Reflection From UK Aortic Group: Frozen Elephant Trunk Technique as Optimal Solution in Type A Acute Aortic Dissection

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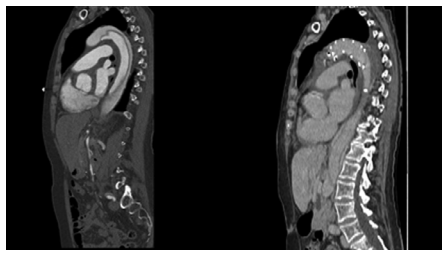
Diseases of the thoracic aorta are increasing in prevalence worldwide. Recent data indicated wide regional variation in the volume and complexity of aortic cases undertaken in United Kingdom cardiac centers, especially in case of acute type A aortic dissection (ATAAD) conditions. Patients treated in high-volume centers with a specific multidisciplinary aortic program had a significant reduction in ATAAD mortality when compared with low-volume centers. Following the initial phase of a national aortic center reorganization, the current study reflects the initial experience of a national collective of cardiothoracic surgeons with expertise in complex aortic surgery, using frozen elephant trunk as standard technique for the surgical treatment of patients affected by ATAAD. Between June 2013 and October 2017, 66 ATAAD patients (45% women) underwent hybrid aortic arch and frozen elephant trunk repair with the Thoraflex hybrid graft at 8 UK high-volume aortic centers. The in-hospital mortality accounted for 8 patients (12%). Postoperative temporary or permanent neurologic events and temporary renal replacement therapy occurred in 17% and 20% of patients, respectively. No spinal cord injury events were documented. Our data were similar to those reported in literature in the 2 largest experiences with the use of frozen elephant technique in ATAAD condition (in-hospital/30-day mortality: 11–12%). This



Preoperative and postoperative computed tomography angiographies showing a type A acute aortic dissection case with its subsequent (final) treatment with a Thoraflex hybrid graft.

Central Message

The "frozen elephant trunk technique" combining endovascular treatment with conventional surgery enables the single-stage treatment of the combined lesions of the thoracic aorta. In patients affected by type A acute aortic dissection, a national collective of UK cardiothoracic surgeons with expertise in complex aortic surgery, proved that to be an optimal surgical solution even in this high-risk population of patients.

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initial experience demonstrated that frozen elephant technique can potentially be adopted as standard approach in life-threatening aortic diseases, with acceptable complication and mortality rates.

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INTRODUCTION

Diseases of the thoracic aorta are increasing in prevalence, accounting for 1−2% of all deaths in Western countries.[1,2] The true incidence might even be higher since unexplained sudden deaths can hide a fatal complication of an underlying aortic disease.[1,2] In the United Kingdom (UK), thoracic aortic diseases cause over 6500 deaths per year, and hospital admissions for thoracic aortic diseases are increased from 4.4 to 9.0 per 100,000 inhabitants in the last decade.[3] A detailed analysis of UK data extracted from the Hospital Episode Statistics and the National Adult Cardiac Surgery Audit (NACSA) between the financial years 2004/2005 and 2012/2013 revealed a wide variation in the management of these patients, with significant regional variation in terms of admission rates, mortality outcomes in both treated and untreated patients.[4] This reflects the different model organizations of UK cardiac centers despite comparable geographical populations, with reference to the presence of dedicated aortic teams, multidisciplinary aortic team meetings, specific on-call rotas for aortic emergencies, and the use of hybrid operating theatres.[4] High-volume centers also demonstrated lower hospital mortality in comparison with low-volume centers, especially for acute type A aortic dissection (ATAAD).[4,5] This is also corroborated by literature data, indicating that delivery of care by multidisciplinary teams in high-volume centers resulted in better outcomes.[4−9] As a consequence, a UK center reorganization with new service specifications have been proposed, and in 2013, a dedicated UK aortic surgery group was created, encompassing all aortic surgeons with the aim to redefine the standard of care for patients affected by diseases of the thoracic aorta.[10] In the present paper, the UK initial experience with frozen elephant technique (FET) in treating ATAAD patients in high-volume centers is presented along with a systematic review of existing evidences.

