Frozen Elephant Trunk Procedure for Treatment of Acute Complicated Type B Aortic Dissections

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ABSTRACT

Introduction: This study aimed to define midterm clinical outcomes and morphological changes of acute complicated type B aortic dissections after the application of frozen elephant trunk technique.

Patients and Methods: Data were collected from 143 patients treated with frozen elephant trunk procedure for complex thoracic aortic diseases between May 2012 and October 2018. Twenty-seven patients with acute complicated type B aortic dissection were included in the study.

Results: The mean age of the study population was 56.9 ± 9.1 years, and 23 (85.2%)patients were male. Complete false lumen thrombosis in the descending aorta before the distal end of the stent graft was achieved in 88.9% of cases. There was no late mortality observed at a mean follow-up of 50.7 ± 22.5 months. Only one patient died due to multiple organ failure 62 days after the operation. Five patients underwent secondary distal aortic endovascular repair because of stent graft-induced new entry (n= 3) and second-stage treatment for post-dissection aneurysm (n= 2).

Conclusion: Aortic arch involvement in acute complicated type B aortic dissections requires more extensive treatment, and frozen elephant trunk procedure serves as an alternative treatment modality.

Key Words: Aortic pathology; descending aorta; false lumen; frozen elephant trunk; type B dissection

Komplike Akut Tip B Aortik Diseksiyonların Tedavisinde Donmuş Fil Hortumu Prosedürü

ÖZET

Giriş: Bu çalışma, akut komplike tip B aortik diseksiyonlarında donmuş fil hortumu tekniği uygulanmasından sonraki orta dönem klinik sonuçları ve morfolojik değişikleri tanımlamayı amaçlamıştır.

Hastalar ve Yöntem: Veriler, Mayıs 2012-Ekim 2018 tarihleri arasındaki kompleks torasik aorta hastalıkları nedeniyle donmuş fil hortumu prosedürü ile tedavi edilen 143 hastadan toplandı. Akut komplike tip B aortik diseksiyonu olan 27 hasta çalışmaya dahil edildi.

Bulgular: Çalışma popülasyonunun ortalama yaşı 56.9 ± 9.1 yıl ve 23 (%85.2) hasta erkekti. Olguların %88.9'unda stent-greft seviyesindeki inen aortada tam yalancı lümen trombozu sağlandı. Ortalama 50.7 ± 22.5 aylık takipte geç dönem mortalite gözlenmedi. Sadece bir hasta operasyondan 62 gün sonrasında çoklu organ yetmezliği nedeniyle kaybedildi. Beş hastaya stent-greft kaynaklı yeni yırtık (n= 3) ve postdiseksiyon anevrizması (n= 2) için ikinci bir distal aortik endovasküler onarım yapıldı.

Sonuç: Akut komplike tip B aortik diseksiyonlarda arkus aortanın tutulumu daha genişletilmiş bir tedavi gerektirmektedir ve donmuş fil hortumu prosedürü bu yönde hizmet eden alternatif bir yöntemdir.

Anahtar Kelimeler: Aortic patoloji; donmuş fil hortumu; tip B aortik diseksiyon; inen aorta; yalancı lümen

INTRODUCTION

Acute complicated type B aortic dissection is associated with a high risk of early death if untreated[1]. Even in cases of survival in the acute phase, presence of a patent false lumen is a risk factor for late aortic complications that may develop because of aneurysmatic enlargement. With today's current approach, thoracic endovascular aortic repair (TEVAR), we can successfully treat the majority of patients with type B aortic dissection. Even so, presence of any contraindication for endovascular procedures necessitates additional cardiac surgery, or in cases of aortic disease where aortic arch involvement is also present, TEVAR alone can-

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not offer adequate treatment and more extensive treatment options are required. In our study, we evaluated the outcomes of treatment of acute complicated type B aortic dissections with complex thoracic aortic disease using the frozen elephant trunk (FET) technique.

PATIENTS and METHODS

Ethics committee approval was received for this study from the Health Sciences University Kartal Kosuyolu High Specialty Training and Research Hospital Non-Interventional Clinical Researches Ethics Committee (Decision Number: 2017.6/10-54; Decision Date: August 22, 2017).

