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Case Report

Advantages of Transesophageal Echocardiography during Stent Grafting for Aortic Dissection: A Report of Three Cases

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We report the cases of three patients who underwent thoracic endovascular aortic repair for type B aortic dissection in which transesophageal echocardiography (TEE) was used to guide the procedure in addition to fluoroscopy. TEE was found to be advantageous because it can visualize vascular structures along with the guidewire and devices. Furthermore, it provides real-time hemodynamic and hematological information without the need for contrast injection or radiation exposure. Although TEE assessment requires expertise, the efficient use of TEE appears to be helpful for further improving the outcomes of endovascular surgery for aortic dissection.

Keywords: aortic dissection, stent graft, transesophageal echocardiography

Introduction

Thoracic endovascular aortic repair (TEVAR) has recently been used to treat aortic dissections as well as aortic aneurysms and has yielded fairly good results; however, various complications have been reported.[1–4] Although TEVAR is commonly performed under fluoroscopic guidance, we have applied transesophageal echocardiography (TEE) to TEVAR for aortic dissection based on our experience in aortic surgery, including open-stent grafting.[5,6] To the best of our knowledge, there have been only two previous reports on this topic: navigation of a guidewire to the true lumen[7] and TEE assessment of re-entry closure.[8] We report three recent cases with type B aortic dissection, focusing on the advantages of TEE.

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Case Report

Patient 1 had experienced chest pain at 1 year after the onset of aortic dissection and underwent two-debranched TEVAR. Angiography as well as TEE revealed an entry flow below the left subclavian artery (LSCA) (**Fig. 1G**). The flow in the false lumen was stagnant in the former, whereas there was no flow signal in the false lumen of the distal aorta, which was filled with spontaneous echo contrast (SEC) in the latter. An Amplatzer vascular plug (AVP, Abbott Vascular, Santa Clara, CA, USA) was placed in the LSCA, and an acceptable AVP position without protrusion into the aorta or occlusion of the left vertebral artery was confirmed (**Fig. 1A**). Although a guidewire inserted from the femoral artery was observed in the true lumen of the descending aorta, it also entered the false lumen through the entry (**Fig. 1B**); however, this could not be recognized on fluoroscopy. To minimize manipulation in the false lumen, the guidewire was advanced to the aortic arch under dual guidance by TEE and fluoroscopy.

After two Zenith TX2 TAA Endovascular Grafts (Cook, Bjæverskov, Denmark) were distally deployed to accommodate the dimensional difference of the true lumen between the proximal and distal portions, another TX2 graft was placed to close the entry. However, TEE revealed an endoleak (**Fig. 1C**) that was confirmed by angiography (**Fig. 1H**). As TEE revealed that the endoleak flow was through the gap between adjacent stents, indicating a wrinkle in the graft, and the patient had a history of dissection for more than 1 year, we decided to touch up the stent graft with a Tri-lobe balloon catheter (Gore & Associates, Newark, NY, USA). After this procedure, the leak flow disappeared (**Fig. 1I**), and this was confirmed by both angiography and TEE. TEE revealed no retrograde aortic

