TEVAR for thoracic aortic aneurysm

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Introduction:

The management of thoracic aortic aneurysm (TAA) is dependent on aneurysm size, growth and shape.

Treatment options for TAA include open surgical repair (OSR) and thoracic endovascular aortic aneurysm repair (TEVAR).

OSR has been the traditional treatment, but it has been associated with high mortality especially in a patient of an older age or a surgically high-risk patient leading medical professionals to seek alternative less invasive interventions.

TEVAR for treatment of TAA was first reported in 1990s[1)], and has continued spread worldwide because of its low invasiveness and significant reduction of perioperative mortality rate. TEVAR is currently the most common treatment approach for descending thoracic aortic aneurysm (DTAA).

Regarding the treatment for aortic arch aneurysm, however TEVAR often requires some additional techniques including chimney, in-situ fenestration or branched devices.

In this session, I would like to introduce conventional TEVAR, some challenging cases which are out of the instructions for use and complications including endoleaks. I hope to allow the audience to better understand the indications of TEVAR and limitations.

Indications

It depends on the size or shape of the aneurysm, its rate of growth and location, and general medical condition of the patient.

Indications included a size of 6 cm or larger, a saccular configuration, and symptomatic aneurysm, including rupture. Regarding the location of the aneurysm, Ishimaru's classification which classifies the proximal landing zone into 5 areas, is often used for the planning of TEVAR **(Fig 1)**[2)].

The pathologic conditions of TAA include degenerative, traumatic or post-surgical pseudoaneurysm.

According to international guidelines[3)], it is recommended that TEVAR be performed for the treatment of DTAA (Class Ⅱa, level B), ruptured TAA (Class Ⅱa, level C) and traumatic TAA (Class I, level B).

Contraindication

Aortic size exceeding the treatment range of available devices can cause type 1 endoleak. A severely tortuous aorta included landing zone may also increase type 1 endoleak. Severely angulated aortic arch (> 60 degree) increases the difficulty of tracking and sealing at that level.

Aortoiliac occlusive disease is a potential consequence of arterial injury and shaggy aorta can cause distal embolization such as cerebral infarction, bowel necrosis, renal insufficiency or lower limb ischemia.

Patients who have a life-threatening allergic reaction to contrast material, nickel or have severe renal insufficiency also should avoid TEVAR treatment.

Equipment

Five devices are now commercially available for the treatment of TAA in Japan.

Most of the devices are designed for landing at zone 3 or 2 (covering the left subclavian artery) according to instructions for use.

The C-TAG (Gore) device is made of a self-expanding nitinol stent with ePTFE and has a flexibility enabling augmented contact with aortic wall over a wide range of aortic tortuosities and angulation.

The Valiant captivia (Medtronic), Relay plus (Bolton Medical) and Najuta (Kawasumi) devices have a proximal capture mechanism which reduces windsock phenomenon during deployment. With this mechanism, most of patients do not need flow control during deployment.

Zenith alpha (Cook) is a new model with a low-profile delivery system and is made of a self-expanding nitinol stent with woven polyester graft material. It has greater flexibility than the previous model (Zenith TX2).

The Najuta device is the only fenestrated stent graft that is available for zone 1 TEVAR.

The description of these devices is shown in Table.

Preoperative imaging and planning

Evaluation of anatomical morphology and accurate measurement of the aorta and access vessels are important to achieve favorable TEVAR results.

All patients who require TEVAR should undergo CT angiography (CTA), which provides all preoperative anatomical information. The CTA should include not only the chest-abdomen, but also pelvis to evaluate access route.

Three-dimensional volume rendering as well as maximum intensity projection, curved planner reconstruction, sagittal or coronal reconstructions further clarify the analysis of angles and relationship to adjacent branch vessels.

When patients cannot undergo CTA because of severe allergy to contrast material or renal failure, MR angiography is useful for additional information and is usually added to plain CT.

Evaluation of arch disease for atherosclerotic burden as well as the presence of the vertebral artery arising from arch is essential to minimize the risk of cerebral complications when zone 0-2 TEVAR is planned.

The appropriate size of the stent-graft is typically oversized 10 to 20 % depending on each IFU.

Too small stent-graft can result in type 1 endoleaks or migration, whereas excessive oversizing may cause in-folding (resulted in gutter leak) and excessive radial force with accelerated degeneration of the neck.

Appropriate landing zones should be maintained both proximally and distally to allow firm sealing and exclusion of the aneurysm from the circulation.

TEVAR requires at least 2 centimeters of healthy aorta as both a proximal and distal landing zone. Several patients, however, do not have perfect anatomy for TEVAR because those aneurysms often involve aortic arch branches that must be covered for adequate sealing.

For those patients who require zone 0-2 TEVAR, several treatment options exist such as surgical bypass or 'debranching', chimney technique[4], in-situ fenestration[5,6], or branched devices[7,8] to maintain perfusion while extending the sealing zone **(Fig 2)**.

