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REVIEW ARTICLE

Renal artery occlusion after complex endovascular aortic repair: A narrative review.

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ABSTRACT

INTRODUCTION: Fenestrated and branched endovascular aneurysm repair (F/BEVAR) has become the preferred treatment for most patients with complex aortic aneurysms. Although overall technical success rates exceed 95%, renal arteries remain the most vulnerable target vessels, with higher rates of instability and occlusion than mesenteric arteries. We aimed to review the current literature on renal artery bridging stent occlusion after F/BEVAR, focusing on the incidence, anatomical factors contributing to instability, and outcomes of reintervention strategies.

METHODS: We conducted a narrative review, drawing on data from large cohort studies, systematic reviews, and multicenter registries. Key endpoints included technical success, target vessel instability, primary and secondary patency rates, incidence of acute renal occlusion, reintervention techniques and timing, and renal functional outcomes.

RESULTS: Renal arteries show a higher incidence of target vessel instability, up to 7%, compared with 5% for the superior mesenteric artery and 4% for the celiac trunk. Anatomical factors, including diaphragmatic motion, distal segment mobility, and aortic remodeling, contribute to cyclic tension and branch instability. Additionally, fenestrations have shown higher primary patency rates than directional branches. Acute renal stent occlusion often presents asymptomatically, complicating timely diagnosis. However, studies indicate that revascularization, even after median ischemia times of 27.5 hours, is associated with high technical success rates (up to 95.7%) and can lead to significant recovery of renal function, particularly in patients with bilateral occlusion or a solitary kidney.

CONCLUSIONS: Despite high overall patency rates, renal arteries remain particularly susceptible to post-F/BEVAR occlusion. Acute occlusions, often clinically silent, may benefit from reintervention after prolonged ischemia, owing to the protective effect of renal collateral networks. Standardized reporting of occlusion characteristics and reintervention techniques is essential to optimize renal outcomes after F/BEVAR.

Keywords: BEVAR; FEVAR; Endovascular complex repair; Renal stent occlusion

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INTRODUCTION

Complex endovascular treatment of aortic pathology has undergone major advances over the past 20 years. Today, branched or fenestrated endografts enable the treatment of a wide range of patients who, because of anatomical complexity or significant comorbidities, would otherwise have no surgical alternative.

Midterm outcomes have been favorable, demonstrating that complex endovascular treatment is a safe and effective resource.[1] Oderich et al. published a cohort study showing that, at 5 years, freedom from aortic-related mortality was 98% ± 1%, primary target vessel patency was 94% ± 1%, and freedom from secondary intervention was 64% ± 4%.

However, a key concern is the performance of the bridging stents and target vessels, as complications such as stenosis or occlusion can have a major clinical impact. Mastracci et al. addressed this issue and, in 2013, published[2] a large series including 650 patients and 1,679 target vessels. They reported 30 stent occlusions (1.7%), with renal stents most frequently affected (n=24). An Italian multicenter registry[3], including 1,824 target vessels, reported 43 occlusions (2.4%), with 67% involving the renal arteries.

Although bridging stents appear to maintain primary patency during follow-up, the impact of occlusion should not be underestimated, particularly in the renal arteries.[3] Moreover, most of the existing literature does not adequately address acute occlusions of bridging stents or target vessels, nor the possibilities for reintervention and the associated clinical outcomes.

Thus, the objective of this review is to analyze the literature on renal artery bridging stent occlusion and to discuss technical aspects related to their reintervention.

METHODS

A non-systematic Medline literature search was conducted using the following terms: “endovascular complex repair”, “renal bridging stent”, “FEVAR”, “BEVAR”, and “Renal stent occlusion”. Only reviews and original articles in English were considered. No specific time period was predefined. We also analyzed additional relevant articles, including those identified through cross-referencing.

DISCUSSION

Outcomes of complex endovascular repair with fenestrated and branched endografts (F/BEVAR) are well established, with several large series published by experienced centers and multi-center databases. However, these results are based on observational studies, and randomized trials are lacking.

