Aortic Valvuloplasty Performed for Residual Aortic Regurgitation after Ascending Aortic Graft Replacement in a Case of Acute Aortic Dissection

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Abstract

Background: Aortic regurgitation (AR) can complicate acute aortic dissection (AAD). Treatment requires differentiation between AR that was present before onset of the AD and not directly involved in the dissection and AR that occurred as a result of ascending aorta dilatation associated with the AD. We encountered a case of AD accompanied by AR for which replacement of the ascending aorta was indicated on the basis of initial transesophageal echocardiography (TEE) findings and exploration of the surgical field. Despite aortic replacement, the AR persisted, requiring aortic valvuloplasty (AVP).

Case presentation: The patient was a 67-year-old woman (height, 162 cm; weight, 67 kg) with Stanford type A AAD. Preoperative TEE revealed an aortoventricular junction (AVJ) of 18 mm, an effective height (eH) of 7 mm, sinuses of Valsalva of 38 mm, and a sino-tubular junction of 39 mm, together indicating severe AR. There was no pericardial effusion, and the ejection fraction was 60%. The eH throughout the surgical field measured 8 mm, and the AVJ measured 24 mm. AR resulting from dilatation of the ascending aorta was diagnosed, and we simply replaced the ascending aorta. Immediately after removal of the cross-clamp, we observed moderate central valvular regurgitation as well as a trace AR jet emanating from the commissure between the left and non-coronary cusps, so we performed AVP (involving central plication and 20-mm suture annuloplasty) to treat the residual AR. After central plication, the eH measured 8 mm throughout the field, and TEE performed after discontinuation of cardiopulmonary bypass revealed an AVJ of 19 mm, an eH of 8 mm, sinuses of Valsalva of 31 mm, and an STJ of 23 mm, confirming that the AR was resolved.

Conclusion: Our case illustrates the importance of determining, during the initial intraoperative TEE evaluation of patients undergoing surgery for AAD, a need for AV management and the advisability of AVP. Comprehensive TEE evaluation is called for—evaluation that includes not only measurement of the aortic complex, the eH, and coaptation lengths, but also measurement of the short axis of the valve leaflets and the extent of dissection.

Key words
Aortic valvuloplasty, residual aortic regurgitation, acute aortic dissection, transesophageal echocardiography

Background

Aortic regurgitation (AR) that occurs as a complication of acute aortic dissection (AAD) is usually treated by means of aortic valve replacement (AVR) or aortic valve resuspension. However, AR usually improves after replacement of a dilated ascending aorta, so very few cases of ADD require treatment that involves the aortic valve (AV)1. It is difficult to differentiate between AR that was present before the onset of aortic dissection (AD) and AR that occurred as a result of ascending aortic dilatation associated
with the AD. Accordingly, there is no specific standard form of treatment for AR that complicates AAD. We describe a case in which AVP was performed to treat AR that had complicated AAD. The need for AV management and the indication for AVP were determined during intraoperative transesophageal echocardiography (TEE) performed for initial evaluation of the AD.

Case presentation

The patient was a 67-year-old woman (height, 162 cm; weight, 67 kg). She presented with back pain, and Stanford type A AAD was diagnosed. Her level of consciousness was normal, her blood pressure was 174/52 mmHg, her pulse rate was 76 bpm, she was in sinus rhythm, and her oxygen saturation (SPO₂) was 96%.

She was placed under general anesthesia, which was induced with 120 mg of propofol, 70 mg of rocuronium, and 0.1 mg of fentanyl and maintained thereafter with 1 to 7 mg/kg/h of propofol and 7.5 μg/kg of fentanyl. TEE was performed after anesthesia induction that showed severe AR, and the following measurements were obtained: aortoventricular junction (AVJ), 18 mm in diameter; effective height (eH), 7 mm, sinuses of Valsalva, 38 mm, and the sino-tubular junction (STJ), 39 mm. No pericardial effusion was seen, and the ejection fraction was 60% (Fig. 1). On inspection of the surgical field, the entry tear was found 5 cm distal to the STJ, and the dissection extended from the noncoronary cusp (NCC) to the right coronary cusp (RCC), then to the RCC-left coronary cusp (LCC) commissure and across the STJ. The eH measured 8 mm throughout the surgical field, and the AVJ measured 24 mm.

There was virtually no calcification of the aortic annulus or AV cusps, and there were no issues with the valves themselves, so, as the Heart Team, we simply replaced the ascending aorta (with a 24-mm J-graft SHIELD NEO, Japan Lifeline Co. Ltd., Tokyo, Japan). Before removing the aortic cross-clamp, we infused cardioprotective solution into the graft, applied 250 mmHg of pressure to the clamp using forceps, and evaluated the AR by means of TEE. At this point, we determined that the central AR jet was at a trace level and therefore within permissible range. After induction of anesthesia, the dose of nicardipine was adjusted to maintain systolic blood pressure at 80 to 120 mmHg. Once cardiopulmonary bypass was discontinued, dobutamine was readily administered at 3 μg/kg/min.

