catheter embolisation and sclerotherapy, should be the basis of treatment, and surgery should be minimally used. Irrespective of the treatment procedure, use of repeated condition-specific therapies is indispensable for CVM patients. Rockman et al. reported that >70% of CVM patients had already undergone initial therapies.[8] In our series, one patient underwent 17 surgical shunt ligations. Mendel at al. have reported 12 recurrences in 17 cases of surgically treated CVMs of the upper extremity.[9] In another report, 12 CVM patients were mainly treated with endovascular embolisation, and eight experienced recurrence.[10] Some patients in our series have not undergone any additional treatments, such as endovascular procedures, after surgery. Although we never opine that endovascular treatment is not necessary and that 'wait and watch' is the best choice for CVM patients, we selected a 'wait and watch approach' in most cases, taking into account the results of previous reports.

Aggressive treatment for CVM in the limb may result in critical limb ischaemia. In an emergency case (such as patient #1) involving ligation of the brachial artery connecting to the ruptured aneurysm, a lateral branch of the brachial artery might serve as an abnormal vessel feeding the nidus. We preserved the vessel fearing limb loss and eventually obtained a good long-term result. Ankle-pressure measurement was an effective monitoring tool for preventing ischaemic complications after major artery ligation. In addition, skin-perfusion-pressure measurement at distal sites with arterial compression may also be useful for predicting limb prognosis after arterial ligation.

There are some reports of CVM-associated CHF located in the extremities or body trunk.[3,8,11,12] In such cases, endovascular embolisation procedures were mainly performed for shunt closure with acceptable outcomes. However, in patient #4 of the present study, large inflow arteries and broad areas of AV shunt lesions led us to select femoral-artery ligation and banding as the surgical procedures to decrease the shunt flow, while avoiding necrosis, which might occur with catheter embolisation or sclerotherapy in high-flow conditions. In this case, after surgical closure of the large AV fistula, additional endovascular therapy was also performed for the other feeding vessels and the nidus.

We consider it necessary to search for the presence of aneurysms upon initial consultation or to examine for aneurysm formation during follow-up visits, especially in patients with CVM classified as 'predominantly AV shunting defect type' or 'combined vascular defects + predominantly AV shunting defects type'. Once an aneurysm is detected, regular follow-up to check its growth is mandatory. As our study possibly indicates that saccular aneurysms are likely to enlarge or rupture, such aneurysms should be observed more carefully. In some cases, planned preventive surgery is indicated before an aneurysm emerges.

Conclusion

Aneurysm is not a rare complication of extracranial CVM. In CVM patients, it is important to treat CVM before an aneurysm emerges. In addition to treatment for CVM, regular screening for and appropriate management of aneurysms in CVM patients are indispensable.

Conflict of Interest

None declared.

Funding

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Middle-term results of endovascular aneurysm repair in Japan: does intraoperative endovascular management against the hostile aneurysmal neck prevent the proximal type I endoleak?

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Aim. Endovascular aneurysm repair (EVAR) was first approved in Japan in 2007. In order to avoid the learning curve generally seen in the initial stages of implementation, we have aimed for procedural perfection. As the proximal type I endoleak (EL) is associated with a higher risk of late conversion and rupture, so we have treated the intraoperative type I EL scrupulously. The hostile neck, which is known to be a risk for perigraft leakage, is the focus of this study. We showed both the middle-term results of EVAR in our country and the possible necessity of intraoperative management for the hostile neck.
Methods. From a consecutive series of 134 patients who underwent EVAR of abdominal aortic aneurysms, 129 cases in which contrast agent was used intraoperatively were selected. All cases had at least 12-month follow-up postoperatively (12-40 months). Of the 129 selected cases, 49 cases (37%) that did not fulfill the commercially recommended criteria of the aneurysmal neck (length <15 mm and angle >60° of the aneurysm or >45° of the suprarenal aorta) were assigned to the off-label group. The other 80 cases were assigned to the on-label group. We carefully observed the completion angiography, and when we found or suspected a type I EL, we performed a re-touch up, changed to a non-compliant balloon, and used a supportive device, such as a Palmaz™ stent or aortic cuffs, in sequence.
Results. No postoperative type I ELs were detected within the follow-up period. Intraoperative type I ELs were detected more frequently in the off-label group (51%) than the on-label group (20%) (P<0.01). The rate of type I EL in the off-label group in terms of the neck length criteria (11/14 cases) was higher than that in the on-label group (30/115 cases) (P<0.01). In terms of the neck angle, patients in the off-label group had a greater tendency to develop the type I EL than those in the on-label group (18/42 vs. 23/87 cases) (P=0.06).
Conclusion. Off-label usage regarding aneurysmal neck length and angle tends to be incomplete without additional procedures. Conversely, various techniques, including non-compliant balloon usage and aortic stenting or cuffs, produce good results for the intraoperative type I EL. We found a relationship between the neck condition and the intraoperative type I EL, and showed the importance of strictly obeying our simple algorithm against the proximal type I EL.
[Int Angiol 2011;30:1-2]

Key words: Endoleak - Endovascular aneurysm repair - Neck.

The stent-graft was first approved in Japan in 2007. Although we do not reach the level of other countries in the use of this procedure, we have learnt about the pros and cons of endovascular aneurysm repair (EVAR) techniques from a number of previous studies.[1-3] One of the drawbacks of this stressless treatment is the high reintervention rate, which is mainly caused by endoleaks (ELs). We have performed EVAR with scrupulous care in order to prevent the development of proximal perigraft leakage.

The type I EL, which is defined as the persistence of a perigraft aperture of blood flow caused by an inadequate and ineffective seal at the proximal and distal attachment zones,[4] has been correlated with a higher risk of late conversion [1] and rupture.[2] An inexperienced operator sometimes overlooks the proximal type I EL, as it is more difficult to detect than the distal type. Some skilled operators often leave a slight proximal type I EL because they have experienced that such leakage is often stopped by a thrombus within several days. However, we have attributed the high reintervention rate due to the type I EL to such incomplete procedures. We also believe that our intraoperative (intra-op) management

for the type I EL can consistently achieve good results after the EVAR procedure.

The hostile neck, which is known to be a risk for perigraft leakage, is the focus of this study. The anatomical criteria, including the neck length and neck angulation, which are thought to be strongly related to the proximal type I EL, were set by the commercially available devices. We revealed the necessity of intra-op management, especially for those cases that did not fulfill the criteria regarding the aneurysmal neck. In addition, we retrospectively examined the EVAR cases, all of which were performed our simple algorithm against the intra-op type I EL and show the middle-term results.

Materials and methods

A series of 134 consecutive patients who underwent EVAR in Morinomiya Hospital (Osaka, Japan) between December 2006 and August 2008 were selected. Of these, 129 patients in whom contrast agents had been used intraoperatively were included in our study. Two kinds of commercially available devices were used: 72 cases (56%) were treated with the Gore Excluder™ AAA endoprosthesis (W.L. Gore & Associates, AZ, USA) and the remaining 57 cases (44%) were treated with the Zenith endovascular graft™ (COOK Medical, IN, USA). Follow-ups were performed until April 2010. Surveillance was performed with contrast CT scan at four days after the operation during in-hospital stay. After the discharge, patients were surveyed with CT at 6, 12, 24, and 36 month postoperatively.

Among the anatomical criteria documented in the instructions for use recommended by these companies, three factors considered to be strongly related to perigraft leakage were adopted in our study: a non-aneurysmal infrarenal aortic segment (neck) proximal to the aneurysms: 1) with a length > 15 mm; 2) with an angle of <60° relative to the long axis of the aneurysm; and 3) with an angle of <45° relative to the axis of the suprarenal aorta. Eighty cases satisfied the criteria, and this group was classified as the on-label group. The 49 cases that did not satisfy the criteria were classified as the off-label group.

The off-label group included 14 cases of short aortic neck, 22 cases of severe suprarenal angu-
lation, and 35 cases of severe aneurysm angulation. In cases where the distal landing area was too short, we usually extended the stent-graft leg to the external iliac artery with hypogastric artery coil embolization. If both the hypogastric arteries needed to be embolized, we performed a contralateral external iliac to hypogastric artery bypass. To avoid the difficulties encountered while accessing the aneurysm with the device, we often accessed via the retroperitoneal approach.