Regarding occlusion of the left subclavian artery (LSA), it is generally well tolerated because of a rich collateral network. However, in cases with post coronary bypass using the left internal thoracic artery, post abdominal aortic grafting, or hemodialysis, it is recommended to conduct revascularization in order to keep coronary perfusion or to prevent spinal cord ischemia (SCI).

When the distal landing zone involves the celiac trunk, the operator faces similar situation as with the LSA.

When adequate collateral communication between the celiac trunk and superior mesenteric artery is achieved, the celiac trunk may be occluded safety. If the collateral communication is poor, a bypass or snorkel technique may be necessary.

The length of the aorta to be covered should be minimized to prevent SCI, though it remains controversial and is determined by clinical situations, case by case.

Neck diameters between the proximal and distal landing zones often varies, which may lead to inappropriate oversizing on the smaller landing zone. Using tapered stent-graft or shorter devices deploying a larger device inside the smaller one may solve this problem.

Procedures

TEVAR is generally performed via unilateral common femoral artery under cut-down skin incision.

It is recommended that patient be heparinized with 100 IU/kg during the procedure to prevent thrombus formation.

An introducer sheath is carefully inserted over a stiff wire. The exact placement of the stent-graft should be determined by aortography. Specially, aortography with a left anterior oblique projection when the proximal zone is close to the arch.

Marking of landmarks for positioning the stent-graft is recommended to ensure accurate deployment. After that, the stent-graft is advanced to intended position, and then deploy accurately. **(Fig.3)**

When conducting TEVAR in the aortic arch, application of steady forward pressure on the wire tends to keep it pushed against the outer curvature of the aorta for accurate estimation of deployment.

When more than one device is used, the smaller one should be deployed first to allow sealing at the overlap zone to prevent type 3a endoleak.

Completion aortography is performed to evaluate stent-graft patency, branch patency and the presence of endoleaks. Iliac arteriography is also needed if the iliac arterial injury is suspected. The guide wire should not be removed until access vessel injury is excluded.

Complications

Rupture of the aneurysm, vessel injury, distal embolization (cerebral, renal, bowel or extremity) or SCI can occur during the procedure.

For all patients with TEVAR, mean blood pressure should be kept above 80 mmHg just after stent-graft deployment to prevent SCI.

The risk factors of SCI include long-segment stent-graft coverage (Adamkiewicz artery is usually located between Th8 and L2), concomitant post-abdominal aortic grafting, occlusion of the left subclavian artery or bilateral internal iliac artery.
For patients with those risk factors, drainage of cerebrospinal fluid may be considered[9]. The drain is typically inserted preoperatively, though the timing of drain insertion depends on physician's decision.

The drain is maintained for around 24 to 72 hours while keeping pressure less than 10 cm H_2O.

Intravenous administration of steroids or naloxone and SEP monitoring should be conducted to prevent SCI progression.

Endoleak management

If type 1 or 3 endoleaks are seen on completion DSA, ballooning should be initially performed intraoperatively. Additional stent-graft should be considered if these endoleaks remain even after that.

When zone 0-2 TEVAR is performed, LSA should be embolized using coils or vascular plug in order to prevent type 2 endoleak. The incidence of type 2 endoleaks after TEVAR is less than that after EVAR though it is often difficult to treat due to a complex collateral circulation.

The involved branches include bronchial arteries or intercostal arteries, but most of cases with type 2 endoleaks from these branches can be observed conservatively. Embolization by direct puncture or transarterial approach should be considered if the aneurysm sac continues to expand during follow up.

Postoperative surveillance

Patients require long term surveillance consists of clinical evaluation and imaging of the aorta. A control CT examination is needed shortly after the procedure to evaluate technical success or the presence of complications. All patients should have a follow up CT examination at 1, 12 months and every year thereafter unless the patient's status has changed indicating developing complications. If there are endoleaks or other device-related complications on CT at 1 month, it should be followed by CT at 3 or 6 months.

Summery

Although TEVAR has been widely accepted as a first line treatment for the DTAA because of its low invasiveness and it offers a perioperative and short-term survival benefit over OSR, TEVAR for aortic arch aneurysm is still being challenged and requires hybrid treatment (debranching), chimney technique or in-situ fenestration to maintain branch vessel perfusion. To improve outcomes of TEVAR for these patients, we should understand the adjunctive options and its limitations.

On the other hand, several branched stent grafts are now on development, and hope that 'total endovascular treatment' will come in the near future.