METHODS

Patient Population

Between June 2013 and October 2017, 66 patients affected by ATAAD underwent surgical hybrid aortic arch and descending thoracic aorta repair with the Thoraflex hybrid graft (Vascutek, Inchinnan, United Kingdom) at 8 UK high-volume centers. Data were prospectively collected and extracted from the National Institute for Cardiovascular Outcomes Research (NICOR) NACSA registry.[11] As described elsewhere, reproducible cleaning algorithms were applied to the database, and transcriptional discrepancies harmonized.[11−13] All included patients were operated at high-volume aortic centers as previously defined.[4] For each procedure, data were recorded on patient characteristics, comorbidities, operative details, and postoperative outcomes. Data on patient age at the time of procedure (years), gender, history of major cardiac surgery, diabetes mellitus (diet or insulin controlled), history of pulmonary disease, history of hypertension, concomitant connective tissue disorder, and presence of preoperative collapse/malperfusion were all documented. Similarly, data on concomitant cardiac procedures, cardiopulmonary bypass (CPB) time, cardiac and distal body ischemic time, lowest body temperature, and selective antegrade cerebral perfusion time were collected. Outcome and administrative data were also extracted, including patient admission, procedure and discharge dates, and follow-up mortality. All participating surgeons were part of the UK aortic surgery group (UK-AS), a national collective of cardiothoracic surgeons with expertise in complex aortic surgery.[4]

Surgical Technique

Generally, after median sternotomy, CPB was initiated via a right axillary arterial (or femoral) cannulation and right atrial venous cannulation. Myocardial protection was achieved with cold blood cardioplegia. During the cooling process, concomitant cardiac procedures were performed. After the patient was cooled to the desired body temperature (18−25°C), under a brief period of deep hypothermic circulatory arrest, the arch was opened longitudinally. Distal organ protection was achieved with deep hypothermic circulatory arrest, whereas cerebral protection was accomplished with antegrade selective cerebral perfusion as previously described.[14] The stented portion of the Thoraflex hybrid graft was bent slightly to conform to the curvature of the descending thoracic aorta, and deployed under direct vision into the aortic true lumen. The distal aortic reconstruction was performed with the sewing collar of the hybrid graft, and subsequently, antegrade distal organ perfusion was restarted from the side branch of the Thoraflex graft as previously described.[15] The left subclavian artery, the left common carotid artery, and the innominate artery were finally anastomosed to the supra-aortic branches of hybrid graft. The graft was deaired and antegrade perfusion to each supra-aortic vessel was re-established. The operation was completed with an end-to-end anastomosis between the Thoraflex graft and the proximal aorta. Generally, the size of

the Thoraflex was decided based on the total aortic diameter, including the true and false lumens, in order to avoid the oversizing of the stent graft.

Outcomes and Statistical Analysis

The primary outcome for this study was in-hospital mortality, defined as death due to any cause during admission to the base hospital for cardiac surgery. The secondary outcomes included postoperative neurologic events (temporary or permanent), spinal cord injury, renal replacement therapy (RRT), and length of stay in the intensive care unit and in the hospital. Postdischarge survival data were collected from the Office for National Statistics (ONS) death registry. Continuous variables are expressed as mean ± standard deviation (min-max range), and categorical variables were summarized as total number and percentages. Clinical data were prospectively recorded and tabulated using Microsoft Excel software (Microsoft, Redmond, WA), and data analysis was performed using IBM SPSS version 24.0 software (IBM, Armonk, NY).

Systematic Review of Literature

A parallel literature search was conducted to compare the present outcome results with those presented from other non-UK large aortic centers. The systematic review was systematically performed with electronic databases (PubMed/MEDLINE, Embase, and Cochrane Library) without date or language restriction from inception to the end of November 2018. References of all eligible studies were also screened to identify potential sources that were not previously identified. Only studies reporting on the use of the FET were considered. Search strategy combined "aortic dissection," "frozen elephant trunk," "Thoraflex," and "E-Vita." Outcomes of interest included all-cause mortality in hospital or within 30 days from the index surgical procedure, included postoperative neurological events, spinal cord injury, and RRT. Year of publication, study design, country, sample size, recruitment period, baseline patient demographics, cardiac status, and comorbidities were also extracted. Data were summarized in mean ± standard deviation or range for continuous variables, and number and percentages for categorical variables.

