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ORIGINAL ARTICLE

Conservative treatment of type A aortic dissection following hybrid arch repair

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Abstract

Objective Type A aortic dissection (TAAD) following hybrid arch repair (HAR) is a lethal complication. Open surgical repair is the ideal treatment, but this can be difficult, as most candidates have complications and are unsuitable for the conventional open aortic repair. We herein report three cases of TAAD after HAR and assess the treatment options.

Methods Of 261 aortic arch repair cases between April 2010 and March 2018, 38 underwent HAR using debranching of all the arch vessels followed by stent graft implantation landing proximally in zone 0 (type 1 HAR). Three cases suffered from TAAD, and their background characteristics and post-operative outcomes were studied retrospectively.

Results The three TAAD cases were elderly with a high risk of mortality due to comorbidities. TAAD for Cases 1, 2, and 3 was detected on post-operative day (POD) 11, POD11, and during the procedure, respectively. Case 1 was complicated with both respiratory and renal failures, and Case 3 suffered from severe neurological impairment when TAAD was detected. No additional open aortic repair was performed in any cases. Case 3 died on POD5 due to aortic rupture. Cases 1 and 2 have survived for more than 50 months since their initial surgeries.

Conclusions TAAD following HAR can be detected with post-operative imaging despite a lack of signs noted during the intra- and post-operative periods. Conservative therapy might, therefore, be an acceptable option for subacute-onset TAAD following HAR with stable hemodynamics, even though such patients do required a very careful follow-up.

Keywords Type A aortic dissection · Thoracic endovascular repair · Medical treatment · Hybrid arch repair · Retrograde type A aortic dissection

Introduction

Open aortic arch repair (OAAR), the conventional surgical management approach for patients with aortic arch diseases had been continually improving its operative techniques, such as being combined with wither hypothermia or selective cerebral perfusion [1, 2]. Given the acceptable outcomes, the surgical indications have been expanding to include patients with severe comorbidities. However, while thoracic endovascular repair (TEVAR) may be a viable alternative to high-risk OAAR cases, it cannot be performed for aortic arches with certain morphologies, so hybrid arch repair (HAR) with both debranching of all arch vessels and stent graft implantation landing proximally in zone 0 (Type 1 HAR) has been expected to be a more promising surgical option [3, 4].

Some reports have described the post-HAR aortic complications related to TEVAR, such as type A aortic dissection (TAAD), despite the reports of acceptable early and mid-term survivals [5–9]. Several reasons for these complications have been reported, including clamp damage at the ascending aorta during complete debranching and compliance mismatch between the ascending aorta and stent graft [4, 7]. Open surgical repair should be considered for treatment; however, this can be difficult, as most candidates have complications and are unsuitable for the conventional OAAR.

We herein report three cases of TAAD after HAR and assess the treatment options with regard to the timing of TAAD onset.

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Methods

Patients' population and data collection

Between April 2010 and March 2018, 261 patients received aortic arch repair in our institution, which involved 38 cases of type 1 HAR. Our primary approach for aortic arch aneurysm was the conventional OAAR, but we considered type 1 HAR for certain situations. Type 1 HAR was essentially indicated for patients with a limited life expectancy, particularly elderly patients and those with a high comorbidity burden, including active malignancy. For patients with active malignant disease, aortic surgery was only indicated if the life expectancy was at least 1 year and the risk of aortic rupture exceeded the risk of death related to the malignant disease. From an anatomical point of view, we excluded any thoracic aortic aneurysm cases which can be treated with one or two debranching TEVAR.

We encountered three cases of TAAD following type I HAR (Cases 1, 2, and 3). The present retrospective review study was approved by the Institutional Review Board of Nagoya University Graduate School of Medicine (IRB 655-2; individual consent waived). Continuous variables are expressed as the mean ± standard deviation.

Operative technique

The protocol had been described before [6]. In brief, type I HAR entailed the reimplantation of all aortic arch vessels (total debranching) with stent graft implantation landing proximally in zone 0 via median sternotomy. Type I HAR was performed for the aortic arch aneurysmal cases without ascending or descending thoracic aortic aneurysm. Specifically, the diameter of the ascending aorta should be ≤ 42 mm due to the size of the stent graft. If the diameter was > 42 mm, the ascending aorta was made smaller with artificial graft wrapping for the proximal landing zone. In addition, because the side clamp had to be applied to the ascending aorta, patients with an ascending aorta exhibiting heavy calcification or a 'shaggy' internal surface were not suitable for this procedure.