We evaluated the EL very carefully by performing a completion angiography, because the appropriate management of the proximal type I EL is extremely important for avoiding future reinterventions. We changed the angle of the C-arm and repeatedly checked the angiography. The angiography directly from the femoral sheath was useful for evaluating the distal type I EL. The retrograde flow from the lumbar artery, inferior mesenteric artery, and medial sacral artery into the aneurysmal sac in the late phase of the completion angiography was thought to indicate intra-aneurysm decompression, which meant successful exclusion.

When we found or suspected a type I EL during the completion angiography, we firstly performed a re-touch up with a semi-compliant occlusion balloon, then changed it to a PTA non-compliant balloon (balloon exchange), and finally used ancillary procedures, such as the use of aortic cuffs (Main body extension: Zenith™, or Aortic Extender Endoprosthesis: Excluder™) or a Palmaz™ (Cordis, Johnson & Johnson, Japan) stent insertion (Figure 1).

The TMP Lock-Balloon Catheter™ (Tokai Medical Products Co., Kasugai, Aichi, Japan) and the Equalizer™ Occlusion Balloon Catheter (Boston Scientific Co., Japan) are the most frequently used semi-compliant occlusion balloons. Their material is relatively soft and their inflation pressure is low. The Maxi-LD™ (Cordis, Johnson & Johnson, Japan) is a non-compliant PTA balloon with a high inflation pressure. It is very important to consult the compliance chart before using this balloon. In order to avoid the risk of aortic dissection, one should select the balloon size whose diameter is less than the native aortic diameter. When using a palmaz™ stent, one should also take the balloon size into consideration. The use of too much pressure and repeated touch-up should be avoided.
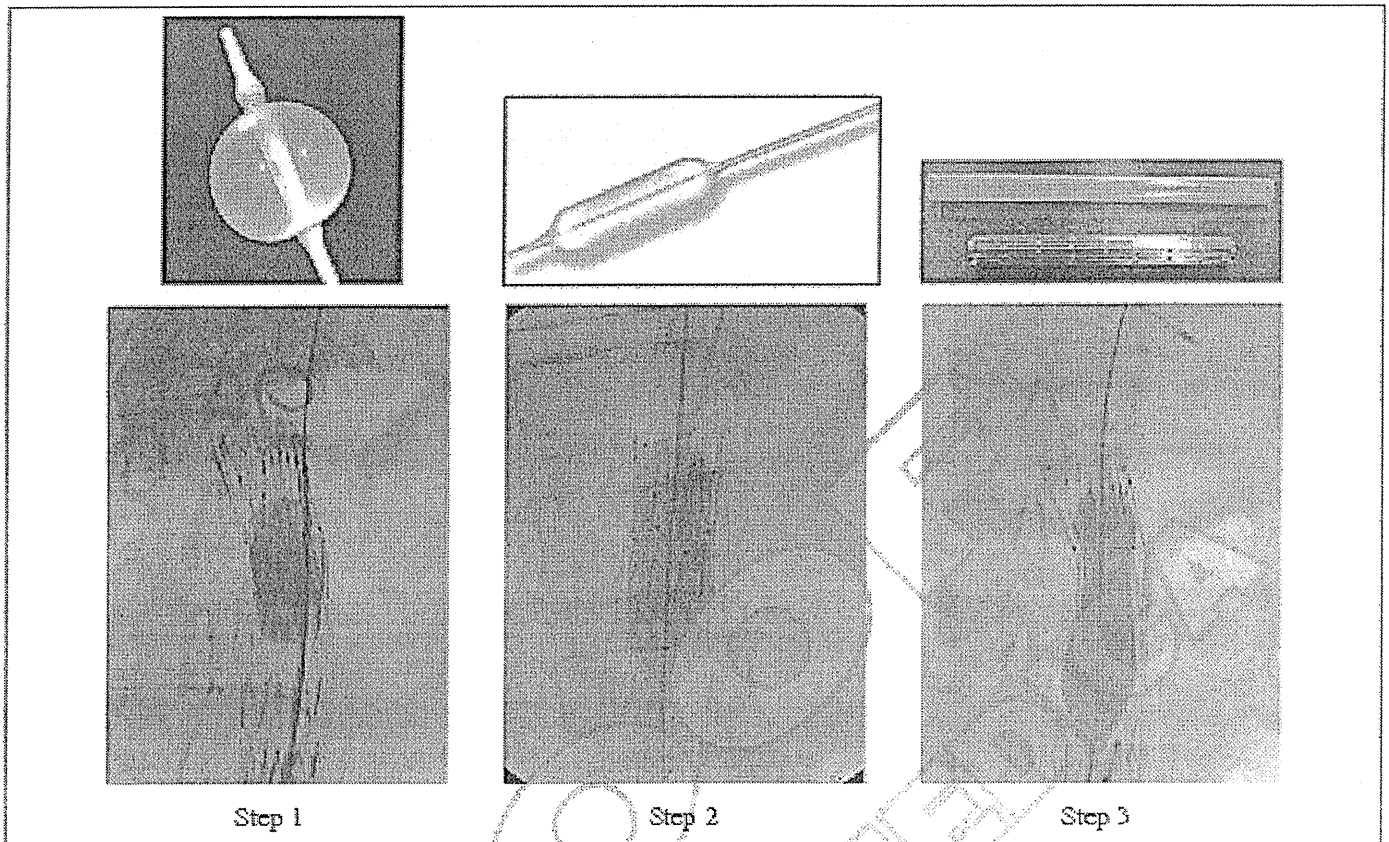
Figure 1.—Two kinds of stent-grafts were used in this study. Gore Excluder™ AAA endoprosthesis (W.L. Gore & Associates, AZ, USA) and the Zenith endovascular graft™ (COOK Medical, IN, USA). Step 1: re-touch up with semi-compliant balloon (The TMP Lock-Balloon Catheter™ [Tokai Medical Products Co., Kasugai, Aichi, Japan] or the Equalizer™ Occlusion Balloon Catheter [Boston Scientific Co., Japan]). Step 2: re-touch up with non-compliant balloon (The Maxi-LD™ [Cordis, Johnson & Johnson, Japan]). Step 3: Palmaz™ stent (Cordis, Johnson & Johnson, Japan) stent or aortic cuff (Main body extension: Zenith™, or Aortic Extender Endoprosthesis: Excluder™) insertion.

Where appropriate, unpaired Student's *t*-tests were used to make comparisons between the treatment groups. Significance was defined as P<0.05. The Kaplan-Meier life table analysis was used to estimate the overall survival, aneurysm-related mortality, and rate of freedom from re-intervention.

Results

During the follow-up period, which ranged from 12 to 40 months, no postoperative type I ELs were detected. A greater number of intra-op ELs were detected in the 27 cases of the on-label group (27/80: 33%) than in the 28 cases of the off-label group (28/49: 57%) (P<0.01). The intra-op type I EL was observed in a greater number of patients in the off-label group than in the on-label group (25 cases in the off-label group *vs.* 16 cases in the on-label group) (Table I). Ancillary procedures were also performed in a greater number of patients in the off-label group (Table I).

When we focused on the proximal type I EL, 78% (11/14 cases) of the patients who did not fit the proximal neck length criteria showed significantly higher proportion of early type I EL than those in the group that fit the criteria (Table II). The degree of neck angulation is a potential predictor for the proximal type I EL (Table II).

The aneurysm size decreased (>5 mm) in 70 cases (52%), unchanged (within 5 mm) in 63 cases (47%), and increased (more than 5 mm) in 1 case (0.7%).

