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Frozen Elephant Trunk for Acute Type A Dissection: Is Risk from Procedure or Patient Characteristics?

R. Wilson King, MD, MBA[1] Adam M. Carroll, MD[1] Kelly C. Higa, MD[2] Joseph C. Cleveland Jr., MD[3] Jessica Y. Rove, MD[3] Muhammad Aftab, MD[3] Thomas Brett Reece, MD, MBA[3]

[1] Department of Surgery, University of Colorado, Denver, Colorado
[2] Department of Cardiothoracic Surgery, Stanford University, Stanford, California
[3] Department of Cardiothoracic Surgery, University of Colorado, Denver, Colorado

Address for correspondence R.W. King, MD, Department of Surgery, University of Colorado, Denver, CO 80212 (e-mail: robert.3.king@cuanschutz.edu).

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Abstract

Background The initial goal of acute Type A aortic dissection (ATAAD) repair remains to get the patient off the table safely. More extensive repair is being pushed at the index operation with the frozen elephant trunk (FET) operation, but outcomes are suggested to be worse. However, we hypothesize that the risk associated with the FET in ATAAD is from the patient presenting factors rather than the operation itself.

Methods A retrospective review of a single institution prospective database from 2015 to 2021 was performed. Two cohorts were created based on the indication for FET: evidence of radiographic malperfusion ($n = 44$) or clinical malperfusion ($n = 31$). Data were analyzed for preoperative characteristics, intraoperative characteristics, and postoperative outcomes. Statistical univariate analysis was performed with chi-square analysis and *t*-tests with significance determined at an alpha level of 0.05.

Results Preoperative characteristics were similar in each group, independent of malperfusion markers. The intraoperative characteristics were similar, except the clinical malperfusion group had more packed red blood cells and cryoprecipitate given. The clinical malperfusion group had longer intensive care unit length of stay ($p < 0.001$), more postoperative strokes ($p < 0.001$), more reoperations ($p < 0.0001$), and higher mortality rate ($p = 0.0003$).

Conclusion These data suggest that clinical malperfusion increases the risk of major complications and death. However, full arch replacement with FET in the absence of clinical malperfusion does not appear to add risk to the operation for ATAAD. Patients with increased risk of distal degeneration should be considered for more aggressive replacement to avoid subsequent arch replacement.

Keywords
- malperfusion
- total arch replacement
- frozen elephant trunk

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Introduction

Acute Type A aortic dissection (ATAAD) is a surgical emergency requiring immediate intervention. The goal of intervention with an ATAAD is to get the patient off of the operating table safely. A recent meta-analysis found that stroke rates and mortality rates approach 12.3 and 11.2%, respectively, in the frozen elephant trunk (FET) operation for ATAAD (and rates even higher in individual series), and the appropriateness of aggressive one-stage replacement has created debate.[1,2] With improvements in cerebral protection and efficiency of open arch replacement, some centers have begun to advocate for more extensive repair at the initial operation, such as the FET procedure. The FET in ATAAD is interpreted to be higher risk than a less extensive operation; however, this operation may produce better long-term outcomes and result in fewer aortic interventions. We hypothesize that the reported risk of the FET in ATAAD are related to specific patient presenting factors, such as clinical malperfusion, rather than the distal extent of the aortic repair.

Materials and Methods

A retrospective review of a single-institution prospective database with consecutive patients who received aortic surgery was used to identify all patients who had received an FET procedure for a Type A aortic dissection from 2015 to 2021. Nearly all of the patients received a Gore TAG graft, whereas the remaining received a RELAY graft. These patients were then split into two cohorts based on whether the patient had clinical malperfusion versus radiographic malperfusion. A patient had clinical malperfusion if there was symptomatology or convincing laboratory evidence of end organ ischemia, which included chest pain with myocardial infarction, neurological deficits/stroke, visceral ischemia (abdominal pain with symptomatology or laboratory evidence such as acidosis suggesting mesenteric ischemia), extremity sensorimotor deficits, and acute limb ischemia. In other words, all the clinical malperfusion patients had malperfusion syndrome. Radiographic malperfusion was defined as simply radiographic evidence of malperfusion to any end organ on preoperative imaging, specifically a greater than 50% reduction in true lumen size of the aorta or branch vessels, without clinical evidence of end organ ischemia. The primary endpoint of interest was postoperative death within 30 days of the operation (or during the index hospitalization), with secondary outcomes as common postoperative indices. Univariate analysis was done using the Fisher's exact test, *t*-test, and chi-square analysis using statistical software and *p*-values were reported as significant at an alpha level of 0.05. The study was approved by the Colorado Multiple Institutional Review Board with waived individual patient consent.