For the debranching process, we used trifurcated prosthetic grafts sewn to the native ascending aorta just above the sinotubular junction in a side-to-side fashion, usually using a side-biting clamp. In single-stage repair cases ($n = 32$), the stent grafts were deployed in an antegrade fashion via the proximal limb of the graft into the aortic arch after completing arch vessel debranching. In second-stage repair cases ($n = 6$), TEVAR might be delayed and the stent graft deployed later via a retrograde femoral approach. A GORE TAG or Conformable GORE TAG (W. L. Gore & Associates, Inc., Flagstaff, AZ, USA) was used in 35 patients, and a Cook Zenith (Cook Medical, Bloomington, IN, USA) was used in 1 patient. Cardiopulmonary bypass (CPB) was performed in four cases, including two cases of elective usage for expected hemodynamic instability, a case of concomitant valve surgery, and emergent usage due to massive bleeding.

Results

Pre- and intra-operative patient demographics and the early outcome for all cohorts are shown in Tables 1 and 2. There were three cases of TAAD following type 1 HAR, and conservative management was performed for all cases due to severe preoperative comorbidities and/or a new occurrence of TAAD.

Case 1

An 82-year-old woman with severe cerebral vessel disease (EuroSCORE II: 7.6%) underwent single-stage type 1 HAR for a distal aortic arch aneurysm (Fig. 1a). The patient also underwent ascending aorta wrapping in between the innominate artery and stent graft proximal landing zone to reduce the diameter from 42 to 40 mm, and a 20 cm × 45 mm conformable Gore TAG was implanted. All procedures were performed without CPB, and no signs of TAAD were observed. She developed sudden pericardial effusion on POD11, and computed tomography (CT) revealed localized TAAD (Fig. 1b). Both respiratory and renal failures were present at this point, and therefore, surgery was not performed. Follow-up CT showed no further dilation or progression of the dissection (Fig. 1c). She was doing well at 5 years after the procedure.

Case 2

An 81-year-old man with a shaggy internal surface of the distal arch aorta (EuroSCORE II: 3.9%) underwent single-stage type 1 HAR for a distal aortic arch aneurysm. The diameter of the ascending aorta was 40 mm (Fig. 2a), and a 20 cm × 45 mm conformable Gore TAG was used. All procedures were performed without CPB, and no signs of TAAD were observed. His post-operative course was uneventful; however, CT on POD11 demonstrated localized TAAD (Fig. 2b). Surgery was not performed due to his stable condition in the subacute phase and also due to the fact that the patient did not want to undergo any further procedures. Follow-up CT at 36 months after the procedure showed slight dilation of the ascending aorta but no progression of the dissection. He was doing well at 50 months after surgery (Fig. 2c).

Table 1 Pre- and intra-operative patient demographics

Variables	All cohort ($n=38$)	Case 1	Case 2	Case 3
Preoperative				
Age (years, mean ± SD)	77.1 ± 4.7	82	81	82
Gender, male	32 (84%)	Female	Male	Male
Aneurysm type: chronic direction	2 (5%)	True	True	True
COPD	10 (26%)	Y	N	Y
Renal dysfunction (Cre > 1.5)	3 (8%)	N	N	N
Hemodialysis	0	N	N	X
History of CVD	8 (21%)	Y	N	N
CAD	8 (21%)	N	N	Y
PVD	15 (39%)	N	Y	Y
DM	8 (21%)	Y	N	N
Malignant disease present	12 (32%)	N	N	X
Impaired LV function (LVEF < 30%)	0	N	N	N
Previous cardiac surgery	4 (11%)	N	N	N
EuroScore II (mean ± SD)	6.4 ± 0.06	7.6	3.9	17.3
Diameter of ascending aorta > 40 mm	10 (26%)	42 mm	40 mm	33 mm
Urgent emergent operation	2 (5%)	Elective	Elective	Elective
Intra-operative				
Use of CPB	4 (11%)	N	N	N
Two-stage approach	6 (16%)	N	N	N

COPD chronic obstructive pulmonary disease, *CVD* cerebral vessel disease, *PVD* peripheral vessel disease, *DM* diabetes mellitus, *LVEF* left-ventricular ejection fraction, *CPB* cardiopulmonary bypass

Table 2 Post-operative outcome

	All cohort ($n=38$)	Case 1	Case 2	Case 3
In-hospital mortality	11 (7.9%)	Survived	Survived	Dead at POD5
Prolonged ventilation (> 72 h)	11 (2%)	Y	N	Y
ICU stay (days)	8.8 ± 13	36	1	5
Post-operative hospital stay (days)	36.5 ± 33.4	73	19	5
Reoperation for bleeding	2 (5.3%)	N	N	N
Stroke	9 (23.7%)	N	N	Y
Requiring of HD	5 (13.2%)	Y	N	N
Permanent paraplegia	0	N	N	N/A
Transient paraparesis	2 (5.2%)	N	N	N/A
Mediastinitis	0	N	N	N
Type A aortic dissection	3 (7.9%)	Y	Y	Y
General condition at discharge	$n=35$			
Not affected	25 (71.4%)	Not	Not	**N/A**
Moderately compromised	5 (14.3%)			
Severely compromised	5 (14.3%)			