Effectiveness and Safety Outcomes

According to the Society for Vascular Surgery (SVS) standardized definition, technical success is achieved when stent grafts are successfully deployed, there is no type I or III endoleak within 30 days post-procedure, and the target vessels remain patent.[4] Indeed, current experience demonstrates high technical success rates, often exceeding 95%, with progressive improvement over the years, likely related to advancements in both technique and device technology.[3,4-7]

In terms of safety, SVS proposed a composite endpoint — major adverse events — which includes death and any major complications. Published literature reports 30-day mortality rates ranging from 0% to 8%, permanent paraplegia rates from 1% to 4%, acute kidney injury rates from 9% to 14%, and permanent dialysis rates from 2% to 3.7%.[5,7,8]

Importantly, the populations included in these studies often present with significant clinical conditions and comorbidities. Nevertheless, a systematic review comparing endovascular and open repair showed fewer perioperative complications with endovascular treatment.[9] Despite these favorable outcomes, one of the most concerning aspects of aortic endovascular repair remains the high rate of reintervention, with target vessel instability as a leading cause.

Target Vessels and Patency

Target-vessel anatomy can limit these procedures and is a major cause of technical failure. Factors such as cranio-caudal and anteroposterior orientation, angulation, tortuosity, vessel diameter, and atherosclerosis can all influence catheterization, procedural stability, bridging stent sealing, and long-term outcomes.

Renal arteries pose additional challenges for long-term outcomes.[10] These arteries are more mobile, likely because diaphragmatic movements during respiration shift the kidneys. However, movement is primarily confined to the distal portion of the renal arteries, as the proximal segment remains fixed to the retroperitoneum near the aorta. This differential motion generates cyclic tension on the prostheses and arteries. These mechanisms can increase stress at the transition zone between the stent and the target vessel, leading to endothelial damage and intimal hyperplasia. Cyclic motion can also cause stent fatigue and fractures, compromising lumen patency. Aortic remodeling over time and changes in the position of the renal ostia relative to the initial planned configuration further contribute to instability.

Regarding how arteries are incorporated into endografts, different strategies can be employed depending on technical and anatomical considerations.[11] Fenestrated endografts incorporate fenestrations that require precise alignment with the target vessel and a minimal gap between the graft and the artery. Another option is branched endografts, which include side branches that may be internal, internal-external, or external directional branches. In these configurations, a gap between the main graft and the target vessel is expected, particularly when the arteries are located within the aneurysm sac. Multiple endograft configurations are possible, including combinations of fenestrations and branches within the same device.

To evaluate outcomes for target vessels and bridging stents, a composite endpoint called target vessel instability has been proposed, encompassing vessel complications such as occlusion, stent disconnection, stenosis, kinking, or endoleaks requiring intervention. In 2023, Tenorio et al. published midterm outcomes for renal and mesenteric target arteries using data from the United States Multicenter Aortic Research Consortium Database.[12] Target vessel instability occurred in 6% of cases (368/6155), with higher rates in renal arteries than in the superior mesenteric artery (SMA) and celiac trunk (7% vs. 5% vs. 4%, $p < 0.001$). Endoleaks were the most common cause, followed by occlusions. The 5-year primary and secondary patency rates for renal arteries were 90% and 95%, respectively.

In 2013, Mastracci et al. reported a series of 650 patients with acceptable outcomes, with 89% freedom from secondary interventions at 5 years.[2] However, among 30 total occlusions observed, 24 involved renal arteries.

A 2021 systematic review evaluated target vessel outcomes after F/BEVAR and found an overall target vessel instability rate of 4% and a reintervention rate of 3%.[13] Notably, renal arteries were three times more likely to show instability than the SMA and celiac trunk combined.