Type II ELs were found in 33 cases. Although 2 type I ELs remained even after our 3 step algorithm, neither of these ELs was detected with the

TABLE I.—*The early type I EL was observed in a greater number of patients in the off-label group than in the on-label group. Ancillary procedures were also performed in a greater number of patients in the off-label group.*

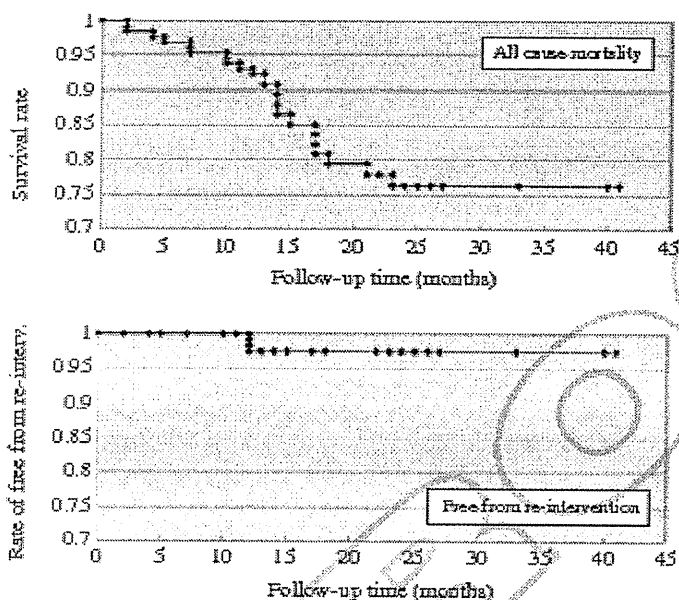|		On-label group (80 cases)	Off-label group (49 cases)
Intraoperative type-I endoleaks	Proximal	16 (20%)	25 (51%)* (p<0.01)
	Distal	11 (13%)	3 (6%) (p=0.17)
	Total	27 (33%)	28 (57%)* (p<0.01)
Ancillary methods			
Palmaz™ stent or aortic cuff		9 (11%)	24 (48%)* (P<0.01)
Balloon Exchange		7 (8%)	1 (2%)* (P<0.01)

Figure 2.—All causes of mortality and the rate of periods free from re-intervention.

TABLE II.—*When focused on the proximal type I EL, a greater number of the patients who did not fit the proximal neck length criteria showed significantly higher proportion of early type I EL than those in the group that fit the criteria. The degree of neck angulation is a potential predictor for the proximal type I EL.*

Proximal neck length	Intra-op type I EL
Neck length ≥15 mm (115 cases)	30 cases (26%)
Neck length < 15 mm (14 cases)	11 cases (78%)*
Neck angulation	*P<0.01 (X2=15.8)
Suprarenal < 45° and aneurysmal neck < 60°, (87 cases)	23 cases (26%)
Suprarenal ≥ 45° and/or aneurysmal neck ≥60° (42 cases)	18 cases (42%)**
	**P=0.06 (X2=3.5)

contrast CT performed at 4 postoperative days. Three type IV ELs were found. None of these cases showed any remnant of an EL after discharge.

The all cause mortality rate is shown in Table I. The aneurysm related death rate was zero. The aneurysm-related reintervention rate is shown in

Figure 2. Four cases required reintervention (Table III). One graft limb occlusion and three graft migration-related complications are shown. The stent graft used for the reintervention was contralateral leg of Excluder™ because of its flexibility. There were no complications related to the proximal neck.

Discussion

The stent-graft was first approved in Japan in 2007, and the Japanese Committee for Stentgraft

TABLE III.—*Patients list of reintervention. All the stent grafts used for the reintervention was contralateral leg of Excluder™ because of its flexibility.*

Age and gender	Complication	Onset (month)	Treatment	Prognosis after the re-intervention
75 M	Graft limb occlusion	12	Thrombectomy and stent-graft insertion	Alive for 16 months
83 F	Graft migration and type 1 and 2 endoleaks	12	Stent-graft insertion Coil embolization	Alive for 5 months
82 F	Graft migration and impending rupture due to type 1 endoleak	10	Stent-graft insertion	Alive for 9 months
75 M	Graft migration and type 1 endoleak	12	Stent-graft insertion	Alive for 5 months

Management (JACSM) was established with the aim of ensuring the safe and proper use of commercial stent-grafts following their regulatory approval.[5] Stent-graft materials have improved over the last two decades. Zenith™ and Excluder™ were the first two devices introduced to Japan. We were fully prepared to use these devices and aimed for procedural perfection in order to avoid the learning curve generally seen in the initial stages of implementation. In view of previous prospective studies of EVAR,[1-3] we focused on the importance of the type I EL and concentrated on its prevention. Therefore, we often used supportive devices, such as the palmaz™ stent or the aortic cuff, not only for cases of obvious intra-op proximal type I EL but also for remarkably difficult off-label cases (i.e., neck length <10 mm, or neck angulation >90°) before completion angiography. Although in some cases this might mean oversurgery, we did not experience any complications caused by such procedures.

As Dias demonstrated, among the EVAR patients whose proximal type I ELs were treated with the palmaz™ stent, 10 out of 33 patients (30%) were treated for proximal perigraft leakage (9 intraoperatively and 1 postoperatively).[6] Non of these cases showed any anatomical difficulty regarding neck length (21 mm), neck angulation (30 degree), or conical neck. These cases corresponded to the off-label group in our study, and showed a relatively high rate of perigraft leakage. This may be due to the improvement of the endovascular device in this era.

Incomplete endovascular exclusion causes increases in intrasac pressure, which leads to a high risk of late rupture.[7,8] Parodi found that the intrasac pressure was close to the systemic pressure in the presence of the type I EL.[9] We confirmed the absence of the type I EL by carefully observing direct leakage into the aneurysmal sac, and by confirming the retrograde flow from the branches of the aneurysm into the sac in the late phase of the completion angiography, which indicated the an intra-aneurysm decompression. We also employed completion angiography to reveal the stent-graft alignment.

Our endeavor to minimize perigraft leakage was partly grounded in the fact demonstrated by Li that sac pressure and AAA wall stress increased in proportion to the size of the leakage aperture.[10] On the contrary, Matsumura reported that 14 out of 28 cases that demonstrated initial ELs showed spontaneous sealing.[11] He indicated the beneficial effects of hemodynamical modification as a result of the stent-graft insertion itself. We also experienced one case in which we left an intraoperative type I EL and the leak spontaneously sealed postoperatively. We generally expected good results, however, by completing our algorithm.

An intraoperative evaluation of the proximal type I EL is difficult because the amount of contrast agent per cross-section area was less at the proximal site than at the distal one, and performing ancillary procedures near the renal arteries, such as the renal artery occlusion by the stent-graft, was sometimes troublesome. On the contrary, we did not focus on the distal EL in this study because an angiography directly from the femoral sheath can easily reveal a distal EL and defining a distal landing area can be ambiguous. Sometimes the common femoral artery has scattered sealing zones. If the distal EL was suspected, it is generally treated by the extension of the stent-graft leg to the external iliac artery.

In our study, about half of the off-label group patients required additional procedures at the proximal neck. This seemed to be a high additional intervention rate, and may be considered to be oversurgery. We are satisfied, however, with the result of no postoperative residual type I EL.

We revealed a higher rate for additional intervention of the short neck group and the tendency of the angulated group. This result was partly supported by the report of Albertini, who found that the neck angulation and neck diameter were significantly greater in patients who had a proximal type I EL, compared to patients who had none.[12] A short, heavily calcified and conical aneurysmal neck [6,13] was also reported as an increased risk of the type I EL, which corresponds with our results. Mohan pointed out that the stent-graft oversize, as well as short aortic neck, had close correlations with type I ELs.[7] Oversizing causes infolding of the stent-graft, which is sometimes difficult to mend without additional device such as the palmaz™ stent.[6] We did not experience such an infolding, however, possibly because we used a 64-slice CT and <3 mm slices for preoperative sizing in all of our cases.

The limitation of our study is that we did not take the multi-factors of hostile neck, such as

calcification or mural thrombus, into consideration. As such neck factors might be not independent, we should examine the data with a multifactorial analysis in the future, using a higher volume of patients.

The more than 97% free from reintervention rate at three years was satisfactorily high. The cause of postoperative reintervention in three cases was migration of the distal end attached on the common iliac artery. In our study, we performed coil embolization for the hypogastric artery, followed by extension of the stent-graft leg to the external iliac artery, for cases in which the landing zone was <15 mm. This is the reason that all cases fit the anatomical criteria of the distal landing. Some cases, however, including these three migration cases, had a tapered-shaped common iliac artery, whose landing condition might contain the risk of migration. We hypothesized that if severe aneurysmal angulation is remodeled, the inserted stent-graft might shift to the angulated site, resulting in the migration of the distal end of the stent-graft. We should take care in such angulated cases for the migration of the distal site rather than proximal one.