HD hemodialysis, *POD* post-operative day, *Not* not affected, *N/A* not applicable

Case 3

An 82-year-old man with severe COPD (EuroSCORE II: 17.3%) underwent single-stage type 1 HAR for a distal aortic arch aneurysm. The diameter of the ascending aorta was 33 mm, and a 20 cm × 40 mm conformable Gore TAG was used. All debranching of the neck vessels and stent graft implantation were performed without CPB. When we started to close the chest, temporary circulatory collapse occurred, and epi-aortic echo revealed TAAD. Additional surgery was not performed, because severe neurological complications were suspected with the development of new anisocoria. The patient maintained stable hemodynamics under medical treatment but ultimately died due to aortic rupture on POD5.

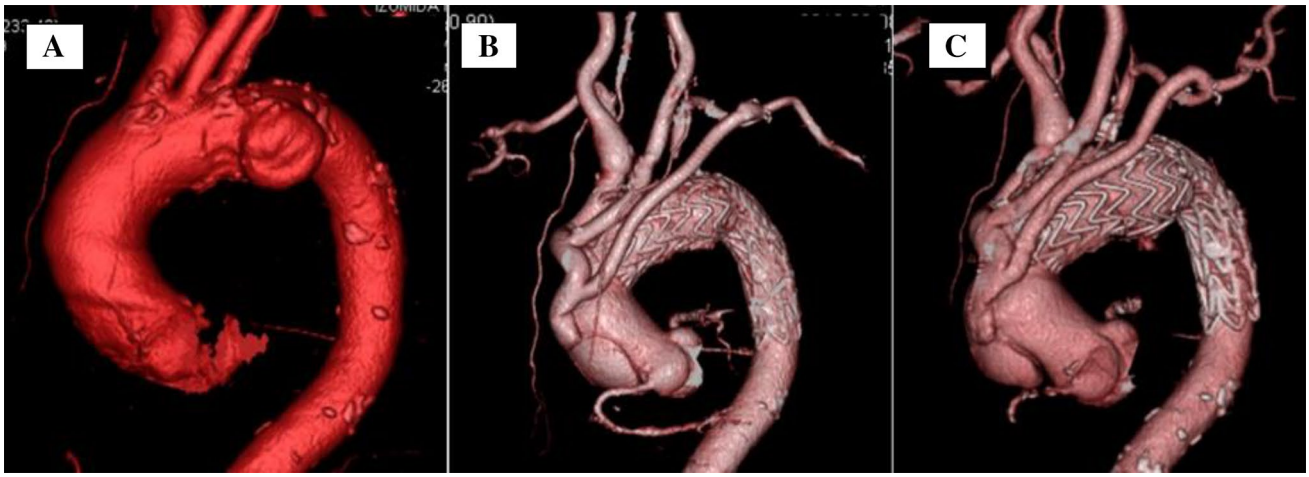

Fig. 1 Three-dimensional computed tomography findings for Case 1 showing **a** the distal arch aneurysm before the initial procedure. **b** A new type A aortic dissection with ascending aorta diameter 54 mm at POD11. **c** Chronic type A aortic dissection with ascending aorta diameter 55 mm 5 years after the initial procedure

