Usefulness of Transesophageal Echocardiographic Monitoring in Transluminal Endovascular Stent-Graft Repair for Thoracic Aortic Aneurysm

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The endovascular stent-graft has been devised for the treatment of thoracic aortic aneurysm (TAA) to reduce complications associated with conventional surgical repair. The present study assessed the usefulness of transesophageal echocardiography (TEE) for intra- and post-operative examinations in patients treated with transluminal endovascular stent-graft repair for TAA. Nine patients with TAA and 2 with chronic type B aortic dissection were studied. Immediately after stent-graft deployment, perigraft leakage was evaluated with both intraoperative TEE and aortography. In 9 of 11 patients, TEE and aortography immediately after stent-graft deployment revealed the same perigraft leakage results. TEE might therefore be useful for evaluating perigraft leakage and thrombus formation after stent-graft repair for TAA and could be an alternative to aortography, especially for patients with renal dysfunction who have the possibility of contrast agent-induced complications. (*Jpn Circ J* 2000; 64: 960–964)

Key Words: Endovascular stent-graft; Thoracic aortic aneurysm; Transesophageal echocardiography

The traditional treatment for thoracic aortic aneurysm (TAA) is surgical replacement using a graft, but the management of such aneurysms is challenging because of the frequency of coexistent cardiovascular diseases, and the considerable morbidity and mortality associated with conventional open repair via a left thoracotomy. In 1994, Dake et al devised the less invasive treatment of endoluminal repair to reduce complications associated with conventional surgical repair and reported that endovascular stent-graft repair was safe in carefully selected patients with descending TAA¹.

Aortography is the standard modality to assess the integrity of the proximal and distal implant sites intraoperatively, and for confirming the absence or presence of perigraft leakage². Intraoperative transesophageal echocardiography (TEE) has been widely used in cardiovascular surgery and although it has also been used intraoperatively in endovascular stent-graft repair of TAA^{1,3,4} there is not a detailed description of the usefulness of intraoperative TEE.

In this study, we performed intra- and post-operative TEE, assessed the clinical usefulness of TEE in endovascular stent-graft repair for patients with descending TAA, and compared the findings with those from aortography.

Methods

Patients

From May to November 1998, 11 patients (10 men and 1 woman) had transluminal endovascular stent-grafting performed for 9 distal arch descending TAA and 2 chronic aortic dissections (Stanford type B). The average age of the patients was 68 years old (range, 51–81; Table 1). Three of the 11 patients had chronic renal insufficiencies and 2 of these had been treated with maintenance hemodialysis.

Procedures for Transluminal Endovascular Stent-Graft Repair

All procedures, including intraoperative aortography and TEE, were performed under general anesthesia with endotracheal intubation and mechanical ventilation. A portable radiographic image intensifier was used for intraoperative aortography. The external iliac artery was surgically isolated and a transverse arteriotomy was performed. A right brachial artery puncture was performed for the passage of a long guidewire directed via the exposed external iliac artery and then brought out via the arteriotomy site. After systemic heparinization, a 20–24 French (Fr) delivery sheath and a dilator were passed over the wire through the open iliac arteriotomy and placed proximal to the aneurysm. The dilator was removed, a 5 Fr pigtail catheter was placed in the ascending aorta, and aortography was performed to observe the position of the delivery sheath. A compressed woven, Dacron-covered, self-expanding stent-graft was then placed into the sheath using a pusher and under fluoroscopic guidance, the self-expandable stent-graft was then deployed by manipulating the pusher.

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Table 1 Detection of Perigraft Leakage With TEE or Aortography: Intra-Operative and Follow-up Examinations

Patient no.	Age (years) /sex	Type of aneurysm	Intra-operative imaging		Follow-up	
			TEE	AG	TEE	AG
1	60/M	AoD	—	—	—	—
2	76/M	TAA (ARCH)	1+	+	—	—
3	68/M	TAA (ARCH)	—	—	—	—
4	81/M	TAA (ARCH)	1+	+	—	—
5	59/M	TAA (ARCH)	2+	+	1+	—
6	64/M	AoD	—	—	—	—
7	71/F	TAA (D.Ao)	1+	+	—	—
8	72/M	TAA (ARCH)	3+	+	—	—
9	71/M	TAA (ARCH)	—	+	—	—
10	51/M	TAA (ARCH)	2+	+	—	—
11	73/M	TAA (D.Ao)	1+	—	—	—

AoD, aortic dissection; TAA, thoracic aortic aneurysm; ARCH, aortic arch; D.Ao, descending aorta; TEE, transesophageal echocardiography; AG, aortography.

