Original Article

OPEN ACCESS

Turkish Journal of Vascular Surgery 2022;31(2):91-97

DOI: 10.9739/tjvs.2022.1236
www.turkishjournalofvascularsurgery.org

Branch-first approach in aortic dissection: Initial results

Bülent Mert, Adil Polat

Department of Cardiovascular Surgery, Bağcılar Training and Research Hospital, Istanbul, Türkiye

ABSTRACT

Objectives: This study aims to evaluate the outcomes of "branch-first" approach in aortic arch repair in aortic dissection for the first time in Türkiye.

Patients and methods: Between January 2015 and December 2021, a total of 20 patients (18 males, 2 females; mean age: 51.3±11.1 years; range, 36 to 82 years) who underwent surgery for arch branches were retrospectively analyzed. The "branch-first" approach was used for the perfusion strategy and the repair was commenced accordingly. We used innominate artery and femoral artery for most cases as the primary arterial line and the secondary line was performed at one of the arch branches according to the preoperative imaging findings. These areas were used for the consecutive branch anastomosis.

Results: Overall 30-day mortality occurred in three (15%) patients. Thirteen (65%) patients had postoperative morbidity. Postoperative stroke was seen in one (5%) patient and the most common morbidity was revision surgery for bleeding in five (25%) patients. During follow-up, one patient had debranching graft stenosis (5%), but had no clinical problems. According to the Kaplan-Meier analysis, the mean one- and two-year survival rates were 91.7±8.0% and 78.6±13.9%, respectively.

Conclusion: The "Branch-first" technique is a feasible technique for aortic dissection repairs, when the arch branches should be intervened. The mortality is compatible with the literature and the morbidity is low.

Keywords: Aortic arch, aortic dissection, branch-first, debranching, perfusion strategy.

Aortic dissection repair is one of the most extensive procedures of cardiac surgery. In particular, procedures involving aortic arch have a significant mortality and morbidity rate. The latest analysis from the United Kingdom (UK) national data reported 50% mortality before reaching hospital[1] and mortality after operations were reported around 16 to 18%.[1] Involvement of aortic arch and the need to operate the arch branches impose an additional risk to the surgical outcome which is already at a substantial degree. In the UK data, 3.0% of the 4,203 patients were reported to receive total arch replacement.[1]

To reduce the operative risk and total circulatory arrest (TCA) durations, various "branch-first" techniques have been described.[2-4] In general, surgeons prefer using trifurcation grafts in these cases. In our practice, we use basic "on-the-shelf" tubular grafts for the operations due to the problems with reimbursement. In the present study, we aimed to examine the outcome for these cases and compare our results with the literature data. To the best of our knowledge, this is the first paper on the "branch-first" approach for arch repair in Türkiye.

PATIENTS AND METHODS

This single-center, retrospective study was conducted at University of Health Sciences, Istanbul Research and Training Hospital, Department of Cardiovascular Surgery between January 1st, 2015

Received: February 16, 2022 ***Accepted:*** April 20, 2022 ***Published online:*** May 13, 2022

Correspondence: Bülent Mert, MD. Bağcılar Eğitim ve Araştırma Hastanesi, Kalp ve Damar Cerrahisi Kliniği, 34200 Bağcılar, İstanbul, Turkey.
e-mail: mebulkvc@hotmaill.com

Citation:
Mert B, Polat A. Branch-first approach in aortic dissection: Initial results. Turk J Vasc Surg 2022;31(2):91-97

and December 31st, 2021. A total of 20 patients (18 males, 2 females; mean age: 51.3±11.1 years; range, 36 to 82 years) who underwent surgery for arch branches were included. Inclusion criteria were as follows: aortic dissection indicated for surgery, aortic dissection involving aortic arch, surgery for aortic dissection and need for cannulation of arch branches due to inadequate perfusion with axillary or femoral cannulation, and need for debranching procedure. Exclusion criteria were as follows: dissection repair performed with ascending or hemiarch replacement without debranching, axillary or femoral cannulation sufficient for perfusion and cerebral perfusion, no involvement of aortic arch.