Another important point concerns patency when comparing branches versus fenestrations. Theoretically, the greater mobility and longer distance from the main graft to the target vessel inherent in branches could predispose to extreme angulation or even kinking. Martin-Gonzalez et al. evaluated changes in renal artery angulation after complex endovascular repair and observed that fenestrated grafts increased the perpendicularity of renal arteries relative to the aortic centerline, whereas branched configurations decreased angulation.[14] However, in this study, these findings were not associated with an increased risk of occlusion. One year later, T. Martin-Gonzalez et al. published additional data from a multicenter study, showing that freedom from branch instability was 86% after BEVAR and 95% after FEVAR at two years ($p < 0.01$).[15] Subsequent studies have confirmed this trend, suggesting better long-term renal artery patency for fenestrated versus branch repairs.[12]

In addition to selecting between branches and fenestrations to incorporate the vessels and considering the angulation and direction of the renal arteries—which may contribute to renal occlusion during follow-up—other factors can also be considered. Ostial disease has been identified as a risk factor, as well as vessel diameter, which has been recognized as a determinant of target artery events.[12]

Renal Occlusion Intervention

A common finding across studies evaluating renal artery outcomes after F/BEVAR is the lack of detailed characterization of renal occlusions and the strategies used for reintervention. In Mastracci's report, 11 cases of complete occlusion were reported in which recanalization was not possible; however, no details on ischemia time or intervention strategies were provided.[2] Interventions were described in 19 patients, generally involving stenoses and occlusions, but without specifying the techniques used. Conversely, in his 10-year experience, Verhoeven described 15 renal artery occlusions, with three patients ultimately requiring permanent dialysis.[7] Nonetheless, reinterventions on target vessels were performed only in cases of endoleaks or stenoses, not in occlusions.

Intervention for acute renal artery occlusion remains rare, often resulting in loss of the organ and impaired renal function. Diagnosis can be challenging because the clinical presentation is often nonspecific or even silent, particularly in patients with a single affected kidney and a normally functioning contralateral kidney. Additionally, the presumption that revascularization must occur within a short time window to be viable has often discouraged intervention. Silverberg et al. evaluated outcomes in patients undergoing catheter-directed thrombolysis for acute renal artery occlusions.[16] The mean time to intervention was 42 hours post-occlusion, with 38% of patients treated after more than 60 hours of ischemia. Of the 11 patients treated, 9 showed imaging evidence of restored renal perfusion.

Given the known occlusion rates of renal bridging stents and associated morbidity, Konstantinou et al. initiated a multicenter study of 38 patients who underwent revascularization of renal stents after F/BEVAR occlusion.[17] In total, 46 target vessels were included, with a median renal ischemia time of 27.5 hours. Technical success was achieved in 95.7% of cases, using aspiration thrombectomy, aspiration thrombectomy combined with stent relining, or stent relining alone. Bilateral renal ischemia or ischemia in solitary kidneys was present in 14 cases; among them, 9 patients recovered renal function and avoided permanent dialysis. In addition, the median serum creatinine level decreased significantly after occlusion and subsequent revascularization.

An alternative option is open surgical reintervention, such as bypass. However, patients undergoing complex endovascular aortic repair are typically older, have multiple comorbidities, and are often unfit for open surgery.

These findings suggest that ischemia time alone should not determine whether to attempt intervention. This may be because renal collateral circulation maintains parenchymal perfusion and preserves viability despite prolonged ischemia.

CONCLUSION

Managing renal artery occlusions after complex endovascular aortic repair remains challenging and underexplored. Although the primary and secondary patency rates of renal bridging stents are acceptable, renal arteries remain the most vulnerable target vessels, and occlusions carry significant clinical consequences. Recent evidence suggests that timely revascularization, even after prolonged ischemia, can restore renal function, particularly when collateral circulation is present. Therefore, renal artery occlusion should not be considered an absolute contraindication to intervention. Greater awareness, early diagnosis, and standardized reintervention strategies are essential to optimize outcomes and preserve renal function in this complex patient population.

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REFERENCES

1. Oderich GS, Tenorio ER, Mendes BC, Lima GBB, Marcondes GB, Saqib N, et al. Midterm outcomes of a prospective, nonrandomized study to evaluate endovascular repair of complex aortic aneurysms using Fenestrated-Branched endografts. Ann Surg. 2021;274:491–9.

2. Mastracci TM, Greenberg RK, Eagleton MJ, Hernandez AV. Durability of branches in branched and fenestrated endografts. J Vasc Surg 2013;57:926–33.