Fig 1. Transesophageal echocardiography (TEE) could visualize both the proximal and distal aortic landing zones of the stent-graft (arrowheads: edge of the stent-graft, case 8 in Table 1).

Transesophageal Echocardiography (TEE)

TEE was performed with a 5-MHz multiplane transducer (Aloka SSD-2200 or Hewlett Packard SONOS-5500). Before placement of the stent-graft, the shape and size of the aneurysm was estimated with TEE, and immediately after placement of the stent-grafts, we examined the proximal and the distal aortic landing zones of the stent-grafts (Fig 1), the existence of perigraft leakage (defined as residual flow in the aneurysm surrounding the endovascular stent-graft; Fig 2), and the relation to the arch vessels. The perigraft leakage was visually graded by 2 experts as follows: 1+ (color flow mapping, which reflected perigraft leakage, extended over less than one-third of the area of the extra stent-graft aneurysm), 2+ (color flow mapping extended over one-third to two-thirds of the extra stent-graft aneurysm), or 3+ (color flow mapping extended over more than two-thirds of the extra stent-graft aneurysm). In 5 of the patients, follow-up TEE and aortography were undertaken 2 weeks to 4 months after stenting. All echocardiographic images were continuously recorded on videotapes for review.

The study was approved by the Yamaguchi University Hospital Institutional Review Board.

Results

Immediately After Stent-Graft Implantation

TEE could visualize both ends of the implanted stent-grafts in all patients. Comparisons of perigraft leakage detection between aortography and TEE are summarized in

Table 1. TEE and aortography showed identical leakage detection results in 9 of the 11 patients. One patient (case 9) showed no leakage with TEE, but aortography showed a little leakage. In another patient (case 11), TEE initially detected a small mid-graft leakage, whereas angiography showed a negative finding, but then thrombus formation in the aneurysm and disappearance of the leakage were observed during the following 20–30 min (Fig 3). In another case that had a small leakage after stenting, TEE showed spontaneous echo contrast in the aneurysm surrounding the endovascular stent-graft. During additional procedures for stenting, the spontaneous echo contrast disappeared with the increase in perigraft leakage caused by dislodgement of the stent-graft (Fig 4), suggesting that the appearance of spontaneous echo contrast might reflect a lesser degree of perigraft leakage. In 9 of the 11 patients, TEE could clearly visualize the left subclavian artery even after stent-graft implantation.

Follow-up TEE in the Chronic Phase

We performed follow-up TEE in 5 patients within 2 weeks and within 4 months after surgery (Table 1). In 3 patients who had perigraft leakage on intraoperative TEE, 2 no longer had leakage, and complete or incomplete thrombus formation was observed in the aneurysms (cases 7 and 8 as shown in Fig 5). Neither of these 2 patients showed perigraft leakage on angiography. The other patient was followed only with TEE, without angiography, because of renal insufficiency (case 5). Although there was some residual perigraft leakage 3 months after stenting, progression of thrombus

Fig 2. Perigraft leakage (arrows) from the proximal end of the stent-graft (case 5 in Table 1). (a) Longitudinal view, (b) transverse view (arrowheads indicate stent-graft).

Fig 3. (a) Mid-graft leakage (arrow) was observed immediately after stenting (case 11 in Table 1). (b) The leakage disappeared 20–30 min after stenting, followed by thrombus formation in the aneurysm.

Fig 4. (a) After the first stenting, spontaneous echo contrast was observed with transesophageal echocardiography (open arrow: spontaneous echo contrast) in the aneurysm surrounding the stent-graft (case 10 in Table 1). (b) After the second stenting, the spontaneous echo contrast completely disappeared in an aortogram with an increase in perigraft leakage caused by the dislodgement of stent-graft. Arrowheads in lower panel indicate stent-grafts.

Fig 5. (a) Immediately after stenting, TEE revealed perigraft leakage (case 7 in Table 1). (b) Two weeks later, the leakage disappeared and thrombus formation in the aneurysm was observed.

formation in the aneurysm was revealed with TEE. No patients showed new perigraft leakage on follow-up TEE.