The all-cause mortality rate was similar to that of other high volume trials.[1,3] The mortality rate at three years was a little more than 70%. In spite of a good reintervention rate, the middle-term mortality rate did not surpass that of other reports. The causes of death were various, and we could not find any peculiar adverse factors. A higher volume of patients should be used in the future to examine the long-term results of these procedures.

Our strategy mainly included three steps, as mentioned above. A re-touch up with a semi-compliant occlusion balloon should be approached from the contralateral side. The direction of the radial force at the proximal landing site might change by a contralateral approach in the angulated neck. Although a PTA non-compliant balloon is certainly guarantees a firmer adherence to the aortic wall, it has the risk of dissection of the fragile atherosclerotic aortic wall. We referred to the compliant chart of the balloon and used an undersized one compared to the native aorta. A Palmaz™ stent was used as a last resort for persistent ELs.[6] We believe that the aortic cuffs, with its additional radial force, might be a good alternative to the Palmaz™ stent. However,

we have experienced certain cases for which we could not use the cuffs because of the angulation and shortness of the neck.

We need to consider the cases of postoperative type I ELs that did not show any intra-op ones. Sampio demonstrated 8 cases of type I ELs among 202 EVAR patients.[13] Five cases did not show any intra-op type I ELs, and the time intervals after EVAR for these cases were 253, 155, 1, 1, and 21 days, respectively. We did not find any such cases in our study. However, we should pay specific attention to those patients with hostile neck in any future follow-up.

Conclusions

Off-label usage regarding aneurysm neck length and angle tends to be incomplete without ancillary procedures; the techniques we used for treating intra-op type I ELs produced good results. On the basis of the mid-term results, we should consider neck length and angulation when we expand the instructions for use. Furthermore, while aiming to perfect the intra-op procedure, we should have sufficient data regarding the various types of balloons and other supportive devices and also be skilled in using them in order to avoid intra-op complications such as aortic dissection.

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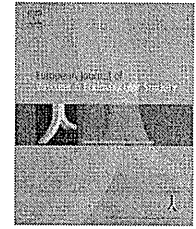
ELSEVIER

A Retrospective Study of Intravascular Ultrasound use in Patients Undergoing Endovascular Aneurysm Repair: Its Usefulness and a Description of the Procedure

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Abstract *Objectives:* To verify the usefulness and limitation of intravascular ultrasound (IVUS) in endovascular aneurysm repair (EVAR).

Methods: A total of 112 consecutive patients, who underwent EVAR to treat abdominal aortic aneurysms, were examined retrospectively. Of these, 33 patients were assigned to the IVUS group because of renal failure, a suspected allergy to contrast agents or anatomical difficulties; the remaining 79 patients were assigned to the non-IVUS group.

Results: Patients in the IVUS group required fewer intra-arterial contrast agents (IACAs) than those in the non-IVUS group (67 ± 34 ml vs. 123 ± 50 ml; $p < 0.01$). Blood loss and operation time were comparable between the two groups. No patients died within 30 days of the operation. Three major renal complications occurred in the non-IVUS group. Renal deterioration evaluated by chronic kidney disease (CKD) stage was found to a greater extent in the non-IVUS group.

Conclusions: IVUS is a powerful auxiliary method in EVAR for reducing the required volume of contrast agents. The combination of IVUS and IACA usage showed good overall performance; thus, we propose the routine use of IVUS in EVAR procedures.
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Introduction

Refinements in endovascular techniques have steadily improved perioperative survival rates among patients undergoing endovascular aneurysm repair (EVAR).[1] EVAR procedures require the use of intra-arterial contrast agents (IACA), which aid in verifying aortic aneurysm morphology and in identifying the ostia of renal and hypogastric arteries. However, IACA are not recommended for use in patients with renal dysfunctions or allergies to contrast agents. Since the 1990s, intravascular ultrasound (IVUS) has been used as an alternative to IACA.[2-4] Originally, IVUS images had low accuracy,[5-7] but recent improvements have resulted in very high-quality images of intra-aortic structures, which makes the use of IACA almost unnecessary.[8] An additional advantage of IVUS is that it facilitates the precise placement of stent grafts, because it is more accurate in locating hypogastric arteries and renal arteries,[2] which have parallax from the anteroposterior (A-P) view rather than from angiography.

We retrospectively studied 112 cases of EVAR performed in patients with non-ruptured infrarenal abdominal aortic aneurysms. The purpose of this study was to examine both the usefulness and limitations of IVUS, and also whether using IVUS in cases of EVAR can reduce the amount of IACA required without lowering the quality of the procedure. Furthermore, we aimed to provide a detailed description of the basic steps of the IVUS procedure to highlight its ease of use.

Patients and Methods

At Morinomiya Hospital (Osaka, Japan), 112 consecutive EVAR procedures were performed on patients with non-ruptured infrarenal abdominal aortic aneurysms (AAA) between January 2008 and November 2008. IVUS (Volcano Visions, PV 8.2F: Volcano Japan Inc., Tokyo, Japan) was used in 33 cases (i.e., the IVUS group) for the following reasons: (1) anatomical difficulties (16 cases; criteria included neck length < 15 mm, peripheral landing length < 10 mm, or overlapping aortic branches, defined as any case where aortic branches could not be clearly separated unless C-arm rotation of more than 45° was used), (2) renal dysfunction (14 cases; defined as serum creatinine level > 1.4 mg dl^{-1}) or (3) allergy to contrast agents (three cases). The remaining 79 patients received an EVAR with IACA-only (i.e., the non-IVUS group). Age, gender, aneurysmal diameter and co-morbid conditions of all patients are shown in Table 1. We also examined the factor of aortic wall condition. Shaggy aorta was defined by the presence of mural thrombus more than 3/4th of the circumflex of the thoracic aorta or the abdominal aneurysmal neck. Three shaggy aortas were observed (two thoracic and one abdominal) in the IVUS group and 21 (eight thoracic and 13 abdominal) in the non-IVUS group. Follow-ups of all cases continued for 12–24 months, postoperatively. No patients experienced severe allergic reactions to the contrast agents.

Two kinds of commercially available devices were used in this study: a Gore Excluder® AAA endoprosthesis (W.L. Gore and Associates, Newark, DE, USA) and a Zenith® endovascular graft (COOK Medical Inc. Bloomington, IN, USA). There were no definite criteria that dictated device selection. In general, we preferred to use the Excluder® for

Table 1	Patients' characteristics.		
	IVUS	Non-IVUS	p-value
Age			
Gender	75.1 ± 8.6	74.4 ± 8.9	N.S.
(Male/Female)			
AAA diameter(mm)	52.8 ± 9.9	51.1 ± 10.9	N.S.
Risks			
Cardiac	5 (15%)	9 (11%)	N.S.
Cerebrovascular	7 (21%)	5 (6%)	0.02
Respiratory	9 (27%)	5 (6%)	<0.01
Renal	14(42%)	2(2%)	<0.01
Device			
Excluder®	24	39	
Zenith®	9	40	

AAA with angulated aortic morphology because of its flexible stent framework. On the other hand, we preferred to use the Zenith® for AAA in cases of short aortic necks because its bare top stent facilitated firmer fixation.

