False lumen–dependent segmental arteries are associated with spinal cord injury in frozen elephant trunk procedure for acute type I aortic dissection

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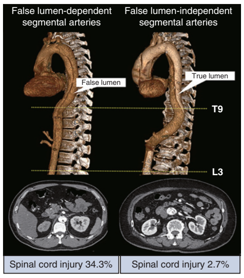
ABSTRACT

Objective: To investigate the association between false lumen (FL) dependency of segmental arteries (SAs) at T9-L3 levels and the risk of spinal cord injury (SCI) following total arch replacement and frozen elephant trunk (FET) implantation in the setting of acute DeBakey type I aortic dissection (AAD).

Methods: The study involved consecutive patients with AAD who underwent total arch replacement and FET implantation between 2020 and 2022. Primary outcome was postoperative SCI. The inverse probability of treatment weighting (IPTW) method was employed to minimize the impact of no-randomization bias. Antegrade placement of FET was followed by end-to-end anastomosis of a 4-branch arch graft at the proximal landing site of FET.

Results: A total of 146 patients were included (age, 50.5 ± 11.7 years, 115 male), of whom 35 (24%) had SAs at T9-L3 levels completely dependent on FL (FL-dependency group). There was no significant difference in early (30-day or in-hospital) mortality rates between FL-dependency (14.3%) and FL-independency (18.0%) groups (P = .80), however, the rate of SCI was significantly higher in the FL-Dependency group (34.3% vs 2.7%, P < .001). After adjustments, FL dependency was associated with a significantly increased risk of SCI (odds ratio, 13.1; 95% confidence interval, 4.2-41.0; P < .001), whereas it was not significantly associated with risks of early mortality or other major complications (P = .16-.98).

Conclusions: FL dependency of SAs at the T9-L3 levels was significantly associated with the development of SCI following FET implantation in AAD, warning against its uses on patients presenting with FL dependency of SAs at critical segments. (JTCVS Open 2023;15:16-24)



SCI occurrence in the FL-dependency group was obviously more than FL-independency group.

CENTRAL MESSAGE

FL-dependent SAs at the T9-L3 level were significantly associated with the development of SCI following FET implantation in AAD.

PERSPECTIVE

FL dependency of SAs was significantly associated with the development of SCI following total arch replacement and FET implantation in DeBakey type I AAD. We believe this result raises an alarming sign in the use of FET in this clinical setting.

See Discussion on page 25.

▶ Video clip is available online.

Total arch replacement combined frozen elephant trunk (FET) implantation has become the preferred surgical approach in a number of centers to treat selected patients presenting with acute DeBakey type I aortic dissection (AD)

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Abbreviations and Acronyms

AD = aortic dissection
ASA = anterior spinal artery
CPB = cardiopulmonary bypass
CSFD = cerebrospinal fluid drainage
CTA = computed tomography angiography
FET = frozen elephant trunk
FL = false lumen
IPTW = inverse probability of treatment weighting
SAs = segmental arteries
SCI = spinal cord injury

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because of its proven benefits of superior aortic remodeling effect in the downstream aorta, and it also offers an "ideal landing zone" for endovascular intervention in the descending thoracic aorta for those in need of late reintervention.[1] However, studies have shown that FET implantation is associated with a greater risk of postoperative spinal cord injury (SCI) in the setting of acute type I AD.[2] SCI is one of the most devastating operative complications of surgeries on the arch and descending aorta, which seriously affects the quality of life negatively and also compromises long-term survival.[3] Although previous studies have suggested several risks factors for SCI in the setting of acute type I AD, such as older age, lower level of distal FET, and lower mean arterial pressure, the potential effect of false lumen (FL) dependency of segmental arteries (SAs) on SCI has remained uncertain. Assuming a circumstance that critical SAs arise completely from the FL of the acutely dissected aorta, immediate obliteration of this FL by the adoption of FET may induce global ischemic insults to the spinal cord, resulting in postoperative SCI. In order to test this hypothesis, therefore, we sought to explore the impact of FL dependency of SAs at T9-L3 levels on the risk of SCI following total arch replacement and FET in the setting acute DeBakey type I AD.

METHODS

Study Cohort

From January 2020 through December 2022, patients with acute DeBakey type I AD who underwent emergency total arch repair and FET implantation in the First Affiliated Hospital of Nanjing Medical University were retrospectively reviewed. To form a homogenous cohort with reasonable comparability, the following exclusion criteria were applied: (1) previous history of SCI, (2) paraplegia before operation, (3) previous history of cerebral infarction, and (4) chronic AD.

