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Aortomonoiliac Endografting after Failed Endovascular Aneurysm Repair: Indications and Long-term Results

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WHAT THIS PAPER ADDS?

- Some indications after previous endovascular aneurysm repair are known which may lead to open surgical conversions. These conversions are technically demanding and associated with considerable mortality rates. Our study provides long-term results following treatment of graft-related endoleaks by aortomonoiliac endografting after failed endovascular aneurysm repair. This procedure represents a safe and feasible as well as less invasive alternative compared to open surgical conversion.

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ABSTRACT

Objectives: To present long-term results of endoleak/endograft migration treatment by aortomonoiliac (AMI) endografting after failed endovascular aneurysm repair (EVAR) of infrarenal abdominal aortic aneurysms.
Design: Post hoc analysis of a prospectively gathered database at a tertiary care university hospital.
Materials and methods: From March 1995 to November 2010, 23 patients were identified who underwent modification into AMI configuration after failed elective EVAR. Major causes for modification were type I (with/without endograft migration) or type III endoleaks with aneurysm expansion. An average increase in aneurysm size of 1.6 cm (range: −1.5 to 10.5 cm) since initial aneurysm treatment was observed. Interventional outcomes and long-term results were recorded for analysis.
Results: Technical success rate of AMI endografting was 95.65% ($n = 22$). All except two endoleaks could be successfully sealed with this manoeuvre (94.44%). Median time to modification was 5.3 years (interquartile range Q1–Q3: 1.3–9.3 years). No intra-operative conversion to open surgery was necessary and mortality was 0%. Median follow-up was 44 months (interquartile range Q1–Q3: 17–69 months).
Conclusions: Treatment of graft-related endoleaks/endograft migration by AMI endografting after failed EVAR represents a safe and feasible procedure. This approach broadens the minimal invasive opportunities of aneurysm treatment, and open surgical conversion may be avoided except in selected patients.

Following the introduction of endovascular aneurysm repair (EVAR), a minimal invasive alternative method to exclude abdominal aortic aneurysms[1] became available offering curative treatment to high-risk otherwise incurable patients.[2,3] Initially inspired by open graft replacement, tube grafts were often deployed which were later on replaced by bifurcated devices. The feasibility to deploy grafts of bifurcated configuration depends on arterial anatomy. In case the iliac vessels are suitable to introduce, advance and deploy grafts on one side only, devices of aortomonoiliac (AMI) configuration may be an alternative, although conjunction with crossover bypass grafting is often required. This method has already been reported in the early days of EVAR,[4] and 5-year patency rates of 83% have been presented.[5] However, potential complications like thrombosis and infection of the crossover bypass graft or formation of pseudoaneurysms must be kept in mind.

Most adverse events after EVAR are successfully managed by minimal invasive procedures using transarterial or translumbar

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approaches. Graft-related endoleaks, representing a harbinger of aneurysm rupture, can be treated with a variety of options including placement of proximal cuffs or Palmaz stents, distal extension with or without coverage of hypogastric arteries, overstenting in case of component separation and coil embolisation of the aneurysm sac itself.[6,7] In addition, sealing of type II endoleaks may also be achieved by catheter-based interventions. Nevertheless, some indications are known which necessitate conversion into open surgery. These include formation of endoleaks with aneurysm enlargement refractory to secondary minimal invasive procedures (e.g., type II endoleaks in which embolisation/clipping of the persistent branch vessel failed), aneurysm sac expansion without visualisation of an endoleak – a phenomenon entitled endotension,[8] graft thrombosis or infection and aortoenteric fistula. Moulakakis and co-workers[9] performed a systematic literature research regarding conversion to open repair and reported an average mortality rate exceeding 10%. Therefore, the procedure is considered a 'hazardous procedure'.[10]

The purpose of this investigation was to present our experience with AMI endografting as treatment option of graft-related endoleaks after failed EVAR and its long-term outcome. This approach represents a less invasive procedure thereby avoiding major open surgery in patients with otherwise untreatable endoleaks.