The IVUS procedure steps used are summarised here. First, the bilateral common femoral arteries were exposed and a 9-F sheath introducer – the lowest profile adjusted to the 8.2-F of the outer diameter of the IVUS transducer – was inserted retrograde. A soft guidewire was used to introduce a calibrated pigtail catheter, graduated in centimetres, up to the thoracic aortic arch. The guidewire was then replaced with a stiff wire followed by IVUS insertion. IVUS was used to locate the renal arteries and hypogastric arteries by mapping them on the monitor; then, IVUS was switched to the calibrated catheter to determine the length of the main body. IVUS was introduced using the monorail system. In patients receiving IACA, a 4-F sheath was inserted into the left brachial artery to introduce the 4-F pigtail catheter, which was positioned with its tip near the ostium of the renal artery. After deployment of the main body, the soft guidewire was cannulated into the contralateral limb. The guidewire was replaced with the stiff wire, followed by the IVUS insertion (Fig. 1). The length of the contralateral site was determined by measuring the length from the edge of
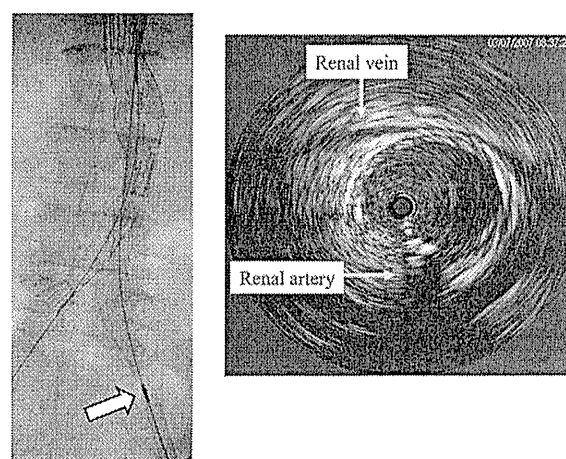

Figure 1 Transducer of the IVUS was detected on the intraoperative fluoroscopy. IVUS image showed the intra-aortic structures.

the main body to the site of the hypogastric ostium. Using the same technique, we estimated the stent graft length with the calibrated catheter. (Fig. 2) Finally, completion angiography was used to check for proper alignment of the stent graft and to confirm that there were no endoleaks.

In procedures without IVUS, IACA are usually required in the following steps: (1) 20 ml of contrast agent from the pigtail catheter for measuring the distance from the renal artery to the ipsilateral iliac bifurcation before main body delivery: (2) 15 ml for accurately measuring proximal non-aneurysmal aortic neck length: (3) 10 ml from the femoral sheath introducer system for taking the contralateral leg measurement: (4) in the same way, 10 ml from the sheath for taking the ipsilateral leg measurement (Zenith® only) in the same fashion as (3): and (5) 20 ml from the pigtail catheter for the completion angiography. When we used the contrast agent according to the procedure mentioned above, patients in the non-IVUS group and IVUS group required at least 65–75 ml and 0–20 ml of IACA, respectively. However, our primary focus was to avoid type I endoleak rather than reduce the amount of IACA used. Consequently, additional IACA was used to perform multiple completion angiographies in some cases.

Renal function was defined using the CKD (chronic kidney disease) staging system (National Kidney Foundation/Kidney Disease Outcomes Quality Initiative — NFK/KDOQI).[9] Severe renal deterioration was defined as more than two down-staging.

Where appropriate, unpaired Student's t-tests were used to make comparisons between treatment groups. Significance was defined as $p < 0.05$.

Results

Patients in the IVUS group received significantly less IACA than patients in the non-IVUS group (67 ± 34 ml vs. 123 ± 50 ml; $p < 0.01$). (Table 1) Furthermore, less IACA (39 ± 14 ml) was required for a subgroup of the IVUS group, consisting of 17 patients with renal dysfunction or a suspected allergy to IACA, for whom we specifically chose to use IVUS to reduce their exposure to IACA.

As shown in Table 1, cerebrovascular disease, and respiratory and renal dysfunctions were more often co-morbid in the IVUS group - this indicates that patients in this group were at higher risk for surgery.

Blood loss (IVUS vs. non-IVUS: 172 ± 135 ml vs. 165 ± 135 ml; $p > 0.05$) and operation time (IVUS vs. non-IVUS: 157 ± 45 min vs. 165 ± 76 min; $p > 0.05$) were comparable between the two treatment groups, indicating that the IVUS procedure did not impose any additional intra-operative surgical stress during the EVAR procedures.

No patients died within 30 days of the operation; there were no IVUS manoeuvre-related complications. Two patients, who had EVAR performed exclusively with IVUS, received re-interventions during the follow-up period. Two patients required dialysis after developing renal failure, and one patient experienced a postoperative increase in creatinine levels (up to 2.9 mg dl^{-1}) — all three of these patients belonged to the non-IVUS group, had normal renal function preoperatively and had shaggy abdominal and/or thoracic aortas. In the IVUS group, no patients with renal

insufficiency experienced deterioration after the procedure. CKD staging was examined in both groups. In the IVUS group, five cases of down-staging (one case decreased by two stages) and four cases of up-staging were found. In the non-IVUS group, 29 cases of down-staging (4 cases decreased 2 stages, and 1 case decreased 3 stages), and 14 cases of up-staging were observed. Renal deterioration was found more frequently in the non-IVUS group (IVUS vs. non-IVUS; 15% vs. 36%, $p = 0.02$). In the subgroup of IVUS that suffered renal dysfunction or contrast allergy (17 cases), there were two cases of down-staging (one case decreased by two stages) and two cases of up-staging (subgroup of IVUS vs. non-IVUS; 11% vs. 36%, $p = 0.04$).

EVAR was performed exclusively with IVUS in seven cases. The average operation time was 134 ± 108 min, during which time 144 ± 59 ml of blood was lost. Although statistical comparisons were not possible, these values were consistently lower than for the patients in the non-IVUS group. There were one intra-operative wire trouble and one postoperative complication observed in this IACA-free group. The intra-operative wire trouble occurred in an 86-year-old patient with a short aneurysmal neck. We had planned to deploy a Palmaz® stent (Cordis Corporation, Bridgewater, NJ, USA) into the stent graft trunk. However, the edge of stent was hooked on the flow divider and did not expand completely. After confirming the patient's peripheral flow, we terminated the procedure. The single postoperative complication occurred in a 63-year-old female patient with renal insufficiency. The patient was re-admitted to our hospital after complaining of pain in her left lower extremity after undergoing EVAR without IACA 16 days earlier. Her ankle—bracheal index (ABI) had dropped from 0.8 to 0.45 and an ultrasound revealed an occlusion in the left stent graft leg. We performed a thrombectomy and found that the stent had developed a kink. We also performed balloon expansion for the kinked site.

Postoperative computed tomography (CT) angiography revealed that the use of IVUS enabled accurate landing of the devices within 5 mm of their targets in all 16 patients in whom we encountered anatomical difficulties. In such cases, we were able to use IVUS in combination with IACA because patients had satisfactory renal functioning. The use of IVUS allowed us to omit several steps of IACA, although we had to use IACA to a greater extent for precise device delivery in anatomically difficult cases. As a result, there were no significant differences in the amount of IACA used in the group requiring IVUS for anatomical reasons (118 ± 43 ml) and in the non-IVUS group (123 ± 50 ml) ($p > 0.05$).

Discussion

The 8.2-F monorail system of IVUS is a simple and less-invasive auxiliary method. Our analyses indicate that there were no significant differences in operation time or blood loss between patients in the IVUS and non-IVUS groups. In addition, IVUS catheter manoeuvres themselves did not cause any major adverse events. Usage of IVUS does not appear to have any contraindications for EVAR procedures, nor does IVUS have any obvious drawbacks. We encourage

the routine use of this technique because of its harmlessness and convenience.

IACA plays two important roles in stent graft delivery: facilitating detection of endoleaks and verifying aortic morphology. Incomplete endovascular exclusion causes increases in intrasac pressure, leading to a high risk of late rupture.[10,11] We confirmed the absence of type I endoleaks by carefully observing any direct leakage into the aneurysmal sac and by confirming any backflow from collateral arteries (e.g., lumbar, inferior mesenteric and sacral medial arteries) towards the sac.[11] We also employed completion angiography to reveal the aortic morphology of the deployed stent graft.

Initially, IVUS was mainly used for determining graft size.[3,4] Commercial stent grafts have been improved since their usage began, and are now made in a variety of sizes adapted to a wide range of intra-operative situations. The resolution in the early days of IVUS imaging was insufficient for detecting aortic branches; one study found that both arteries could only be detected in 63% of EVAR patients.[5] By 2003, IVUS techniques had become so efficient that some claimed that angiography was not necessary.[8] However, among the seven IACA-free cases of EVAR in this study, one developed a leg occlusion 16 days after experiencing intra-operative procedural difficulties. If we had used IACA, the intra-operative procedures would have been easier and the kinking would have been easily detected. Contrast-enhanced ultrasonography could be useful in some cases for detecting endoleaks, although it has some limitations; obesity and bowel gas can interfere with scanning. Furthermore, the examination is operator-dependent and requires specific skills and training.[12] We are considering the combined use of IVUS and contrast-enhanced ultrasound in cases of contraindication regarding contrast agents. Another weakness of IVUS is that it is not useful for independently confirming type I endoleaks, which are the most common cause of postoperative rupture.[11] For these reasons, we conclude that we cannot confirm graft exclusion accuracy without performing completion angiography.