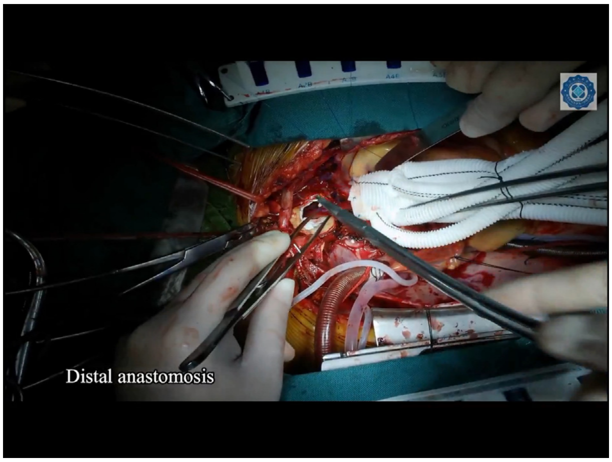
This study was approved by the institutional review board of the First Affiliated Hospital of Nanjing Medical University (no. 2021-SR-080, approval date: April 20, 2021). The requirement for informed consent was waived due to the retrospective nature of the study design.

Surgical Procedure

After median sternotomy was achieved, we dissected the innominate artery, left common carotid artery, and left subclavian artery. Cardiopulmonary bypass (CPB) was instituted by cannulating either on the right axillary or on the innominate arteries, in which the latter was preferred if the innominate artery was sizable (>10 mm) and free of dissection or atherosclerosis. The ascending aorta was clamped and transected at the cooling phase. Del Nido cardioplegia was directly infused into the orifice of the coronary arteries. When the cooling temperature reached the target temperature (21-23 °C at the bladder), circulatory arrest was started with selective unilateral antegrade cerebral perfusion at a flow rate of 5.0 mL/kg/min. A stented graft (CRONUS stent graft; MicroPort Scientific Corp) was inserted into the true lumen of the descending aorta. Then, the stented graft and the descending aorta was anastomosed end-to-end with the 4-branched graft. After the completion of the distal anastomosis, perfusion in the lower body was resumed through the 4-branched graft. In order to restore the left cerebral perfusion, the second branch of 4-branched graft was anastomosed with the left common carotid artery, and rewarming was followed. The left subclavian artery was anastomosed with the third branch of 4-branched graft by the same fashion. Then, the proximal ascending aorta was anastomosed with the proximal end of the 4-branched graft. After deairing, the crossclamp was removed and the innominate artery was anastomosed with the first branch of 4-branched graft. CPB was weaned off under stable hemodynamic parameters, and this was followed by complete protamine neutralization. Finally, meticulous hemostasis and sternal closure were achieved. Our operative procedure for total arch replacment with FET and Bentall in DeBakey type I AAD is presented in Video 1. All patients were admitted to the cardiac intensive care unit and were managed to maintain target blood pressure of approximately 120/80 mm Hg, and a cerebrospinal fluid drainage (CSFD) catheter was inserted immediately only if postoperative SCI observed.

Data Collection

The baseline demographic, clinical, and laboratory parameters collected were as follows: sex, age, body mass index, hypertension, diabetes mellitus, coronary heart disease, Marfan syndrome, previous aortic surgery, hematocrit, lactic acid, white blood cell, hemoglobin, serum creatinine, C-reactive protein, cardiac troponin T, D-dimer, and B-type natriuretic peptide. Procedural data included CPB, aortic crossclamping, and circulatory



VIDEO 1. Total arch replacement with FET and Bentall procedure for DeBakey type I AAD. *FET*, Frozen elephant trunk; *AAD*, acute aortic dissection. Video available at: https://www.jtcvs.org/article/S2666-2736(23)00164-X/fulltext.