Results

Using a prospectively created database and retrospective review of cases between 2015 and 2021, we identified 205 Type A dissections. Seventy-five patients received an FET for an ATAAD at a single high aortic volume institution. A total of 58.7% (31) of the patients presented with radiographic evidence of malperfusion and 41.3% (44) presented with clinical malperfusion as defined above. Preoperative patient characteristics were similar across both the radiographic malperfusion and clinical malperfusion group. The mean age was 58.5 ± 13.1 and 56.5 ± 10.1 years for the radiographic and malperfusion group, respectively. Both groups were predominately male and white. There were no statistically significant differences in preoperative patient characteristics aside from markers of malperfusion (►**Table 1**). See ►**Table 2** for the various presentations of clinical malperfusion. A total of 45% (14) of the patients with clinical malperfusion had evidence of malperfusion in more than one vascular bed.

With regard to intraoperative characteristics, the groups were similar, except for the amount of blood products given intraoperatively (►**Table 3**). The clinical malperfusion group required more packed red blood cells and cryoprecipitate intraoperatively. Cardiopulmonary bypass times were similar between groups with a mean of 219.1 ± 80.9 minutes in the radiographic malperfusion group and 254.1 ± 88.3 minutes in the clinical malperfusion group ($p = 0.080$).

Postoperatively (►**Table 4**), the clinical malperfusion group had a longer intensive care unit length of stay (11.4 ± 19.3 d, $p < 0.001$), more postoperative strokes (51.6 vs. 6.8%, $p < 0.001$), more reoperations (25% vs. 77.4%, $p < 0.0001$), and a higher mortality rate (45.2 vs. 9.1%, $p < 0.001$). Of those with preoperative strokes, 67% had persistent postoperative strokes. Of those with preoperative visceral ischemia, 37.5% had persistent visceral ischemia. Of those patients with limb paraparesis/paraplegia, 18.8% had persistent symptoms postoperatively. In the clinical malperfusion group, all patients without an early mortality were found to be alive at 1-year postoperative.

Discussion

Despite marked improvements in elective aortic arch replacement, the outcomes of FET procedures in Type A dissection continue to be disappointing[1] (mortality range of 0–21.6% in FET). However, as more aggressive approaches to aortic repair have been adopted, the indications have expanded beyond the known high-risk situations of clinical malperfusion. The operative risk for patients without clinical malperfusion and only radiographic evidence of malperfusion should be less than those with clinical signs of malperfusion.

In our initial analysis, we found that patients who presented with any malperfusion (clinical or radiographic) had a very high mortality rate of 33%. Because of this, we decided to compare patients with clinical evidence of malperfusion (malperfusion syndrome) with those with radiographic evidence of malperfusion without clinical signs of end organ ischemia. While some studies have shown that the FET have higher complication rates due to the extent of the operation, these series fail to separate the indications for extensive operation.[3–6] The presentation would logically change

Table 1 Preoperative characteristics

Variables	Radiographic malperfusion		Clinical malperfusion		*p*-Value
N	44		31		
Age	58.5 ± 13.1		56.51 ± 10.1		0.470
Gender:					
Male	35	80%	23	74%	0.585
Female	9	20%	8	26%	0.585
Race:					
Caucasian	32	73%	20	65%	0.447
African American	8	18%	5	16%	0.817
Hispanic	2	5%	3	10%	0.380
Asian	1	2%	1	3%	0.801
Other	1	2%	2	7%	0.363
Comorbidities:					
Dyslipidemia	15	34%	5	16%	0.083
Hypertension	37	85%	24	77%	0.465
Smoking	12	27%	10	32%	0.641
Diabetes	3	7%	1	3%	0.495
Renal disease	5	11%	3	10%	0.819
Obesity	5	11%	5	16%	0.550
Stroke	3	7%	1	3%	0.495
BMI	29.8 ± 5.4		29.71 ± 8.29		0.950

