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FULL PAPER

Proximal occlusion of unaffected internal iliac artery versus distal occlusion of aneurysmatic internal iliac artery prior to EVAR: a comparative evaluation of efficacy and clinical outcome

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Objective: Occlusion of the internal iliac artery (IIA) may be necessary prior to endovascular aneurysm repair (EVAR) to prevent endoleak Type II. We compared efficacy and clinical outcome after proximal occlusion of an unaffected IIA (ProxEmbx) using an Amplatzer vascular plug (AVP) I vs distal occlusion of aneurysmatic IIA with coils and plugs (DistEmbx).

Methods: Between 2009 and 2012, 22 patients underwent EVAR. In 9 patients with unaffected IIA, occlusion was performed by a single AVP. In 13 patients with aneurysmatic IIA, more distal embolization (DistEmbx) was conducted by using several coils and additional AVPs. Retrospectively, technical success, clinical outcome and complications were evaluated.

Results: Embolization of the IIA was successful in all patients. Three patients with more DistEmbx of aneurysmatic IIAs suffered from new onset of sexual dysfunction

after occlusion without statistically significant difference ($p > 0.05$). Transient buttock claudication was observed in three patients in each group. Bowel ischaemia did not occur. The procedure time ($p = 0.013$) and fluoroscopy time ($p = 0.038$) was significantly lower in the ProxEmbx group than in the DistEmbx group.

Conclusion: Proximal occlusion of an unaffected IIA and more distal occlusion of an aneurysmatic IIA prior to EVAR had the same technical and clinical outcome. However, proximal plug embolization of an unaffected IIA prior to EVAR was associated with shorter procedure and fluoroscopy time in comparison with more DistEmbx of aneurysmatic IIAs.

Advances in knowledge: Proximal embolization of unaffected IIA and DistEmbx of aneurysmatic IIA before EVAR are both effective in preventing Type II endoleaks and have the same technical and clinical outcome.

INTRODUCTION

Endovascular aneurysm repair (EVAR) is an established alternative to open repair of abdominal aortic aneurysm (AAA).^{1–4} 20% of AAA involves the distal common iliac arteries.^{5,6} In these cases, EVAR may require an extension of the distal stent graft limb into the external iliac artery (EIA) to reach an adequate anchor zone. Occlusion of the internal iliac artery (IIA) is performed to prevent Type II endoleak from retrograde perfusion.⁷ Coil embolization has become the standard technique for induction of segmental occlusion of the IIA. Certain pathological and anatomical constellations may require time consuming and costly placement of multiple coils.

In order to avoid side effects such as bowel ischaemia, buttock claudication and sexual dysfunction, it is important

to embolize as proximal as possible. This provides sufficient collateral flow among distal side branches and also allows development of additional peripheral collateralization from the contralateral side.⁸ Since 2004, the AMPLATZER™ vascular plug (AVP) (St. Jude Medical, St. Paul, MN) has been available as an alternative embolic armamentarium. This device allows a more precise proximal embolization (ProxEmbx) in comparison with embolization with several coils.¹ Recent studies demonstrated that the AVP is a suitable alternative to coil embolization to achieve successful occlusion of the IIA before EVAR.^{9–12} Isolated AVP embolization seems to be reasonable in case of an unaffected IIA. Otherwise, the combined use of multiple coils and/or AVPs seems to be inevitable, as embolization of both afferent and efferent arteries of the IIA aneurysm is necessary.^{13,14} A few studies have been published

comparing proximal plug embolization vs distal embolization (DistEmbX) with coils and/or plugs.^{11,12,15} However, no study has set a special focus on presence of distal aneurysmatic disease. The aim of this retrospective single centre study was to compare ProxEmbX strategies in unaffected IIAs with DistEmbX procedures performed in cases of aneurysmatic IIAs.