Patients and Methods

From March 1995 to November 2010, data of all consecutive patients who received elective endovascular repair of their infrarenal abdominal aortic aneurysm at our tertiary care university hospital were collected prospectively and entered in an institutional database. This date was chosen to ensure a minimum 1-year follow-up. The database was reviewed to identify patients who underwent endoleak treatment by AMI endografting after failed EVAR. Our definition of; 'failure' was development of a graft-related endoleak at the proximal/distal attachment site or a type III endoleak following previous EVAR. Patients with type II endoleaks/endotension were not treated with this approach. The decision whether or not the modification seems technically feasible was always reached in an interdisciplinary consensus with interventional radiologists. All subsequent secondary interventions were documented and included in the analysis.

In the early years, EVAR was performed under fluoroscopic guidance in a specially equipped operating room with a ceiling-mounted C-arm. Nowadays, deployment of endografts takes place in an angiography suite. Endografts used in the investigation period were commercially available. Prostheses were deployed by interdisciplinary teams of vascular surgeons and interventional radiologists. After removal of all angiography sheaths and wires the procedure was completed by crossover bypass grafting to revascularise the contralateral limb. Type, diameter, need of external support as well as routing of the crossover bypass graft were left to the surgeon's preference.

Prior to discharge, a computed tomography (CT) scan was performed to identify and classify possible endoleaks. According to our protocol, postoperative follow-up included outpatient visits at 1, 3, 6 and 12 months combined with CT scans at 6 and 12 months as well as annually thereafter. In general, colour-coded duplex ultrasonography scans were undertaken at the above-mentioned appointments. In case that an increase in aneurysm diameter was documented and an endoleak was presumed, CT angiography or magnetic resonance angiography were performed. Endoleaks, complications and post-procedural events were classified according to definitions proposed by the Ad Hoc Committee for Standardized Reporting Practices in Vascular Surgery of The Society for Vascular Surgery/American Association for Vascular Surgery.[11]

During the more than 15-year observation period, 23 patients underwent endoleak treatment by AMI endografting after failed EVAR. All of these identified patients had presented either with significant accompanying risk factors at initial aneurysm exclusion and have been classified to have an increased preoperative risk profile, as expressed by the American Society of Anesthesiologists (ASA), class $\geq$3 or had a hostile abdomen. They have been considered at high risk for open surgery and therefore the less invasive technique of EVAR was chosen. The mean aneurysm size at initial exclusion was 6.5 $\pm$ 1.4 cm (median: 6.0 cm, interquartile range Q1–Q3: 5.5–7.4 cm). Mean age at modification was 76.8 $\pm$ 6.3 years (median: 77.6 years, interquartile range Q1–Q3: 74.4–81.6 years), and 91.30% of them were men (n = 21). All except one initially placed endografts (95.65%) were of bifurcated configuration and one index endovascular repair was performed in an outlying hospital (modification rate: 3.5%). Noteworthy, the single tubular endoprosthesis was implanted to treat a penetrating atherosclerotic ulcer occurring in an inflammatory aneurysm. At time of modification, the mean aneurysm size was 8.1 $\pm$ 2.9 cm (median: 7.8 cm, interquartile range Q1–Q3: 6.7–9.0 cm) with an average increase in aneurysm size of 1.6 cm (median: 0.8 cm, interquartile range Q1–Q3: 0.0–2.0 cm) since initial aneurysm exclusion. An average time of 5.5 years (median: 5.3 years, interquartile range Q1–Q3: 1.3–9.3 years) elapsed between the two procedures.

The predominant cause for modification was evidence of a graft-related endoleak not treatable by local measures which resulted in aneurysm expansion. Indications for modification were 20 type Ia or Ib endoleaks, 17 type III and one additional type IV endoleak. Four patients underwent modification during initial EVAR and three of the procedures were labelled as technical failures in Table 1. Sixteen patients had growing aneurysms and five had an aneurysm of stable size (including the four patients with modification during initial EVAR). The remaining two patients initially showed aneurysm size reduction but later on, complete disintegration as well as fabric disruption of their Vanguard devices occurred. Noteworthy, patient no. 15 did not follow the suggested post-interventional surveillance CT scans and visits for more than 5 years and ultimately presented with a giant aneurysm of 17 cm. As also seen in Table 1, the majority of patients underwent endoleak correction procedures during follow-up. Type II endoleaks with evidence of aneurysm enlargement were not treated with this approach. Patients with these procedure-related endoleaks underwent coil embolisation or clipping of the respective patent collateral vessel, or CT-guided injection of thrombogenic substances into the aneurysm sac.

