Limited *vs.* extended repair for acute type I aortic dissection: long-term outcomes over a decade in Beijing Anzhen Hospital

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To the Editor: For patients with acute DeBakey type I aortic dissection, ascending aortic or hemiarch replacement can reduce the surgical time and save lives in critical situations. However, residual distal dissection increases the risk of dilatation, rupture, and death.[1] In contrast, total aortic arch replacement (TAR) with frozen elephant trunk (FET) implantation can minimize the need for re-intervention,[2] but may increase the risk of operative mortality, stroke, paraplegia, and other complications. Currently, the question of the optimal surgical strategy for acute DeBakey type I aortic dissection remains controversial owing to the scarcity of long-term follow-up data and the technical diversities among different institutions. Therefore, in this study, we compared the early and long-term outcomes of limited *vs.* extended repair in the management of patients with acute DeBakey type I aortic dissection.

From January 2009 to December 2013, 511 consecutive patients who were diagnosed with acute DeBakey type I aortic dissection (from symptom onset to surgery: ≤14 days) underwent surgical treatment at the Beijing Anzhen Hospital, Beijing. Of these, 21 patients underwent limited repair (LR), including ascending aortic or hemiarch replacement (LR group), and 490 patients underwent TAR with FET implantation (TAR + FET group). The indications and techniques of TAR + FET which are followed at the Beijing Anzhen Hospital have been described in detail previously,[2] while the indications for LR were critically ill patients of advanced age, and those with multiple comorbidities or those at very high mortality risk (pre-operative cardiogenic shock or pericardial tamponade). Owing to the marked difference in the number of patients between the two groups, propensity score matching based on gender and age was used to create a cohort at a 1:3 ratio; this ratio resulted in 21 and 63 patients being placed in the LR and TAR + FET groups, respectively. The Ethics Committee of Beijing Anzhen Hospital (affiliated to Capital Medical University) approved this retrospective study, and informed consent was obtained from each patient.

The mean ages were 51.0 ± 11.7 years and 51.5 ± 10.5 years in the LR and TAR + FET groups, respectively ($P = 0.848$). The LR group constituted 42.9% (9/21) men, in comparison with 46.0% (29/63) men in the TAR + FET group ($P = 0.800$). There was no significant difference in the rates of previous aortic/cardiac procedures (4.8% [1/21] *vs.* 4.8% [3/63], LR *vs.* TAR + FET, respectively; $P = 1.000$); the groups had a similar incidence of Marfan syndrome (9.5% [2/21] *vs.* 11.1% [7/63], LR *vs.* TAR + FET, respectively; $P = 0.839$). The comorbidity rates for diabetes mellitus, coronary artery disease, cerebrovascular disease, chronic obstructive pulmonary disease, and chronic kidney disease did not differ between the LR and TAR + FET groups, respectively: 4.8% (1/21) *vs.* 6.3% (4/63), $P = 0.790$; 4.8% (1/21) *vs.* 7.9% (5/63), $P = 0.625$; 4.8% (1/21) *vs.* 3.2% (2/63), $P = 0.734$; 4.8% (1/21) *vs.* 1.6% (1/63), $P = 0.409$; and 0.0% (0/21) *vs.* 1.6% (1/63), $P = 0.561$. However, the locations of the entry tear differed significantly ($P = 0.020$). In the LR group, the most common location was the ascending aorta (63.2% [12/21]), followed by the sinuses of Valsalva (21.1% [4/21]), the sinotubular junction (9.5% [2/21]), and the aortic arch (5.3% [1/21]). In the TAR + FET group, the entry tear was located in the ascending aorta in 47.5% (29/63) of the patients, in the aortic arch in 34.9% (22/63), in the sinotubular junction in 13.1% (8/63), and in the sinuses of Valsalva in 3.3% (2/63). Malperfusion syndrome was more common in the LR group, as compared with the TAR + FET group (42.9% [9/21] *vs.* 22.2% [14/63]); this was not statistically significant ($P = 0.066$).