METHODS AND MATERIALS

Study sample

Between April 2009 and December 2012, 22 patients with AAA (mean age 73 ± 8 years; 21 males and 1 female) underwent EVAR with stent graft extension into the EIA. All patients with aneurysmatic involvement of the common iliac arteries (CIA) received extension of the aortic stent graft into the EIA. According to our hospital guidelines, patients with an unaffected native IIA (with a normal size) underwent more ProxEmbX to prevent compromise of collateral vessels. Patients with an aneurysmatic IIA received more DistEmbX to prevent retrograde perfusion with the risk of rupture by collateral vessels. Consequently, patients were included in each group depending on the particular embolization approach (ProxEmbX vs DistEmbX). Informed consent was obtained from all patients. The local institutional review board waived its approval. All patients were treated as part of routine care. In 9 patients, the IIA was normal in size (diameter 8 ± 1 mm), and a single AVP was deployed for ProxEmbX. In 13 patients, the IIA was aneurysmatically dilated (diameter 23 ± 11 mm) and more distal occlusion was performed by using several coils and/or additional AVPs (DistEmbX) (Table 1). A pre-interventional CT angiography (CTA) was performed in all patients for evaluation of the aortoiliac vasculature and measurement of the diameter of the anchor zones, target arteries for embolization and aneurysm size. There were no significant differences in demographic parameters between both patient groups (Table 2). IIA embolization was performed 1–37 days (mean 9.5 days) prior to EVAR. Follow-up (mean 15 ± 12.4 months) was based on clinical and radiological examinations [CTA and contrast-enhanced ultrasound (CEUS)].

Interventional technique

All procedures were conducted in our angiography suites equipped with a state-of-the-art flat-panel detector C-arm angiographic system (AXIOM Artis; Siemens AG, Healthcare Sector, Forchheim, Germany). All interventions were performed using a femoral artery approach under local anaesthesia. The embolization procedures were conducted by two board-certified interventional radiologists with more than 9 and 19 years' experience. Initial angiography of the pelvic vasculature was performed by a pigtail catheter (AngioDynamics, Queensbury, NY)

placed just above the aortic bifurcation to identify the IIAs and to measure their diameters. Selective catheterization of the target IIA was performed with an appropriate catheter, typically a cobra-shaped or single-curved configuration (Cook Medical, Limerick, Ireland) and a steerable, hydrophilic wire (0.035 inch) (Radifocus Guide Wire M®; Terumo, Tokyo, Japan).

Proximal embolization in native internal iliac artery

A contralateral approach was performed whenever possible (seven of nine patients). In two patients, an ipsilateral approach was necessary owing to a steep bifurcation and extensive hard plaques in the CIAs. A long 6-F introducer sheath (Destination®; Terumo, Tokyo, Japan) was placed over the wire beyond the target level of the IIA. The diagnostic catheter and guidewire were removed and the loader with the AVP I (size 14 mm or 16 mm in diameter) inside was inserted into the sheath and advanced to the target level. According to general recommendations, the AVP I size was selected 30–50% larger than the diameter of the treated IIA (as described before⁹ and Instructions for Use, AGA Medical Corporation). For device implantation, the sheath was withdrawn while the delivery wire was held in place. Pelvic angiography was performed for verification of the correct position in the proximal segment of the IIA. If the position was not satisfactory, the device was repositioned. In adequate position, the AVP was released by rotating the delivery cable in a counter-clockwise direction. Successful embolization was documented by minimal or absent antegrade flow into the IIA. This was usually performed 5–15 min after plug deployment. The procedure as described above is shown in Figure 1.

Distal embolization in affected internal iliac artery

A contralateral approach was followed in all 13 patients with aneurysmatic IIA. A long 6-F introducer sheath (Destination) was placed—over the wire—beyond the orifice of the IIA. By using a 5-F diagnostic catheter (C1 cobra-shaped or single-curved catheter) (Cook, Bloomington, IL) in 13 patients or a coaxial technique with a 2.7-F microcatheter (Progreat®; Terumo, Tokyo, Japan) in 4 patients, the efferent and afferent arteries of the IIA aneurysm were cannulated and occluded with pushable coils. In the distal IIA embolization group, a total of 128 coils were used [(52 VortX® coils; Boston Scientific, Natick, MA), (35 Nester® embolization coils; Cook Medical, Limerick, Ireland), (36 MReyeT® Coils; Cook Medical, Limerick, Ireland) and (5 Azur® coils; Terumo, Tokyo, Japan)]. An average number of 9.9 coils (range 0–34 coils) were used for each patient. Additional plugs were deployed in 11 patients (9 AVP I, 4 AVP II and 1 AVP IV) via introducer sheath or diagnostic catheter. The procedure as described above is shown in Figure 2.