Results

Successful deployment of the device was achieved in 95.65% of patients. The single failure took place in patient no. 13 in whom the right external iliac artery was considerably narrowed and the right common iliac artery was elongated. Even after implantation of a self-expandable stent and multiple balloon dilatations, the AMI device could not be introduced as indicated in Table 2. The combined type III and distal attachment leaks were successfully treated by separate overstenting and distal extension. Femorofemoral bypass grafting completed the procedure because of preexisting thrombosis of the contralateral graft limb.

In 14 patients, the configuration of AMI endografting consisted of placement of the proximal end originating in the infrarenal aorta and its distal landing zone in the right iliac axis. The iliac limb of the device was carried to the right external iliac arteries in seven patients. Occlusion of contralateral common iliac arteries was achieved with application of Amplatzer Vascular Plugs 2, the Talent Endoluminal Occluder System or embolisation using Cook IMWCE

Table 1
Summary of indications and previous correction procedures of patients undergoing aortomonoiliac modification.

Patient	Type of device	Endoleak during follow-up	Endoleak treatment during follow-up	AAA sac at modification (cm)	AAA sac change since EVAR (cm)	Indication for modification	Time to modification (months)
1	Stentor	Type IIIa Type II	Overstenting No therapy	4.8	−0.8	Proximal type I Distal type I Type IIIb	119
2	Stentor	Distal type I	Right iliac limb extension	6.7	0.7	Type IIIa Type IV	109
3	Stentor	Type IIIa Distal type I	Overstenting Right iliac limb extension	7.5	2.0	Proximal type I[a] Type IIIa	94
4	Vanguard	Type IIIa Proximal type I[a] Type II Type IIIa	Overstenting Proximal cuff placement Embolisation of IMA Overstenting	12.3	4.7	Proximal type I[a] Type IIIa	81
5	Vanguard	Type II	Coil embolisation, laparoscopic clipping of IMA	6.7	1.2	Type IIIb	150
6	Vanguard	Proximal type I Type IIIa	Proximal extension (Passager) Overstenting	6.9	1.9	Type IIIb	116
7	Vanguard	No endoleak	–	7.8	0.8	Proximal type I[a] Distal type I Type IIIa	44
8	Vanguard	Distal type I	Left iliac limb extension	6.8	1.0	Proximal type I[a] Type IIIb	87
9	Excluder	Proximal type I[a]	Proximal cuff placement	8.5	2.5	Distal type I Type IIIa	59
10	Vanguard	Distal type I	Left iliac limb extension	3.2	−1.5	Type IIIb	148
11	Excluder	Type II	Coil embolisation of lumbar artery	11.8	5.7	Distal type I Type IIIa	141
12	Vanguard	Type IIIa	Overstenting	6.1	1.6	Type IIIb	69
13	Vanguard	Distal type I Type II Type IIIa	Left iliac limb extension Coil embolisation of lumbar artery Overstenting	8.6	0.6	Distal type I Type IIIb	48
14	Vanguard	Type II Type II	Coil embolisation of lumbar artery Coil embolisation of IMA, CT-guided thrombin injection	9.2	3.7	Proximal type I Distal type I Type IIIa	64
15	Excluder	Type II	No therapy	17.0	10.5	Distal type I Type IIIa	114
16	Zenith	No endoleak	–	6.0	0.0	Technical failure	0
17	Zenith	Type II	No therapy	7.2	0.0	Distal type I with cranial migration	50
18	Talent	No endoleak	–	7.8	0.0	Proximal type I[a]	0
19	Talent	No endoleak	–	7.8	0.0	Technical failure Proximal type I[a]	0
20	Talent	Proximal type I Type II Type IIIa	Proximal extension (Palmaz) Embolisation of IMA, operative ligation Overstenting	8.8	1.8	Proximal type I[a] Type IIIa	28
21	Talent	No endoleak	–	10.0	0.1	Proximal type I[a] Type IIIa	0.3
22	TAG thoracic	Type II	No therapy	4.8	0.3	Distal type I with cranial migration	2
23	Excluder	No endoleak	–	9.1	0.0	Technical failure Proximal type I[a]	0

AAA: abdominal aortic aneurysm; EVAR: endovascular aneurysm repair; IMA: inferior mesenteric artery.
[a] With distal migration of endograft.

