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Proximalization of Frozen Elephant Trunk Procedure: Zone 0 or 1 versus Zone 2 or 3 Arch Repair

Kwok Fai Lucius Lee[1] Inderjeet Bhatia[1] Tai Leung Daniel Chan[1] Wing Kuk Timmy Au[1] Ka Lai Cally Ho[1]

[1] Department of Cardiothoracic Surgery, Queen Mary Hospital, Hong Kong SAR, People's Republic of China

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Address for correspondence Kwok Fai Lucius Lee, MB ChB, Department of Cardiothoracic Surgery, Queen Mary Hospital, Hong Kong SAR, People's Republic of China (e-mail: luciusleekwokfai@gmail.com).

Abstract

Background Total arch replacement with the frozen elephant trunk (FET) procedure has changed the landscape of therapy for aortic arch diseases. The optimal landing zone for a FET is controversial. We sought to share our early and midterm results of the FET procedure as well as compare the clinical outcomes of proximal and distal FET anastomosis.

Methods A total of 100 patients who underwent total arch replacement using the FET technique were identified between November 2014 and August 2021. According to the FET anastomosis over the aortic arch, patients were classified into two groups (zone 0/1 vs. zone 2/3). In-hospital mortality, complications, and midterm outcomes were assessed based on patient characteristics.

Results The overall in-hospital mortality was 8%. Major complications occurred in 32% of patients, including spinal cord injury (5%), stroke (7%), and acute kidney injury requiring dialysis (7%). Zone 2/3 FET (odds ratio: 6.491, 95% confidence interval: 1.930–21.835, $p = 0.003$) was an independent predictor of the composite endpoint of major complications. The rate of complete false lumen thrombosis was comparable (64.3% vs. 71.4%, $p = 0.567$). All patients, patients with zone 0/1 FET, and patients with zone 2/3 FET had 3-year freedom from aorta-related events of 73.0, 70.2, and 75.0%, respectively. There were no significant differences (log-rank test, $p = 0.500$).

Conclusion Compared with zone 2/3, proximalization of FET using zone 0/1 for anastomosis was associated with better early outcomes and comparable rates of midterm aorta-related events. To substantiate its use, more research on this approach is required.

Keywords
- aorta/aortic
- aneurysm
- surgery
- complications
- cardiac

Introduction

Total arch replacement with the frozen elephant trunk (FET) surgery has changed the landscape of treatment for complex aortic arch diseases. FET not only improves aneurysm exclusion and intimal tear coverage, both of which promote distal aortic remodeling, but it also facilitates vascular reintervention when required.[1]

There is no clear consensus on the optimal FET landing zone. FET was traditionally anastomosed in zone 3 of the Ishimaru zones.[2] Many studies have recently compared the outcomes of patients whose FET device landed in zone 2 instead of zone 3[3–5]; moreover, a zone 0 repair has been advocated.[6] The term "proximalization" refers to the process of moving the FET landing zone forward. FET proximalization reduces surgical trauma, visceral ischemic time, and

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descending thoracic aorta coverage, all of which may be associated with better clinical outcomes.[3,4] However, there is a possibility of suboptimal aortic remodeling if this approach is used.[5] This study aimed to compare the clinical outcomes of proximal (zone 0 and 1) and distal (zone 2 and 3) FET anastomosis and to report our early and midterm results of patients who received total arch replacement with FET procedure.

Patients and Methods

Study Design

This was a single-center retrospective observational study. One hundred consecutive patients who underwent total arch replacement using the FET technique for acute and chronic aortic arch pathologies were identified from the hospital electronic database between November 2014 and August 2021. The location of FET anastomosis over the aortic arch was used to classify patients into two groups. FET was performed on 67 patients in zone 0/1 and 33 patients in zone 2/3. To ensure comparability, variables including age 70 or above, gender, concomitant procedure, and previous sternotomy were matched. Thirty-one matched pairs were obtained. Early outcomes, including in-hospital mortality and major morbidities, reassessment computed tomography (CT) findings, and aorta-related events were examined. Our clinic regularly follows up patients. The most recent follow-up for this analysis occurred in December 2021. After discharge, two patients continued to receive follow-up care in their home country, their follow-up data were not available. Therefore, complete follow-up was conducted in 97.8% of patients (90/92). A schematic illustration of the study design and patient selection criteria is shown in ►**Supplementary Fig. S1** (available in the online version). The local institutional review board approved this study (Reference number: UW 21–647) with patients' informed consent.

