Asian Journal of Surgery (2019) 42, 482–487

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.e-asianjournalsurgery.com

ORIGINAL ARTICLE

Supra-aortic vessel reconstruction in total arch replacement for acute type A dissection: Comparison of en bloc and separate graft techniques

Yi Lin, Wei-Guo Ma, Jun Zheng, Xiao-Yan Xing, Xu-Dong Pan, Jun-Ming Zhu, Li-Zhong Sun*

Department of Cardiovascular Surgery, Beijing Aortic Disease Center, Beijing Anzhen Hospital, Capital Medical University, Beijing Institute of Heart, Lung and Blood Vessel Diseases, Beijing 100029, China

Received 23 August 2018; received in revised form 19 September 2018; accepted 25 September 2018
Available online 28 October 2018

KEYWORDS
Aortic dissection;
Aortic arch;
Surgery;
Total arch replacement;
Vascular prosthesis/frozen elephant trunk

Summary *Objective:* To compare the outcomes of the en bloc and branched graft techniques for supra-aortic vessel reconstruction in total arch replacement (TAR) for acute type A aortic dissection (ATAAD).
Methods: In 53 ATAAD patients with intact supra-aortic arch vessels undergoing TAR, the arch vessels were reconstructed using the branched graft technique in 35 patients and en bloc technique in 18, i.e. reimplantation of the innominate artery and the left carotid artery (LCA) and transposition of left subclavian artery to LCA. The early and mid-term outcomes were compared between two groups.
Results: The selective antegrade cerebral perfusion time in en bloc group was significantly longer (33 ± 10 vs 24 ± 7 min, $p = 0.001$). Operative mortality was 5.7% (3/53), including 1 and 2 in the en bloc and branched graft groups, respectively (5.6% vs 5.7%, $p = 0.981$). Stroke occurred in 1 patient. No spinal cord injury occurred. At mean 4.3 ± 1.6 years, clinical and CT follow-up were complete in 100% and 86% (43/50). No cerebrovascular accidents or upper extremity claudication occurred. There were 4 deaths and 1 reintervention in follow-up. Survival was 88.6% and 88.9% at 3 months, and 83.3% and 88.6% at 6 months, 3 and 5 years in the en bloc and branched graft groups, respectively ($p = 0.597$). The arch vessels were patent in 100% (43/43) without stenosis or aneurysm.
Conclusions: The modified en bloc technique could achieve comparable early and mid-term outcomes to the branched graft technique in patients undergoing TAR for ATAAD. This approach may be an alternative technique for ATAAD patients with intact supra-aortic arch vessels.

* Corresponding author. Beijing Aortic Disease Center, Beijing Anzhen Hospital, Capital Medical University, 2 Anzhen Rd, Beijing 100029, China.
E-mail address: lizhongsun@outlook.com (L.-Z. Sun).

https://doi.org/10.1016/j.asjsur.2018.09.011
1015-9584/© 2018 Asian Surgical Association and Taiwan Robotic Surgery Association. Publishing services by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

© 2018 Asian Surgical Association and Taiwan Robotic Surgery Association. Publishing services by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

1. Introduction

Surgical treatment remains the standard of care for patients with acute type A aortic dissection (ATAAD).[1,2] However, there has been continued controversy regarding the optimal surgical approach.[3–6] In patients with an arch entry tear or proximal descending aortic dilation, total arch replacement (TAR) with frozen elephant trunk (FET) has achieved satisfactory outcomes.[7–11] There are two broad categories of methods for aortic arch reconstruction during TAR: the en-bloc (island) technique and the branched graft technique. Although literature shows that both methods could achieve similar results,[12,13] there is no consensus on which approach is the preferred for arch vessel reconstruction.[14] In our team, the separate graft technique has been the standard technique for TAR since 2003.[15] Since 2011, we started using a modified en bloc technique, i.e., en bloc reimplantation of the innominate artery (IA) and the left carotid artery (LCA) and transposition of the left subclavian artery (LSA) to left carotid artery in an end-to-side fashion during TAR + FET.[16] In this study, we seek to compare the two arch reconstruction techniques with respect to operative mortality and morbidity, survival, reoperation and CT imaging in the medium term for patients with ATAAD.