Table 2
Characteristics of aortomonoiliac modification.

	No. of patients ($n = 23$)
Distal landing zone of aorto-monoiliac graft[a]	
Right CIA	7
Right EIA	7
Left CIA	6
Left EIA	2
Fate of contralateral graft limb	
Endovascular occlusion	19
Preexisting limb thrombosis	4
Crossover bypass graft	
Femoro-femoral	17
Ilio-femoral	6

CIA: common iliac artery; EIA: external iliac artery.
[a] Not successful deployment of endograft ($n = 1$).

coils in 19 patients while the remainder showed preexisting contralateral occlusion due to already thrombosed graft limbs. Two patients had previous crossover bypass grafting and two patients suffered from newly occurring symptoms of disabling claudication. Therefore, crossover bypass grafting was performed to revascularise the respective limb. Type and diameter of the crossover graft varied according to the surgeon's preference and patients characteristics and was between 7 mm and 12 mm. The crossover graft was tunnelled anterior to the rectus sheath in 15 patients while in the remaining ones the graft was routed through the space of Retzius. A configuration overview after modification is given in Table 2. Talent AMI devices were used in 17 patients whereas the remaining received Endurant ($n = 2$), Zenith ($n = 2$) and Valiant ($n = 1$) endografts with diameters ranging from 24 mm to 34 mm.

In all but one patient, the underlying endoleaks could be sealed with this manoeuvre (34 of 36 endoleaks, 94.44%). Merely, in patient no. 20 with multiple previous correction procedures, the endoleaks still remained and caused further aneurysm expansion. He ultimately had to undergo endograft explantation and aorto-femoral bypass grafting. During modification procedures into AMI configuration, no conversion to open surgery was necessary. There were no perioperative or in-hospital deaths in patients who received AMI endografting after failed EVAR.

Early modifications

A total of five modification procedures were performed within 30 days. Technical failures included inability to introduce the contralateral iliac limb in retrograde as well as via crossover technique. In one patient each, insufficient opening of the endograft itself and, alternatively, the ipsilateral iliac limb were observed. The fourth patient with intraprocedural modification presented at completion angiography with a proximal type I endoleak due to distal migration of the endograft which could not be sufficiently treated by cuff placement. In addition, another patient with a type Ia endoleak complicated by distal migration of the endograft combined with modular disconnection was transferred to our institution 1 week after index EVAR in an outlying hospital. In all of these patients, modification procedures were successful and both occurring endoleaks were already detected within the hospital stay. The type II endoleak arising from a lumbar artery was observed while one redo endovascular procedure took place to seal the incomplete occluded contralateral iliac artery (Table 3).

Delayed modifications

The remaining eighteen modifications were undertaken later than 1 month after initial EVAR and therefore classified as delayed procedures (78.26%). Table 3 summarises complications, endoleaks and adverse events after AMI modification. The second type II endoleak observed has not been described until after the modification procedure which was done because of a combined type III/IV endoleak. It is most likely that the endoleak via the lumbar artery already existed before the modification and could not be differentiated from the other endoleaks. As the aneurysm diameter remained stable during follow-up, no further intervention was performed. A small type III endoleak occurred in an 84-year-old multimorbid patient and was therefore carefully monitored by surveillance CT scans as it did not result in aneurysm expansion. Noteworthy, the depicted type Ia and Ib endoleaks all occurred in one patient. He developed a proximal as well as distal attachment endoleak resulting in aneurysm expansion. Three years after modification, the 77-year-old patient had to undergo debranching of the visceral aorta and subsequent revascularisation of the superior mesenteric and the left renal artery to elongate the proximal aortic neck region and facilitate endovascular treatment of the type Ia endoleak. Both endoleaks could be successfully treated by endovascular relining using a second Talent AMI graft. Another 3 years after successful cessation of these leaks, a new distal attachment leak was observed which was treated by embolisation of the ipsilateral hypogastric artery and extension of the graft into the external iliac artery. Buttock claudication was present in one patient in whom the right hypogastric artery was occluded prior to the modification procedure. Reduction in endograft flow because of device stenosis necessitating catheter-based interventions occurred in three patients.