Data were collected from 143 patients treated with FET procedure due to complex thoracic aortic diseases between May 2012 and October 2018. Twenty-seven patients with complicated acute type B aortic dissection were included in the study. The mean age of the study population was 56.9 ± 9.1 years and 23 (85.2%) patients were male. Data on patient demographics, indications for intervention, risk factors, procedures, and outcomes were collected. Thoracoabdominal computerized tomographic angiography (CTA) was used for diagnosis and follow-up of aortic pathologies. The preoperative clinical details and patient characteristics are presented in Table 1.

The proximal intimal tear was located in the proximal descending thoracic aorta in all cases. The maximal diameter of the descending thoracic aorta was 51.6 ± 11.9 mm; the maximal diameters of the ascending aorta and aortic arch were 45.5 ± 7.7 mm and 39.9 ± 8.2 mm, respectively. Patient inclusion criteria were FET procedure being applied, ascending aorta and aortic arch diameter of 40 mm and more, and the thrombosed false lumen extending to the aortic arch. Patients who underwent surgery within the first 14 days from the start of back pain and other symptoms were considered as acute dissection. Complicated type B aortic dissection was defined as aortic rupture or impending rupture (pleural effusion, hematoma, or eccentric bulging), visceral and renal ischemia, lower extremities ischemia or spinal cord ischemia, persistent pain, and uncontrolled hypertension despite maximal medical therapy or rapid early diameter expansion on CTA.

Table 1. Patient characteristics

	Overall	%
Age	56.9 ± 9.1	
Male	23	85.2
CAD	3	11.1
EF < 50%	3	11.1
COPD	4	14.8
Diabetes mellitus	3	11.1
Creatinine > 2 mg/dL	4	14.8
History of stroke	1	3.7
ARSA	2	7.4
Valve disease:		
AR	2	7.4
MR	2	7.4
Surgical indications		
Impending rupture	2	7.4
Persistent pain	9	33.3
Malperfusion		
Visceral	4	14.8
Iliofemoral	2	7.4
Spinal	2	7.4
Rapid diameter expansion	3	11.1
Uncontrolled hypertension	5	7.4
Aortic diameters (mm)		
Ascending aorta	45.5 ± 7.7	
Aortic arch	39.9 ± 8.2	
Descending aorta	51.6 ± 11.9	

AR: Aortic regurgitation, ARSA: Aberrant right subclavian artery, CAD: Coronary artery disease, COPD: Chronic obstructive pulmonary disease, EF: Ejection fraction, MR: Mitral regurgitation, TEVAR: Thoracic endovascular repair.

Surgical Technique

In our study, E-vita Open Plus (JOTEC® GmbH, Germany) prostheses were used in all cases. Central venous catheter, arterial monitoring at left arm, and near-infrared spectroscopy (NIRS) were routinely used in all of our patients. Aortic arch repair was performed at moderate hypothermia using unilateral selective antegrade cerebral perfusion (flow rate= 10-15 mL/kg/min). In any case of a significant decrease in saturation levels at NIRS, bilateral antegrade selective cerebral perfusion was initiated.

Median sternotomy was performed in all patients. Right subclavian artery was used for direct arterial cannulation and venous drainage was provided through the right atrium. A venting cannula was placed through the upper-right pulmonary vein. Myocardial protection was ensured with blood cardioplegia. Supracoronary aortic repair was done during cooling phase. When nasopharyngeal temperature reached to 26°C, aortic clamp was removed and selective antegrade cerebral perfusion was started. E-vita Open Plus prosthesis was introduced and released in an antegrade fashion into the true lumen of the descending aorta over the guidewire with the guidance of transesophageal echocardiography and was fixed to the aorta.

Table 2. Operational data

	Overall [n (%)]
Temperature (C), mean ± SD	26 ± 1.7
Total perfusion time (min), mean ± SD	158.2 ± 47.1
ASCP time (min), mean ± SD	71.5 ± 19.1
Visceral ischemia time (min), mean ± SD	65.1 ± 22.9
Reimplantation of the supraaortic vessels	
Island	17 (62.9)
Total	10 (37)
Concomitant operation	
Mitral valve reconstruction	2 (7.4)
Bentall-De Bono	1 (3.7)

ASCP: Antegrade selective cerebral perfusion, LSA: Left subclavian artery.