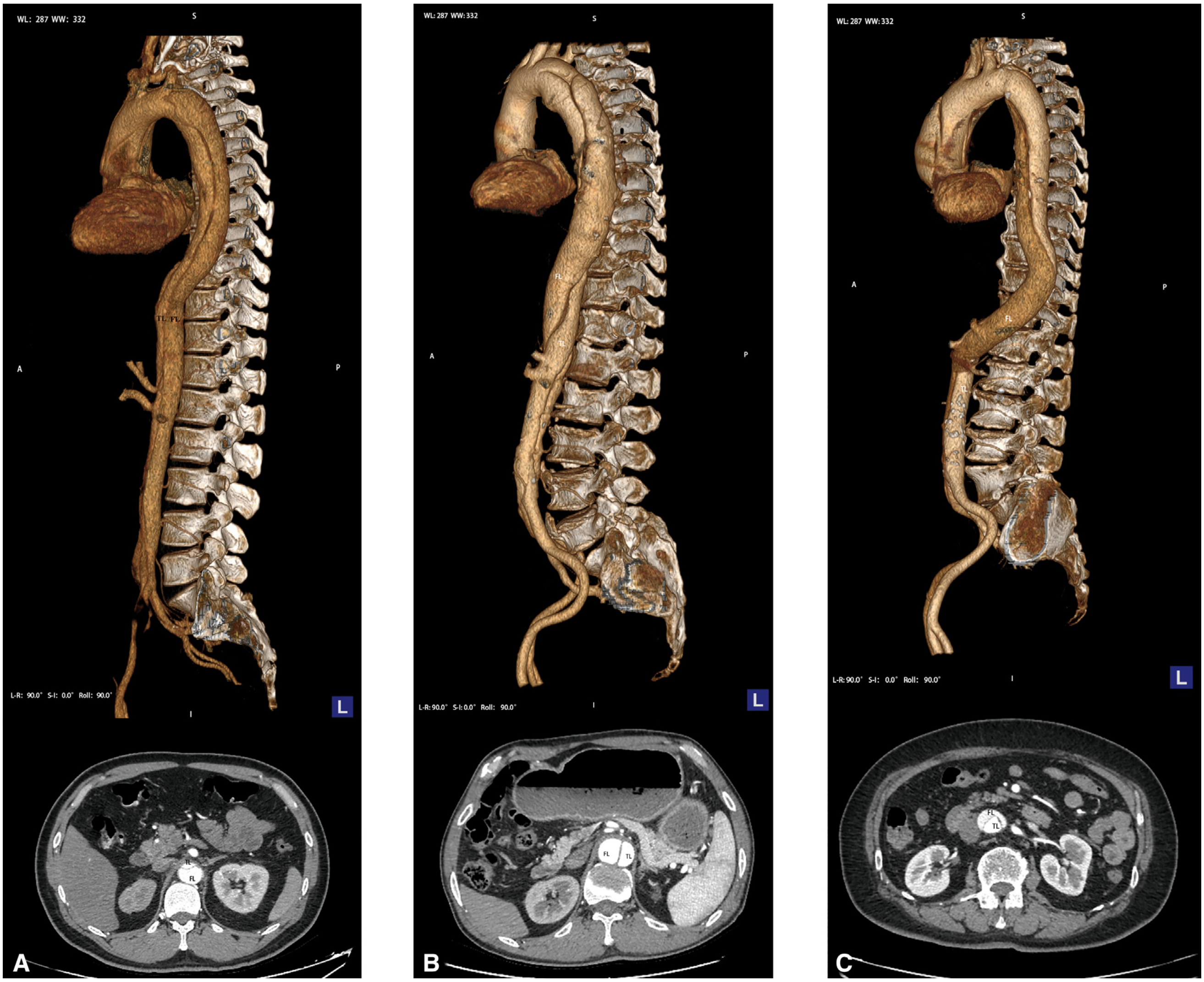


FIGURE 1. Three categories of SA origination. A, SAs completely from FL at the Th9-L3 level. B, SAs partially from FL at the Th9-L3 level. C, SAs completely from TL at the Th9-L3 level. *FL*, False lumen; *TL*, true lumen.

arrest times. All of these data were collected from the institutional database.

Computed Tomography Angiography (CTA) Imaging

We carefully reviewed the CTA of all patients to assess the involvement of the aorta and SAs and categorized patients into 3 groups depending on the origination of SAs at the Th9-L3 level: (1) completely from FL, (2) partially from FL, and (3) completely from true lumen (Figure 1). We classified SAs at Th9-L3 completely from FL into FL-dependency group and the latter 2 categories into FL-independency group.

Outcomes Definition

The primary outcome was SCI after surgery. SCI was defined as a newly developed paraplegia or paraparesis, which was confirmed by multidisciplinary evaluation as follows: the impairment or loss of motor and/or sensory function in the thoracic, lumbar, or sacral (but not cervical) segments of the spinal cord, secondary to damage of neural elements within the spinal canal.[4] For further measures, postoperative complications during hospitalization were recorded and evaluated.

Statistical Analyses

Descriptive statistics are presented as mean ± standard deviation or median with interquartile range for continuous variables and as counts (%) for categorical variables. Categorical variables were compared with χ^2 test or Fisher exact test, and continuous variables were compared using Student *t*-test or Mann–Whitney *U* test based on the normality of the distributions.

The inverse-probability-of-treatment weighting (IPTW) based on propensity score modeling was employed to minimized the impact of no-randomization bias between FL-dependency and FL-independency groups. The propensity score was defined as the probability of a patient with FL dependency of SAs conditional on prespecified baseline parameters and was estimated from the logistic regression analysis incorporating all covariates listed in Table 1.