Surgical technique

All patients were operated under general anesthesia. Median sternotomy was used in all cases. Arterial cannulation was made by two arterial cannulas: one from femoral or innominate artery and second from an arch branch as seen in Table 1. In our clinic, we prefer using innominate artery for the cannulation site for the last six years. In case the innominate artery does not seem to be sufficient to provide enough cerebral perfusion, we decided to use an additional site for arterial cannulation (such as carotid or subclavian on the contralateral site) or femoral arterial cannulation was utilized together with an arch branch cannulation. Each patient was individually evaluated with preoperative imaging. The cannulation site was determined depending on the ischemic threat and extension of aortic dissection. The probable requirement for complementary staged procedures (thoracic endovascular aortic repair [TEVAR], re-debranching) was kept in mind.

The exploration of arch branches was performed as follows: The innominate artery was explored via median sternotomy and a Dacron® graft was anastomosed in a side-to-end (S/E) fashion with running 5/0 prolene suture. The carotid arteries were explored with longitudinal incision anterior to the sternocleidomastoid muscle. The common carotid arteries were surgically explored and a Dacron® graft was anastomosed in a S/E fashion with running 5/0 prolene suture. After the anastomosis was completed, the graft was tunneled subcutaneously and was brought to mediastinum. The proximal end of the graft was cannulated with a straight tip cannula. In case of innominate artery cannulation, a Dacron® graft was anastomosed to the proximal site of innominate artery and was cannulated similarly. Figure 1 shows a bilaterally cannulated carotid arteries with a Y Dacron® graft and the perfusion was instituted before sternotomy (Figure 1). Femoral cannulation was performed with straight tip cannula directly without any graft anastomosed. Venous cannulation was achieved with a dual-stage venous cannula in each case. Diastolic arrest was achieved with retrograde cardioplegia and maintenance was achieved with continuous retrograde and intermittent antegrade isothermic blood cardioplegia via ostial coronary cannulas.

The cerebral protection was obtained as follows: The body temperature was kept between 24 and 26°C.

Table 1. Cannulation data

Cannulation site	n	%
Femoral	15	75.0
Right	7	
Left	8	
Innominate	10	50.0
Carotid	10	50.0
Right	6	
Left	1	
Bilateral	3	
Left subclavian	1	5.0

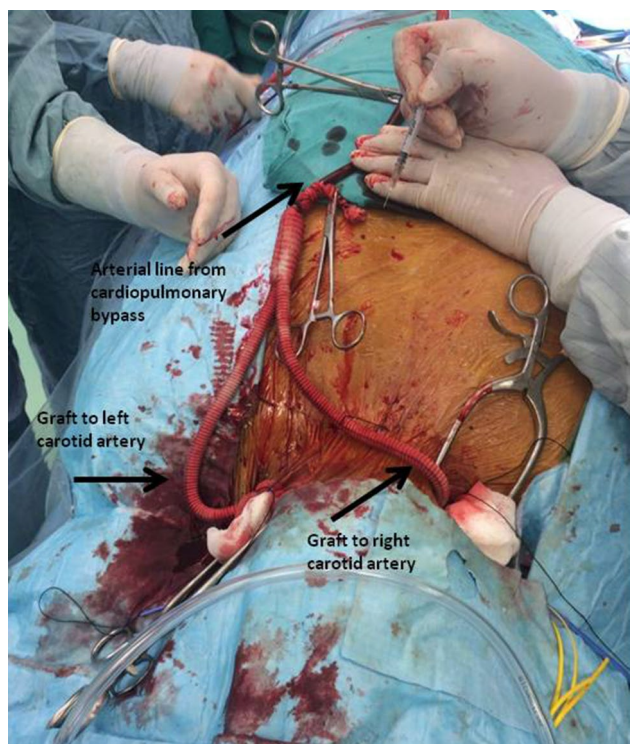

Figure 1. Intraoperative image for bilateral cannulation of carotid arteries.

The antegrade cerebral perfusion was maintained with 900 to 1,000 mL/min flow and the pressure was kept between 60 and 80 mmHg as measured from the cardiopulmonary bypass (CPB) circuit. Local ice packs were applied around the head. Methylprednisolone (1 g) was applied (Prednol-L, 250 mg amp, Mustafa Nevzat, Istanbul, Türkiye) and 20 mg thiopental (Pentothal 0.5 g, Abbott, Istanbul, Türkiye) were applied via the intravenous route.