The durations required for cardiopulmonary bypass (CPB), aortic cross-clamp, and selective anterograde cerebral

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perfusion in the LR group were significantly shorter than those for the TAR + FET group (159.9 ± 52.1 *vs.* 195.2 ± 42.1 min, $P = 0.002$; 86.8 ± 36.4 *vs.* 107.3 ± 30.3 min, $P = 0.012$; and 15.0 ± 9.8 *vs.* 24.8 ± 8.9 min, $P < 0.001$; respectively). Patients in the LR group were more likely to require a root procedure compared with the TAR + FET group (80.9% [17/19] *vs.* 52.4% [33/63], $P = 0.020$). Concomitant procedures included coronary artery bypass grafting in 11 patients (13.1%), extra-anatomic bypass in 2 (2.4%), and mitral valve surgery in 1 (1.2%); these values did not differ significantly between the two groups. Operative mortality occurred in six patients; this number did not differ between the LR and TAR + FET groups (6.3% [4/63] *vs.* 9.5% [2/21], $P = 0.625$). Multiorgan failure was the leading cause of death, followed by respiratory failure and cardiac arrest. Respiratory complications were the most common form of post-operative complications and necessitated prolonged ventilation and re-intubation in 35.7% (30/84). Acute kidney injury was the second most common complication, and was seen in 8.3% of patients (7/84). Spinal cord injury and stroke occurred in four patients and one patient in the LR and the TAR + FET groups, respectively. Although the TAR + FET group had more complications, this difference was not a statistically significant difference (29.7% [25/63] *vs.* 23.8% [5/21], $P = 0.189$).

Follow-up was completed in 97.4% (76/78) of the patients, with a mean duration of 7.6 ± 3.4 years (range: 0–11.6 years; median: 8.5 years). Late death occurred in 11 patients and was more likely in the LR group (29.4% [5/17] *vs.* 10.2% [6/59], $P = 0.047$). Distal aortic rupture was the leading cause of late death in the LR group and was seen in 80% (4/5); this value differed significantly from the corresponding figure for the TAR + FET group (20.0% [1/5]). In the TAR + FET group, other causes of death included distal infection in one patient (1.7%) and stroke and non-cardiac reasons in two patients each (3.4%). Overall survival did not differ significantly between the LR and TAR + FET groups ($P = 0.056$). The incidence of aortic events was significantly higher in the LR group (35.3% [6/17] *vs.* 5.1% [3/59], $P = 0.001$) and included distal aortic rupture in four patients and distal new entry and residual dissection in one patient each. Reoperation was performed in four patients of the entire cohort; this number did not differ significantly between the two groups (5.9% [1/17] *vs.* 5.1% [3/59], $P = 0.897$). One patient in the LR group (5.9%) underwent total arch replacement for residual arch dissection. Reoperations in the TAR + FET group involved thoracic endovascular aortic repair in two (3.4%) patients (for distal new entry and type Ib endoleak, respectively) and thoracoabdominal aortic replacement for residual dissection in one (1.7%) patient [Table 1].

Table 1: Operative outcomes of Limited and extended repair for acute type I aortic dissection, *n* (%).

Variables	LR ($n = 21$)	TAR + FET ($n = 63$)	*P*
Operative mortality	2 (9.5)	4 (6.3)	0.625
Multiorgan failure	2 (9.5)	3 (4.8)	0.424
Acute kidney failure	1 (4.8)	1 (1.6)	0.409
Low cardiac output	1 (4.8)	1 (1.6)	0.409
Cardiac arrest	2 (9.5)	1 (1.6)	0.090
Respiratory failure	2 (9.5)	1 (1.6)	0.090
Infection	1 (4.8)	1 (1.6)	0.409
Coagulopathy	1 (4.8)	0	0.081
Operative morbidity	5 (23.8)	25 (39.7)	0.189
Stroke	0	1 (1.6)	0.561
Spinal cord injury	0	4 (6.3)	0.237
Re-exploration for bleeding	0	4 (6.3)	0.237
Acute kidney failure	3 (14.3)	4 (6.3)	0.254
Low cardiac output	1 (4.8)	4 (6.3)	0.790
Limb ischemia	0	4 (6.3)	0.237
Recurrent laryngeal nerve injury	0	1 (1.6)	0.561
Pneumonia	2 (9.5)	16 (25.4)	0.125
Prolonged ventilation (>48 h)	4 (19.0)	16 (25.4)	0.554
Tracheal re-intubation	2 (9.5)	8 (12.7)	0.697
Late death	5 (29.4)	6 (10.2)	0.047
Stroke	0	2 (3.4)	0.442
Infection	0	1 (1.7)	0.589
Non-cardiac causes	1 (5.9)	2 (3.4)	0.642
Adverse aortic events	6 (35.3)	3 (5.1)	0.001
Distal aortic rupture	4 (23.5)	1 (1.7)	0.001
Distal new entry	1 (5.9)	1 (1.7)	0.342
Residual dissection or dilation	1 (5.9)	1 (1.7)	0.342
Neurologic events	1 (5.9)	2 (3.4)	0.642
Coronary anastomotic leakage	1 (5.9)	0	0.061
Pneumonia	1 (5.9)	0	0.061
Late reoperation	1 (5.9)	3 (5.1)	0.897

