

# The Fate of the Superior Mesenteric Artery in Fenestrated Endovascular Repair of Complex Abdominal Aortic Aneurysms

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## Abstract

Issues related to the superior mesenteric artery (SMA) in fenestrated endovascular aortic aneurysm repair (f-EVAR), such as misalignment of the endograft and bridging devices-associated complications, are rarely reported. Moreover, the absence of autopsies in the majority of patients who died in the published series makes a possible correlation with occlusion of the SMA unknown. Current studies that reported on f-EVAR were reviewed accordingly, aiming to improve our understanding of the natural course of the SMA in fenestrated technology and to explore the associated clinical complications.

## Keywords

Fenestrated endografting, superior mesenteric artery, aortic aneurysm, endovascular aneurysm repair, juxtarenal aortic aneurysm.

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Since its introduction in 1996, fenestrated endovascular aortic aneurysm repair (f-EVAR) has made the endovascular treatment of pararenal aortic aneurysms possible. The devices are individually customised to the patient's vascular anatomy, and especially to the morphology of the visceral vessels. In the typical fenestrated endovascular device design, the superior mesenteric artery (SMA) is involved, either having a large non-strut fenestration or a single-wide scallop (10 mm in diameter). According to the instructions for use, stenting for vessels accommodated by a scallop is optional and not recommended for large fenestrations.

Involvement of the SMA improves the fixation and sealing zone of the fenestrated endograft; however, any deterioration of its perfusion can be associated with life-threatening complications.

Despite the existence of a plethora of reports on f-EVAR, limited information is available about the outcome of the SMA with this therapeutic approach. The aim of this article was to carry out a review analysis to improve our understanding of the natural course of the SMA in fenestrated technology, and to explore the associated clinical complications.

## Methods

The MEDLINE, EMBASE and Cochrane databases were searched to identify all studies published in English between January 1996 and May 2017 that reported on f-EVAR. The included review studies reported on SMA-related events.

## Results

The research revealed two pathological mechanisms that seem to be related to the deterioration of the perfusion of the SMA. One of the

mechanisms is associated with the fenestrated endograft, and the other mechanism with the bridging devices that were used.

Lala et al. reported the phenomenon of misalignment of the SMA scallop.<sup>1</sup> In the case of demanding anatomical conditions, such as angulations of the iliac arteries or the neck, the scallop of the SMA can partially cover the orifice of the vessel. Nine of 21 patients (43%) of that group had some degree of misalignment of the SMA (range 9–71%). Among those patients, four (44%) developed complications, such as three high-grade SMA stenoses, and one occlusion. Overall, patients with unstented SMAs had significantly more adverse events directly attributable to SMA misalignment than the stented group (44% versus 5%, respectively;  $p < 0.05$ ). The median follow-up period for this group of patients was 7.7 months.

The next issue, which was observed in relation to the SMA, implies different modes of failure of the bridging device used. Mastracci et al. suggested three different modes of failure.<sup>3</sup> Two of the modes of failure relate to the branch–main body or branch–branch interface, which can be inadequate, and the third described pattern relates to material fatigue in the branch stent graft. The consequence is SMA stent graft occlusion. Mastracci et al. also demonstrated the cause for reintervention with SMA stents was stenosis or thrombosis of the bridging device in 50% of the overall occluded bridging devices.<sup>3</sup> Three of these patients died.

## Discussion

Profound evaluation and reporting of the current literature on the fate of the patency of the SMA in f-EVAR is lacking. This issue is relevant due to the inevitable forces over time in the deployment of fenestrated bridging devices. These conditions can lead to separation, fracture

and occlusion of the bridging devices. These events can be accurately detected by CT angiography, but the majority of the patients treated by F-EVAR underwent duplex ultrasound.<sup>2</sup> In the case of fenestrated endografting, the SMA is always involved either as a scallop or as triple fenestration and stenting.