Definitions

Major morbidities included stroke with persistent neurological deficit, bleeding requiring reexploration for hemostasis, spinal cord injury (SCI) with transient or permanent paraplegia, hoarse voice with documented vocal cord palsy, prolonged ventilation with a tracheostomy, acute kidney injury requiring dialysis, thromboembolic event other than stroke (myocardial infarction, pulmonary embolism, and "trash foot" phenomenon), and major infection (mediastinitis and deep sternal wound infection). Composite endpoint was defined as resternotomy for bleeding, requirement for dialysis, and SCI. Acute malperfusion syndrome referred to major organ or limb ischemia in patients with acute aortic dissection. At least two of the three criteria (clinical, biochemical, or radiological) had to be considered malperfusion, including the following conditions: renal (increased creatinine, kidney hypoenhancement, and renal artery disruption/dissection), mesenteric (abdominal pain, hyperlactatemia, metabolic acidosis, and mesenteric artery disruption/dissection), limb (signs of acute limb ischemia and peripheral artery disruption/dissection), cerebral (neurological deficit and head and neck vessel disruption/dissection), and coronary (raised cardiac enzymes, electrocardiographic changes, and coronary artery disruption/dissection). Aorta-associated mortality, unknown sudden death, death related to an aortic procedure, and aortic reintervention were all examples of aorta-related events. Distal stent graft-induced new entry (dSINE) was defined as new communications between true and false lumens via an intimal tear adjacent to the distal end of the FET that was absent before FET implantation.

FET Technique and Prosthesis Types

The E-VITA open plus/open neo prosthesis (Jotec Inc., Hechingen, Germany) or the Thoraflex hybrid graft (Vascutek, Inchinnan, United Kingdom) were implanted in patients who underwent total arch replacement and FET procedure. The operating surgeon chose the stent graft at his or her discretion. The extent of arch resection and choice of FET distal landing zone was determined by the presence of an intimal tear in the arch. Otherwise, the FET distal landing zone was decided according to the surgeon's preference. In cases of acute aortic dissection, graft oversizing was avoided. We oversized the FET by 20% relative to the mean diameters of the true and false lumen over the proximal thoracic descending aorta for chronic aortic dissection. To achieve a tight distal seal for aortic aneurysms, the FET diameter was 20% greater than the aorta distal to the aneurysm. For the length of the FET, the general rule of avoiding extensive coverage of the descending thoracic aorta was followed. The length of FET was determined by the length of the aneurysm to achieve complete exclusion of the aneurysmal sac in aortic aneurysm.

Surgical Procedure

All cases were performed in the operating theater with on-request portable fluoroscopic support. Perioperative cerebral spinal fluid drainage was not routinely performed. Depending on the etiology, different cannulation strategies were adopted after systemic heparinization. Axillary artery cannulation via an 8-mm Hemashield graft was preferred. Routine carbon dioxide field flooding was used to reduce the risk of air embolism. The left heart was vented by inserting a Medtronic DLP 16 Fr cannula through the right superior pulmonary vein. The distal ascending aorta was cross-clamped when the heart started to fibrillate during systemic hypothermia. After aortotomy, the heart was arrested by infusing Custodiol HTK solution through the coronary ostia. The proximal aorta was trimmed at the level of the sino-tubular junction and prepared using the "sandwich" technique with Teflon felt strips or the adventitial inversion technique. Upon reaching 22°C to 25°C, circulatory arrest and selective antegrade cerebral perfusion (SACP) to all three head and neck vessels were started. Pharmacological cerebral protection with steroids and mannitol was administered in selected patients. Head and neck vessels were disconnected from the arch of the aorta. If the left subclavian artery origin was located deep, a Hemashield graft extension was adopted to facilitate subsequent anastomosis. Extra-anatomical aorta-left subclavian artery bypass was performed only in the case of left upper limb malperfusion. The FET was deployed in the true lumen and the collared skirt was fixed to the arch of the aorta using multiple interrupted felt sutures. When a visual inspection was inadequate to distinguish between the true and false lumen, a guidewire was advanced through the femoral artery for rail guidance. Direct examination using an angioscope was rarely performed. Cardiopulmonary bypass through the side branch of the graft and rewarming were initiated after reapplying the cross-clamp to the proximal prosthetic graft. The aortic cross-clamp was removed after the proximal end of the FET was anastomosed to the ascending aorta. Head and neck vessels were anastomosed to the side branches of the FET and SACP was stopped.