RESULTS

The study group included 39 males and 27 females with a mean age of 62 years (range, 36–84 years). Comprehensive patient characteristics are outlined in Table 1. Peripheral malperfusion was present in 17 individuals (26%). The mean duration of antegrade selective cerebral perfusion was 77 ± 31 minutes, with a mean CPB time of 338 ± 104 minutes, myocardial and visceral ischemic times of 197 ± 72 and 79 ± 33 minutes, respectively. Concomitant cardiac procedures were performed in 31 patients (47%; Table 2). In the current series, all 66 device implants were successful, and the mean adopted stent size was 30 mm (range, 24–38 mm). The overall in-hospital mortality accounted for 8 patients (12%), while neurologic events and temporary RRT were recorded in 11 (17%) and 13 (20%) individuals, respectively (Table 3). No spinal cord injuries were observed. The mean hospital stay was 22.8 ± 14.7 days. After a mean follow-up of 15.5 months (range, 1–55 months), only 1 late death was registered, and 4 thoracic endovascular aortic repairs were required.

The parallel literature search yielded a total of 216 records, but only 2 retrospective studies performed at 2 high-volume centers reporting on FET use in ATAAD patients were identified.[16,17] A total of 196 patients were comprised. In-hospital/30-day mortality ranged from 11% to 12%, stroke occurrence from 7% to 18%, spinal cord injury from 4% to 5%, and finally RRT from 16% to 41%, respectively (Table 4).

Table 1. Baseline Characteristics of the Patient Population

Variables	*N* (%)
Patients	66
Age, y	62 (36–84)
Male	39 (59%)
Hypertension	38 (58%)
Diabetes	15 (22%)
COPD	7 (11%)
Connective tissue disorder	16 (25%)
Previous surgery	3 (5%)
Collapse or malperfusion	17 (26%)

COPD, chronic obstructive pulmonary disease.

Table 2. Intraoperative Data

Variables	*N* (%)
Concomitant cardiac procedure	31 (47%)
AVR	9 (14%)
Aortic root replacement/repair	19 (29%)
MVR	1 (2%)
Tricuspid valve repair	1 (2%)
CABG	1 (2%)
Cardiopulmonary bypass time, min	338 ± 104
Lowest temperature, °C	21.4 ± 2.2 (15–25)
Cardiac ischemic time, min	197 ± 72
Distal body ischemia time, min	79 ± 33
SACP time, min	77 ± 31

AVR, aortic valve replacement; CABG, coronary artery bypass grafting; MVR, mitral valve replacement/repair.

Table 3. Outcome Data

Variables	*N* (%)
ITU stay, d	10.7 ± 10.3
Hospital stay, d	22.8 ± 14.7
Stroke/temporary neurologic events	11 (17%)
Spinal cord injury	0
RRT	13 (20%)
In-hospital mortality	8 (12%)

ITU, intensive care unit; RRT, renal replacement therapy.

Table 4. Systematic Review of Patient Population Affected by Type A Acute Aortic Dissection Treated With Frozen Elephant Trunk Technique in High-Volume Aortic Centers

Authors, Y	Country	Period	N.Pts	Male (%)	Device	Concomitant Procedures (%)	In-Hospital Mortality (%)	Stroke (%)	SCI (%)	RRT (%)
Jakob et al, 2017[16]	Germany	2005–2015	96	32	Jotek E-vita	77	11	7	5	41
Shrestha et al, 2017[17]	Germany	2001–2016	100	53	Chavan-Haveric, Jotec E-vita, Thoraflex	72	12	18	6	17
UK-AS (present series)	UK	2013–2017	66	59	Thoraflex	47	12	17	0	20