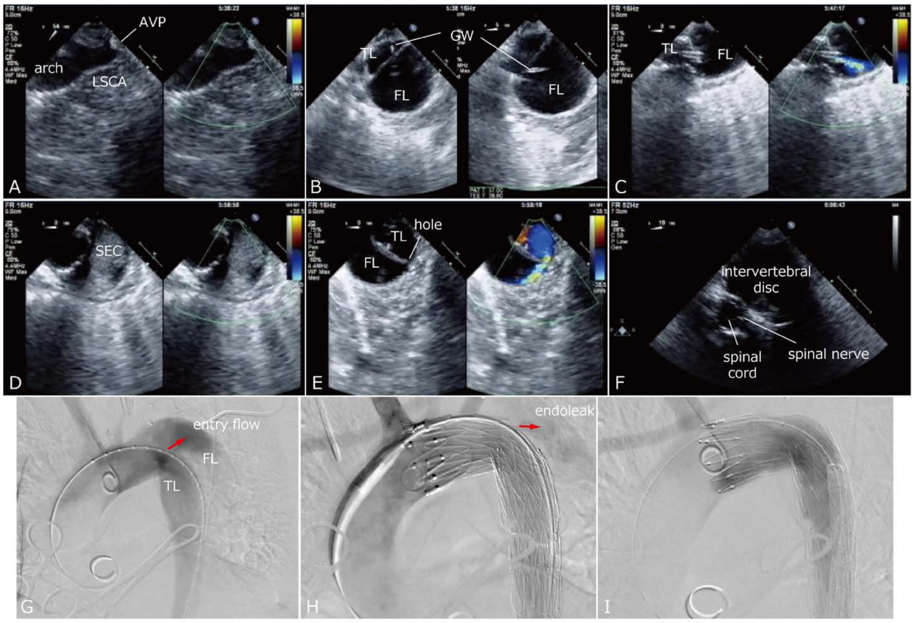

Fig. 1 Transesophageal echocardiographic (TEE) and angiographic findings in case 1.
A: An Amplatzer vascular plug (AVP) is depicted together with the left subclavian artery (LSCA). **B**: A guidewire (GW) in the true and false lumens (TL and FL) is apparent. **C**: Endoleak through the gap between the adjacent stents. **D**: Spontaneous echo contrast (SEC) immediately following entry closure. **E**: Flow through a hole. **F**: Spinal cord and spinal nerve with pulsating movement. An entry flow was markedly reduced but with endoleak revealed in angiography (**G** to **H**: red arrows), corresponding to **C**, disappeared following touch-up procedures (**I**).

dissection or aortic rupture. The false lumen was filled with SEC in its proximal portion (**Fig. 1D**) but was distally echo-free owing to the flow through a small hole in the descending aorta that had been created by avulsion of an intercostal artery (**Fig. 1E**). With angiography, the false lumen was opacified at the corresponding level. In addition, the spinal cord around the Th8 level was visualized by TEE through the intervertebral disc. Preserved spinal cord perfusion was shown by the pulsatile movement of a spinal nerve after deployment of the stent graft (**Fig. 1F**). The patient had no paraplegia, and postoperative computed tomography (CT) findings were compatible with the intraoperative TEE findings.

Patient 2 presented with an ischemic limb and incontinence of the rectum and bladder due to a narrowed true lumen. He underwent one-debranched TEVAR at 3 months after the onset of dissection. As a guidewire was proximally advanced through the vascular graft anastomosed to the left axillary artery, where dissection had already been present, TEE revealed that it was in the false lumen in the LSCA, indicated by the loss of mobilization and blood flow around it (**Fig. 2A**). Another guidewire was inserted from the brachial artery (**Fig. 2G**); it was confirmed to be in the true lumen by TEE (free mobilization in the flow signal), and an AVP was placed.

TEE revealed an intense entry flow (**Fig. 2B**) and a flow into the false lumen through a small hole at a level just distal to the left lower pulmonary vein (**Fig. 2C**): the former was apparent but the latter was not detectable in angiography (**Fig. 2H**). The false lumen was echo-free above this level but was filled with SEC in the distal aorta. Although the true lumen in the abdominal aorta was narrow, TEE revealed an adequate pulsatile flow in the celiac and superior mesenteric arteries. After TEE confirmed that the guidewire was in the true lumen, a Zenith TX2 TAA Endovascular Graft was advanced to cover the entry. Angiography revealed successful entry closure (**Fig. 2I**). Although SEC appeared around the closed entry, TEE revealed a residual flow via the distal hole, making the surrounding area echo-free (**Fig. 2D**). A flow signal was observed in the avulsed intercostal artery adjacent to the aorta; however, there was no type 2 endoleak (**Fig. 2E**). We decided to wait and observe before making any further interventions as the residual flow was mild and not apparent by angiography and the touch-up procedure in the subacute phase was hesitated. The residual flow became undetectable but the trivial entry flow reappeared (**Fig. 2F**), which slightly stirred the SEC. However, both residual and entry flows finally disappeared. TEE confirmed that there was no retrograde dissection, and pulsating movement of the spinal nerve persisted. Postoperative CT revealed a trivial endoleak at the level corresponding to **Fig. 2D** without