Proximal type I endoleak is sometimes a problem in cases of hostile aneurysmal necks.[13] Precise measurement is critical for maintaining the landing area for as long as possible. Slovut reports that the SOS catheter set in the renal artery can minimise the number of cine runs needed to verify graft positioning during deployment,[14] which results in a comparatively low renal artery occlusion rate (0.6%). To avoid renal artery embolisation and dissection, we did not use wire cannulation or balloon occlusion. In addition, when we used the C-arm, we performed cranial rotation to adjust the renal artery ostium parallax because most infrarenal AAAs tended to meander in the ventral direction. One of the potential benefits of combining IVUS and IACA is the ability to double-check the precise position of the stent graft.

Distal type I endoleaks caused by AAAs accompanied by common iliac artery aneurysms can be very difficult to fix. In such cases, we set the peripheral edge of the leg just above the hypogastric artery ostium so that arterial flow was maintained. A landing zone of at least 1 cm is necessary, and precise placement is sometimes difficult because the ostium of the hypogastric artery is separated from the external iliac artery by the C-arm. In such cases, we usually used IVUS for detecting the ostium site — this can be done without the use of IACA.

Another important use of IVUS is measuring the distance between aortic branches. In many cases of AAA, iliac arteries in the IACA images overlapped with the ostium of the hypogastric artery. To produce images that show a clear separation of the branches, it was necessary to swing the C-arm at exaggerated angles that were difficult for operators to achieve and maintain. Rotation of the C-arm also increases both patients' and operators' exposure to intra-operative radiation. Thus, using IVUS saves time and energy, and creates a safer work environment.

Thus far, no drawbacks of IVUS usage have been identified. We found that both the IVUS and non-IVUS groups had no mortality within the 30-day postoperative period, and that there were no major operation-related complications in the IVUS group, despite its higher co-morbid risk.

We successfully reduced the use of IACA. Furthermore, it is interesting to note that renal deterioration was found more frequently in the non-IVUS group, indicating the beneficial effect of IVUS usage. However, the limitation regarding the renal function is related to the ambiguous and operator-dependent criteria of assigning patients to the IVUS group. Indeed, there was a rough threshold of creatinine level (1.4 mg dl^{-1}). However, this should be evaluated with glomerular filtration rate (GFR) and CKD staging, preoperatively. We should take the causes of renal dysfunction into account when evaluating results. There are assumed to be two causes of renal dysfunction: nephrotoxicity in response to contrast agents and nephropathy due to cholesterol crystal embolisation (CCE) — both can be difficult to distinguish. Contrast agents induce renal vasoconstriction and interfere with water and sodium absorption by the renal tubules, leading to increased vascular resistance and decreased GFR.[15] In cases of chronic renal insufficiency, contrast agents are excreted more slowly, which in turn increases the risk of nephrotoxicity.[16]

Shaggy aorta is thought to be a strong risk factor for CCE.[17] In the present study, all three individuals, who experienced renal deterioration, had shaggy aortas above their renal arteries. Because these patients had previously demonstrated good renal function and belonged to the non-IVUS group, it appears that CCE and the use of contrast agents might have been responsible for these renal failures.

Previously, carbon dioxide (CO_2) angiography was used as an alternative method to IACA in patients with pre-existing renal dysfunction.[18,19] In the present study, we opted to use IVUS for device deployment to reduce the volume of contrast agent required for the procedure. In addition, we used conventional IACA to perform the completion angiography. Although CO_2 angiography is not currently used by many endovascular surgeons, its ability to produce high-quality images and reduce the risk of complications is noteworthy.[18] In addition, some authors report that CO_2 angiography is highly sensitive in pinpointing endoleaks, which is possibly due to the fact that CO_2 fills the sac earlier due to its low viscosity.[19] However, some negative reviews of CO_2 angiography exist. For example, Lee reports that renal arteries are not satisfactorily shown,[18] whereas Chao points out that this technique requires longer fluoroscopy and operating-room times and increases exposure to radiation.[19] Therefore, while it does

not seem that CO_2 angiography could completely replace IACA, it might successfully be combined with IVUS to improve EVAR performance.

In conclusion, IVUS is a powerful auxiliary method in EVAR for reducing the required volume of contrast agent, as well as saving the time and labour required for rotating the C-arm, thereby reducing unnecessary radiation exposure among both patients and operators. The quality and simplicity of IVUS imaging has improved over the past decade — it is both an effective and comparatively stress-free method. However, exclusive use of IVUS carries a risk of complications because it is not possible to evaluate endoleaks and stent alignment. Thus, we recommend the routine use of IVUS during EVAR procedures, but stress that IACA are usually a necessary component of this technique. Furthermore, we suggest that use of these two methods should be determined on a case-by-case basis.

Conflict of Interest/Funding

None.

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therapeutical impact. In all cases both the source of infection and the 'infected aneurysm' itself have to be addressed.

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Comments regarding "A Retrospective Study of Intravascular Ultrasound use in Patients Undergoing Endovascular Aneurysm Repair: Its Usefulness and a Description of the Procedure"

The use of Contrast Enhanced Ultrasound for Intra-procedural EVAR deployment completely eliminates the need for nephrotoxic iodinated intra-arterial contrast.

Dear Editor,

I was delighted to read your retrospective study using Intravascular Ultrasound (IVUS) during EVAR stent-graft deployment[1] and commend you for describing a technique to significantly reduce the intra-arterial contrast used. The availability of EVAR and the number of patients deemed suitable for these procedures is growing immensely. As techniques evolve and become more complex, such as fenestrated and branched grafts, the corresponding procedure times and thus exposure to greater volumes of nephrotoxic iodinated contrast and radiation[2,3] also increases.

I agree that your IVUS technique will help with these matters but will not eliminate them completely. In 2008 Dr Dirk Clevert first described the use of real-time intra-operative microbubble contrast-enhanced ultrasound for EVAR stent deployment and for post-procedural endoleak detection[4] (both immediate and late as part of a surveillance programme). I have visited Munich and witnessed this procedure that requires no intra-arterial contrast but does require the use of much reduced doses of intra-procedural angiographic fluoroscopy. More recently the German group has published their longer experience and refinement of the technique with a series of 17 patients[5] and compared this

group with 20 treated using "conventional EVAR" consisting of iodine contrast media with intra-operative fluoroscopy.

The use of intra-operative microbubble contrast ultrasound for stent deployment completely eliminates to need for any completion angiography or the use of any intra-arterial contrast and significantly reducing the radiation exposure, which IVUS does not appear to match. I look forward to your further work that you allude to regarding the combined use of IVUS and ultrasound contrast, but suggest that this should not be limited to those with a contraindication to iodinated media but can be applied more widely.

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Response to comments regarding "A Retrospective Study Of Intravascular Ultrasound Use In Patients Undergoing Endovascular Aneurysm Repair: Its Usefulness And A Description Of The Procedure."

Dear Editor,

We thank Dr. Dindyal for his comments regarding our paper; we have provided a response regarding the issue that he had raised, mainly regarding the usefulness of contrast-enhanced ultrasonography (CEUS).

We are extremely pleased to obtain his endorsement for our paper, which reports an intravascular ultrasonography (IVUS) technique for reducing the use of contrast agents. We agree that IVUS cannot completely substitute for contrast agents with regard to completion angiography for detecting endoleaks and that CEUS with second-generation contrast agents would be a powerful diagnostic method. The development of CEUS with second-generation agents would be a great boon for patients with renal dysfunction or allergy to contrast agents. Regretfully, in our country, health insurance coverage for CEUS with second-generation contrast agents has only been approved for hepatic diseases; this technique is a more practical one because of the clear images obtained and the durability of echo sound waves. Therefore, we plan to use it in the near future after it is approved.

The complete substitution of conventional contrast agents with CEUS has 2 disadvantages. Firstly, the resonance in ultrasonography (US) may not be adequate for detecting the orifices of the aortic branches.