Table 1. Diameter of involved arteries of proximal embolization (ProxEmbX) and distal embolization (DistEmbX) groups

Mean diameter	ProxEmbX (<i>n</i> = 9)	DistEmbX (<i>n</i> = 13)	<i>p</i> -value
AAA	47 ± 17 mm	49 ± 13 mm	>0.05
CIA	33 ± 13 mm	23 ± 9 mm	>0.05
EIA	9 ± 2 mm	11 ± 1 mm	>0.05
IIA	8 ± 1 mm	23 ± 11 mm	0.0008

AAA, abdominal aortic aneurysm; CIA, common iliac artery; EIA, external iliac artery; IIA, internal iliac artery.

Table 2. Demographic parameters of all patients separated for proximal embolization (ProxEmbx) and distal embolization (DistEmbx) groups

Variables	All patients (<i>n</i> = 22)	ProxEmbx (<i>n</i> = 9)	DistEmbx (<i>n</i> = 13)	<i>p</i> -value
Mean age (years)	73	72	73	>0.05
Male	21	8	13	>0.05
Obesity	11	6	5	>0.05
Hypertension	18	8	10	>0.05
CAD	9	6	3	>0.05
Atrial fibrillation	4	0	4	>0.05
Tobacco history	10	6	4	>0.05
COPD	5	3	2	>0.05
Diabetes mellitus	6	3	3	>0.05

CAD, coronary artery disease; COPD, chronic obstructive pulmonary disease.

Obesity (body mass index $>30 \text{ kg m}^{-2}$); hypertension ($>140/90 \text{ mmHg}$).

There was no significant difference between the ProxEmbx and DistEmbx group.

End point definition

For this retrospective study, primary and secondary end points in terms of technical and clinical practice were defined and evaluated by a side-by-side comparison of ProxEmbx *vs* DistEmbx. Primary end points were technical success, clinical outcome, rates of clinical side effects and complications. Secondary end points were reflected by procedural data such as radiation exposure, fluoroscopy time, amount of contrast medium and costs. All comparative variables are summarized in Table 3. Technical success was defined as the absence of antegrade blood flow into the occluded IIA, which was angiographically evaluated before deploying the endovascular stent graft during each EVAR procedure. Clinical outcome was defined as the absence of Type II endoleaks (retrograde perfusion of the treated IIA) and was evaluated by radiological examinations (CTA and CEUS) during follow-up. Clinical side effects such as buttock claudication, bowel ischaemia and sexual

dysfunction in males were documented prior to occlusion and during follow-up.

Complications of treatment were classified on the basis of outcome according to the reporting standards of the Society of Interventional Radiology.¹⁶ Minor complications included the following two classes: those resulting in (A) no therapy and no consequence or (B) nominal therapy and no consequence including overnight admission for observation only. Major complications included four classes: those (C) requiring therapy and minor hospitalization ($<48 \text{ h}$); (D) requiring major therapy, unplanned increase in level of care and prolonged hospitalization ($>48 \text{ h}$); (E) resulting in permanent adverse sequelae; and (F) resulting in death.¹⁷

Radiation exposure and fluoroscopy time were given by the examination protocol of each patient after intervention. In this

Figure 1. A 79-year-old male patient with aneurysm of the infrarenal aorta and CIA: prior to EVAR, the unaffected internal iliac artery (IIA) was embolized using a single Amplatzer vascular plug I. The pre-interventional angiogram is shown on the left side. On the right side, the angiogram shows no blood flow in the proximal embolized IIA.

Figure 2. A 71-year-old male patient with aneurysm of the infrarenal aorta, CIA and internal iliac artery (IIA): prior to EVAR, the aneurysmatic IIA was embolized by using an Amplatzer vascular plug I and eight coils (4 VortX and 4 Nester Coils). The pre-interventional angiogram is shown on the left side. On the right side, the angiogram shows no blood flow in the embolized aneurysmatic IIA.