The surgical procedures are summarized in Table 2. The mean durations of aortic cross-clamp, CPB and antegrade cerebral perfusion were summarized in Table 3. It can be seen that two patients had arch replacement. In these cases, aortic arch was replaced and separate innominate artery and left carotid bypasses were performed. The TEVAR grafts were implanted to descending thoracic aorta in one patient and to aortic arch in another patient. In TEVAR patients, debranching procedures were performed as the first operation and, then, the patients were transferred to the angiography suite and the TEVAR was implanted through the femoral artery. Of these aortic arch cases, only one of them was a reoperation after a hemiarch procedure for acute dissection. Figure 2 shows the final result in a patient operated for brachiocephalic trunk and left carotid artery bypass with the proximal anastomosis was placed on the interposition Dacron® graft for the ascending aorta (Figure 2).

At the completion of the procedure, meticulous bleeding control was performed. After the CPB was terminated and normothermia was achieved, all the surgical incisions were controlled with surgical gauze and with warm saline washing. Additional single sutures were placed, when necessary. The aortic root and the dissected segments at the suture lines were supported with BioGlue® routinely.

Follow-up

The follow-up after discharge from the hospital was performed in the outpatient clinic of the hospital. Follow-up imaging studies with computed tomography (CT) angiography were made in 13 (65%) patients. In the rest, three were patients with mortality and the other four patients had elevated urea/creatinine values and contrast studies could not be made.

Statistical analysis

Statistical analysis was performed using the SPSS version 16.0 software (SPSS Inc., Chicago, IL, USA). Descriptive data were expressed in mean ± standard deviation (SD), median (min-max) or number and frequency. The Kaplan-Meier analysis was used for survival analysis.

Table 2. Surgical procedures

Surgical procedure	n	%	Mean±SD	Range
Ascending aortic replacement	12	60.0		
Bentall de Bono	8	40.0		
Hemiarcus	4	20.0		
Arcus	2	10.0		
Aortic valve suspension	4	20.0		
Innominate bypass	9	45.0		
Carotid bypass	15	75.0		
Right	5	50.0		
Left	5	50.0		
Bilateral	5	50.0		
Subclavian bypass				
Left	1	5.0		
Right	1	5.0		
CABG	2	10.0		
TEVAR	2	10.0		
Operation data				
Aortic cross-clamp (min)			139.3±45.4	73-226
Cardiopulmonary bypass (min)			203.7±56.9	119-286
Antegrade cerebral perfusion (min)			35.1±20	13-72

SD: Standard deviation; CABG: Coronary artery bypass graft; TEVAR: Thoracic endovascular aortic repair.

Table 3. Descriptive data

	n	%	Mean±SD	Range
Age (year)			51.3±11.1	36-82
Sex				
Male	18	90.0		
Female	2	10.0		
Timing of dissection				
Acute	16	80.0		
Subacute	1	5.0		
Chronic	3	15.0		
1 (reoperation after an acute dissection due to arcus aneurysm)				
Hypertension	19	95.0		
Diabetes mellitus	7	35.0		
Tobacco use	7	35.0		
Chronic obstructive pulmonary disease	3	15.0		
Peripheral arterial disease	1	5.0		
Hyperlipidemia	6	30.0		

SD: Standard deviation.

RESULTS

A total of 74 patients were operated for aortic dissection throughout the study period. Of these 74 patients, 20 patients required branch-first approach as outlined in the methods section. The 30-day mortality occurred in three (15%) patients. Demographic features of the patients are summarized in Table 3. Only three patients had chronic and one patient had subacute dissection, while the rest of the patients (n=16) were operated in the emergency setting.

The mean duration of follow-up was 17.1±17.9 months with a total of 32.7 patient/years. The postoperative course is summarized in Table 4. Thirteen (65%) patients had morbidity (Table 5). The most frequent cause of mortality was revision surgery for bleeding. After discharge, the mean one-year survival rate was 91.7±8.0%, but was reduced below 40% at five years (Figure 3). However, the number of patients at risk was one at five years. Only one patient had debranching stenosis. This patient had