Imaging

Contrast-enhanced CT images were evaluated before and after surgery. Within 3 to 6 months of discharge, the initial postoperative CT reassessment was arranged. An earlier scan was considered within the same admission if clinically indicated. Using multiplanar or three-dimensional reconstruction images, the extent of FET coverage was determined with reference to the vertebral level (►**Fig. 1**). The degree of aneurysm and false lumen thrombosis was assessed. At the distal end of the FET stent, complete false lumen thrombosis was evaluated.

Statistical Analysis

SPSS software version 28 was used to analyze all of the data (IBM Corporation, Armonk, New York, United States). The Shapiro–Wilk test was used to determine whether the distribution of continuous variables was normal. The mean and standard deviation of normally distributed continuous data are reported, and between-group differences were examined using the *t*-test. The median and interquartile range (IQR) are used to show nonnormally distributed continuous variables, and the Mann–Whitney *U* test was used to analyze between-group differences. Numbers and proportions are used to represent categorical variables. If the minimum predicted count was at least one, the chi-square test was employed to compare categorical variables. Fisher's exact test was used in the other cases. Kaplan–Meier survival estimates were used to analyze the freedom from aorta-related events, and the log-rank test was performed to investigate between-group differences. To identify independent risk factors for the composite endpoint, binary logistic regression was used. Univariable testing was used as a prescreening method, and variables with a p-value of < 0.25 were chosen for multivariable analysis. The enter method was used to perform logistic regression. Statistical significance was defined as a p-value of < 0.05.

Results

Patient characteristics are summarized in ►**Table 1**. Operative and postoperative details are shown in ►**Table 2**. Before matching, when compared with zone 2/3 FET, patients with zone 0/1 FET had a higher mean age (59.2 ± 12.7 vs. 56.0 ± 8.8, $p = 0.035$) and shorter circulatory arrest time (57 minutes [IQR, 48–75 minutes] vs. 73 minutes [IQR, 51–89.5 minutes], $p = 0.032$). Majority of patients had DeBakey I aortic dissection and more than half of them had an intimal tear identified in the arch. After matching, the circulatory arrest time was 12 minutes longer in the zone 2/3 group. Slightly more patients in the zone 0/1 group received branched FET. However, the differences were not statistically significant. There was no difference in the use of stent graft lengths greater than 150 mm between the two groups. The in-hospital mortality rates in patients with zone 0/1 FET and zone 2/3 FET were 3.2% versus 9.7%, respectively ($p = 0.301$). Zone 2/3 FET was associated with significantly higher rates of resternotomy for bleeding (3.2% vs. 19.4%, $p = 0.045$) and SCI (0% vs. 12.9%, $p = 0.039$).