Table 3. Postoperative data

	Overall (n)	%
In hospital mortality	1	3.7
Pulmonary complication	3	11.1
Dialysis (temporary/permanent)	1	3.7
Stroke	1	3.7
Spinal cord ischemia	2	7.4
Low cardiac output syndrome	7	25.9
Re-sternotomy (bleeding-tamponade)	2	7.4
ICU stay (days), median (min-max)	4.3 (1-15)	
Extubation time (hours), median (min-max)	17.7 (4-67)	
Hospital stay (days), median (min-max)	13.6 (5-45)	

ICU: Intensive care unit.

Stent graft size was determined by measuring actual lumen diameter and native descending aorta diameter at the level of left subclavian and it was not oversized. Two different anastomotic techniques, islet-shape arch repair and arch debranching, were used when aortic arch replacement was performed. Then, E-vita Open plus prosthesis was anastomosed to the preimplanted proximal Dacron graft. Details of aortic and concomitant cardiac procedures are presented in Table 2.

Statistical Analyses

In descriptive statistics, continuous data are expressed in mean and standard deviation, minimum, and maximum values and categorical data are expressed in number and percentage values. In statistical comparison of data, chi-square, Fisher's exact, and likelihood-ratio tests were used appropriately for categorical data. The Fisher's exact and likelihood-ratio tests were used when the expected value in any of the cells was < 5 in the evaluated probability tables. For continuous data, normal distribution was evaluated with Kolmogorov-Smirnov analysis while t-test and Mann-Whitney U test were used for independent groups. Survival was calculated by Kaplan-Meier analysis. For statistical significance, $p< 0.05$ was considered as statistically significant in 95% confidence interval. For statistical analysis, SPSS software version 21.0 (SPSS Inc. Chicago, IL, USA) was used.

RESULTS

Early Outcomes

Postoperative outcome data are presented in Table 3. Early death occurred in 1 (3.7%) patient who had severe aortic and mitral regurgitation. The patient underwent Bentall-De Bono procedure and mitral reconstruction but suffered postoperative stroke. She died on the 62nd postoperative day due to multiple organ failure. An acute complicated type B aortic dissection patient who was referred to our clinic with paraplegia was discharged with full recovery of all neurological findings. Postoperative transient paraplegia was observed in two patients and patients recovered completely with the aid of physiotherapy within a few months after surgery.

Follow-up

The follow-up protocol included postoperative CTA evaluation before discharge, a clinical examination, and a CTA imaging 3 months postoperatively and annually thereafter. No late deaths were observed at a mean follow-up of 50.7 ± 22.5 months (Figure 1). The false lumen at stent level was completely thrombosed in 24 (88.9%) patients and partial thrombosis in the remaining patients continued at the diaphragmatic level. Five (18.6%) patients underwent secondary distal aortic endovascular repair. Secondary intervention was due to stent graft-

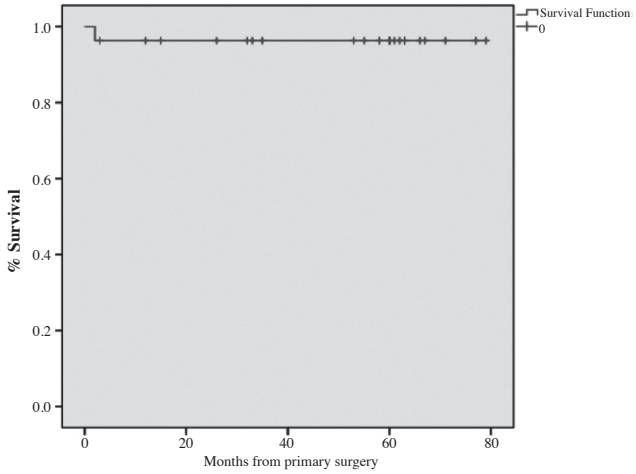

Figure 1. The 5-year survival rate was 96.3%.

