no. Supplement_1, pp. S21–S34, Jan. 2020, doi: 10.1093/neuros/nyz323.
6. T.-M. Liou and Y.-C. Li, "Effects of stent porosity on hemodynamics in a sidewall aneurysm model," *J. Biomech.*, vol. 41, no. 6, pp. 1174–1183, 2008, doi: 10.1016/j.jbiomech.2008.01.025.
7. D. Dai, Y.-H. Ding, M. Kelly, R. Kadirvel, and D. Kallmes, "Histopathological findings following pipeline embolization in a human cerebral aneurysm at the basilar tip," *Interventional Neuroradiology*, vol. 22, no. 2, pp. 153–157, Apr. 2016, doi: 10.1177/1591019915622165.
8. D.-S. Shin, C. P. Carroll, M. Elghareeb, B. L. Hoh, and B.-T. Kim, "The Evolution of Flow-Diverting Stents for Cerebral Aneurysms; Historical Review, Modern Application, Complications, and Future Direction," *J. Korean Neurosurg. Soc.*, vol. 63, no. 2, pp. 137–152, Mar. 2020, doi: 10.3340/jkns.2020.0034.
9. S. Schob *et al.*, "The treatment of challenging visceral and peripheral arterial aneurysms with flow diversion—a German multicentric observational study," *Front. Med. Technol.*, vol. 7, Jan. 2026, doi: 10.3389/fmedt.2025.1693030.
10. M. A. Chehab *et al.*, "Adult and Pediatric Antibiotic Prophylaxis during Vascular and IR Procedures: A Society of Interventional Radiology Practice Parameter Update Endorsed by the Cardiovascular and Interventional Radiological Society of Europe and the Canadian Association for Interventional Radiology," *Journal of Vascular and Interventional Radiology*, vol. 29, no. 11, pp. 1483-1501.e2, Nov. 2018, doi: 10.1016/j.jvir.2018.06.007.
11. M. A. Tipaldi *et al.*, "Flow Diverting Stents for the Treatment of Complex Visceral and Renal Aneurysms—A Systematic Review," *J. Cardiovasc. Dev. Dis.*, vol. 12, no. 9, p. 346, Sep. 2025, doi: 10.3390/jcdd12090346.
12. A. Discalzi *et al.*, "Study Protocol DEDICATE: Italian Multicenter Study on the Treatment of Visceral Aneurysms with the Derivo Peripher and Derivo 2 Flow Diverter Stent," *Cardiovasc. Intervent. Radiol.*, vol. 48, no. 5, pp. 694–701, Mar. 2025, doi: 10.1007/s00270-025-04016-8.
13. F. Al-Mufti *et al.*, "Bailout Strategies and Complications Associated with the Use of Flow-Diverting Stents for Treating Intracranial Aneurysms," *Interv. Neurol.*, vol. 8, no. 1, pp. 38–54, 2019, doi: 10.1159/000489016.