3. Fargion AT, Esposito D, Speziali S, Pulli R, Gallitto E, Faggioli G, et al. Fate of target visceral vessels in fenestrated and branched complex endovascular aortic repair. J Vasc Surg 2023;78:584-92.

4. Oderich GS, Forbes TL, Chaer R, Davies MG, Lindsay TF, Mastracci T, et al. Reporting standards for endovascular aortic repair of aneurysms involving the renal-mesenteric arteries. J Vasc Surg 2020;73:4S-52S.

5. Dias-Neto M, Tenorio ER, Lima GBB, Baghbani-Oskouei A, Saqib N, Mendes BC, et al. Outcomes of low- and standard-profile fenestrated and branched stent grafts for treatment of complex abdominal and thoracoabdominal aortic aneurysms. J Vasc Surg 2022;76:1160-69.

6. Tsilimparis N, Bosiers M, Resch T, Torsello G, Austermann M, Rohlffs F, et al. Two-year target vessel-related outcomes following use of off-the-shelf branched endografts for the treatment of thoracoabdominal aortic aneurysms. J Vasc Surg 2023;78:289–98.

7. Verhoeven ELG, Katsargyris A, Bekkema F, Oikonomou K, Zeebregts CJAM, Ritter W, et al. Ten-year Experience with Endovascular Repair of Thoracoabdominal Aortic Aneurysms: Results from 166 Consecutive Patients. Eur J Vasc Endovasc Surg. 2015;49:524–31.

8. Oderich GS, Ribeiro M, Hofer J, Wigham J, Cha S, Chini J, et al. Prospective, nonrandomized study to evaluate endovascular repair of pararenal and thoracoabdominal aortic aneurysms using fenestrated-branched endografts based on supraceliac sealing zones. J Vasc Surg 2016;65:1249-59.

9. Rocha RV, Lindsay TF, Friedrich JO, Shan S, Sinha S, Yanagawa B, et al. Systematic review of contemporary outcomes of endovascular and open thoracoabdominal aortic aneurysm repair. J Vasc Surg 2019;71:1396-412.

10. Conway BD, Greenberg RK, Mastracci TM, Hernandez AV, Coscas R. Renal artery implantation angles in thoracoabdominal aneurysms and their implications in the era of branched endografts. J Endovasc Ther. 2010;17:380–7.

11. Greenberg RK, Lytle B. Endovascular repair of thoracoabdominal aneurysms. Circulation 2008;117:2288–96.

12. Tenorio ER, Schanzer A, Timaran CH, Schneider DB, Mendes BC, Eagleton MJ, et al. Mid-term renal and mesenteric artery outcomes during fenestrated and branched endovascular aortic repair for complex abdominal and thoracoabdominal aortic aneurysms in the United States Aortic Research Consortium. Ann Surg. 2023;278:e893–902.

13. Mezzetto L, Scorsone L, Silingardi R, Gennai S, Piffaretti G, Mantovani A, et al. Bridging stents in fenestrated and branched endovascular aneurysm Repair: A Systematic REVIEW. Ann Vasc Surg 2021;73:454–62.

14. Martin-Gonzalez T, Pinçon C, Maurel B, Hertault A, Sobocinski J, Spear R, et al. Renal outcomes following fenestrated and branched endografting. Eur J Vasc Endovasc Surg 2015;50:420–30.

15. Martin-Gonzalez T, Mastracci T, Carrell T, Constantinou J, Dias N, Katsargyris A, et al. Mid-term outcomes of renal branches versus renal fenestrations for thoraco-abdominal aneurysm repair. Eur J Vasc Endovasc Surg 2016;52:141–8.

16. Silverberg D, Menes T, Rimon U, Salomon O, Halak M. Acute renal artery occlusion: Presentation, treatment, and outcome. J Vasc Surg 2016;64:1026–32.

17. Konstantinou N, Kölbel T, Dias NV, Verhoeven E, Wanhainen A, Gargiulo M, et al. Revascularization of occluded renal artery stent grafts after complex endovascular aortic repair and its impact on renal function. J Vasc Surg 2020;73:1566–72.