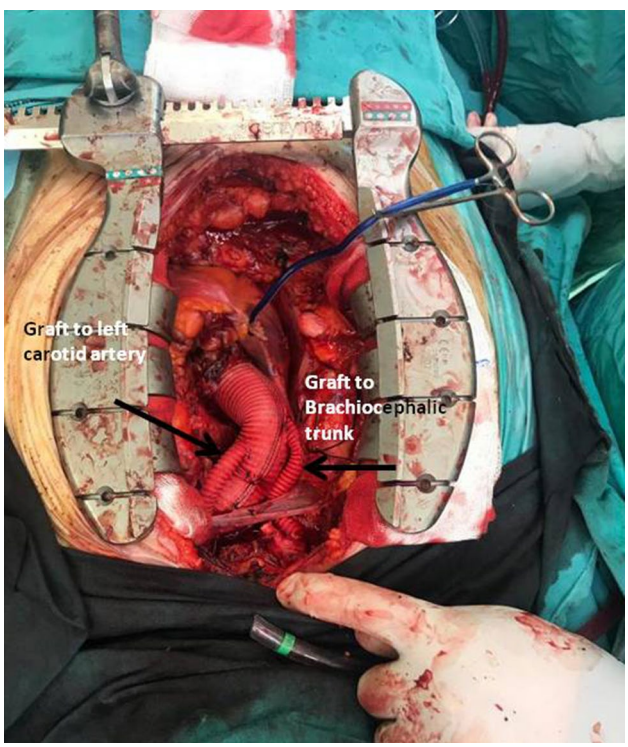

Figure 2. View from the end of the procedure. Orientation of the grafts and proximal anastomoses.

Table 4. Postoperative course

Postoperative data	n	%	Mean±SD	Min-Max
ICU stay (day)			11.4±10.9	1-47
Hospital stay (day)			17.0±11.7	1-47
30-days mortality	3	15.0		
Morbidity	13	65.0		
Survival (month)			17.1±17.9	
Sum (patient/years)		32.7		
1-year†	7		91.7±8.0	
2-years†	4		78.6±13.9	
5-years†	1		39.3±28.6	
Debranching stenosis*	1	5.0		

SD: Standard deviation; ICU: Intensive care unit; † Patients at risk; * Carotid bypass stenosis within first year.

Table 5. Postoperative morbidity

Morbidity	n	%
Revision surgery for bleeding	5	25
Pneumonia	4	20
Low cardiac output	3	15
Pleural effusion	2	10
Cerebrovascular event	1	5
Atrial fibrillation	1	5
Wound infection	1	5
Sternal dehiscence	1	5
Pericardial effusion	1	5
Pneumothorax	1	5
Hematoma in the neck incision (carotid incision)	1	5
Retrograde dissection	1	5

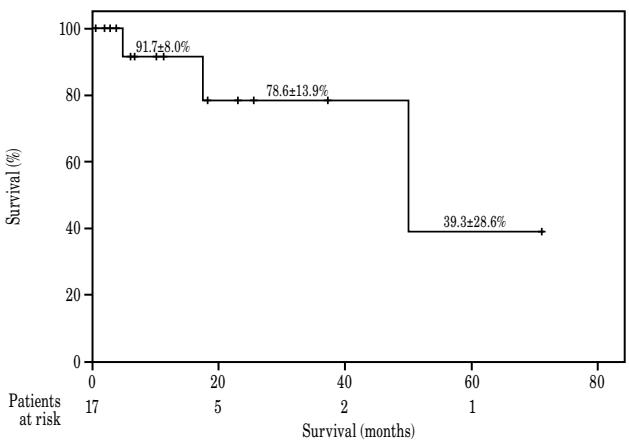

Figure 3. Survival curve

a right carotid bypass with a Dacron® graft. The debranching graft showed stenosis; however, the native carotid artery was patent and the patient did not have any problems during follow-up. This patient had a branch-bypass (to carotid) due to the dissection flap in the origin of the artery. However, as the proximal tear was closed and BioGlue® was applied to the dissected media at the anastomosis site, the native artery flow was reinstituted afterwards and probably the competitive flow caused the graft to occlude. This patient was still alive and well on Day 307 during follow-up.

DISCUSSION

This is a single-center outcome data for aortic dissection repair with a "branch-first" approach and the first report about this approach from Türkiye. The 30-day mortality was favorable (15%) for a complex group like this and the survival was satisfactory up to three years for the time being. In the UK registry, total arch replacement operations had 22.6% mortality, 14.5% non-fatal stroke, and 21.1% need for dialysis and re-exploration.[1] Our series showed similar mortality, but much lower stroke rates.