2. Material and methods

The Ethics Committee of Beijing Anzhen Hospital, Capital Medical University approved this retrospective study.

2.1. Patient population

Between May 2013, and April 2014, we operated on 176 patients with ATAAD (all DeBakey type I) using the TAR + FET technique. Among them, 53 patients had intact supra-aortic vessels, i.e., their aortic arch were free from aneurysm and dissection. Mean age was 46.1 ± 10.1 years (range 18—64) and 41 were male. Of those 53 patients, 35 (66%) were managed with separate graft technique and 18 were managed with the en-bloc approach. The time from symptom onset to surgery was 4.3 ± 4.0 days. As shown in Table 1, the two groups did not differ significantly in terms of preoperative demographics, including age, gender, body mass index, comorbidities, time from onset to surgery (day) and malperfusion. The en bloc group had a significantly higher percentage of entry tear in the ascending aorta, seen in 83.3% of patients (15/18) compared to the separate graft group (18/35, 51.4%; $p = 0.023$).

Table 1 Preoperative profile.

Variable	Whole cohort ($n = 53$)	Branch graft group ($n = 35$)	En bloc group ($n = 18$)	p Value
Age (year)	46.3 ± 9.4	46.1 ± 10.1	46.8 ± 8.0	0.811
Male gender	41 (77.4%)	26 (74.3%)	15 (83.3%)	0.214
Height (cm)	170.6 ± 7.2	170.9 ± 7.6	170.0 ± 6.5	0.675
Weight (kg)	76.5 ± 13.9	77.1 ± 15.6	75.4 ± 10.0	0.683
Body mass index (kg/m^2)	26.5 ± 3.7	26.2 ± 4.3	26.7 ± 2.3	0.895
Time from onset to surgery (day)	4.3 ± 4.0	4.5 ± 3.9	3.9 ± 4.2	0.592
Comorbidity				
Hypertension	44 (83.0%)	30 (85.7%)	14 (77.8%)	0.466
Prior cardiac surgery	2 (3.8%)	0	2 (11.1%)	0.340
Coronary artery disease	6 (11.3%)	6 (17.1%)	0	0.062
Cerebral hemorrhage	1 (1.9%)	0	1 (5.6%)	0.159
Chronic renal dysfunction	4 (7.5%)	3 (8.6%)	1 (5.6%)	0.694
Malperfusion				
Preoperative tamponade	3 (5.7%)	2 (5.7%)	1 (5.6%)	0.981
Cerebral ischemia	1 (1.9%)	1 (2.9%)	0	0.469
Acute visceral ischemia	2 (3.8%)	2 (5.7%)	0	0.301
Acute renal failure	2 (3.8%)	2 (5.7%)	0	0.301
Lower extremity ischemia	5 (9.4%)	5 (14.3%)	0	0.092
Location of entry tear				
Ascending aorta	33 (62.3%)	18 (51.4%)	15 (83.3%)	0.023
Transverse arch	9 (17.0%)	7 (20%)	2 (11.1%)	0.476
Proximal descending aorta	8 (15.1%)	7 (20%)	1 (5.6%)	0.240
Unidentified	3 (5.7%)	3 (8.6%)	0	0.314

2.2. Surgical indications and techniques

Our indication for TAR + FET in patients with ATAAD are: (1) entry tear in the arch or descending aorta; (2) dissection, occlusion, or aneurysm of the arch vessels; (3) intimal intussusception in the arch; (4) concomitant connective tissue disorders such as Marfan syndrome; (5) dissection in a dilated arch >4 cm in diameter and extending beyond the descending aorta.[17] During TAR + FET, we would use the modified en bloc technique if the innominate artery (IA) and left carotid artery (LCA) are intact, i.e., free from dissection, aneurysm, atherosclerosis and occlusion. For patients with connective tissue disorders, we prefer using the separate graft technique for arch reconstruction.