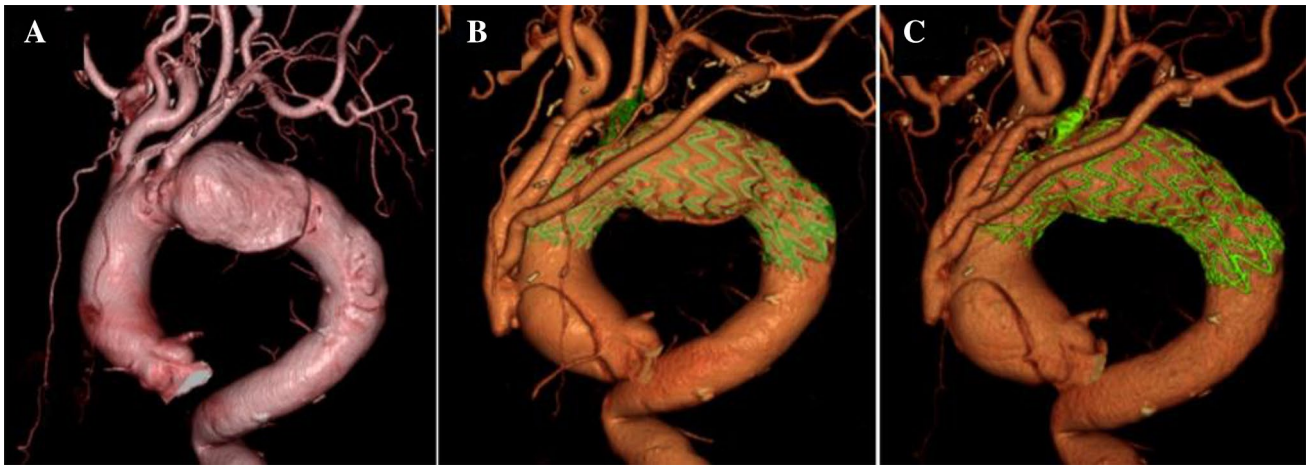

Fig. 2 Three-dimensional computed tomography findings for Case 2 showing **a** the distal arch aneurysm before the initial procedure. **b** A new type A aortic dissection with ascending aorta diameter 50 mm on POD11. **c** Chronic type A aortic dissection with ascending aorta 57 mm 36 months after the initial procedure

Discussion

Most HAR procedures are performed in high-risk patients because of the approach being less invasive than OAAR and excellent short- and long-term outcomes being reported [3–6]. However, this technique can be complicated with TAAD due to TEVAR, with a reported incidence of 1.3–6.3%, predominately occurring in the first month after surgery [7, 8]. We experienced three cases of TAAD among 38 type 1 HAR patients with a 7.9% occurrence rate. In Case 3, TAAD was detected intra-operatively due to circulatory instability. The precise onset of the other two cases was unclear. In our series, TAAD was difficult to detect macroscopically during the procedure, so epi-aortic echo should be performed for all HAR cases.

Czerny et al. suggested that TAAD following HAR might be related to compliance mismatch between the ascending aorta and the stent graft [4]. Bavaria et al. also recommended replacing an ascending aorta with a diameter > 40 mm to avoid TAAD following HAR [3]. In our series, subacute-onset TAAD in Cases 1 and 2 with an ascending aorta diameter ≥ 40 mm might have been caused by compliance mismatch. Regarding Case 3, the cause of intra-operative TAAD case might not have been compliance mismatch but clamp injury, as its diameter was less than 40 mm.

TAAD following HAR is generally treated with an open aortic repair despite the high mortality rate. However, the

timing of the onset of TAAD following HAR was important, with an intraprocedural onset associated with a significantly higher mortality than a subacute onset [8]. A high mortality for TAAD following TEVAR with unstable hemodynamics was also reported, even though emergent open aortic repair was performed [10].

Our early outcome with type 1 HAR showed a high morbidity rate for stroke (23.7%) and the main reasons for this phenomenon could be due to intra-operative atherosclerotic plaque embolism from the aortic arch or neck vessels, or thrombosis caused by post-operative paroxysmal atrial fibrillation (PAF).

Some cases had a large number of plaques in the orifice of the neck vessels. Intra-operative echo to examine the arch vessels might, therefore, be efficient for determining the optimal placing of the aortic clamp. There were three cases (33%) who suffered from stroke due to post-operative PAF. A post-operative hypercoagulable state may, therefore, be closely associated with the onset of stroke due to PAF.

These complications resulted in a delay in the post-operative recovery in high-risk patients and their general condition at discharge was severely compromised (14.3%) despite the fact that they had an acceptable in-hospital mortality rate (7.9%) (Table 2).

This high incidence of morbidities motivated studying suitable conditions for possible conservative management for TAAD following HAR. We can perform emergent open surgery if there are the signs of any sudden hemodynamical collapse, such as a rupture, an acute onset of aortic insufficiency, or coronary artery troubles. Case 3 which demonstrated acute hemodynamic instability is, therefore, considered to be indicated for emergent open surgery if no neurological issues are present.

Possible candidates for conservative management were patients who had no signs of dissection either during or after the operation, but they were found to have dissection incidentally in follow-up imaging studies, such as was observed in Cases 1 and 2. The early and sequential long-term follow-up images were, therefore, crucial to accurately identify debranching TEVAR cases. With access to more cases, we would be able to explore the anatomical characteristics suitable for conservative management.

In the two long-term survivors in our series, TAAD was detected in the subacute phase with stable hemodynamics. Our findings suggest that conservative therapy may, therefore, be an acceptable option for cases of subacute asymptomatic TAAD as a palliative therapy, if the hemodynamics is stable, while open aortic repair should be performed for TAAD that is detected during HAR.

Study limitation

There were some study limitations associated with this study. First, the size of the cohort was small. Second, this study was retrospective and carried out at a single institution. As a result, there may have been some potential bias associated with the patient selection.

Conclusion

We experienced three cases of TAAD after HAR treated without surgical intervention. The phase after the initial procedure and the patient's general condition might, therefore, be crucial factors for deciding whether emergent/urgent surgery is necessary. Conservative therapy may be acceptable for such high-risk cases when they demonstrate stable hemodynamics; however, a careful follow-up in required.

Compliance with ethical standards

Conflict of interest The authors declare no conflicts of interest in association with this study.

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