LR: Limited repair; TAR + FET: Total arch replacement using frozen elephant trunk.

In this study, we observed no significant difference in operative mortality and complication rates between the LR and TAR + FET groups. In the long term, however, patients undergoing LR showed higher incidences of late death caused due to aortic rupture. Also, the incidence of certain complications reported in this cohort was higher compared to the incidence mentioned in our previous reports.[2] We speculate that this difference may be ascribed to the small sample size which was involved in the present study.

Although the FET technique is more time-consuming and is believed to increase the potential risk of paraplegia, stroke, and death,[1] our previous report demonstrated that TAR did not significantly increase operative mortality and morbidity.[2] The development of paraplegia may not be related to the FET procedure but to the disease which it is intended to address. Likewise, stroke is thought to be caused by multiple factors, such as longer CPB and circulatory arrest times. Consistent with our previous reports, the incidence of stroke was low in this series.[2] Respiratory complications represent a common problem after acute aortic dissection operation. We are now switching to a CPB strategy of using more of isolated crystalloids for pump priming to minimize respiratory complications. Acute kidney injury is also very common (11.9% in this series) and is closely related to CPB time and intra-operative blood transfusion.[3] Therefore, early prediction and timely treatment are essential to optimizing patient outcomes. The most important weakness of LR of acute type I dissection is the untreated patent false lumen in the distal aorta, which increases the risk of dilation, rupture, and death.[1] The incidence of patent false lumen was in the range of 42.0% to 65.0%,[1,4] leading to a high mortality (20.0%) arising from distal aortic rupture.[5] The results of this study

reiterate the ominous impact of patent false lumen on long-term survival after the LR procedure, which may also cause organ malperfusion due to true lumen collapse within 10 years in 30% of patients.[6] The FET technique can effectively open the true lumen and improve distal organ perfusion. Most centers experienced in FET techniques recommended the TAR + FET procedure for aortic dissections with intimal tears on the greater curvature of the arch, for proximal descending aorta, or for all arch tears.[7] Others considered that the TAR + FET procedure should be performed for young patients and in cases of connective tissue disease, dilated aortic arch, and malperfusion.[1,8] Our experience shows that the TAR + FET procedure is safe and can achieve durable results in patients with type I aortic dissection, and that it is particularly efficacious for those with Marfan syndrome, arch entry tear, arch vessel involvement, and arch anomalies.[2] The results of this study also show that thoracic endovascular aortic repair is an effective re-intervention strategy which can be followed subsequent to the TAR + FET procedure in cases of distal new entry, residual dissection or dilatation, and rupture, because the distal end of the FET prosthesis provides a reliable proximal landing zone or suture margin for re-intervention or second thoracoabdominal aortic replacement.

This study has several limitations, including its retrospective nature and single-center setting. Most Chinese patients are reluctant and unlikely to undergo reoperation on the distal aorta, even if it presents a clear indication for re-intervention. On the other hand, the majority of patients with aortic dissection in China have a younger age. Consequently, we have been adopting the more aggressive strategy of total arch repair for acute type I dissection to improve long-term prognosis in addition to saving lives, while LR is reserved only for critically ill patients of advanced age or who are at very high mortality risk, or in very special circumstances, such as emergency operations during the COVID-19 pandemic. This strategy led to a selection bias that accounts for the small number of ascending aortic or hemiarch repairs in this study, which affects comparison and reduces the possibility of demonstrating a significant difference in survival and freedom of reoperation between the two operative strategies. Other limitations pertain to the small number of variables in the propensity matching and the lack of data on imaging follow-up in the long term. Therefore, the results of this study have limited value and should be interpreted with caution. In conclusion, LR was associated with higher incidences of late death and adverse events. TAR + FET may provide better long-term results than LR.

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Conflicts of interest

None.

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