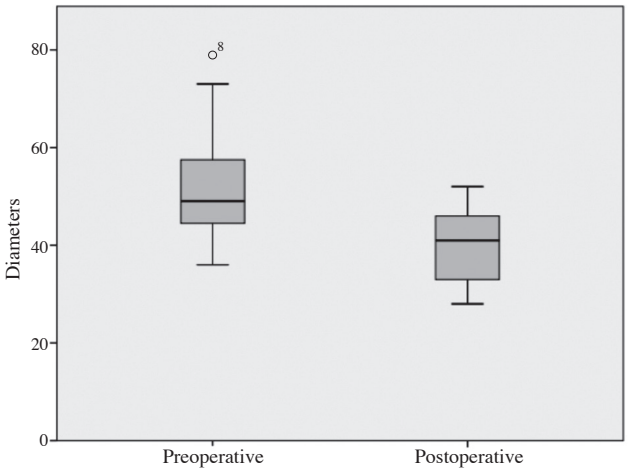

Figure 2. Preoperative and postoperative descending aortic diameters were 51.6 mm ± 11.9 and 39.8 mm ± 7.5, respectively (p< 0.0001). The median shrinkage in descending aorta diameter was 11.9 mm (min-max: 0-31 mm).

induced new entry in three patients and second-stage treatment for post-dissection aneurysm in two patients. Changes in preoperative and postoperative descending aortic diameters are shown in Figure 2.

DISCUSSION

In the presence of any signs of malperfusion syndrome, rupture, or disease progression, type B aortic dissections are defined as "complicated" and require early endovascular or surgical treatment. Even if these signs are absent, eventually medical treatment fails on aortic remodeling, and late interventions are required for aneurysmatic enlargement and late aortic complications[2,3]. TEVAR is the well-accepted treatment choice in complicated type B aortic dissections. Even in uncomplicated cases, it has proven superior to medical treatment in 5-year follow-ups with better survival rates and lesser dissection-related complications[4-6].

Access vessel compliance, proximal and distal landing zone status, and aortic arch angulation are the technical constraints of all endovascular techniques. A short proximal landing zone or excessive angulation of the aortic arch will adversely affect the success of TEVAR[7]. According to the International Registry of Acute Aortic Dissection (IRAD), 25.5% of type B aortic dissections showed aneurysmatic enlargement extending to the aortic arch, and even additional tears were present[8]. In cases where the proximal landing zone extension is performed using carotid-subclavian or carotid-carotid bypass without sternotomy, the retrograde dissection risk increases during or after the endovascular repair if the diameter of the ascending aorta is 40 mm or more[9]. Aortic arch involvement in type B aortic dissections increases the risk of complications, and additional cardiac surgery requirement necessitates more extensive interventions instead of an endovascular procedure alone[10-12].

For open surgical repair, lateral thoracotomy is sufficient when the distal aortic arch is involved, but if the pathology extends to the entire aortic arch and the ascending aorta, clamshell incision is required. Open surgical approaches increase mortality and morbidity; therefore, hybrid strategies should be addressed such as single-stage FET or two-stage TEVAR with cervical debranching through a sternotomy[13,14].

In order to ensure proper fixation of the stent graft and prevent any endoleak formation, the landing zone needs to be expanded during two-stage hybrid methods. However, if the landing zone is extended toward the proximal, there is a higher risk for mortality. Particularly, proximal (zones 0 and 1) hybrid repair has higher mortality rates than zones 2 and 3. They also bear increased endoleaks and stroke rates due to wire manipulation[15-17]. Fixation of the proximal edge of the stent graft with sutures not only prevents formation of proximal endoleaks and retrograde dissections[18] but also promotes aortic remodeling without increasing the operative risks in FET procedure[19-22].