After removing the aortic cross-clamp, we administered dobutamine, nicorandil and alprostadil as well as nicardipine at 1 μg/kg/min. We performed TEE again while the patient’s blood pressure was 83/44 mmHg and heart rate was 86 bpm, maintained with ventricular pacing, and we observed moderate central valvular regurgitation, as well as trace regurgitation at the LCC-NCC commissure (Fig. 2). We thus decided that the AV required treatment. The TEE short-axis view of the AV revealed partial prolapse of the RCC extending from the cusp belly to the tip. We, the Heart Team, discussed treatment of the residual AR with the surgeons and concluded that the central AR could be treated successfully by annuloplasty. We also concluded that it was possible to restore the proper valve cusp adjustment to treat the AR between the LCC and NCC. As noted above, the patient’s cardiac function was favorable, no calcification of the annulus or valve cusps was observed during the initial TEE examination, and multiorgan failure had not occurred, so we planned to perform AVP by means of central plication and annuloplasty.

Measurements taken within the surgical field revealed an AVJ of 24 mm, and the geometric heights of the LCC, NCC, and RCC were 17 mm, 16 mm, and 20 mm (Fig. 3), respectively. Thus, we believe that AR occurred in this case because the surface area of the RCC was larger than that of the LCC and NCC. After central plication, the eH throughout the surgical field measured 8 mm. We also performed external suture annuloplasty with a 20-mm Hegar dilator. TEE performed after discontinuation of the cardiopulmonary bypass following AVP showed an AVJ of 19 mm, an eH of 8 mm, sinuses of Valsalva measuring 31 mm, and an STJ measuring 23 mm, evidence that the AR had resolved (Fig. 4). The operation time was 359 minutes, during which the cardiopulmonary bypass time was 189 minutes, first aortic cross-clamp time was 98 minutes, second aortic cross-clamp time was 50 minutes, and circulatory arrest was 23 minutes. Time to extubation was 38 hours, the ICU stay was 3 days, and the hospital stay was 31 days.

The patient was discharged without postoperative complications. TTE performed 1 week and 3 months postoperatively revealed ejection fractions of 60% and 76%, respectively. Trace AR was observed during both investigations. The additional suture annuloplasty had increased the coaptation length, so the AR disappeared despite non-achievement of a postoperative eH ≥ 9 mm (Fig. 4).
Transesophageal echocardiography images obtained after anesthesia induction
a. Image on which the following measurements were obtained: aortoventricular junction 18 mm, sinuses of Valsalva 38 mm, sino-tubular junction (STJ) 39 mm. The entry tear is seen along the anterior wall, 5 cm distal to the STJ.

b. Image on which the following measurements were obtained: effective height (eH) 7 mm, ejection fraction 60%. Pericardial effusion is absent. The false lumen extends to the commissure.
c, d. Images depicting severe aortic regurgitation.
e. Images depicting severe aortic regurgitation (aortic valve short-axis view).

Figure 1. Transesophageal echocardiography images obtained after anesthesia induction

Discussion

There is no standard treatment for AR that occurs as a complication of AAD. Treatment approaches differ, depending on the patient’s preoperative condition, severity of the AR, and characteristics of the valve cusps. If AR is seen on TEE performed during surgery to treat AD, and the AR is severe in that it is associated with calcification of the aortic annulus and cusps, the need for AVR needs to be communicated to the surgeons. However, if the AR is expected to improve after replacement of the ascending aorta, there is no need to perform AVR.

Approximately half of all cases of AR that occur as a complication of AD require additional surgical manipulation of the valve cusps. When we detect moderate or worse AR during TEE performed after anesthesia induction, we determine what treatment is indicated on the basis of the preoperative TEE findings and microscopic examination of the AV within
Figure 2. Transesophageal echocardiography images obtained after graft replacement of the ascending aorta. 

a, b. Moderate central aortic regurgitation and trace aortic regurgitation in the commissure between the non- and left coronary cusp are evident.

c. Images depicting severe aortic regurgitation (aortic valve short-axis view).

Figure 3. Measurement of valve leaflets in the surgical field.

There are three possible mechanisms underlying AR that occurs in the absence of organic valvular lesions: (1) restricted valve cusp mobility associated with sudden dilatation of the aortic root, (2) valve prolapse caused by internal deviation of the commissure, and (3) impedance of valve closure by a graft that descends during diastole. The NCC and its surroundings are commonly involved in the dissection when AR is the result of valve prolapse, and anterior regurgitation will be evident on TEE if NCC prolapse has occurred.