Table 3. Primary and secondary end points of the study evaluated by a side-by-side comparison of proximal vs distal embolization

Primary end points
Technical success of embolization procedure
Clinical outcome (absence of Type II endoleak)
Complications of treatment
Clinical side effects (buttock claudication, bowel ischaemia, sexual dysfunction)
Secondary end points
Radiation exposure
Fluoroscopy time
Amount of contrast medium
Costs

context, radiation exposure was calculated by applying the dose–area product and an effective dose conversion factor given by the manufacturer. The procedure time was taken as the time between the first image and the last image in the picture archiving and communication system. The amount of contrast medium was taken from the medical records. Costs were calculated based on the number of coils and plugs used for embolization. Costs of wires, diagnostic catheters, introducer sheaths and contrast medium for the embolization manoeuvre itself were not taken into account. Calculation of costs is further explained in the Results section.

Follow-up

After successful IIA occlusion, all patients were monitored for at least 24 h. Peri- and post-interventional complications were documented. All patients were examined every 3 months at the outpatient clinic. In some cases, clinical follow-up was performed by the general practitioner. Patients were regularly asked for new onset of sexual dysfunction, bowel ischaemia or buttock claudication. In addition, a standardized survey was sent to all involved general practitioners concerning the above-mentioned topics. All patients were advised to contact the outpatient clinic in case of new or worsening symptoms. Follow-up CTA and/or CEUS were performed at discharge and after a period of 12 months. In some cases, there were additional radiological examinations 3 months after EVAR. A standardized protocol for CTA of the abdominal and pelvic vessels was used. All CTAs were reviewed independently by two experienced radiologists who were not involved in performing the EVAR procedures. One had 5 years' radiological experience and, one had 6 years' radiological experience. Inconsistent evaluations occurred in three cases, and consensus meetings with the two board-certified interventional radiologist and the reviewers themselves were held to reach agreement in those three cases. The mean follow-up time of this study was 15 ± 12.4 months.

Statistical analysis

Data are expressed as mean $\pm$ standard deviation. The Mann–Whitney *U* test was performed for statistical analysis to prove significant differences between the two groups. A *p*-value < 0.05

was determined as significant. Significant differences between two groups are also shown (*p*-value < 0.05 ; *p*-value < 0.01 ; and *p*-value < 0.001).

RESULTS

Successful embolization of IIA was performed in all 22 (100%) patients. Technical success was documented angiographically during the IIA occlusion session and prior to deploying the endovascular stent graft during the EVAR procedure. No technical complication such as plug or coil displacement was observed.

In all follow-up examinations (CTA, CEUS), no secondary endoleaks originating from the IIA were detected. The two readers concordantly found no secondary endoleak originating from the IIA at follow-up examinations (CTA, CEUS). In this context, there was no significant difference in the ProxEmbx group or DistEmbx group ($p > 0.05$). In the ProxEmbx group, three non-IIA originating endoleaks were detected, all of them Type II endoleaks due to retrograde perfusion of the inferior mesenteric artery. Seven non-IIA originating endoleaks were identified in the DistEmbx group: four Type II endoleaks due to a retrograde perfusion of the inferior mesenteric artery ($n = 2$) and lumbar arteries ($n = 2$); two minimal Type III endoleaks due to minimal junctional separation of the modular components; and one initial Type IA endoleak which disappeared in the post-interventional CTA. There was a consensus of a watchful waiting approach between vascular surgeons and interventional radiologists in all reported non-IIA endoleaks, and no further therapy was necessary.

Minor complications such as vasovagal reaction, groin haematoma or pseudoaneurysm were not observed in both groups. Clinical side effects such as bowel ischaemia, buttock claudication and sexual dysfunction in males were evaluated before the occlusion of IIA and in follow-up. No patient reported symptoms of bowel ischaemia relating to embolization. One major complication Class D was observed after EVAR: a patient of the DistEmbx group presented with an acute abdomen 13 days after right-sided IIA occlusion and aortomonoiliacal EVAR (left sided) and femorofemoral crossover bypass. Emergency left hemicolectomy was performed. There was no clear hint of a connection between right-sided IIA occlusion and the left-sided ischaemia of the descending colon.