DISCUSSION

The current study reflects the initial experience of a national collective of cardiothoracic surgeons with expertise in complex aortic surgery, using FET as standard technique in ATAAD patients. The results presented here demonstrated that FET technique in this patient population proved to be satisfactory when compared with previous national surgical data. This initial experience demonstrated a reduction in ATAAD mortality, falling from 23% to 12% after UK care implementation for diseases of the thoracic aorta.[18] This reorganization was stimulated by the observed significant regional variation in access to treatment, the organization of clinical services, and mortality for patients with diseases of thoracic aorta in England.[4,8,19] However, currently, there is no accepted minimum service specification for the delivery or commissioning of care for patients with aortic disease.[20,21] The analysis of national data indicated wide regional variation in the volume and complexity of aortic cases undertaken in English cardiac centers.[4] The significant impact of aortic configuration in clinical ATAAD outcomes has recently been confirmed by a large systematic review and meta-analysis.[4,9] Patients treated in high-volume centers with a specific multidisciplinary aortic program had a 50% relative risk reduction in mortality when compared with low-volume centers.[9] Andersen et al[6] observed a dramatic reduction in mortality (from 33.9% to 2.8%) in surgically treated ATAAD patients after the introduction of a multidisciplinary thoracic aortic surgery program. Similarly, Harris et al[7] demonstrated a significant reduction in the length of time to both ATAAD diagnosis and surgical repair (median time reduction of 30% and 50%, respectively), leading to an improved postoperative survival, following the introduction of a standardized protocol within a regional hospital network.

Based on the above clinical evidences, a national reorganization of UK aortic services was initiated in 2013 with creation of a UK collective of cardiothoracic surgeons with expertise in complex aortic surgery. The aim was to develop local and supraregional referral networks, based on high-volume surgeons, established multidisciplinary teams, including cardiac and vascular surgeon, and interventional radiologist, and the utilization of hybrid theaters. The subsequent reorganization led to initially concentrating complex aortic surgery such as FET in ATAAD patients in well-recognized UK high-volume aortic centers. The present case series is a testament of this initial reorganization, showing improved outcome in the ATAAD condition in high-volume centers, even with adoption of more complex surgical techniques (FET) in comparison with standard and more conservative approaches.[16,17,22]

FET operations have been demonstrated to be potentially very complex, requiring long operative times, especially in high-risk populations such as patients affected by acute aortic syndromes.[22] In addition, FETs are associated with a not negligible incidence of neurologic and renal complications, including spinal cord injury.[16,17,22] However, our results were comparable with those reported by other high-volume aortic centers with a large FET experience in patients affected by ATAAD condition.[16,17] Jakob et al[16] collecting data on 96 AADA patients treated with E-vita Open hybrid graft (Jotec GmbH, Hechingen, Germany) showed a 12% hospital mortality with 7% and 5% of postoperative stroke and spinal cord injury, respectively. Similar data were also reported by Shrestha et al[17] with 100 ATAAD patients treated with the Thoraflex hybrid graft. Also of interest is that our data have not shown any incidence of spinal cord injury.

The present study presents some limitations. The study is limited in statistical terms based on relatively small sample size, although this is the third largest series published on ATAAD patients treated with FET.[16,17] The small sample size and relatively low rate of complications also prevent us to detect differences in the rate of complications among centers. Finally, another limitation is the lack of long-term follow-up.

In conclusion, we have reported our early clinical experience with hybrid arch and FET repair with the Thoraflex hybrid graft in patients affected by ATAAD across high-volume UK aortic centers, in an initial service reorganization. This initial experience demonstrated that FET can potentially be adopted as standard approach in life-threatening aortic diseases, with acceptable complication and mortality rates.

COLLABORATORS

UK Aortic Surgery (UK-AS) group (Chairman: Mr Geoff Tsang); Mr Hassan Kattach, Southampton General Hospital, Southampton; Mr Alex Cale, Castle Hill Hospital, Hull; Miss Deborah Harrington, Liverpool Heart and Chest Hospital; Mr Ulrich Rosendahl, Mr George Asimakopoulos and Mr Sunil Bhudia, Royal Brompton and Harefield NHS Trust, London;

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