Measurements performed during the initial TEE study showed the eH to be 7 mm, whereas measurements in the surgical field showed the eH to be 8 mm, so there was a discrepancy. Our patient’s aortic annulus was elliptical, and we believe this explains why accurate evaluation of all three valve cusps by means of 2D echocardiography was not possible. We also believe that an RCC lesion was present prior to the onset of dissection, and thus we should have used 3D imaging to determine the annulus diameter and eH. Three-dimensional short-axis imaging performed after anesthesia induction might facilitate diagnosis of RCC prolapse.

Before we removed the aortic cross-clamp in the present case, we infused cardioplegic solution into...
the graft, applied 250 mmHg pressure to the clamp, and evaluated the AR by TEE. At this point, we determined that there was only trace AR, which we consider to be within permissible range\textsuperscript{4}. The evaluation of AR is affected by afterload, circulating volume, and pulse rate, so it is important to perform evaluation under conditions in which the pulse can be measured by the evaluator. In addition, if cusp coaptation improves due to an adequate circulating volume and elevated blood pressure after AVP, then it is important to re-evaluate the valve by means of TEE after cross-clamping is removed.

Increasingly, AD is being treated surgically\textsuperscript{5}, although there are some reports of AVP being performed to manage dissection\textsuperscript{6}. AVP is usually considered successful when an eH ≥ 9 mm is achieved, and a coaptation length of ≥ 4 is considered desirable\textsuperscript{7}.

We have encountered cases at our hospital in which AR did not improve despite achievement of an eH of 11 mm, and we have encountered other cases in which the AR resolved at an eH of 9 mm. Vanoverschelde et al. reported that the eH is between 4 and 10 mm in healthy individuals, and that the coaptation length is > 4–5 mm\textsuperscript{7}. The body surface area of Japanese is relatively small, so the aortic valve complex is small. Thus, further studies involving fairly large patient groups are needed going forward.

AR that occurs as a complication of AAD is usually treated by means of AVR, although challenges arise when surgery is performed under conditions in which detailed preoperative investigations are not possible or cardiopulmonary bypass is prolonged. In some cases in which AVP is performed, AVR becomes necessary because the AR is not controlled by the AVP alone. There are very few reports documenting long-term outcomes after AVP in Japan\textsuperscript{6}. We do know the shorter cardiopulmonary bypass time associated with AVP (vs. AVR) to be generally beneficial.

In cases in which AVP is being considered, it is absolutely essential for the anesthesia physician to provide the surgeons with detailed TEE-based information about the valve. Surgery for AD is emergency surgery, so preoperative evaluation is often inadequate, and it is difficult to determine whether the presence of AR is due to preexisting valvular lesions. It is important to communicate to the surgeons whether the disease state is acute, whether the etiology is degenerative, what condition the valve cusps are, and whether AVP is even possible.

Normally, whether AVP is indicated is determined during preoperative TEE by measuring the AVJ, the sinuses of Valsalva, the STJ, the ascending aorta, and the direction and number of AR jets. The mechanism underlying the AR is determined on the basis of the classification system described by El Khoury, et al.\textsuperscript{8}. Boodhwani et al. also reported a classification system oriented to valve repair\textsuperscript{9}. During TEE, it is possible to use multi-slice reconstruction or volume rendering to create 3D images, and thus accurately measure the eH of all three valve cusps or evaluate the presence of valve cusp prolapse on arbitrary slices\textsuperscript{10}. It may be possible to identify asymmetrical valve cusps or coronary cusp prolapse by evaluating...
calcification of the valve cusps and the overall disposition of the three cusps along the long and short axis during 2D investigation, and by measuring the coaptation lengths of the three cusps during 3D investigation.

The shape of the aortic annulus differs between individuals, ranging from round to elliptical, so in addition to the coaptation length and eH values, the calcification and balance of the annulus and valve cusps, the findings during examination of the extent of dissection, the direction of the regurgitation jets, the width and the regurgitation volume should all be communicated to the surgeons.

The present case illustrates the importance of determining the need for AV management and the advisability of AVP during the initial intraoperative TEE evaluation of patients undergoing surgery for AAD. Comprehensive TEE evaluation is called for—evaluation that includes not only measurement of the aortic complex, the eH, and coaptation lengths, but also measurement of the short axis of each the valves and the extent of dissection.

**Abbreviations**

AR: Aortic regurgitation; AVJ: Aortoventricular junction; AVP: Aortic valvuloplasty; eH: Effective height; GH: Geometric height; LCC: Left coronary cusp; NCC: Noncoronary cusp; RCC: Right coronary cusp; STJ: Sino-tubular junction; TEE: Transesophageal echocardiography

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**Conflicts of Interests** The authors have nothing to disclose.

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