Abbreviation: BMI, body mass index, kg/m^2; (%)

Table 2 Symptoms of patients presenting with clinical malperfusion

Presentation of malperfusion	*N* (%)	
Acute MI	1	3%
Acute limb ischemia	15	48%
Visceral ischemia	8	26%
Stroke/TIA	9	29%
Limb paraparesis/paraplegia	16	51%

Abbreviations: MI, myocardial infarction; TIA, transient ischemic attack.

outcomes after repair. The patients who present with clinical malperfusion have a very large stroke rate of 51.6% in our series, and mortality rate of 45.2 versus 9.1% of patients in the radiographic group. Further, the reoperation rate in the clinical malperfusion group was higher than the radiographic group. Although not statistically significant, there was a clinical trend for the clinical malperfusion to have a higher rate of requiring continuous renal replacement therapy postoperatively. These data provide more evidence for the overall safety profile of the FET in patients with radiographic evidence of malperfusion, bearing in mind that patients who present with clinical signs of malperfusion are extremely high-risk patients. Although the more extensive operation of the FET can appear in some series to have higher complication rates, our experience suggests that the presenting patient factors are more responsible than the operation itself, as evidenced by a more acceptable risk profile for radiographic malperfusion patients. Limitations of our study include it being a retrospective review, a single-institution, a high-volume center, and most of the operations done by the aortic surgeons of our group. Although these data are exploratory in nature, it is a start in understanding risk stratification in patients who need an FET.

Conclusion

These data suggest that the more extensive FET operation on the index operation for ATAAD may not add risk to the patient. In our series, patients who present with clinical malperfusion have longer intensive care lengths of stays, more postoperative strokes, more reoperations, and much higher death rates. The patients who present with radiographic malperfusion have a more acceptable risk profile when compared with those with clinical signs of malperfusion. This protocol for treating ATAAD aggressively with FET may be a start to reducing the long-term need for future aortic arch interventions by repairing it at the index operation.

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Table 3 Intraoperative characteristics

Variables	Radiographic malperfusion		Clinical malperfusion		*p*-Value
N	44		31		
Additional interventions:					
Aortic valve repair	4	9%	1	3%	0.316
Aortic valve replacement	3	7%	2	6%	0.95
Aortic root replacement	22	50%	22	71%	0.069
Cardiopulmonary bypass time (min)	219.1 ± 80.9		254.08 ± 88.27		0.0798
Cross-clamp time (min)	123.4 ± 69.6		152.41 ± 66.66		0.2401
Circulatory arrest time (min)	30.5 ± 14.7		34.00 ± 14.56		0.3119
Nadir bladder temperature (°C)	24.1 ± 2.5		23.49 ± 3.13		0.3574
Intraoperative blood products:	11 ± 5.4		15.57 ± 14.35		0.0564
Red blood cells	2.6 ± 2.3		4.48 ± 5.26		**0.037**
Fresh-frozen plasma	5.7 ± 2.8		7.93 ± 7.27		0.0726
Cryoprecipitate	0.3 ± 0.6		0.93 ± 1.28		**0.009**
Platelets	2.5 ± 1.1		2.57 ± 1.09		0.7869

Table 4 Postoperative outcomes

Variables	Radiographic malperfusion		Clinical malperfusion		*p*-Value
n	44		31		
Total length of stay (d)	15.0 ± 11.1		17.87 ± 23.79		0.4858
ICU length of stay (d)	7.6 ± 9.1		11.38 ± 19.30		**0.0001**
ICU complications:					
New CRRT	5	11.4%	9	29%	0.0531
SCI	0	0	3	9.7%	0.545
Stroke	3	6.8%	16	51.6%	<**0.0001**
Delirium	11	25%	6	19.4%	0.565
Reoperation	11	25%	24	77.4%	<**0.0001**
Death	4	9.1%	14	45.2%	**0.0003**

Abbreviations: CRRT, continuous renal replacement therapy; ICU, intensive care unit; SCI, spinal cord injury.

Conflict of Interest
The authors declare no conflict of interest related to this article.

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