Transient buttock claudication was reported in three cases of both groups, respectively. After a follow-up of 3 months, 3 (33%) of 9 patients in the ProxEmbx group and 3 (23%) of 13 patients in the DistEmbx group complained of initial mild buttock claudication at < 250 m of walking distance. Two patients in both groups reported complete remission within 6 weeks. In one case of each group, buttock claudication disappeared after 12 months. There was no significant difference in the incidence of buttock claudication between ProxEmbx and more DistEmbx ($p > 0.05$). No new onset of sexual dysfunction in males was reported in the ProxEmbx group. 3 (23%) patients of the DistEmbx group suffered from sexual dysfunction after occlusion of IIA ($p > 0.05$), primarily owing to the required more DistEmbx. There was no case of plug/coil migration, non-

target embolization or sepsis. No deaths occurred in relation to IIA occlusion.

Procedure and fluoroscopy time, dose–area product and the amount of contrast medium were taken from the patient records (Table 4). Concerning all interventional procedures, the total procedure and fluoroscopy times were 61 ± 29 min and 23 ± 19 min, respectively. The dose–area product was $35,662 \pm 31,513 \mu\text{Gym}^2$, and the amount of contrast medium was 102 ± 59 ml.

In the ProxEmbx group, procedure time was significantly lower than that in the DistEmbx group (ProxEmbx: 43 ± 20 vs DistEmbx: 73 ± 29 min; $p = 0.01$). Also, fluoroscopy time was significantly lower in the ProxEmbx group (ProxEmbx: 15 ± 4 vs DistEmbx: 29 ± 7 min; $p = 0.04$). The amount of contrast medium was not significantly less for the ProxEmbx manoeuvre (ProxEmbx: 89 ± 50 vs DistEmbx: 110 ± 60 ml; $p > 0.05$). There was no significant difference in radiation dose (dose–area product ProxEmbx: $25,620 \pm 9382$ vs DistEmbx: $46,819 \pm 11,215 \mu\text{Gym}^2$; $p > 0.05$).

Calculation of costs was based only on the number of coils and plugs used for embolization (Table 4). We used nine AVP I (each 510 USD) in nine patients in the ProxEmbx group. In the DistEmbx group, we used 52 VortX coils (each 52 USD), 35 Nester embolization coils (each 108 USD), 36 MReyeT coils (each 42 USD) and 5 Azur coils (each 100 USD) in 13 patients. Furthermore, we used seven AVP I (each 510 USD), four AVP II (each 510 USD) and one AVP IV (510 USD) in this group. In the ProxEmbx group, we deployed one AVP in each case. In the DistEmbx group, we used a mean number of 9.9 coils (range 0–34 coils) and additional AVP. In summary, total mean costs for ProxEmbx were 510 USD and 1124 USD for DistEmbx.

DISCUSSION

Endovascular embolization of the IIA is mandatory for extension of aortoiliac stent grafts into the external iliac arteries in case of a short or aneurysmatic common iliac artery.^{7,8} Embolization of IIA can be achieved by using coils, plugs or a combination of both devices. In this study, we retrospectively compared technical and clinical results of proximal vs distal IIA embolization before EVAR in different scenarios (native vs aneurysmatic IIA). We performed proximal plug embolization

in native IIA and coil and/or plug embolization in affected aneurysmatic IIA. Literature concerning complications after occlusion of the IIA prior to EVAR is inconclusive with regard to side effects such as bowel ischaemia, buttock claudication and sexual dysfunction in males. Generally, the rate of buttock claudication ranges from 16%¹⁸ to 55%.¹⁹ The rate of new onset of erectile dysfunction also varies from 13%²⁰ to 45%.²¹ To determine reliably the risk of side effects after occlusion of IIA, additional studies are necessary. Furthermore, this is the first study explicitly comparing clinical outcome for occlusion of non-affected vs aneurysmatic IIA. Anatomic condition can determine clinical outcome besides embolization technique. Because of better anatomic conditions, we expected better clinical outcomes for ProxEmbx in patients with non-aneurysmatic IIA, like other investors did.^{22–24}

Coil embolization is the standard procedure for embolization of IIA prior to EVAR. Several studies reported high technical success rates.^{8,15,21,22,25} The number of coils used varies from patient to patient. Coil embolization may be complicated by compromising collateral vessels. During the past years, plug embolization of non-aneurysmatic IIA became more and more common. Previous studies have shown that precise proximal IIA occlusion can be achieved with only one AVP I.^{9,11,12}