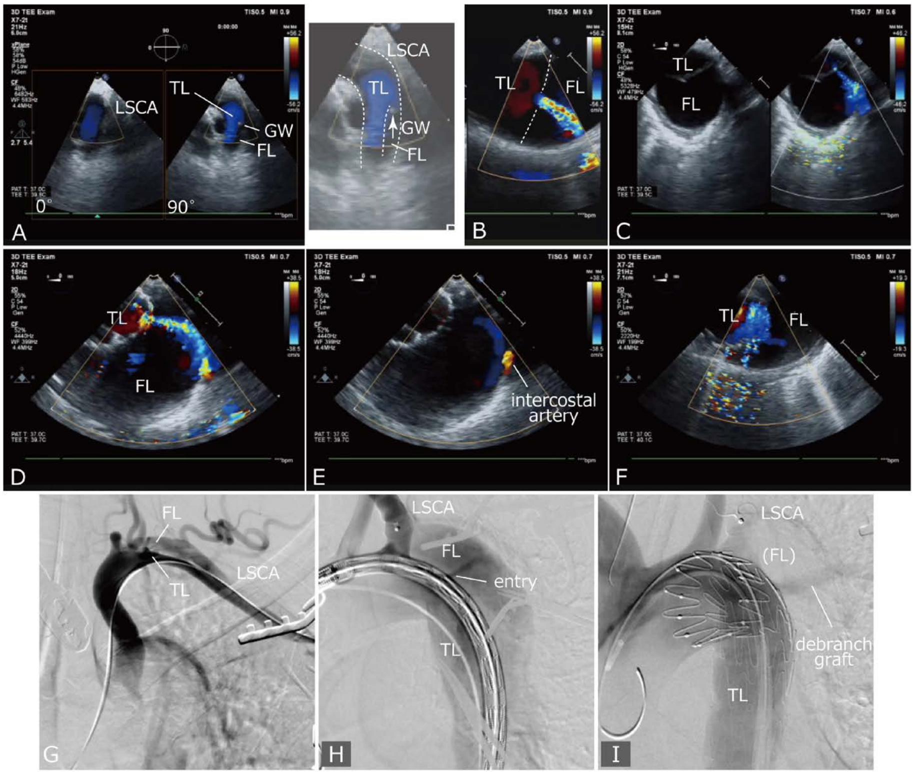

Fig. 2 Transesophageal echocardiography (TEE) and angiographic findings in case 2.
A: A guidewire (GW) in the false lumen (FL) of the left subclavian artery (LSCA). **B**: Intense entry flow. **C**: Mild flow through a small hole in the flap. **D**: Slightly augmented flow through the hole following stent graft placement. **E**: Flow in the avulsed intercostal artery without type 2 endoleak. **F**: Transient endoleak at the entry, which gradually disappeared. **G**: Dissection revealed in angiography with the catheter in the true lumen (TL). An entry flow disappeared following stent graft placement (**H** to **I**).

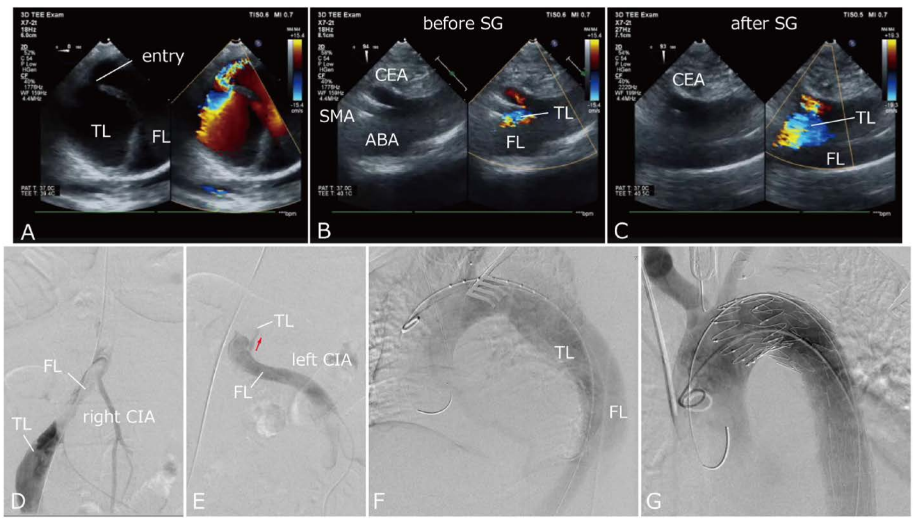

Fig. 3 Transesophageal echocardiography (TEE) and angiographic findings in case 3.
A: Intense entry flow. **B**: Hypoperfusion in the celiac and superior mesenteric arteries (CEA, SMA) through the narrow true lumen (TL) in the abdominal aorta (ABA). **C**: Restored visceral flow and TL following stent graft (SG) placement. **D**: The right common iliac artery (CIA) was obstructed by an expanded false lumen (FL). **E**: The catheter inserted from the left femoral artery entered the FL in the left CIA with a small hole to the TL. Opacification of FL in the aorta (**F**) disappeared following SG placement (**G**).

any findings of a type 2 endoleak.

Patient 3 developed leg ischemia and renal dysfunction on the 5th day after the onset of dissection due to a compressed true lumen in the abdominal aorta. He underwent one-debranched TEVAR in the acute phase. TEE revealed an intense entry flow through a large tear (**Fig. 3A**) and a flow into the false lumen at multiple holes in the intimal flap created by avulsion of the intercostal arteries. The true lumen in the abdominal aorta was compressed, and the flap nearly obstructed the orifice of the celiac and superior mesenteric arteries, resulting in visceral malperfusion with weak and delayed blood flow (aortic type: **Fig. 3B**).