TABLE 1. Baseline characteristics between FL-dependency versus FL-independency groups

Variables	FL-independency (n = 111) x ± s/n (%)	FL-dependency (n = 35) x ± s/n (%)	*P* value	SMD
Age, y	50.7 ± 11.1	49.7 ± 13.6	.633	8.80%
Male sex, %	88 (79.3)	27 (77.1)	.974	5.20%
BMI, kg/m^2	25.9 ± 4.5	26.0 ± 3.8	.867	3.40%
Hypertension, %	80 (72.1)	22 (62.9)	.41	19.8%
Diabetes mellitus, %	1 (0.9)	1 (2.9)	.385	14.4%
Coronary artery disease, %	6 (5.4)	1 (2.9)	.872	12.8%
Marfan syndrome, %	3 (2.7)	2 (5.7)	.748	15.0%
Valvular heart disease, %	7 (6.3)	5 (14.3)	.252	26.5%
Preoperative glucose, mmol/L	7.8 ± 2.4	7.0 ± 1.9	.072	37.1%
Preoperative lactic acid, mmol/L	2.0 ± 1.4	1.8 ± 1.1	.559	12.2%
Preoperative WBC, 10^9/L	12.8 ± 3.9	12.2 ± 3.5	.423	15.9%
Preoperative Hb, g/L	138.0 ± 16.3	139.5 ± 17.5	.638	9.00%
Preoperative SCr, μmol/L	80.1 ± 34.7	123.9 ± 215.3	.04	28.4%
Preoperative CRP, mg/L	21.6 ± 27.2	19.5 ± 25.7	.689	7.90%
Preoperative CTnT, ng/L	102.3 ± 789.2	41.5 ± 105.4	.651	10.8%
Preoperative D-dimer, mg/L	9.8 ± 11.0	7.62 ± 11.16	.297	20.2%
Preoperative BNP, pg/mL	680.0 ± 1135.8	2709.6 ± 6592.7	.002	42.9%
Max AAD, mm	46.7 ± 6.8	46.6 ± 6.5	.974	0.70%
Max DAD, mm	36.0 ± 5.8	34.3 ± 6.6	.161	26.3%
LSA involved, %	49 (44.1)	14 (40.0)	.813	8.40%
TL compressed, %	40 (36.0)	19 (54.3)	.085	37.3%
Re-entry at Th9-L3, %	66 (59.5)	19 (54.3)	.73	10.5%
CPB time, min	215.0 ± 52.6	223.8 ± 74.7	.442	13.6%
Aortic crossclamping time, min	160.7 ± 47.8	172.8 ± 64.6	.234	21.3%
Circulatory arrest time, min	18.5 ± 7.1	19.2 ± 8.3	.625	9.10%
The distal position of FET (vertebra)	T7.1 ± 0.6	T7.5 ± 0.7	.002	60.5%

TL compressed was defined as the ratio of the area of the narrowest true lumen to the area of the aorta <0.2 (80% occlusion); $P < .05$ was considered as statistical difference. *FL*, False lumen; *SMD*, standardized mean difference; *BMI*, body mass index; *WBC*, white blood cell; *Hb*, hemoglobin; *SCr*, serum creatinine; *CRP*, C-reactive protein; *CTnT*, cardiac troponin T; *BNP*, B-type natriuretic peptide; *Max AAD*, maximum ascending aorta diameter; *Max DAD*, maximum descending aorta diameter; *LSA*, left subclavian artery; *TL*, true lumen; *CPB*, cardiopulmonary bypass; *FET*, frozen elephant trunk.

The adjustment with IPTW was performed based on the trimmed stabilized weight with robust standard errors. The balance of the covariates was assessed by the standardized mean difference, in which a difference of <10% was considered to indicate a reasonable balance. For the assessment of perioperative complications, IPTW-adjusted logistic regression model was used to yield adjusted odd ratio and 95% confidence interval.

Data were analyzed using the SPSS 23.0 software (IBM Corp) and R software, version 4.2.0 (R Foundation for Statistical Computing). All reported *P*-values were 2-sided.

RESULTS

Patients Characteristics

A total of 146 patients were enrolled. The average age was 50.49 ± 11.72 years, and 115 (78.8%) were male. Thirty-five patients had completely FL dependency of SAs, whereas the remaining 111 showed FL independency of SAs. Table 1 summarizes the baseline characteristics between the 2 groups. In patients with FL dependency of SAs, preoperative serum creatinine and B-type natriuretic peptide were significantly greater and had longer stents during operation, compared with patients with FL independency of SAs. IPTW adjustment yielded well-balanced cohorts for the baseline characteristics, with standardized mean differences of <10% for most covariates in Table E1.