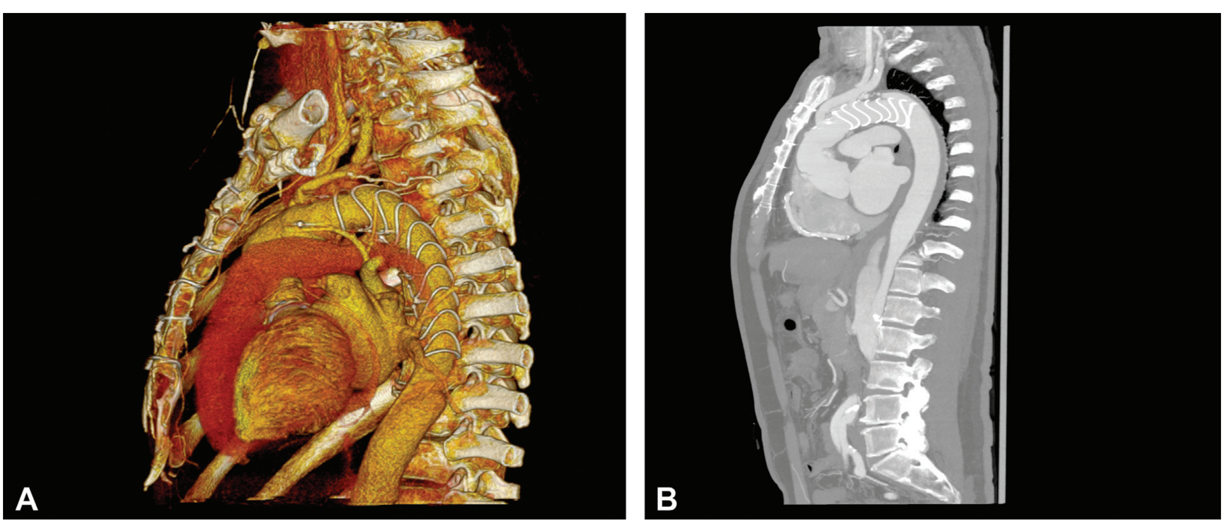

Fig. 1 Patient's postoperative contrasted computed tomography (CT) after total arch replacement and the frozen elephant trunk (FET) procedure. (**A**) Three-dimensional (3D) volume rendering of intrathoracic structures showing the T8 coverage of the descending thoracic aorta by the stented portion of the FET in a patient with zone 2 FET. (**B**) Sagittal image of a contrasted CT scan of a patient with zone 0 FET and a 100-mm graft. The FET extended to the T4 level of the descending thoracic aorta.

Table 1 Preoperative patient characteristics

	Unmatched Overall ($n = 100$)	Matched pairs		*p*-Value
		Zone 0/1 ($n = 31$)	Zone 2/3 ($n = 31$)	
Mean age, y (SD)	58.2 (11.6)	53.6 (11.1)	56.5 (8.9)	0.260
Male, *n* (%)	85 (85)	29 (93.5)	29 (93.5)	> 0.99
Resternotomy, *n* (%)	27 (27)	10 (32.3)	10 (32.3)	> 0.99
MFS/LDS, *n* (%)	6 (6)	2 (6.5)	3 (9.7)	0.641
Hypertension, *n* (%)	66 (66)	8 (25.8)	11 (35.5)	0.409
Diabetes mellitus, *n* (%)	8 (8)	3 (9.7)	2 (6.5)	0.641
Chronic lung disease, *n* (%)	4 (4)	1 (3.2)	2 (6.5)	0.554
Creatinine > 115 μ mol/L, *n* (%)	33 (33)	9 (29.0)	11 (35.5)	0.587
Preserved LVEF, *n* (%)	94 (94)	3 (9.7)	1 (3.2)	0.301
Indication for FET, *n* (%)				
- Acute aortic dissection	46 (46)	15 (48.4)	14 (45.2)	0.799
- Chronic aortic dissection	38 (38)	13 (41.9)	14 (45.2)	0.798
- Aortic aneurysm	16 (16)	3 (9.7)	3 (9.7)	> 0.99
DeBakey I, *n* (%) - Intimal tear at arch	76 (90.5) 43 (56.6)	27 (87.1) 15 (55.6)	25 (80.6) 13 (52.0)	0.490 0.797
Presentation, *n* (%)				
- Incidental finding	13 (13)	2 (6.5)	5 (16.1)	0.229
- Chronic pain	4 (4)	2 (6.5)	1 (3.2)	0.554
- Progression	33 (33)	12 (38.7)	10 (32.3)	0.596
- Acute pain	27 (27)	6 (19.4)	9 (29.0)	0.374
- Malperfusion	18 (18)	8 (25.8)	5 (16.1)	0.349
- Rupture/tamponade	5 (5)	1 (3.2)	1 (3.2)	> 0.99

Abbreviations: FET, frozen elephant trunk; LDS, Loeys–Dietz syndrome; LVEF, left ventricular ejection fraction; MFS, Marfan syndrome; SD, standard deviation.
Note: Values are presented as mean (standard deviation) or *n* (%).

Risk Factor Analysis

We first performed univariable analysis for the in-hospital mortality, resternotomy for bleeding, SCI, and requirement for dialysis (►**Supplementary Tables S1–S4**, available in the online version). Age $\geq$ 70 years was associated with higher in-hospital mortality (odds ratio: 4.418, 95% confidence interval: 0.925–21.105, $p = 0.046$). We only performed the multivariable binary logistic regression analysis on the composite endpoint due to the small number of events. Zone 2/3 landing (odds ratio: 6.491, 95% confidence interval: 1.930–21.835, $p = 0.003$) was identified as independent predictors of the early composite endpoint of complications (resternotomy for bleeding, dialysis, and SCI). The detailed results are shown in ►**Table 3**.