Our surgical techniques of TAR + FET have been described in detail previously.[16,18–20] Briefly, right axillary artery cannulation is used for cardiopulmonary bypass (CPB) and unilateral selective antegrade cerebral perfusion (uSACP) under moderate hypothermic circulatory arrest (HCA) at 25 °C. The left sternocleidomastoid and ambient muscles are partially transected and the arch branches are adequately exposed. The transverse arch is transected between the LCA and LSA. A frozen elephant trunk, Cronus® (MicroPort Medical, Shanghai, China) is deployed in the descending aorta. Arch reconstruction was achieved using a 4-branched vascular graft (Maquet Cardiovascular, Rastatt, Germany) or modified en bloc technique. The "island" of the arch we use is smaller than that used in the traditional en bloc technique and just contains the IA and the LCA. After the IA and LCA are confirmed to be free of dissection, aneurysm or arteriosclerosis, a straightened Dacron graft was trimmed to match and sewn to the "island" surrounding the IA and the LCA. During rewarming, the LSA is transected and oversewn and then anastomosed to the LCA in an end-to-side manner (Fig. 1).[16]

Figure 1 Sagittal reconstructed computed tomographic images after total arch replacement for acute type A aortic dissection: A) at 33 months in 70-year-old male with the modified en bloc technique; B) at 34 months in a 57-year-old male with the separate graft technique.

All operative survivors were followed up regularly and recommended to have computed tomography (CT) scan at 3, 6 months and thereafter annually to detect vessel and graft patency, endoleak, thrombosis and obliteration of the false lumen, residual intimal tear or distal new entry, aneurysmal dilatation in the distal aortic segments and other complications.

2.3. Statistical analysis

All statistical analyses were performed using SPSS for Windows 19.0 (SPSS Inc, Chicago, IL). Data were presented as the mean ± standard deviation (SD) or number and percentage as appropriate. Student's *t*-test and chi-square test were used for continuous and categorical variables respectively. Survival was analyzed with the Kaplan–Meier method and compared using the log-rank test. Any two-tailed *p* value of <0.05 was considered statistically significant.

3. Results

3.1. Operative data

The time of cardiopulmonary bypass (CPB) and cross-clamp were 190 ± 66 and 204 ± 61 min ($p = 0.444$), 98 ± 43 and 113 ± 36 min ($p = 0.169$) in the en bloc and branched graft groups, respectively. SACP time was significantly longer in the en bloc group compared to branched graft group (33 ± 10 vs 24 ± 7 min, $p = 0.001$).

Concomitant surgical procedures and amount of transfused blood products did not differ between two groups (Table 2).

3.2. Operative mortality and morbidity

Operative mortality was 5.7% (3/53) for the whole cohort. One patient (5.6%, 1/18) of the en bloc group died of cerebral infarction at 4 days postoperatively. In the branched graft group, one patient died of multiorgan failure at 11 postoperative days and another with preoperative acute lung injury died of ischemic hypoxic encephalopathy at 12 days after operation.

Cerebral infarction occurred in 1 patient (5.6%) in the en bloc group, who eventually expired at 4 postoperative days. No patient sustained spinal cord injury in both groups. Reexploration for bleeding was required in 4 patients (11.4%) with the branched graft technique. In the branched graft group, 5 patients sustained acute kidney failure, which was resolved after continuous renal replacement therapy (CRRT); two patients developed multiorgan failure that necessitated support with extracorporeal membrane oxygenation (ECMO), one of whom recovered and the other expired. One patient experienced slight weakness of the left lower extremity at discharge, which was thought to be due to lower limb ischemia and resolved during follow-up. The time of mechanical ventilation (33 ± 31 vs 87 ± 112 h, $p = 0.053$) and length of ICU stay (112 ± 125 vs 51 ± 38 h, $p = 0.051$) were shorter in the en bloc group, almost reaching significant difference (Table 2).

Table 2 Operative data and early outcomes.