Clinical Outcomes

The incidences of adverse events are shown in Table 2. Postoperative SCI occurred in 15 (10.3%) patients, 12 patients in the FL-dependency group and 3 in the FL-independency group; 13 patients presented with paraplegia and 2 with paraparesis, and presentation occurred in 9 patients within postoperative 1 day and in 6 later than that. Further details on the occurring time of SCI profiles are presented in Figure 2. Fourteen patients had recovered within

TABLE 2. Clinical outcomes of the FL-dependency versus FL-independency groups

Outcomes	FL-independency (n = 111) n (%)	FL-dependency (n = 35) n (%)	*P* value
SCI, %	3 (2.7)	12 (34.3)	**<.001**
Retracheal intubation, %	12 (10.8)	3 (8.6)	.951
Tracheotomy, %	5 (4.5)	5 (14.3)	.107
Pulmonary infection, %	33 (29.7)	17 (48.6)	.065
Pleural effusion, %	39 (35.1)	12 (34.3)	.927
Hydropericardium, %	5 (4.5)	4 (11.4)	.279
Hemodialysis, %	40 (36.0)	16 (45.7)	.408
ECMO, %	8 (7.2)	3 (8.6)	1.000
Hemorrhagic complications, %	6 (5.4)	0	.160
Incision complication, %	4 (3.6)	0	.617
Arrhythmia, %	1 (0.9)	0	.573
Reoperation, %	8 (7.2)	4 (11.4)	.660
Death, %	20 (18.0)	5 (14.3)	.800

P value in bold was considered as statistically significant difference. *FL*, False lumen; *SCI*, spinal cord injury; *ECMO*, extracorporeal membrane oxygenation.

1 month postoperatively following the institution of pertinent treatment such as CSFD and methylprednisolone and anticoagulation therapy, whereas only 1 patient manifested persistent paraplegia at 2-year follow-up. Twenty-five (17.1%) patients died during hospitalization. The causes of death included low cardiac output syndrome (n = 7, 28.0%), pulmonary infection (n = 6, 24.0%), gastrointestinal hemorrhage (n = 3, 12.0%), thoracic hemorrhage due to distal descending aorta rupture (n = 1, 4.0%), subarachnoid hemorrhage (n = 1, 4.0%), intracranial hemorrhage (n = 1, 4%), withdrawal of care (n = 2, 8%), mediastinal infection (n = 2, 8%), and multiple organ dysfunction syndrome (n = 2, 8%).

The risk of SCI in the FL-dependency group was significantly greater than that in FL-independency group in IPTW models (adjusted odds ratio, 13.12; 95% confidence interval, 4.19-41.04; $P < .001$). The risks of adverse events after adjustment with IPTW are presented in Table 3. There were no significant differences in the risks of adverse events between the 2 groups in either the crude or IPTW models.

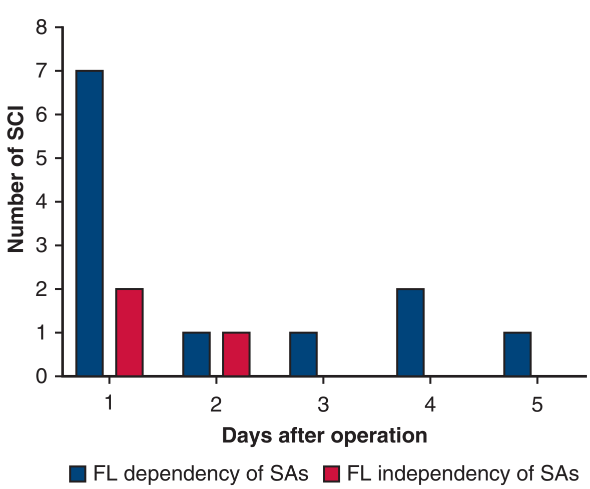


FIGURE 2. Occurrence time of postoperative SCI. *SCI*, Spinal cord injury; *FL*, false lumen; *SA*, segmental artery.

DISCUSSION

In our study, the incidence of SCI was 10.3%, which is consistent with previous studies.[5-7] The present study demonstrated that FL dependency of SAs was significantly associated with the development of SCI following total arch replacement and FET implantation in acute DeBakey type I AD (Figure 3). We believe this result raises alarming sign in the use of FET in this clinical setting in the era of expanding endovascular therapies in aortic diseases.

Since total arch replacement and FET has been performed in the clinic regularly, its safety has been verified by number of studies, which have shown improved survival by this technique in patients with acute DeBakey type I AD.[8-11] However, it is noteworthy that SCI seriously affects survival rate and prognosis for patients with acute DeBakey type I AD.[5,6,12] As a potentially deadly consequence, SCI is still remaining a major concern with this procedure.