Midterm Outcomes

Among the 92 survivors in the entire cohort, two defaulted our follow-up. Of these, the mean follow-up duration was 32.3 ± 22.4 months. A total of six (6.5%) late postdischarge deaths were noted. Four of these were due to aorta-related event. Twenty patients (22.2%) required reintervention. Seven patients (9.2%) who suffered from either acute or chronic aortic dissection developed dSINE. The overall 3-year survival was 92.7%. In the matched cohort, the reintervention rates were 22.6 and 16.1% in zone 0/1 and zone 2/3 groups, respectively ($p = 0.520$). More dSINE was observed after zone 0/1 FET in patients with aortic dissection (14.8% vs. 4.0%, $p = 0.186$). There was no significant difference in the number of aorta-related events between patients who underwent zone 0/1 and zone 2/3 FET (30.0% vs. 21.4%, $p = 0.456$). On Kaplan–Meier analysis, the 3-year freedom from aorta-related events in all patients, and in patients with zone 0/1 and zone 2/3 FET were 73.0, 70.2, and 75.0%, respectively. In this, there were no significant between-group differences (log-rank test, $p = 0.500$) (►**Fig. 2**).

Radiological Follow-Up

In the matched cohort, after an average of 73.4 ± 85.9 days, 56 patients (90.3%) underwent contrast CT scans. Patients who underwent zone 2/3 FET had more coverage of the descending thoracic aorta T8 or beyond than those who received zone 0/1 FET (21.4% vs. 32.1%, $p = 0.365$); however, the between-group difference was not statistically

Table 2 Operative and postoperative data

	Unmatched	Matched pairs		p-Value
	Overall ($n = 100$)	Zone 0/1 ($n = 31$)	Zone 2/3 ($n = 31$)	
Emergency, n (%)	51 (51)	16 (51.6)	15 (48.4)	0.799
Axillary cannulation, n (%)	72 (72)	25 (80.6)	22 (71.0)	0.374
Bypass time, min (SD)	236 (57)	233 (51.3)	245 (60.1)	0.397
Aortic cross-clamp time, min (SD)	140 (50)	136 (40.9)	152 (38.8)	0.132
Circulatory arrest time, min (SD)	60 (28)	63 (18.8)	75 (30.4)	0.068
Branched FET, n (%)	91 (91)	30 (96.8)	26 (83.9)	0.086
Stent graft length $\geq$ 150 mm, n (%)	32 (32)	8 (25.8)	12 (38.7)	0.277
Concomitant procedure, n (%)	42 (42)	10 (32.3)	10 (32.3)	> 0.99
Postoperative ECMO, n (%)	2 (2)	1 (3.2)	1 (3.2)	> 0.99
Major complications, n (%)	32 (32)	4 (12.9)	15 (48.4)	0.002
- Stroke	7 (7)	1 (3.2)	1 (3.2)	> 0.99
- Resternotomy for bleeding	10 (10)	1 (3.2)	6 (19.4)	0.045
- Spinal cord injury	5 (5)	0	4 (12.9)	0.039
- Vocal cord palsy	7 (7)	1 (3.2)	4 (12.9)	0.162
- Tracheostomy	6 (6)	1 (3.2)	2 (6.5)	0.554
- Dialysis	7 (7)	1 (3.2)	4 (12.9)	0.162
- Thromboembolic event	3 (3)	0	2 (6.5)	0.151
- Major infection	7 (7)	1 (3.2)	4 (12.9)	0.162
In-hospital mortality, n (%)	8 (8)	1 (3.2)	3 (9.7)	0.301

Abbreviation: ECMO, extracorporeal membrane oxygenation; FET, frozen elephant trunk; SD, standard deviation.
Note: Values are presented as mean (standard deviation) or n (%).

significant. All individuals with an aortic aneurysm had complete thrombosis of the aneurysmal sac. Complete false lumen thrombosis around the end of the FET stent was similar in both groups (64.3% vs. 71.4%, $p = 0.567$) among the patients with aortic dissection.