Although being devoid of a statistical significance, total arch replacement was associated with high mortality in a German retrospective analysis.[5] Arch replacement had 23.8% mortality and ascending aorta replacement with a 16.8% and the propensity matching showed a lack of significance. Salem et al.[5] reported 20.9% need for new-onset dialysis and 30.2% stroke rate postoperatively. These rates are significantly higher than the rates of postoperative morbidity in our study. Thus, debranching procedure with a branch-first approach seems a reasonable choice with this simple (though not conclusive) comparison. However, some very low rates of postoperative mortality (7%) and stroke (7%) after arch replacement have also been reported.[6]

The "branch-first" approach is not a totally new technique.[2-4] We have used simple tubular grafts different from the aforementioned techniques. Using a "hand-made" graft in such a debranching procedure may be demanding for the surgeon, but the cost decreases dramatically. Also, the surgeon has the chance of tailoring the graft according to the patient anatomy under direct vision. Of five cases requiring revision surgery for bleeding, only one was related to the branch-graft anastomosis. The rate of revision surgery was high (25%), although we do not think that the postoperative bleeding was related to these extra-anastomosis *per se*.

One of the reasons we preferred this hand-made technique is that we use this technique in urgent cases mostly unlike other reports.[3,4] Another technique with a Y-graft was reported by Orlov et al.[7] This graft was first introduced by Orlov et al.[7] and the results are compatible with the favorable outcome in the literature. Orlov et al.[7] reported 5% in-hospital mortality and the five- and 10-year survival rates were 78% and 73%, respectively.

Hybrid solutions for arch reconstruction were first classified in 2013 and the classification has been revised recently.[8] These debranching procedures aim to decrease the substantial mortality and morbidity associated with arch repair. The TEVAR procedure is combined with some form of debranching in these hybrid approaches. In general, trifurcated grafts are

utilized. We used debranching procedures with some form of conventional graft interposition in most cases. The TEVAR was used in two (10%) of the cases only. This is mostly due to the fact that the majority of our cases were operated in the emergency setting, and on-the-shelf grafts are not available in Türkiye in most centers and almost none of the cardiovascular surgery units all over the country have their own hybrid operating theatre. If the operating theaters can be converted to hybrid units, the rate of endovascular procedures would surely increase, particularly in these complicated aortic procedures. Except for a single arch aneurysm after a previous hemiarch repair, we did not encounter reoperation in our series. This was probably related to the relatively short-term follow-up. A Chinese report comparing the surgical and hybrid procedures' outcomes reported similar drop in survival after five years in hybrid group (from 82% at five years to 43.6% at nine years) compared to the surgical supra-arch repair which was dedicated to the endoleaks in the hybrid group.[9] Another Chinese study reported 78.3% survival rate at seven years.[10]

One of the main advantages expected from the antegrade perfusion and avoiding or limiting the TCA durations is to decrease the postoperative stroke rate. Our analysis is another contribution in this regard with a 5% stroke rate postoperatively. However, an important limitation is that we did not have a complete magnetic resonance imaging (MRI) control in all patients. An interesting randomized trial by Leshnower et al.[11] showed 100% embolization rate in antegrade perfusion contrary to the 45% embolization rate with retrograde cerebroplegia without a significant clinical difference or increased stroke rates. Elefteriades,[12] one of the important advocates of retrograde cerebroplegia with TCA from Yale University, continues to argue in favor of retrograde cerebroplegia; however, antegrade approach seems to be attracting more attention with the favorable clinical outcome data as mentioned above.

Much favorable results were reported from more experienced centers. The outcome data of more than 1,000 cases of arch repair was reported from Japan.[13] With a huge experience, they reported 5.2% hospital mortality and the survival rate at five and 10 years were 80.7% and 63.1%, respectively. Yanh et al.[6] reported the late outcomes after arch replacement in acute aortic dissection and the survival at 15 years was 72% and the cumulative rate for reoperation at 10 years was 12% and they found no significant difference with comparison with the hemiarch procedures. The survival was 78.6% at three years and fell abruptly afterwards in our analysis. However, the number of patients was low in the long-term follow-up which interferes with any decisive conclusion in our patient cohort. These reports also support the favorable outcome of debranching procedures in the long run. However, none of these papers reported the patency rates for the debranching grafts. In our series, only one patient had debranching graft stenosis; however, there was no clinically significant cerebrovascular event.

Aortic arch repair was recommended as a IIa recommendation in Society of Thoracic Surgeons (STS) consensus in Type A aortic dissection patients in following situations:[14] "primary entry tear in the arch or proximal descending thoracic aorta, brain or peripheral malperfusion, arch or descending thoracic aortic aneurysm or rupture". The STS document did not give specific recommendations regarding "branch-first" technique.