Plenty of studies have been carried out to explore the risk factors of SCI following FET in acute AD. In the study by Preventza and colleagues,[5] SCI was found to be significantly associated with longer stent, and 11.6% of the patients with stent length 15 cm or greater or coverage T8 or beyond had a spinal cord ischemic event after FET, compared with 2.5% of the patients with stent length 10 cm. A study from Flores and colleagues[7] also supported this view. They found that extensive deployment of the stent seems to be at a greater risk for SCI, which may be attributable to the occlusion of the intercostal arteries extensively

TABLE 3. Clinical outcomes of the FL-dependency versus FL-independency groups after adjustment

Outcomes	aOR (95% CI)	*P* value
SCI	13.1 (4.2-41.0)	**<.001**
Retracheal intubation	0.9 (0.4-2.0)	.927
Tracheotomy	0.9 (0.4-2.4)	.911
Pulmonary infection	0.9 (0.6-1.5)	.824
Pleural effusion	1.0 (0.6-1.6)	.164
Hydropericardium	0.9 (0.4-2.6)	.980
Hemodialysis	0.9 (0.6-1.5)	.949
ECMO	0.6 (0.2-1.6)	.442
Hemorrhagic complications	0.1 (0.0-1.4)	.083
Incision complication	0.1 (0.0-2.9)	.207
Arrhythmia	0.3 (0.0-8.6)	.521
Reoperation	1.1 (0.5-2.4)	.887
Death	0.8 (0.4-1.5)	.695

P value in bold was considered as statistically significant difference. *aOR*, Adjusted odds ratio; *CI*, confidence interval; *SCI*, spinal cord injury; *ECMO*, extracorporeal membrane oxygenation.

either by direct closure by the stents or by thromboembolism. In a study by Hoffman and colleagues,[13] in contrast, total occlusion of the SAs down to T10-12 might have enhanced the redistribution of the collateral network, thus reducing the risk of SCI. Considering these 2 contradictory notions with regard to the impact of stent length on the risk of SCI, the length of FET was also considered as a potentially important risk factor in the present study. The distal position of FET in patients with FL dependency of SAs was significantly lower than patients with FL independency of SAs group, but after adjusted by IPTW model, the difference between the 2 groups in the stent length was neutralized to blunt its impact in the final results.

The main blood supply of the spinal cord comes from the anterior spinal artery (ASA) and the SAs, the former originating from the vertebral artery and the latter usually from the posterior wall of the aorta.[14,15] Due to its long course, the ASA requires an additional arterial supply via the anterior radiculomedullary arteries in order to maintain adequate blood flow to the entire spinal cord. The most important