Discussion

Extensive evidence supporting the FET technique is available worldwide, especially in the Western countries.[7–9] However, there is a paucity of reports from the Asian regions.[10–12] In

Table 3 Risk factor analysis for composite endpoint (resternotomy for bleeding, dialysis, and spinal cord injury)

	Univariable analysis			Multivariable analysis		
	p-Value	OR	95% CI	p-Value	OR	95% CI
Age $\geq$ 70 y	0.719	1.291	0.321–5.197			
Male	0.827	0.857	0.215–3.416			
Hypertension	0.033	0.331	0.117–0.941	0.082	0.343	0.103–1.144
Creatinine $> 115\ \mu$ mol/L	0.090	2.417	0.855–6.832	0.194	2.292	0.655–8.024
Previous sternotomy	0.614	0.733	0.218–2.461			
Malperfusion/rupture/tamponade	0.077	2.625	0.879–7.837	0.198	2.462	0.625–9.710
Acute aortic dissection	0.884	0.926	0.332–2.584			
Concomitant procedure	0.448	1.485	0.533–4.134			
Axillary cannulation	0.981	1.014	0.325–3.164			
Zone 2/3 landing	< 0.001	5.810	1.937–17.423	0.003	6.491	1.930–21.835
Stent graft length $\geq$ 150 mm	0.489	1.451	0.504–4.179			
Branched FET	0.573	1.838	0.215–15.693			

Abbreviations: CI, confidence interval; FET, frozen elephant trunk; OR, odds ratio.

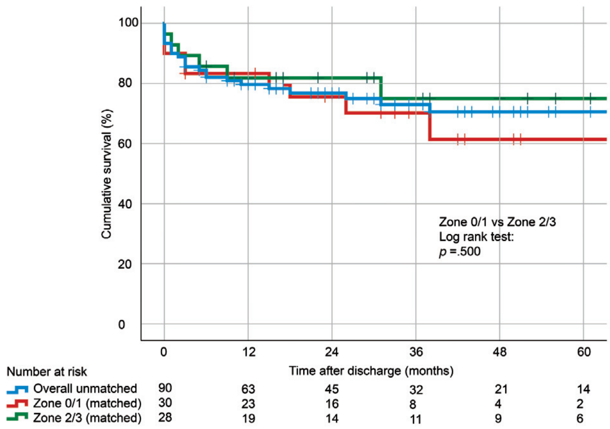

Fig. 2 Kaplan–Meier plot of freedom from aortic events after receiving total arch replacement and frozen elephant trunk operation (FET). Three-year freedom from aortic event in all patients, patients with FET landed at zone 0/1, and patients with FET landed at zone 2/3 were 73.0, 70.2, and 75.0%, respectively. There were no significant differences in this respect (log-rank test, $p = 0.500$).

this single-center review, the in-hospital mortality rate was 8% and the overall 3-year survival was 92.7%. In a recent systematic review of 37 studies (combined $n = 4{,}178$), the pooled in-hospital mortality rate and 3-year survival after the FET procedure was 10.2% (range 0–20%) and 85.2%, respectively.[13] Our results are comparable to those reported from other countries.

FET is a more complex surgical procedure that requires a higher level of surgical expertise as well as a longer operative time. Despite advances in surgical techniques, the FET procedure has still been linked to a high rate of postoperative mortality and morbidity. Conventionally, the FET device was implanted in zone 3 of the thoracic aorta. Our research has found that anastomosing the FET to zone 2 or beyond (zone 2/3 FET) increased the risk of resternotomy for bleeding, acute kidney injury requiring dialysis, and SCI by six times. However, previous studies have found conflicting evidence of the benefits of proximalization of FET. Zone 3 FET exhibited a greater 30-day mortality rate than zone 2 FET in research by Detter et al (3.3% vs. 17.7%), but the difference was not statistically significant.[3] Two other studies showed comparable in-hospital/30-day mortality rates between zone 2 FET and zone 3 FET.[4,5] There were no significant between-group differences in the rates of SCI and dialysis in the three abovementioned studies. These studies, however, only compared zone 3 and zone 2 FET. As shown in our study, the benefits of proximalization become clearer as the anastomosis moves closer to zone 0 or zone 1. In their cohort of 108 patients, Yamamoto et al reported outstanding outcomes with the "zone 0 repair" strategy. Their cohort had a 30-day death rate of 2.8%, and none of the patients developed SCI.[6]