Variable	Whole cohort (n = 53)	Branched graft group (n = 35)	En bloc group (n = 18)	p Value
Procedural times (min)				
Cardiopulmonary bypass	199 ± 62	204 ± 61	190 ± 66	0.444
Cross-clamp	108 ± 39	113 ± 36	98 ± 43	0.169
SACP	27 ± 9	24 ± 7	33 ± 10	0.001
Concomitant procedure				
Bentall procedure	17 (32.1%)	13 (37.1%)	4 (22.2%)	0.270
Wheat procedure	1 (1.9%)	1 (2.9%)	0	0.469
David procedure	1 (1.9%)	1 (2.9%)	0	0.469
Aortic valve resuspension	2 (3.8%)	2 (5.7%)	0	0.301
Coronary artery bypass grafting	5 (9.4%)	5 (14.3%)	0	0.092
Ascending aortic—femoral bypass	1 (1.9%)	1 (2.9%)	0	0.469
Blood transfusion				
Packed red blood cells (unit)	5.4 ± 6.8	6.3 ± 7.8	3.6 ± 4.1	0.178
Fresh frozen plasma (ml)	840.0 ± 718.0	945.7 ± 800.5	633.3 ± 476.5	0.135
Platelets (unit)	1.4 ± 1.9	1.6 ± 2.2	0.8 ± 1	0.156
Early outcomes				
Ventilation time (h)	68.6 ± 95.4	86.7 ± 111.6	33.3 ± 30.5	0.053
Length of ICU stay (h)	91.5 ± 107.6	112.1 ± 125.2	51.4 ± 38.4	0.051
Operative mortality	3 (5.7%)	2 (5.7%)	1 (5.6%)	0.981
Operative complications				
Reexploration for bleeding	4 (7.5%)	4 (11.4%)	0	0.136
Stroke	1 (1.9%)	0	1 (5.6%)	0.159
Spinal cord injury	0	0	0	NA
CRRT for acute renal failure	5 (9.4%)	5 (14.3%)	0	0.092
Lower extremity ischemia	1 (1.9%)	1 (2.9%)	0	0.469

SACP, selective antegrade cerebral perfusion; ICU, intensive care unit; CRRT, continuous renal replacement therapy; NA, not applicable.

3.3. Mid-term outcomes

At a mean duration of 4.3 ± 1.2 years (range 0.1—5.2; median 4.6), follow-up was complete in 100% and CT scan was available in 86% (43/50).

3.3.1. Survival

Four patients died during follow-up. In the branched graft group, 2 patients died from infection and multiorgan failure at 2 and 3 months, respectively. In the en bloc group, one patient died at 2 months due to wound infection and another patient died from unknown reasons at 5 months.

The remaining 46 patients were doing well at the latest follow-up. No cerebrovascular accidents occurred. Nor did any patient complain of upper or lower extremity weakness or claudication.

For the whole cohort, survival was 92.5% at 1 month, 88.7% at 3 months, and 86.8% at 1 year and thereafter, respectively. The survival rates were 88.6% (95% confidence interval, CI, 72.4—95.6%) and 88.9% (62.4—97.1%) at 3 months, and 83.3% (56.8—94.3%) and 88.6% (72.4—95.6%) at 6 months, 1 year, 3 and 5 years, in the en bloc and branched graft groups, respectively (p = 0.597) (Fig. 2).

3.3.2. Reintervention

One patient of the branched graft group was found to develop a new entry tear distal to the frozen elephant trunk on follow-up CT at 5 months after TAR. He was successfully managed with thoracic endovascular aortic repair (TEVAR). No reinterventions on the proximal aorta and arch vessels were required to the latest follow-up.

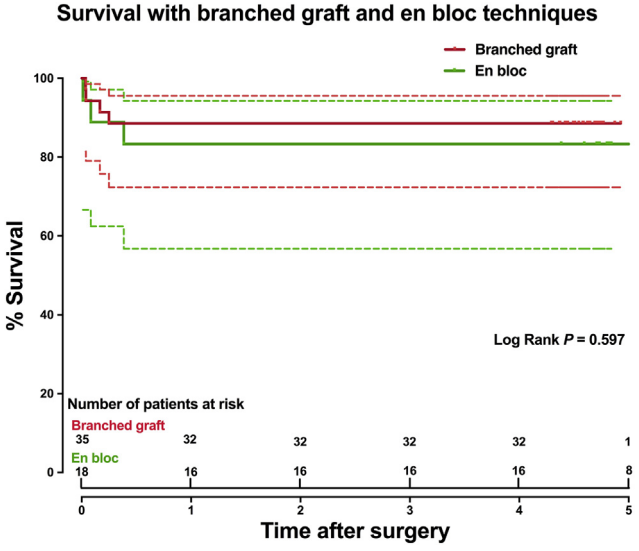

Figure 2 Survival in patients with the branched graft and en bloc techniques did not differ significantly.