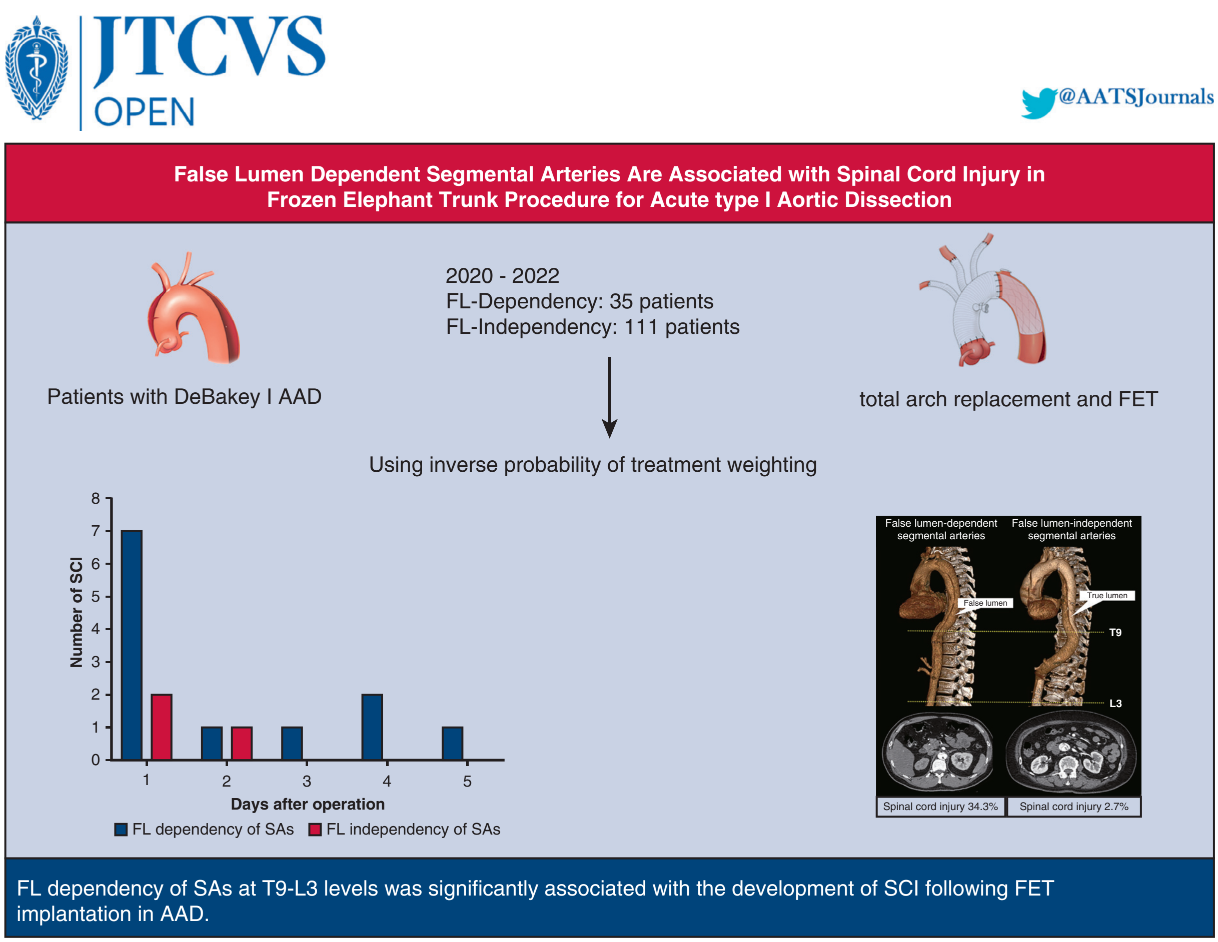


FIGURE 3. A graphical summary of our study. The FL dependency of SAs at T9-L3 levels was significantly associated with the occurrence of SCI following aortic arch replacement and FET implantation in AAD. *FL*, False lumen; *AAD*, acute aortic dissection; *FET*, frozen elephant trunk; *SA*, segmental artery; *SCI*, spinal cord injury.

one is known as the Adamkiewicz artery, a branch of SAs. It almost always arises in the thoracolumbar region, between T9 and L3 in 70% to 90% of cases.[16,17] Portions of the thoracic and upper lumbar spinal cord are extremely vulnerable to ischemic compromise, as there is minimal collateral supply to the spinal cord inferior to the junction of the Adamkiewicz artery and ASA.[18] We analyzed the aortic CTA scans of the 15 patients with postoperative SCI and found a characteristic that FL dependency of SAs at the T9-L3 levels in 12 patients. If the FL is located on the spinal side at the T9-L3 level, it happens to make the most of critical SAs originating from the FL. If the primary entry is closed by the stent, the blood perfusion of the FL will decrease suddenly, then the Sas that originate from the FL may also be affected negatively, which will finally compromise the blood supply of the spinal cord.[6,19] Extensive loss of SAs is a well-known predisposing event of SCI, which is also reflected in the results of the present study.[3,7,20,21] Among the 12 patients who developed SCI in the FL-dependency group, 5 occurred later than postoperative day 1, in which gradual formation of thrombosis in the FL during aortic remodeling might have been causing the process (Figure 2). The mortality and SCI rate in our study were 17.1% and 10.3%, respectively, which seem a little greater than other studies. This reminds us that simpler surgery may be beneficial for some high-risk patients, such as patients with an older, previous aortic surgery history and multiple underlying conditions. Meanwhile, FET should be carefully used in patients with FL dependency of SAs detected on preoperative imaging. A number of previous studies have shown that persistent re-entry site in the distal untreated aorta prohibits positive aortic remodeling following the proximal aortic surgery, by which the FL is likely to persist, as the re-entry between the true lumen and FL provides continuous blood supply to FL.[22-24] When patients have the FL dependency of SAs, however, leaving the re-entry left open may be a reasonable option to prevent SCI at the cost of the risk of later aneurysmal formation for downstream aorta. Another option in performing FET in the setting of FL-dependency of SAs may include conducting proactive management against SCI, such as minimizing circulatory arrest time, placing a CSFD catheter, using a shorter FET, and adopting earlier anticoagulation.

For patients who have already had SCI, we advocate the comprehensive management for rescuing them involving CSFD, raising their blood pressure, the administration of methylprednisolone anticoagulation, and rehabilitation treatment. In our study, 9 of 15 patients with postoperative SCI were completely recovered in 1 week after CSFD, which implies that early implement CSFD is the most crucial procedure for the prognosis of these patients.