Organ malperfusion in acute complicated type B aortic dissections was shown to be an independent risk factor for operative mortality[16]. However, in a multicenter study, mortality rates of acute and chronic type B dissections with FET procedure were 13% (2/16) and 15% (6/41), respectively, and no significant difference was present between two groups[23]. Furthermore, the high number of previous cardiac operations in the chronic patient group did not allow equal evaluation of both groups and increased the mortality rates of chronic type B aortic dissections. In our study, death occurred in only 1 (3.7%) patient who had congestive heart failure and additional cardiac surgery. No other mortality was observed due to any cause in 3-year follow-up. Similar to our study, Zue et al. performed FET procedure for 19 patients with complicated type B acute aortic dissections, and no deaths were reported during hospital stay or in 17-month follow-up[18].

Spinal cord injury is a complication that affects quality of life in cases involving surgery of the descending aorta. CSF drainage, keeping the distal landing zone above the T7 level, short antegrade cerebral perfusion times, and left subclavian artery revascularization are technical measures that can be taken to protect the spinal cord damage. As a reflection of the success of these preservation techniques, a multicenter study that included 57 patients with type B aortic dissection showed that paraplegia and paraparesis rates due to spinal cord injury could be reduced by 4%. Although the difference between acute and chronic cases was not statistically significant, it was found that there was more intensity of neurological impairment in chronic patients (0% and 5%, respectively)[23]. In our study, spinal cord

ischemia was observed in two patients who were treated for chronic type B aortic dissection. After 4 months, neurological condition of the patients improved. FET proximal fixation was applied to zone 0 with total supraaortic debranching in two patients and spinal cord ischemia developed despite the stent graft covering the aorta above the T7 level.

The remodeling response triggered by intimal tear during the acute phase in type B aortic dissections accelerates spinal cord collateral circulation even after the spinal arteries are covered with stent graft. However, since aortic remodeling is complete in chronic type B dissection, immediate closure of the spinal cord-feeding arteries on the true lumen with stent graft placement causes spinal cord ischemia leading to neurological symptoms. Collateral network development is slower in chronic than in acute dissections, and clinical recovery occurs later.

In type B aortic dissections, the dissection flap is not sufficiently mature and stable in the acute phase, increasing the risk of operation-related complications. Nevertheless, rapid closure of the intimal tear and early thrombosis of the false lumen will increase the success rate of the treatment. We also know that in patients with chronic aortic type B dissections, following endovascular treatment, remodeling of aorta is not as conspicuous as in acute aortic dissections and therefore requires further reintervention for distal aorta in midterm follow-up[24]. Eusania et al. reported that 18 (42%) patients who underwent FET repair for chronic type B aortic dissection had reintervention with endovascular repair due to distal aneurysm formation[25]. However, the fact that acute cases have false lumen thrombosis earlier than chronic type B aortic dissections does not represent statistical significance for reintervention[23]. False lumen and maximal thoracic aortic diameters are larger in patients with chronic type B dissection and those are related to the progression of the disease and therefore increase reintervention rates. However, in late distal aortic reinterventions, proximal stabilization of the graft stent with sutures facilitates the second procedure by forming a safer landing zone for TEVAR[26]. In our study, secondary distal aortic endovascular repair was performed easily and successfully to five patients for stent graft-induced new entry (n= 3) and scheduled second-stage treatment for post-dissection aneurysm (n= 2). Complete thrombosis of false lumen along the aorta covered by the stent graft was achieved in 88.9% of cases.

CONCLUSION

The retrospective nature and small sample size were limitations of the study. Aortic arch involvement in type B aortic dissections requires more extensive treatment and cannot be standardized with a single treatment protocol, but our results demonstrate that FET is an alternative solution to treat acute complicated type B aortic dissections.

Ethics Committee Approval: Ethics committee approval was received for this study from the Health Sciences University Kartal Kosuyolu High Specialty Training and Research Hospital Non-Interventional Clinical Researches Ethics Committee (Decision Number: 2017.6/10-54; Decision Date: August 22, 2017).

Informed Consent: Written informed consent was obtained from patients who participated in this study.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept/Design – MA; Analysis/Interpretation – MA, ST; Data Collection – DÇ, OA; Writing – MA; Critical Revision – AA; Final Approval – AAD, AA; Statistical Analysis – MA; Overall Responsibility – MS, MAT

Conflict of Interest: The authors have no conflict of interest to declare.

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