3.3.3. CT imaging

CTA was available in 93.5% (29/31) of patients in the branched graft group and 93.3% (14/15) in the en bloc group. The supra-aortic vessels were patent in 100% (43/43) without stenosis or aneurysm on CTA, which did not differ between two groups. In the en bloc group, the blood flow across the anastomosis of LSA-LCCA was unobstructed in 100% (14/14) (Fig. 2).

4. Discussion

Although the extensive total arch replacement and frozen elephant trunk has achieved favorable short- and long-term outcomes in experienced centers,[16,18,21] continuous debates exist regarding the optimal method for arch vessel reconstruction during TAR and few studies have compared the outcomes of the en bloc vs the separate branch techniques in a homogenous patient population.

The en bloc (island) technique was widely used for replacement of the entire aortic arch in the past, but more and more centers prefer to use the branched graft technique in recent years.[22] A retrospective study from Europe for patients with connective tissue disorders have shown that the residual aortic tissue left during en bloc reimplantation of the supra-aortic branches will dilate over time and may result in the need for reintervention.[23] Kazui and associates argue that the separated branch graft technique has several advantages over the en-bloc technique including: (a) it can be safely used in patients with degenerative, atherosclerotic aneurysm or acute type A aortic dissection and; (b) vascular prostheses used for the separated graft technique are commercially available collagen-pretreated 4-branched aortic arch graft, which helps simplify the conduct of the operation.[14] In contrast, colleagues from European centers came to an opposite conclusion. Shrestha and colleagues maintain that the branched graft technique is not inferior to the en bloc technique perioperatively or in mid-term follow-up based on a retrospective study of 103 patients undergoing TAR.[13] Di Eusanio from Italy reached the same conclusion from a multicenter retrospective study of 352 patients.[12] Recently, Schoenhoff and associates have reported similar findings and found no difference in stroke and mortality rates with the two techniques.[22]

However, one major limitation of the above-mentioned studies is the patient heterogeneity in terms of etiology (Marfan vs non-Marfan), pathology (dissection vs aneurysm), and urgency of operation (acute vs chronic dissection). It is unclear in these studies whether the en bloc and separate branch graft techniques were compared in patients with identical arch and supra-aortic pathologies. The en bloc and separate graft techniques may be performed in different patients, thus the comparison of early and late surgical outcomes was less intuitive and convincing. In the present study, only patients with acute type A dissection who had an intact innominate and left carotid arteries were selected, which ensures a more homogenous patient cohort to compare the two arch reconstruction techniques. Although the sample size is small, the homogeneity of patients is an advantage of our study. The results of this study have shown that the early and mid-term outcomes of our modified en bloc technique are similar to those of the separate graft technique in respect to mortality and morbidity, late survival and reoperation, late graft patency and patient symptoms.

Compared to the results of the en bloc techniques used in centers of excellence,[12,13] our modified en bloc technique is associated with shorter CPB, DHCA and cross-clamp times. The averages durations of CPB, cross-clamp and DHCA were 249 and 215, 147 and 131, and 59 and 70 min in European experience,[12,13] compared to 190, 98 and 33 min in the present series. These shorter durations may result from the difference in the anastomotic sequence for arch vessel reconstruction. In the classic en bloc technique, all the anastomoses have to be completed, namely the distal and proximal anastomoses as well as reimplanting the supra-aortic 'island' to the aortic graft before myocardial, cerebral and lower body perfusion is resumed. After establishing selective antegrade cerebral perfusion, it requires a period of DHCA for approximately 30 min to complete two anastomoses (proximal and distal) to reimplant the arch vessels. In our modified en bloc technique, only one anastomosis is required, which comprises the en bloc cuff, the proximal end of the frozen elephant trunk before perfusion is resumed to the brain and lower body, Proximal anastomosis was performed during the rewarming phase.[16] In addition, the en bloc cuff contains two ostia of arch vessels (IA and LCA). It is smaller in area compared to the classic en bloc technique, which allows for easier manipulation, better surgical view and facilitates hemostasis. These are associated with a shorter duration of DHCA, SCAP and CPB, all of which are well recognized risk factors for adverse events after cardiac and aortic surgery.[12,17,24,25] The reduction of DHCA, SCAP and CPB times, together with preservation of the innominate and left carotid arteries help minimize early adverse outcomes and avoid the risk of anastomotic stenosis seen in separate graft technique, which may lead to better long-term outcomes.