Limitations

Some limitations exist in our study, and the data should be interpreted with caution. First, our study was a single-center retrospective study, by which the findings may not be representative of the total population. Second, our sample size is not large enough, the statistical power may be limited to draw a robust conclusion.

CONCLUSIONS

FL dependency of SAs at the T9-L3 levels was significantly associated with the development of SCI following total arch replacement and FET implantation in acute DeBakey type I AD, warning against its use in patients presenting with FL dependency of SAs at critical segments. Further large-scale studies may help validate the results of the present study.

Webcast

You can watch a Webcast of this AATS meeting presentation by going to: https://www.aats.org/resources/false-lumen-dependent-segmental-arteries-are-associated-with-spinal-cord-injury-in-total-arch-repair-and-frozen-elephant-trunk-procedure-in-acute-de-bakey-type-i-aortic-dissection.

Conflict of Interest Statement

The authors reported no conflicts of interest.

The *Journal* policy requires editors and reviewers to disclose conflicts of interest and to decline handling or reviewing manuscripts for which they may have a conflict of interest. The editors and reviewers of this article have no conflicts of interest.

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Key Words: acute DeBakey type I aortic dissection, false lumen, frozen elephant trunk, risk factors, spinal cord injury, total arch replacement

TABLE E1. Baseline characteristics between FL-dependency versus FL-independency groups after adjustment

Variables	FL-independency (n = 111) x ± s/%	FL-dependency (n = 35) x ± s/%	*P* value	SMD
Age, y	50.29 ± 11.16	47.94 ± 11.90	.744	7.23%
Male sex	78.80	84.00	.868	3.40%
BMI	26.15 ± 4.73	26.28 ± 3.35	.877	3.40%
Hypertension	68.5	56.9	.775	4.60%
Diabetes mellitus	1.5	1.6	.968	0.70%
Coronary artery disease	5.5	2.8	.513	13.90%
Marfan syndrome	2.8	1.7	.588	7.50%
Valvular heart disease	7.0	5.9	.779	4.60%
Preoperative glucose, mmol/L	7.62 ± 2.42	7.64 ± 2.07	.969	0.90%
Preoperative lactic acid, mmol/L	2.05 ± 1.41	2.20 ± 1.05	.559	12.10%
Preoperative WBC, 10^9/L	12.73 ± 3.86	12.48 ± 3.25	.735	6.90%
Preoperative Hb, g/L	139.17 ± 17.60	140.24 ± 15.05	.751	6.60%
Preoperative SCr, μmol/L	80.36 ± 36.34	93.55 ± 111.53	.578	8.20%
Preoperative CRP, mg/L	20.51 ± 26.23	21.22 ± 25.62	.909	2.70%
Preoperative CTnT, ng/L	86.39 ± 696.16	26.44 ± 78.80	.313	12.10%
Preoperative D-dimer, mg/L	9.28 ± 10.74	8.26 ± 11.61	.716	9.20%
Preoperative BNP, pg/mL	767.24 ± 1337.78	1156.11 ± 3561.39	.631	9.80%
Max AAD, mm	46.87 ± 6.78	46.76 ± 5.81	.933	1.70%
Max DAD, mm	35.57 ± 5.76	34.26 ± 5.93	.603	10.10%
LSA involved	42.1	41.0	.928	2.10%
TL compressed	39.7	32.0	.485	16.00%
Re-entry at Th9-L3	56.7	58.0	.922	2.60%
CPB time, min	219.56 ± 54.94	207.01 ± 72.94	.622	9.80%
Aortic crossclamping time, min	166.40 ± 52.19	156.97 ± 63.96	.584	7.50%
Circulatory arrest time, min	18.34 ± 7.27	17.89 ± 7.88	.816	5.90%
The distal position of FET (vertebra)	T7.23 ± 0.69	T7.34 ± 0.56	.386	17.60%

TL compressed was defined as the ratio of the area of the narrowest true lumen to the area of the aorta <0.2 (80% occlusion); *P* < .05 was considered as statistical difference. *FL*, False lumen; *SMD*, standardized mean difference; *BMI*, body mass index; *WBC*, white blood cell; *Hb*, hemoglobin; *SCr*, serum creatinine; *CRP*, C-reactive protein; *CTnT*, cardiac troponin T; *BNP*, B-type natriuretic peptide; *Max AAD*, maximum ascending aorta diameter; *Max DAD*, maximum descending aorta diameter; *LSA*, left subclavian artery; *TL*, true lumen; *CPB*, cardiopulmonary bypass; *FET*, frozen elephant trunk.