Angiography revealed that the right common iliac artery was obstructed and the catheter inserted from the left femoral artery entered the false lumen (**Figs. 3D** and **3E**). A guidewire was carefully advanced via the compressed true lumen, which was confirmed by TEE at the level of the thoracic descending aorta, and a Zenith TX2 TAA Endovascular Graft was placed. Successful entry closure was confirmed by angiography (**Figs. 3F** and **3G**), whereas TEE revealed that SEC immediately filled the false lumen without a type 2 endoleak from the avulsed intercostal artery. In addition, Zenith TX2 dissection endovascular stents were placed, and the true lumen in the aorta as well as blood flow in the visceral arteries were restored without any delay (**Fig. 3C**). However, the flow through the holes of the flap became apparent, probably because the flap was extended by the dissection endovascular stent, and SEC in the false lumen of the thoracoabdominal aorta disappeared. Pulsatile movement of the spinal nerve persisted. The restored true lumen was shown in the postoperative CT.

Discussion

As TEE has been routinely used in cardiovascular surgery as one of the optimal surgical strategies, its application has been recently extended to every TEVAR case for treating aortic aneurysms. TEE can visualize the morphology and evaluate the perfusion status of nearly the entire portion of the aorta and its branches, from the ascending aorta to the renal artery level. Since last year, we have applied TEE to TEVAR for aortic dissection based on such experiences.

Our experience with three type B aortic dissection cases has demonstrated the unique features of TEE and the useful information that it can provide for TEVAR. In contrast to fluoroscopy, TEE can visualize vascular structures together with the guidewire and devices. Furthermore, hemodynamic as well as hematological information, such as perfusion, stagnation (SEC), and thrombus formation, are provided by TEE without contrast media injection or radiation exposure. However, a drawback of TEE is the limited area of visualization and need for operator expertise, indicating that TEE is not necessarily feasible in every institute.

TEE readily confirms successful entry closure by disappearance of the flow signal and appearance of SEC in the false lumen. TEE can accurately locate and detect an endoleak because it visualizes even a trivial flow, whereas angiography necessitates contrast injection and cannot recognize a trivial flow. Furthermore, TEE assessment can be performed in seconds, whereas angiography requires repeated injections of contrast media. As shown in **Fig. 1C**, the origin of the endoleak could be accurately identified. The leak flow originated at the gap between the adjacent stents. Such information is helpful for making decisions whether or not to perform a touch-up procedure, which is hesitated in aortic dissection cases.

The holes in the intimal flap generated by avulsion of an intercostal artery varied among cases but were clearly visualized and precisely located by TEE. The flow through the entry and holes as well as the flow in the false lumen considerably changed after the placement of stent grafts. The appearance of SEC indicates successful entry closure but it is easily eradicated by an endoleak. Interestingly, an endovascular stent may enlarge the hole and augment the leak flow. However, TEE may be too sensitive to detect an endoleak. Most endoleaks detected only by TEE diminish and disappear toward the end of surgery. Therefore, we cannot draw definitive conclusions at this time.

Real-time assessment of perfusion by TEE is helpful in debranched TEVAR, which potentially occludes the arch branch by the stent graft or the vertebral artery by an AVP. This feature is also useful in cases with visceral malperfusion, as in case 3. The use of TEE may reduce the amount of the injected contrast media and radiation exposure.

The complications of TEVAR include the following: 1) stent graft-induced new entry, 2) aortic rupture, 3) retrograde aortic dissection, and 4) spinal cord injury,[3,4] especially in the acute phase. Identification of the guidewire in the true lumen by TEE allows progression to the next step without a concern, whereas additional contrast injection is essential with fluoroscopic guidance. The manipulation of the guidewire or catheter will be minimized under TEE guidance. In case 2, the potential placement of an AVP in the false lumen and/or arterial rupture was prevented. Although the above complications were fortunately not encountered in this series, they cannot always be avoided. The best possible and practical strategy would be to minimize catheter entry into the false lumen. In addition, early action should be taken based on the information provided by TEE. The use of TEE can reduce the need for multiple contrast injections. Although spinal cord injury is always a concern, routine motor-evoked potential monitoring and cerebrospinal fluid drainage are not practical. If TEE assessment of spinal cord perfusion by pulsatile movement of spinal nerves is sensitive enough, it may be helpful to evaluate the need for cerebrospinal fluid drainage and therapeutic medications. However, this assessment needs further investigation.

Conclusion

Through the experience of three cases, we found that TEE provides a variety of information that is helpful in the treatment of type B aortic dissection. Although it is time-consuming and requires appropriate training to acquire the TEE skills necessary to obtain the type of information reported here, our experience suggests that TEE is unique and its value may be worth such an effort.

Disclosure Statement

All authors have no conflict of interest regarding this manuscript.

Author Contributions

Study conception: NH, KO
Data collection: KO
Analysis: NH, KO
Investigation: NH, KO, MY
Writing: NH, KO
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Critical review and revision: all authors
Final approval of the article: all authors
Accountability for all aspects of the work: all authors

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