This retrospective study has several limitations, including the small sample size and relatively short duration of follow-up. One important weakness is the selection bias associated with the delay in surgery (4.3 days). The main reason for this delay was that more than 80% of our patients had been referred and transferred from outlaying hospitals, which in many cases is a long distance away. In our recent series of 832 patients with TAAD, the average distance of transfer was 405 miles (650 km) and the chance of getting surgical repair within the first 48 h from onset was significantly influenced by transfer distance (in miles) (odds ratio, 0.998; 95% confidence interval, 0.997—0.999; $p < 0.001$). This means that with every mile added during transfer, the chance of getting surgery would be decreased by 0.2%, which accounts for, to a large extent, the delay in surgery in this series.[15,26] As a result of this natural selection, we were operating on a subset of lower-risk patients and survivors of the early hazard phase of aortic dissection. Despite the patient homogeneity in this series, i.e., all acute type A dissection with intact innominate and left carotid arteries, the numbers of patients are not equal in two groups, which may skew the estimate and limit the statistical power. In addition, our modified en bloc technique is technically complex and poses very high demands on surgical proficiency. Up to date, the separate graft

technique remains the standard of care for patients with acute type A dissection undergoing total arch replacement in our team. Therefore, this technique is not applicable to all patients with acute type A dissection.

5. Conclusions

In this series of patients with acute type A aortic dissection, our modified en bloc technique was associated with shorter CPB and cross-clamp times compared with the separate graft technique. The results of this study show that the modified en bloc technique could achieve comparable early and mid-term outcomes to the separate graft technique, including mortality and morbidity, late survival and reoperation, late patency and patient symptoms. Our modified en bloc technique may be a feasible alternative approach for ATAAD patients with intact supra-aortic vessels.

Funding

Supported in part by 1) the Special Fund for Clinical Medicine Development from Beijing Municipal Administration of Hospitals (ZYLX201503); and 2) the National Key Technology R & D Program (2015BAI12B03).

Conflicts of interest

The authors have no conflicts of interest to declare.