The main limitation of our report is the retrospective nature. The use of a hand-made graft also may pose some problems compared to an industrially prepared graft. However, we did not have increased bleeding or anastomosis problems in our cases. The lack of complete MRI analysis also precludes any significant conclusions be drawn about the cerebral protection; however, the clinical outcome is favorable. The long-term follow-up shows severely decreased survival after three years, but the number of patients-at-risk is low. The future analysis would provide more significant and meaningful conclusions as the patient number increases.

In conclusion, the "branch-first" technique is a feasible technique for aortic dissection repairs, when the arch branches should be intervened. The mortality is compatible with the literature and the morbidity is low.

Ethics Committee Approval: The study protocol was approved by the University of Health Sciences, Istanbul Research and Training Hospital Ethics Committee (Date: 14.01.2022, No: 20). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Patient Consent for Publication: A written informed consent was obtained from each patient.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions: Data collection, design: B.M.; Statistics, draft, final approval: A.P.

Conflict of Interest: The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

Funding: The authors received no financial support for the research and/or authorship of this article.

REFERENCES

1. Benedetto U, Dimagli A, Kaura A, Sinha S, Mariscalco G, Krasopoulos G, et al. Determinants of outcomes following surgery for type A acute aortic dissection: The UK National Adult Cardiac Surgical Audit. Eur Heart J 2021;43:44-52.
2. Matalanis G, Perera NK, Galvin SD. Aortic arch replacement without circulatory arrest or deep hypothermia: The "branch-first" technique. J Thorac Cardiovasc Surg 2015;149(2 Suppl):S76-82.
3. Perera N, Matalanis G. Trends and controversies in type A aortic surgery in the 21st century: Branch first aortic arch replacement. J Card Surg 2021;36:1766-9.
4. Kim M, Matalanis G. Technique and rationale for branch-first total aortic arch repair. JTCVS Tech 2020;4:1-4.
5. Salem M, Friedrich C, Rusch R, Frank D, Hoffmann G, Lutter G, et al. Is total arch replacement associated with an increased risk after acute type A dissection? J Thorac Dis 2020;12:5517-31.
6. Yang B, Norton EL, Shih T, Farhat L, Wu X, Hornsby WE, et al. Late outcomes of strategic arch resection in acute type A aortic dissection. J Thorac Cardiovasc Surg 2019;157:1313-21.e2.
7. Orlov CP, Orlov OI, Shah VN, Kilcoyne M, Buckley M, Sicouri S, et al. Total arch replacement with hypothermic circulatory arrest, antegrade cerebral perfusion and the Y-graft. Semin Thorac Cardiovasc Surg 2020;32:683-91.
8. Hughes GC, Vekstein A. Current state of hybrid solutions for aortic arch aneurysms. Ann Cardiothorac Surg 2021;10:731-43.
9. Qiao Z, Chen S, Guo R, Zhong Y, Ge Y, Li C, et al. Comparison of open repair vs. the one-stage hybrid extra-anatomic technique for distal aortic arch disease treatment: Mid-term outcomes with a risk-adjusted analysis. Front Cardiovasc Med 2021;8:725902.
10. Chen SW, Zhong YL, Qiao ZY, Li CN, Ge YP, Qi RD, et al. One-stage hybrid procedure for distal aortic arch disease: Mid-term experience at a single center. J Thorac Dis 2020;12:7117-26.
11. Leshnower BG, Rangaraju S, Allen JW, Stringer AY, Gleason TG, Chen EP. Deep hypothermia with retrograde cerebral perfusion versus moderate hypothermia with antegrade cerebral perfusion for arch surgery. Ann Thorac Surg 2019;107:1104-10.
12. Elefteriades JA, Ziganshin BA. Commentary: Surgery is an art. JTCVS Tech 2020;4:7-9.
13. Minatoya K, Inoue Y, Sasaki H, Tanaka H, Seike Y, Oda T, et al. Total arch replacement using a 4-branched graft with antegrade cerebral perfusion. J Thorac Cardiovasc Surg 2019;157:1370-8.
14. Malaisrie SC, Szeto WY, Halas M, Girardi LN, Coselli JS, Sundt TM 3rd, et al. 2021 The American Association for Thoracic Surgery expert consensus document: Surgical treatment of acute type A aortic dissection. J Thorac Cardiovasc Surg 2021;162:735-58.e2.