Better outcomes with proximalization of FET may be related to the reduced visceral ischemic time. In our study, zone 0/1 FET required a shorter circulatory arrest time, although the difference was not statistically significant, and it could be due to the more frequent use of branched FET. Nevertheless, this phenomenon has been observed in studies comparing zone 2 FET and zone 3 FET.[3,4,14]

According to Preventza et al's meta-analysis, a stent graft length of 15 cm or longer was associated with a greater SCI rate.[15] This was also demonstrated in our univariable analysis. However, zone 0/1 FET did not reliably reduce distal thoracic aorta coverage. Hence, the extent of coverage is multifactorial. Other important determinants are the length, tortuosity, and elasticity of the thoracic aorta, in addition to the location of the FET anastomosis and the length of the FET graft. Therefore, the 100-mm graft is becoming more popular for aortic dissection.[16] The use of transesophageal echocardiography as intraoperative guidance during FET deployment has also been proven to be beneficial.[17]

The FET proximalization method was associated with lower surgical trauma. In our investigation, the incidence of left recurrent laryngeal nerve injury was lower in the zone 0/1 group; however, the difference was insignificant. This could be due to our preference for direct end-to-end anastomosis of the left subclavian artery, as indicated by the fact that only 7% of our cohort received extra-anatomical axillary artery bypass. Zone 2 FET was associated with a decreased frequency of recurrent laryngeal nerve injury in a study by Leone et al.[4] They used a hybrid vascular graft instead to allow for a sutureless anastomosis when the left subclavian artery was difficult to reach. In another study, when extra-anatomical bypass of limb vessels was used exclusively throughout the FET surgery, none of the patients developed recurrent laryngeal nerve palsy.[18]

It is difficult to access the distal anastomosis of the aortic arch and the head and neck vessels to guarantee hemostasis.[19] In our group, zone 0/1 FET was also associated with fewer episodes of resternotomy for bleeding, despite inconsistent results in prior studies comparing zone 2 and zone 3 FET.[5,20] In the zone 0/1 FET group, less frequent resternotomy for hemostasis may be related to less blood product transfusion, and hence contribute to a lower rate of dialysis necessity.

FET has been demonstrated to improve the coverage of the distal descending thoracic aorta, resulting in improved false lumen or aneurysm exclusion. Residual false lumen patency after aortic dissection repair was linked to more aorta-related events, including late deaths, according to a meta-analysis by Li et al.[21] Positive aortic remodeling with false lumen thrombosis and aorta shrinkage were found after the FET procedure.[22,23] In a study by Panfilov et al, however, the rate of complete false lumen thrombosis in zone 2 FET was lower than in zone 3 FET.[5] Therefore, zone 3 FET had a higher 2-year freedom from reintervention (74.1% vs. 91.7%), but the difference was not statistically significant. In our study, the rate of reintervention and early complete false lumen thrombosis around the level of FET were comparable in the zone 0/1 FET and zone 2/3 FET groups. Aorta-related events were also comparable in incidence. The potential negative impact of proximalization necessitates more research and a longer follow-up period.

Proximalization of FET improves surgical outcomes even more. To get satisfactory results, however, careful patient selection and an understanding of the risk–benefit profile are still required. Although patients of any age should be able to undergo the FET procedure, the increased surgical risk of FET in this demographic deserves attention. According to a recent study, in-hospital mortality after FET was approximately 2.5 times higher in patients $\geq$ 70 years old.[24] In our study, age $\geq$ 70 years was found to be a predictor of in-hospital mortality in univariable analysis as well. Physiological changes due to aging, including frailty and multiple comorbidities, are likely the underlying causes that hinder recovery and increase the likelihood of complications in older patients. We believe that there should not be an age cutoff for FET; older patients, if chosen appropriately, can benefit from the procedure with an acceptable risk level.

Limitations

The heterogeneity in our cohort limited our initial assessment of the FET procedure. Further comparisons were also hindered by the small number of patients. As the operating surgeon decided whether they should use FET, the results are prone to selection bias. Despite this, we could portray the real-world situation of FET use at our institution. Finally, our study has a retrospective design, which would be a limitation.

Conclusion

Zone 0/1 FET was associated with a lower composite endpoint of resternotomy for bleeding, dialysis-dependent acute kidney injury, and SCI. At 3 years, similar aorta-related events were observed. Further research into to the strategy of more aggressive proximalization of FET is required.

Conflict of Interest
None declared.

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