CEUS appears to be adequate for detecting obvious perigraft leakage and the pooling of endoleaks in the aneurysmal sac. However, it is important to know which branch of the aorta is causing the endoleaks.

In addition, we usually check the route (collateral vessels) of backflow into the sac in order to prepare for future re-intervention.

The resolution of the currently used CEUS technique may not be adequate for detecting the lumbar artery or the median sacral artery, and the artifact of colon gas may impede precise examination. We agree with your recommendation of preoperative simulation with the US device; however, this requires skills and a lot of experience.

Secondly, evaluation of US imaging results is less objective than that of fluoroscopy imaging results, i.e. US imaging can be evaluated by only a small number of technicians. This is not desirable with respect to the training of vascular surgeons in our institute for this technique as well as with respect to the risk-management aspect such as overlooking minor endoleaks.

However, the combination of CEUS and IVUS would a powerful weapon for patients with aneurysms, in cases where there is a contraindication for the use of contrast agents. Our dream is the real-time three-dimensional construction of each US cross section during surgery. If this can be achieved, then CEUS can provide a complete and non-invasive alternative to contrast agents.

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How to Do It

Successful Endovascular Repair in Two Cases of Graft Limb Occlusion After Endovascular Aneurysm Repair for Abdominal Aortic Aneurysms

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Abstract

Among 148 abdominal aortic aneurysm patients who underwent endovascular aneurysm repair at our institution, two cases of graft limb occlusion (GLO) were identified and successfully treated with endovascular repair. Guidewire cannulation against the occluded limb is the most important aspect of the procedure. After a thrombectomy, balloon dilatation is performed followed by stent-graft deployment. Various procedures such as thrombectomy, thrombolysis, and extra-anatomical bypass have been adopted for the treatment of GLO. Our use of endovascular techniques, including overlapping stent grafts, has some benefits, namely, better patency of anatomical route revascularization, decreased risk of ipsilateral shower embolization due to the stent graft's sealing over the irregular remnant thrombus, and easy access to angioplasty for tortured iliac arteries. However, shower embolization during catheter handling or future fabric failure due to friction is the potential complication associated with endovascular techniques. Intravascular repair techniques and stent-graft use should therefore be an early step of the GLO treatment algorithm.

Key words Endovascular aneurysm repair · Graft limb occlusion · Abdominal aortic aneurysm · Stent graft

Introduction

Graft limb occlusion (GLO) is a complication associated with endovascular aneurysm repair (EVAR) of abdominal aortic aneurysms. The culprit thrombus is thought to be caused by kinking of the stent graft or tortuosity of the iliac artery;[1] however, the precise etiology of GLO is still unclear. Although it is not a rare complication, optimal therapeutic strategies are largely unknown. In cases of acute occlusion, a thrombectomy would be the easiest and most effective treatment strategy. However, in cases of chronic occlusion, other methods such as thrombolytic therapy or extra-anatomical bypass are often adopted[2] because thrombectomy of a hardened thrombus has an increased potential of failure. Bare stent coverage is another treatment option,[3] although this procedure might result in shower embolization of the remnant thrombus.

We herein report two successful cases of chronic GLO treated by endovascular technique. We passed a guidewire through the hard thrombus using various methods. Thereafter, balloon dilatation and stent-graft leg deployment were performed.

Case Reports

Case 1

A 77-year-old man who had undergone EVAR for an abdominal aortic aneurysm in December 2006 complained of coldness and intermittent claudication in the lower right extremity. He had also undergone graft replacement for a right common iliac artery aneurysm 10 years before. The symptoms appeared in January 2008, when he underwent treatment for brain infarction at another hospital, and GLO was diagnosed 3 months later. On physical examination, the patient suffered mild coldness and no pain in the lower right extremity. The ankle-brachial index (ABI) at this time was lower (0.5) than the ABI in the preoperative data (0.8). Computed tomography (CT) angiography performed after the EVAR procedure revealed no severe tortuosity of the right graft limb (Fig. 1), while the most recent CT displayed right GLO from the flow divider at the bifurcation of the aortic endograft (Fig. 2). The cause of the

occlusion was unclear from a hemodynamic perspective. A repair operation was performed in May 2008.

An open puncture of the right common femoral artery was performed and a 6-F sheath was inserted. We utilized both angled and straight 0.035-inch guidewires in order to pass through the thrombus. After the can-
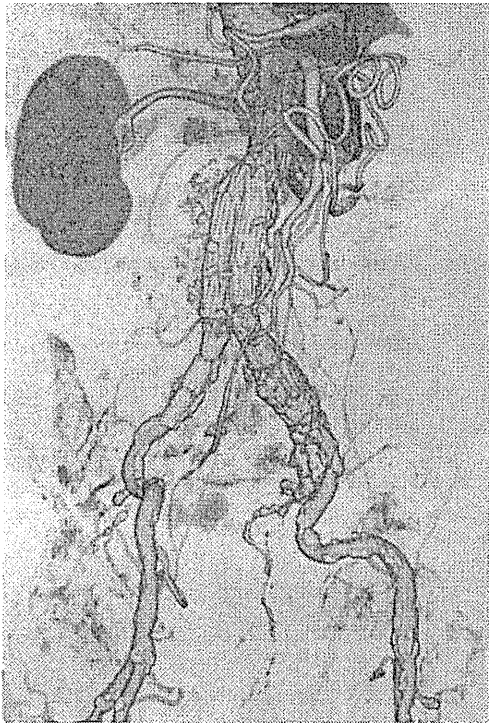

Fig. 1. Preoperative three-dimensional computed tomography (3D-CT) scan revealed no evidence of severe tortuosity of the right graft limb

nulation, the puncture site was cut and extended under hemorrhage control with a vascular clamp. A thrombectomy was performed with a Fogarty thru-lumen catheter (Edwards Lifesciences, Irvine, CA, USA), and a large thrombus was removed. However, intra-arterial contrast agent revealed the irregular shape of the inner lumen of the graft leg. After balloon dilatation with an ATB Balloon Catheter (Cook Medical, Bloomington, IN, USA), a 12-F sheath was carefully inserted. The stent-graft leg (the contralateral leg of the Gore iliac extender [Gore Medical, Flagstaff, AZ, USA]) was overlapped from the flow divider to the external iliac artery where the irregular internal lumen persisted. A balloon catheter was used for touching up the stent graft. After the procedure, the pedal pulse was palpable, and a CT scan revealed patent blood flow with no endoleak (Fig. 3).

Case 2

A 63-year-old woman underwent EVAR for an infrarenal abdominal aortic aneurysm with a Zenith endovascular graft (Cook Medical) in July 2008. A preoperative MR scan had shown severe tortuosity at the terminal aorta (Fig. 4). The procedure was performed with intravascular ultrasound (IVUS) guidance because of renal dysfunction, as her creatinine (Cr) level was over 3 mg/dl. An X-ray revealed kinking of the left stent-graft leg, but the left femoral artery pulse was palpable. Sixteen days after the operation, she was readmitted to our hospital complaining of coldness and pain in the lower left extremity. Her ABI dropped from 0.80 immediately after the operation to 0.45 when she was readmitted. A physical examination revealed coldness of the foot, a weak right femoral artery pulse, and inter-
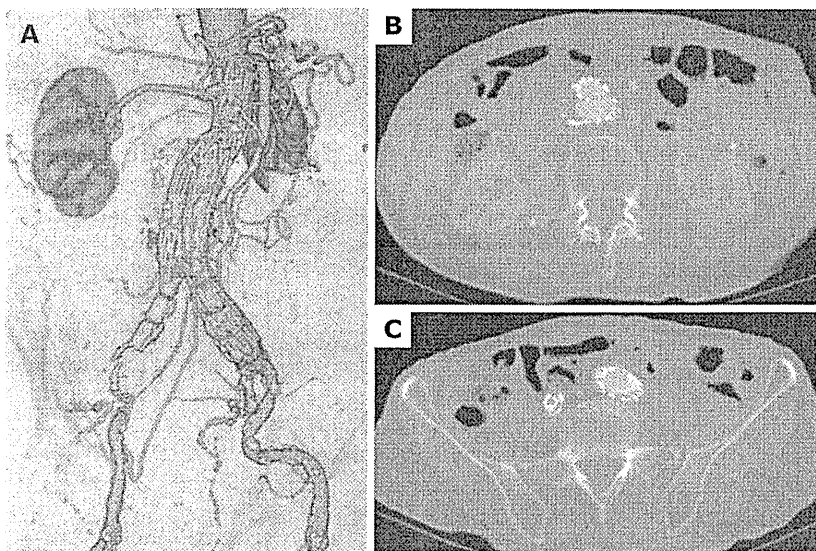