The AVP is an established embolic device nowadays. For ProxEmbx of non-aneurysmatic IIA, we used AVP I, which was successfully used in 2004 for the first time.²⁶ Although there is no clinical evidence that the AVP I has better results than the AVP II in terms of EVAR preparation, it is undoubtedly more suitable for intended ProxEmbx without compromise of collateral vessels.²⁷ Spontaneous recanalization is a rare finding. One report of recanalization after AVP placement and one rupture of an IIA caused by recanalization of the AVP are described in the current literature.^{27,28}

Bowel ischaemia, buttock claudication and sexual dysfunction are well-known side effects of IIA embolization. In 2013, Chun J et al¹⁵ retrospectively analyzed data of 88 patients with unilateral and bilateral IIA embolization prior to EVAR. They further investigated symptoms of pelvic ischaemia in 47 patients. This study has analyzed the largest cohort so far published. The authors did not distinguish between unaffected and aneurysmatic IIA in their study. They did not find a significant

Table 4. Fluoroscopy and procedure time, dose–area product, amount of contrast agent and number of embolization devices of all patients, proximal embolization (ProxEmbx) and distal embolization (DistEmbx) groups

	All patients ($n = 21$)	ProxEmbx ($n = 9$)	DistEmbx ($n = 13$)	p -value
Fluoroscopy time (min)	22.8 ± 18	14.6 ± 4	29.2 ± 7	0.04 ^a
Procedure time (min)	60.8 ± 29	43 ± 20	73 ± 29	0.01 ^a
Dose–area product (μGym^2)	$35,661 \pm 31,513$	$25,620 \pm 9382$	$46,819 \pm 11,215$	>0.05
Contrast agent (ml)	102 ± 59	89 ± 50	110 ± 60	>0.05
Number of plugs	21	9	12	
Number of coils	128	0	128	

^aSignificant differences between the ProxEmbx group and DistEmbx group.

difference in clinical outcome and side effects between ProxEmbX and DistEmbX (unaffected and aneurysmatic IIA in both groups).¹⁵ In accordance with their results, we did not find a significant difference between ProxEmbX of unaffected IIA and DistEmbX of aneurysmatic IIA; however, in our study, another scenario in each group was reflected. Chun et al¹⁵ reported pelvic ischaemia in 30% of patients with ProxEmbX and in 52% of patients with DistEmbX without statistic difference. In a recent systemic review of literature, Rayt et al¹⁹ showed an overall incidence of buttock claudication and erectile dysfunction of 28% and 17%, respectively. These data are concordant with our results in patients with unilateral IIA embolization. There is a tendency towards reduced buttock claudication with ProxEmbX; however, a statistically significant difference was not found. Some authors do not discriminate between unilateral and bilateral IIA embolization.¹⁹ There is widespread consensus concerning the higher frequency of pelvic ischaemia in cases of bilateral occlusion of the IIA. Several authors report no significant difference in ischaemic side effects between unilateral and bilateral embolization.^{15,19} In contrast, Chun et al¹⁵ did not observe a significant advantage of a specific embolization technique. However, contrary to a bilateral occlusion strategy, iliac sidebranch stent graft devices can be useful to preserve at least one IIA.²⁵ This relatively new development seems to be suitable for specific anatomic conditions only. It is also performed at our hospital, but was not investigated. Kritpracha et al²⁴ reported significantly higher symptoms of pelvic ischaemia occurring with more distal placement of coils for IIA embolization. We expected cases of bowel ischaemia rather in the DistEmbX group, but did not observe any case of bowel ischaemia after embolization of IIA. The one patient described above cannot be linked clearly to embolization of IIA. This is concordant to the literature. There are only a small number of severe complications reported after embolization of IIA.²²

Buttock claudication generally seems to be a more common side effect of occlusion of IIA.^{9,11} Vandy et al²⁹ reported a significantly lower rate of buttock claudication after plug embolization in comparison with coil embolization. But, the follow-up period of this study was only 1 month and reported only the initial period after embolization. Likewise, Libicher et al¹¹ demonstrated that initial buttock claudication is significantly more severe after coil embolization as compared with a vascular plug.¹¹ There are various possible explanations for this. We expected buttock claudication in a higher frequency in the DistEmbX group than in the ProxEmbX group owing to the required more DistEmbX. In addition, coils can accidentally migrate more distally. However, our data demonstrate no significant difference for the occurrence of buttock claudication between the two groups. In both groups, three patients complained of initial buttock claudication, and we did not observe an initially significantly higher percentage of buttock claudication in the ProxEmbX group. Two patients in both groups reported a complete remission within 6 weeks. After 3 months, we observed no difference between the ProxEmbX and DistEmbX group. In summary, we observed buttock claudication in both groups approximately in 10% of patients. This result is comparable with previous data published from Chun et al.¹⁵ In one of the largest cohorts

investigated, they did not find a significant difference between the DistEmbX and ProxEmbX technique.