References

1. Knipp BS, Deeb GM, Prager RL, Williams CY, Upchurch Jr GR, Patel HJ. A contemporary analysis of outcomes for operative repair of type A aortic dissection in the United States. *Surgery*. 2007;142:524—528. Discussion 8 e1.
2. Geirsson A, Bavaria J, Swarr D, et al. Fate of the residual distal and proximal aorta after acute type A dissection repair using a contemporary surgical reconstruction algorithm. *Ann Thorac Surg*. 2007;84:1955—1964.
3. Gariboldi V, Grisoli D, Kerbaul F, et al. Long-term outcomes after repaired acute type A aortic dissections. *Interact Cardiovasc Thorac Surg*. 2007;6:47—51.
4. Halstead JC, Meier M, Etz C, et al. The fate of the distal aorta after repair of acute type A aortic dissection. *J Thorac Cardiovasc Surg*. 2007;133:127—135.
5. Spielvogel D, Etz CD, Silovitz D, Lansman SL, Griepp RB. Aortic arch replacement with a trifurcated graft. *Ann Thorac Surg*. 2007;83:791—795. Discussion 824—31.
6. Waterford SD, Gardner RL, Moon MR. Extent of aortic replacement in type A dissection: current answers for an endless debate. *Ann Thorac Surg*. 2018. https://doi.org/10.1016/j.athoracsur.2018.03.088.
7. Sun L, Qi R, Zhu J, Liu Y, Zheng J. Total arch replacement combined with stented elephant trunk implantation: a new "standard" therapy for type a dissection involving repair of the aortic arch? *Circulation*. 2011;123:971—978.
8. Di Bartolomeo R, Pantaleo A, Berretta P, et al. Frozen elephant trunk surgery in acute aortic dissection. *J Thorac Cardiovasc Surg*. 2015;149:S105—S109.
9. Hoffman A, Damberg AL, Schalte G, Mahnken AH, Raweh A, Autschbach R. Thoracic stent graft sizing for frozen elephant trunk repair in acute type A dissection. *J Thorac Cardiovasc Surg*. 2013;145:964—969 e1.
10. Roselli EE, Rafael A, Soltesz EG, Canale L, Lytle BW. Simplified frozen elephant trunk repair for acute DeBakey type I dissection. *J Thorac Cardiovasc Surg*. 2013;145:S197—S201.
11. Chen LW, Dai XF, Lu L, Zhang GC, Cao H. Extensive primary repair of the thoracic aorta in acute type A aortic dissection by means of ascending aorta replacement combined with open placement of triple-branched stent graft: early results. *Circulation*. 2010;122:1373—1378.
12. Di Eusanio M, Schepens MA, Morshuis WJ, et al. Separate grafts or en bloc anastomosis for arch vessels reimplantation to the aortic arch. *Ann Thorac Surg*. 2004;77:2021—2028.
13. Shrestha M, Martens A, Behrendt S, Maeding I, Koigeldiyev N, Haverich A. Is the branched graft technique better than the en bloc technique for total aortic arch replacement? *Eur J Cardiothorac Surg*. 2014;45:181—186. Discussion 6—7.
14. Kazui T. Total arch replacement with separated graft technique and selective antegrade cerebral perfusion. *Ann Cardiothorac Surg*. 2013;2:353—357.
15. Ma WG, Zhang W, Wang LF, et al. Type A aortic dissection with arch entry tear: surgical experience in 104 patients over a 12-year period. *J Thorac Cardiovasc Surg*. 2016;151:1581—1592.
16. Zhu JM, Qi RD, Chen L, et al. Surgery for acute type A dissection using total arch replacement combined with stented elephant trunk implantation: preservation of autologous brachiocephalic vessels. *J Thorac Cardiovasc Surg*. 2015;150:101—105.
17. Ma WG, Zheng J, Zhang W, et al. Frozen elephant trunk with total arch replacement for type A aortic dissections: does acuity affect operative mortality? *J Thorac Cardiovasc Surg*. 2014;148:963—970. Discussion 70—2.
18. Gong M, Ma WG, Guan XL, et al. Moderate hypothermic circulatory arrest in total arch repair for acute type A aortic dissection: clinical safety and efficacy. *J Thorac Dis*. 2016;8:925—933.
19. Ma WG, Zheng J, Liu YM, Zhu JM, Sun LZ. Dr. Sun's procedure for type A aortic dissection: total arch replacement using tetrafurcate graft with stented elephant trunk implantation. *Aorta (Stamford)*. 2013;1:59—64.
20. Ma WG, Zhu JM, Zheng J, et al. Sun's procedure for complex aortic arch repair: total arch replacement using a tetrafurcate graft with stented elephant trunk implantation. *Ann Cardiothorac Surg*. 2013;2:642—648.
21. Sun L, Qi R, Chang Q, et al. Surgery for acute type A dissection with the tear in the descending aorta using a stented elephant trunk procedure. *Ann Thorac Surg*. 2009;87:1177—1180.
22. Schoenhoff FS, Tian DH, Misfeld M, et al. Impact of reimplantation technique of supra-aortic branches in total arch replacement on stroke rate and survival: results from the ARCH registry. *Eur J Cardio Thorac Surg*. 2018 May 8. https://doi.org/10.1093/ejcts/ezy194 [Epub ahead of print].
23. Schoenhoff FS, Kadner A, Czerny M, et al. Should aortic arch replacement be performed during initial surgery for aortic root aneurysm in patients with Marfan syndrome? *Eur J Cardio Thorac Surg*. 2013;44:346—351. Discussion 51.
24. Preventza O, Garcia A, Cooley DA, et al. Reoperations on the total aortic arch in 119 patients: short- and mid-term outcomes, focusing on composite adverse outcomes and survival analysis. *J Thorac Cardiovasc Surg*. 2014;148:2967—2972.
25. Pocar M, Passolunghi D, Moneta A, Donatelli F. Recovery of severe neurological dysfunction after restoration of cerebral blood flow in acute aortic dissection. *Interact Cardiovasc Thorac Surg*. 2010;10:839—841.
26. Ma WG, Wang LF, Peterss S, et al. Frozen elephant trunk for type A aortic dissection: interactions of transfer distance, acuity and mortality. *J Am Coll Cardiol*. 2016;67:2273.