Fig. 2. The most recent CT revealed right graft limb occlusion (A) from the flow divider at the bifurcation of the aortic endograft (B) to the external iliac artery (C)

mittent claudication after walking 10 m. An ultrasound scan showed severe stenosis of the left leg. The symptoms did not worsen, and the repair operation was performed two months after the EVAR.
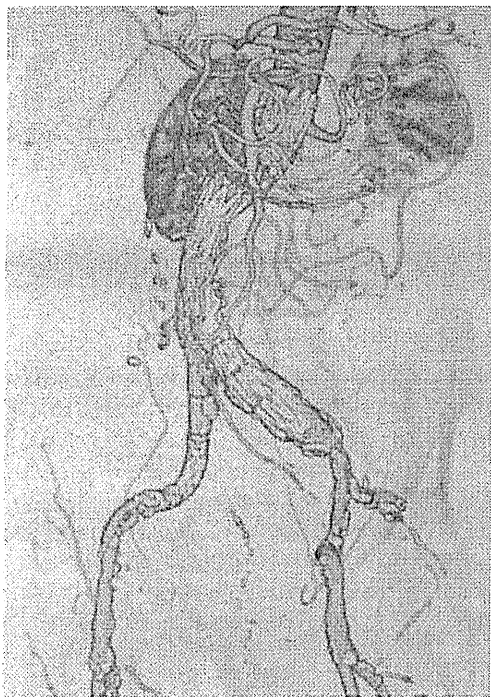

Fig. 3. Postoperative 3D-CT demonstrated patent blood flow of the right graft limb

The procedure was performed with IVUS guidance. The guidewire passed easily through the occluded lumen. A 4-F guiding catheter also passed over the flow divider along the guidewire. After confirming no blood pressure gradation between the radial artery and the level of the flow divider, a thrombectomy was performed with a Fogarty thru-lumen catheter. Balloon angioplasty was also performed to correct the kinking (Fig. 4). A Gore iliac extender was used to overlap the left leg. After the procedure, the ABI improved to 0.85. There was no indication of any endoleaks on an ultrasound scan. An X-ray revealed that the previous kinked stent graft was straightened.

Discussion

Graft limb occlusion after EVAR is a relatively common complication. We confirmed GLO in 2 of 148 cases (1.3%), which is slightly less than the rates reported in other studies,[1,2,4] possibly because we have the benefit of recent technological improvements. Maleux et al. reported nine GLO cases, among which three were treated with thrombolysis or stent insertion, five were treated with operation, and two were monitored.[4] According to the algorithm of the Trans Atlantic Inter-Society Consensus (TASC) 2, a thrombectomy is the first option for acute thrombosis.[5] However, as a thrombus in a stent graft lacks plasticity, it is difficult to remove completely and additional treatment is often necessary. An extra-anatomical bypass procedure, such
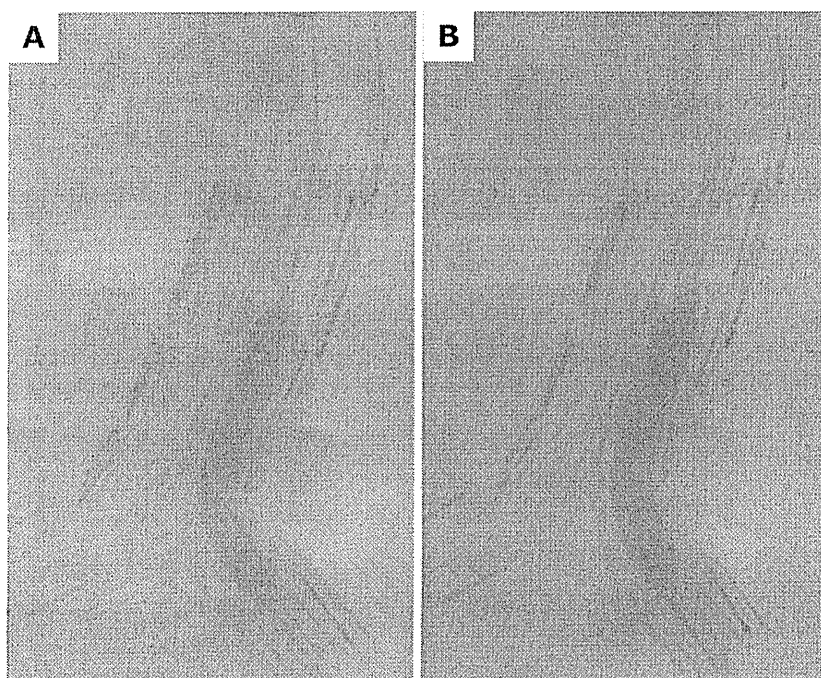

Fig. 4. A Intraoperative angiography revealed kinking of the stent-graft leg. B Balloon angioplasty was subsequently performed

as a femorofemoral bypass graft, would be the second option. However, this procedure is controversial because the patency is relatively low.[5] We chose to employ intravascular techniques for the treatment of GLO in order to achieve better patency by revascularization of the anatomical route. Furthermore, this procedure is less stressful for patients than open surgery,[3] and the ballooning of the stent graft can crush the remnant thrombus.[6] Finally, stent grafts can straighten tortuous iliac arteries. The use of bare stents can also bring about the same results,[3] but it may also cause shower embolization to the ipsilateral site from the crevice.

Shower embolization to the contralateral site during catheter handling is a possible complication of the procedure we utilized. We carefully observed the contralateral femoral pulse during operations in order to avoid embolization. The risk of future fabric failure by reinforcement of the stent has also been suggested as a possible complication.[1] However, using the same material for the stent-graft leg may minimize friction. The narrowing of the internal lumen is another potential problem of stent graft overlapping. Overlapping more than three times may cause reocclusion of the vessel. Touching-up with a noncompliant balloon may be necessary to create enough pressure on the overlapped site.

Cannulation of the occluded site is very important for the success of the procedure. We have found that guidewire cannulation is often possible within 2 or 3 months after limb occlusion. In Case 1, the thrombectomy was successful even after several months had passed. Various types of guidewire should be employed in order to pass through the thrombus. We usually initially use an angled Radifocus Glidewire (Terumo Medical, Shizuoka, Japan) and then carefully change to a straight guidewire to avoid arterial wall dissection. For better control of the guidewire, a thick, hard guiding catheter should be advanced around the thrombus edge.

Upon successful cannulation, a thrombectomy is usually possible. If the balloon catheter passes through the thrombus, a sheath thick enough to introduce the stent graft should be inserted. An additional stent-graft leg is subsequently deployed, and ballooning for touching up and angioplasty should be performed. Regarding the type of stent graft, we think that the structure and arrangement of the Gore Excluder endograft (Gore

Medical) might be more tolerable than that of the Zenith endograft in regard of vascular tortuosity.

Regarding the possible causes of GLO, Carroccio et al. suggested that the condition was due to device kinking, migration, or device elongation to the external iliac artery.[1] In Case 2, kinking of the left leg was shown in the X-ray. This kinking should have been corrected during the initial operation. The kinking was manipulated and dilated using balloon angioplasty during the subsequent operation. If either kinking or a tortured iliac artery is noted, balloon angioplasty should be performed in order to prevent future GLO. Furthermore, a completion angiogram with the least amount of contrast medium should be performed to ensure the success of the procedure. However, the patient in Case 1 was not at risk for GLO from a hemodynamic point of view. It was assumed that GLO occurred concurrently with the patient's brain infarction. Hemoconcentration frequently occurs in such situations, and might have caused the GLO in Case 1.

The present study indicated that intravascular repair techniques and the use of stent grafts should be an early step of the GLO treatment algorithm. However, careful follow-up for these cases is necessary, because the subsequent vascular patency has only been proved for up to 12 months.

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