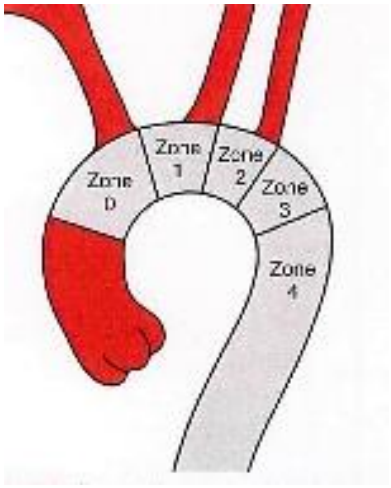

Figure 1. Five landing zones of the thoracic aorta

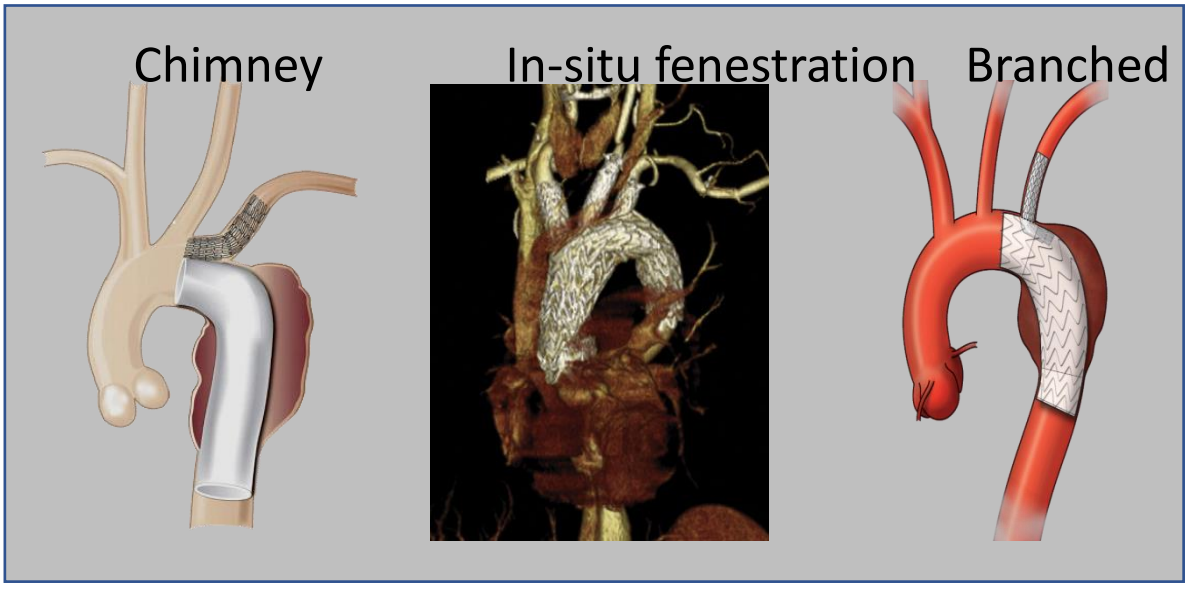

Figure 2. Various techniques for Zone 0-2 TEVAR

	CTAG	Zenith alpha	VALIANT captivia	Relay plus	Najuta
Graft material	ePTFE	Polyester	Polyester	Polyester	ePTFE
Structure	Nitinol	Nitinol	Nitinol	Nitinol	Nitinol
Diameter (mm)	21-45	28-46	22-46	22-46	24-42
Delivery system (Fr.)	20-26	16-20	22-25	22-26	21-23

CTAG

Zenith

VALIANT captivia

Najuta

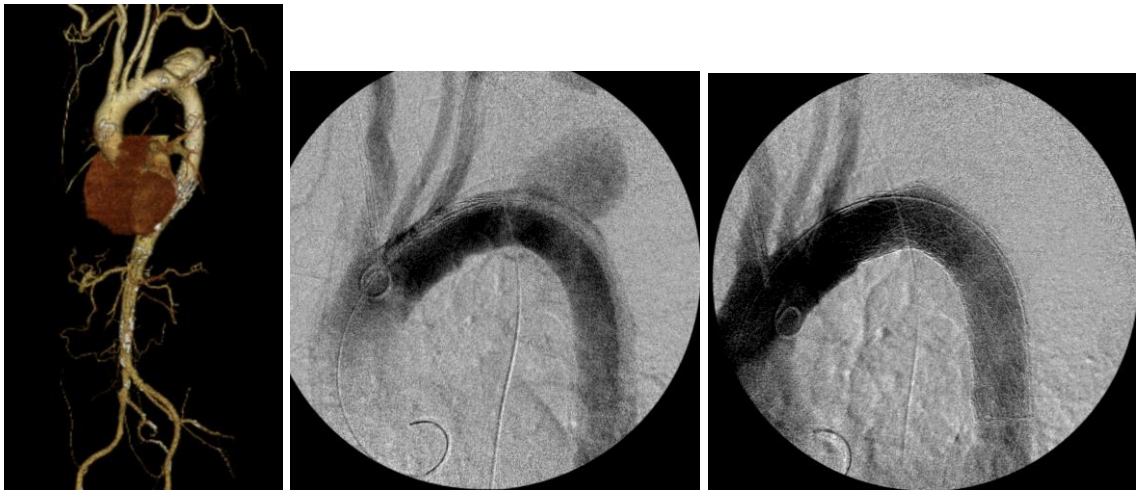

Figure 3. Saccular aneurysm involves distal aortic arch (a) and proximal landing zone was measured 26mm in diameter, 27mm inlength. C-TAG (31-15cm) was deployed just below the left subclavian artery (b) and no endoleak was seen on completionDSA (c).

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