This article shows for the first time the published experience of SMA outcomes in f-EVAR in the literature. There are two major complications that are mainly reported: SMA occlusions and SMA coverage due to misalignment of the fenestrations, respectively.

Even if the patency rate in the SMA deployed bridging devices is high, any relevant stenosis or occlusion of the SMA stent/stent graft is associated with life-threatening complications. Often the stenosis and intimal hyperplasia are located at the distal edge of the device in the transition to the vessel, and this makes the detection of lesions more demanding. The reported occlusion rate is low if we consider that a dedicated bridging device for this technology is still not available. Issues, such as the performance of the devices after flaring with the balloons and the pullout forces, still remain and have not been evaluated, making the high percentage of almost 95% patency incongruous. One possible explanation may be the poor quality of the radiological follow-up and the inappropriateness of duplex ultrasound for pararenal aortic aneurysms treated by f-EVAR. Mastracci et al. demonstrated reintervention for SMA stents in 26 patients, with half involving stenosis or thrombosis.<sup>3</sup> Three of these patients died. Consequently, routine stenting with bridging devices not dedicated to this indication is not without risk.

The next limitation is the fact that there is a plethora of different types of bridging devices available. These devices have different designs, and all of them attempt to address the features required for use in visceral vessels. These characteristics include advanced trackability, high radial force and adaption in angulated visceral

vessels. The plethora of existing devices can also lead to different types of complications based on their design and characteristics. For example, single-layer coverage of the bare metal stent with expanded polytetrafluoroethylene can lead to separation of the expanded polytetrafluoroethylene with the creation of endoleaks, which requires reintervention and lining with additional placement of covered stents. The use of stainless steel devices can provide high radial force; however, the distal edge can provoke a stenosis in angulated visceral vessels due to its rigidity. Other devices with increased flexibility due to their design (cobalt chromium) can have poorer radial force, showing that the existing body of stent/stent grafts does not cover all needs for this indication for use.

Lala et al. highlighted the phenomenon of SMA misalignment in up to half of the patients treated with stent-free SMA.<sup>1</sup> This condition represents the critical threshold required to produce symptoms and mesenteric life-threatening complications. Moreover, the observed cases that occurred at 6 or 12 months indicated that there are dynamic changes of the graft over time that potentiate the misalignment. This makes the need for CT follow-up evaluation mandatory, and shows the significant limitation in the published literature in this context as, for example, one of the largest series published by Grimme et al. reported only 52% of patients had a 1-year CT follow-up, and 11% of patients had a 4-year CT follow-up.<sup>2</sup>

In summary, the reported SMA patency rates are high. In contrast, profound evaluation of the SMA outcomes in the fenestrated technology is lacking. There is very scant information about issues, such as misalignment of the device in the SMA and radiological CT angiography-based evidence about the SMA bridging device in order to exclude the failure modes, as reported by Mastracci et al.<sup>3</sup> Issues, such as fractures or kinking of the SMA devices, are underreported in the literature, highlighting the need for a dedicated bridging device for this indication, which is still lacking. ■

1. Lala S, Knowles M, Timaran D, et al. Superior mesenteric artery outcomes after fenestrated endovascular aortic aneurysm repair. *J Vasc Surg* 2016;64:692-7. <https://doi.org/10.1016/j.jvs.2016.02.031>; PMID: 27288103.

2. Grimme FA, Zeebregts CJ, Verhoeven EL, et al. Visceral stent patency in fenestrated stent grafting for abdominal aortic aneurysm. *J Vasc Surg* 2014;59:298-306. <https://doi.org/10.1016/j.jvs.2013.08.005>; PMID: 24080136.

3. Mastracci T, Eagleton MJ, Kuramochi Y, et al. Twelve-year results of fenestrated endovascular repair for juxtarenal and thoracoabdominal aneurysms. *J Vasc Surg* 2015;61:355-64. <https://doi.org/10.1016/j.jvs.2014.09.068>; PMID: 25619574.