Three major complications occurred in one patient. First, he received percutaneous transluminal angioplasty including stent placement within the initial hospital stay because of iliac artery dissection and stenosis. Twelve months after the modification procedure he presented with thrombosis of the AMI as well as the crossover bypass graft and subsequently received axillo-bi-femoral bypass grafting. On the same day he had to undergo embolectomy due to a peripheral thrombo-embolic event. In the other patient, infection of the crossover bypass graft 2 months after the modification procedure was diagnosed. The infected crossover graft was explanted and the procedure was completed by axillo-femoral bypass. Noteworthy, the patient, in whom the modification procedure was not successful, developed ischaemic colitis with bowel necrosis which necessitated left-sided colectomy. She was discharged 3 weeks later and survived for almost 3 years. All patients survived the management procedures due to complications depicted in Table 3.

Table 3
Complications, endoleaks, and adverse events after aortomonoiliac modification.

	Treatment	Number
Early (within 30 days)		
Iliac artery dissection	PTA and stent placement	1
Type Ic	Redo endovascular occlusion	2
Type II endoleak (via patent lumbar artery)	No therapy	1
Type IV endoleak	No therapy	1
Groin Haematoma	Surgical evacuation	2
Lymphatic fistula	Conservative	2
Buttock claudication	Conservative	1
Delayed (>30 days)		
Endograft and crossover bypass thrombosis	Axillo-bi-femoral bypass grafting	1
Peripheral thrombo-embolic event	Embolectomy	1
Crossover bypass infection	Axillo-femoral bypass grafting	1
Type Ia[a]	Proximal extension	1
Type Ib[a]	Distal extension	2
Type II endoleak (via patent lumbar artery)	No therapy	1
Type III endoleak	No therapy	1
Endograft stenosis	PTA	2
	PTA and stent placement	2
Mortality rate (0%)		0

PTA: percutaneous transluminal angioplasty.
[a] Occurring in one patient.

Follow-up

During a mean follow-up of 43 months (median: 44 months, interquartile range Q1–Q3: 17–69 months), the mean aneurysm diameter decreased to 7.7 ± 3.5 cm (median: 7.0 cm, interquartile range Q1–Q3: 4.8–10.0 cm). This represents an average decrease of 0.4 cm (median: 0.0 cm, interquartile range Q1–Q3: −0.5 to 0.0 cm). Overall survival of this patient group at 1, 4 and 7 years was 90%, 73% and 37%, respectively. One patient did not follow the suggested post-interventional surveillance CT scans and visits for more than 3 years and sustained fatal late aneurysm rupture 51 months after the modification procedure.

Discussion

Almost 20 years have elapsed since the pioneers of EVAR reported their experience. Subsequently, the frequency of the procedure grew substantially[12] and it became an accepted alternative to conventional open graft replacement of abdominal aortic aneurysms. Due to the minimal invasive technique, a method of aneurysm exclusion in otherwise incurable patients because of their extensive accompanying risk factors was at hand.[2,13] Nevertheless, the benefits of this approach do not come freely. Endoleaks

decrease the overall durability and effectiveness of EVAR and can lead to aneurysm sac enlargement which even may occur several years after initial endograft treatment.