We also investigated the rate of new onset of sexual dysfunction in males after embolization of IIA prior to EVAR, which is less well investigated than the rate of buttock claudication.¹⁹ In the ProxEmbX group, no patient reported sexual dysfunction. In our study, three patients in the DistEmbX group suffered from new onset of sexual dysfunction after embolization, primarily owing to the required more DistEmbX in this group. Instead of buttock claudication, sexual dysfunction did not resolve over time. The incidence was 23% in the DistEmbX Group. Rayt et al¹⁹ reported a rate of 14–17%. The higher rate of sexual dysfunction in our group may be due to the relatively high number of coils used and extended embolization performed in these patients. Although we had not seen any significant difference between ProxEmbX and DistEmbX, our results concerning sexual dysfunction have to be considered with care owing to the small study sample. Chun et al¹⁵ had not seen any difference in their study consisting of a larger patient cohort.

Furthermore, we investigated technical success of IIA interruption. Embolization of IIA was successful in all patients, and no secondary endoleak of the IIA was detected. Our data are in accordance with the literature concerning technical results and safety. Chun et al¹⁵ also reported a high technical success rate approaching 100% with only one single implanted AVP.

Fluoroscopy and procedure time were shorter in the ProxEmbX group than in the DistEmbX group, which concurs with Libicher et al.¹¹ Fluoroscopy and procedure time was not examined in the study of Chun et al.¹⁵ Surprisingly, we did not observe a significantly higher dose–area product in the DistEmbX group. Potentially, dose–area product may be higher in the DistEmbX group because of different body mass indexes in both groups. However, this cannot be statistically testified, since data concerning body mass index had not clearly been documented for both groups.

The overall amount of contrast media did not reveal any differences between the two groups. Generally, we would have expected a decrease of contrast media in the ProxEmbX group, in which a single plug was deployed. Repetitive control angiograms after plug embolization may cause the comparative amount of contrast media administered, since the AVP I needs more time to occlude the aimed vessel. Other investigators also have not observed any difference in the amount of contrast medium.^{11,12} As described in the literature,²⁹ costs for the ProxEmbX procedure were lower in comparison with more DistEmbX using several coils.

Several limitations of our study need to be discussed. The study was performed retrospectively, and the relatively few patients were not randomized. Accurate information on new onset of erectile dysfunction relies on the patient compliance to the questionnaire. These limitations are nevertheless representative of a large proportion of studies on this topic.

We compared two groups with differential anatomic conditions resulting in two different embolization techniques. The

advantages found in the ProxEmbx embolization can be due to better anatomic conditions in this group. However, differences did not reach the level of significance, and we did not find a better clinical outcome in the ProxEmbx group.

Larger long-term trials are necessary to validate our findings. Stents with iliac side branches are under clinical investigation and may further lower the rate of ischaemic side effects.²⁵ The benefit of embolization of IIA prior to EVAR is disputable.^{30–32} We demonstrated that embolization of IIA prior to EVAR is effective to prevent Type II endoleaks. Both ProxEmbx of unaffected IIA and DistEmbx of aneurysmatic IIA have a low risk of lifestyle-limiting side effects without significantly different clinical outcomes. However, a ProxEmbx strategy should be

preferred to minimize the risk of side effects and to reduce procedure times and costs.

CONFLICTS OF INTEREST

Ralph Kickuth is a consultant for Abbott Vascular. Thorsten Bley is a consultant for GSK and MSD and is also in the speakers bureau of Abbvie, Bayer, GE, Guerbet, HeartFlow and Siemens. Richard Kellersmann is a speaker for Lombard Medical, Maquet Gettinge Group and WL Gore.

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