Discussion

We evaluated the clinical usefulness of TEE in intraoperative and follow-up examinations of stent-graft repairs for TAA. We found a high degree of agreement (82%) in detection of perigraft leakage between TEE and aortography immediately after stent-graft implantation. In follow-up examinations, TEE was useful for confirming leakage disappearance and observing thrombus formation in aneurysms surrounding the stent-grafts.

Aortography is the standard imaging modality used for intraoperative assessment of perigraft leakage after stenting for making the decision on the need for additional stent-grafts to obtain complete exclusion of the aneurysm from circulation.² However, aortography is invasive and is thought to be unsuitable for routine postoperative follow-up examinations of stent-grafts. Computed tomography (CT) and magnetic resonance imaging (MRI) are noninvasive techniques that would be useful for preoperative and/or postoperative assessment of endovascular aortic stent-graft placement;^{5,6} they too have some limitations in postoperative follow-up studies after successful stent-graft placement. For example, the metallic artifact produced from the stent will hamper precise examination of the stented regions and another disadvantage of these modalities, as with aortography, is the requirement for a contrast agent. Because contrast agents may cause deterioration of renal function, they should be avoided in patients with renal dysfunction.

However, TEE is a feasible modality for visualization of the aortic arch and the thoracic descending aorta. It has been reported that TEE is useful for assessment of aortic aneurysm, aortic dissection and atherosclerotic lesions in the thoracic aorta.⁷⁻⁹ The present study is the first to show that TEE is also useful in intraoperative and postoperative diagnosis of perigraft leakage, or of thrombus formation, after stent-graft repair for TAA. We also showed that TEE can detect spontaneous echo contrast in an aneurysm, which is suggestive of stagnation of blood flow in the aneurysm. In one case, we observed that spontaneous echo contrast quickly disappeared with an increase in leakage, suggesting that spontaneous echo contrast in the aneurysm indicates a mild leakage, and that thrombus formation in the aneurysm

can be expected without an additional stent-graft even if some leakage exists. Another advantage of TEE is in evaluating the pathology of the aorta and measuring the distance from the landing zone to the major aortic branches. Also, TEE does not require a contrast agent, one of its advantages over angiography and CT. Most patients with aortic aneurysm or dissection are elderly, and often have coexistent underlying diseases such as renal insufficiency. For such cases, TEE would be more suitable for postoperative follow-up examinations of stent-grafts.

Recently, the use of intravascular ultrasound devices (IVUS) has rapidly advanced and these can provide high-quality imaging of medial and large arteries. There are some reports of IVUS being used for the evaluation of aortic dissection in humans,^{10,11} and a report describing IVUS for stent placement in canines.¹² Although IVUS can detect thrombus formation and spontaneous echo contrast in aneurysms or the false lumen surrounding stent-grafts, artifacts from stent-struts and grafts may affect image quality. Further, because we cannot obtain blood flow information with IVUS, they are not suitable for the assessment of perigraft leakage.

Some limitations of TEE must be considered.

(1) Complete evaluation along the stent-graft by TEE is time-consuming compared with aortography.

(2) TEE cannot be offered to patients with contraindications to TEE, such as esophageal disorders (tumor, varices, diverticulum, etc).

(3) With TEE, the far-field image will sometimes be somewhat poor, caused by the artifacts of the stent-grafts. In case 9, poor detection of perigraft leakage with TEE in spite of finding a small leakage with aortography may be attributed to stent-graft artifact.

(4) Furthermore, when TEE visualizes perigraft leakage immediately after stenting, there are still no quantitative indices for predicting thrombus formation in the aneurysm.

(5) In cases where TEE cannot well visualize the aortic arch, or the extent of the stent-graft implantation to the abdominal aorta, observation of the whole stent-graft is difficult.

In the present study, TEE could not show relevance between the degrees of perigraft leakage and the outcomes in follow-up studies partly because of the small number of cases. A more detailed study is necessary to reveal the degree of perigraft leakage that needs to be carefully followed up

or requires re-operation.

In conclusion, TEE is useful for evaluating perigraft leakage and thrombus formation after stent-graft repair for TAA. Moreover, as TEE can clearly visualize aneurysms and stent-graft delivery systems, it may be useful for deciding the position of the stent-graft during operation.

We would choose TEE as the modality for evaluating the pathology of the stent-graft site, and believe that TEE should be the first-choice modality for follow-up evaluation of stent-graft repairs for TAA in patients with renal dysfunction.

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