Secondary interventions to maintain aneurysm exclusion are frequent and endoleak treatment by catheter-based interventions is nearly always possible but even open surgical conversion may sometimes be required. This procedure may be necessary in a variety of indications following primary EVAR. The frequency of conversion to open repair is reported widely in the literature and is depending on centre experience, indications seen for conversion, generation of implanted grafts and length of follow-up.[14] Large single-centre reviews publish incidences of this procedure to be around 2%.[15–17] The rate of conversion was somewhat higher (8.6%) analysing long-term results of EVAR with the first generation of commercially available stent grafts.[18]

Frequency of open surgical conversion is rather low compared to the high numbers of secondary catheter-based interventions. Nevertheless, it represents an increased burden to the patient due to the even more extensive dissection compared to conventional primary open graft replacement. Sometimes, open conversions have to be performed immediately during initial EVAR due to technical difficulties such as endograft misdeployment or intra-operative vessel injury. These acute emergent as well as peri-interventional conversions within 30 days following primary endograft placement are accompanied with unfavourable mortality rates which exceed 20%.[14,19] Secondary conversions defined as any open graft replacement performed later can be felt necessary either under elective conditions or in an emergent manner because of aneurysm rupture. In most cases, patients present with higher operative risk due to meanwhile advanced age and probably worsened co-morbidities present at time of conversion as compared to primary aneurysm exclusion. Furthermore, presence of the endograft increases the technical challenge during open surgical conversion. Because only a small amount of patients having undergone secondary conversion under elective conditions are published, it is difficult to precisely estimate mortality rates. The results vary from no deaths[20] up to 25% as reported in an analysis of a French multicentric study.[19]

The use of AMI grafts along with crossover bypass grafting has broadened the applicability of endovascular techniques in abdominal aortic aneurysm exclusion. Patients with complex arterial anatomy who might not be candidates for bifurcated endografting can be treated with this approach. Although concerns were raised that the additional extra-anatomic reconstruction in the groin may increase the incidence of possible complications, and limits thereby the durability of the procedure, encouraging mid- and long-term patency rates were published.[5] Cumulative patency rate was 91% at 3 years and 83% at 5 years. Lipsitz et al.[21] reported that patency rates of crossover grafts in conjunction with EVAR surpass those performed for occlusive disease. Therefore, Yilmaz and co-workers[22] concluded in their analysis of 148 patients that the need for additional extra-anatomic bypass grafting should not discourage the use of AMI devices in patients with anatomy unfavourable for other EVAR approaches. Although a multicentre randomised study showed that late patency was higher after direct bypass than crossover bypass in good-risk patients with unilateral iliac occlusive disease not amenable to angioplasty,[23] the use of AMI endografting combined with crossover bypass grafting compared to bifurcated endografting did not independently increase the risk of major complication during follow-up.[24] Similarly, Lazaridis and co-workers[25] concluded that AMI configuration for elective aneurysm repair has proven to be safe and efficacious. In addition, they reported that long-term follow-up results compare well with primarily reported results for endografting using bifurcated endoprostheses.

Modification into AMI configuration was previously described to seal a type III endoleak[26] or alternatively to treat aneurysm expansion in the absence of an endoleak.[27] Recently, Baril and co-workers[28] summarised, after 15 of these modifications, that AMI devices offer a more durable repair than proximal cuff placement for treatment of proximal type I endoleaks as they presented successful repairs in 86% of patients compared to 45% treated with proximal cuffs. Our findings regarding treatment of these proximal attachment endoleaks are consistent as we could seal more than 90% with this procedure. The achieved overall success rate of 95% is in accordance to the results from the analysis of the Zenith Renu AAA Ancillary Graft Converter.[29] Follow-up length of our patient cohort is exceeding theirs[29] which enables us to draw relatively safe conclusions.

Conclusion

Frequency of open surgical conversion after primary EVAR is rather low but the procedure is technically demanding and represents a remarkable operative burden to the patient being more extensive compared to standard primary open graft replacement. Therefore, the procedure should be performed only as a last opportunity under strict indication. Considering the large numbers of endografts being implanted worldwide, the issue of modification into AMI configuration will increase in importance. This procedure allows safe and effective treatment of graft-related endoleaks representing a harbinger of aneurysm rupture. Especially when multiple graft-related endoleaks are present, AMI endografting successfully relines the entire length of the previously implanted device. With this procedure, a minimally invasive alternative is at hand and open surgical conversion may be avoided in many instances.

Conflict of Interest

The authors have no commercial, proprietary or financial interest in any products or companies described in this article.

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